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Master Thesis

MSc Financial Economics

Capital Structure Determinants: Nonlinearities, Financing constraints, and Endogeneity

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Abstract

This thesis examines capital structure determinants for unregulated publicly traded U.S firms from 2003 to 2021. In line with prior findings, I find that we can explain about one third of the variation in market leverage by including core and minor leverage factors. Core factors include median industry leverage, profitability, market-to-book assets ratio, log of assets, and tangibility. For the best performing leverage measure in my sample, nonlinearities are statistically significant for all core factors except median industry leverage and add considerable explanatory power to the regression's R^2, which increases by 2% when squared terms are enhanced in the model. Additionally, nonlinearities remain robust when fixed effects are included in the regression model. Moreover, I demonstrate that the level of financing constraints is nontrivial for the performance of the core five factor model, and most importantly the core leverage factor profitability is statistically insignificant for small firms when considering market leverage. Also, under a 2SLS framework, I display that leverage declines as cash holdings increase. Most of the empirical evidence seems consistent with the trade-off theory of capital structure. Finally, implications for future research in capital structure are discussed.

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I. Introduction

Capital structure determinants is one of the most important topics in the field of applied corporate finance because it is very important to identify and interpret factors that influence corporate borrowing. Despite decades long of empirical research in the most prominent theories of capital structure, we still elude knowledge on what determines firm leverage and how to encounter previously ignored caveats in capital structure determinants. This problem is exacerbated by the lack of up-to-date research papers, as most capital structure studies focus on empirical patterns that existed 20 or 30 years ago. Therefore, the literature needs a recent study that will refresh our understanding on factors that affect leverage and highlight key elements often ignored before, such as the role of financing constraints and the presence of endogeneity and nonlinear relationships in capital structure. In the present thesis, I tackle these challenging issues in a solid theoretical and empirical framework.

Several theories of capital structure exist, but none seems to be the complete story. The most widely cited is the trade-off theory, in which a firm has an optimal target debt ratio that depends on the benefits of the tax-deductible interest expenses, and the potential costs of financial distress. This theory was built upon loosening the assumptions of the proposition I of the Modigliani and Miller theorem of capital structure irrelevance, which stated that firm value is unaffected by its capital structure. In plain words, the value of a levered firm is equal to the value of an unlevered firm under certain circumstances, i.e., absence of taxes, bankruptcy costs or information asymmetry. Furthermore, Myers and Majluf (1984) introduced a much different theory of corporate financing, the pecking order theory. This theory proposes the existence of information asymmetry in firms' capital structure. In brief, their model suggests that corporations first rely on internal funds, prefer debt to equity if external financing is required, while equity is issued only as a last resort, resulting in a hierarchy of financing.

Furthermore, a crucial assumption of the trade-off theory and the pecking order model is that managers act in the best interests of shareholders. Jensen (1986) suggests that managers act in their own interests and they invest sub-optimally in many investment projects, for example, they invest cash below the cost of capital or waste it on organizational inefficiencies (Myers, 2001). Therefore, firms borrow in order to curb overinvestment, whereas the ideal level of debt leaves just enough cash to fund only the positive NPV projects. It is worth to mention that Jensen's (1986) free-cash-flow theory does not provide a solid framework for explaining firm financing; it rather supports the view that managers tend to overinvest (Myers, 2003). Finally, Baker and Wurgler (2002) state that firms are more likely to issue equity when their market values are high, relative to book and past market values, and to repurchase equity when their market values are low. This is a simple theory of capital structure, often mentioned as market timing theory.

To begin with, the most classic papers of the capital structure literature disagree over basic facts. Titman and Wessel (1988) find that nondebt tax shields, collateral, or future growth do not affect leverage. Frank and Goyal (2009) find that market leverage is positively related to median industry leverage, firm size, tangibility, and expected inflation, while it is negatively related to profitability and market-to-book assets ratio. These findings can be rather contrasting and I aim to give a clearer explanation for these basic findings in the capital structure of U.S firms'. Lemmon, Roberts, and Zender (2008) find that the majority of variation in leverage is driven by unobserved time-invariant effect that generates surprisingly stable capital structures.[1] DeAngelo and Roll (2015) suggest that median industry leverage varies widely over time and capital structure stability is the exception, not the rule, occurs primarily at low leverage and is virtually always temporary. My findings shed light on these contradictory findings as well.

Moreover, Frank and Goyal (2009) demonstrate that that the most reliable factors for explaining market leverage are: median industry leverage (+ effect on leverage), market-to-book assets ratio (-), profitability (-), log of assets (+), and expected inflation (+), which they consider core factors of leverage. However, their findings for book leverage are not reliable because firm size and market-to-book assets ratio have the opposite coefficient sign than the one they have with market leverage. De Jong et al. (2010) find that financing constraints play a crucial role in determining financing decisions while examining a very large cross-section of U.S firms. Also, Frank and Goyal (2009) examine the robustness of the determinants of capital structure display that financing constraints do not affect the robustness of their core leverage model, and minor factors (see Appendix B) should be excluded when examining different types of firms in order to achieve robustness. Because the core leverage factors may matter more for firms in different circumstances, it is appropriate to examine in greater detail the determinants of capital structure for financially constrained and unconstrained firms. This will also aid into providing a clearer picture for the leverage regressions between different types of firms, since Frank and Goyal (2009) mainly focus on core factors that matter for both financially constrained and unconstrained firms.

[1] Lemmon, Roberts, and Zender (2008) also display that firm size as measured by the log of assets is positively related to leverage and the market-to-book ratio is negatively related to leverage. This is in line with both book and market leverage in their sample and comes in contrast to the findings of Frank and Goyal (2009) who suggest that the effect of firm size and market-to-book ratio is not reliable for book leverage.

Furthermore, I do not provide structural tests for the aforementioned theories in my thesis; my aim is to obtain valid empirical evidence using leverage regressions with core and minor leverage factors widely used in prior literature, and to address important issues often ignored in capital structure studies while using a more recent sample. In order to observe capital structure stability, I do not build a target-leverage model, but instead I observe changes in the core leverage factor of median industry leverage which has been widely used as a proxy for target capital structure. In addition, I suggest that the Fama and French (1997) definition is the most robust one for median industry leverage.[2] Core factors include median industry leverage, profitability, market-to-book assets ratio, log of assets, and tangibility. Minor factors include taxes, stock market and debt market conditions, supply-side factors, and macroeconomic conditions. The variables are defined in the Appendix B. My thesis contributes to the empirical corporate finance literature in four ways. First, I analyze the variation explained in leverage by including most of the core and minor factors of Frank and Goyal (2009). Secondly, I examine the nontrivial issue of nonlinear relationships in capital structure that is often ignored. Third, I explain the impact that the level of financing constraints has on the core leverage model. Fourth, I examine the relationship between cash holdings and leverage in the capital structure of U.S firms'. Therefore, the main research question of my thesis can be summarized as follows:

" How can we understand more about the capital structure determinants of U.S firms while using a more recent sample?"

The main research question, which is quite broad because I aim to give a clearer picture of the empirical patterns observed in capital structure, leads to the following testable hypotheses:

H_1: Core and minor leverage factors can explain about one third of the variation in market leverage in a linear regression model.

H_2: Nonlinearities are present in capital structure determinants and their magnitude is statistically significant.

H_3: The determinants of capital structure are not affected by the level of financing constraints.

H_4: Cash holdings and leverage are jointly determined in capital structure and negatively related.

The aforementioned hypotheses are both testable and realistic. The main research question and the subsequent hypotheses are inspired to a large degree by the findings and

[2] The Fama and French (1997) 48 industry definition is the most solid definition (compared to FF-12 or FF-17) because leverage regressions have the highest R-squared and the distribution of firms is well-established; there are no industries with a small number of firms. This aids to avoid bias at the coefficient estimates. The frequency tables of industry definitions are available upon request.

suggestions of Frank and Goyal (2009). The authors find that by including both core and minor factors in the best performing market leverage model, we can explain about 29% of the variation in market leverage, and financing constraints do not affect the robustness of their core leverage model. Also, the authors suggest that future research could focus on the incorporation of fixed effects, general nonlinearities, and/or other models that are robust to endogeneity. Finally, the last hypothesis is relevant to cash holdings management in capital structure. Opler et al. (1999) provide time-series and cross-section tests for a supportive static tradeoff model of cash holdings, in which they find that large firms tend to hold lower cash ratios and firms with strong growth opportunities hold relatively high ratios of cash. In addition, Acharya et al. (2007) suggest that cash should not be viewed as negative debt in the presence of financing frictions. Since prior research does not focus on the relationship between cash holdings and leverage, I deem it appropriate to use the core leverage factors and provide a solid framework in order to determine the relationship between cash holdings and leverage in the capital structure of U.S firms'. Therefore, it is important to understand how cash holdings is related to leverage for both financially constrained and unconstrained firms.

The main findings of my thesis can be summarized as follows. First of all, I provide empirical evidence (Table IV) for the leverage regressions using both core and minor factors and I find out that we still can explain about one third of the variation in market leverage because the R^2 is 30.7% without fixed effects. In contrast to the findings of Frank and Goyal (2009), I display that the effects of firm size and market-to-book assets ratio are reliable for book leverage as well. On the second stage, I keep only the core five leverage factors of median industry leverage, profitability, tangibility, market-to-book assets, and firm size and enhance the leverage regression with an additional squared term for each factor. For the best performing leverage measure, I find out (Table V) that all nonlinear terms except median industry leverage are statistically significant, and the R^2 of the regression is 30.8%, which means that nonlinearities add considerable explanatory power to the regression's R^2. In the third place, I classify firms on firm size and payout status to examine if the level of financing constraints is important for capital structure determinants. Surprisingly, I find out (Table VII) that the core factor profitability is not statistically significant for small firms when considering market leverage. Finally, under a 2SLS framework, I demonstrate (Table IX) that leverage declines as cash holdings increase. The outline of my thesis is as follows. Section II discusses the theoretical framework. Data and univariate evidence are presented in Section III. Section IV presents the bivariate plus multivariate evidence and the methodology used in the leverage regressions. Section V reports the relationship between cash holdings and leverage under a joint determination framework. Section VI discusses the robustness of the results and highlights the implications for future research. Section VII concludes the thesis.

II. Theoretical Framework

A. Trade-off Theory

2.1.1. Theoretical framework

According to the trade-off theory, optimal capital structure is determined by the trade-off between the benefits of debt and the costs of debt (Frank and Goyal, 2009). The benefits of debt include the interest tax shields that corporations can take advantage of, especially when tax rates are high. On the other hand, the costs of debt can be obtained in several ways. First, the most commonly cited costs of debt include direct and indirect costs of financial distress that originate from "excessive" borrowing.[3] Therefore, firms will have to consider direct costs of financial distress that are incurred in bankruptcy and reorganization, such as legal and administrative costs (Myers, 2003).

In addition, Andrade and Kaplan (1998) found that most of the costs of financial distress are explained by indirect costs, and economies of scale are persistent in bankruptcy. Indirect costs of financial distress are mostly due to agency costs generated by conflicts of interest between debt and equity investors (Myers, 2003). Under such circumstances, managers usually act in the interests of existing shareholders. For example, they invest in very risky investment projects in which stockholders have upside potential and the downside risk is absorbed by the creditors (Jensen and Meckling, 1976). Furthermore, managers may be able to borrow still more and pay out cash to shareholders, which does not affect the overall firm value but makes creditors worse off because the market value of the debt declines.[4] (Myers, 2003).

Moreover, the agency perspective suggests that debt disciplines managers and mitigates problems of free cash flow because firms must pay off debt to avoid bankruptcy (Jensen and Meckling 1976 and Jensen, 1986). Morellec (2004) provides additional support for the view of Jensen (1986) and suggests that optimal capital structure reflects both the tax advantage of debt less bankruptcy costs and the agency costs of managerial discretion. Also, the model of Morellec (2004) shows that manager-shareholder conflicts can explain the low debt levels

[3] Myers (2003) suggests that the trade-off theory has common-sense appeal because interest tax shields appear to have significant value, at least under the USA corporate tax system, and there are ample examples of costs triggered by "excessive" debt.

[4] New debt does not suffer because it is issued at market value and the cash that shareholders receive more than offset the drop in the value of their shares (Myers, 2003).

observed in practice. Finally, Titman (1984) argues that firms making unique products will lose customers if they appear to be in financial distress. To conclude with, the trade-off theory can be viewed as trading off the benefits of debt with the (in)direct costs of financial distress and agency costs and/or other liquidation costs.

2.1.2 Predictions

To begin with, the static trade-off theory yields predictions for all the core and minor leverage factors that are used in my thesis and will be briefly explained below.[5] Unsurprisingly, high taxes increase the benefits of interest tax shields and thus a positive relationship is predicted between leverage and taxes. Growth opportunities should be negatively related to leverage because growth increases the costs of financial distress, reduces cash flow problems, and exacerbates debt-related agency problems (Frank and Goyal, 2009). When considering leverage and debt market conditions, a negative prediction is made for term spread, assuming that a higher term spread implies higher growth opportunities.[6] Firm size should be positively related to leverage because large firms are more diversified and face lower default risk and lower debt-related agency costs (Frank and Goyal, 2009). Tangibility is also predicted to increase leverage because it increases collateral value and makes it harder for managers to engage in risk shifting, thus lowering the expected costs of financial distress and debt-related agency costs.

In addition, firms that operate in high levered industries should accumulate more debt, according to the trade-off theory, when median industry leverage is considered as a leverage factor.[7] The static trade-off theory predicts that profitability and leverage should be positively related as well, because more profitable firms face lower costs of financial distress and are attracted by the interest tax shields.[8] Furthermore, firms that possess a good credit rating should accumulate more debt because of easier access to capital markets or less debt because of restricted debt market access (Faulkender and Petersen, 2006), which results in a positive relationship between credit rating and debt. Leverage and macroeconomic conditions are also positively related according to the trade-off theory because both profits and hence taxes increase while the economy is expanding. Finally, leverage and stock market conditions should be

[5] Frank and Goyal (2009) provide a very detailed analysis for the predictions between leverage and core/minor factors.

[6] If expected inflation is used as a factor for debt market conditions, then the trade-off theory predicts that leverage is positively related to expected inflation.

[7] If median industry growth is used, then the trade-off theory predicts a negative relationship between this industry variable and the debt ratio.

[8] Under a dynamic trade-off theory, leverage and profitability can be negatively related due to various model assumptions and/or frictions. For example, see Fischer et al. (1989) and Kayhan and Titman (2007).

negatively related under any of the leading capital structure theories, because strong market performance results in a reduction in market leverage (Frank and Goyal, 2009).

B. Pecking order Theory

2.2.1. Theoretical background

Myers and Majluf (1984) introduce a model of corporate financing that assumes financial markets are efficient, except for asymmetric information. This pecking order model suggests that managers know more about the firm's value than investors, however, investors interpret the firm's actions rationally (Myers, 1984). Myers and Majluf derive an equilibrium in which firms issue shares to fund their growth opportunities only at a marked-down price because of the information inferred from the decision to issue (Myers, 2003). In other words, firms that have undervalued shares will forgo the valuable growth opportunity by not issuing shares, while firms that have overvalued shares will decide to issue shares and hence investors will negatively react to the equity issuance announcement. As a result, firms prefer internal to external financing because of informational asymmetries, and if external funds are required then debt is preferred to equity.[9] Finally, equity is issued only as a last resort in case there are substantial costs of financial distress. Although the key assumption in the pecking order theory is information asymmetry, it can also be generated from agency, tax, or behavioral considerations.[10] (Frank and Goyal, 2009).

2.2.2 Predictions

To begin with, the usual version of the pecking order theory relies on the existence of information asymmetry in firms' capital structure, as explained before. In contrast to the predictions of the trade-off theory, the pecking order theory predicts that virtually all leverage factors are negatively related to leverage. For example, low information asymmetry associated with tangible assets makes equity issuances less costly and thus leverage should be lower for firms with higher tangibility (Frank and Goyal, 2009). Moreover, firm size should be negatively related to leverage under the pecking order, since large firms have had numerous opportunities to retain earnings, and their reputation aids to alleviate asymmetric information concerns. Profitability increases retained earnings and the internal financing of firms, which prefer

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9 In the pecking order theory, firms will work down the pecking order and prefer safer to riskier debt.

10 See, Jensen and Meckling (1976) for a pecking order that considers trade-offs between "inside" shareholders and new stockholders, and Frank and Goyal (2008) for a discussion of how tax and agency considerations can lead to a hierarchy of financing (Frank and Goyal, 2009).

internal over external financing, and thus more profitable firms are less levered.[11] Growth opportunities is the only factor positively related to leverage under the pecking order theory because of the hierarchy in financing; firms should use more debt in order to fund their growth opportunities, holding profitability fixed. Furthermore, firms that possess a credit rating should be less levered as well, because credit ratings reduce information asymmetry problems and encourage firms to issue equity, since the issuance announcement would not negatively affect the firm's stock. Finally, macroeconomic conditions (GDP growth) are also negatively related to debt under the pecking order model, because profits and hence internal funds increase during economic expansions. Last but not least, I do not report the theoretical predictions if the pecking order theory does not predict a relationship between leverage and core or minor factors or if this relationship is quite unclear.[12]

C. Market timing Theory

2.3.1. Theoretical structure

The notion of market timing had been around for many years, prior to the introduction of the market timing theory by Baker and Wurgler in 2002. Lucas and MacDonald (1990) suggest that if the stock is undervalued due to information asymmetry, then firms will issue equity after information release and ensuing stock price increase. Loughran and Ritter (1995) also support the view that firms will issue equity after a recent increase in stock price ("a window of opportunity"). Graham and Harvey (2001) survey 392 CFOs and many of them admit that they attempt to time the equity market and issue equity after the stock price has risen, verifying prior arguments about the concept of market timing. Baker and Wurgler (2002) introduce the market timing theory in a formal way, and support that firms are more likely to issue equity when their market values are high, relative to book and past market values, and to repurchase equity when their market values are low. In addition, Baker and Wurgler (2002) argue that these findings are very persistent in the capital structure and hence capital structure decisions are the cumulative outcome of past attempts to time the equity market. Finally, there are 2 versions of the market timing theory. The first one is a dynamic form of Myers and Majluf (1984) with rational managers and investors and adverse selection costs that vary across firms

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[11] Assuming that investments and dividends are fixed, then more profitable firms will become less levered over time (Frank and Goyal, 2009).

[12] For example, under a pure pecking order perspective the industry median leverage, which is one of the most important leverage factors, should only matter to the extent that it serves as a proxy for the firm's financing deficit- a rather indirect link (Frank and Goyal, 2009).

or across time, and the second version, which suggests irrational investors (or managers) and time-varying mispricing.[13]

2.3.2. Predictions

Market timing theory only makes predictions for three leverage factors: growth (core factor), stock market conditions and debt market conditions (minor factors).[14] To begin with, leverage should be negatively related to stock market conditions because strong market performance results in a reduction in market leverage, as explained in the section of the trade-off theory. Moreover, growth increases the market-to-book assets ratio and thus firms should reduce leverage in order to exploit equity mispricing through equity issuances (Frank and Goyal, 2009). Similarly, if the term spread implies higher growth opportunities, then leverage should be negatively related to debt market conditions as well. To conclude Section II, I present a table that summarizes all of the theoretical predictions of the capital structure theories discussed in this section.

Table I

Theoretical Predictions of Capital Structure Theories

	Static trade-off theory	Pecking order theory	Market timing theory
Industry	+	n/a	n/a
Profitability	+	-	n/a
Firm size	+	-	n/a
Growth	-	+	-
Nature of Assets	+	-	n/a
Taxes	+	n/a	n/a
Supply-side factors	+	-	n/a
Stock market conditions	-	-	-
Debt market conditions	-	n/a	-
Macroeconomic conditions	+	-	n/a

Table I summarizes the theoretical predictions of the capital structure theories described in Section II. The symbol + means that leverage is predicted to be positively related to the mentioned factor, while the symbol – means that it is negatively related, respectively. The abbreviation n/a is used when the capital structure theory does not predict a relationship between leverage and the factor, or their relationship is unclear (see footnote 12). The variables as well as core and minor factors are defined in the Appendix B.

[13] Baker and Wurgler (2002) mention that the second version of market timing does not require that the market be inefficient, but rather that managers simply believe that they can time the market.

[14] For sample size robustness issues, I include only the cumulative market returns (CrspRet) in my thesis, and I do not use individual firm stock returns as a minor factor.

III. Sample Description and Univariate Evidence

My initial sample of 81,806 firm-years consists of unregulated publicly traded U.S firms from 2003 to 2021, with nonzero total assets. Financial and utilities firms are excluded. The main data source for firm-specific variables is Compustat and the stock market return data are obtained from the Center for Research in Security Prices (CRSP). The rest of the data are obtained from several data sources and are defined in the Appendix.[15] Leverage factors are scaled by the book value of total assets and their definitions are provided in the Appendix as well.[16] Similarly to Frank and Goyal (2009) I winsorize the variables at the 0.50% level in both tails of the distribution to remove the effects of the most extreme outliers in the sample.[17] The final sample consists of 71,940 observations and 9,537 unique firms. I do not allow for missing data; however, my panel data is unbalanced which means that many firms do not have to report data for every single year throughout the sample period. The latter aids to reduce the usual survivorship bias and also allow firms in the sample that are financially constrained.

3.1. Leverage Definitions

Several leverage definitions have emerged throughout the years in the capital structure literature as there is no optimal way to define leverage. In my thesis, I apply both book and market leverage measures that have been used by Lemmon, Roberts, and Zender (2008) and Frank and Goyal (2009). Naturally, there are significant differences between book and market leverage measures. Myers (1977) suggests that managers focus on book leverage because debt is better supported by assets in place than it is by growth opportunities. On the other hand, Welch (2004) proposes that the book value of equity can even be negative and the book measure is backward looking, while financial markets are assumed to be forward looking. Considering both views and the sample period used in my thesis, I mainly focus on the market leverage definition, both long-term debt and total debt by market assets. However, when necessary, I report the results for book leverage as well. The variables are defined in the Appendix B.

Similarly to Frank and Goyal (2009), I study four alternative definitions of leverage: 1) the ratio of long-term debt to market value of assets (LDM), 2) the ratio of total debt to market

[15] Macroeconomic and debt market conditions data are obtained from the Federal Reserve Bank of St. Louis (FRED) and the credit ratings are downloaded from the Compustat S&P Ratings. Credit Ratings are not available after February 2017 because the database has been discontinued. Also, the data on the tax rate for U.S corporations are obtained from TradingEconomics.

[16] The core leverage factors including median industry leverage, profitability, market-to-book assets ratio, tangibility and the minor leverage factors of Capex and Depr (capital expenditures and depreciation) are scaled by the book value of total assets and a 100% cutoff level is used for all of them, except the market-to-book assets ratio which is bounded between the values of zero and ten. Also, leverage is bounded between zero and one. The rest of the minor factors which are expressed as percentages or dummy variables are not scaled by total assets.

[17] Variables that are expressed in percentages or dummy variables are not winsorized.

value of assets (TDM), 3) the ratio of total debt to book value of assets (TDA), and 4) the ratio of long-term debt to book value of assets (LDA).[18] I mainly focus on the LDM as a leverage measure; however the results are similar when the TDM is considered instead.

3.2. Univariate Evidence

Table II demonstrates the univariate evidence of the sample. To begin with, it is evident that the mean leverage is above median leverage, which suggests that there is significant variation in firm borrowing. The 10th percentile for all leverage measures is zero, while the 90th percentile is 0.46 for the LDM measure. The latter is also in line with the findings of DeAngelo and Roll (2015) who find that only few firms keep debt-to-assets ratios consistently above 0.5.

In addition, important differences between mean and median values are observed in several leverage factors. Profitability has a mean value of 0.03 while the median is 0.09, and that is because there are some firms that are very unprofitable, in contrast to other firms that are very profitable. I revisit this pattern in Section IV, in which I show that small firms are the most unprofitable and large firms are the most profitable ones. Moreover, both the mean and the median value of the market-to-book-assets ratio are above 1, which means that most U.S firms have valuable growth opportunities. The amount spent on capital expenditures is also considerable for U.S firms' inventories, while the mean value of net property plant and equipment (Tangibility) is equal to 0.25, which is somehow lower than in the samples of Frank and Goyal (2009) and Lemmon, Roberts, and Zender (2008). The soundest explanation for this finding is that intangible assets have become increasingly important in the last two decades for firms in the U.S. Also, the corporate tax rate in the U.S is declining throughout the sample period, from 35% prior to 2018 to 21% afterwards.

Furthermore, both the long-term and total debt (market leverage) remain remarkably stable throughout 2003-2021, although this should not be perceived as capital structure stability because it is the overall amount of leverage that is probably remaining stable in the cross-section.[19] More specifically, the mean value of long-term debt is 0.14 in 2003 and 0.17 in 2021. Similarly, the value of the total market debt is 0.194 in 2003 and 0.195 in 2021. The latter results are not driven by the Covid-19 crisis (2020-2021) because the debt ratios are similar to the ones in other years in the sample period. Overall, the mean values of the leverage measures

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[18] Some scholars argue that cash holdings should be considered negative debt and thus subtracted from the debt measure. Similarly to Frank and Goyal (2009) I do not carry out a full treatment of all candidate leverage definitions, although, I revisit the relationship between leverage and cash holdings under a joint determination framework in Section V.

[19] My argument is in line with the comprehensive study of DeAngelo and Roll (2016) who explain how such capital structure instability works throughout time.

in my sample seem reasonable and are somehow lower compared to the ones of Frank and Goyal (2009). Finally, variables that are expressed as percentages only have one observation available for each fiscal year and thus the cumulative number of observations is equal to 19.

Table II

Summary statistics for Publicly Traded Unregulated US firms, 2003-2021

Variable	N	Mean	SD	p10	p50	p90
Leverage measures						
TDM	71,940	0.21	0.23	0.00	0.12	0.57
TDA	71,940	0.22	0.21	0.00	0.17	0.53
LDM	71,940	0.16	0.20	0.00	0.08	0.46
LDA	71,940	0.17	0.20	0.00	0.11	0.46
Factors						
Profitability						
Profit	71,940	0.03	0.23	-0.28	0.09	0.21
Firm size						
Log Assets	71,940	6.30	2.55	3.02	6.27	9.59
Growth						
Mktbk	71,940	1.78	1.51	0.59	1.27	3.67
Capex	71,940	0.05	0.06	0.00	0.03	0.11
Industry						
IndustLev	71,940	0.15	0.12	0.02	0.11	0.33
Nature of assets						
Tang	71,940	0.25	0.25	0.02	0.16	0.67
Taxes						
TaxRate	19	0.32	0.05	0.21	0.35	0.35
Depr	71,940	0.05	0.04	0.00	0.04	0.09
Supply side factors						
Rating	71,940	0.08	0.28	0.00	0.00	0.00
Stock market conditions						
CrspRet	19	0.12	0.16	-0.05	0.13	0.30
Debt market conditions						
TermSprd	19	0.02	0.01	-0.00	0.02	0.03
Macroeconomic conditions						
Inflation	19	0.02	0.01	0.00	0.02	0.03
MacroGr	19	0.02	0.02	-0.02	0.02	0.04

This table displays the summary statistics of the sample. The leverage measures and factors are winsorized at the 0.5% level in both tails of the distribution and then the summary statistics are calculated (see footnote 17). The sample period is 2003-2021. Financial firms and utilities are excluded from the sample. The variables as well as core and minor factors are defined in the Appendix B. The table is a replication of Table I of Frank and Goyal (2009). Distribution percentiles are shown in the last three columns.

IV. Bivariate and Multivariate Evidence

4.1. Bivariate Evidence

Table III reports the correlations between the four leverage measures and core/minor factors, in order to better understand their relationship throughout the sample. In the brackets below each correlation, I report the sign of each correlation coefficient during two decades in the sample, from 2003 to 2012 and from 2012 to 2021. Only when combined with the triple-star symbol (***), the positive sign + means that the correlation is positive and statistically significant at the 1% level, and the negative sign – means that the correlation is negative and statistically significant at the 1% level as well. Moreover, a zero (0) in the bracket means that the correlation is not statistically significant at the 10% level or higher, and the question mark (?) displays that the correlation is omitted due to collinearity.

In both sub-sample periods, positive and statistically significant correlations for all leverage measures are observed for the following core factors: profitability, log of assets, median industry leverage, and tangibility. The market-to-book assets ratio, which is also a core factor, is strongly negatively correlated with all leverage measures as well. Moreover, the minor factors of stock market conditions (CrspRet) and macroeconomic conditions (MacroGr) have negative and statistically significant correlations for most leverage definitions. In contrast to GDP growth, the statistical significance of the correlations of expected inflation is quite problematic, but this is not surprising because Frank and Goyal (2009) point out that it is the least reliable "core factor" in their sample. Interesting bivariate evidence is also found for the rest of the minor factors, and for that reason I include them in the leverage regressions.[20]

4.2. Methodology and Multivariate Evidence

4.2.1. Methodology

Bivariate evidence is compelling, but a more formal methodology is needed to capture the effects of each factor on leverage. For this purpose, I apply the usual OLS methodology and perform leverage regressions. Furthermore, I tackle the usual linear regression issues that violate the assumptions of the OLS model, such as endogeneity and serial correlation along with heteroskedasticity of unknown form, which is highly present in panel data. In order to avoid endogeneity, I use the first lag in all leverage factors that are used in the leverage regressions, which aids to ensure exogeneity of the factors. Furthermore, it is sensible to include

[20] All of the minor factors have been examined in unreported leverage regressions, and thus I report the most robust results in the multivariate evidence part of this section.

the first lag because a firm could pay down debt at time t, while it is very profitable at time t-1, which provides further support for the use of proxy variables in the regressions.

Table III

Correlations between Leverage measures and Factors

	Total Debt/Market Assets (TDM)	Total Debt/Book Assets (TDA)	Long-term Debt/Market Assets (LDM)	Long-term Debt/Book Assets (LDA)
Profit	0.124^{***}	0.095^{***}	0.166^{***}	0.160^{***}
	[++]	[++]	[++]	[++]
Log Assets	0.259^{***}	0.236^{***}	0.343^{***}	0.330^{***}
	[++]	[++]	[++]	[++]
Mktbk	-0.419^{***}	-0.142^{***}	-0.359^{***}	-0.132^{***}
	[--]	[--]	[--]	[--]
Capex	0.106^{***}	0.117^{***}	0.132^{***}	0.343^{***}
	[++]	[++]	[++]	[++]
IndustLev	0.428^{***}	0.338^{***}	0.430^{***}	0.340^{***}
	[++]	[++]	[++]	[++]
Tang	0.359^{***}	0.307^{***}	0.376^{***}	0.316^{***}
	[++]	[++]	[++]	[++]
TaxRate	-0.049^{***}	-0.096^{***}	-0.070^{***}	-0.112^{***}
	[?-]	[?-]	[?-]	[?-]
Depr	0.179^{***}	0.195^{***}	0.163^{***}	0.162^{***}
	[++]	[++]	[++]	[++]
Rating	0.017^{***}	0.140^{***}	0.039^{***}	0.069^{***}
	[+0]	[++]	[++]	[++]
CrspRet	-0.055^{***}	0.002	-0.044^{***}	0.003
	[-0]	[-0]	[--]	[-0]
TermSprd	-0.003	-0.046^{***}	-0.015^{***}	-0.050^{***}
	[+-]	[0-]	[+-]	[0-]
Inflation	-0.026^{***}	-0.026^{***}	-0.027^{***}	-0.028^{***}
	[0-]	[0+]	[00]	[0+]
MacroGr	-0.064^{***}	-0.008^{***}	-0.046^{***}	0.004
	[--]	[--]	[--]	[-0]

This table displays correlation coefficients between leverage measures and core/minor factors. The variables as well as core and minor factors are defined in the Appendix B. The sample is split between 2003-2012 and 2012-2021, and the sign of the correlation coefficient is reported in the brackets. A + indicates that the correlation was positive and statistically significant, whereas the – shows that the correlation was negative and statistically significant, throughout the sub-sample periods. A 0 displays that the correlation was not statistically significant at a 10% confidence level or at a higher level, and the ? mark displays that the correlation is omitted due to multicollinearity. The symbol *** display statistical significance at the 1% level. This table is similar to Table II of Frank and Goyal (2009).

Similarly to the methodology of Frank and Goyal (2009), let $L_{i,t}$ denote the leverage of firm i at date t and the set of factors observed at firm i at date t-1 denoted by $F_{i,t-1}$. The constant term α and the coefficient vectors β and γ are the parameters to be estimated for the linear regression model. In addition, I cluster the coefficients at the firm level in order to remove the effects of clustering on the estimated standard errors and t-statistics. Furthermore, in line with Harford et al. (2014) I also include dummy variables to capture industry fixed effects and time fixed effects. The basic model for the leverage regressions is:

$$L_{i,t} = \alpha + \alpha_\kappa + \alpha_\lambda + \beta F_{i,t-1} + \gamma F_{i,t-1}^2 + \varepsilon_{i,t} \quad (1)$$

Where α_κ and α_λ capture the industry fixed effects and time fixed effects, respectively.[21] The squared term in the leverage factors is used only in Table V. Furthermore, I also include the usual Akaike and Bayesian information criteria (AIC and BIC) in my analysis because they provide additional support for model selection, for example, they aid into comparing two models with two different leverage measures, when nonlinear factors are added in the core leverage model.[22] Similarly to Frank and Goyal (2009) let P be the number of parameters and let N be the number of observations in a fitted model. The AIC and BIC are defined as follows,

$$AIC = -2\ x\ log - likelihood + 2\ x\ P \quad (2)$$

$$BIC = -2\ x\ log - likelihood + P\ x\ log(N) \quad (3)$$

and the purpose is to minimize each of the information criteria, since a higher log-likelihood value combined with a large sample increases the probability that the model has better performance.

4.2.2. Multivariate Evidence

4.2.2.1. Leverage Factors with Fixed Effects

To begin with, Table IV reports the leverage regressions for LDM and TDM, for both core and minor factors.[23] The empirical findings verify that standard leverage factors explain a portion of the variation in firm leverage, under any leverage measure.

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[21] Note that I do not use industry and/or time fixed effects in every regression model. When industry fixed effects and time fixed effects are excluded, the parameters α_κ and α_λ are omitted from the model.

[22] Table V presents the results when the nonlinear factors are added in the core leverage model. Although the two models with nonlinear factors have very similar R-squared values, the information criteria differ significantly. Thus, these information criteria are helpful for model selection, especially when the sample size is large enough.

[23] I report the minor factors that are the most reliable. For example, tax rate (TaxRate) is negatively related to leverage, and depreciation (Depr, nondebt tax shield proxy) is positively related to leverage. Also, I include GDP growth (MacroGr) instead of expected inflation because it is more robust. Capital expenditures (Capex), which is the leftover minor factor, can be a relatively good proxy for growth opportunities but I include the market-to-book assets ratio because the latter is more robust. These results are robust for almost all four leverage measures and are available upon request.

Table IV

Revisiting Core and Minor Factors with Fixed Effects

	Long-Term Debt/Market Assets (LDM) (1)	Long-Term Debt/Market Assets (LDM) (2)	Total Debt/Book Assets (TDA) (3)	Total Debt/Book Assets (TDA) (4)
IndustLev	0.379***	0.280***	0.392***	0.188***
	(19.3)	(11.3)	(19.4)	(7.01)
Profit	-0.065***	-0.069***	-0.080***	-0.088***
	(-13.1)	(-12.5)	(-10.3)	(-10.8)
Mktbk	-0.026***	-0.027***	-0.003***	-0.005***
	(-34.4)	(-35.5)	(-3.24)	(-4.42)
Tang	0.151***	0.204***	0.141***	0.217***
	(15.4)	(16.6)	(13.9)	(17.9)
Log Assets	0.025***	0.025***	0.018***	0.019***
	(29.2)	(29.6)	(18.1)	(18.9)
Dividend	-0.020***	-0.022***	-0.011**	-0.015***
	(-5.50)	(-6.03)	(-2.52)	(-3.65)
Rating	-0.087***	-0.082***	-0.039***	-0.032***
	(-15.6)	(-14.5)	(-5.98)	(-5.00)
CrspRet	0.018***	-0.082***	0.026***	-0.137***
	(5.83)	(-8.76)	(7.78)	(-13.3)
TermSprd	-1.130***	-0.92***	-1.27***	-3.24***
	(-17.2)	(-2.83)	(-17.0)	(-8.43)
MacroGr	0.152***	0.110***	0.260***	0.133***
	(4.66)	(2.75)	(7.12)	(2.71)
Constant	-0.011**	-0.012	0.041***	0.077***
	(-2.04)	(-0.50)	(6.06)	(2.85)
Industry Fixed Effects	No	Yes	No	Yes
Year Fixed Effects	No	Yes	No	Yes
R^2-adjusted	0.307	0.334	0.167	0.204
N	62,085	62,085	62,085	62,085

This table displays the OLS regressions with both core and minor factors. The variables as well as core and minor factors are defined in the Appendix B. All core factors (rows 1-6) except firm size (Log Assets) and the dividend dummy (Dividend) are scaled by the book value of total assets. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial and utilities firms are excluded from the sample. Abbreviations for the variables are defined as in Frank and Goyal (2009). Industry fixed effects are dummy variables for each of the Fama and French (1997) 48 industry groups. Year fixed effects are dummy variables for each calendar year throughout 2004-2016. Because of collinearity, year fixed effects are excluded from 2017 to 2021. The symbols *** and ** denote statistical significance at the 1% and 5% level, respectively, and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Secondly, even if we consider the best performing leverage model (LDM), the R^2 is 30.7%. Similarly, Frank and Goyal (2009) find that the R^2 of their core market leverage model (TDM) is about 29%, after examining a large panel of 54 years, covering about 180,000 observations. Unsurprisingly, by using standard leverage factors we can explain just about one third of the variation in market leverage (Table IV). Moreover, in line with prior findings, dividend-paying firms are less levered. In contrast to the findings of Frank and Goyal (2009) and in line with the findings of Lemmon, Roberts, and Zender (2008) I display that the effect of market-to-book assets ratio and log of assets are reliable for both book and market leverage. Finally, I examine the core leverage factor model in two sub-sample periods and find no crucial differences in terms of R^2.[24] The results are reported in the Appendix (Table X).

Furthermore, Table IV highlights the nontrivial role of fixed effects in leverage regressions. Unsurprisingly, the fixed effects are statistically significant and also correct the coefficient sign of the factors. That is because these dummy variables are able to capture time-invariant industry effects and macroeconomic developments that occur over time. It is important to incorporate fixed effects in leverage regressions because stock market performance is negatively related to firm leverage when fixed effects are considered, which is more sensible, while this is not the case when fixed effects are excluded from the model (columns 1 and 3). Most of the theoretical predictions of the trade-off theory are verified by the empirical evidence in Table IV. The only two empirical findings that are not in line with the static trade-off theory is that investment grade firms are less levered and profitable firms use less debt as well. However, the focus is mainly on the core five leverage factors (rows 1-5) because they include virtually all of the explanatory power of the regression's R^2. In contrast to the trade-off theory, the pecking order theory makes correct predictions only for profitability (core factor) and for supply-side factors and stock market conditions (minor factors). The market timing theory correctly predicts the coefficient sign of growth opportunities, stock market and debt market conditions, but it is unable to explain the rest of the empirical evidence found in capital structure. Therefore, I can't disagree with the fact that these capital structure theories are conditional and should be jointly considered to explain capital structure.

In addition, Table IV sheds light on another interesting issue for capital structure determinants: the coefficient of median industry leverage is around 0.38 when fixed effects are excluded from the model, which is significantly lower than in other prominent capital structure studies. For example, Frank and Goyal (2009) find that median industry leverage has a

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[24] Clearly there are some differences in the core leverage factor model throughout the sub-sample periods. However, it is still evident that we can explain about one third of the variation in leverage during both periods.

coefficient of 0.85 and an own R^2 of 19% in a univariate regression model, while the same coefficient is about 0.65 in a multivariate regression model for the TDM measure. The empirical findings of Lemmon, Roberts, and Zender (2008) are similar to those of Frank and Goyal (2009) in terms of the magnitude of the coefficient estimate. In the Appendix (Table XI, column 1), I report the results for the univariate regression of median industry leverage on the second-best performing leverage measure (TDM). The coefficient estimate of median industry leverage is significantly lower than the one of Frank and Goyal (2009) and most importantly, the R^2 is 15.7% which means that median industry leverage has lost about 17% of its explanatory power as a core leverage factor throughout 2004-2021.[25] Since median industry leverage is used as a proxy for target capital structure, the latter empirical finding provides support for the findings of DeAngelo and Roll (2015) who suggest that capital structure instability is very persistent.

The robustness of the results in Table IV is achieved by the following research design: 1) I use at least the five core leverage factors of Frank and Goyal (2009), 2) Median industry leverage is defined at the Fama and French 48 definition (see footnote 2), and 3) I incorporate fixed effects to correct for the coefficient estimates. Any violation of this research design could alter the results to a mediocre extent. For example, the coefficient estimate for median industry leverage and the regression's R^2 can differ if another industry definition is used, especially when fixed effects are incorporated as well.[26] Finally, it is worth mentioning that the inclusion of fixed effects in the model impacts the coefficient of median industry leverage the most. Future research in capital structure determinants should consider fixed effects, especially when an industry variable is omitted from their model, in order to correct the coefficient estimates.

4.2.2.2. Nonlinearities in capital structure determinants

The linear regression model is often assumed to be valid in many applications in capital structure. In order to examine the presence of nonlinearities in capital structure, I apply the usual Ramsey's reset test, but it rejects the null hypothesis that the model is correctly specified, and thus I extend the linear model with squared terms for the core factors.[27] I exclude all the minor factors as well as the dividend dummy from the analysis and keep only the robust core five leverage factors. Moreover, I report the results for the multivariate regressions on the core five factors (without nonlinearities) to make comparisons about the additional explanatory power of nonlinearities compared to the additional explanatory power of all the minor factors.

[25] Note that my sample period is 2003-2021 but when the 1st lag is used in all factors to avoid endogeneity, the leverage regressions are run throughout 2004-2021. The sample period of Frank and Goyal (2009) is 1950-2003.
[26] The results are available upon request.
[27] The Ramsey's Reset Test for model specification can be easily applied in STATA using the command "ovtest".

Ultimately, since the estimated model remains linear to its parameters it can still be estimated using the usual OLS method.

To begin with, column (1) of Table V reports the results for the core five factor model without nonlinearities or fixed effects. Comparing the results with those of column (1) of Table IV, I find that the additional explanatory power of all the minor factors combined is less than 2% to the regression's R^2. Similarly, column (2) of Table V highlights that nonlinearities add considerable explanatory power and are slightly more important than all minor factors combined, since the additional explanatory power of the nonlinearities is 2% to the regression's R^2. For the best performing leverage measure (LDM) we can see that all nonlinear factors except median industry leverage are statistically significant. For the second-best performing leverage measure (TDM), three out of five nonlinear leverage factors are statistically significant: profitability, market-to-book assets ratio and log of assets. Also, it is not surprising that median industry leverage does not exhibit significant nonlinearities as a factor because it is expressed as a median and has a lower standard deviation than other core leverage factors.

Secondly, interpreting the parameters of the model can be tricky. For example, since a squared term is enhanced in each factor, firm leverage will depend upon the amount of each factor as well.[28] Moreover, quadratic functions are able to capture decreasing or increasing marginal effects. To make things clearer, the negative coefficient on the squared term of firm size (Log Assets^2) along with the positive coefficient on firm size (Log Assets), implies that firm size has a diminishing effect on leverage (columns 2 and 4). It is worth to mention that since the natural logarithm is used for firm size, its coefficients should be expressed as percentage changes. In addition, the coefficient estimates of the market-to-book assets ratio imply that growth opportunities have an increasing effect on the debt ratio. Moreover, the coefficient estimates of profitability are negative in both cases, which suggests that as profitability increases then leverage decreases, with the magnitude of the effect increasing as profitability gets larger (Wooldridge, 2020). On the other hand, the positive coefficients of tangibility (column 2) suggest that collateral value has a positive and increasing effect on leverage. Nevertheless, having more than one core leverage factors in the regression model makes it tougher to quantify the effect of each variable on leverage or make inferences about the slope of the dependent variable (U-shape/Parabolic shape).

[28] More specifically, the slope of the relationship between the leverage factors and leverage will depend on the value of the leverage factors. To get a better grasp on this, assume the following model as presented in Wooldridge (2020): $y = \beta_0 + \beta_1 x + \beta_2 x^2 + u$. The relationship between x and y depends on the value of x: the estimated slope is $\hat{\beta}_1 + 2\hat{\beta}_2 x$ (Wooldridge, 2020).

Table V

Nonlinearities and the core 5 factor model

	Long-Term Debt/Market Assets (LDM) (1)	Long-Term Debt/Market Assets (LDM) (2)	Total Debt/Market Assets (TDM) (3)	Total Debt/Market Assets (TDM) (4)
IndustLev	0.373***	0.319***	0.438***	0.417***
	(19.2)	(9.25)	(20.6)	(10.7)
Profit	-0.066***	-0.083***	-0.087***	-0.120***
	(-13.3)	(-11.7)	(-14.2)	(-14.9)
Mktbk	-0.026***	-0.07***	-0.041***	-0.109***
	(-34.2)	(-30.0)	(-43.3)	(-40.1)
Tang	0.152***	0.086***	0.164***	0.146***
	(15.2)	(3.55)	(15.1)	(5.31)
Log Assets	0.019***	0.037***	0.013***	0.023***
	(24.7)	(16.4)	(15.1)	(8.09)
$IndustLev^2$		0.062		-0.070
		(0.82)		(-0.83)
$Profit^2$		-0.05***		-0.116***
		(-4.83)		(-9.58)
$Mktbk^2$		0.006***		0.001***
		(25.2)		(33.4)
$Tang^2$		0.078***		0.016
		(2.59)		(0.49)
Log $Assets^2$		-0.001***		-0.000***
		(-7.59)		(-2.97)
Constant	0.001	0.004	0.095***	0.149***
	(0.22)	(0.57)	(14.0)	(14.4)
AIC	-42,233.19	-43,987.52	-27,235.18	-24,406.06
BIC	-42,178.97	-43,888.12	-27,135.78	-24,351.84
R^2	0.288	0.308	0.279	0.312
N	62,085	62,085	62,085	62,085

The following table presents the OLS regressions for the core 5 factor leverage model of median industry leverage, profitability, tangibility, growth, and the log of assets, enhanced with a squared term for each factor (columns 2 and 4). The variables as well as core factors are defined in the Appendix B. All core factors except firm size (Log Assets) are scaled by the book value of total assets. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity bias. Financial firms and utilities are excluded from the sample. AIC and BIC are the Akaike and Bayesian information criteria, respectively. Abbreviations for the variables are defined as in Frank and Goyal (2009). The symbol *** displays statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Finally, the AIC and BIC information criteria are reported for each model in order to perform easier comparisons between models with similar R^2 values, as in column (2) for the LDM and in column (4) for the TDM model. Since a higher R^2 value does not necessarily capture a better model in terms of goodness-of-fit, I compare the two best performing leverage measures, LDM & TDM, and minimize the information criteria, which results into accepting the model in column (2) that has a lower R^2 value than the model in column (4). To conclude with, the model with LDM as a dependent variable can be better to the one with TDM in column (4) for two more reasons: it has an additional statistically significant leverage factor that exhibits nonlinearities and a much less noisy constant term.

4.2.2.3. Robustness of the nonlinear terms

Nonlinear terms are indeed statistically significant for the core five factor model, but it is also appealing to examine if nonlinearities are robust to the inclusion of fixed effects. This will make sure that the empirical findings in the previous sub-section do not suffer from the usual omitted variable bias and further display if nonlinearities are very persistent in the capital structure determinants. Moreover, I now include not only industry and time fixed effects, but also firm-specific fixed effects, which are able to capture a broad range of (unobserved) firm characteristics, such as managerial and/or board characteristics, preference for a particular credit rating, ESG considerations, firm culture, etc. Firm-specific fixed effects include a dummy variable for each unique firm in the sample, and also do not restrict the use of clustered robust standard errors as previously applied. I provide an additional discussion on the firm-specific fixed effects in Section VI.

Table VI reports the results for the core five factor model enhanced with squared terms and also incorporates the fixed effects for the two market leverage measures (LDM & TDM) as in Table V. In order to examine the robustness of the nonlinear terms, I focus on their statistical significance. For the LDM measure (Table VI), all squared terms remain statistically significant even if one accounts for industry and time fixed effects or firm-specific fixed effects. In contrast to prior findings (Table V), all squared factors including median industry leverage exhibit significant nonlinearities when fixed effects are included in the model. Similarly, for the TDM measure (Table VI), all nonlinear terms are statistically significant when firm-specific fixed effects are included (column 4); however, the squared terms of tangibility and log of assets are statistically insignificant in column 3 when industry and time fixed effects are enhanced in the model. Therefore, the empirical findings strongly suggest that nonlinearities remain statistically significant even when fixed effects are incorporated in the regression model.

Table VI

Nonlinearities and Fixed Effects

	Long-Term Debt/Market Assets (LDM) (1)	Long-Term Debt/Market Assets (LDM) (2)	Total Debt/Market Assets (TDM) (3)	Total Debt/Market Assets (TDM) (4)
IndustLev	0.152***	0.390***	0.175***	0.424***
	(3.05)	(9.66)	(3.06)	(9.50)
Profit	-0.080***	-0.092***	-0.127***	-0.148***
	(-10.3)	(-10.7)	(-14.4)	(-14.7)
Mktbk	-0.082***	-0.039***	-0.123***	-0.061***
	(-32.7)	(-19.5)	(-42.6)	(-25.4)
Tang	0.148***	0.052*	0.204***	0.090***
	(5.86)	(1.86)	(7.11)	(2.76)
Log Assets	0.032***	0.030***	0.018***	0.043***
	(14.3)	(8.76)	(6.53)	(10.1)
$IndustLev^2$	0.161**	-0.160**	0.204**	-0.156*
	(1.96)	(-2.13)	(2.19)	(-1.90)
$Profit^2$	-0.060***	-0.096***	-0.139***	-0.141***
	(-5.21)	(-8.54)	(-10.3)	(-10.6)
$Mktbk^2$	0.008***	0.004***	0.012***	0.006***
	(28.1)	(17.7)	(36.8)	(23.0)
$Tang^2$	0.064**	0.085**	0.024	0.091**
	(1.97)	(2.54)	(0.68)	(2.41)
Log $Assets^2$	-0.001***	-0.001***	-0.000	-0.002***
	(-5.62)	(-5.45)	(-1.34)	(-6.70)
Constant	0.086***	0.013	0.251***	0.027
	(3.60)	(0.89)	(7.64)	(1.53)
Industry Fixed Effects	Yes	No	Yes	No
Year Fixed Effects	Yes	No	Yes	No
Firm Fixed Effects	No	Yes	No	Yes
R^2-adjusted	0.344	0.685	0.350	0.697
N	62,085	62,085	62,085	62,085

This table displays the OLS regressions for the core 5 factor model enhanced with nonlinear terms and fixed effects. The variables as well as core factors are defined in the Appendix B. All core factors except firm size (Log Assets) are scaled by the book value of total assets. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial and utilities firms are excluded from the sample. Industry fixed effects are dummy variables for each of the Fama and French (1997) 48 industry groups. Year fixed effects are dummy variables for each calendar year in the sample. Firm fixed effects are dummy variables for each firm. Abbreviations for the variables are as in Frank and Goyal (2009). The symbols ***, **,* denote statistical significance at the 1%, 5%, and 10% level, respectively. T-statistics are reported in the parentheses and the standard errors of the coefficients are clustered at the firm level.

Overall, the most important nonlinearities are observed for the following three core factors: profitability, market-to-book assets ratio, and log of assets. Also, it is evident that median industry leverage has a higher robust standard error when fixed effects are included and is only marginally statistically significant at the 10% and 5% level (Table VI). Some moderate nonlinearities are also found for tangibility, which is not statistically significant at the 1% level or higher under any leverage measure. To sum up, three out five core factors exhibit highly significant nonlinearities whereas some minor nonlinearities are found for median industry leverage and tangibility when fixed effects are considered. To conclude with, nonlinearities are statistically significant and remain robust when fixed effects are included in the model.

4.2.2.4. Financing constraints and determinants of capital structure

Financial constraints are very important for financing decisions and thus it is very likely that capital structure determinants will be affected as well. De Jong et al. (2010) find that small firms behave much less according to the pecking order theory, despite the fact that they have a much bigger potential for information asymmetry. In contrast, large firms have the highest pecking order coefficient in their sample, which means that large firms are the ones that mostly behave according to the pecking order model. Frank and Goyal (2009) also consider financial constraints, such as payout status and firm size, but do not examine the impact of financing constraints on the core leverage model since their goal is to identify factors that matter for both financially constrained and unconstrained firms. Therefore, I choose payout status and firm size to classify firms that are financially unconstrained, for example, firms that pay dividends and those that are larger should find it easier to access the capital markets and raise financing.

Table VII reports the empirical results of the leverage regressions using the core five factor leverage model. The minor factors are excluded from the analysis because they are not robust among different types of firms. First of all, for the best performing market leverage measure (LDM), the core leverage factor profitability is not statistically significant for small firms, while the opposite holds true for large firms. Mainly, that is because small firms are very unprofitable in contrast to large firms that are much more profitable (rows 9-10). Moreover, small firms rely on the core five factor leverage model much less, since the regression's R^2 is only 11.1%. On the other hand, the R^2 for large firms is 28.6%, much higher than the one of small firms. Also, large firms have a bigger potential to behave according to the trade-off theory than small firms, since they depend on median industry leverage more than small firms do. For large firms, a univariate regression between median industry leverage and LDM (Appendix, Table XI, column 2) has a higher R^2 than the entire explanatory power of the core five factor leverage model for small firms.[29] The empirical patterns of Table VI remain the same when the total debt to market assets (TDM) is used, instead of the Long-term debt to market assets (LDM). Consequently, profitability is not statistically significant for small firms when considering market leverage. However, profitability is statistically significant when book leverage is considered instead (Appendix, Table XII). Finally, no major differences between dividend-paying and nondividend-paying firms are found when considering payout status (Appendix, Table XIII).[30]

Table VII

Financing constraints and the core 5 factor model

	Small firms (1)	Large firms (2)
IndustLev	0.164***	0.351***
	(7.20)	(11.4)
Profit	-0.003	-0.362***
	(-0.80)	(-10.8)
Mktbk	-0.010***	-0.060***
	(-17.2)	(-21.2)
Tang	0.120***	0.133***
	(10.0)	(8.39)
Log Assets	0.009***	-0.011***
	(7.34)	(-5.52)
Constant	0.026***	0.385***
	(4.32)	(18.1)
R^2	0.111	0.286
N	20,489	20,489
Profit Mean	-11.2%	13.1%
Profit Median	-3.31%	12.4%

This table presents the differences between small and large U.S firms using the core 5 leverage factors. The dependent variable is long-term debt to market assets (LDM). The variables are defined in the Appendix B. The percentage Profit Mean (Median) reports the mean (median) of the core leverage factor profitability. All core factors except firm size (Log Assets) are scaled by the book value of total assets. Similarly to Frank and Goyal (2009), small firms have log of assets that are smaller than the 33rd percentile and large firms have log of assets larger than the 67th percentile in the annual Compustat cross-sections. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial firms and utilities are excluded from the sample. Abbreviations for the variables are defined as in Frank and Goyal (2009). The symbol *** displays statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

[29] The effect of firm size (Log Assets) is not reliable for large firms. Partly this is because of the diminishing effect of firm size on leverage (Table V).

[30] Firms with different payout status clearly have some slight differences in my sample, although it is also difficult to make inferences due to the significant difference in the number of observations (Table XIII).

So far I have demonstrated that there are differences between small and large firms but not whether they are statistically significant or not. In order to do so, I use interaction terms which are able to capture the interaction effect between the core leverage factors in the regression model. Moreover, it is natural that the partial effect of a core leverage factor (i.e., log of assets) depends on the magnitude of yet another factor in the regression model. Since the level of financing constraints seems to be very important for capital structure determinants, it is interesting to capture the interaction effect between firm size and the rest of the core factors. Therefore, equation (1) is now enhanced with interaction terms, which includes firm size multiplied by the rest core leverage factors. For instance, for columns (1) and (2) of Table VIII, equation (1) becomes:

$$L_{i,t} = \alpha + \beta F_{i,t-1} + \delta F_{i,t-1} * LogAssets_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

And the focus is mainly on the market leverage measures since they capture more variation in leverage than book leverage does, however, I report the results for book leverage as well.

To begin with, most of the interaction terms are statistically significant (Table VIII) and thus small and large firms have statistically significant differences in the core leverage model. The only interaction term that is not statistically significant is the one with firm size by tangibility for long term debt to market assets (column 1), while it is only marginally significant at the 10% level for the total debt to market assets (column 2). However, the interaction term of firm size with tangibility is statistically significant at the 1% level for book leverage. Therefore, there only some slight differences between small and large firms when it comes to tangibility, especially when market leverage is considered. Nonetheless, the coefficient estimates of small and large firms (Table VII) differ significantly when it comes to profitability, growth opportunities, log of assets, and median industry leverage, since the respective interaction terms are statistically significant under all leverage measures (Table VIII). The most significant differences are observed in profitability and growth opportunities, since the interaction terms are highly statistically significant, and thus small firms are very different to large firms when profitability and the market-to-book assets ratio are considered. Therefore, the level of financing constraints is important for the performance of the core leverage model.

Moreover, since the interaction terms are statistically significant, the partial effect of leverage with respect to a core factor will depend on the magnitude of yet another core factor. For example, the partial effect of firm size on leverage depends on all remaining four core factors of profitability, market-to-book assets ratio, median industry leverage, and tangibility.[31]

[31] To better understand this, assume the first derivative is used with respect to firm size (Table VIII).

The only exception is that the partial effect of firm size will not depend on tangibility (Table VIII, column 1), since the interaction term is statistically insignificant. Finally, the use of interaction terms in the core leverage regression model comes at a cost; the model becomes more complex and the results are tougher to interpret.

Table VIII

Leverage regressions with interaction terms

	Long-term Debt/Market Assets (LDM) (1)	Total Debt/Market Assets (TDM) (2)	Total Debt/Book Assets (TDA) (3)
IndustLev	0.145***	0.317***	0.265***
	(3.84)	(6.59)	(5.50)
Profit	0.042***	0.080***	-0.111***
	(4.24)	(6.28)	(-6.74)
Mktbk	0.019***	0.004**	0.004**
	(12.5)	(2.03)	(2.12)
Tang	0.152***	0.201***	0.251***
	(7.67)	(8.23)	(10.1)
Log Assets	0.057***	0.040***	0.026***
	(18.6)	(10.6)	(7.13)
Log Assets*IndustLev	0.028***	0.013*	0.017**
	(4.90)	(1.87)	(2.42)
Log Assets*Profit	-0.019***	-0.032***	0.007*
	(-7.35)	(-10.5)	(1.92)
Log Assets*Mktbk	-0.008***	-0.008***	-0.001***
	(-25.0)	(-20.4)	(-3.55)
Log Assets*Tang	-0.000	-0.006*	-0.017***
	(-0.27)	(-1.74)	(-4.67)
Log Assets^2	-0.002***	-0.001***	-0.000*
	(-10.0)	(-3.03)	(-2.06)
Constant	-0.125***	-0.011	-0.001
	(-12.0)	(-0.83)	(-0.11)
R^2	0.318	0.301	0.162
N	62,085	62,085	62,085

This table reports the regression results with the use of interaction terms for the two market leverage measures (LDM & TDM) and for the total debt to book assets (TDA). The variables as well as core factors are defined in the Appendix B. All core factors (rows 1-5) except firm size (Log Assets) are scaled by the book value of total assets. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial firms and utilities are excluded from the sample. Abbreviations for the variables are defined as in Frank and Goyal (2009). The symbols ***,**,* display statistical significance at the 1%, 5%, and 10% level, respectively. T-statistics are reported in the parentheses and the standard errors of the coefficients are clustered at the firm level.

To conclude with, Section IV highlights the following empirical findings: 1a) we still can explain about one third of the variation in market leverage by including standard leverage factors, 1b) the impact of firm size and market-to-book assets ratio are reliable for both market and book leverage, 2) nonlinearities are statistically significant for all core factors except median industry leverage and are robust to the inclusion of fixed effects, 3) profitability is statistically insignificant for small firms when considering market leverage. In addition, the interaction terms of firm size with the remaining core factors are statistically significant and thus the level of financing constraints is important for the performance of the core leverage model. It is worth mentioning that my panel data cover 19 years in total and thus for larger samples the core factor of profitability may be statistically significant for small firms. However, how do we interpret that profitability is not significant for small firms when studying the market leverage definition? Recall that Barclay, Morellec, and Smith (2006) suggest that market leverage is forward-looking, in contrast to book-leverage that is backward-looking. From this perspective, it seems that the market leverage of small firms is mostly affected by their growth opportunities and collateral value, while profitability does not significantly affect leverage.

V. The Joint Determination of Cash Holdings and Leverage

5.1. Theoretical background

Cash holdings play an important role in the capital structure of U.S firms. Opler et al. (1999) provide time-series and cross-section tests for a supportive static tradeoff model of cash holdings, in which they find that large firms tend to hold lower cash ratios and firms with strong growth opportunities hold relatively high ratios of cash. Bates et al. (2009) display that U.S firms increase their cash holdings for precautionary purposes, while agency costs do not contribute to this increase. Harford et al. (2014) demonstrate that cash reserves are particularly valuable for firms with refinancing risk, and refinancing risk is a key determinant of cash holdings. The latter authors also find that larger cash holdings can lead to firms holding long-term debt with a shorter maturity, however, this effect is economically small. Acharya et al. (2007) suggests that cash should not be viewed as negative debt in the presence of financing frictions. In addition, some scholars argue that cash holdings is negative debt and hence cash should be subtracted from the debt measure. At this point, two important questions arise: 1) Are cash holdings and leverage jointly determined? And 2) What is the relationship between leverage and cash holdings? Unsurprisingly, since the usual Hausman test for endogeneity rejects the null hypothesis, cash holdings and leverage are indeed endogenous and thus their relationship will be examined under a joint determination framework.

5.2. Empirical Results

5.2.1. Methodology

Because cash holdings and firm leverage are determined jointly, I quantify the effect of cash holdings on debt under a 2SLS framework in which the estimated standard errors of the coefficients are clustered at the firm level, as in Section IV. First, I regress cash on the dividend dummy, log of assets, market-to-book assets ratio, profitability, and a vector of explanatory variables and save the fitted values of the dependent variable, which is cash holdings. On the second stage, I regress leverage on the dividend dummy, growth opportunities, profitability, firm size, and on the predicted values of cash that are obtained from the first stage (Table IX). It is worth mentioning that lagged values are used in all factors to avoid endogeneity, with the exception of not using the lag at cash holdings on the second stage.

To begin with, cash is defined as cash and short-term investments over book assets.[32] Similarly to Opler et al. (1999) I include the following variables for the cash holdings model: capital expenditures, research and development expenditures, net working capital, acquisition expenditures, net debt issuance, all scaled by the book value of total assets, and a dividend dummy for whether the firm paid dividends. Furthermore, four out of the six core leverage factors are also used for the cash holdings model: log of assets, profitability, market-to-book assets ratio, and the dividend dummy.[33] A brief overview of the summary statistics of the additional factors is provided in the Appendix (Table XIV).

Similarly to the methodology of Harford et al. (2014), net working capital can substitute for cash, and thus firms with a higher value of net working capital are expected to hold less cash. Firm size controls for the fact that smaller firms suffer from greater information asymmetry problems, as explained in Section II, and should hold more cash. Moreover, firms that have more growth opportunities or large research and development expenses should use more cash in order to mitigate underinvestment, especially when informational asymmetries are severe. Also, firms that spend more on capital expenditures should accumulate less cash in order to finance their investments. In addition, firms that pay dividends are less financially constrained and are expected to hold less cash. Furthermore, more profitable firms should

[32] Cash holdings could alternatively be defined as cash (ch) over total book assets (at). The empirical patterns observed in this section remain the same if this alternative definition is used instead.

[33] I do not use tangibility as a factor for the 2SLS regressions because it is not clear if firms that have more collateral should use more or less cash. Furthermore, the effect of median industry leverage is not clear for cash holdings. Nevertheless, one could use the median industry volatility as a factor for the 2SLS methodology, because more volatile firms should hold more cash and also be less levered. Because this factor is not robust in my sample, I do not use it. However, the empirical patterns observed in Table IX remain the same, even if one accounts for such factor. Appendix B describes the core leverage factors.

accumulate less cash for two reasons: they mitigate the usual agency costs related to managerial discretion (Morellec, 2004) and they are less likely to be financially constrained and need large cash balances for precautionary purposes (Harford et al., 2014). As in Bates et al. (2009), acquisition expenses also proxy for investment and should be negatively related to cash holdings. Controlling for net debt issuance aids to identify increases in cash holdings that occur in cases that firms issue more long-term debt than they retire in a given fiscal year. Finally, industry and time fixed effects are incorporated into the model to capture unobserved time-invariant industry effects and time effects that are potentially correlated with cash holdings.

5.2.2. Multivariate Evidence

Table IX reports the multivariate evidence for the 2SLS methodology explained above. In column (1) we can see that all of the theoretical predictions regarding the reasons firms hold cash turn out to be correct. Firms with higher growth opportunities and research and development expenditures hold more cash. Unsurprisingly, firms that issue more long-term debt than they retire in a given year hold more cash as well. In contrast, firms that have higher profitability, net working capital, capital expenditures, and acquisition expenditures hold less cash. Furthermore, the negative coefficient on firm size implies that larger firms are more likely to be profitable and payout dividends or pay down debt so they end up holding less cash, since the coefficient sign of firm size is reliable for small firms (Appendix, Table XV).

In both stages, all factors are highly statistically significant, including cash on the second stage. We can see that a 100% increase in cash holdings leads to a 36.3% decrease in leverage (LDM), assuming that other are factors equal to zero. Therefore, leverage declines as cash holdings increase throughout 2003-2021.[34] This empirical finding provides additional support for the view that cash is negative debt and should be subtracted from the debt measure. Also, since long-term debt declines as cash holdings increase, it could be possible that debt maturity decreases as well, since firms may attempt to mitigate refinancing risk with cash. This result is potentially interesting and encourages further research into cash holdings. The negative coefficient estimate on cash holdings is also robust for financially constrained firms in my sample, such as small firms or nondividend-paying firms. I report the results for constrained firms in the Appendix (Table XV/XVI). For small firms, the dividend dummy is excluded for robustness issues. To conclude with, leverage and cash holdings are jointly determined and negatively related for both financially constrained and unconstrained firms in my sample.

[34] This empirical finding is robust across all leverage measures used in my analysis. The results for the rest three leverage measures are available upon request. In addition, the number of observations is slightly lower than before (Table IX, N=55,010) because I drop additional missing observations.

Table IX

The joint determination of leverage and cash holdings

	First Stage -Cash (1)	Second Stage -LDM (2)
Cash		-0.363
		(<0.001)
Profit	-0.051	-0.154
	(<0.001)	(<0.001)
Mktbk	0.026	-0.019
	(<0.001)	(<0.001)
Log Assets	-0.009	0.022
	(<0.001)	(<0.001)
Dividend	-0.020	-0.025
	(<0.001)	(<0.001)
Capex	-0.429	
	(<0.001)	
R&D	0.567	
	(<0.001)	
Net working capital	-0.129	
	(<0.001)	
Acquisition expenses	-0.430	
	(<0.001)	
Net Debt issuance	0.049	
	(<0.001)	
Constant	0.204	0.154
	(<0.001)	(<0.001)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
R^2-adjusted	0.495	0.221
N	55,010	55,010

The table presents OLS regressions under a 2SLS framework. On the first phase, Cash is regressed on some of the core leverage factors (rows 2-5) and a vector of explanatory variables. On the second phase, the fitted values of Cash that are obtained from the first stage, are used as an explanatory variable in the OLS regression of LDM (Long-term Debt/Market Assets) on Cash and some of the core leverage factors. All variables except firm size and the dividend dummy are scaled by the book value of total assets and their definitions are provided in the Appendix B. The sample period is 2003-2021 and the first lag is used in all factors except Cash to avoid endogeneity. Financial and utilities firms are excluded from the sample. Industry fixed effects are dummy variables for each of the Fama and French (1997) 48 industry groups. Year fixed effects are dummy variables for each calendar year throughout the sample period. Significance levels for whether coefficient estimates are different from zero are in parentheses (Harford et al., 2014). The standard errors of the coefficients clustered at the firm level.

VI. Discussion

6.1. Research Design

Throughout the thesis I apply widely accepted econometric techniques in order to make good use of my panel data. First, I report the correlations of the factors (Table III) to quietly alleviate concerns regarding multicollinearity among the variables. Secondly, I use the first lag in all factors to avoid endogeneity in the regressions. Third, I apply clustered robust standard errors that account for both arbitrary serial correlation and heteroskedasticity of unknown form. Petersen (2009) provides a detailed explanation on why to apply clustered robust standard errors in panel data instead of using the White's robust standard errors or an alternative technique. Also, the main workhorse of my methodology is enhanced with fixed effects to obtain more solid estimates, since the clustered robust standard errors do not account for cross-sectional correlation, whereas time dummies are able to capture common shocks that occur over time and are cross-sectionally correlated. Nevertheless, time fixed effects do not add significant explanatory power to the leverage regressions' R^2 (Table IV) mainly because my sample consists of 19 years in total, in contrast to other prominent papers that cover about 50 years in total. Also, I do not adjust for missing data and I also drop missing observations.[35] Adjusting for missing data would generate more firm-years for the sample, but I conjecture that the empirical patterns would not be altered even if the data were to be stochastically imputed. However, the predicted data are less certain than are the observed data (Frank and Goyal, 2009), and thus it is up to the researcher to decide whether to use such a technique for his/her sample.

Moreover, I avoid reporting results in my thesis that are sensitive to the underlying research design, for example, nonlinearities are statistically significant (Table V) regardless of the industry definition (FF-48 or FF-12).[36] The industry definition may seem naïve on a first sight but that's not true because it has a significant impact on one of the most important core leverage factors- median industry leverage. Past research in capital structure such as in Frank and Goyal (2009) does not discuss this important issue. Also, I prefer to quantify changes in the core factor median industry leverage in order to observe capital structure instability. Alternatively, one could build a target-adjustment model for this purpose. However, target-adjustment models are sensitive to the underlying econometric techniques being used (Frank

[35] Research and development expenditures (R&D) are recorded as zero if missing. Huang and Ritter (2007) point out that the majority of firms with missing R&D are firms in industries where R&D expenses are likely to be zero (Frank and Goyal, 2009).

[36] Similarly, the level of financing constraints plays a crucial role regardless of the industry definition. Under all three Fama and French industry definitions (FF-12, FF-17, FF-48) profitability is not statistically significant for small firms when considering market leverage.

and Goyal, 2009) and most importantly Chang and Dasgupta (2009) display that simulated data also shows mean reversion. Furthermore, I report the empirical findings for both market and book leverage in the leverage regressions, which is necessary since these leverage measures can have significant differences. Market leverage is forward-looking and captures more variation in firm leverage than the book leverage does, however, that is not due to a mechanical relationship between the market-to-book assets ratio and market leverage because the three most significant core leverage factors for market leverage are median industry leverage, log of assets, and tangibility for the overall sample.

In addition, allowing for unbalanced panel data in my sample aids to reduce the familiar survivorship bias.[37] Allowing for small firms in the sample has important implications for the findings of my thesis; profitability is not statistically significant for small firms when considering market leverage (Table VI). One should think wisely before removing different types of firms from the sample and impose any further restrictions in the research design.[38] Moreover, I acknowledge that my thesis has certain important omissions as well. I do not examine financing constraints based on growth opportunities given the sample size. Also, many small/growth firms went bankrupt during the financial crisis of 2007-2009 and this worsens the survivorship bias in my sample. In addition, although I allow for general nonlinearities, it is only with a squared term for each leverage factor, while other quadratic terms could also be statistically significant. In addition, I have excluded stock returns and stock variance as minor factors from the leverage regressions, which are useful for the predictions of the market timing theory. These issues are interesting for future research in capital structure and I hope to further examine them in the future.

6.2. Robustness of the empirical findings

The robustness of the empirical findings is an important issue for every paper in the capital structure literature. In my thesis, I achieve robustness in the empirical findings as follows. First of all, I use the core leverage factors of Frank and Goyal (2009) who display their robustness using random sub-samples and information criteria (AIC & BIC) to evaluate their performance throughout a large sample period. Secondly, I use a sample size (2003-2021) that is large enough and expands the sample of Frank and Goyal (2009) who examine the core

[37] Compustat includes data only on firms in year t that continue to exist long enough to file an annual financial statement for year t in year t+1 (Frank and Goyal, 2009), which leads to the well-known problem of survivorship bias.

[38] For example, Shyam.S and Myers S.C (1999) examine a balanced panel of 157 mature U.S firms that survive throughout the period of 1971-1989. Undoubtedly, these imposed restrictions (i.e., small firms are excluded) have a significant impact on the findings of the paper.

factors throughout the 54-year period of 1950-2003. For instance, if an alternative sample period were to be used I would not have been able to capture that median industry leverage has lost about 17% of its explanatory power as a core factor throughout 2004-2021.

In addition, the first empirical finding of my thesis suggests that we can explain about one third of the variation in market leverage with standard leverage factors, and this is line with the findings of Frank and Goyal (2009) as well. Therefore, the first empirical finding is very robust for U.S firms. In addition, the fact that the level of financing constraints is important for the performance of the core leverage model has not been well-established in the literature, although Frank and Goyal (2009) find that the core leverage factors matter for both financially constrained and unconstrained firms. My thesis clearly displays that the level of financing constraints is important for capital structure determinants, since small firms depend on the core leverage factors less than large firms do. Nonetheless, the core leverage factor profitability may be statistically significant for small firms in larger samples.

Furthermore, I am confident that at least some of the core capital structure determinants display significant nonlinearities even in larger samples, since the core factors exhibit significant decreasing/increasing marginal effects and are also robust to the inclusion of fixed effects. It is also possible that median industry leverage will vary more in bigger samples and thus display statistically significant nonlinearities as well, when fixed effects are excluded from the model. Finally, the negative relationship between cash holdings and leverage is quite robust too, since I apply a 2SLS regression with explanatory variables and fixed effects that are widely used in prior literature. Overall, the empirical findings of my thesis are very robust for U.S firms.

6.3. Implications for Future Research

My thesis examines capital structure determinants under a static framework; however, dynamic models of leverage have become increasingly popular in the corporate finance literature because they provide more flexibility and pragmatism to the model. Nonetheless, static and dynamic models are interrelated and are both useful to explain capital structure. Static models are useful in explaining most of the empirical patterns observed in panel data for firm leverage. Dynamic models can supplement the static ones and help us understand if the underlying assumptions of the static models turn out to be correct or false. For example, what does it mean that most of the empirical evidence are in line with the trade-off theory? Does it mean that the assumptions of the static trade-off model turn out to be correct? Sometimes yes, but this is not always the case. A recent example is provided by De Marzo and Zhiguo (2021) who build a dynamic leverage model in which the firm can continuously adjust leverage and cannot commit to a policy ex ante. De Marzo and Zhiguo (2021) display that asset growth and debt maturity cause leverage to mean-revert slowly toward a target, while investors anticipate future debt issuance and raise credit spreads, fully offsetting the tax benefits of new debt. Therefore, shareholders can significantly affect credit spreads, firm leverage, the speed of adjustment, future investment, and future growth (De Marzo and Zhiguo, 2021). To sum up, a firm might indeed mean-revert towards a target debt ratio, but not because of tax considerations or costs of financial distress.

Dynamic models of capital structure can also aid into identifying situations that significantly influence capital structure and its determinants. DeAngelo et al. (2011) find that firms deliberately but temporarily deviate from permanent leverage targets by issuing transitory debt to fund investment, whereas leverage targets conservatively embed the option to issue transitory debt, with the evolution of leverage reflecting the sequence of investment outlays. The dynamic model of DeAngelo et al. (2011) explains debt issuances and repayments better than tradeoff models, and accounts for the leverage changes accompanying investment “spikes”. The resulting leverage ratios have slow average speed of adjustment, which are dampened by intentional temporary movements away from the target, not debt issuance costs (DeAngelo et al., 2011). Moreover, Morellec (2004) and Hackbarth (2008) demonstrate how managerial discretion and managerial traits are important for dynamic capital structure decisions, respectively. Gryglewicz et al. (2020) build a dynamic agency model in which the agent controls both current earnings via short-term investment and firm growth via long-term investment. Under the optimal contract, agency conflicts can induce short- and long-term investment levels beyond the first best, leading to short- or long-termism in corporate policies (Gryglewicz et al., 2020). Recall that most of the variation in firm leverage is due to unobserved time-invariant effects. Therefore, dynamic models aid into identifying these effects that persistently affect capital structure via dynamic corporate policies.

Furthermore, almost any realistic optimizing model of corporate leverage is likely to have time-varying costs and benefits (Frank and Goyal, 2009). Fischer et al. (1989) highlight the role of recapitalization costs in dynamic corporate policies which can lead to a wide swing in the firms’ debt ratio over time. Rather than static leverage measures, the observed debt ratio range of a firm can be used as an empirical measure of capital structure relevance (Fischer et al., 1989). Therefore, dynamic models are also helpful for the trade-off framework because they can capture a negative relationship between leverage and profitability, which is the only empirical prediction for the core leverage factor model that the theory does not correctly predict.

Moreover, financial flexibility is also important for capital structure determinants and hence future research could shed more light on the design of a proxy variable for financial flexibility. Graham and Harvey (2001) survey 392 CFOs and about 60% of them respond that financial flexibility is the most important factor when considering the corporation's debt policy. To sum up, financial flexibility could aid into providing a clearer picture for the static trade-off theory, since firm borrowing will also depend on financial flexibility and not just on costs of financial distress and/or agency costs.

VII. Conclusions

This thesis examines unregulated publicly traded U.S firms from 2003 to 2021 in order to enrich our knowledge in capital structure determinants. In line with prior findings, I find that we still can explain about one third of the variation in market leverage by including both core and minor factors. In contrast to Frank and Goyal (2009) I find that the impact of firm size and market-to-book assets ratio are reliable for both market and book leverage. Moreover, when enhancing the best performing leverage measure with a squared term for each core factor, I display that nonlinearities are statistically significant, and their additional explanatory power to the regression's R^2 is considerable, since it increases by 2%. For the best performing leverage measure (LDM) all core leverage factors except median industry leverage exhibit significant nonlinearities. Since nonlinearities are statistically significant, the core factors that exhibit nonlinearities have statistically significant increasing/decreasing marginal effects. Also, nonlinearities remain statistically significant even when fixed effects are included in the regression model and thus they are very persistent. In addition, I demonstrate that profitability is statistically insignificant as a core factor when considering market leverage, and the level of financing constraints is important for the performance of the core leverage model. In contrast to small firms, large firms have a bigger potential to behave according to the trade-off theory based on the empirical evidence, since they depend on median industry leverage more than small firms do. Furthermore, the interaction terms of firm size with the remaining core factors are statistically significant for the core leverage model, and this highlights that the differences between small and large firms are statistically significant in all core factors. The only exception is tangibility, in which only some minor differences are observed between the tangibility of small and large firms, especially for market leverage. Finally, in an effort to highlight the role of cash holdings in the capital structure of U.S firms', I display that leverage declines as cash holdings increase and that is observed for both financially constrained and unconstrained firms.

Future research in capital structure determinants could take such considerations into account. For example, financing constraints such as firm size can be important, since there are major differences between small and large firms. The choice between book and market leverage is nontrivial as well, and one should examine both measures since they can have significant differences. In addition, recall that Frank and Goyal (2009) find that dividend-paying firms are less levered, when examining a large panel of 54 years in total (1950-2003), which is in line with the findings in my sample as well (2003-2021). Therefore, a significant amount of empirical evidence suggests that U.S firms that pay dividends are less levered. Do these firms introduce a payout status to reduce agency costs? This is a potentially interesting query and merits future attention from researchers in corporate finance. A very promising avenue for future research is also the development of a trade-off theory under a dynamic framework. Such a theory could predict a negative relationship between leverage and profitability and hence correctly predict all of the empirical evidence for the core leverage factors.

Nevertheless, we still only have conditional theories to explain capital structure, and these theories need considerable improvements. For instance, financial flexibility is very important and thus the construction of a proxy variable could turn out to be very useful. Section V highlights this, since the most liquid asset a firm can have is cash. Moreover, the static trade-off theory correctly predicts most of the empirical evidence in my thesis, however it can’t explain why more profitable firms borrow less. The pecking-order theory provides a pleasing explanation for the fact that leverage and profitability are negatively related and highlights the role of retained earnings in capital structure. In addition, the market timing theory can easily explain the fact that firms are less levered when stock market conditions are favorable. However, neither the pecking order theory nor the market timing theory can explain most of the empirical patterns observed. To sum up, one should jointly consider all these capital structure theories in order to interpret capital structure determinants.

Finally, do not forget that most of the empirical evidence in capital structure comes from the U.S, which is a mature country with well-developed financial markets. Emerging economies could have severe agency costs, information asymmetries, distress costs and distorting taxes and regulations (Myers, 2003). There is no a priori reason to believe that all of the empirical patterns this thesis presents will continue to hold outside the U.S. To conclude with, I believe that my thesis explains more thoroughly the impact that nonlinearities and the level of financing constraints have on the performance of the core leverage model, and also effectively highlights the negative relationship between leverage and cash holdings.

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Appendix A

Tables

Table X

The Core Leverage model during two sub-sample periods

	All Years	2004-2012	2013-2021
	(1)	(2)	(3)
IndustLev	0.373***	0.361***	0.333***
	(19.2)	(15.9)	(14.0)
Profit	-0.066***	-0.071***	-0.059***
	(-13.3)	(-11.7)	(-8.83)
Mktbk	-0.026***	-0.026***	-0.027***
	(-34.2)	(-29.2)	(-28.2)
Tang	0.152***	0.160***	0.152***
	(15.2)	(14.8)	(12.2)
Log Assets	0.019***	0.016***	0.023***
	(24.7)	(20.9)	(22.8)
Constant	0.001	0.007	-0.007
	(0.22)	(1.18)	(-1.01)
R^2	0.288	0.264	0.312
N	62,085	33,711	28,374

This table reports the OLS regressions for the best performing leverage measure, Long-term debt to market assets (LDM), throughout the whole sample period and for 2 sub-sample periods, 2004-2012 and 2013-2021. All core factors (rows 1-5) except firm size (Log Assets) are scaled by the book value of total assets. The variables as well as core factors are defined in the Appendix B. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial and utilities firms are excluded from the sample. Abbreviations for the variables are as in Frank and Goyal (2009). The symbol *** denotes statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Table XI

Univariate regressions between leverage and median industry leverage

	Overall-TDM	Large firms-LDM
	(1)	(2)
IndustLev	0.766***	0.605***
	(39.4)	(20.7)
Constant	0.099***	0.143***
	(34.1)	(24.3)
R^2	0.157	0.125
N	62,085	20,489

This table presents the univariate regressions for Total Debt/Market Assets (TDM) and Long-term Debt/Market Assets (LDM) to median industry leverage (core factor). Median industry leverage is defined in the Appendix B. Column (1) presents the R^2 for the overall sample, 2003-

2021, providing additional evidence for the findings in Table IV, column (1). Column (2) displays the R^2 only for large firms and provides additional support for the findings in Table VI. In order to avoid endogeneity, the first lag is used for median industry leverage. The symbol *** denotes statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Table XII

Leverage regressions for small firms

	Total Debt/Market Assets (TDM) (1)	Total Debt/Book Assets (TDA) (2)	Long-term Debt/Book Assets (LDA) (3)
IndustLev	0.303***	0.224***	0.105***
	(9.08)	(7.15)	(4.72)
Profit	-0.009	-0.064***	-0.034***
	(-1.57)	(-7.91)	(-5.44)
Mktbk	-0.025***	-0.002*	0.002***
	(-25.2)	(-1.80)	(2.63)
Tang	0.158***	0.169***	0.127***
	(9.62)	(10.4)	(10.2)
Log Assets	0.005***	-0.006***	0.008***
	(2.63)	(-2.69)	(4.99)
Constant	0.110***	0.122***	0.021***
	(11.2)	(11.2)	(2.87)
R^2	0.149	0.062	0.047
N	20,489	20,489	20,489

This table presents the OLS regressions for three different leverage measures, for financially constrained U.S firms (small firms). All core factors except firm size (Log Assets) are scaled by the book value of total assets. The variables as well as core factors are defined in the Appendix B. Similarly to Frank and Goyal (2009), small firms have log of assets that are smaller than the 33rd percentile of log assets in the annual Compustat cross-sections. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial firms and utilities are excluded from the sample. Abbreviations for the variables are defined as in Frank and Goyal (2009). The symbol *** displays statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Table XIII

Financing constraints: Dividend-Paying vs Nondividend-Paying firms

	Dividend-Paying firms (1)	Nondividend-Paying firms (2)
IndustLev	0.351***	0.405***
	(12.2)	(18.3)
Profit	-0.152***	-0.051***
	(-10.4)	(-9.66)
Mktbk	-0.039***	-0.020***
	(-20.0)	(-27.4)
Tang	0.146***	0.161***
	(9.56)	(14.5)
Log Assets	0.013***	0.027***
	(11.69)	(27.7)
Constant	0.062***	-0.050***
	(5.70)	(-8.48)
R^2	0.266	0.307
N	22,798	39,287

This table presents the differences between financially constrained and unconstrained U.S firms. The leverage measure is Long-term Debt/Market Assets (LDM). All core factors except firm size (Log Assets) are scaled by the book value of total assets. The variables as well as core factors are defined in the Appendix B. The payout status is used to classify if a firm is financially constrained. Dividend-Paying firms have a positive dividend payout and nondividend-paying firms have a payout of zero. The sample period is 2003-2021 and the first lag is used in all factors to avoid endogeneity. Financial firms and utilities are excluded from the sample. Abbreviations for the variables are defined as in Frank and Goyal (2009). The symbol *** displays statistical significance at the 1% level and t-statistics are reported in the parentheses. The standard errors of the coefficients are clustered at the firm level.

Table XIV

Summary Statistics of Cash Holdings and its Determinants

	N	Mean	SD	p10	p50	p90
Cash	55,187	0.23	0.25	0.01	0.14	0.63
R&D	55,187	0.06	0.11	0.00	0.00	0.18
Capex	55,187	0.05	0.07	0.00	0.03	0.11
Net working capital	55,187	0.03	0.19	-0.17	0.02	0.26
Net debt issuance	55,187	0.01	0.09	-0.05	0.00	0.10
Acquisition expenses	55,187	0.02	0.06	0.00	0.00	0.07

The table presents the univariate characteristics for Cash and its determinants that are used in the OLS regressions in Table VIII. The variables are scaled by total assets and are defined in the Appendix B. The sample period is 2003-2021. Financial and utilities firms are excluded from the sample. Distribution percentiles are reported in the last three columns.

Table XV

Small firms - The joint determination of leverage and cash

	First Stage -Cash (1)	Second Stage -LDM (2)
Cash		-0.171
		(<0.001)
Profit	-0.071	-0.035
	(<0.001)	(<0.001)
Mktbk	0.024	-0.009
	(<0.001)	(<0.001)
Log Assets	0.016	0.011
	(<0.001)	(<0.001)
Capex	-0.743	
	(<0.001)	
R&D	0.498	
	(<0.001)	
Net working capital	-0.103	
	(<0.001)	
Acquisition expenses	-0.553	
	(<0.001)	
Net Debt issuance	-0.043	
	(<0.001)	
Constant	0.128	0.035
	(<0.001)	(<0.001)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
R^2-adjusted	0.413	0.124
N	14,619	14,619

The table presents OLS regressions under a 2SLS framework for small firms. Small firms have log of assets that are smaller than the 33rd percentile of log of assets in the annual Compustat cross-sections. On the first phase, Cash is regressed on some of the core leverage factors (rows 2-4) and a vector of explanatory variables. On the second phase, the fitted values of Cash that are obtained from the first stage, are used as an explanatory variable in the OLS regression of LDM (Long-term Debt/Market Assets) on Cash and some of the core leverage factors. The variables are scaled by the book value of total assets (except Log Assets) and their definitions are provided in the Appendix B. The sample period is 2003-2021 and the first lag is used in all factors except Cash to avoid endogeneity. Financial and utilities firms are excluded from the sample. Industry fixed effects are dummy variables for each of the Fama and French (1997) 48 industry groups. Year fixed effects are dummy variables for each calendar year throughout the sample period. Significance levels for whether coefficient estimates are different from zero are in parentheses (Harford et al., 2014). The standard errors of the coefficients are clustered at the firm level.

Table XVI

Nondividend-Paying firms - The joint determination of leverage and cash

	First Stage -Cash (1)	Second Stage -LDM (2)
Cash		-0.214
		(<0.001)
Profit	-0.072	-0.083
	(<0.001)	(<0.001)
Mktbk	0.026	-0.017
	(<0.001)	(<0.001)
Log Assets	-0.004	0.027
	(0.001)	(<0.001)
Capex	-0.483	
	(<0.001)	
R&D	0.544	
	(<0.001)	
Net working capital	-0.122	
	(<0.001)	
Acquisition expenses	-0.455	
	(<0.001)	
Net Debt issuance	0.003	
	(0.015)	
Constant	0.213	0.137
	(<0.001)	(0.003)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
R^2-adjusted	0.481	0.308
N	35,278	35,278

The table presents OLS regressions under a 2SLS framework for nondividend-paying firms. Nondividend-paying firms have a payout of zero. On the first phase, Cash is regressed on some of the core leverage factors (rows 2-4) and a vector of explanatory variables. On the second phase, the fitted values of Cash that are obtained from the first stage, are used as an explanatory variable in the OLS regression of LDM (Long-term Debt/Market Assets) on Cash and some of the core leverage factors. The variables are scaled by the book value of total assets (except Log Assets) and their definitions are provided in the Appendix B. The sample period is 2003-2021 and the first lag is used in all factors except Cash to avoid endogeneity. Financial and utilities firms are excluded from the sample. Industry fixed effects are dummy variables for each of the Fama and French (1997) 48 industry groups. Year fixed effects are dummy variables for each calendar year throughout the sample period. Significance levels for whether coefficient estimates are different from zero are in parentheses (Harford et al., 2014). The standard errors of the coefficients are clustered at the firm level.

Appendix B
Variables

A. Variable Definitions

1) Leverage Measures (Frank & Goyal, 2009)

Total debt / market value of assets (TDM) is the ratio of total debt (Compustat item 34, debt in current liabilities + item 9 , long-term debt) to market value of assets (MVA). MVA is the sum of the market value of equity (item 199, price-close x item 54, shares outstanding) + item 34, debt in current liabilities + item 9, long-term debt + item 10, preferred-liquidation value – item 35, deferred taxes, and investment tax credit.

Total debt/assets (TDA) is the ratio of total debt (item 34, debt in current liabilities + item 9, long-term debt) to item 6, assets.

Long-term debt/ market value of assets (LDM) is the ratio of item 9,long-term debt, to MVA.

Long term debt/assets (LDA) is the ratio of item 9, long-term debt, to item 6, assets.

2) Profitability (Frank & Goyal, 2009)

Profitability (Profit) is the ratio of Compustat item 13, operating income before depreciation, to item 6, assets.

3) Firm size (Frank & Goyal, 2009)

Log of assets (Log Assets) is the log of Compustat item 6, assets deflated to 2015 dollars using the GDP deflator from FRED (Federal Reserve Bank of ST.LOUIS).

4) Growth (Frank & Goyal, 2009)

Market-to-book-ratio (Mktbk) is the ratio of MVA to Compustat item 6 , assets. MVA is obtained as the sum of the market value of equity (item 199, price-close x item 54, shares outstanding) + item 34, short-term debt + item 9 , long-term debt + item 10, preferred-liquidation value – item 35, deferred taxes, and investment tax credit.

Capital expenditures/assets (Capex) is the ratio of Compustat item 128, capital expenditure, to item 6,assets.

5) Industry (Frank & Goyal, 2009)

Median industry leverage (IndustLev) is the median of total debt to market value of assets by SIC code and by year. Industry is defined at the 4-digit SIC code level in the main results. Robustness is examined by redefining industry at the 3-digit SIC code.

6) Nature of Assets (Frank & Goyal, 2009)

Tangibility (Tang) is the ratio of Compustat item 8,net property, plant, and equipment, to item 6,assets.

7) Taxes (Frank & Goyal, 2009)

Top tax rate (TaxRate) is the top statutory tax rate. It was 35% prior to 2017 and 21% afterwards.

Depreciation/assets (Depr) is the ratio of Compustat item 125, depreciation expense, to item 6, assets.

8) Supply-Side Factors (Frank & Goyal, 2009)

Debt rating dummy (Rating) is a dummy variable that takes a value of one if Compustat item named S&P Domestic Long term issuer Credit Rating (SPLTICRM) is investment-grade rated. If a firm is below investment-grade rating or if the debt is not rated the dummy variable is equal to zero. As of the end of February 2017, the Compustat S&P ratings database has been discontinued, therefore the dummy variable takes the value of zero throughout this period.

9) Stock market Conditions (Frank & Goyal, 2009)

Cumulative market returns (CrspRet) is the annual CRSP value-weighted index return, including distributions.

10) Debt Market Conditions

Term spread (TermSprd) is the difference between a 10-year Treasury constant maturity minus the federal funds rate (Source: FRED) . I found this factor on my own, and it has relatively lower robust standard error (at least in my sample) than other term spread factors used in the literature, such as the 10-year interest series and the one-year interest series (Frank & Goyal 2009)

11) Macroeconomic Conditions (Frank & Goyal, 2009)

Growth in GDP (MacroGr) is differences in log of real gross domestic product in 2012 dollars. (Source : FRED)

Expected inflation rate (Inflation) is the 1-Year Expected Inflation rate. (Source : FRED)

Note: Compustat variable names are in parentheses. (Source: Disatnik et al. 2014, Harford et al. 2014)

12) Cash

Cash and short-term investments (che) over book assets (at)

13) R&D

The ratio of R&D expenses (xrd) over book assets (at), set to zero if missing.

14) Net debt issuance

Long-term debt issuance (dltis) minus long-term debt reduction (dltr) divided by the book assets (at).

15) Acquisition expenses

Acquisition expenses (aqc) over book assets (at).

16) Net working capital

Current assets (act) minus current liabilities (lct) minus cash (che), over book assets (at).

17) Dividend

A dummy variable that is equal to 1 if cash dividends (dv) is positive, zero otherwise.

B. Core and Minor leverage factors

Core leverage factors: Median industry leverage (IndustLev), profitability (Profit), market-to-book assets ratio (Mktbk), log of assets (Log Assets), tangibility (Tang), and the dividend dummy (Dividend). The dividend dummy is a core leverage factor only for the overall sample.

Minor Leverage factors: Capital expenditures (Capex), taxes (TaxRate), supply-side factors (Rating), stock market conditions (CrspRet), debt market conditions (TermSprd), and macroeconomic conditions (MacroGr).