REPUBLIC OF TURKEY
YILDIZ TECHINCAL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS
M.A. PROGRAM IN ECONOMICS

MASTER'S THESIS

THE ROLE OF BOARD CHARACTERISTICS IN CAPITAL STRUCTURE DECISIONS: ECONOMETRIC AND MACHINE LEARNING EVIDENCE FROM TURKISH LISTED FIRMS

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THESIS SUPERVISOR
Prof. Dr. HÜSEYİN TAŞTAN

İSTANBUL
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ÖZ

YÖNETİM KURULU ÖZELLİKLERİNİN SERMAYE YAPISI KARARLARINDAKİ ROLÜ: HALKA AÇIK TÜRK FİRMALARI İÇİN EKONOMETRİ VE MAKİNE ÖĞRENMESİ BULGULARI

Alican Yıldırım

Aralık, 2021

Bu tezde, Türkiye'deki halka açık finans dışı sektörde yer alan firmaların sermaye yapılarına ilişkin dört soruya cevap aranmıştır: 1) Sermaye yapısı literatüründe öne çıkan ödünleşme ve finansman hiyerarşisi teorilerinden hangisi bu firmaların sermaye yapısı kararlarını açıklamakta başarılıdır? 2) Yönetim kurulu bağımsızlığı, yönetim kurulu büyüklüğü ve kurul içerisindeki kadın üyelerin oranı gibi kurumsal yönetişim kalitesi göstergeleri sermaye yapısı kararlarında belirleyici bir rol oynuyor mudur? 3) Sermaye yapısı kararları, ağaç bazlı makine öğrenmesi yöntemleri kullanılarak doğrusal modellerden daha başarılı bir şekilde öngörülebilir mi – eğer öyle ise en başarılı yöntem hangisidir? 4) Sermaye yapısını makine öğrenmesi yöntemleriyle öngörürken yönetim kurulu özelliklerini de dikkate almak öngörü performansını nasıl etkiler? 257 firmanın 2009-2019 yıllarını kapsayan bilanço ve gelir tabloları kullanılarak yapılan ekonometrik tahmin sonuçları, ödünleşme ve finansman hiyerarşisi teorilerinin hiçbirinin sermaye yapısı kararlarını tek başlarına tamamen açıklayamadığını göstermektedir. Teorik olarak sermaye yapısını etkileyeceği öngörülen firma karakteristiklerinden kârlılık, firma büyüklüğü ve likiditenin kaldıraç oranları üzerinde istatistiksel olarak anlamlı bir etkisi olduğu bulunmuştur. Ayrıca, bazı tahmin sonuçları yönetim kurulu büyüklüğü ve kaldıraç oranları arasında pozitif ve anlamlı bir ilişki olduğunu göstermektedir. Diğer yönetim kurulu karakteristikleri ve kaldıraç oranları arasında güçlü bir anlamlı ilişki bulunamamıştır. Sermaye yapısı makine öğrenmesi yöntemleriyle öngörüldüğünde, ağaç bazlı makine öğrenmesi yöntemlerinden rassal ormanlar ve boosting algoritmalarının doğrusal modellerden genel olarak daha başarılı öngörü performansı sergilediği bulgusuna erişilmiştir. Son olarak, yönetim kurulu özelliklerinin dikkate alınmasının öngörü performansını iyileştirmediği tespit edilmiştir.

Anahtar Kelimeler: Sermaye yapısı, kaldıraç oranı, kurumsal yönetişim, yönetim kurulu bağımsızlığı, makine öğrenmesi

ABSTRACT

THE ROLE OF BOARD CHARACTERISTICS IN CAPITAL STRUCTURE DECISIONS: ECONOMETRIC AND MACHINE LEARNING EVIDENCE FROM TURKISH LISTED FIRMS

Alican Yıldırım

December, 2021

In this thesis, we try to answer the following questions regarding the capital structure decisions of Turkish non-financial firms: 1) which one of the most prominent capital structure theories, the trade-off theory and the pecking order theory, is successful at explaining the capital structure decisions of these firms? 2) Do the characteristics of the board of directors such as the share of independent members, share of women directors and board size play an important role in their capital structure decisions? 3) Can tree-based machine learning methods predict the capital structure decisions of these firms more accurately than linear models? If yes, which method has the best predictive performance? 4) When implementing machine learning, does accounting for board characteristics improve predictive performance? We use data on 257 public non-financial firms that are quoted in the Istanbul Stock Exchange, and the data covers the period 2009-2019. Results from fixed-effects and system GMM estimations suggest that neither the trade-off theory nor the pecking order theory by itself is successful in explaining the capital structure decisions of the firms in our sample. We find that firm characteristics such as profitability, firm size, and liquidity have a statistically significant impact on leverage ratios. Moreover, in some cases, we find evidence suggesting a positive relationship between board size and leverage ratios. We fail to find any evidence for a statistically significant relationship between other board characteristics and leverage ratios. When we predict leverage ratios using machine learning methods, we find that tree-based methods generally outperform linear models. In addition, we find that taking board variables into account does not improve predictive performance. Finally, we find that the best machine learning algorithms in terms of predictive performance are random forests and boosting.

Key Words: Capital structure, leverage ratio, corporate governance, board independence, machine learning

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İstanbul; Aralık 2021 Alican Yıldırım

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ABBREVIATIONS

FINNET : Financial Information News Network

GMM : Generalized Method of Moments

KAP : Kamuyu Aydınlatma Platformu (Public Disclosure Platform)

OLS : Ordinary Least Squares

RMSE : Root Mean Squared Error

1. INTRODUCTION

A firm can finance its assets with debt or equity, and the mixture of these two sources of finance is called the capital structure of the firm. Debt can take the form of bank loans, commercial papers, trade credits, and corporate notes and bonds, while equity can be either internal (retained earnings) or external (share issues). Research on capital structure mainly tries to answer the following question: how do firms choose a specific mixture out of infinitely many combinations of these financing sources?

Several theories have been formulated in order to answer this question. A consensus, however, is yet to be reached. The most prominent theories of capital structure are the trade-off theory and the pecking order theory[1]. The primary focus of the trade-off theory is the tax advantages of issuing debt. The tax base of a firm does not include interest payments made over its debt, which implies that the use of debt can significantly reduce the taxes paid by the firm: the government effectively pays a proportion (equal to the tax rate) of the interest payments made by the firm. Of course, tax advantages of debt can be offset by several phenomena, the most important one being financial distress, which increases the chances of bankruptcy. After a certain point, debt can no longer provide benefits through tax reliefs, but it can damage financial health. Consider the case of a firm that is highly indebted. For such a firm, holding other factors fixed, additional debt can engender difficulties in meeting its debt obligations. As a result, the firm may face some constraints in capital markets. That is to say, creditors that provide funds to the firm may demand higher interest rates, or investors with rational expectations (who foresee the financial distress) would offer lower prices for its stocks. This simple example illustrates the loss in the value of the firm that would occur due to issuing too much debt.

Another critical thing to consider is the agency costs of debt, which arise due to the divergence of interests between managers (who act on behalf of shareholders) and

[1] We discuss alternative theories in the literature review section.

creditors. Simply put, creditors want their money to be used wisely, and they want to ensure that the firm repays its debt. If creditors anticipate managers' tendency to prioritize shareholders, they will take some precautionary measures (e.g., higher interest rates, covenants), which drive up the cost of borrowing. The implication of this framework is an optimal capital structure for every firm, where the marginal benefit of additional debt is offset by the marginal cost of increased financial distress. In other words, a specific mixture of debt-equity exists such that it maximizes the value of the firm.

On the other hand, pecking order theory rejects this hypothesis of optimal capital structure and argues that a typical firm relies on internal sources of funds. When external finance is necessary, firms should prefer debt over equity. The idea is that investors interpret external equity issues as bad news due to the information asymmetry between managers and investors. Managers, knowing more about the firm's prospects and acting in the interests of the shareholders, are not expected to issue equity if they think the firm is undervalued. This suggests that equity issues may be indicative of managers' pessimism about the future of the firm. In other words, managers would issue equity only if they think that the firm is overvalued. Using internally generated funds instead does not have such implications on the value of the firm. When external finance is necessary, then firms should prefer low-risk debt instead of external equity.

Our first aim in this thesis is to test the validity of these capital structure theories for Turkish non-financial firms that are quoted in the Istanbul Stock Exchange. Besides some firm characteristics that are theoretically and empirically relevant, our second aim is to examine whether characteristics of the board of directors also have any significant impact on financing decisions. To be more specific, we try to understand whether the size of the board of directors, the proportion of women directors, and the proportion of independent members in the board have any impact on debt policy. For instance, a high proportion of independent members may help to reduce the information asymmetries between firms and investors, which may lead to an upward movement in the pecking order. Alves, Couto & Francisco (2015) find evidence for such change in the capital structure of firms with more independent boards. Alternatively, a board with more independent members may reduce the agency problems between managers and creditors, which may mitigate agency costs and thus

increase the use of debt (this can also be interpreted as an upward movement in the pecking order). Furthermore, as suggested by Jensen (1993) and Lipton & Lorsch (1992), large boards may suffer from communication problems, which in turn results in poor decision-making. On the other hand, from a resource dependence perspective, larger boards may provide more resources through their linkages to the external environment (Hillman, Cannella, Paetzold, 2000), which is capital markets in our case. This in turn may play an important role in financing decisions. As for gender diversity, Charness & Gneezy (2012) find that women are more risk-averse than men, which is in line with the findings of Aduse & Obeng (2019) and García & Herrero (2021) that more gender-diverse boards lead to lower leverage ratios.

We model capital structure decisions (leverage ratio) as a function of profitability, tangibility, firm size, liquidity, non-debt tax shields, growth opportunities, the proportion of independent members on the board, the proportion of women on the board, and board size. All of these variables are discussed in the 3rd section. Our data set, which we obtained from the Finnet data stream, consists of balance sheets, income statements, and end-of-year market values of 257 non-financial firms and covers the period 2009-2019. We combine this with another data set on board characteristics, which we hand-collected from the annual reports of each firm in our data set. Board size and composition display some variation during the sample period, mainly due to the Communiqué on Corporate Governance issued by the Capital Markets Board (SPK) of Turkey at the end of 2011. The communiqué mandated for public firms the appointment of independent members to the board of directors. Depending on the market value of the firm, the required number of independent members ranges from 2 to one-third of the total members.

To take into account the maturity structure of debt, we run separate regressions on short-term, long-term, and total leverage ratios. Due to our concerns regarding firm-level heterogeneity, we first run panel fixed-effects regressions. However, another concern arises from the possibility of simultaneity bias in the parameter estimates, which motivates us to employ the Generalized Method of Moments (GMM) framework as an alternative. We discuss these at length in the 3rd section.

Our third aim is to see how successfully we can predict leverage ratios using machine learning methods, to which we devote the 4th section. We employ linear models and tree-based learning methods such as bagging, random forests, and

boosting. No matter which theory better explains capital structure decisions, an apparent implication of each theory is that capital structure is in some way related to firm value. As an indicator of financial health, leverage ratios may bolster or damage public confidence in firms, which will be reflected in the stock prices. Furthermore, since higher leverage ratios increase financial distress, which in turn results in a higher probability of bankruptcy, we think that predicting leverage ratios more accurately may help investors, to a certain extent, in constructing better portfolios. It can also improve the research on the probability of default, as in Löffler & Maurer (2011).

Finally, our fourth aim is to investigate whether taking board characteristics into account improves prediction accuracy. Our approach here differs in two respects from that in the 3rd section where we use econometric techniques. First, we are not interested in how board characteristics influence capital structure decisions, we are interested in whether they are helpful, one way or another, in obtaining accurate predictions of capital structure. Technically, we are no longer interested in consistent estimates of the slope parameters, our focus is on the fitted values. Second, we are also not interested in testing any capital structure theory, by assessing how other firm characteristics impact capital structure decisions.

The thesis is organized as follows. In Section 2, we provide a broad review of the literature on the most prominent theories of capital structure, keeping our focus on the trade-off and pecking order theories for the most part. Furthermore, we discuss the firm-specific, macroeconomic, and institutional determinants of capital structure from the extant literature. We also discuss the key findings in the literature on board characteristics, focusing mainly on their impact on firm performance, on firm value, and on a limited scale, their impact on capital structure. In passing, we note that not many studies examine how board characteristics influence capital structure decisions. Last but not least, we discuss the empirical literature on the capital structure of Turkish firms.

In Section 3, we introduce our data set and discuss the variable definitions. We also examine the evolution of leverage ratios over the sample period, as well as the trends in board composition. We also introduce the econometric methods we used for estimation, elaborate on their relevance, and discuss our findings. In Section 4, we discuss the machine learning algorithms we used to predict leverage ratios and

discuss their predictive performances. Finally, we summarize our conclusions in Section 5.

2. LITERATURE REVIEW

The question of how do firms make their capital structure decisions became relevant following the publication of the seminal work of Modigliani & Miller (1958), who argued that in an environment where capital markets are perfect and frictionless (i.e., in the absence of information asymmetries, taxes, transaction costs, arbitrage opportunities, or a market imperfection of any sort), capital structure decisions are irrelevant, thus have no impact on firm value. Later on, having integrated corporate taxes into this framework, Modigliani & Miller (1963) suggested that the value of a firm increases with the amount of debt since the tax-deductibility of interest payments provides tax advantages. If this were the case, then a uniform capital structure would prevail across all firms (100% debt), which is in stark contrast with observed data. Besides, Miller (1977) has shown that when personal taxes are also taken into account, the irrelevance proposition still holds. Nonetheless, this has led scholars to search for potential impediments to full debt financing.

In arguing that firms cannot issue as much debt as they desire without any limitations, Stiglitz (1972) suggests that if there is a possibility of bankruptcy in future periods, the cost of issuing debt increases and issuing more debt after a certain point is no longer value-enhancing, but instead, the opposite is true. Commonly referred to as "bankruptcy costs" or more generally "financial distress costs", these costs capture the hardships faced by firms in meeting their debt obligations, which in turn may reduce the funds available to them or result in an increase in the risk premia demanded by creditors. In addition to bankruptcy costs, firms also incur "agency costs" associated with issuing debt, which arise due to the divergence of interest between creditors and managers (Jensen, Meckling, 1976). Managers may find it advantageous to invest in riskier projects with borrowed funds since it opens up a window of opportunity to transfer wealth from creditors to shareholders (which may include themselves). Anticipating this tendency, creditors may want to monitor the managers to ensure they do not engage in such activities. The monitoring of managers is costly, and these costs may translate into higher interest rates, driving up

the cost of borrowing. One of the most prominent theories of capital structure, the "trade-off theory", is based on the idea that firms, when making capital structure decisions, seek to equalize the marginal cost of issuing additional debt to the marginal benefit it provides. What naturally follows is the existence of an optimum capital structure for every firm. Figure 1 illustrates this situation. The red line represents the Modigliani & Miller (1963) framework, where there are no bankruptcy costs and firm value is continuously increasing with debt until debt capacity is exhausted. The horizontal green line represents the value of the firm if it avoids issuing debt entirely. The blue curve represents how firm value changes with different debt levels when both tax benefits and expected financial distress costs are taken into account. The value-maximizing firm should borrow until it reaches the optimum level of debt denoted by D*.

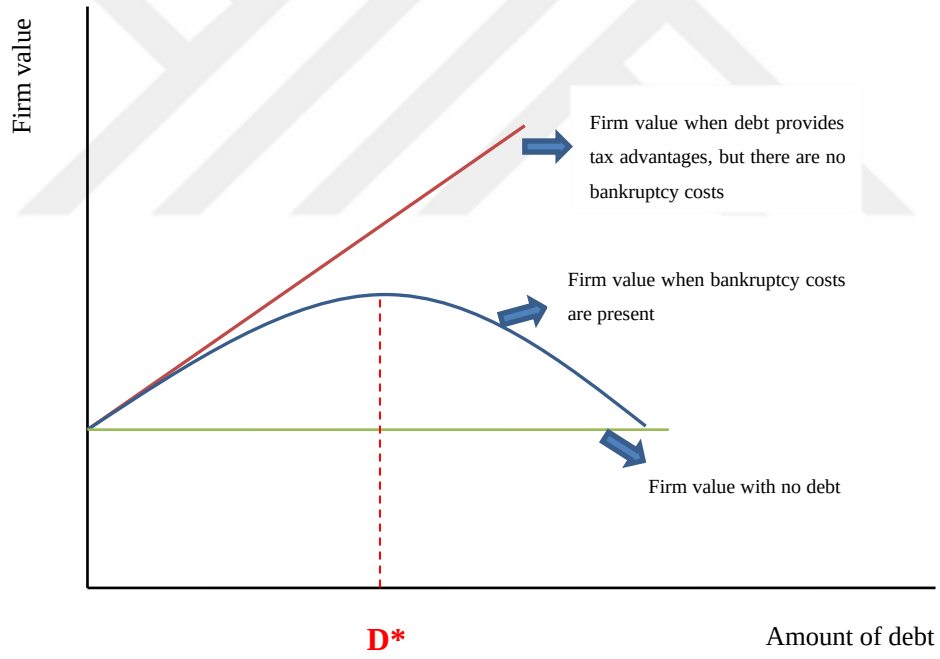


Figure 1: Tax Benefit of Debt, Cost of Financial Distress and Firm Value

Shyam-Sunder, Lakshmi, and Stewart C. Myers. 1999. "Testing Static Tradeoff against Pecking Order Models of Capital Structure." **Journal of Financial Economics**. v. 51, n. 2 (1999): 219–44.

An approach based on information asymmetries draws a substantially different picture. First introduced by Donaldson (1961) and popularized by Myers (1984) and Myers & Majluf (1984), "pecking order theory" suggests that firms do not have an

optimum capital structure, but they choose among different financing sources based on the degree of information asymmetry associated with each. Since managers know more about the firm than potential investors, equity issues are usually interpreted by investors as bad news, i.e., a signal of overvaluation. The idea is that managers would be willing to issue equity only if they believe that the current stock price is higher than what it is supposed to be. Then, investors with rational expectations would offer a lower price for the newly issued equity, which decreases the current stock price and, consequently, the value of the firm. This renders equity issues less desirable, for they bear a high amount of information asymmetry. According to pecking order theory, firms should prefer internal financing as much as they can. When internal funds are exhausted, firms should switch to debt, and equity issues should be the last resort. In short, pecking order theory suggests a hierarchical order of preference whereby firms try to minimize information asymmetries when making financing decisions.

There are some alternative explanations for capital structure decisions, such as the "market-timing hypothesis", the "signaling theory", or the "free-cash-flow theory". The market-timing hypothesis puts forward that a firm's capital structure is "the cumulative outcome of attempts to time the equity market" (Baker, Wurgler, 2002); that is, firms issue equity when the prices of their stocks are high and refrain from issuing equity when prices are low. In a similar vein as the pecking order theory, signaling theory suggests that the capital structure can be interpreted as a signal of its quality; equity issues signal low quality, and high debt signals high quality (Ross, 1977). In a sense, capital structure is thought to reflect the private information held by managers. Only the managers of firms with promising growth opportunities would be willing to hold onto higher debt levels since high debt would increase the probability of bankruptcy if the firm does not have such opportunities (Swanson, Srinidhi, Seetharaman, 2003). Finally, the free-cash-flow hypothesis is based on the agency framework where the incentives of managers and shareholders of a diffuse-ownership firm may diverge, and managers may focus more on maximizing their own utility (e.g., higher perquisite consumption). In this case, issuing debt plays a disciplinary role by increasing the probability of bankruptcy, which in turn imposes pressure on the manager and forces the manager to align her interests with that of shareholders (profit maximization), since she would otherwise lose not only the

perquisites but also her job (Grossman, Hart, 1982). Jensen (1986) argues that issuing debt can play a significant role in mitigating agency problems, especially for firms with fewer growth opportunities but that generate large cash-flows.

2.1. Determinants of Capital Structure

In this subsection, we discuss some of the firm-specific (*profitability*, *tangibility*, *growth opportunities*, *firm size*, *liquidity*, *non-debt tax shields*), industry-specific (*industry median leverage)*, macroeconomic (*inflation*, *GDP growth*, *corporate income tax rate*), and institutional determinants of capital structure decisions that are well-documented in the prior literature. Our focus remains predominantly on the predictions of trade-off theory and pecking order theory, the two competing capital structure theories. We also cover some of the findings in the empirical literature for Turkish non-financial firms. As an indicator of capital structure, most studies use the leverage ratio (ratio of debt to assets).

2.1.1. Profitability

Earnings brought by increases in profitability can be retained or used to retire existing debt. They can also be used to finance a new investment project. The trade-off argument is that when profitability increases, a value-maximizing firm should shield these newly generated earnings from taxation as much as it can. Put differently, higher profitability reduces the marginal cost of borrowing and thus pushes up the optimum leverage ratio. Hence, the trade-off theory suggests that leverage increases with profitability.

In contrast, pecking order theory predicts an inverse relationship between profitability and leverage since the theory suggests that firms should prefer the safest financing source, which is internally generated funds. In a pecking order environment, debt increases only if retained earnings are not sufficient to cover the cost of investments. Therefore, given fixed investments, more profitable firms have lower leverage ratios, and given fixed profitability, firms with more investments have higher leverage ratios (Fama, French, 2002).

Profitability is consistently found to be negatively associated with leverage, which supports the pecking order hypothesis (Fama, French, 2002; Frank, Goyal, 2009; Myers, 1984; Titman, Wessels, 1988). Studies on Turkish firms also report similar

findings (Bayrakdaroğlu, Ege, Yazıcı, 2013; Cevheroğlu-Acar, 2018; Köksal, Orman, 2014; Karaşahin, Küçüksaraç, 2016; Okuyan, Taşçı, 2010; Sayılgan, Karabacak, Küçükkocaoğlu, 2006, Yarba, Güner, 2019).

Indeed, these findings are pervasive and seem to prove the trade-off theory to be invalid. However, in their survey study, Graham & Harvey (2001) show that a nonnegligible number of firms in their sample actually do have target leverage ratios. In addition, the generally reported negative association between profitability and leverage is based on static models, in which an implicit assumption of immediate leverage adjustment is made. Dynamic trade-off models such as that in Strebulaev (2007) allow for the presence of adjustment costs whereby firms adjust their leverage ratios infrequently. The infrequency in leverage adjustments results in a negative relationship between profitability and leverage when firms do not refinance. This negative cross-sectional relation merely reflects the fact that the majority of firms do not immediately lever up following an increase in profitability. Dannis, Rettl & Whited (2014) document evidence supporting this hypothesis. They show that the relationship between profitability and leverage becomes positive at refinancing points, while the relationship is negative prior to refinancing.

2.1.2. Type of Assets (Tangibility)

The type of assets of a firm can have significant implications for its capital structure (Titman, Wessels, 1988). More tangible assets (buildings, land, vehicles, equipment, etc.), practically mean that the firm has more assets to be used as collateral when issuing debt. Furthermore, Frank & Goyal (2009) argue that firms with more tangible assets face lower expected bankruptcy costs. Consequently, trade-off theory anticipates that firms with more tangible assets should borrow more.

The pecking order theory suggests an opposite relatioship. Frank & Goyal (2009) argue that tangible assets bear relatively lower information asymmetries, making equity issues less costly. As a result, firms with more tangible assets are expected to have lower leverage ratios.

Evidence for Turkish firms is mixed. Cevheroğlu-Acar (2018) and Gönenç (2003) find that leverage ratios are positively related to tangibility, whereas findings in Bayrakdaroğlu, Ege & Yazıcı (2013) and Sayılgan, Karabacak & Küçükkocaoğlu (2006) suggest an inverse relationship. Karaşahin & Küçüksaraç (2016), Okuyan &

Taşçı (2010), and Yarba & Güner (2019) show that the relationship depends on the maturity structure of debt. Namely, they find that tangibility is positively related to long-term debt, whereas it is negatively related to short-term debt. An intuitive explanation for this is that long-term assets (fixed assets) are usually financed with long-term liabilities, and firms try to match the maturity structure of their debt with the nature of their assets (Booth et al., 2001).

2.1.3. Growth Opportunities

According to Myers (1977) and Myers (1984), unlike tangible assets, which are assets-in-place, growth opportunities can be regarded as call options on real assets, and they are more prone to lose value in the case of financial distress. In other words, expected financial distress costs are higher for high-growth firms. Such firms should refrain from issuing debt in order to decrease their expected financial distress costs so that they will not have to pass up a valuable investment project when the time comes. Growth opportunities also lead to more severe agency problems associated with debt (Frank, Goyal, 2009; Myers, 1977) since managers of high-growth firms are more inclined to underinvest with borrowed funds. Consequently, the trade-off prediction is lower leverage ratios for firms with high growth opportunities.

As mentioned before, firms in a pecking order environment should issue debt only if internally generated funds are no longer sufficient to finance an investment. Given fixed profitability, this is most likely the case for a high-growth firm (Frank, Goyal, 2009). Therefore, pecking order theory predicts higher leverage ratios for high-growth firms.

With regards to Turkish firms, Bayrakdaroğlu, Ege & Yazıcı (2013), Gönenç (2003) and Okuyan & Taşçı (2010) document evidence that firms with more growth opportunities have higher leverage ratios. On the other hand, Cevheroğlu-Acar (2018) and Karaşahin & Küçüksaraç (2016) fail to identify any significant relationship between growth opportunities and leverage.

2.1.4. Firm Size

Titman & Wessels (1988) and Frank & Goyal (2009) put forward that default risks and agency costs of debt are lower for large firms, implying relatively easier and

cheaper access to credit. Hence, large firms are expected to borrow more according to trade-off theory.

Alternatively, the size of a firm can reflect the degree of information asymmetries between the firm and investors; information asymmetries are likely to be lower for large firms (Rajan, Zingales, 1995), possibly because large firms tend to disclose more information to the public. A low degree of information asymmetry makes equity issues less costly. Under this rationale, pecking order theory suggests that equity issues may become preferable for large firms, which implies an inverse relationship between firm size and leverage.

For Turkish firms, Bayrakdaroğlu, Ege & Yazıcı (2013), Cevheroğlu-Acar (2018), Gönenç (2003), Köksal & Orman (2014), Okuyan & Taşçı (2010) and Yarba & Güner (2019) find that leverage ratios increase with firm size, which is in line with the trade-off theory.

2.1.5. Liquidity

Liquidity is closely linked to the free cash flow generated by the firm and is among the important determinants of capital structure decisions. Liquidity is indicative of the ease with which the firm meets its debt obligations. Naturally, holding other factors fixed, we can expect that firms that can comfortably meet their debt obligations are more likely to face lower financial distress costs. Furthermore, as suggested by Jensen (1986), agency costs that arise due to the existence of free cash flows can be reduced by issuing more debt. Thus, we can safely conclude that leverage should increase with liquidity according to both the trade-off theory and the free cash flow theory.

As liquidity and internally generated funds are also closely related, increases in liquidity can be regarded as increases in the availability of internal funds to be used for financing. Therefore, firms with higher liquidity should have lower leverage ratios according to the pecking order theory.

For Turkish firms, Cevheroğlu-Acar (2018) and Karaşahin & Küçüksaraç (2016) find that liquidity and leverage are inversely related. On the contrary, Kadıoğlu & Yılmaz (2017) find evidence supporting the free cash flow hypothesis.[2]

2.1.6. Non-Debt Tax Shields

Non-debt tax shields are outside the scope of the capital structure theories mentioned thus far. Non-debt tax shields are expected to serve as an alternative to debt-related tax shields. The idea is that along with interest payments; corporate taxes are calculated after depreciation expenses are also deducted from corporate income. Therefore, firms can effectively substitute debt with these investment-related (non-debt) tax shields (DeAngelo, Masulis, 1980). Then, firms with higher non-debt tax shields may find it redundant to borrow more so as to exploit the tax advantages of debt. Fama & French (2002) show that for a sample of non-financial firms in the US, leverage ratios are inversely related to non-debt tax shields. Bayrakdaroğlu, Ege & Yazıcı (2013), Cevheroğlu-Acar (2018) and Sayılgan, Karabacak & Küçükkocaoğlu (2016) find that the relationship is the same for Turkish firms.

2.1.7. Industry Mean/Median Leverage

As Frank & Goyal (2009) point out, leverage ratios are known to display substantial variation across industries. There may be two possible explanations for this. First, there may be industry-specific forces that drive capital structure decisions. For example, it might be relatively more challenging for a construction firm to operate without debt. Another possible explanation is that firms may consider median leverage ratios in their industries to be optimal. In fact, some studies use the industry median leverage as a proxy for target leverage (see, for example, Fama, French, 2012; Flannery, Rangan, 2006). If that is true, then firms in industries with higher median leverage ratios should have more debt according to trade-off theory. On the other hand, industry median leverage is irrelevant in a pecking order environment.

Karaşahin & Küçüksaraç (2016), Köksal & Orman (2014) and Yarba & Güner (2019) show that leverage ratios of Turkish firms are positively related to their

[2] The authors investigate the impact of dividend payments and leverage ratios on free cash flows, and document that both are negatively related to free cash flows. Their definition of free cash flows somewhat differs from the liquidity measures used in Cevheroğlu-Acar (2018) and Karaşahin & Küçüksaraç (2016).

respective industry mean (or median) leverage ratios, confirming the trade-off prediction.

2.1.8. Inflation

A major implication of inflation is that it makes a firm's existing debt less valuable. Also, holding interest rates fixed, increases in the inflation rate make interest deductions more valuable. Therefore, according to trade-off theory, inflation should result in higher leverage ratios. On the other hand, pecking-order theory does not have a definite prediction.

Frank & Goyal (2009) find that inflation is positively related to leverage ratios for a sample of non-financial firms in the US. Karaşahin & Küçüksaraç (2016) and Köksal & Orman (2014) show that inflation has the same effect on the leverage ratios of Turkish firms.

2.1.9. GDP Growth

Frank & Goyal (2009) argue that income and stock prices go up in a growing economy, and expected bankruptcy costs go down. Then, firms should borrow more during expansions according to the trade-off theory. In other words, leverage ratios should be procyclical.

Conversely, a declining economy may exacerbate agency problems between managers and shareholders (Frank, Goyal, 2009). If debt can serve as a tool to align the interests of both parties, then leverage ratios should be countercyclical according to the free cash flow hypothesis. Pecking order theory has similar predictions. Since income goes up during high growth periods, and firms should first use their internally generated funds when financing an investment; leverage ratios should be countercyclical.

Contrary to the interpretation of Frank & Goyal (2009), an alternative interpretation follows that GDP growth can be a proxy for growth opportunities (see, for example, Jöeveer, 2013). Such an interpretation brings about diametrically opposing predictions regarding the impact of GDP growth on leverage ratios. Namely, if GDP growth is indicative of firms' growth opportunities, then it should be negatively related to leverage ratios according to trade-off theory. In contrast, the pecking

prediction under this interpretation would be a positive relationship between GDP growth and leverage.

For Turkish firms, Karaşahin & Küçüksaraç (2016) and Köksal & Orman (2014) find that GDP growth and leverage ratios are inversely related, and interpret this finding as evidence against the pecking order theory. On the other hand, Yarba & Güner (2019) show that leverage ratios are procyclical and again interpret this as evidence against the pecking order theory.

2.1.10. Corporate Tax Rates

According to trade-off theory, increases in the corporate tax rates make interest tax shields more valuable, which implies that leverage ratios should increase with corporate tax rates. On the other hand, corporate tax rates are irrelevant to the pecking order theory.

Karaşahin & Küçüksaraç (2016) show that the relationship between corporate tax rate and leverage ratios is ambiguous: it is positively related to short-term and total leverage, while its impact on long-term leverage is negative. Köksal & Orman (2014), on the other hand, confirm the predictions of the trade-off theory.

2.1.11. Institutional Factors

Evidently, a major concern in corporate finance literature is the information asymmetries between stakeholders, which strongly depend on the legal and institutional environment (Demirgüç-Kunt, Maksimovic, 1999). Demirgüç-Kunt & Maksimovic (1996) show that stock market development is an important determinant of capital structure decisions. They find that initial improvements in the stock market result in higher leverage ratios, but as stock markets mature, firms' preferences shift from debt to equity. Booth, Aivazian, Demirgüç-Kunt & Maksimovic (2001) also find that country differences explain a significant part of the variation in capital structure decisions across a sample of developed and developing countries. Finally, Öztekin & Flannery (2012) show that leverage adjustment speeds improve in a favorable institutional environment where transaction costs and information asymmetries are significantly reduced.

So far, we discussed some of the determinants of capital structure decisions from the extant literature, as well as how they are expected to impact leverage ratios according

to the trade-off theory and the pecking order theory. We also discussed the findings for Turkish non-financial firms, a summary of which is provided in Table 1. Clearly, a consensus is yet to be reached regarding the success of either theory in explaining the capital structure decisions of Turkish non-financial firms.

In the next subsection, we continue with the impact of corporate governance on capital structure decisions and firm performance.

Table 1: Findings in the Empirical Literature for Turkish Firms

	Reported Sign (+)	Reported Sign (-)
Profitability		• Bayrakdaroğlu, Ege & Yazıcı (2013) • Cevheroğlu-Acar, (2018) • Köksal, Orman (2014) • Karaşahin, Küçüksaraç (2016) • Okuyan, Taşçı (2010) • Sayılgan, Karabacak & Küçükkocaoğlu (2006) • Yarba & Güner (2019)
Tangibility	• Cevheroğlu-Acar (2018) • Gönenç (2003) • Karaşahin & Küçüksaraç (2016) (Long-Term Leverage) • Okuyan & Taşçı (2010) (Long-Term Leverage) • Yarba & Güner (2019) (Long-Term Leverage)	• Bayrakdaroğlu, Ege & Yazıcı (2013) • Okuyan & Taşçı (2010) (Short-Term Leverage) • Karaşahin & Küçüksaraç (2016) (Short-Term Leverage) • Sayılgan, Karabacak & Küçükkocaoğlu (2006) • Yarba & Güner (2019) (Short-Term Leverage)
Growth Opportunities	• Bayrakdaroğlu, Ege & Yazıcı (2013) • Gönenç (2003) • Okuyan & Taşçı (2010)	
Firm Size	• Bayrakdaroğlu, Ege & Yazıcı (2013) • Cevheroğlu-Acar (2018) • Gönenç (2003) • Köksal & Orman (2014) • Okuyan & Taşçı (2010) Yarba & Güner (2019)	

Liquidity		• Cevheroğlu-Acar (2018) • Karaşahin & Küçüksaraç (2016)
Industry Median Leverage	• Karaşahin & Küçüksaraç (2016) • Köksal & Orman (2014) • Yarba & Güner (2019)	
Inflation	• Karaşahin & Küçüksaraç (2016) • Köksal & Orman (2014)	
GDP Growth	• Köksal & Orman (2014) • Yarba & Güner (2019)	• Karaşahin & Küçüksaraç (2016)
Corporate Tax Rates	• Köksal & Orman (2014) • Karaşahin & Küçüksaraç (2016) (Short-Term and Total Leverage)	• Karaşahin & Küçüksaraç (2016) (Long-Term Leverage)

2.2. Corporate Governance, Capital Structure, and Firm Performance

Characteristics of the board of directors may be essential for effective decision-making. One of the key responsibilities of the board of directors is to "review and, where appropriate, approve the financial objectives, major strategies and plans of the corporation" (The Business Roundtable, 1990, 7). This practically means that the board of directors also oversees the company's capital structure decisions (Monks, Minow, 1995, 201). In this section, we review the literature on how characteristics of the board of directors such as *board size*, *gender diversity*, and *degree of independence* can influence capital structure decisions as well as firm performance.

2.2.1. Board Size

Jensen (1993) and Lipton & Lorsch (1992) argue that too many members on a board may exacerbate communication problems and decrease cohesiveness, resulting in poor decision-making. Cheng (2008) finds that variability in firm performance is lower for firms with large boards and argues that it is indicative of the difficulty of building consensus in large boards, which leads to less extreme decisions. Conyon & Peck (1998), Eisenberg, Sundgren & Wells (1998), Guest (2009), and Yermack (1996) document a negative relationship between board size and firm performance.

However, findings in Coles, Daniel & Naveen (2008) suggest that more complex firms (such as firms that have higher debt levels and that are larger and more diversified) may require larger boards. Pfeffer (1972) provides similar results regarding board size. The author finds that large and diversified organizations that need access to external capital more tend to have larger boards.

2.2.2. Gender Diversity

Gender diversity is said to improve decision-making since women's inclusion brings different perspectives to the boardroom (Campbell, Minguez-Vera, 2007, 440). Higgs Report (2003), which was prepared by a businessman with the aim of promoting better corporate governance practices, is in favor of gender diversity in the board on the grounds that diversity helps to enhance board effectiveness. Countries such as Belgium, Finland, Iceland, Italy, Norway, and The Netherlands have already legislated gender quotas (Smith, 2018). Some studies find a positive relationship between gender diversity in the board and firm performance (Agyemang-Mintah, Schadewitz, 2019; Gordini, Rancati, 2017). On the other hand, Adams and Ferreira (2009) challenge legislating gender quotas and suggest that imposing these quotas may have adverse effects on firms that are already well-governed, although they find that gender-diverse boards are more likely to hold CEOs accountable for poor performance. Charness & Gneezy (2012) document convincing evidence that women are more financially risk-averse than men, a finding supported by Adusei & Obeng's (2019) study where they find that microfinance institutions with more gender-diverse boards have lower leverage ratios and argue that gender diversity reduces the exposure to bankruptcy risk. Finally, for a sample of European firms, García & Herrero (2021) find that more gender-diverse firms have lower leverage ratios.

2.2.3. Board Independence

In a modern corporation, ownership and control are usually separated, which, as previously mentioned, engenders agency problems (Fama, Jensen, 1983; Fama, 1980; Jensen, Meckling, 1976). Under this setting, some measures should be taken to align the interests of both parties or to make sure that managers refrain from taking actions that otherwise would harm shareholders. Debt is one monitoring mechanism to achieve that, according to the free cash flow hypothesis. However, there are alternative suggestions. It is a widely held belief that appointing independent

members to the board facilitates effective monitoring. For instance, corporate scandals in the US, such as those involving Enron and WorldCom, paved the way for the enactment of the Sarbanes-Oxley Act in 2002, which required publicly listed firms to appoint independent directors to the board in order to enhance effective monitoring. Many countries followed suit and implemented board independence thresholds. In its Communiqué on Corporate Governance Principles (2011), Capital Markets Board of Turkey (SPK) mandated the appointment of at least two independent members to the boards of public firms. Depending on their market values, the requirement for some firms is at least a one-to-two outsider-insider ratio.

Naturally, one can question the ability of independent directors to mitigate agency problems, given that CEOs play a dominant role in the appointment of board members or considering that independent directors are themselves agents (Hermalin, Weisbach, 1991; Shivdasani, Yermack, 1999.). Furthermore, the social ties of the so-called independent directors with the managers may impede their ability to remain objective and monitor effectively (Ansari, Goergen, Mira, 2018; Bruynseels, Cardinaels, 2014; Hwang, Kim, 2009). In fact, this is the reason why some strict definitions of independence require that top managers have never met these independent directors (Monks, Minow, 1995, 227).

Another question that requires attention is that from what/whom these independent members should be independent, and the answer certainly depends on the circumstances. According to Baum (2017), independence can take many forms. Does independence pertain to independence from the CEO and possibly from the CEO's family and friends? From other board members or other executives? From the company itself, from its parent company, or all companies that belong to the same corporate group? What about the controlling shareholder? Furthermore, what if a specific corporate transaction to be monitored by the independent director benefits the independent director herself (perhaps through her seat in another company's board as an insider), which makes her the director that should actually be monitored? All these make it harder to assess the degree of independence in a corporate board.

Prior literature provides conflicting results as to whether pushing for more independence in the board of directors pays off in terms of more effective monitoring, and consequently, better performance. For instance, Bøhren & Strøhm (2010), Hermalin & Weisbach (1991), and Wintoki, Linck & Letter (2012) fail to

find a significant relationship between board independence and firm performance. Coles, Daniel & Naveen (2008) find that board independence actually has a negative impact on the performance of R&D intensive firms; a higher fraction of insiders in a board is sometimes preferable since knowledge and experience of insiders can be essential for better firm performance. Agrawal & Knoeber (1996) and Bhagat & Black (2001) document similar results. In contrast, some studies find that board independence is positively related to firm performance (Black, Jang, Kim, 2006; Uribe-Bohorquez, Martinez-Ferrero, García-Sánchez, 2018; Rosenstein, Wyatt, 1990), monitoring intensity (Ararat, Aksu, Çetin, 2010), firm transparency (Armstrong, Core, Guay, 2014), use of external equity (Alves, Couto, Francisco, 2015), and negatively related to the cost of debt (Anderson, Mansi, Reeb, 2004).

These results should be interpreted cautiously due to potential endogeneity issues with the variables in question (Hermalin, Weisbach, 2003; Wintoki, Linck, Netter, 2012). Better governance may as well be driven by firm performance, or some other exogenous factor may drive both. For instance, Hermalin & Weisbach (1998) develop a model of corporate boards in which the degree of independence depends on a bargaining process between the CEO and other directors. They argue that CEOs with a proven record of good performance will be monitored less since better past performance strengthens the CEO's hand in the aforementioned bargain. If this were true, then ignoring this may lead to erroneous conclusions regarding the impact of independence on performance. Last but not least, institutional factors also matter for the effectiveness of board independence. As suggested by Ararat, Orbay & Yurtoğlu (2010), appointing board members that are more likely to monitor can be regarded as a sign of the goodwill of controlling shareholders, especially when investor rights are weakly protected (a characteristic of emerging markets). Thus, independent board members may matter more under such an institutional setting. Ararat & Dallas (2011) find in their review of investment policies of major institutions that investors expect the boards in developing economies (characterized by companies with concentrated ownership) to have some degree of independence.

2.2.4. Findings for Turkish Firms

Turkey is an emerging economy and is characterized by firms with concentrated ownership and weak investor protection (Ararat, Orbay, Yurtoğlu, 2010). Although

this should make independent boards more crucial, Ararat, Orbay & Yurtoğlu (2010) find that board independence does not have a significant impact on the performance of Turkish firms. Findings of Topak (2011) suggest that board size also does not have a significant impact on the performance of Turkish firms. However, Karayel & Doğan (2016) find that firm performance increases with board size, share of women directors, and board independence. Ararat & Yurtoğlu (2020) find that measures such as the share of women on the board of directors do not predict better performance; but they show that the inclusion of women on the board as shareholders as well as their board committee memberships are associated with higher firm value. Kılıç & Kuzey (2016) report similar results regarding the impact of gender diversity. Finally, Ararat, Black & Yurtoğlu (2017) find that disclosure of the number of board meetings, another aspect of corporate governance, predicts higher firm value and performance for Turkish firms.

Overall, appointing independent directors to the board seems to have no clear implications for firms. However, the majority of the empirical work point to a negative (positive) relationship between board size (gender diversity) and firm performance, although we should note that the majority of these work cover developed countries. Our understanding of how corporate governance is related to firm performance in developing countries such as Turkey remains quite limited, let alone our understanding of its impact on capital structure.

3. ECONOMETRIC ANALYSIS

In this section, we aim to identify the causal impact of a set of firm characteristics (which are to be defined in the following pages) on capital structure decisions, using econometric techniques. Furthermore, we investigate whether the trade-off theory or the pecking order theory is successful in explaining the capital structure decisions of Turkish non-financial firms. Finally, we examine whether board characteristics play any important role in capital structure decisions.

3.1. Econometric Model

Our data set involves both cross-section and time dimensions. Since we cannot account for all relevant firm-specific factors, a reasonable choice for our baseline econometric model would be the fixed-effects model where firm-specific unobservable factors are allowed to be correlated with the explanatory variables (Cameron, Trivedi, 2008, 251). Namely, we estimate the equation below

$$y_{it} = x'_{it}\beta + \alpha_i + \nu_t + \epsilon_{it} \tag{3.1}$$

where $i = 1, \dots, 257$ denotes firms, $t = 2009, \dots, 2019$ denotes years, y_{it} is the leverage ratio of firm i at time t, β is the parameter vector, x_{it} are explanatory variables, α_i is unobservable time-invariant firm-specific factors, ν_t is time fixed-effects, and ϵ_{it} is the idiosyncratic error term with zero mean and constant variance.

Consistent estimation of Equation (3.1) requires that we eliminate α_i, which can be achieved by subtracting from it the model for individual means. That is, we can subtract $\bar{y}_i = \bar{x}_i\beta + \bar{\nu}_t + \bar{\alpha}_i + \bar{\epsilon}_i$ (where $\bar{\alpha}_i = \alpha_i$ since α_i does not change over time) from Equation (4.1), which leads us to what is called the within model or mean-difference model (Cameron, Trivedi, 2008, 251):

$$y_{it} - \bar{y}_i = (x_{it} - \bar{x}_i)'\beta + \nu_t - \bar{\nu}_t + \epsilon_{it} - \bar{\epsilon}_i \quad (3.2)$$

where β is the within estimator obtained using Ordinary Least Squares (OLS). The advantage of the within estimator is that x_{it} are allowed to be endogenous as long as they are correlated only with α_i.

We estimate the model for debt-to-assets and debt-to-capital ratios, using both their book and market values. Each model is estimated with cluster-robust standard errors which allows observations to be correlated at the firm level. We first run regressions using only financial variables as explanatory variables. Then, we add board characteristics to the equation one at a time. We include time dummies in each model. We also run separate regressions using short-term and long-term leverage ratios as the dependent variable.

One shortcoming of the static fixed-effects model described above is that it does not capture the dependency of leverage ratios to their past realizations. In fact, this kind of relationship is reported in numerous studies (see, for example, Flannery & Rangan (2006), Hovakimian & Hovakimian (2019), Lemmon, Roberts & Zender (2008), among others). We can capture this relationship by using the lagged value of leverage ratios as an additional explanatory variable. That is, we can estimate the model below

$$y_{it} = \rho y_{i,,t-1} + x'_{it}\beta + \alpha_i + \nu_t + \epsilon_{it} \quad (3.3)$$

where $y_{i,,t-1}$ is the leverage ratio of firm i at time $t-1$. Estimating Equation (3.3) yields inconsistent parameter estimates, since the lagged dependent variable $y_{i,,t-1}$ will be correlated with $\epsilon_{i,t-1}$, hence, it will be correlated with $\epsilon_{it} - \bar{\epsilon}_i$ (Cameron, Trivedi, 2008, 288).

A potential strategy to obtain consistent parameter estimates is to use instrumental variables. First-differencing Equation (3.3) and using second and further lags of independent variables as instruments can solve the endogeneity problem, since lags of the independent variables will be, to a certain extent, correlated with their first differences, but they will not be correlated with the first differences of the

idiosyncratic error term. This is the main idea behind the difference Generalized Method of Moments (GMM) estimator (Arellano, Bond, 1991).

System GMM (Arellano, Bover, 1995; Blundell, Bond, 1998) is an augmented version of difference GMM, where the additional assumption that the first differences of instruments are uncorrelated with the time-invariant fixed effects increases the number of candidate instruments, which can improve efficiency (Roodman, 2009). While difference GMM uses lagged levels of independent variables as instruments for first differences, system GMM allows for the use of first differences as instruments for levels. This is especially useful when the dependent variable exhibits a random-walk-like behavior, i.e., $x_t = x_{t-1} + \epsilon_t$.

To be more precise, first differencing Equation (3.3) yields

$$\Delta y_{it} = \rho \Delta y_{i,t-1} + \Delta x'_{it}\beta + +\Delta \nu_t + \Delta \epsilon_{it} \tag{3.4}$$

Now, $\Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2}$ is correlated with $\Delta \epsilon_{it} = \epsilon_{it} - \epsilon_{i,t-1}$, by definition. In difference GMM, the instrumenting variables for $\Delta y_{i,t-1}$ are second and further lags of levels, i.e., $y_{i,t-2}$, $y_{i,t-3}$, … . For example, at $t = 3$, the instrument for $\Delta y_{i,2}$ is y_{i1}, because it is correlated with $\Delta y_{i,2} = y_{i2} - y_{i1}$ but not correlated with $\Delta \epsilon_{i3} = \epsilon_{i3} - \epsilon_{i2}$. However, if y_{it} is close to a random walk, then $y_{i,t-2}$, $y_{i,t-3}$, … are weaker instruments for $\Delta y_{i,t-1}$ since past levels convey less information about future changes than do past differences about future levels (Roodman, 2009). In system GMM, along with past levels for differences, past differences are also used as instruments for levels. Our suspicion is that leverage ratios may also exhibit random-walk-like behavior, hence the choice of system GMM.

3.2. Data

We use balance sheets and income statements of 257 non-financial firms that are quoted in the Istanbul Stock Exchange. The data is obtained from Financial Information News Network (FINNET) and covers the period 2009 – 2019. We also utilize a dataset on board characteristics that is hand-collected from annual reports

issued over the sample period. Annual reports are obtained from the Public Disclosure Platform (KAP). Among the 257 firms, 166 are in manufacturing; 19 are in wholesale and retail trade; 12 are in restaurants and hotels; 9 are in electricity, gas and water; 18 are in technology; 4 are in construction and public works; 21 are in services; 5 are in mining and quarrying, and 3 are in agriculture, forestry and fishing industries (industry classifications are based on KAP's).

3.3. Variable Definitions

We use book and market leverage ratios as our dependent variable. Book leverage is defined as the ratio of debt to total assets, which is usually called the *debt-to-assets ratio*. To calculate market leverage, we subtract from total assets the book value of equity and add the market value of equity.[3] This is only a proxy for true market leverage since we still use the book value of debt in the numerator. It can be considered as the quasi-market value of leverage.

Rajan & Zingales (1995, 1429) argue that an increase in trade credits is reflected as a decrease in this leverage ratio since trade credits are part of total assets, the denominator. Alternatively, we can replace debt with liabilities, which encapsulates accounts payable (thus trade credits). Then, for firms that use trade credits mainly for transactions purposes rather than for financing, leverage ratios can be overstated. Therefore, they suggest using the ratio of debt to the sum of debt and equity, which they argue best represents a firm's financing decisions. We use this alternative measure of leverage as well, which is usually called the *debt-to-captial ratio*. When debt-to-assets and debt-to-capital ratios are calculated with short-term, long-term, and total debt as well as with book and market values of equity, we end up with 12 leverage ratios. Table 2 shows how we calculate book and market leverage ratios using both leverage measures.

Our independent variables are *profitability, tangibility, growth opportunities, firm size, liquidity, non-debt tax shields, industry median leverage, board size, share of independent directors on the board,* and *share of women on the board.* Commonly used proxies for profitability include return on assets (ROA) (Cevheroğlu-Acar, 2018) and operating return on assets (OROA) (Fama, French, 2002; Karaşahin,

[3] Market value of equity is calculated by multiplying the number of outstanding shares with the current stock price.

Küçüksaraç, 2016; Köksal, Orman, 2014). ROA is defined as the ratio of net income to total assets, while OROA is defined as the ratio of operating income (EBIT) to total assets. The fundamental difference is that the latter does not take into account financing and tax expenses. We use OROA as a proxy for profitability.

Table 2: Book and Market Leverage Ratios

	Book Leverage	**Market Leverage**
Debt-to-Assets	$\frac{Total\ Debt}{Total\ Assets}$	$\frac{Total\ Debt}{Total\ Assets - Book\ Equity + Market\ Equity}$
Debt-to-Capital	$\frac{Total\ Debt}{Total\ Debt\ + Book\ Equity}$	$\frac{Total\ Debt}{Total\ Debt + Market\ Equity}$

Following Frank & Goyal (2009) and many others, we use the ratio of fixed assets (properties, plants, and equipment) to total assets as a proxy for tangibility and the ratio of depreciation to total assets as a proxy for non-debt tax shields.

We use Tobin's Q to proxy for growth opportunities. Following Coles, Daniel & Naveen (2008), we use the market-to-book ratio (total assets minus book equity plus market equity, all divided by total assets) as a rough approximation of Tobin's Q. Market-to-book ratio is a commonly used proxy for growth opportunities (e.g., Bauer, 2004; Frank, Goyal, 2009; Gaud et al., 2003; Karaşahin, Küçüksaraç, 2016).

As an indicator of firm size, we use the natural logarithm of sales, in parallel with Rajan & Zingales (1995), Titman & Wessels (1998), Özkan (2001), Köksal & Orman (2014), among others. We adjust sales for inflation. There are a small number of observations (18) where sales are 0; hence we increment sales by one before taking the logarithm.

As a measure of liquidity, Karaşahin & Küçüksaraç (2016) use the ratio of cash and cash equivalents to total assets (cash ratio). Cevheroğlu-Acar (2018) uses current assets divided by current liabilities (current ratio). We use the former as a proxy for liquidity. The reason is that the latter might overstate the liquidity conditions of a firm since current assets include inventories too, which are relatively less liquid as

opposed to cash and cash equivalents. In that sense, cash ratio is a stricter definition of liquidity.

Table 3 shows how we define the independent variables mentioned thus far. The definitions of the remainder are fairly straightforward. Board size is the total number of directors; share of independent directors (women) is calculated by dividing the number of independent directors (women) by board size.

Table 3: Variable Definitions

Variable	**Proxy**
Profitability	$\text{OROA} = \frac{EBIT}{Total\ Assets}$
Tangibility	$\frac{Fixed\ Assets}{Total\ Assets}$
Growth Opportunities	$\frac{Total\ Assets - Book\ Equity + Market\ Equity}{Total\ Assets}$
Firm Size	$\log(1 + sales)$
Liquidity	$\text{Cash Ratio} = \frac{Cash\ and\ Cash\ Equivalents}{Total\ Assets}$
Non-Debt Tax Shields	$\frac{Depreciation}{Total\ Assets}$

3.4. Summary Statistics

Table 4 shows the summary statistics for the explanatory variables.[4] Notice that mean long-term leverage ratios are higher than short-term no matter the leverage measure or the book/market definition. Also, mean market leverage ratios are lower than mean book leverage ratios. Mean debt-to-capital ratio (Leverage 2) is higher than mean debt-to-assets (Leverage 1) ratio, which must hold by definition. Figure 2 shows how both leverage ratios have evolved over the sample period.

The most apparent thing about Figure 2 is the sharp decline in leverage ratios that took place in 2012, which can partly be attributed to the increase in interest rates in

[4] We drop observations with negative equity (91 observations).

that period. Leverage ratios seem to have followed a positive trend after 2012. Overall, mean debt-to-assets ratio fluctuated around 20%, while mean debt-to-capital ratio displayed relatively higher variability.

Table 4: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Leverage 1	2580	.196	.172	0	.901
Short-Term	2580	.097	.113	0	.697
Long-Term	2580	.099	.13	0	.794
Leverage 2	2580	.294	.251	0	.995
Short-Term	2580	.145	.167	0	.924
Long- Term	2580	.149	.194	0	.976
Market Leverage	2319	.17	.157	0	.832
Short-Term	2319	.082	.102	0	.69
Long-Term	2319	.087	.118	0	.733
Market Leverage 2	2319	.243	.225	0	.991
Short-Term	2319	.117	.145	0	.849
Long-Term	2319	.126	.17	0	.867
Profitability	2580	.061	.094	-.514	.746
Tangibility	2580	.477	.234	0	.997
Firm Size	2580	17.914	2.669	0	23.836
Non-debt Tax Shields	2580	.029	.028	-.151	.647
Cash Ratio	2580	.729	2.797	0	85.814
Tobin's Q	2319	1.457	1.114	.219	16.586
Share of Ind.	2370	.232	.155	0	.667
Share of Women	2370	.138	.155	0	.8
Board Size	2370	6.746	2.135	2	15

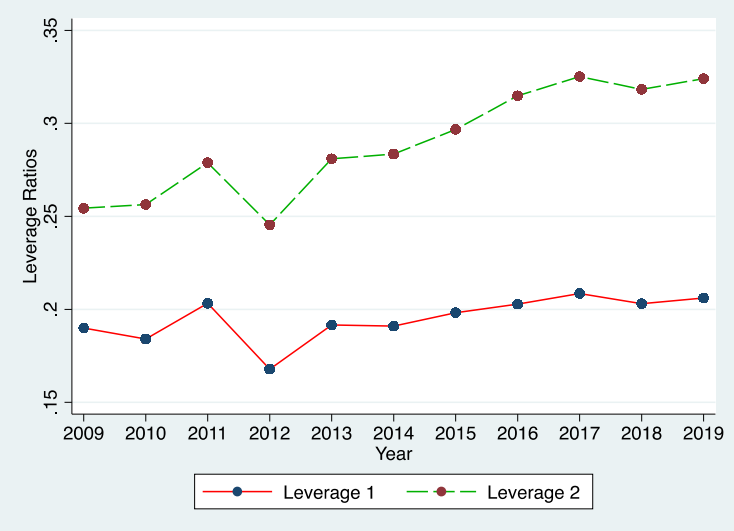


Figure 2: Leverage Ratios (Mean, 2009-2019)

Leverage 1 (Debt-to-assets) = $\frac{Total\ Debt}{Total\ Assets}$, Leverage 2 (Debt-to-capital) = $\frac{Total\ Debt}{Total\ Debt+Book\ Equity}$

Figures 3 and 4 show how mean book and debt-to-assets (Leverage 1) and debt-to-capital (Leverage 2) have evolved over time, respectively. Not surprisingly, book leverage ratios have remained above market leverage ratios (on average). Although book and market leverage ratios have more or less moved in tandem, the relationship seems to have reversed its course after 2016.

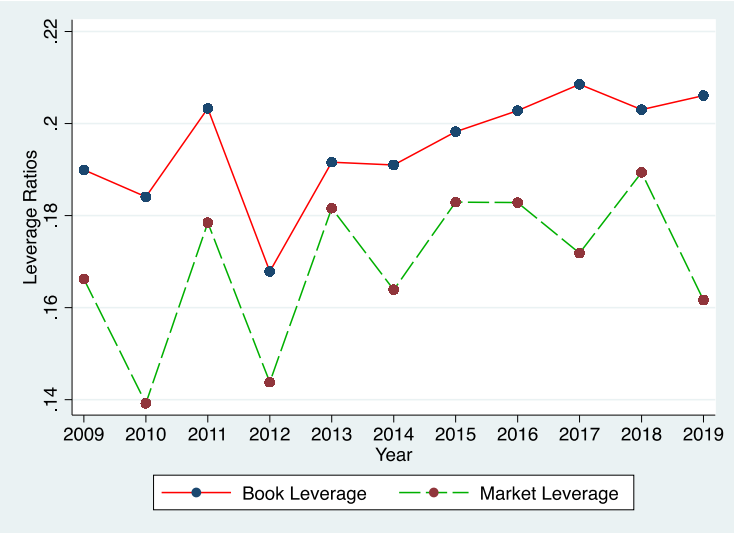


Figure 3: Book and Market Debt-to-Assets Ratio (Mean, 2009-2019)

Book Leverage = $\frac{Total\ Debt}{Total\ Assets}$, Market Leverage = $\frac{Total\ Debt}{Total\ Assets - Book\ Equity + Market\ Equity}$

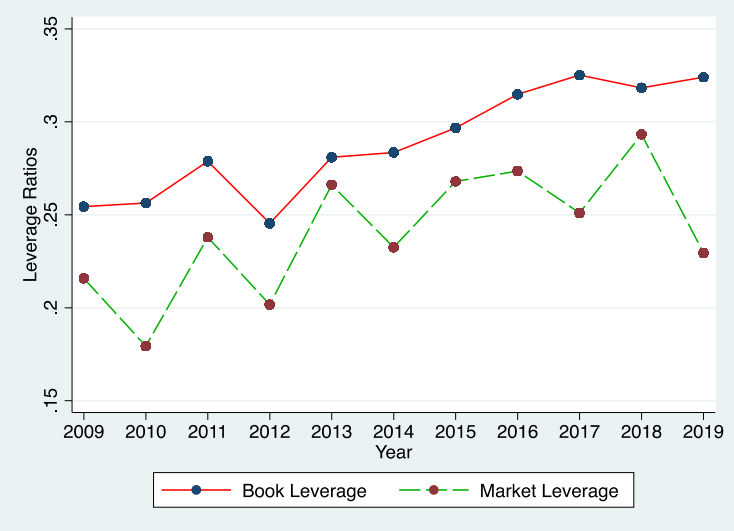


Figure 4: Book and Market Debt-to-Capital Ratio (Mean, 2009-2019)

Book Leverage = $\frac{Total\ Debt}{Total\ Debt + Book\ Equity}$, Market Leverage = $\frac{Total\ Debt}{Total\ Debt + Market\ Equity}$

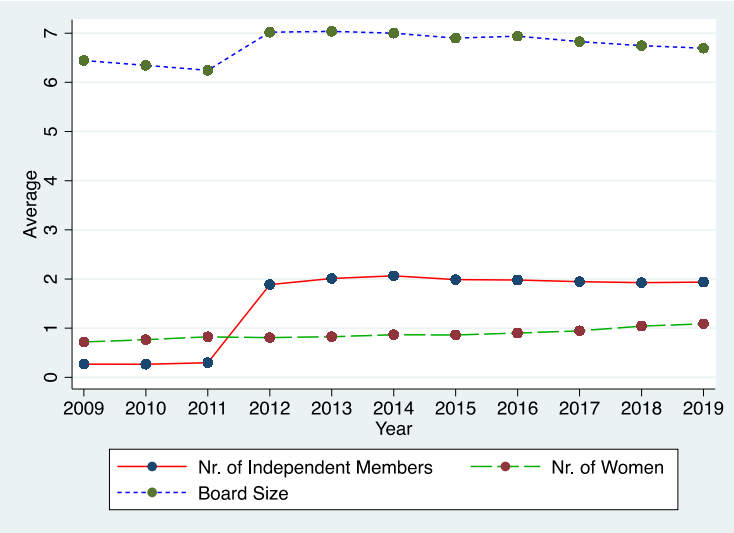


Figure 5: Board Size, Nr. of Independent Members and Nr. of Women (Mean, 2009-2019)

Figure 5 shows annual averages of board size, the number of independent members, and the number of women on the board over the sample period. The number of women on the board remained more or less stable. There was a slight increase in average board size after 2011. Except for 2019, the average number of women has remained below 1, which is potentially a sign of significant underrepresentation. On the other hand, the average number of independent board members rose dramatically from just above 0 to around 2 after the year 2011. This is due to the Communiqué on Corporate Governance Principles issued at the end of 2011, which imposed a mandatory threshold for the number of independent members in corporate boards. The requirement was that one-third of the board members should be independent (depending on their market values, the requirement for some firms was a minimum of two independent board members). However, firms that were listed under particular sub-markets of the Istanbul Stock Exchange, namely, the Watchlist Market and the Pre-market Trading Platform, were held exempt from the independent board member requirement. Our sample includes 27 firms that are listed under these sub-markets or firms that were previously listed under different sub-markets but moved to these sub-markets at some point during the sample period. Overall, given the average board size and the average number of independent members, it seems safe to conclude that the majority of firms in our sample were not willing to appoint independent members more than the required minimum. The fact that only 25 out of the 256 firms

voluntarily appointed independent board members prior to the communiqué is indicative of the unwillingness of firms to make their boards more independent.

3.5. Empirical Results

Tables 5 and 6 present the results obtained from static fixed-effects models for book and market leverage ratios, respectively. That is, we estimate Equation (3.1) using the within estimator. We use both leverage measures (debt-to-assets and debt-to-captial ratios), and run separate regressions for short-term, long-term, and total leverage ratios.

First of all, results suggest that profitability, firm size, and industry median leverage ratios are statistically significant across all models, and each of these variables enter each model with the same sign. In other words, their impact on leverage is the same no matter the term structure of debt or the book or market definition of leverage ratios. Profitability has a statistically significant negative impact on leverage, which is consistent with the pecking order prediction that highly profitable firms issue less debt. A quick look at the coefficients on profitability reveals that the negative impact of profitability is more pronounced for short-term leverage (when compared to long-term leverage). On the other hand, firm size has a statistically significant positive impact on leverage, a finding that supports the trade-off argument that bigger firms are able to borrow more. Finally, industry median leverage has a positive sign and is statistically significant, which may indicate a leverage targeting behavior anticipated by the trade-off theory.

The results show that, consistent with the findings of Karaşahin & Küçüksaraç (2016) and Yarba & Güner (2019), tangibility is positively (negatively) associated with long-term (short-term) leverage. This is consistent with the idea that long-term assets are usually financed with long-term liabilities, while less debt can be issued against short-term assets (Booth et al., 2001). However, tangibility does not have a statistically significant impact on total leverage ratios.

Liquidity is statistically significant for short-term leverage ratios. The relationship is negative, meaning that higher liquidity decreases the need for short-term funds, which is indicative of a pecking order behavior. Finally, non-debt tax shields are

insignificant: we fail to confirm the DeAngelo & Masulis (1980) hypothesis that non-debt tax shields can be substitutes for debt.

Table 5: Fixed-Effects Estimation Results for Book Leverage

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.228***	-0.104***	-0.338***	-0.323***	-0.161***	-0.493***
	(0.0506)	(0.0396)	(0.0690)	(0.0753)	(0.0574)	(0.102)
Tangibility	-0.0947***	0.154***	0.0615	-0.139***	0.177***	0.0369
	(0.0300)	(0.0288)	(0.0421)	(0.0440)	(0.0470)	(0.0628)
Firm Size	0.00760***	0.0119***	0.0204***	0.0104***	0.0142***	0.0262***
	(0.00246)	(0.00230)	(0.00325)	(0.00350)	(0.00270)	(0.00487)
Liquidity	-0.00302***	0.0000265	-0.00286	-0.00396***	0.000214	-0.00378
	(0.00111)	(0.00128)	(0.00189)	(0.00139)	(0.00160)	(0.00234)
Non-Debt	0.0395	-0.0974	-0.0539	0.0911	-0.0669	0.0165
	(0.0960)	(0.146)	(0.145)	(0.160)	(0.176)	(0.197)
Growth Opp.	-0.00251	0.00294	0.00104	-0.00371	0.00164	-0.00112
	(0.00253)	(0.00307)	(0.00465)	(0.00355)	(0.00414)	(0.00646)
Industry Median	0.414***	0.445***	0.403***	0.378**	0.514***	0.327***
	(0.135)	(0.0996)	(0.105)	(0.150)	(0.109)	(0.0940)
Constant	0.00271	-0.244***	-0.279***	0.00705	-0.284***	-0.314***
	(0.0458)	(0.0433)	(0.0613)	(0.0666)	(0.0506)	(0.0935)
Observations	2319	2319	2319	2319	2319	2319
Within R-sq	0.0786	0.188	0.118	0.0643	0.206	0.150
Between R-sq	0.0854	0.344	0.240	0.131	0.293	0.209
Overall R-sq	0.0806	0.296	0.202	0.103	0.257	0.188

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Growth opportunities is statistically significant only for market leverage ratios. Recall that we defined growth opportunities as a rough approximation of Tobin's Q, which was basically the market-to-book ratio. Since market leverage ratios contain the market value of equity in the denominator, a negative relationship is perhaps not surprising. Potentially, there is a simultaneity problem going on. Finally, R-squareds are higher for long-term leverage: the chosen firm characteristics explain long-term leverage ratios relatively more successfully.

Now we extend the model with board variables (share of independent members, share of women, and board size). We add each board variable to the model one at a time. Tables 7 and 8 present the results when we include the share of independent

board members as an additional explanatory variable. Share of independent members is statistically insignificant in all models. Extending the model with this variable does not lead to any notable change in terms of the coefficient estimates or their statistical significance. The results are qualitatively the same as those obtained without taking board independence into account.

Table 6: Fixed-Effects Estimation Results for Market Leverage

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.180***	-0.111***	-0.289***	-0.239***	-0.153***	-0.394***
	(0.0374)	(0.0309)	(0.0537)	(0.0525)	(0.0423)	(0.0739)
Tangibility	-0.0905***	0.143***	0.0534	-0.131***	0.180***	0.0523
	(0.0251)	(0.0253)	(0.0346)	(0.0352)	(0.0359)	(0.0472)
Firm Size	0.00494**	0.0135***	0.0186***	0.00665**	0.0159***	0.0230***
	(0.00220)	(0.00344)	(0.00291)	(0.00265)	(0.00406)	(0.00404)
Liquidity	-0.00226**	0.000390	-0.00167	-0.00282**	0.000768	-0.00171
	(0.000916)	(0.000795)	(0.00136)	(0.00111)	(0.00103)	(0.00163)
Non-Debt	-0.0470	-0.0866	-0.126	-0.0896	-0.0963	-0.157
	(0.0641)	(0.119)	(0.123)	(0.0888)	(0.152)	(0.169)
Growth Opp.	-0.0113***	-0.00405*	-0.0153***	-0.0162***	-0.00780**	-0.0242***
	(0.00245)	(0.00227)	(0.00444)	(0.00367)	(0.00351)	(0.00681)
Industry Median	0.526***	0.493***	0.472***	0.442**	0.628***	0.458***
	(0.184)	(0.0849)	(0.104)	(0.182)	(0.0950)	(0.0925)
Constant	0.0473	-0.267***	-0.240***	0.0755	-0.318***	-0.270***
	(0.0413)	(0.0651)	(0.0526)	(0.0489)	(0.0750)	(0.0736)
Observations	2319	2319	2319	2319	2319	2319
Within R-sq	0.0865	0.222	0.164	0.0751	0.239	0.199
Between R-sq	0.114	0.356	0.277	0.157	0.322	0.256
Overall R-sq	0.101	0.310	0.235	0.124	0.287	0.231

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Tables 9 and 10 present the results when we extend the model further with the share of women directors. Results suggest that neither the share of independent members nor the share of women have a statistically significant impact on any of the leverage ratios. In all the models, these variables are insignificant and their inclusion does not necessarily alter the remaining coefficient estimates in terms of sign and statistical

significance. Once again, the results are qualitatively the same as those obtained without board variables.

Finally, Tables 11 and 12 present the results when we include all of the board variables in the model. Results suggest that board size has a positive impact on long-term leverage ratios, and the impact is statistically significant at the 1% level for the book value of long-term leverage, and at the 5% level for the market value of long-term leverage. Share of independent members and share of women are still insignificant.

Table 7: Fixed-Effects Estimation Results for Book Leverage (Extended with Share of Independent Members)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.234***	-0.112***	-0.352***	-0.330***	-0.175***	-0.514***
	(0.0520)	(0.0406)	(0.0710)	(0.0775)	(0.0587)	(0.105)
Tangibility	-0.0975***	0.157***	0.0622	-0.144***	0.177***	0.0312
	(0.0309)	(0.0298)	(0.0435)	(0.0454)	(0.0486)	(0.0644)
Firm Size	0.00760***	0.0119***	0.0204***	0.0104***	0.0143***	0.0262***
	(0.00245)	(0.00225)	(0.00327)	(0.00348)	(0.00270)	(0.00490)
Liquidity	-0.00306***	0.0000214	-0.00290	-0.00403***	0.000185	-0.00386*
	(0.00111)	(0.00128)	(0.00189)	(0.00140)	(0.00159)	(0.00233)
Non-Debt	0.0337	-0.0820	-0.0466	0.0769	-0.0482	0.0214
	(0.0959)	(0.141)	(0.145)	(0.158)	(0.172)	(0.198)
Growth Opp.	-0.00176	0.00413	0.00307	-0.00282	0.00296	0.00125
	(0.00280)	(0.00369)	(0.00536)	(0.00395)	(0.00481)	(0.00721)
Industry Median	0.407***	0.450***	0.398***	0.359**	0.513***	0.323***
	(0.136)	(0.101)	(0.105)	(0.149)	(0.110)	(0.0946)
Share of Ind.	0.00564	-0.0155	-0.00487	0.00920	-0.00562	0.0115
	(0.0363)	(0.0260)	(0.0430)	(0.0511)	(0.0395)	(0.0570)
Constant	0.00469	-0.249***	-0.281***	0.0132	-0.288***	-0.314***
	(0.0458)	(0.0426)	(0.0618)	(0.0659)	(0.0512)	(0.0942)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0788	0.189	0.119	0.0643	0.206	0.150
Between R-sq	0.0920	0.340	0.241	0.142	0.291	0.214
Overall R-sq	0.0810	0.294	0.200	0.104	0.256	0.188

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We previously mentioned that leverage ratios are known to be highly correlated with their past values. Now we include the lag of leverage ratios as an additional explanatory variable. That is, we estimate Equation (3.3). However, as explained in detail before, introducing the lagged value of the dependent variable and estimating the model with the within estimator results in endogeneity. For that reason, we estimate Equation (3.3) using the system GMM estimator.

Equation (3.3) can also be interpreted as a partial adjustment model. Suppose that, as predicted by the trade-off theory, firms actually do have target leverage ratios (Lev_{it}^{*}), and the target is a function of firm characteristics such as those we have been using so far. To be more precise

$$Lev_{it}^{*} = x_{it}'\beta + \gamma_i + \sigma_t + u_{it} \tag{3.5}$$

where x_{it}' is the usual firm characteristics, and γ_i is the time-invariant firm-specific fixed-effects, σ_t is time fixed-effects, and u_{it} is the error term. In the presence of adjustment costs, deviation from target leverage can be expressed as

$$Lev_{it} - Lev_{i,t-1} = \lambda(Lev_{it}^{*} - Lev_{i,t-1}) \tag{3.6}$$

where λ is the adjustment parameter (Fama, French, 2002). A high λ implies easier and less costly adjustment to target leverage. In the case where there are no adjustment costs, λ should be unity. Substituting the right handside of Equation (3.5) with Lev_{it}^{*} in Equation (3.6) yields

$$\begin{aligned} &Lev_{it} - Lev_{i,t-1} = \lambda\left(x_{it}'\beta + \gamma_i + \sigma_t + u_{it} - Lev_{i,t-1}\right) \\ &\Longrightarrow Lev_{it} = (1-\lambda)Lev_{i,t-1} + x_{it}'\theta + \mu_i + \tau_t + \epsilon_{it} \end{aligned} \tag{3.7}$$

where $\theta = \lambda\beta$, $\mu_i = \lambda\alpha$, $\mu_i = \lambda\tau_t$, and $\epsilon_{it} = \lambda u_{it}$. After estimating Equation (3.3) with system GMM, the $(1-\lambda)$ in Equation (3.7) will be equivalent to the coefficient on lagged leverage. Therefore, as $(1-\lambda)$ gets bigger, we can infer that adjustment costs are high, and leverage ratios are more persistent.

We estimate the model with the user-written Stata command xtabond2 (Roodman, 2009), and all estimates are obtained with "two-step" and "robust" options. The two-step option yields efficient and heteroskedasticity-robust parameter estimates, while the robust option implements Windmeijer's (2005) small-sample correction for the

standard errors (Roodman, 2009). Following Gaud et al. (2003), we treat all of the explanatory variables as endogenous, except for industry median leverage, which we treat as strictly exogenous. We use up to two available lags as instruments for endogenous variables: first and second lags of the lagged dependent variable in differences for the level equations, and just the second lags of remaining explanatory variables in levels for the difference equations. We also use the "collapse" option to prevent instrument proliferation. We include time dummies in each model.

Table 8: Fixed-Effects Estimation Results for Market Leverage (Extended with Share of Independent Members)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.178***	-0.112***	-0.287***	-0.237***	-0.153***	-0.391***
	(0.0381)	(0.0315)	(0.0545)	(0.0534)	(0.0427)	(0.0742)
Tangibility	-0.0960***	0.147***	0.0523	-0.140***	0.184***	0.0485
	(0.0258)	(0.0259)	(0.0354)	(0.0362)	(0.0366)	(0.0484)
Firm Size	0.00491**	0.0135***	0.0186***	0.00658**	0.0159***	0.0230***
	(0.00216)	(0.00339)	(0.00297)	(0.00259)	(0.00403)	(0.00417)
Liquidity	-0.00226**	0.000431	-0.00161	-0.00280**	0.000836	-0.00161
	(0.000924)	(0.000795)	(0.00137)	(0.00112)	(0.00104)	(0.00165)
Non-Debt	-0.0515	-0.0750	-0.120	-0.0961	-0.0823	-0.149
	(0.0638)	(0.116)	(0.123)	(0.0884)	(0.149)	(0.168)
Growth Opp.	-0.0123***	-0.00416	-0.0166***	-0.0179***	-0.00834**	-0.0265***
	(0.00240)	(0.00264)	(0.00454)	(0.00349)	(0.00388)	(0.00670)
Industry Median	0.518***	0.492***	0.471***	0.427**	0.625***	0.457***
	(0.185)	(0.0854)	(0.103)	(0.183)	(0.0954)	(0.0920)
Share of Ind.	0.0281	-0.00467	0.0252	0.0556	0.00450	0.0601
	(0.0331)	(0.0240)	(0.0375)	(0.0449)	(0.0366)	(0.0503)
Constant	0.0520	-0.270***	-0.238***	0.0837*	-0.320***	-0.265***
	(0.0405)	(0.0644)	(0.0539)	(0.0474)	(0.0746)	(0.0758)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0879	0.224	0.165	0.0776	0.241	0.202
Between R-sq	0.120	0.355	0.285	0.164	0.323	0.267
Overall R-sq	0.103	0.309	0.238	0.128	0.287	0.237

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Fixed-Effects Estimation Results for Book Leverage (Extended with Share of Independent Members and Share of Women)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.237***	-0.109***	-0.351***	-0.334***	-0.170***	-0.512***
	(0.0521)	(0.0403)	(0.0707)	(0.0774)	(0.0582)	(0.104)
Tangibility	-0.0990***	0.159***	0.0623	-0.146***	0.179***	0.0322
	(0.0312)	(0.0296)	(0.0438)	(0.0457)	(0.0484)	(0.0647)
Firm Size	0.00762***	0.0119***	0.0204***	0.0104***	0.0142***	0.0262***
	(0.00247)	(0.00225)	(0.00327)	(0.00349)	(0.00268)	(0.00489)
Liquidity	-0.00300***	-0.0000384	-0.00290	-0.00397***	0.0000853	-0.00390*
	(0.00111)	(0.00128)	(0.00189)	(0.00140)	(0.00160)	(0.00234)
Non-Debt	0.0265	-0.0749	-0.0462	0.0694	-0.0366	0.0260
	(0.0953)	(0.140)	(0.146)	(0.157)	(0.170)	(0.200)
Growth Opp.	-0.00163	0.00399	0.00306	-0.00269	0.00272	0.00116
	(0.00271)	(0.00372)	(0.00532)	(0.00385)	(0.00489)	(0.00721)
Industry Median	0.411***	0.456***	0.398***	0.359**	0.519***	0.325***
	(0.136)	(0.103)	(0.105)	(0.149)	(0.110)	(0.0942)
Shr of Ind.	0.00612	-0.0161	-0.00490	0.00970	-0.00658	0.0112
	(0.0364)	(0.0259)	(0.0430)	(0.0511)	(0.0396)	(0.0572)
Shr of Women	0.0366	-0.0378	-0.00237	0.0382	-0.0625*	-0.0260
	(0.0325)	(0.0258)	(0.0409)	(0.0485)	(0.0371)	(0.0526)
Constant	0.000582	-0.245***	-0.281***	0.00925	-0.281***	-0.312***
	(0.0462)	(0.0428)	(0.0617)	(0.0665)	(0.0504)	(0.0939)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0803	0.191	0.119	0.0651	0.208	0.151
Between R-sq	0.0813	0.334	0.241	0.133	0.283	0.214
Overall R-sq	0.0753	0.291	0.200	0.0998	0.253	0.188

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Tables 13 and 14 present system GMM results for book leverage and market leverage, respectively. As we did before, we initally estimate the model without board variables. Tables 15 and 16 present the results when we extend the model by including the share of independent members in the board. Likewise, the results when we also add share of women are provided in tables 17 and 18. Finally, results from the model extended with all of the board variables are provided in tables 19 and 20.

Table 10: Fixed-Effects Estimation Results for Market Leverage (Extended with Share of Independent Members and Share of Women)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.182***	-0.109***	-0.289***	-0.242***	-0.150***	-0.393***
	(0.0384)	(0.0314)	(0.0545)	(0.0536)	(0.0425)	(0.0742)
Tangibility	-0.0978***	0.148***	0.0516	-0.142***	0.186***	0.0477
	(0.0261)	(0.0257)	(0.0357)	(0.0365)	(0.0363)	(0.0487)
Firm Size	0.00493**	0.0135***	0.0186***	0.00661**	0.0159***	0.0230***
	(0.00219)	(0.00341)	(0.00297)	(0.00261)	(0.00405)	(0.00416)
Liquidity	-0.00219**	0.000386	-0.00159	-0.00271**	0.000770	-0.00158
	(0.000917)	(0.000798)	(0.00136)	(0.00111)	(0.00104)	(0.00164)
Non-Debt	-0.0603	-0.0696	-0.123	-0.108	-0.0744	-0.152
	(0.0635)	(0.114)	(0.124)	(0.0889)	(0.146)	(0.169)
Growth Opp.	-0.0121***	-0.00426	-0.0165***	-0.0177***	-0.00849**	-0.0264***
	(0.00238)	(0.00264)	(0.00454)	(0.00348)	(0.00388)	(0.00671)
Industry Median	0.523***	0.493***	0.471***	0.429**	0.628***	0.456***
	(0.184)	(0.0857)	(0.103)	(0.183)	(0.0952)	(0.0919)
Shr of Ind.	0.0287	-0.00505	0.0254	0.0564	0.00392	0.0604
	(0.0332)	(0.0241)	(0.0375)	(0.0450)	(0.0368)	(0.0502)
Shr of Women	0.0447*	-0.0280	0.0170	0.0608*	-0.0417	0.0193
	(0.0263)	(0.0220)	(0.0310)	(0.0342)	(0.0326)	(0.0394)
Constant	0.0471	-0.267***	-0.240***	0.0774	-0.316***	-0.267***
	(0.0410)	(0.0653)	(0.0541)	(0.0479)	(0.0754)	(0.0760)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0908	0.225	0.166	0.0802	0.242	0.202
Between R-sq	0.103	0.349	0.283	0.145	0.317	0.267
Overall R-sq	0.0928	0.306	0.237	0.117	0.283	0.237

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

First of all, lagged leverage ratios are statistically significant at the 1% level in all models, and the coefficient on lagged leverage is bigger in the models where long-term leverage is the dependent variable. This therefore suggests that leverage ratios are persistent, and that long-term leverage ratios are relatively more persistent than short-term and total leverage ratios. Overall, adjustment costs are substantial, and they are higher for book leverage ratios in general and for long-term leverage ratios in particular.

Table 11: Fixed-Effects Estimation Results for Book Leverage (Extended with Share of Independent Members, Share of Women, and Board Size)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.237***	-0.112***	-0.353***	-0.332***	-0.173***	-0.513***
	(0.0520)	(0.0407)	(0.0706)	(0.0771)	(0.0586)	(0.104)
Tangibility	-0.0985***	0.156***	0.0605	-0.144***	0.175***	0.0306
	(0.0311)	(0.0296)	(0.0438)	(0.0456)	(0.0482)	(0.0648)
Firm Size	0.00763***	0.0118***	0.0204***	0.0104***	0.0141***	0.0262***
	(0.00250)	(0.00245)	(0.00331)	(0.00358)	(0.00279)	(0.00488)
Liquidity	-0.00297***	-0.000168	-0.00300	-0.00389***	-0.0000961	-0.00399*
	(0.00111)	(0.00127)	(0.00189)	(0.00139)	(0.00157)	(0.00233)
Non-Debt	0.0277	-0.0809	-0.0503	0.0731	-0.0458	0.0220
	(0.0950)	(0.138)	(0.146)	(0.157)	(0.168)	(0.200)
Growth Opp.	-0.00146	0.00321	0.00248	-0.00221	0.00162	0.000636
	(0.00274)	(0.00363)	(0.00528)	(0.00388)	(0.00475)	(0.00719)
Industry Median	0.412***	0.458***	0.392***	0.359**	0.529***	0.325***
	(0.135)	(0.103)	(0.105)	(0.148)	(0.112)	(0.0941)
Shr of Ind.	0.00616	-0.0163	-0.00499	0.00982	-0.00706	0.0110
	(0.0365)	(0.0249)	(0.0424)	(0.0513)	(0.0382)	(0.0566)
Shr of Women	0.0361	-0.0355	-0.000526	0.0368	-0.0593	-0.0244
	(0.0323)	(0.0252)	(0.0406)	(0.0481)	(0.0361)	(0.0525)
Board Size	-0.00172	0.00824***	0.00618*	-0.00512	0.0114***	0.00557
	(0.00281)	(0.00236)	(0.00369)	(0.00421)	(0.00332)	(0.00485)
Constant	0.0101	-0.291***	-0.314***	0.0378	-0.345***	-0.343***
	(0.0483)	(0.0495)	(0.0654)	(0.0700)	(0.0578)	(0.0950)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0806	0.197	0.121	0.0663	0.214	0.151
Between R-sq	0.0870	0.339	0.226	0.147	0.293	0.205
Overall R-sq	0.0805	0.296	0.187	0.113	0.261	0.181

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Fixed-Effects Estimation Results for Market Leverage (Extended with Share of Independent Members, Share of Women, and Board Size)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Profitability	-0.182***	-0.111***	-0.290***	-0.242***	-0.152***	-0.394***
	(0.0383)	(0.0316)	(0.0544)	(0.0536)	(0.0427)	(0.0740)
Tangibility	-0.0979***	0.146***	0.0499	-0.142***	0.183***	0.0459
	(0.0260)	(0.0259)	(0.0358)	(0.0363)	(0.0364)	(0.0487)
Firm Size	0.00493**	0.0135***	0.0186***	0.00662**	0.0158***	0.0229***
	(0.00218)	(0.00361)	(0.00310)	(0.00263)	(0.00430)	(0.00432)
Liquidity	-0.00219**	0.000293	-0.00168	-0.00269**	0.000645	-0.00168
	(0.000919)	(0.000776)	(0.00136)	(0.00111)	(0.00101)	(0.00163)
Non-Debt	-0.0604	-0.0740	-0.127	-0.107	-0.0801	-0.157
	(0.0633)	(0.113)	(0.123)	(0.0886)	(0.144)	(0.168)
Growth Opp.	-0.0121***	-0.00482*	-0.0171***	-0.0176***	-0.00923**	-0.0270***
	(0.00241)	(0.00256)	(0.00449)	(0.00351)	(0.00378)	(0.00666)
Industry Median	0.523***	0.494***	0.468***	0.431**	0.630***	0.452***
	(0.183)	(0.0858)	(0.104)	(0.182)	(0.0944)	(0.0923)
Shr of Ind.	0.0287	-0.00519	0.0253	0.0564	0.00373	0.0603
	(0.0332)	(0.0234)	(0.0370)	(0.0450)	(0.0360)	(0.0496)
Shr of Women	0.0447*	-0.0263	0.0187	0.0605*	-0.0394	0.0212
	(0.0261)	(0.0215)	(0.0307)	(0.0339)	(0.0319)	(0.0390)
Board Size	0.000171	0.00595**	0.00594*	-0.000816	0.00788**	0.00639
	(0.00254)	(0.00231)	(0.00329)	(0.00346)	(0.00338)	(0.00429)
Constant	0.0461	-0.300***	-0.273***	0.0818	-0.360***	-0.302***
	(0.0432)	(0.0691)	(0.0605)	(0.0524)	(0.0814)	(0.0824)
Observations	2312	2312	2312	2312	2312	2312
Within R-sq	0.0908	0.229	0.168	0.0803	0.245	0.203
Between R-sq	0.102	0.343	0.265	0.147	0.316	0.254
Overall R-sq	0.0923	0.300	0.221	0.119	0.280	0.224

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Profitability and firm size have a statistically significant effect on book leverage ratios, which was the case in static fixed-effects models. However, for market leverage ratios, firm size is statistically significant only for total market leverage. Also, there is no significant relationship between profitability and long-term market leverage ratios. The signs of the coefficients are the same as those obtained from static fixed-effects models: the relationship between profitability (firm size) and leverage is negative (positive). On the other hand, tangibility, liquidity and industry

median leverage are no longer statistically significant. Growth opportunities are also statistically insignificant for market leverage ratios, as opposed to the results from static fixed-effects estimations.

Table 13: System GMM Results for Book Leverage

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.607***	0.647***	0.565***	0.561***	0.690***	0.643***
	(0.0602)	(0.0771)	(0.0728)	(0.0606)	(0.0595)	(0.0676)
Profitability	-0.291***	-0.111	-0.379***	-0.425***	-0.0840	-0.478***
	(0.0891)	(0.103)	(0.117)	(0.135)	(0.158)	(0.157)
Tangibility	-0.0304	0.212	0.0686	-0.0582	0.233	0.269
	(0.105)	(0.140)	(0.126)	(0.178)	(0.169)	(0.202)
Firm Size	0.0225***	0.0184**	0.0517***	0.0300***	0.0277**	0.0752***
	(0.00708)	(0.00724)	(0.0121)	(0.0100)	(0.0110)	(0.0195)
Liquidity	-0.00985	-0.0108	-0.0206*	-0.0161	-0.0144	-0.0184
	(0.00765)	(0.00872)	(0.0113)	(0.0108)	(0.0121)	(0.0166)
Non-Debt	-0.110	-0.546	-0.473	-0.119	-0.598	-0.364
	(0.200)	(0.821)	(0.586)	(0.276)	(0.990)	(0.548)
Growth Opp.	0.00909	0.00514	0.0187	-0.00275	0.0135	0.0306
	(0.0117)	(0.0149)	(0.0148)	(0.0204)	(0.0181)	(0.0275)
Industry Median	0.123	0.0639	0.137	-0.0673	0.0415	0.0117
	(0.167)	(0.101)	(0.0969)	(0.242)	(0.108)	(0.101)
Constant	-0.345**	-0.384**	-0.878***	-0.398*	-0.560***	-1.356***
	(0.145)	(0.155)	(0.222)	(0.218)	(0.214)	(0.387)
Observations	2149	2149	2149	2149	2149	2149
Nr. of Instr.	34	34	34	34	34	34
Hansen J	0.885	0.460	0.888	0.664	0.545	0.416
AR (2)	0.670	0.446	0.603	0.506	0.265	0.713

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

When we add the share of independent members to the model, there seems to be a statistically significant positive relationship between share of independent members and the book value of total leverage. However, no such relationship exists when the dependent variable is the market value of leverage. In terms of the signs and statistical significance of the remaining coefficients, the results are more or less the same. Likewise, when we additionally include the share of women (tables 17 and 18) and board size (tables 19 and 20), results remain more or less the same. According to

the static fixed-effects results, board size is statistically significant for both the book value and market value of long-term leverage ratios. System GMM results suggest that board size is significant only for the book value of total leverage.

Table 14: System GMM Results for Market Leverage

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.538***	0.560***	0.531***	0.498***	0.609***	0.546***
	(0.0617)	(0.0555)	(0.0823)	(0.0747)	(0.0791)	(0.0991)
Profitability	-0.260***	-0.107	-0.638**	-0.298**	-0.127	-0.953**
	(0.0995)	(0.116)	(0.257)	(0.119)	(0.197)	(0.399)
Tangibility	-0.0701	0.209*	0.0708	-0.150	0.369**	0.298
	(0.111)	(0.110)	(0.170)	(0.136)	(0.177)	(0.272)
Firm Size	0.0106	0.0142*	0.0390**	0.00554	0.0172	0.0593**
	(0.00702)	(0.00731)	(0.0193)	(0.00989)	(0.0147)	(0.0279)
Liquidity	-0.00535	-0.00963	-0.0261**	-0.00334	-0.00785	-0.0343
	(0.00505)	(0.00710)	(0.0126)	(0.00649)	(0.0124)	(0.0211)
Non-Debt	-0.820	-1.692**	-5.664**	0.216	-3.019*	-7.461*
	(1.038)	(0.824)	(2.645)	(1.198)	(1.678)	(4.256)
Growth Opp.	-0.00676	0.00472	-0.00915	-0.0162	0.00871	-0.0106
	(0.00957)	(0.00798)	(0.0119)	(0.0144)	(0.0144)	(0.0214)
Industry Median	0.338	0.167	0.186*	0.337	0.118	0.0196
	(0.241)	(0.123)	(0.112)	(0.234)	(0.135)	(0.135)
Constant	-0.0822	-0.272**	-0.462*	0.0438	-0.356	-0.771*
	(0.102)	(0.129)	(0.238)	(0.155)	(0.258)	(0.405)
Observations	2056	2056	2056	2056	2056	2056
Nr. of Instr.	34	34	34	34	34	34
Hansen J	0.541	0.208	0.718	0.171	0.0451	0.355
AR (2)	0.409	0.523	0.742	0.508	0.312	0.774

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Overall, we find that profitability, firm size and liquidity are the most robust determinants of capital structrure decisions. However, statistical significance of firm size weakens when we estimate the model with system GMM using market leverage ratios as the dependent variable. In some models, it is statistically insignificant. Likewise, liquidity is statistically significant for short-term leverage in all models estimated with the within estimator. However, according to system GMM results, it is significant only for the book value of total leverage when leverage is defined as

debt over assets. The impact is again negative. In general, results suggest that firms that are more profitable have lower leverage ratios (especially short-term), and bigger firms have higher leverage ratios. Also, there is weak evidence that higher liquidity decreases leverage ratios. The negative association between profitability and liquidity and leverage can be regarded as evidence supporting the pecking order theory, while the increase in leverage resulting from bigger firm size is consistent with the trade-off theory.

Table 15: System GMM Results for Book Leverage (Extended with Share of Independent Members)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.629***	0.649***	0.588***	0.595***	0.708***	0.697***
	(0.0623)	(0.0866)	(0.0734)	(0.0671)	(0.0691)	(0.0828)
Profitability	-0.276***	-0.125	-0.402***	-0.371***	-0.103	-0.533***
	(0.0952)	(0.103)	(0.120)	(0.143)	(0.154)	(0.160)
Tangibility	-0.0148	0.182	0.0734	-0.00693	0.200	0.131
	(0.106)	(0.140)	(0.122)	(0.171)	(0.158)	(0.213)
Firm Size	0.0202***	0.0190**	0.0438***	0.0255**	0.0232**	0.0540**
	(0.00748)	(0.00762)	(0.0134)	(0.0104)	(0.0115)	(0.0248)
Liquidity	-0.00814	-0.0110	-0.0192**	-0.0105	-0.0135	-0.0167
	(0.00596)	(0.00974)	(0.00923)	(0.00855)	(0.0125)	(0.0112)
Non-Debt	-0.118	-0.603	-0.586	-0.0737	-0.491	-0.479
	(0.211)	(0.839)	(0.748)	(0.243)	(0.793)	(0.668)
Growth Opp.	0.0139	0.00396	0.0194	0.00763	0.0141	0.0308
	(0.0133)	(0.0137)	(0.0144)	(0.0243)	(0.0150)	(0.0245)
Industry Median	0.179	0.0823	0.126	0.0192	0.0463	0.0415
	(0.164)	(0.0966)	(0.0927)	(0.222)	(0.103)	(0.105)
Share of Ind.	0.166	0.144	0.306**	0.239	0.311*	0.654***
	(0.113)	(0.0983)	(0.154)	(0.183)	(0.186)	(0.246)
Constant	-0.370**	-0.420***	-0.827***	-0.462**	-0.550**	-1.130**
	(0.152)	(0.161)	(0.234)	(0.228)	(0.223)	(0.456)
Observations	2144	2144	2144	2144	2144	2144
Nr. of Instr.	35	35	35	35	35	35
Hansen J	0.968	0.434	0.873	0.861	0.519	0.616
AR (2)	0.848	0.384	0.299	0.725	0.187	0.290

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: System GMM Results for Market Leverage (Extended with Share of Independent Members)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.538***	0.558***	0.527***	0.479***	0.592***	0.524***
	(0.0633)	(0.0616)	(0.0844)	(0.0726)	(0.0865)	(0.103)
Profitability	-0.275***	-0.150	-0.658***	-0.324**	-0.202	-1.082**
	(0.102)	(0.140)	(0.249)	(0.131)	(0.227)	(0.465)
Tangibility	-0.0802	0.186	0.0675	-0.165	0.334*	0.258
	(0.116)	(0.123)	(0.162)	(0.145)	(0.188)	(0.284)
Firm Size	0.0109	0.0166*	0.0407*	0.00647	0.0222	0.0660*
	(0.00710)	(0.00930)	(0.0215)	(0.0109)	(0.0209)	(0.0369)
Liquidity	-0.00648	-0.0112	-0.0275**	-0.00523	-0.0105	-0.0387
	(0.00528)	(0.00793)	(0.0138)	(0.00788)	(0.0154)	(0.0246)
Non-Debt	-0.943	-1.948**	-6.067**	-0.0320	-3.531*	-8.895*
	(1.096)	(0.988)	(2.819)	(1.262)	(2.079)	(5.368)
Growth Opp.	-0.00732	0.00293	-0.00903	-0.0196	0.00382	-0.0141
	(0.0100)	(0.00968)	(0.0122)	(0.0155)	(0.0168)	(0.0245)
Industry Median	0.338	0.197	0.188*	0.334	0.155	0.0280
	(0.248)	(0.134)	(0.114)	(0.312)	(0.140)	(0.143)
Share of Ind.	-0.0507	0.0733	-0.00140	-0.164	0.0426	0.0188
	(0.0998)	(0.148)	(0.187)	(0.164)	(0.266)	(0.374)
Constant	-0.0632	-0.329**	-0.479*	0.100	-0.437	-0.824*
	(0.111)	(0.144)	(0.248)	(0.167)	(0.291)	(0.455)
Observations	2052	2052	2052	2052	2052	2052
Nr. of Instr.	35	35	35	35	35	35
Hansen J	0.494	0.143	0.714	0.197	0.0381	0.388
AR (2)	0.482	0.531	0.837	0.626	0.330	0.987

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Fixed-effects results suggest that board size has a statistically significant positive impact on long-term leverage ratios (book and market), while system GMM results suggest that such a relationship exists only for the book values of total leverage ratios. Similarly, when the model is estimated with system GMM, share of independent members is statistically significant for the book values of total leverage ratios. However, we fail to identify any significant relationship between board independence and leverage when we estimate the model with the within estimator.

Therefore, the positive impact of board size on leverage ratios is relatively more robust, but we refrain from jumping to conclusions regarding board independence.

Table 17: System GMM Results for Book Leverage (Extended with Share of Independent Members and Share of Women)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.637***	0.629***	0.587***	0.598***	0.701***	0.696***
	(0.0635)	(0.0909)	(0.0763)	(0.0672)	(0.0727)	(0.0872)
Profitability	-0.269***	-0.107	-0.385***	-0.350**	-0.0655	-0.496***
	(0.0930)	(0.111)	(0.131)	(0.138)	(0.171)	(0.171)
Tangibility	-0.0161	0.214	0.0519	-0.00252	0.213	0.142
	(0.107)	(0.156)	(0.131)	(0.165)	(0.183)	(0.225)
Firm Size	0.0194***	0.0183**	0.0430***	0.0247**	0.0226*	0.0522**
	(0.00746)	(0.00782)	(0.0132)	(0.0104)	(0.0130)	(0.0249)
Liquidity	-0.00885	-0.0103	-0.0219**	-0.0115	-0.0132	-0.0183
	(0.00627)	(0.00881)	(0.00925)	(0.00872)	(0.0116)	(0.0115)
Non-Debt	-0.115	-0.651	-0.659	-0.0628	-0.504	-0.518
	(0.216)	(0.943)	(0.810)	(0.253)	(0.822)	(0.711)
Growth Opp.	0.0140	0.00564	0.0186	0.00779	0.0149	0.0346
	(0.0136)	(0.0139)	(0.0147)	(0.0240)	(0.0153)	(0.0250)
Industry Median	0.159	0.0708	0.120	-0.000119	0.0435	0.0269
	(0.171)	(0.104)	(0.0962)	(0.223)	(0.107)	(0.109)
Share of Ind.	0.154	0.138	0.318**	0.225	0.313	0.680***
	(0.113)	(0.104)	(0.158)	(0.177)	(0.204)	(0.251)
Share of Wmn	-0.0674	-0.0846	-0.0254	-0.117	-0.0952	-0.127
	(0.0968)	(0.0997)	(0.123)	(0.123)	(0.151)	(0.168)
Constant	-0.353**	-0.408**	-0.798***	-0.430*	-0.536**	-1.094**
	(0.159)	(0.160)	(0.232)	(0.228)	(0.250)	(0.456)
Observations	2144	2144	2144	2144	2144	2144
Nr. of Instr.	36	36	36	36	36	36
Hansen J	0.974	0.359	0.798	0.886	0.452	0.579
AR (2)	0.917	0.355	0.303	0.790	0.172	0.225

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18: System GMM Results for Market Leverage (Extended with Share of Independent Members and Share of Women)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.530***	0.545***	0.527***	0.469***	0.570***	0.530***
	(0.0656)	(0.0720)	(0.0843)	(0.0707)	(0.0962)	(0.106)
Profitability	-0.294***	-0.167	-0.660**	-0.313**	-0.207	-1.132**
	(0.111)	(0.149)	(0.271)	(0.140)	(0.238)	(0.494)
Tangibility	-0.118	0.199	0.0502	-0.163	0.383	0.177
	(0.129)	(0.159)	(0.191)	(0.153)	(0.236)	(0.306)
Firm Size	0.0117*	0.0187*	0.0404*	0.00624	0.0246	0.0657*
	(0.00689)	(0.0109)	(0.0215)	(0.0111)	(0.0231)	(0.0375)
Liquidity	-0.00757	-0.0123	-0.0290**	-0.00700	-0.0111	-0.0410*
	(0.00505)	(0.00827)	(0.0135)	(0.00766)	(0.0157)	(0.0238)
Non-Debt	-1.097	-2.153*	-6.177**	-0.130	-3.740	-8.992*
	(1.068)	(1.209)	(2.734)	(1.266)	(2.305)	(5.383)
Growth Opp.	-0.00884	0.00265	-0.0100	-0.0197	0.00448	-0.0169
	(0.0106)	(0.0111)	(0.0130)	(0.0165)	(0.0189)	(0.0254)
Industry Median	0.332	0.194	0.199	0.312	0.128	0.0626
	(0.238)	(0.166)	(0.128)	(0.301)	(0.171)	(0.145)
Share of Ind.	-0.0285	0.0502	0.00880	-0.146	0.0349	0.0275
	(0.105)	(0.164)	(0.191)	(0.173)	(0.284)	(0.365)
Share of Wmn	-0.00925	-0.0200	-0.0120	-0.0660	-0.0459	0.0800
	(0.0774)	(0.0935)	(0.129)	(0.102)	(0.138)	(0.199)
Constant	-0.0567	-0.340**	-0.463*	0.113	-0.485	-0.796*
	(0.113)	(0.171)	(0.247)	(0.170)	(0.333)	(0.462)
Observations	2052	2052	2052	2052	2052	2052
Nr. of Instr.	36	36	36	36	36	36
Hansen J	0.394	0.123	0.696	0.184	0.0417	0.403
AR (2)	0.569	0.555	0.883	0.629	0.330	0.861

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: System GMM Results for Book Leverage (Extended with Share of Independent Members, Share of Women, and Board Size)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.630***	0.621***	0.535***	0.592***	0.684***	0.625***
	(0.0671)	(0.0977)	(0.0836)	(0.0719)	(0.0797)	(0.0940)
Profitability	-0.304***	-0.136	-0.442***	-0.369**	-0.108	-0.530***
	(0.0968)	(0.110)	(0.129)	(0.147)	(0.161)	(0.167)
Tangibility	-0.0399	0.171	-0.0392	-0.0335	0.176	0.0507
	(0.107)	(0.154)	(0.124)	(0.173)	(0.173)	(0.213)
Firm Size	0.0103	0.00837	0.0254*	0.0117	0.00554	0.0225
	(0.00728)	(0.00866)	(0.0131)	(0.0110)	(0.0136)	(0.0213)
Liquidity	-0.0107**	-0.0103	-0.0248***	-0.0126	-0.0134	-0.0248*
	(0.00523)	(0.00894)	(0.00907)	(0.00855)	(0.0127)	(0.0142)
Non-Debt	-0.126	-0.720	-0.836	-0.0880	-0.598	-0.697
	(0.167)	(1.007)	(0.910)	(0.223)	(0.920)	(0.879)
Growth Opp.	0.00931	-0.000170	0.00748	0.00387	0.00758	0.0187
	(0.0139)	(0.0138)	(0.0132)	(0.0246)	(0.0136)	(0.0212)
Industry Median	0.0996	0.120	0.185**	-0.0458	0.0844	0.0908
	(0.168)	(0.101)	(0.0940)	(0.242)	(0.0974)	(0.106)
Share of Ind.	0.134	0.134	0.326**	0.186	0.321	0.630***
	(0.120)	(0.102)	(0.164)	(0.181)	(0.199)	(0.217)
Share of Wmn	-0.0643	-0.0745	0.0346	-0.0985	-0.107	-0.0903
	(0.0934)	(0.0993)	(0.116)	(0.128)	(0.152)	(0.164)
Board Size	0.0110	0.0117	0.0243**	0.0190	0.0217*	0.0476***
	(0.00909)	(0.00833)	(0.0109)	(0.0128)	(0.0125)	(0.0145)
Constant	-0.234*	-0.280*	-0.594***	-0.291	-0.347	-0.792**
	(0.135)	(0.156)	(0.204)	(0.211)	(0.226)	(0.381)
Observations	2144	2144	2144	2144	2144	2144
Nr. of Instr.	37	37	37	37	37	37
Hansen J	0.951	0.366	0.719	0.949	0.453	0.889
AR (2)	0.855	0.417	0.539	0.747	0.198	0.364

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 20: System GMM Results for Market Leverage (Extended with Share of Independent Members, Share of Women, and Board Size)

	Debt-to-Assets			Debt-to-Capital		
	Short-term leverage	*Long-term leverage*	*Total leverage*	*Short-term leverage*	*Long-term leverage*	*Total leverage*
Leverage(t-1)	0.530***	0.534***	0.547***	0.467***	0.563***	0.546***
	(0.0669)	(0.0818)	(0.0834)	(0.0719)	(0.102)	(0.103)
Profitability	-0.271**	-0.214	-0.588**	-0.295**	-0.255	-1.070**
	(0.113)	(0.170)	(0.262)	(0.147)	(0.273)	(0.452)
Tangibility	-0.104	0.181	0.0533	-0.143	0.371*	0.103
	(0.123)	(0.152)	(0.172)	(0.160)	(0.222)	(0.294)
Firm Size	0.0151	0.0155	0.0459**	0.0102	0.0221	0.0731*
	(0.00972)	(0.00990)	(0.0226)	(0.0135)	(0.0208)	(0.0376)
Liquidity	-0.00766	-0.0135	-0.0277**	-0.00707	-0.0125	-0.0393*
	(0.00524)	(0.00851)	(0.0127)	(0.00769)	(0.0170)	(0.0214)
Non-Debt	-1.151	-2.453*	-5.578**	-0.172	-4.047	-8.449*
	(1.103)	(1.441)	(2.522)	(1.301)	(2.538)	(5.005)
Growth Opp.	-0.00699	0.000104	-0.00708	-0.0172	0.00238	-0.0193
	(0.0102)	(0.0108)	(0.0133)	(0.0168)	(0.0184)	(0.0241)
Industry Median	0.336	0.225	0.189	0.317	0.144	0.0885
	(0.241)	(0.160)	(0.116)	(0.302)	(0.163)	(0.134)
Share of Ind.	-0.0252	0.0317	0.0193	-0.138	0.0198	0.0768
	(0.107)	(0.174)	(0.184)	(0.177)	(0.292)	(0.346)
Share of Wmn	-0.0128	-0.0108	-0.0356	-0.0738	-0.0385	0.0699
	(0.0728)	(0.0877)	(0.119)	(0.100)	(0.128)	(0.184)
Board Size	-0.00547	0.00717	-0.0137	-0.00661	0.00700	-0.0228
	(0.00775)	(0.00958)	(0.00964)	(0.0116)	(0.0149)	(0.0161)
Constant	-0.0901	-0.306*	-0.495**	0.0721	-0.464	-0.778*
	(0.120)	(0.159)	(0.250)	(0.188)	(0.301)	(0.459)
Observations	2052	2052	2052	2052	2052	2052
Nr. of Instr.	37	37	37	37	37	37
Hansen J	0.433	0.152	0.790	0.198	0.0472	0.508
AR (2)	0.603	0.666	0.749	0.672	0.404	0.916

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4. PREDICTING CAPITAL STRUCTURE VIA MACHINE LEARNING

In this section, we implement some machine learning algorithms to predict leverage ratios.[5] Our baseline model is a naïve model (i.e., random-walk), where predicted leverage ratios depend only on their realizations in the previous year. We also make predictions with pooled OLS. Finally, we employ tree-based methods such as bagging, random forests, and boosting, which are known for their ability to capture nonlinear relationships between the predictors and the response variable. Our primary aim is to investigate whether using board characteristics as additional predictors improve predictive performance. We also want to understand which of the models mentioned above have the best predictive performance.

We drop observations where predictors have missing values. This means we automatically lose the year 2009 since we do not have lagged leverage ratios in 2009. We make leverage predictions for the period 2012 – 2019, hence we end up with eight folds. As we move one year ahead, we add the previous test set to the training data. Figure 6 below illustrates how we split the data into training and test sets using an expanding window. For each fold, data that was used as the test set becomes part of the training set as we move one year ahead.

Our motivations for predicting capital structure via machine learning are threefold:

- We want to understand whether board characteristics could help us predict leverage ratios with higher precision.
- If firms have target leverage ratios that depend on certain firm characteristics, then they should be predictable (Löffler, Mauer, 2011, 3351).
- Accurate predictions of leverage ratios may improve the research on the probability of default, à la Löffler & Maurer (2011).

[5] Machine learning procedures are carried out using R.

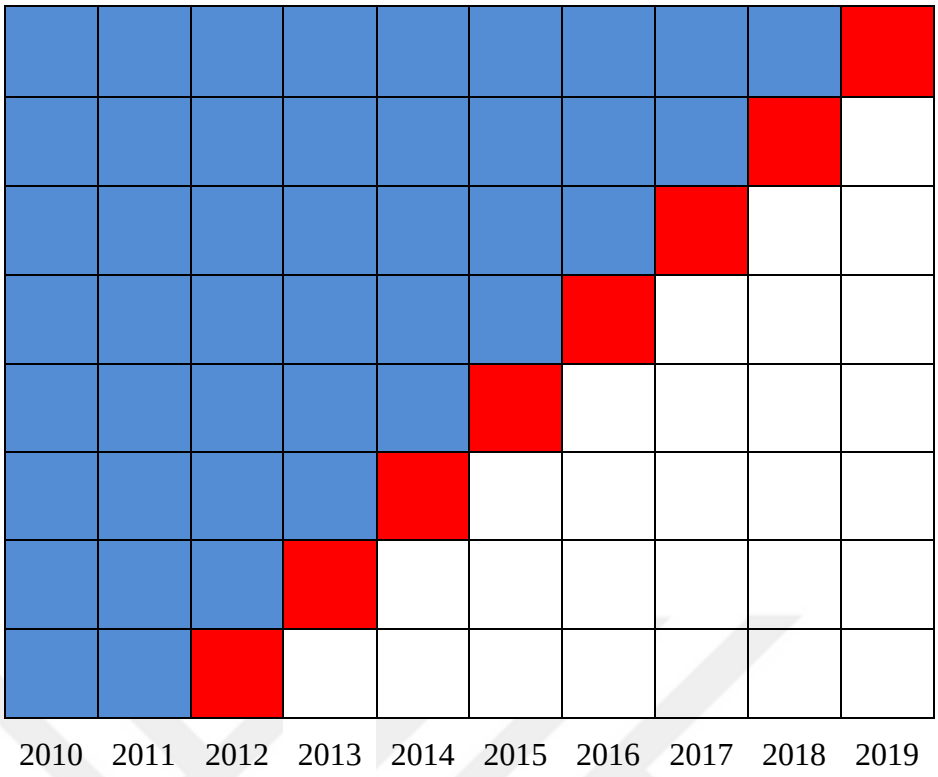


Figure 6: Train / Test Splits

Blue: training set. Red: test set.

4.1. Naïve Model

We start with a naïve model where leverage ratio depends only on its value in the previous year and an error term, which can be expressed as

$$y_{it} = y_{i,t-1} + \epsilon_{it} \tag{4.1}$$

where y_t represents the leverage ratio, y_{t-1} is the book value of leverage ratio in the previous year, and ϵ_t is the error term. Then, predicted leverage at time t ($\hat{y}_t$) would be y_{t-1}.

4.2. Pooled OLS

We also train the model below using pooled OLS

$$y_t = \rho y_{t-1} + x_t'\beta + \epsilon_t \tag{4.2}$$

where x_t' represents predictors (firm characteristics), β is the parameter vector, and ϵ_t is the error term. For each fold, we estimate Equation (4.2) using training data.

After obtaining the parameter estimates, we make predictions using the corresponding test set.

4.3. Tree-Based Methods

Before discussing the tree-based methods that we use, we first briefly explain how regression trees work. In James et al. (2021, 330), building a regression tree is described as a process with two steps:

1. Divide the predictor space (the set of possible values for the predictors) into J non-overlapping regions: $R_1, R_2, \dots R_j$.
2. For every observation that falls into the same region, make the same prediction, which is equal to the mean of the response variable for the training observations in that region.

The regions $R_1, R_2, \dots R_j$ are determined in a such a way that minimizes residual sum of squares. That is, the regions minimize

$$\sum_{j=1}^{J} \sum_{i \in R_j} \left(y_i - \hat{y}_{R_j}\right)^2$$

where $\hat{y}_{R_j}$is the mean value of the response variable in region J for the training observations. In the beginning, all observations belong to a single region, the whole predictor space. Then, among all possible predictors $X_1, X_2 \dots X_p$, one predictor is selected to split the region into two subregions such that the chosen predictor X_j and the cut-off value s leads to the greatest reduction in residual sum of squares (James et al., 2021, 331). To be more specific, for any j and s, the regions are defined as

$$R_1(j,s) = \{X | X_j < s\} \quad \text{and} \quad R_2(j,s) = \{X | X_j \geq s\}$$

where

$$\sum_{i:\, x_i \in R_1(j,s)} (y_i - \hat{y}_{R_1})^2 \; + \sum_{i:\, x_i \in R_2(j,s)} (y_i - \hat{y}_{R_2})^2$$

is minimized with the choices of j and s.

4.3.1. Bagging

Bagging (short for bootstrap aggregating) starts with creating bootstrapped data sets (sampling with replacement) from the training set and creates a regression tree with each bootstrapped data set. In the end, a wide variety of trees are created. After all of the trees are created, for each sample from the test set, predictions from each tree are obtained and averaged. (James et al., 341). This average is the final prediction for the respective sample from the test set. This is the main idea behind bagging. In bagging, the number of trees is a tuning parameter.

4.3.2. Random Forests

Random forest algorithm works in almost the same way as bagging. The only difference is that when building the trees, bagging uses all available predictors, say p, as candidates for splits, while random forest chooses a random sample of m out of p predictors at each split. This helps to "decorrelate" the trees built from each bootstrapped sample, which reduces variance (James et al., 2021, 344). This is important because in the presence of dominant predictors, the trees from each bootstrapped sample will be similar to each other if all predictors are considered for splits, so the variance will remain high even after aggregation. In the random forest algorithm, m and the number of trees are the tuning parameters.

4.3.3. Boosting

Boosted regression trees are also similar to bagging and random forests. However, boosting builds the trees in a sequential fashion, using information from previous trees (James et al., 2021, 345). It does not use bootstrapped samples, it builds each tree from a slightly different version of the original data set, where this different version puts more emphasis on observations that were less successfully predicted in previous trees. The boosting algorithm is as follows (James et al., 2021, 347):

1. Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.
2. For $b = 1, 2, \dots, B$, repeat:
   (a) Fit a tree $\hat{f}_b$ with d splits to the training data (X, r).
   (b) Update $\hat{f}$ by adding a shrunken version of the new tree:

$$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \hat{f}^b(x)$$

(c) Update the residuals,

$$r_i \leftarrow r_i - \lambda \hat{f}^b(x)$$

3. Output the boosted model,

$$\hat{f}(x) = \sum_{b=1}^{B} \lambda \hat{f}^b(x).$$

In words, boosting algorithm first builds a tree with d splits, (in practice, this number can be 1, resulting in stumps) to predict the residuals, which are set equal to the observed value of the outcome variable y_i in the first step. The trees built with boosting algorithm learn slowly, and the rate of learning is determined by λ (a.k.a. the learning rate, or the shrinkage parameter). Each subsequent tree takes into account the errors made by existing trees. This way, the new trees are built in such a way that they make up for the errors made by previous trees. In boosting, d, λ, and the number of trees are the tuning parameters.

4.4. Performance Metrics

We compute the square root of the mean squared errors from the test set (test RMSE) and the out-of-sample R-squared (R^2_{os}) which are defined as follows

$$\text{Test RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_{it} - \hat{y}_{it})^2}$$

$$R^2_{os} = 1 - \frac{\sum_{i=1}^{N}(y_{it} - \hat{y}_{it})^2}{\sum_{i=1}^{N}(y_{it} - \bar{y}_{it})^2}$$

where y_{it} is the leverage ratio in the test set, $\hat{y}_{it}$ is the predicted leverage ratio, and $\bar{y}_{it}$ is the mean leverage ratio in the test set. Since our test set covers eight years, we end up with eight different test RMSE and R^2_{os} obtained from predictions using each fold. We simply take the average of them as the final performance metric.

4.5. Hyperparameter Tuning

We select the tuning parameters via grid search. We follow a forward-chaining cross-validation procedure, which is illustrated in Figure 7. We first construct a grid which consists of all possible combinations of a predefined set of tuning parameters. Then, for each fold, we try out all of these combinations on validation sets (yellow boxes), and choose the combination that yields the lowest RMSE for that fold. For instance, before predicting leverage ratios in 2015, we train the model several times (with all the hyperparameter combinations) using data up to 2013. Then, we predict leverage ratios in 2014 using all of the hyperparameter combinations, and choose the combination that yields the lowest RMSE. Finally, we predict leverage ratios in 2015 using that particular hyperparameter combination. We tune the number of trees, m, d, and λ by this procedure. Chosen hyperparameter combinations are provided in the appendix.

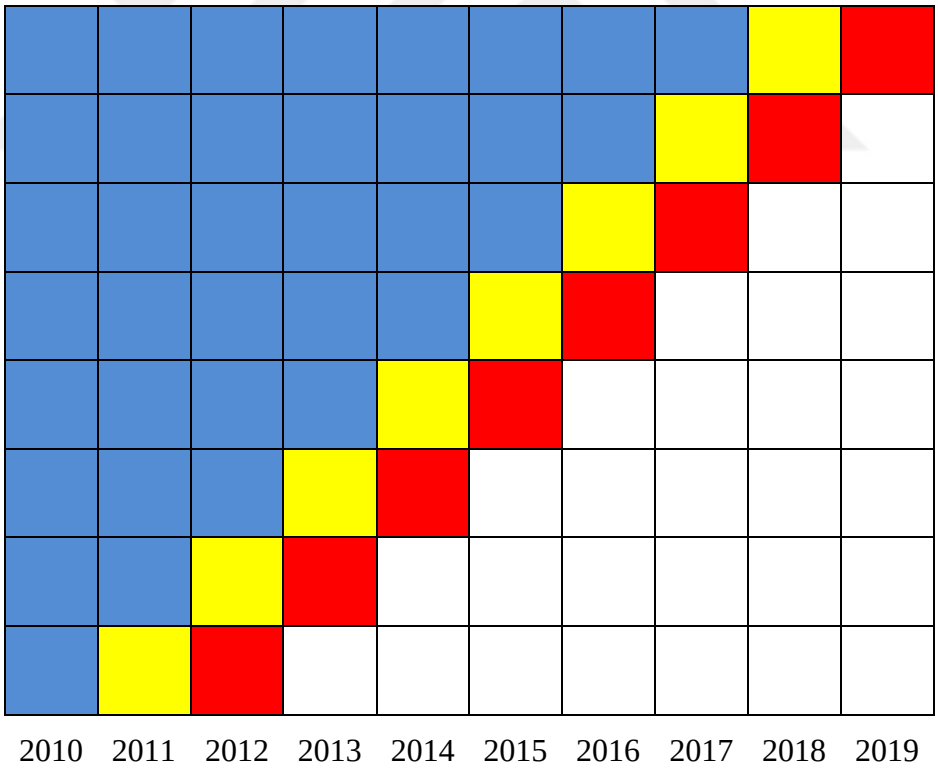


Figure 7: Forward-Chaining Cross Validation

Blue: training set. Yellow: validation set. Red: test set.

4.6. Predictive Performances

We only predict total leverage ratios, using both leverage definitions (debt-to-assets and debt-to-capital ratios) as well as their book and market values.[6] We divide the predictors into two groups: financial variables and board variables. Financial variables include profitability, tangibility, firm size, liquidity, non-debt tax shields, and growth opportunities; board variables include board size, share of independent members, and share of women. We first train the models using financial ratios. Then, we use financial ratios and board variables together. This way, we can assess how the inclusion of board variables contribute to the predictive performance of each model.

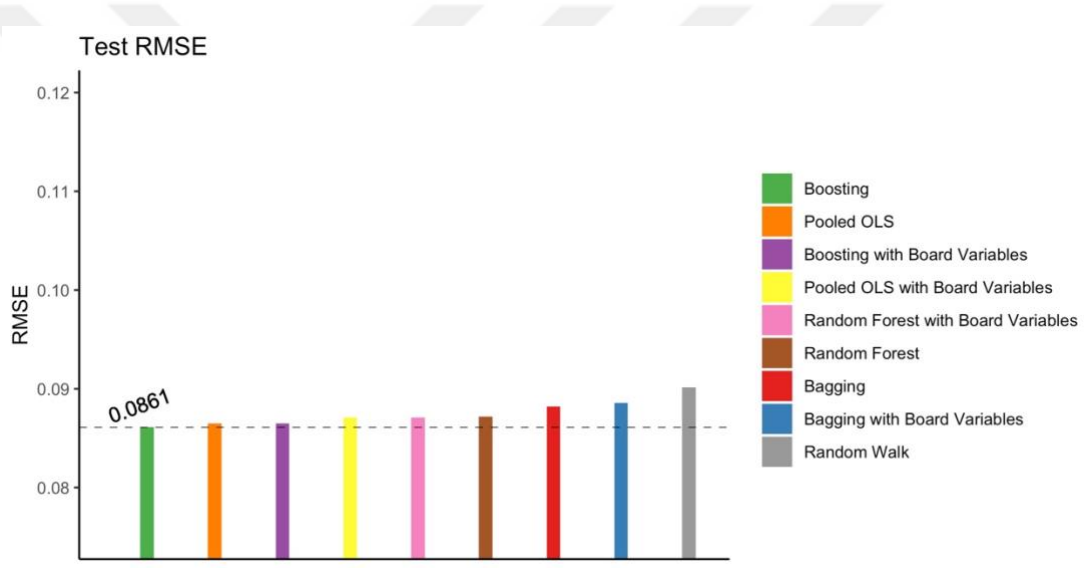


Figure 8: Test RMSE (Book Value of Debt-to-Assets)

We first predict the book value of debt-to-assets ratios. Figures 8 and 9 present the test RMSE (in ascending order) and R^2_{os} (in descending order) associated with each model. Except for random forests, each model yields higher test RMSE when we use board variables along with financial variables. What is striking is that random forests and bagging perform worse than OLS, which is rarely the case in practice. For some reason still unkown to us, OLS outperforms random forests and bagging. The

[6] Debt-to-assets = Debt / Assets
Debt-to-capital = Debt / Debt + Book Equity
Market value of debt-to-assets = Debt / Assets – Book Equity + Market Equity
Market value of debt-to-capital = Debt / Debt + Market Equity

predictive performance of each model is reflected in their R^2_{os}s as well. Boosting has the highest R^2_{os}. Models extended with board variables generally have lower R^2_{os}. Table 21 presents each performance metric numerically (sorted from lowest to highest test RMSE).

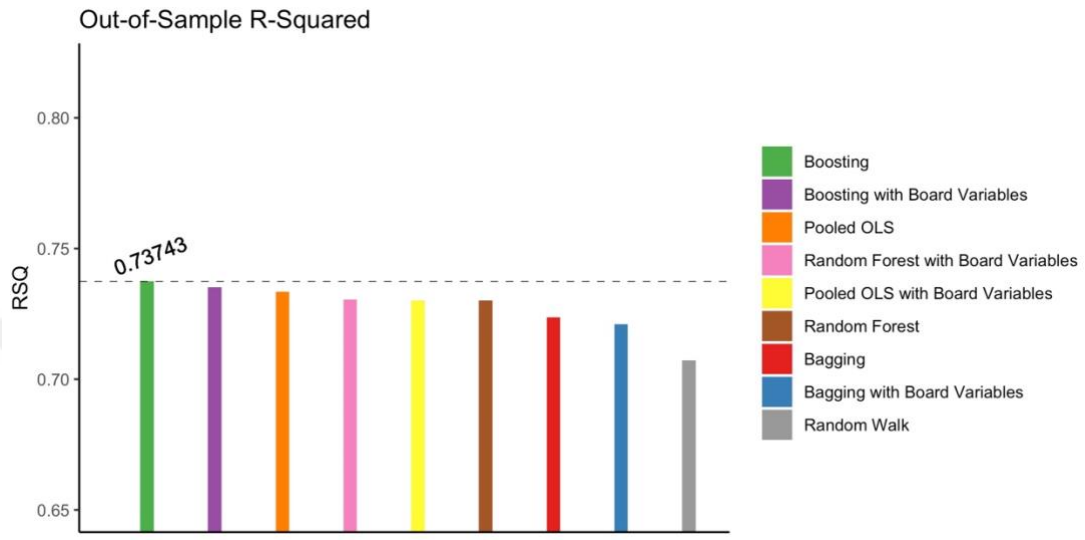


Figure 9: Out-of-Sample R-Squared (Book Value of Debt-to-Assets)

Table 21: Test RMSE and Out-of-Sample R-Squared (Book Value of Debt-to-Assets)

Model	Test RMSE	Out-of-Sample R-Squared
Boosting	0.08609	0.737428
Pooled OLS	0.08647	0.733434
Boosting with Board Variables	0.08648	0.735257
Pooled OLS with Board Variables	0.08707	0.730207
Random Forest with Board Variables	0.08708	0.730449
Random Forest	0.08717	0.730201
Bagging	0.08821	0.723729
Bagging with Board Variables	0.08855	0.721005
Random Walk	0.09013	0.707306

When we instead predict the book value of debt-to-capital ratios, we are confronted with slightly different results. Figures 10 and 11 present test RMSE (in ascending

order) and R^2_{os} (in descending order), respectively. This time, random forests outperform pooled OLS in terms of both metrics, as expected. But pooled OLS still performs better than bagging. Overall, the differences in performance metrics remain small between each model.

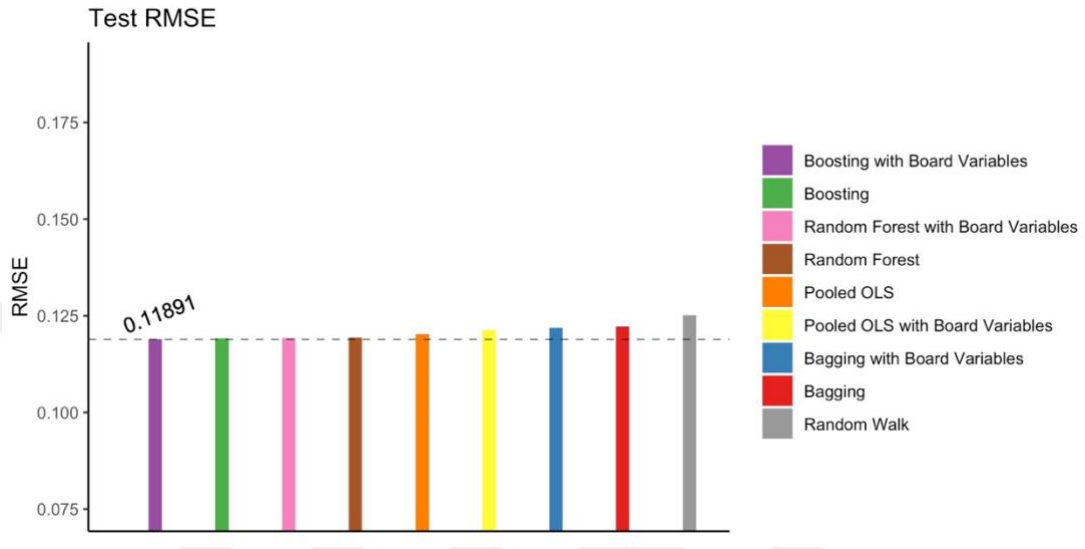


Figure 10: Test RMSE (Book Value of Debt-to-Capital)

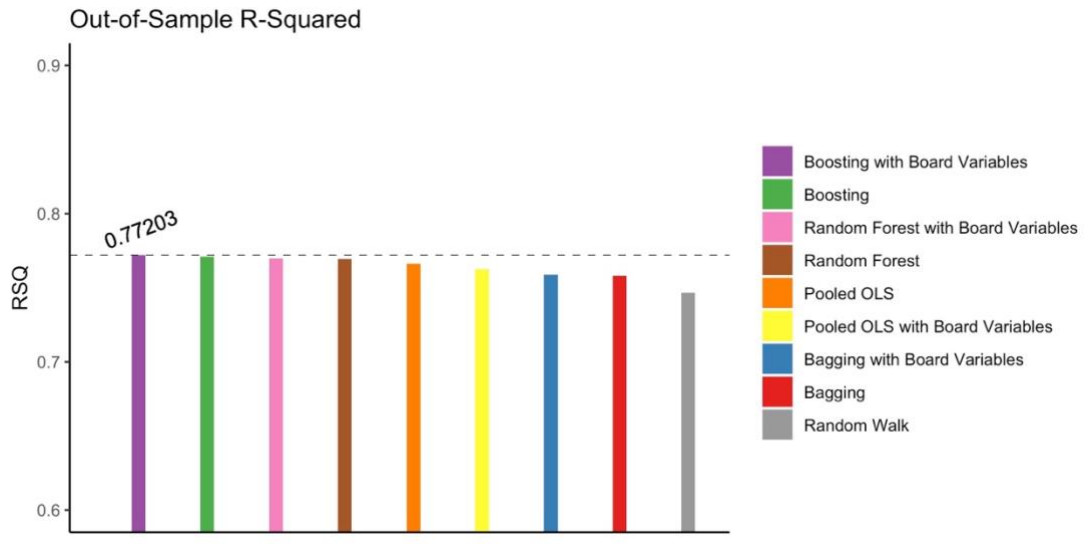


Figure 11: Out-of-Sample R-Squared (Book Value of Debt-to-Capital)

Once again, the best performing model in terms of test RMSE and R^2_{os} is boosting. Including board variables improves the predictive performance of each regression

tree, as opposed to the case for debt-to-assets ratios. However, notice that the differences in both performance metrics are miniscule. Finally, despite the fact that test RMSEs are higher for the book value of debt-to-capital, R^2_{os}s are also higher. Table 22 presents each performance metric numerically.

Table 22: Test RMSE and Out-of-Sample R-Squared (Book Value of Debt-to-Capital)

Model	Test RMSE	Out-of-Sample R-Squared
Boosting with Board Variables	0.118909	0.772031
Boosting	0.119148	0.771084
Random Forest with Board Variables	0.119206	0.769727
Random Forest	0.119309	0.769395
Pooled OLS	0.120316	0.766361
Pooled OLS with Board Variables	0.121325	0.762540
Bagging with Board Variables	0.121923	0.758951
Bagging	0.122150	0.758107
Random Walk	0.125105	0.746605

We now continue with market leverage ratios. Figures 12 and 13 show the test RMSE and R^2_{os}, respectively, when we predict the market value of debt-to-assets ratios. The best performing model in terms of both metrics is random forests. This time, each regression tree outperforms pooled OLS, which is in line with our expectations. Bagging performs substantially better than it did for book leverage, and unlike the case for book leverage ratios, it yields lower (higher) test RMSE (R^2_{os}) than boosting, although the differences are quite small. Regression trees have better predictive performances relative to pooled OLS and the naïve model. Finally, each model returns a higher test RMSE when board variables are included in the predictors. Table 23 presents numerically the test RMSE and R^2_{os} for the market value of debt-to-assets ratios.

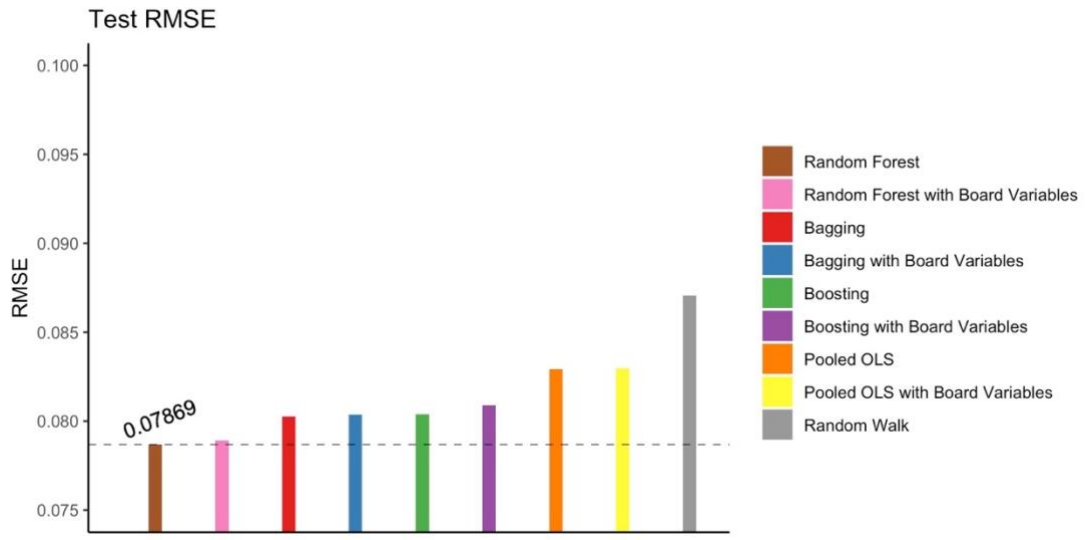


Figure 12: Test RMSE (Market Value of Debt-to-Assets)

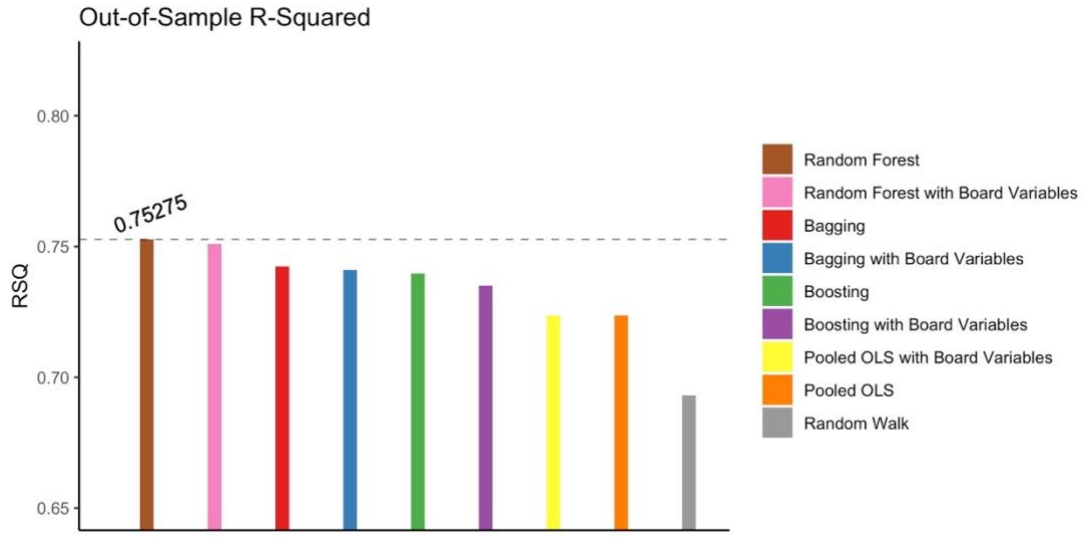


Figure 13: Out-of-Sample R-Squared (Market Value of Debt-to-Assets)

Finally, we predict the market value of debt-to-capital ratios and the associated performance metrics are presented in Figure 14 (test RMSE) and Figure 15 (R^2_{os}). The best performing model in terms of both metrics is again random forests, and including board variables in random forests results in slightly higher test RMSE and lower R^2_{os}. Bagging is the second most successful model, but it performs slightly better when board variables are also included. Again, tree-based methods outperform pooled OLS and the naïve model. Table 24 presents the performance metrics numerically.

Table 23: Test RMSE and Out-of-Sample R-Squared (Market Value of Debt-to-Assets)

Model	Test RMSE	Out-of-Sample R-Squared
Random Forest	0.078685	0.752754
Random Forest with Board Variables	0.078909	0.750944
Bagging	0.080252	0.742358
Bagging with Board Variables	0.080357	0.741013
Boosting	0.080394	0.739677
Boosting with Board Variables	0.080902	0.734993
Pooled OLS	0.082969	0.723693
Pooled OLS with Board Variables	0.082913	0.723664
Random Walk	0.087062	0.693145

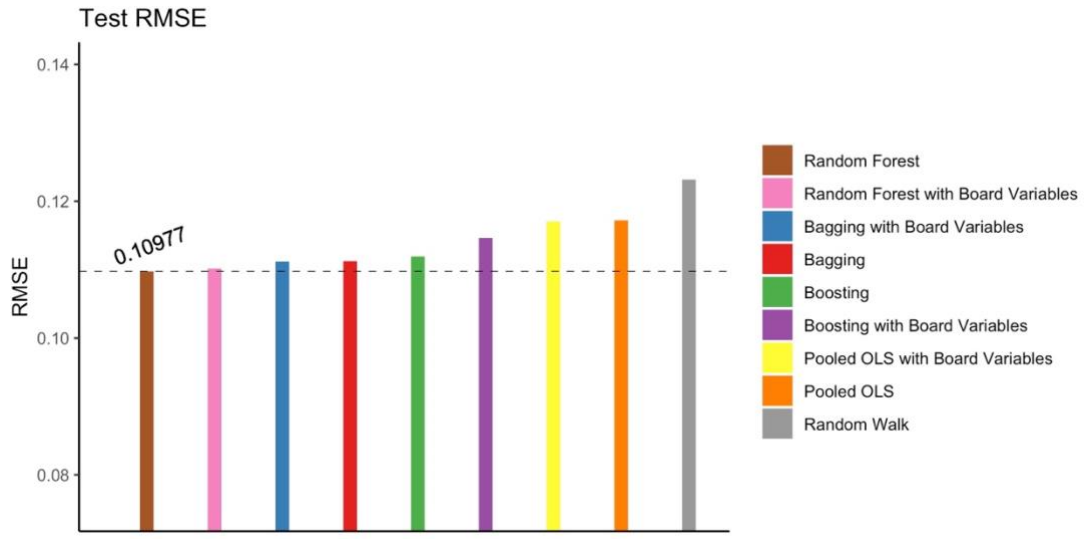


Figure 14: Test RMSE (Market Value of Debt-to-Capital)

Overall, test RMSEs and R^2_{os}s obtained using each leverage measure suggest that the models predict market leverage ratios slightly more accurately. Including board variables among the predictors generally worsens predictive performance, despite improving it in some cases.

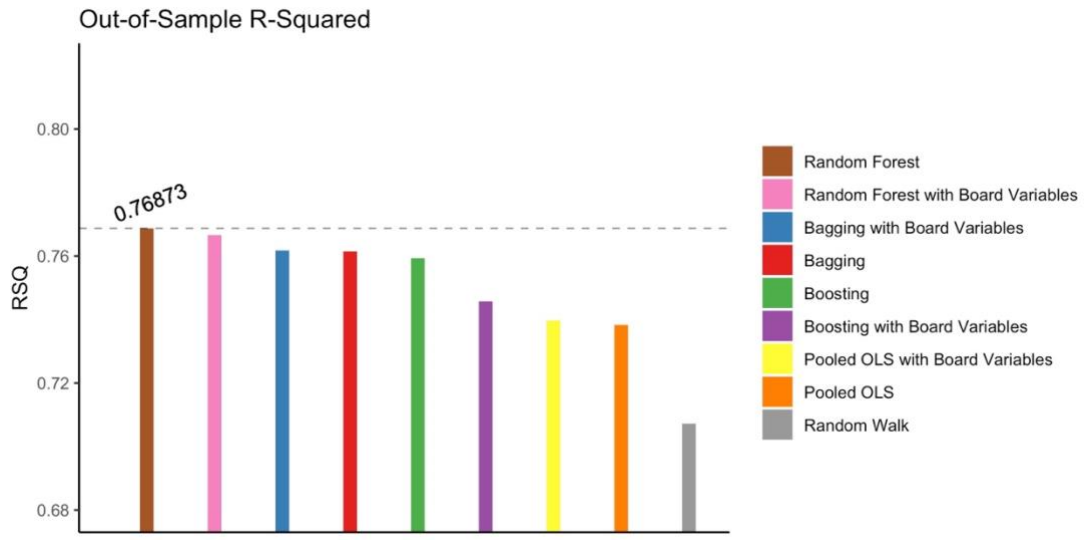


Figure 15: Out-of-Sample R-Squared (Market Value of Debt-to-Capital)

Table 24: Test RMSE and Out-of-Sample R-Squared (Market Value of Debt-to-Capital)

Model	Test RMSE	Out-of-Sample R-Squared
Random Forest	0.109765	0.768729
Random Forest with Board Variables	0.110171	0.766547
Bagging with Board Variables	0.111175	0.761724
Bagging	0.111254	0.761456
Boosting	0.111915	0.759331
Boosting with Board Variables	0.114650	0.745677
Pooled OLS with Board Variables	0.117024	0.739727
Pooled OLS	0.117220	0.738310
Random Walk	0.123155	0.707166

4.7. Variable Importance Measures

We now present the variable importance plots from random forests and the relative influence plots from boosting. The horizontal axis on the variable importance plots shows the increase in the prediction error if the corresponding variable on the vertical axis is randomly shuffled, that is, if it does not follow the order in the original data

set. On the other hand, the horizontal axis on the relative influence plots shows how much the prediction error changes when the corresponding variable on the vertical axis is used for splitting the trees. Each plot shows the seven most important variables chosen by the respective model for a given prediction year. To save space, we only report the plots obtained from models extended with board variables. They are what we are interested in after all. Figures 16 and 17 show the variable importance plots obtained from random forests, while figures 18 and 19 show the relative influence plots obtained from boosted regression trees. Each plot is obtained from the associated model where the book value of debt-to-assets ratio is the response variable.

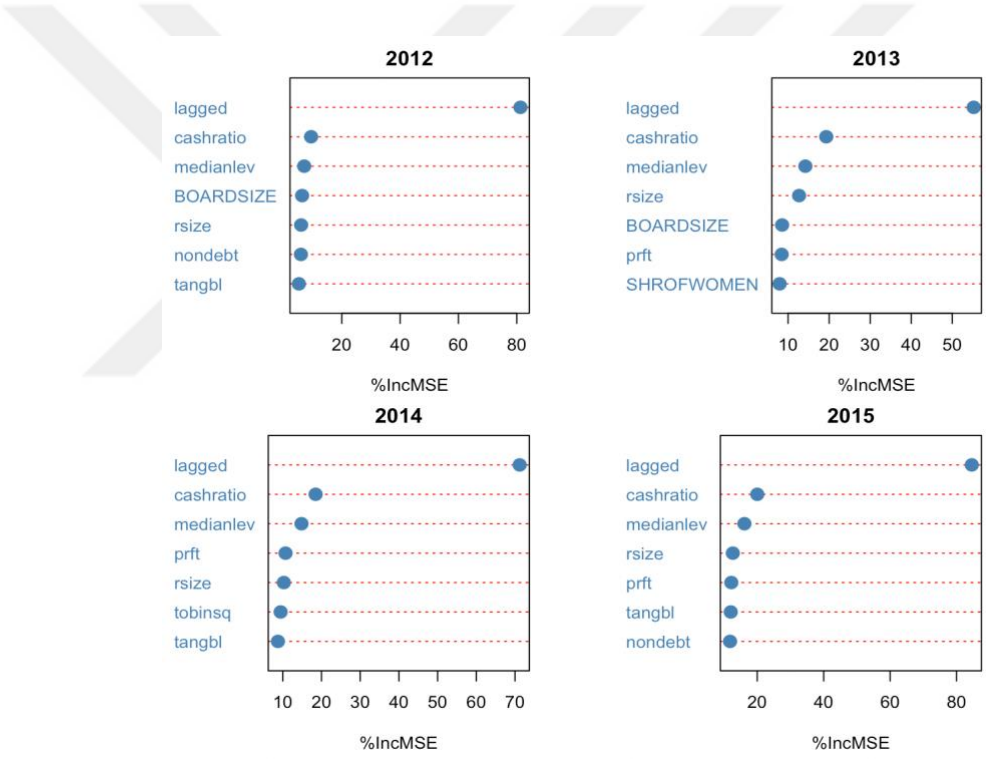


Figure 16: Variable Importance Plots (2012-2015, Book Value of Debt-to-Assets)

Not surprisingly, lagged leverage ratio (lagged) is the most important predictor and is chosen by both random forests and boosting. Following lagged leverage, random forests choose liquidity (cashratio) and industry median leverage (medianlev) as the second and third most important predictors for all prediction years. Board size (BOARDSIZE) appears to be the fourth (fifth) most important predictor in 2012

(2013). Share of women also appears to be the seventh in 2013, but neither board size nor the share of women is chosen after 2013. Overall, board variables are not chosen as the most important predictors, following 2013. Profitability (prft), tangibility (tangbl), and firm size (rsize) are chosen as the fourth most important variable in some years, although profitability consistently appears to be more important in the majority of the prediction years.

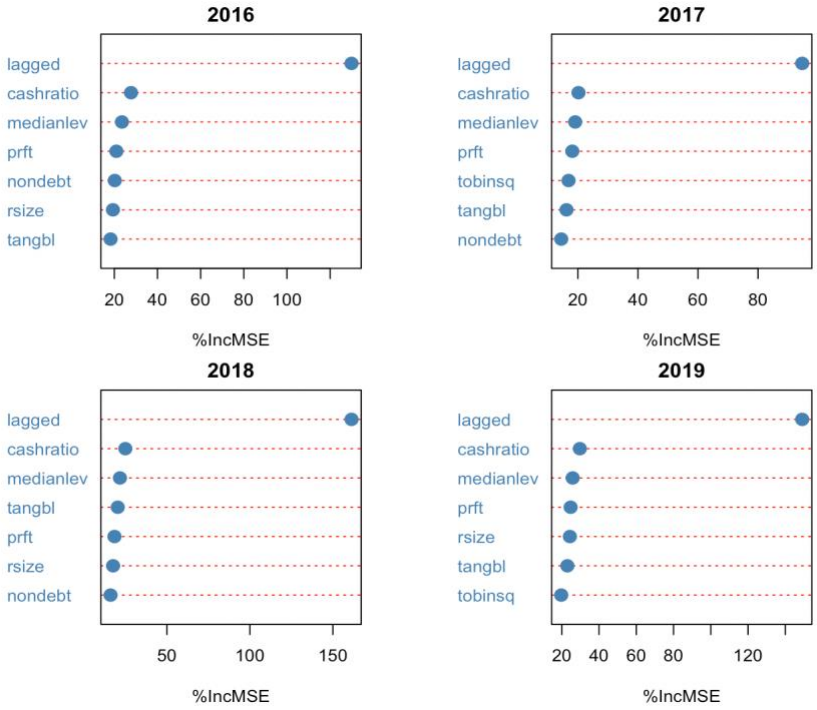


Figure 17: Variable Importance Plots (2016-2019, Book Value of Debt-to-Assets)

Relative influence plots from boosted regression trees present a similar outlook. Again, in most prediction years, liquidity and industry median leverage are the most important predictors following lagged leverage ratio. However, unlike the case for random forests, industry median leverage is more important than liquidity. Although its influence seems to be quite small, board size again appears to be an important predictor for the year 2012, but it is not among the top seven for the following prediction years. Starting from 2015, non-debt tax shields (nondebt) infrequently takes its place among the top three most important variables. Except for 2012, where board size was chosen as the fifth most important predictor, none of the board variables are chosen in the following prediction years. Growth opportunities (tobinsq) is chosen in all of the prediction years. Finally, the influence of industry

median leverage on error reduction seems to be relatively weak after 2015. For the year 2016, it is not even in the top seven most important predictors.

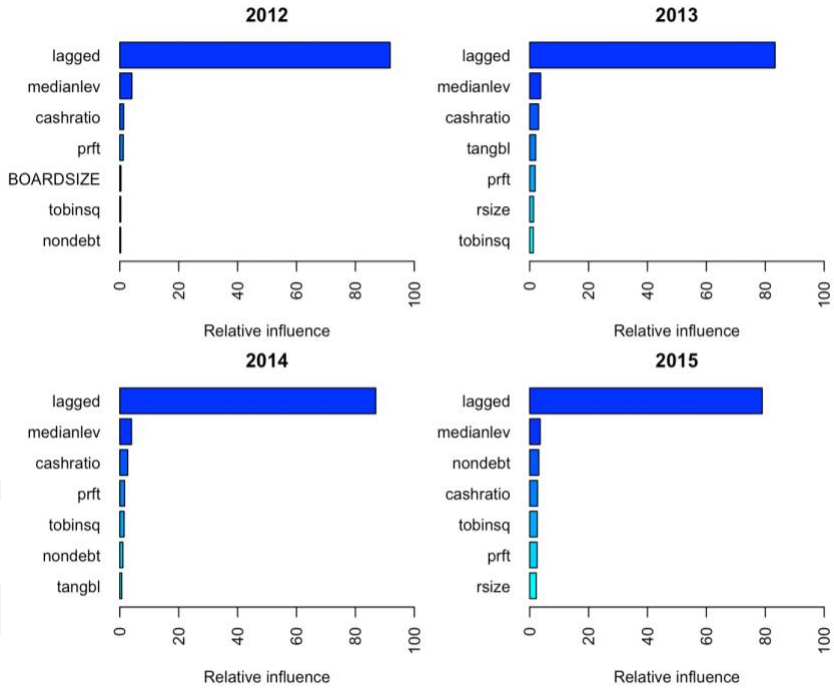


Figure 18: Relative Influence Plots (2012-2015, Book Value of Debt-to-Assets)

For the market value of debt-to-assets, the variable importance measures are not substantially different. Figures 20 and 21 show the associated variable importance plots, and figures 22 and 23 show the relative influence plots. Once again, random forests and boosting choose lagged leverage ratios (laggedmarket) as the most important predictor. Except for the year 2012 where it is the third, random forests choose growth opportunities as the second most important predictor. In almost all of the prediction years, industry median leverage (medianmarketlev) is the third most important predictor. Moreover, random forests choose profitability and liquidity in all of the prediction years, but choose none of the board variables (except for the year 2016, where board size is the fifth most important predictor).

In all of the prediction years, boosting chooses lagged market leverage ratios, growth opportunities, and industry median market leverage ratios as the most important predictors, in that order. None of the board variables are among the top seven most important variables in any prediction year. Boosting chooses profitability, tangibility and liquidity in all prediction years, although their rank varies across years.

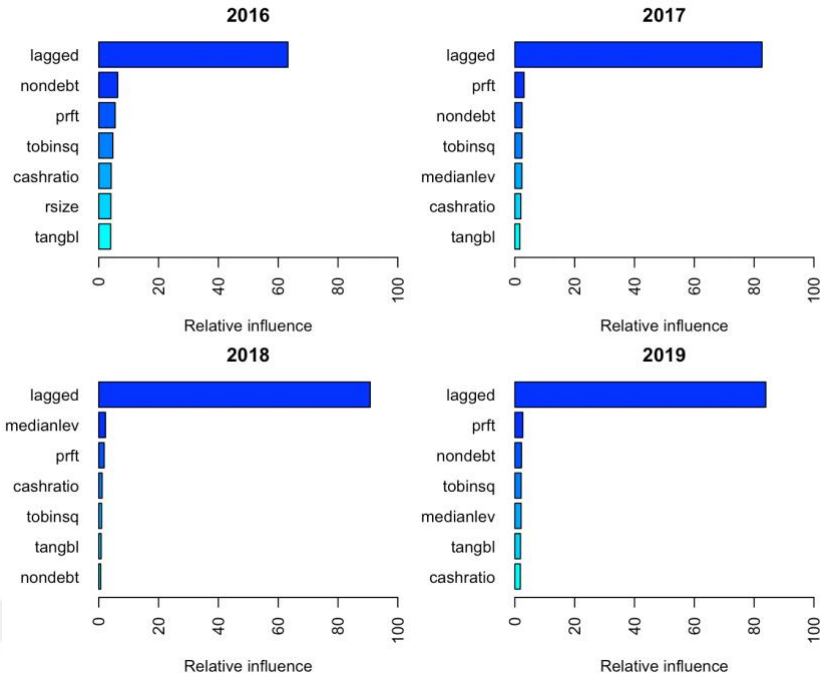


Figure 19: Relative Influence Plots (2016-2019, Book Value of Debt-to-Assets)

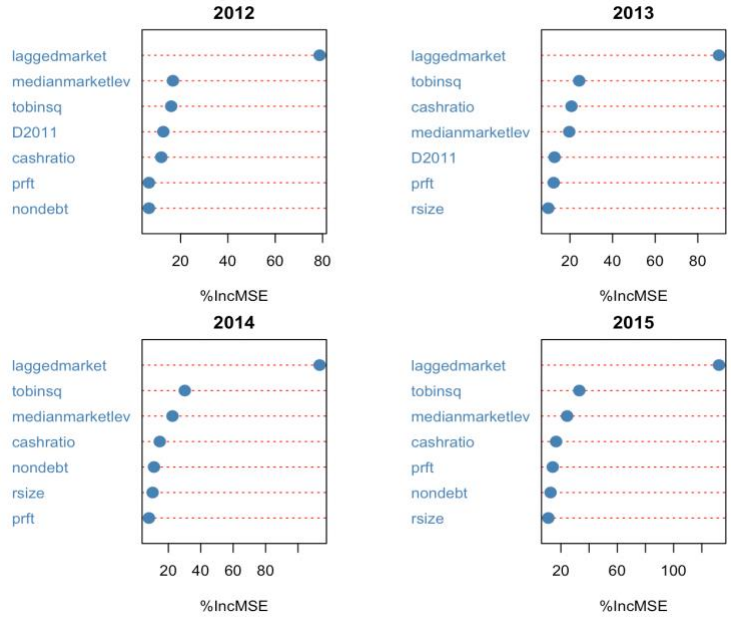


Figure 20: Variable Importance Plots (2012-2015, Market Value of Debt-to-Assets)

Variable importance plots and relative influence plots more or less tell the same story for debt-to-capital ratios, hence we do not explicitly discuss them. They are provided in the appendix.

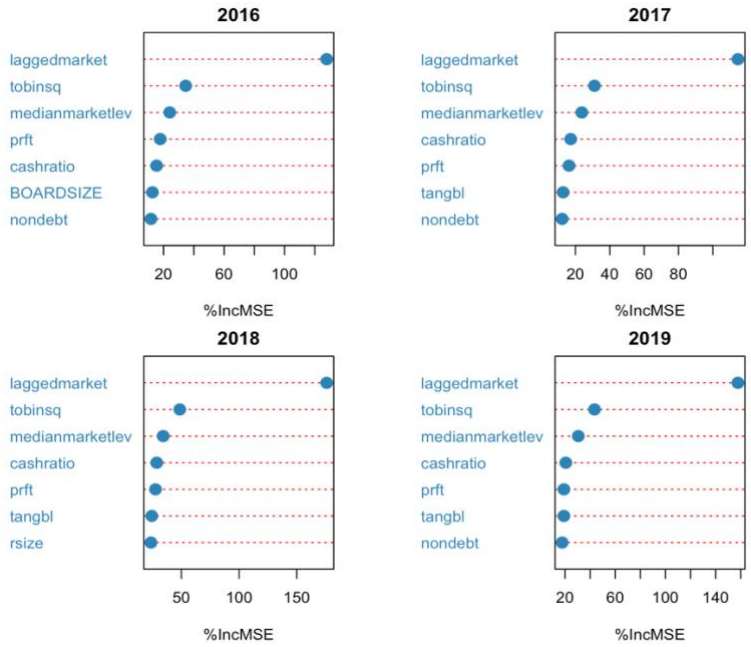


Figure 21: Variable Importance Plots (2016-2019, Market Value of Debt-to-Assets)

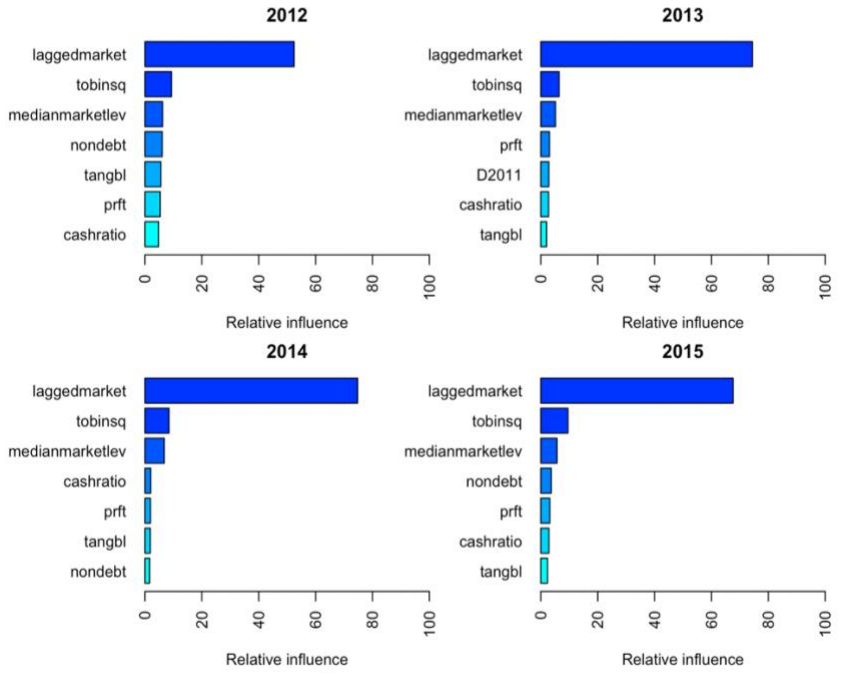


Figure 22: Relative Influence Plots (2012-2015, Market Value of Debt-to-Assets)

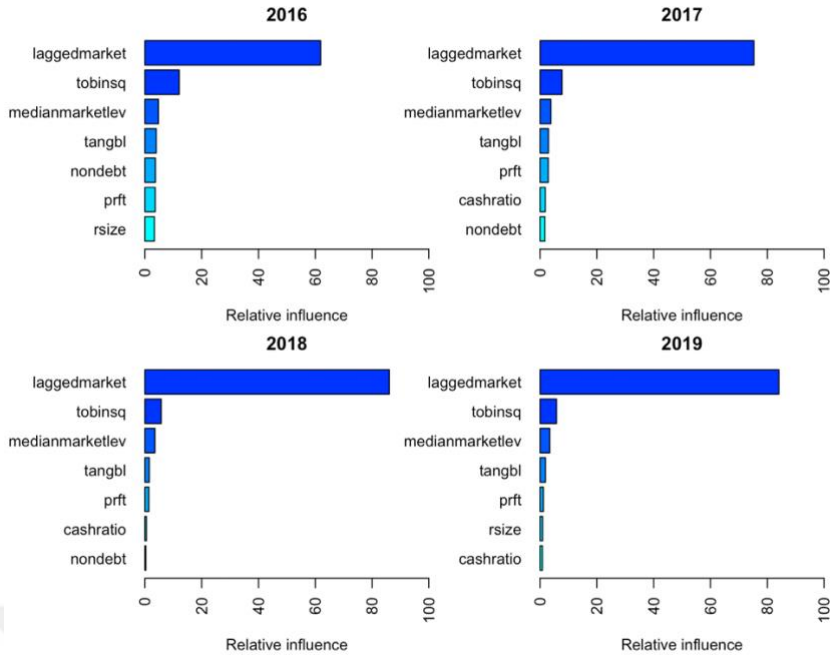


Figure 23: Relative Influence Plots (2016-2019, Market Value of Debt-to-Assets)

5. CONCLUSION

In this thesis, we first tested the two most prominent capital structure theories, trade-off and pecking order theories, and examined which one is successful in explaining the capital structure decisions of Turkish non-financial firms. We used year-end balance sheets, financial statements and market values of these firms over the period 2009-2019. Second, and more importantly, by combining the aforementioned data with a hand-collected data set on board characteristics, we tried to answer the question of whether board size, the proportion of independent members and the proportion of women on the board of directors have any impact on these firms' debt policies.

We modeled capital structure decisions as a function of some firm characteristics such as profitability, tangibility, firm size, liquidity, non-debt tax shields, growth opportunities, share of independent members in the board of directors, share of women on the board of directors, and board size. With the plausible assumption that the firms in our sample are heterogeneous, we estimated the model with the fixed effects estimator, and we ran separate regressions on short-term, long-term and total leverage ratios to identify whether the impacts of these firm characteristics depend on the maturity structure of debt. Our main findings are as follows. We find that profitability has a negative impact for short-term, long-term and total leverage ratios, a finding that is consistent with the literature on Turkish firms. This finding holds for both book and market leverage ratios, and can be considered as evidence supporting the pecking order hypothesis. However, as mentioned in Section 2, although the cross-section relationship between profitability and leverage is usually found negative, there are several explanations as to why this might be the case. Leverage adjustments do no not happen instantly due to the existence of adjustment costs. This means that leverage adjustments (or refinancing) do not occur frequently. Strebulaev (2007) shows that for a firm that does not adjust its leverage ratio, an increase in profitability leads to an increase in the expected profitability, that is future profitability. This results in higher market value, and thus, lower market leverage.

His findings suggest that despite being negatively related to leverage when there is no leverage adjustment, expected profitability is positively related to leverage at refinancing points. Perhaps, this infrequent adjustment behavior should be considered when modelling capital structure decisions, which we could not do due to data limitations.

Results from fixed effects estimations suggest that tangibility is negatively related to short-term leverage, and positively related to long-term leverage. The positive relationship with long-term leverage is in line with the trade-off prediction that firms can use their tangible assets as collateral to issue more debt. The negative relationship with short-term debt can be explained by the tendency of firms to match the maturity of their debt to the tangibility of their assets (Booth et al., 2001). We also find that liquidity has a negative impact on short-term leverage, which partly confirms the pecking order hypothesis. Higher liquidity decreases the need for short-term funds, while there is no evidence that higher liquidity decreases the need for long-term funds as well. When we use total leverage as the dependent variable, we fail to identify any significant relationship between liquidity and leverage.

Fixed-effects estimation results also suggest that firm size has a statistically significant positive impact on short-term, long-term, and total leverage. For market leverage ratios, the impact is again positive and significant. This finding is in line with the trade-off theory: bigger firms incur lower agency costs of debt, and thus are able to borrow more. Fixed-effects estimation results also suggest that Tobin's Q (growth opportunities) is negatively associated with market leverage ratios, although this relationship is not present for book leverage ratios. The negative relationship between growth opportunities and market leverage is in line with the trade-off prediction that firms with more growth opportunities refrain from issuing debt in order to decrease their expected financial distress costs. This negative relationship is especially more pronounced for short-term market leverage.

Furthermore, we failed to find evidence supporting DeAngelo & Masulis' (1980) argument that depreciation expenses can be used in place of debt issues as tax shields. We also fail to identify any notable impact of board independence and share of women in the board on leverage ratios, although they apper to be statistically significant in a few models. Admittedly, the fact that some variables are significant for book leverage but not market leverage (and vice versa), or that they depend on

the definition of leverage ratio, leads us to take such results with a grain of salt: these findings are not robust.

As we noted before, the persistence in leverage ratios is a well-known empirical phenomenon, and we wanted to capture that in our econometric model by controlling for the lagged values of leverage ratios. However, such a model should not be estimated with the within estimator due to the endogeneity problem which the lagged dependent variable engenders. We were also concerned with simultaneity bias since most of our explanatory variables are determined simultaneously with leverage ratios. The reasons outlined above motivated us to estimate the model with lagged leverage ratios using system GMM.

When we estimated the model with system GMM, we found that lagged leverage ratios are statistically significant in all models, implying that leverage ratios are persistent; that is, they depend highly on their values in the previous period. Our findings also suggest that book leverage ratios are more persistent than market leverage ratios, which does not come as a surprise, given the higher volatility in market values relative to book values. However, tangibility, growth opportunities, and in some cases liquidity and firm size, became statistically insignificant. We found that profitability has a statistically significant negative impact on short-term and total leverage ratios, but its impact is insignificant for long-term leverage ratios. As for firm size, we found that it was significant only when we use the book values of leverage ratios as the dependent variable. We suspect that the chosen instruments, (lagged values of the explanatory variables), might be weak instruments.

Overall, we identified four firm characteristics that are statistically significant according to both fixed-effects results and system GMM results: profitability, firm size, liquidity, and board size. The impact of profitability and liquidity on leverage ratios is negative, while leverage ratios increase with firm size and board size. The impact of profitability and liquidity is consistent with the pecking order theory, while the impact of firm size is consistent with the trade-off theory. As emphasized before, neither the trade-off theory nor the pecking order theory is completely successful.

Third, we predicted leverage ratios using machine learning techniques. Particularly, we employed tree-based methods such as bagging, random forests, and boosting, to understand if they yield better results than linear models in terms of predictive

performance. We were particularly interested in the question of whether taking board characteristics into account would improve prediction accuracy. The results we found can be summarized as follows. We found that the machine learning methods we use predict market leverage ratios more successfully than they do book leverage ratios. We also found that, with some exceptions, tree-based methods generally outperform linear models. Furthermore, we found that extending the models with board characteristics generally leads to slightly higher prediction error. Finally, we found that random forests and boosting algorithms are the most successful models in terms of predictive performance.

Variable importance measures from random forests and boosted regression trees suggest that lagged leverage ratios, industry median leverage ratios, growth opportunities, liquidity, and firm size are the most important predictors (not necessarily in that order). On the other hand, despite the fact that board size ranked among the top seven in some prediction years, board variables generally do not appear to be among the most important predictors, as measured by their contribution to the reduction in the prediction error.

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APPENDIX

Appendix 1.

Variable Importance Plots for the Book Value of Debt-to-Capital (2012-2015).

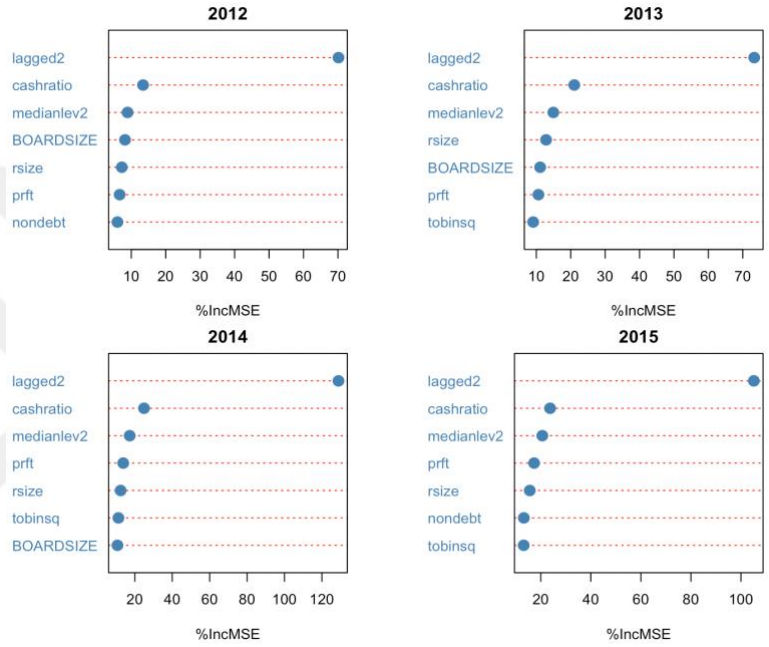


Figure 24: Variable Importance Plots (2012-2015, Book Value of Debt-to-Capital)

Appendix 2.

Variable Importance Plots for the Book Value of Debt-to-Capital (2016-2019).

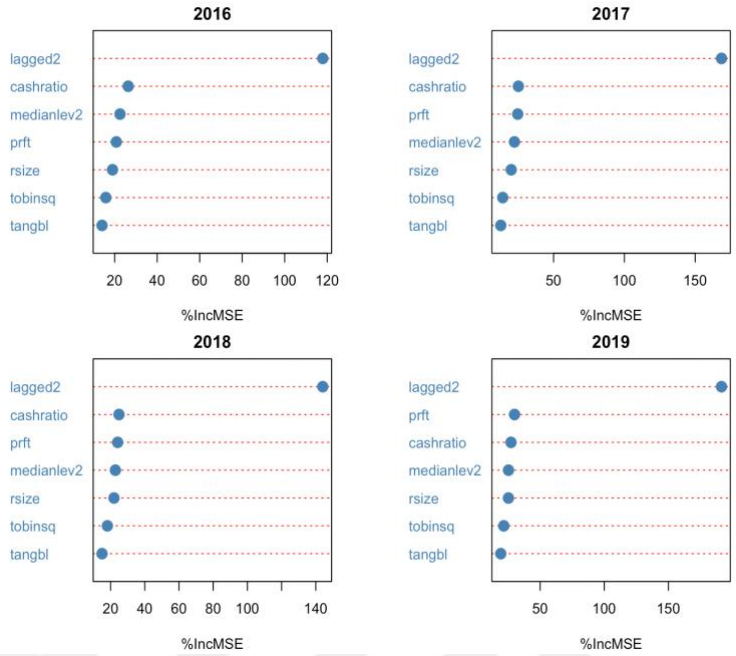


Figure 25: Variable Importance Plots (2016-2019, Book Value of Debt-to-Capital)

Appendix 3.

Relative Influence Plots for the Book Value of Debt-to-Capital (2012-2015).

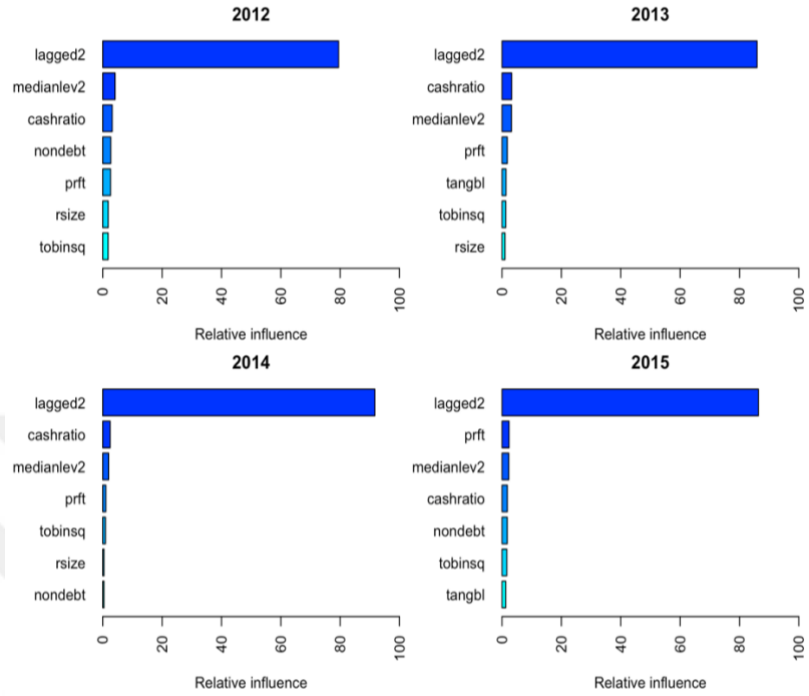


Figure 26: Relative Influence Plots (2012-2015, Book Value of Debt-to-Capital)

Appendix 4.

Relative Influence Plots for the Book Value of Debt-to-Capital (2016-2019).

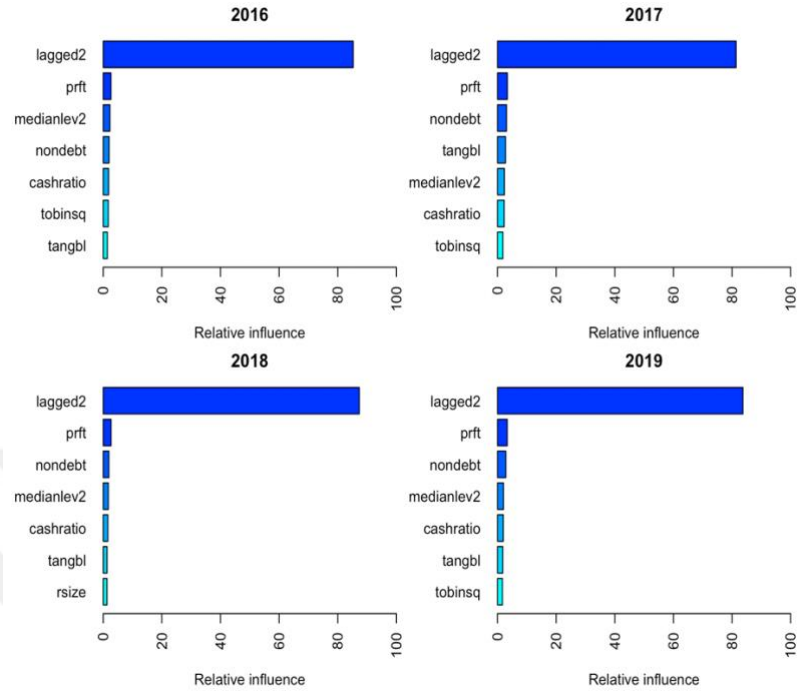


Figure 27: Relative Influence Plots (2016-2019, Book Value of Debt-to-Capital)

Appendix 5.

Variable Importance Plots for the Market Value of Debt-to-Capital (2012-2015).

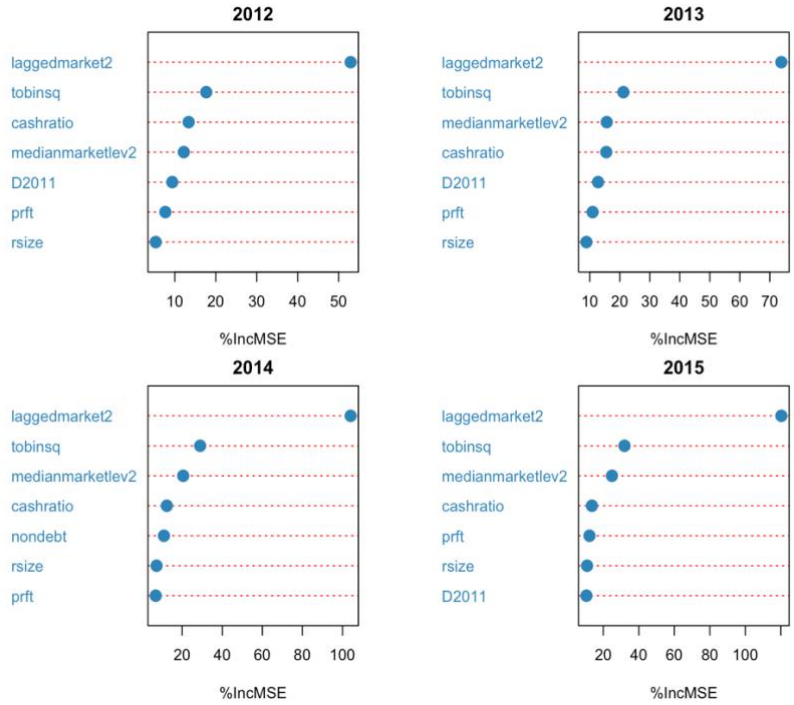


Figure 28: Variable Importance Plots (2012-2015, Market Value of Debt-to-Capital)

Appendix 5.

Variable Importance Plots for the Market Value of Debt-to-Capital (2016-2019).

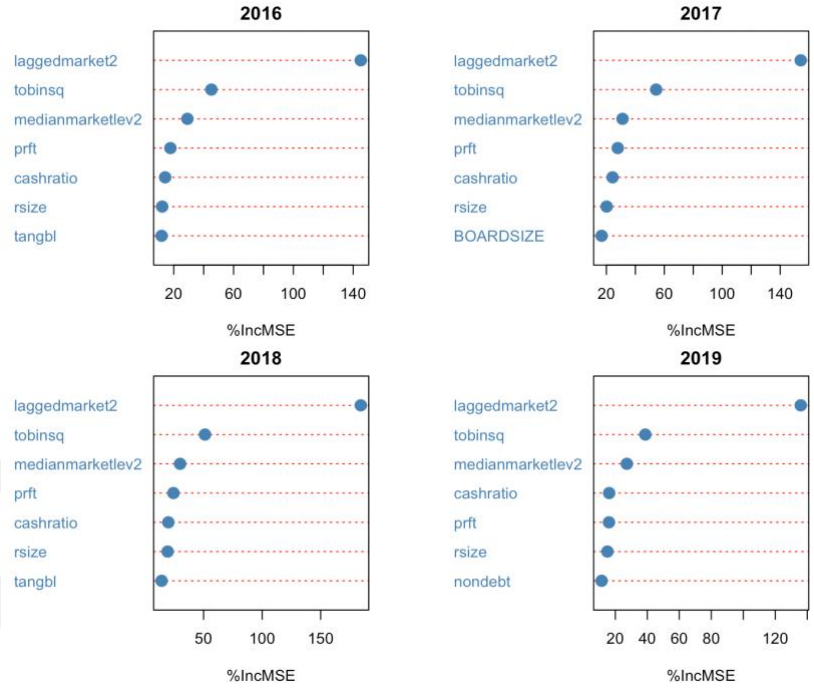


Figure 29: Variable Importance Plots (2016-2019, Market Value of Debt-to-Capital)

Appendix 6.

Relative Influence Plots for the Market Value of Debt-to-Capital (2012-2015).

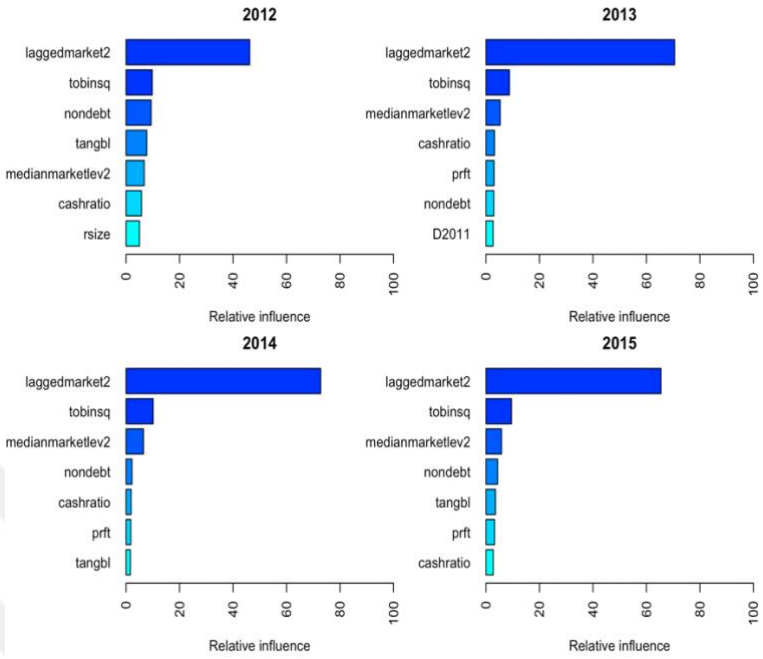


Figure 30: Relative Influence Plots (2012-2015, Market Value of Debt-to-Capital)

Appendix 7.

Relative Influence Plots for the Market Value of Debt-to-Capital (2016-2019).

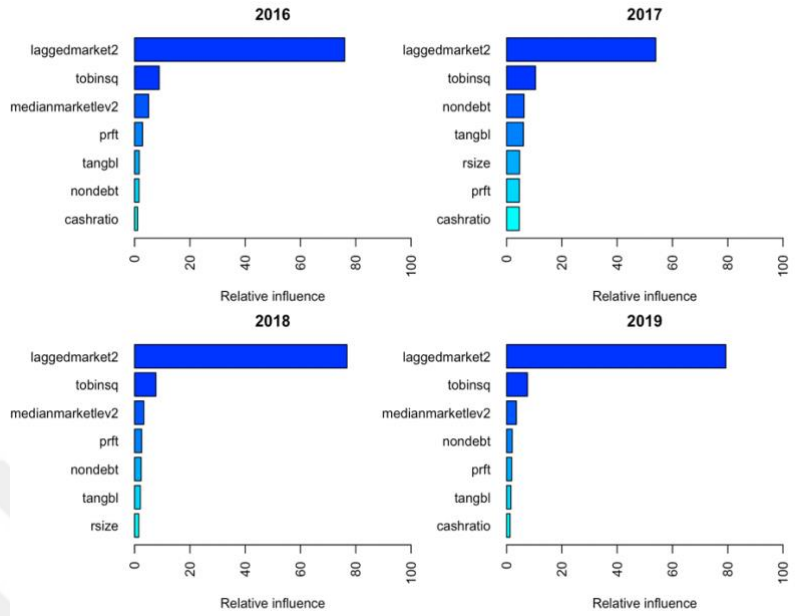


Figure 31: Relative Influence Plots (2016-2019, Market Value of Debt-to-Capital

Appendix 8.

Chosen hyperparameter combinations when the response variable is the book value of debt-to-assets ratio.

Table 25: Chosen Hyperparameters (Book Value of Debt-to-Assets)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	700	400	7	550	0.01	1
2013	750	650	2	350	0.01	4
2014	400	450	3	300	0.02	2
2015	300	550	4	550	0.02	1
2016	650	600	4	600	0.1	2
2017	350	300	4	450	0.02	4
2018	300	400	7	350	0.02	3
2019	350	500	4	700	0.02	3

Appendix 9.

Chosen hyperparameter combinations when the response variable is the book value of debt-to-assets ratio. The models are extended with board variables.

Table 26: Chosen Hyperparameters when the Models are Extended with Board Variables (Book Value of Debt-to-Assets)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	350	300	8	550	0.01	1
2013	350	400	3	300	0.01	4
2014	600	300	4	550	0.01	2
2015	550	300	5	550	0.02	3
2016	400	550	5	400	0.1	4
2017	450	300	5	450	0.02	4
2018	750	400	8	550	0.01	3
2019	600	550	6	550	0.02	4

Appendix 10.

Chosen hyperparameter combinations when the response variable is the book value of debt-to-capital ratio.

Table 27: Chosen Hyperparameters (Book Value of Debt-to-Capital)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	600	600	4	400	0.01	2
2013	300	650	2	350	0.01	3
2014	500	400	4	750	0.01	1
2015	300	450	4	350	0.02	3
2016	750	550	4	300	0.02	4
2017	650	350	5	550	0.02	4
2018	400	350	5	350	0.02	4
2019	700	650	7	600	0.02	4

Appendix 11.

Chosen hyperparameter combinations when the response variable is the book value of debt-to-capital ratio. The models are extended with board variables.

Table 28: Chosen Hyperparameters when the Models are Extended with Board Variables (Book Value of Debt-to-Capital)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	450	350	6	350	0.01	4
2013	450	500	3	350	0.01	3
2014	350	500	7	750	0.01	1
2015	350	400	5	650	0.01	3
2016	750	450	5	300	0.02	4
2017	400	450	8	550	0.02	4
2018	600	400	6	350	0.02	4
2019	600	500	8	600	0.02	4

Appendix 12.

Chosen hyperparameter combinations when the response variable is the market value of debt-to-assets ratio.

Table 29: Chosen Hyperparameters (Market Value of Debt-to-Assets)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	650	500	3	400	0.1	1
2013	450	500	3	300	0.01	4
2014	700	600	8	450	0.01	3
2015	300	300	8	500	0.02	3
2016	300	500	8	400	0.1	2
2017	500	450	8	500	0.02	4
2018	650	350	6	650	0.01	4
2019	350	500	6	350	0.02	3

Appendix 13.

Chosen hyperparameter combinations when the response variable is the market value of debt-to-assets ratio. The models are extended with board variables.

Table 30: Chosen Hyperparameters when the Models are Extended with Board Variables (Market Value of Debt-to-Assets)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	700	500	5	300	0.1	2
2013	650	700	4	300	0.01	4
2014	750	450	7	500	0.01	3
2015	750	450	8	750	0.02	3
2016	550	350	8	500	0.1	2
2017	350	300	7	500	0.02	4
2018	550	750	7	350	0.01	4
2019	700	450	8	400	0.02	3

Appendix 14.

Chosen hyperparameter combinations when the response variable is the market value of debt-to-capital ratio.

Table 31: Chosen Hyperparameters (Market Value of Debt-to-Capital)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	450	400	3	300	0.1	1
2013	400	750	4	750	0.01	2
2014	650	350	6	300	0.02	3
2015	450	300	8	750	0.01	4
2016	600	750	8	700	0.01	4
2017	450	750	6	650	0.1	2
2018	650	500	7	600	0.02	4
2019	550	350	8	700	0.02	3

Appendix 15.

Chosen hyperparameter combinations when the response variable is the market value of debt-to-capital ratio. The models are extended with board variables.

Table 32: Chosen Hyperparameters when the Models are Extended with Board Variables (Market Value of Debt-to-Capital)

Prediction Year	Bagging	Random Forest		Boosting		
	Number of trees	Number of Trees	m	Number of trees	λ	d
2012	500	450	3	300	0.2	1
2013	500	450	6	750	0.01	2
2014	400	350	8	400	0.02	2
2015	500	400	8	700	0.02	4
2016	550	400	8	700	0.01	4
2017	750	750	6	750	0.2	3
2018	750	550	8	600	0.02	4
2019	650	300	8	700	0.02	3