Essays on Firms' Financing and Investment Decisions

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Valeriia Dzhamalova

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Abstract

This thesis analyses how the capital structures of financial and non-financial firms affect each other and how shocks in the financial sector affect investments in non-financial firms. The thesis consists of three self-contained essays.

The first essay provides new evidence on the capital structure determinants of non-financial firms and contributes to the discussion concerning the effect of a regulated financial sector on the real economy. Using syndicated loan contracts, this study identifies the most important lenders for each borrower and analyses the effect of the capital structure of lenders on the capital structure of their borrowers. Keeping the effect of size, tangibility, market to book, profitability and risk fixed, I find that a 1 percentage point increase in the average lenders' leverage leads to an increase of 12 basis points in borrowers' leverage. The regulation of the financial sector has recently led to its deleveraging, but non-financial sectors still use debt intensively. The positive effect of lenders' leverage on the leverage of their borrowers implies that further deleveraging of the financial sector may lead to less indebtedness and less vulnerability of the economy.

The second essay analyses the asset-side determinants of bank leverage and investigates the effect of the riskiness of a bank's assets on its debt issue. The essay uses a novel approach for assessing the riskiness of a bank by analysing the leverage of its borrowers. The advantage of using the borrowers' characteristics when assessing a bank's risk (in comparison with accounting measures of risk) is that borrowers' characteristics are not derived directly from the balance sheet of the bank and the analysis is thus less subject to endogeneity problems. The essay analyses an international sample of financial firms for the period 1995–2014. By estimating a panel logit regression, I find that, when keeping all other covariates constant, a 1 unit increase in the average borrowers' leverage decreases the probability of a bank issuing debt by 0.381. This result demonstrates that a bank's leverage increases when its borrower pool becomes safer; it also questions the presumption that without regulation positive leverage leads to excessive risk taking by banks.

The third essay studies the impact of the financial crisis of 2007–2009 on the real economy, in particular on R&D expenditures. It analyses non-financial firms in high-tech industries in the USA for the period 1998–2012 under the premise that R&D investment is an important driver of economic growth. Using a GMM procedure to estimate a dynamic investment model, the study finds that financial distress only played a minor role, if any, as a determinant of R&D expenditures during the financial crisis. Financial constraints had a substantially greater impact on R&D expenditures during the crisis. All else being equal, more constrained firms invested more during the financial crisis. While at first sight surprising, this result is consistent with the observation that the average R&D expenditures increased during the financial crisis. Moreover, these results are similar to the results of Nanda and Nicholas (2014. Did bank distress stifle innovation during the Great Depression? Journal of Financial Economics 114(2), 273–292), who find that the aggregate effect of banks' distress on innovation during the Great Depression was weak for publicly traded firms, especially in industries that were less dependent on external financing.

Key words: Capital structure; Banks; Borrowers; Bank Debt; Bank Risk; R&D Investment; Financial Constraints; Financial Crisis

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In loving memory of my mum

Contents

Acknowledgement 11

1 Introduction 15
- 1.1 General context and aim of the study 15
- 1.2 Current debates on firms' financing and investment decisions 16
- 1.3 Some comments on endogeneity and statistical significance 19
- 1.4 Contribution of the thesis 21
- 1.5 Summary of the thesis 23
- References 26

2. Capital Structure of Borrowers and Lenders: An Empirical Analysis 29
- 2.1 Introduction 29
- 2.2 Capital structure of non-financial firms: Related literature 33
- 2.3 Modelling the borrower–lender relation 35
  - 2.3.1 Financing through syndicated loans: an overview 35
  - 2.3.2 Why borrowers' capital structure should be related to the capital structure of their lenders 37
  - 2.3.3 Computation of the weighted average of lenders' leverage 39
  - 2.3.4 Description of the model 42
- 2.4 Econometric model 45
- 2.5 Data and empirical results 47
  - 2.5.1 Description of the data and summary statistics 47
  - 2.5.2 Leverage and interest on loans 53
  - 2.5.3 Effect of the lenders' leverage on the leverage of their borrowers 57
  - 2.5.4 Non-linearity in relation of the financing decisions of borrowers and lenders 62
- 2.6 Robustness tests 65
  - 2.6.1 Effect of the money market and macroeconomic conditions on leverage 65
- 2.7 Conclusions 71
- References 73
- Appendix 1 Notation and definition of variables 75
- Appendix 2 Geographical distribution of borrowers 77
- Appendix 3 Correlation matrix for the variables used in the study 78

3. Bank debt and risk taking 79
3.1 Introduction 79
3.2 Related literature 81
3.2.1 Determinants of banks' capital structure 81
3.2.2 Bank leverage and risk taking 84
3.3 Measures of risk 85
3.3.1 Measures of risk in previous studies 85
3.3.2 Computation of the weighted average of borrowers' leverage 86
3.4 Model 90
3.5 Data 94
3.6 Results 97
3.7 Robustness tests 104
3.7.1 Exogenous shocks 104
3.7.2 Alternative measures of risk and the continuous dependent variable 108
3.7.3 Conditional fixed effect model 109
3.8 Conclusions 111
Appendix 1 Definition of the variables 113
Appendix 2 Correlation matrix for the variables used in the analysis 114
References 115

4. The impact of the financial crisis on innovation and growth: Evidence from technology research and development 117
4.1 Introduction 117
4.2 Financing of technology firms: Financial constraints and distress 122
4.2.1 Financing of technology firms 122
4.2.2 Financial constraints 126
4.2.2 Financial distress 131
4.3 Related literature 133
4.4 Data and empirical approaches 137
4.4.1 Empirical model 137
4.4.2 Data 139
4.5 Empirical results 140
4.5.2 Dynamic panel estimation 140
4.5.3 Discussion of the results 142
4.5.3 Robustness 147
4.5.4 Delayed effect of the crisis 153
4.6 Conclusions and discussion 155
References 157
Appendix 160

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Valeriia Dzhamalova

Lund, July 2016

1 Introduction

1.1 General context and aim of the study

The good and the devil: the real economy and the financial sector have always been opposed to each other. The real sector is usually “the good”, because it produces most of the taxable revenue, creates working places and improves the welfare of a nation, and the financial sector is of course “the devil”. The initial purpose of the financial sector was to serve the needs of the real economy and to mediate between firms and individuals with shortages and excesses of funds. Today the financial sector no longer plays the secondary role of merely serving the industrial sector; rather, it represents a self-sustained sector of the economy. The financial and real sectors are highly interdependent, and this dependence comes from not only the impact of the financial sector on the real economy but also the effect of real economic activities on the financial sector. For example, commodity prices and concerns about future growth affect monetary policy and future returns from bonds and stocks in the financial sector, and the availability of funds in the financial sector affects investments in the real economy. This interdependence complicates the assessment of the impact of the financial and real sectors on each other.

The aim of this study is to analyse the interdependence of financing decisions in the financial and non-financial sectors and to explore the effect of financial constraints on investments in non-financial firms. This thesis uses micro-level data to analyse how the capital structures of financial and non-financial firms affect each other and how shocks in the financial sector affect investments in non-financial firms.

1.2 Current debates on firms' financing and investment decisions

Following the famous work of Fama and French (1992), most empirical work today analyses the financing and investment decisions of financial and non-financial firms in isolation from each other. The main reason behind this separation is that their financing and investment decisions are very different both in magnitude and in the fundamentals that determine them. The existing empirical research on firms' financing decisions (hereafter I use the terms capital structure and leverage as synonyms for financing decisions) is concentrated on the tests of two traditional capital structure theories – the pecking order (Myers, 1984) and trade-off models (Kraus and Litzenberger, 1973). The trade-off theory suggests that firms determine their capital structure by trading off the costs (such as bankruptcy costs) and benefits (such as tax advantages) of debt. The pecking order theory suggests that firms would prefer internal funds (retained earnings or initial equity) to finance their investments. If a firm lacks internal financing, it would prefer to issue debt first and only use equity as a last resort due to the information asymmetry between managers and investors. As investors have less information about the value of the firm, they might not be willing to pay as much as managers value their firm, and the issued equity will be underpriced. Hence, if the firm does not have a long financial history on the market, issuing equity is more expensive than issuing debt.

Note, however, that the results of empirical tests of the pecking order and trade-off theories are inconclusive and often contradictory. Graham and Leary (2011) find that the standard variables from the traditional theories of capital structure are less effective in explaining within-firm debt ratio variation. Standard proxies are more successful in explaining cross-sectional and between-industry variation, but the majority of within-firm changes in the debt ratio remain unexplained. Moreover, according to Graham and Leary (2011), the explanatory power of the traditional determinants of capital structure has decreased over time. They show that these determinants explained around 30% of the variation in leverage for a sample of non-financial American firms in the mid-1970s but only around 10% of the variation in the first decade of the twenty-first century.

For a sample of financial firms (large US and European banks for the period 1991–2004), Gropp and Heider (2010) find that standard cross-sectional determinants of non-financial firms' leverage carry over to banks, but that unobserved time-invariant bank fixed effects are the most important determinants of banks' capital structure. However, the existing research on both financial and non-financial firms has still not identified which firm-specific and time-invariant characteristics are missing from the models of capital structure.

As Graham and Leary (2011) note, one of the reasons why traditional capital structure theories fail is that they focus on the relationship between the firm and its financial claimant, without addressing its employees or other claimants. Recent empirical studies have started to incorporate the effect of other stakeholders into models of capital structure. For example, Leary and Roberts (2014) use the characteristics of peer firms in their capital structure models, but no evidence exists concerning the relationship of such important stakeholders as borrowers (non-financial firms) and their lenders (financial firms) with financing decisions. Some theoretical models of the capital structure of financial firms, particularly banks, do incorporate the decisions of multiple stakeholders, such as the banks themselves, banks' debt and equity holders and banks' borrowers (see for example Diamond and Rajan, 2000). Only a few theoretical studies actually derive models in which lenders' capital structure affects the capital structure of their borrowers. Among these are the study by Gornall and Strebulaev (2015), which derives a model of the joint capital structure decisions of banks and borrowers. In their model the tax benefits from debt originate only at the bank level, while banks' and firms' leverages act as strategic substitutes and complements. A strategic complementarity effect arises because banks pass their tax benefits from debt on to their borrowers. A strategic substitution effect arises because banks also pass their distress costs on to their borrowers. According to Thakor (2014), a capital structure theory that characterizes the capital structure of non-financial firms in relation to financial intermediaries (an integrated theory of capital structure) can have great theoretical significance. Since no empirical evidence exists concerning the relationship between borrowers' and lenders' capital structure, this thesis investigates the relation between the leverage ratios of financial and non-financial firms.

Another reason why the traditional theories fail to explain the variation in capital structure is the assumption that the capital supply is not relevant to capital structure decisions. In their famous capital structure irrelevance principle, Modigliani and Miller (1958) state that, in the absence of taxes, bankruptcy costs, agency costs and asymmetric information and in an efficient market, a firm's capital structure is irrelevant to its value. The firm's investment decision is therefore independent of its financing decision, and external and internal funds are perfect substitutes. However, a considerable strand of research builds on the view that external and internal financing are not perfect substitutes and that firms' investment and financing decisions are in fact interdependent. This interdependence of firms' financing and investment decisions and the relevance of financing policies to real investment are often demonstrated by comparing the investments of those firms that have easy access to external financing with those that have difficult access. Since financial crises always imply a contraction in the supply of external financing, the crisis period is often used in the analysis of the effect of the credit supply on investment policies. If firms' investments are affected by financing policies, and if these firms rely to a large extent on external financing, then their investments should decrease during the crisis. The existing empirical studies, however, only provide ambiguous results on the effect of negative supply shocks on firms' investments during a crisis. For example, Almeida et al. (2012) and Campello et al. (2010), Duchin et al. (2010) show that firms reduce their capital expenditures in response to negative shocks to the credit supply (bank lending supply shocks or credit supply shocks in general). Contradicting these results, other researchers (e.g. Hetland and Mjos, 2012; Kahle and Stulz, 2013) find evidence that the lending supply shock is not necessarily the dominant causal factor of financial and investment policies during a crisis and that the investment levels of financially constrained firms are not more affected than the investment levels of financially unconstrained firms. In this thesis I provide further evidence on the effect of the credit supply on real investments.

To summarize, the existing literature provides numerous models of firms' financing and investment decisions, and it is hard to distinguish which path of research is the most promising. This thesis tests a theory of capital structure that incorporates the financing decisions of lenders and their borrowers. It provides empirical evidence concerning the existence of a linear relationship between the capital structure of borrowers and that of lenders, which should further facilitate the development of capital structure models and explain more of the variation in firms' financing and investment decisions. It also contributes to the discussion about how the supply of external financing affects firms' financing decisions.

1.3 Some comments on endogeneity and statistical significance

The endogeneity problem is a main concern of modern research in empirical corporate finance; that is, the correlation between the explanatory variables and the error terms leads to biased and inconsistent estimates. The causes of endogeneity can be simultaneity (the variables on the left- and right-hand sides of the equation affect each other), reverse causality, omitted variables or measurement error. In all the chapters throughout this thesis, I recognize the potential endogeneity problem and specify empirical models in such a way that allows me to mitigate its consequences. Two subsequent paragraphs discuss how I handle each potential endogeneity cause in the empirical models.

To make sure that the simultaneity problem, or reverse causality, is not an issue in this study's models, the explanatory variables are all lagged by one year. For example, in Chapter 2 I investigate the effect of lenders' leverage on the leverage of their borrowers. By lagging lenders' leverage and other explanatory variables, I assume that borrowers make the decision about leverage by observing lenders' leverage in the previous period. Future values of borrowers' leverage are unobservable for lenders, and it is thus unlikely that lenders will decide their own leverage based on unobservable values of borrowers' leverage. In Chapters 3 and 4 I proceed in the same way and lag all of the explanatory variables. The empirical panel data model in Chapter 4 also includes lagged dependent variables, and I use Arellano and Bover's (1995) system GMM instead of fixed-effect OLS in this chapter.

It is difficult to mitigate the omitted variables problem. Economic science has an ambition to model complex economic processes mathematically. This implies not only decisions about the variables that should be included in the model, but also decisions about the distributions of the variables and error terms. In this thesis I am aware of the omitted variables problem but avoid data mining by including in the model all the variables that have a potential correlation with the dependent variable. I prefer to consider variables if their importance has been justified theoretically or strong empirical evidence exists about their importance. My empirical models also include fixed effects, which capture time-invariant firm characteristics and time dummies for capturing changes over time. In the chapters in which I use an international sample, I also include region–time dummies, which capture the difference in the institutional framework, competition in the markets, development of the financial sector and so on among the countries. I also avoid using variables that are difficult to measure in the model, even if they might have potential importance for the research in question. By doing this, I mitigate another cause of endogeneity – measurement error. I reckon that this problem should not be more severe in this study than in the existing empirical literature, since I measure all the variables in a similar manner to previous studies.

Two popular ways of avoiding endogeneity problems or establishing causal effects are to use instrumental variable estimation or difference-in-difference regression. The former implies finding relevant instruments that are correlated with the explanatory variable, but uncorrelated with the model's errors; while the latter implies finding an exogenous event. Finding valid instruments can be difficult, if not impossible, and relevant exogenous events are very rare. In this thesis I prefer to avoid using weak instruments by not using instrumental variables at all. At this stage of my research, I also do not see any exogenous events that could help me to identify casual effects. I consider this thesis to be an exploratory study that gathers potentially interesting findings. Future research might confirm or disprove these findings, and much more work is required to identify any causal effects. I reckon that the estimations presented in all the chapters do not suffer from any serious endogeneity problems and that the estimates presented here are at least approximately unbiased and consistent. The results of this thesis are important for the further development of theories concerning financing and investment decisions and for finding the determinants of their unexplained variation.

Lastly, I want to discuss some issues concerning statistical significance. In March 2016 the American Statistical Association (ASA) released a statement about statistical significance and p-values, which provides some principles for improving the conduct and interpretation of quantitative science. The ASA issued the following statement connected with the problem:

> The p-value has become a gatekeeper for whether work is publishable, at least at some fields. This apparent editorial bias leads to the "file-drawer effect", in which research with statistically significant outcomes is much more likely to be published, while other work that might well be just as important scientifically is never seen in print. It also leads to practices referred to by such names as "p-hacking" and "data dredging", which emphasize the search for small p-values over other statistical and scientific reasoning.

The ASA emphasizes that proper inference requires full reporting and transparency, which implies that researchers should avoid cherry-picking promising findings and disclose all the data collection decisions, all the statistical analyses conducted and all the p-values computed.

In this thesis I follow this principle and present the results that are statistically insignificant as well as those that are significant. Each chapter is aimed at presenting those results that are relevant to the particular research question.

1.4 Contribution of the thesis

The thesis contributes to the literature concerning the interdependence of the financial and real sectors of the economy and to the literature concerning the determinants of the capital structure of financial and non-financial firms. Chapters 2 and 3 add to the literature on the determinants of the capital structure of financial and non-financial firms, while Chapter 4 contributes to the literature on the impact of financial crises on firms' investment policies.

Chapter 2 provides new evidence about the determinants of capital structure for non-financial firms. It presents the first empirical study of an integrated theory of the capital structure of borrowers in relation to their lenders (Gornall and Strebulaev, 2015). This study confirms the existence of a relationship between the capital structures of financial and non-financial companies. Modern economies are highly complex and interdependent, and it is hard to imagine that the financing decisions of different economic agents (borrowers, lenders and peer firms) do not affect each other. The findings of Chapter 2 are important for the further development of a new generation of capital structure theories, which take into account the effect of the interaction of different economic agents.

Chapter 3 contributes to the literature concerning the determinants of the capital structure of financial firms and focuses in particular on banks' decisions to issue debt. High indebtedness of the financial sector makes it vulnerable, especially during times of financial downturns, and understanding what drives banks' decisions to issue debt is important for designing effective financial regulation. Despite this, the existing literature lacks a convincing explanation of the determinants of banks' debt issuance – relatively few studies investigate this topic at all and even fewer focus on the riskiness of a bank. One existing study is that by Shrieves and Dahl (1992), who demonstrate a positive relationship between changes in banks' risk and their capital. This study, however, covers the period of 1983–1987, but in recent decades empirical research has paid surprisingly little attention to the effect of the riskiness of a bank's assets on its decision to issue debt. Chapter 3 provides some recent evidence concerning banks' debt issuance and risk taking. I use a novel approach to assessing a bank's risk by analysing the leverage of the bank's borrowers. I find that a decrease in the safety of a bank's borrowers today decreases the probability of debt issuance for the bank tomorrow.

Chapter 4 contributes to the literature concerning the effect of the financial crisis of 2007–2009 on the real economy. A large emerging literature attempts to understand the effect of financial constraints on intangible and capital investments, but the results are often ambiguous, especially in the case of intangible (R&D) investments. Chapter 4 tackles the relevant macroeconomic question concerning the effect of financial constraints on firms' investments. The main contribution of this chapter is to disentangle the demand versus supply effects on R&D expenditures by distinguishing between financial distress (the demand effect) and financial constraints (the supply effect) at the firm level. The distinguishing feature of this study, compared with the previous literature, is the approach used in assessing the effect of financial crises on firms' investments. To the best of our knowledge, no other studies directly compare financially constrained and distressed firms.

1.5 Summary of the thesis

This section presents a short summary of the three subsequent chapters of this thesis. Chapter 2 analyses the relation between the capital structures of financial and non-financial firms; Chapter 3 discusses the effect of borrowers' characteristics on banks' debt issuance; and Chapter 4 concerns the effect of the financial crisis on technology research and development. The three following paragraphs briefly describe the main idea and present a summary of the three papers.

Chapter 2. Capital Structure of Borrowers and Lenders: An Empirical Analysis

Chapter 2 provides new evidence on the capital structure determinants of non-financial firms and contributes to the discussion concerning the effect of a regulated financial sector on the real economy. Using syndicated loan contracts, this study identifies the most important lenders for each borrower and analyses the effect of the capital structure of lenders on the capital structure of their borrowers. Following the study by Gornall and Strebulaev (2015), this study's empirical model assumes that a borrower makes a decision about his capital structure by trading off the distress costs and tax benefits of his own debt and the distress costs and tax benefits of his banking network. A borrower does not observe the distress costs and tax benefits of a banking network directly; rather, he makes decisions based on the financing terms that his banking network provides. Banks with higher leverage provide better financing terms, since they have a larger surplus due to the tax benefits of debt. I analyse a sample of North American, Asian and European non-financial firms for the period 1995–2014. Keeping the effect of size, tangibility, market to book, profitability and risk fixed, I find that a 1 percentage point increase in the average lenders' leverage leads to an increase of 12 basis points in borrowers' leverage. The regulation of the financial sector has recently led to its deleveraging, but non-financial sectors still use debt intensively. The positive effect of lenders' leverage on the leverage of their borrowers implies that further deleveraging of the financial sector may lead to less indebtedness and less vulnerability of the economy.

Chapter 3. Bank Debt and Risk Taking

Chapter 3 analyses the asset-side determinants of bank leverage and investigates whether the riskiness of a bank's assets has an effect on its debt issue. I use a novel approach to assessing the riskiness of a bank by analysing the leverage of its borrowers. Using data on syndicated loans, I compute the weighted average of the borrowers' leverage for each bank. The advantage of using the borrowers' characteristics when assessing a bank's risk (in comparison with accounting measures of risk) is that borrowers' characteristics are not derived directly from the balance sheet of the bank and the analysis is thus less subject to endogeneity problems. I analyse an international sample of financial firms for the period 1995–2014. By estimating a panel logit regression, I find that, when keeping all the other covariates constant, a 1 unit increase in the average borrowers' leverage decreases the probability of a bank issuing debt by 0.381. This finding supports the arguments of Inderst and Mueller (2008), who question the presumption that without regulation positive leverage leads to excessive risk taking by banks. My results confirm their theoretical proposition that a bank's leverage increases when its borrower pool becomes safer (the riskiness of the borrowers decreases). My results are also in line with those of Gropp and Heider (2010), who find a negative effect of risk on the book and market leverage of banks.

Chapter 4. The Impact of the Financial Crisis on Innovation and Growth: Evidence from Technology Research and Development

The aim of Chapter 4 is to study the impact of the financial crisis of 2007–2009 on the real economy, in particular on R&D expenditures. This chapter analyses non-financial firms in high-tech industries in the USA for the period 1998–2012, under the premise that R&D investment is an important driver of economic growth. This study builds on the literature that analyses the effect of the credit supply on the investments of non-financial firms (Almeida et al., 2012; Brown et al., 2009; Duchin et al., 2010). It explores the effect of financial constraints and distress on firms' R&D investments. Using a GMM procedure to estimate a dynamic investment model, it finds that financial distress only played a minor role, if any, as a determinant of R&D expenditures during the financial crisis. Financial constraints had a substantially greater impact on R&D expenditures during the crisis. All else being equal, more constrained firms invested more during the financial crisis. While this result is at first sight surprising, it is consistent with the observation that the average R&D expenditures increased during the financial crisis. Moreover, it is consistent with the findings of Hetland and Mjos (2012) and Kahle and Stulz (2013), which question whether firms' investment behaviour was affected by a supply-side shock during the financial crisis. Remarkably, the results are also similar to the results of Nanda and Nicholas (2014), who find that the aggregate effect of banks' distress on innovation during the Great Depression was weak for publicly traded firms, especially in industries that were less dependent on external financing. Similar to the recent financial crisis, the effect of bank distress on innovation during the Great Depression was strongest immediately after the collapse of the banking sector, but the effect attenuated as the depression years progressed.

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2. Capital Structure of Borrowers and Lenders: An Empirical Analysis

2.1 Introduction

This paper analyses the effect of the capital structure of lenders on the capital structure of their borrowers. It provides new evidence on the capital structure determinants of non-financial firms and contributes to the discussion on the effect of the regulated financial sector on the real economy. By using syndicated loan contracts, it identifies the most important lenders for each borrower and constructs a proxy for the borrower's banking network. Keeping the effect of size, tangibility, market to book, profitability and risk fixed, it finds that a 1 percentage point increase in the average of lenders' leverage corresponds to an increase of 12 basis points in borrowers' leverage. It also finds evidence that macroeconomic variables, such as GDP growth and inter-bank short-term interest rates, have explanatory power for the leverage of non-financial firms.

Graham et al. (2014) find that the relations between aggregate leverage and financial intermediation as well as corporate debt and supply of securities are the most statistically important and may become the most promising areas for future research. Recent empirical studies incorporate the characteristics of peer firms into capital structure models (Leary and Roberts, 2014), but the empirical research lacks evidence on the relation between the capital structure decisions of lenders and those of their borrowers. I contribute to the literature on the capital structure of non-financial firms by analysing the effect of the capital structure of lenders on the capital structure of their borrowers.

Analysing the effect of the leverage of financial firms on non-financial firms is not only interesting for the corporate finance literature; this analysis also provides evidence on the effect of the regulation of the financial sector on the total indebtedness of the economy. The growing global debt is creating risks of another financial crisis and a slowdown of economic growth. Since 2007 the global debt has increased by 57 trillion USD, raising the ratio of debt to GDP by 17 percentage points.[1] The regulation of the financial sector has recently led to its deleveraging, but non-financial sectors still use debt intensively. In general, according to Graham et al. (2014), unregulated US corporations have substantially increased their debt usage over the past century: the aggregate corporate balance increased from 25% liabilities in the 1930s to over 65% liabilities by 1990.

By limiting banks' leverage, regulators place a stricter limit on the relative level of debt that banks can use to finance their assets. The positive effect of lenders' leverage on the leverage of their borrowers implies that further deleveraging of the financial sector may lead to less indebtedness and vulnerability of the real economy.

Following the model of Gornall and Strebulaev (2015), this study's empirical model assumes that a borrower makes a decision on his capital structure by trading off the distress costs and tax benefits of his own debt and the distress costs and the tax benefits of his banking network. A borrower does not observe the distress costs and tax benefits of a banking network directly, but rather makes decisions based on the financing terms that his banking network provides. These financing terms depend on the level of banks' leverage. The data in my study demonstrate that banks with higher leverage are able to provide their clients with lower interest on loans, because such banks pay less tax on interest income and have a larger surplus to pass on to the borrower. If the banking network charges high interest rates due to its low leverage, I expect a borrower to prefer equity financing. My empirical model further assumes that the leverage

[1] Estimates from McKinsey Global Institute: http://www.mckinsey.com/insights/economic_studies/debt_and_not_much_deleveraging

ratio of a borrower linearly depends on the weighted leverage of lenders. I focus on a linear specification of the model to emphasize the intuition, but I also allow for non-linearity by testing whether the relation between borrowers' and lenders' leverages differs for high and low levels of banks' liabilities-to-assets ratio. The empirical model confirms the existence of a linear effect of lenders' leverage on the leverage of their borrowers, but I do not find evidence of non-linearity in the effect of lenders' leverage on the leverage of their borrowers. The magnitude of the coefficient of lenders' leverage is comparable to the magnitude of the firm-level control variables, and the coefficients of the control variables confirm some findings from previous studies. For example, the positive effect of size and the negative effect of profitability are similar to the results obtained by Frank and Goyal (2009) and Leary and Roberts (2014).

I use several measures of borrowers' leverage as the dependent variable as well as several measures of average lenders' leverage. I find statistically robust results only for leverage as measured by the book value of debt[2] to the book value of total assets. The results for the market leverage are ambiguous. I do not find any effect of lenders' leverage on the leverage of their borrowers if I measure lenders' leverage as the total liabilities to assets or total deposits to assets. I explain the difference in significance for different measurements of leverage by different reasons driving lenders' decision to issue different types of liabilities. One of the reasons why banks prefer to issue debt is tax benefits; if borrowers' and lenders' leverages are related through the tax benefits of debt, this relation should be reflected in the coefficients of debt to assets. The coefficients of total liabilities and deposits to assets are not significant, because it is not clear whether these liabilities transfer the tax benefits of debt to a borrower.

[2] Lenders' debt includes: short-term borrowings; the current portion of long-term debt; the current portion of capital leases; long-term debt; federal home loan bank debt; capital leases; and trust preferred securities. It does not include deposits. Borrowers' debt is the sum of total long-term debt, which is defined as debt obligations due more than one year from the company's balance sheet date, *plus* debt in current liabilities, which is defined as the total amount of short-term notes and the current portion of long-term debt (debt due in one year).

Finally, it is necessary to keep in mind that I measure only part of the lender–borrower relation observed through syndicated lending, and I do not observe exhaustive information on the relation between borrowers and lenders.

To relate borrowers to lenders, I use DealScan, a database that provides historical information on the terms and conditions of syndicated loans in the global commercial market. To include financial statements' information in the analysis, I link DealScan with Compustat North America and S&P Capital IQ. Most of the information for the borrowers is downloaded from Compustat North America using the matching provided by Chava and Roberts (2008). I perform hand matching of lenders with S&P Capital IQ. The sample period is from 1995 to 2014, and the sample contains North American, Asian and European companies.[3] This study is the first to analyse firms from different regions in one sample. Using data from different regions allows the investigation of the differences in capital structure in general rather than the differences in capital structure within a particular region or country. To account for the heterogeneity of firms from different countries, I control for time-invariant, firm-specific characteristics using fixed-effect panel regression, time dummies and region–time dummies. The sample with non-missing data for all the variables consists of around 952 borrowers[4] with an average of 3.7 observations per borrower and around 1200 lenders.

The remainder of the paper proceeds as follows. Section 2.2 discusses the related literature; section 2.3 reviews the theoretical background and describes the empirical model. In section 2.4 I outline the econometric model, and in section 2.5 I describe the data and empirical results. Section 2.6 presents the robustness tests, and section 2.7 concludes.

[3] However, this sample contains data on international companies listed in the USA because Capital IQ was the only database available to the author at the moment of the collection of data for lenders.

[4] The number of borrowers and lenders differs depending on whether the dependent variable is book or market leverage and depending on the missing values for different control variables.

2.2 Capital structure of non-financial firms: Related literature

Two important capital structure theories are the trade-off theory (Kraus and Litzenberger, 1973) and the pecking order theory (Myers, 1984). According to the trade-off theory, debt financing provides a tax advantage compared with equity financing, but at the same time a high level of debt increases the probability of bankruptcy. The trade-off between the tax savings from debt and the financial cost of bankruptcy determines the capital structure of a firm. The pecking order theory suggests that firms would prefer internal funds (retained earnings or initial equity) to finance their investments. If a firm lacks internal financing, it would prefer to issue debt first and equity only as the last resort.

Empirical tests of the pecking order and trade-off theories provide evidence on the important determinants of leverage. For example, Hovakimian et al. (2001) analyse the optimal choice of the debt-to-equity ratio for a large sample of US firms and find that past profits and stock prices play an important role in the firms' decision to issue debt or equity. Jandik and Makhija (2001) examine the firm-specific determinants of leverage for a sample of pooled, time-series, cross-sectional data for a single industry (electric and gas utilities) for the period 1975–1994. They conclude that bankruptcy costs, growth, non-debt tax shields, collateral profitability, size and risk are important determinants of leverage, even though the risk has a positive sign, contrary to both the pecking order and the trade-off theory. Fama and French (2002) conclude that the pecking order and trade-off theories share the same predictions regarding the effect of investments, size and non-debt tax shield and make opposite predictions regarding the effect of profitability on leverage.

Several studies extend the capital structure models with macroeconomic and industry-level variables. Korajczyk and Levy (2003) model the capital structure as a function of the macroeconomic conditions and firm-specific variables for samples of constrained and unconstrained firms. They find that leverage is counter-cyclical for the relatively unconstrained sample but pro-cyclical for the relatively constrained sample. MacKay and Phillips (2005) investigate the effect of the industry on firms' capital structure and find that it accounts for around 13% of the variation in the capital structure, but the capital structure also depends on a firm's position within its industry. Leary and Roberts (2014) further investigate the effect of the industry on the capital structure. They show that firms' financing decisions are responses to the financing decisions and characteristics of their peer firms within the industry.

Several theoretical papers develop models concerning the capital structure of banks by relating the functions of banks (credit and liquidity creation and issuance of deposits) to the characteristics of their customers. Below I briefly describe three of them, and section 2.3.2 reviews the model that serves as the theoretical background for this empirical analysis. Diamond and Rajan (2000) derive the implications of minimum capital requirements for banks, their lenders and their borrowers. The authors model the optimal capital structure using the interaction between the depositors, the equity (debt) holders and the borrowers of a bank. They show that trade-offs between liquidity creation, credit creation and bank stability determine the optimal capital structure. Diamond and Rajan (2000) argue that banks' capital structure also determines the nature of banks' customers, because different customers rely to different extents on liquidity and credit. Sundaresan and Wang (2014) analytically solve the liability structure of banks by connecting banks and non-financial firms. Another paper that relates the capital structure decisions of banks to their borrowers is that by Gornall and Strebulaev (2015). They argue that better diversification reduces banks' asset volatility and enables them to have high leverage and low interest rates. In their model tax benefits from debt originate only at the bank level, and banks' and firms' leverages act as strategic substitutes and strategic complements. A strategic complementarity effect arises because banks pass the tax benefits from debt on to their borrowers. A strategic substitution effect arises because banks pass their distress costs on to their borrowers.

2.3 Modelling the borrower–lender relation

In this paper I conduct an empirical analysis of the capital structure of borrowers in relation to the capital structure of their lenders. One of the biggest challenges of the analysis involves identifying the lenders of each particular firm, because the information on loan contracts is often confidential. To match lenders with their borrowers, I use syndicated loan contracts,[5] because the terms of these contracts are publicly available. The use of syndicated loan contracts suits to connecting borrowers and lenders for the following reasons: 1) the total amount of the debt contract allows me to determine the extent to which a borrower depends on a lender; 2) the repayment schedule of the debt contract allows me to track changes in the borrower–lender relation over time; and 3) syndicated loan contracts allow me to relate a borrower to multiple lenders and a lender to multiple borrowers, modelling the borrower–lender relation most realistically. Non-bank credit institutions can also become participants in a syndicate, but in this paper I focus on banking institutions and the majority of the sample consists of banks (section 2.5.1 describes the sample). To justify the empirical specification, the next section describes how syndicated loans work.

2.3.1 Financing through syndicated loans: an overview

In the absence of internal resources, a firm finances its expenses either with debt or with equity. Usually firms prefer debt to equity due to the tax benefits of debt (trade-off theory) or due to the higher cost of equity arising from asymmetric information between managers and investors (pecking order theory). Firms can borrow from financial markets or from banks. The choice between bank debt and directly placed debt is discussed intensively in the literature (see for example Diamond, 1991). In this article I focus on banks as providers of debt for non-financial firms

[5] Information on banks' loans is usually confidential, but DealScan provides information on the syndicated loan transactions of large corporate and middle-market commercial loans filed with the Securities and Exchange Commission or obtained through other reliable public sources.

and investigate the effect of banks' leverage on the leverage of their borrowers.

Banks provide cheaper "informed" lending by controlling borrowers' investment decisions (reducing the moral hazard) and diminishing the asymmetric information problem by monitoring the information about a borrower. Due to this monitoring activity, firms and financial intermediaries develop a long-term relationship. Through the provision of multiple financial services over time, banks gather information about their borrowers. In addition to monitoring and lending, banks provide payment and saving services for firms, and firms usually establish a relation with their bank at the early stage of their existence.

When a borrower requires a loan, the bank provides financing as the sole lender or arranges a syndicate. Banks choose to syndicate a loan when they want to diversify the risks or the regulation does not allow them to allocate a large loan to a sole borrower (Simons, 1993). Banks usually arrange a syndicate[6] when they have a long relationship history with a borrower. The bank arranging a syndicate is called the lead arranger. The lead arranger prepares the terms and conditions of the deal and tries to sell this deal to other banks. The syndication can be carried out in stages, during which the group of initial lenders (co-arrangers) provides a share of the facility and then finds more lenders to participate in the syndicate. If the borrower's characteristics and terms of a deal are attractive to other lenders, banks can even compete for participation in the syndicate. If, in contrast, other lenders do not consider the deal to be safe or profitable, the lead arranger might have difficulties in selling the syndicate. Not selling the syndicate is costly for an arranger, because firstly he has already invested resources in the preparation of the deal and secondly he might need to finance the total amount of credit, which increases the riskiness of his portfolio.

When a syndicated loan is sold to a sufficient number of participants and they sign the facility agreement, one of the banks plays the role of an agent. The agent is a point of contact in a syndicate and monitors the compliance of the borrower with the terms of the contract; all the payments from and to a borrower are also made through the agent. All the

6 I thank Olga Yurchuk, my former colleague from Unicredit Bank, for explanations and discussions of how syndicated loans are organized in practice.

decisions of a material matter are made by all the participants or by their majority. The agent, lead arranger and co-arrangers receive a fee for their services. The participants in a syndicate perform their own analysis and credit evaluation of a borrower, because they reflect this loan on their balance sheet and make reserves. Moreover, if the participants in a syndicate are from different countries, they might have different standards of reporting for regulators and should implement monitoring of the borrower by themselves through the mediation of an agent. Even if the lead arranger of the syndicate has a close relationship with the borrower from the beginning, all the participants in the syndicate monitor the financial conditions of the borrower and have claims of equal seniority on the debt.

Considering all the participants in syndicated loans is important[7] in this analysis, because all the participants are responsible for a share of the loan and the terms of the loan are identical for all the syndicate members. Moreover, as Sufi (2007) notes, the participants in the syndicate are particularly concerned with problematic loans, because if a loan is downgraded lower than a lender's own rating, the lender must increase the reserves or write off the loan. The next section describes the economic background of the empirical model and the computation of the weights that relate borrowers to lenders.

2.3.2 Why borrowers' capital structure should be related to the capital structure of their lenders

This chapter explains the economic intuition behind the borrower–lender capital structure relation, following the explanation provided by Gornall and Strebulaev (2015). They derive a model of joint capital structure decisions of banks and borrowers by blending a structural model of bank portfolio returns with the trade-off theory of capital structure.

The important assumption of the model is that, to remain on the market, a bank should pass its surplus on to its borrowers by providing better financing terms, such as lower interest rates. In a competitive environment, if a bank does not provide financing terms that maximize

7 I use only the participants in the syndicate for which I have financial data.

the borrower's value, it will be competed out of business. If the bank is a monopolist, it can capture the entire firm's value above the reservation price and still have incentives to set loan conditions that maximize the firm's value.

In my empirical model, I assume that the trade-off theory holds and that tax benefits are important for the capital structure decisions of both borrowers and lenders.[8] Following Gornall and Strebulaev (2015), I also assume that the only real tax benefits arise on the lenders' level: both borrowers and lenders receive tax benefits of debt, but banks also pay the income tax on the interest income received from their borrowers. In other words, the interest deductions of firms constitute part of the taxable income of the bank and the increased interest deductions of a firm correspond to higher tax expenses of the bank. Hence, banks with high leverage have cheaper financing and can charge their borrowers lower interest. On the contrary, banks with low leverage have higher tax expenses and must charge customers higher interest rates to compensate for the tax burden. Borrowers are willing to borrow more from highly leveraged lenders, because such lenders are able to provide lower interest rates.

Since issuing debt always implies insolvency risk and imposes distress costs on lenders and borrowers, the level of lenders' distress affects firms' financing decisions too. According to Gornall and Strebulaev (2015), the total firm value is the sum of a firm's equity and the value that the firm's loan contributes to the bank. Both banks and borrowers choose the capital structure that maximizes the total firm value by trading off the firm's bankruptcy costs, the bank's bankruptcy costs, the firm's and bank's tax shield and the bank's tax costs. To be able to justify the theoretical relationship between borrowers' and lenders' capital structures, data on the capital structures of both borrowers and lenders are required.

[8] This follows the discussions in the study by Gornall and Strebulaev (2015), who use tax benefits and bankruptcy costs to develop their model of financing as a supply chain. However, as the authors note, their framework of risk reduction and supply chain mechanism is general and valid in the presence of other incentives to issue debt. In their model any alternative debt benefits should also be passed on from lenders to borrowers.

The next section describes how I relate a borrower to its lenders and compute the weighted average of lenders' leverage for each borrower.

2.3.3 Computation of the weighted average of lenders' leverage

To test empirically whether the capital structure of borrowers is related to the capital structure of their lenders,[9] I compute the weighted average of lenders' leverage of each borrower in a given time period. To compute this weighted average, I need data on the leverages of lenders and borrowers and the size of the loan that each borrower received from his banks. In practice, the information on the borrowers of the banks and the terms of the loan contracts are confidential. The only publicly available information is that on counterparties and the contract terms of syndicated loans, which constitute a substantial part of firms' debt. By using syndicated loan contracts, I do not observe the total amount of firm k's borrowings from and repayments to banks; rather, I observe how much firm k borrowed within each syndicated loan agreement i (L_{ikt}) with the agreed repayment (p_{ikt}). I use the data on syndicated loans and their repayments to identify the most important banks for each firm and construct an approximate measure of firms' banking network.

I use the following notation for the computation of the banking network measure:

D_{ikt}≡Outstanding debt of firm k within syndicate loan contract i at time t (total amount of outstanding debt to all the banks according to a loan contract);

D_{jkt}≡Outstanding debt of firm k to bank j at time t (outstanding amount of debt for each particular bank according to a loan contract);

s_{ijt}≡Allocation of bank j within syndicate i at time t.

Based on the observed amount of syndicated loan i, I define the three-dimensional matrix **D** of outstanding debt of firm k at time t. Each element of the debt matrix is written as follows:

[9] Hereafter I use leverage as a synonym for capital structure, because both of them indicate how much debt a firm uses to finance its assets.

$$D_{ikt} = \begin{cases} L_{ikt} \; if \; t < t^p \\ L_{ikt} - p_{ikt} \; if \; t \geq t^p \end{cases}, \quad (1)$$

where t^p is the start date of the loan's repayment, L_{ikt} is the amount of loan i that borrower k received at time t and p_{ikt} is the payment instalments repaid in period *t*. As syndicated loans imply multiple lenders, I also consider the allocation of each lender *j* in the total amount of the syndicated loan. To define the outstanding debt of firm *k* to bank *j* at time *t*, I multiply the total amount of the syndicated loan by each bank's allocation (s_{ijt}) within the syndicate:

$$D_{jkt} = \sum_i D_{ikt} s_{ijt}, \quad (2)$$

where D_{ikt} is the amount of outstanding debt of firm *k* at time *t* and s_{ijt} is lender *j*'s allocation within syndicate *i* at time *t*. I obtain the allocation s_{ijt} from the terms of each syndicated contract. I compute weight w_{jkt} as follows and interpret this weight as the measure of importance of each lender in the borrower's banking network:

$$w_{jkt} = \frac{D_{jkt}}{\sum_{j'} D_{j'kt}}, \quad (3)$$

where j' denotes all the bank participants in specific syndicated loan *i*.

In the next step, I multiply w_{jkt} by lenders' leverage at time *t* and interpret w_{jkt} as the measure of importance of each lender to the capital structure decision of a borrower. In contrast to the loan portfolios, information on the leverages of lenders is observable. I denote the leverage of bank *j* at time *t* as Y_{jt}. I compute the average of *j* (*j=1…J*) lenders' leverage for each borrower *k* (Y^*_{kt}**)** at time *t* as follows:

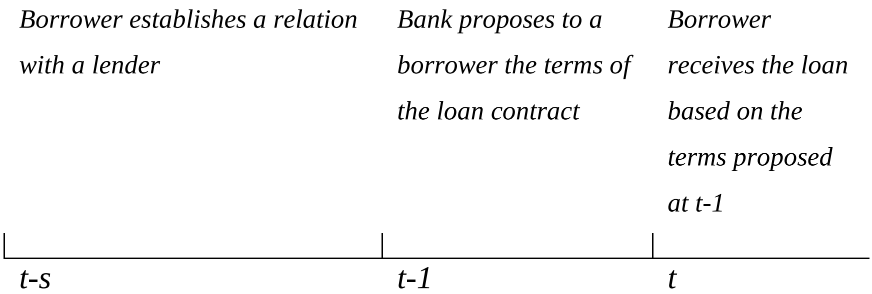
$$Y^*_{kt} = \sum_{j=1}^{J} w_{jkt} \, Y_{jt}. \quad (4)$$

The larger the amount of a loan that a borrower received from a lender, the greater the weight of this lender in the average of lenders' leverage Y^*_{kt}. A syndicated loan implies that the initial terms and conditions of the contract are designed by the lead arranger and then sold to other participants in the syndicate. A bank decides to participate in the syndicate only if it finds the terms of the contract to be such that they maximize the value of the firm; otherwise, the bank would be competed out of business. The decisions on changing the terms of a contract are made only by all the lenders or by their majority. A lender with a larger amount of loan allocation within a syndicate is more concerned about the borrower paying back the loan. Consequently, a lender with a larger allocation is more concerned about adjusting the loan terms such that they would maximize the borrower's firm value. The leverage of such a lender has a greater weight (w_{jkt}) in the average of lenders' leverage for a particular borrower (Y^*_{kt}).

Importantly, I assume that the termination of the syndicated contract is costly for both borrowers and lenders and that both lenders and borrowers will adjust their financing and lending policies to each other rather than terminate the relation. There are two reasons why borrowers and lenders prefer a long-term relation. Firstly, banks always exert as much effort as possible to retain good customers. Retaining as many customers as possible for a long period ensures the profitability and existence of a bank. Secondly, changing the bank relationship is costly for borrowers as well. For example, Petersen and Rajan (1994) show that building close ties with an institutional creditor leads to an increase in the availability of financing. They argue that borrowers' attempt to widen the circle of the relationship increases the price of credit and reduces the availability. Boot (2000) states that relationship banking can facilitate a Pareto-improving exchange of information between the bank and the borrower, because it permits the utilization of non-contractable information and facilitates an implicit long-term relation.

2.3.4 Description of the model

After computing the weighted average of lenders' leverage and assuming that the termination of the syndicated contract is costly for both borrowers and lenders, in this section I describe the timeline and intuition behind the model. The empirical model implies the following timeline in the borrower–lender relationship:



for t=1…T and s=1…S.

At time t-s a bank and a firm establish their relation, and at time t-1 the firm plans its financing investment for time t either through debt or through equity. The firm can borrow from its relationship bank or from other lenders. I assume that the relationship bank has information superiority and, other things being equal, provides better financing terms for the borrower. Therefore, the borrower would prefer to receive the loan from its relationship bank than from other banks. If the relationship bank charges high interest rates due to its low leverage, I expect a borrower to prefer equity financing.

If a borrower expects the financing terms from the relationship bank to be such that they will maximize the borrower's value, he applies for a loan from this bank at time t-1. When a borrower applies for a loan, the bank provides the loan as the sole lender or arranges a syndicate. In this empirical model, I only consider the loans that banks issue through syndicated contracts. The bank analyses the existing history of its relation with the borrower and the expected cash flows from the investment, as well as the costs of its own funding and the costs for potential participants in a syndicate. After consideration of the costs and benefits of a particular loan at *t*-1, the bank prepares a syndicated loan contract and finds other banks that are willing to participate in the syndicate. If the financing conditions are such that they maximize the borrower's value, the borrower and lenders sign a loan contract at time *t*.

At time *t* the borrower receives the loan and the lenders allocate the respective part of the syndicated loan on their balance sheets. One of the participants in the syndicate plays the role of a contact point and collects and distributes the financial information that the participants need for monitoring. One or several banks (lead arrangers) have the most information about the borrower, but all the participants in a syndicate make their own assessment of the borrower's financial conditions. That is why I use the relation established between the borrower and the banks through syndicated loans as a proxy for firms' banking network. If necessary, all the participants in a syndicate (or the majority of them) make the decision to change the terms of the loan contract to maximize the borrower's firm value and extract the surplus from the borrower's cash flow.

According to Gornall and Strebulaev (2015), the effect of lenders' leverage on firms' leverage is non-linear, depending on the level of lenders' leverage.[10] For moderately high levels of lenders' leverage, borrowers receive more tax benefits and borrow more from their lenders (the strategic complementarity effect). For very high levels of lenders' leverage, firms stop borrowing from their lenders, because the distress costs in the case of bankruptcy are too high (the strategic substitution effect). For very low levels of lenders' leverage (but high enough to transfer tax benefits), the probability of bankruptcy and hence the borrowing costs are low and firms borrow more from a lender. Leaving the analysis of non-linearity for further stages of this research, I start the analysis by identifying whether a linear relation exists between the lenders' and the borrowers' leverages. In other words, I assume that the trade-off theory holds, tax benefits are important for the firm's financial decisions, tax benefits originate only at the bank level and the bank transfers the tax benefits to borrowers by issuing loans.

[10] Later on in the empirical analysis, I will distinguish between deposit, non-deposit and total bank liabilities as the measure of bank leverage, but so far by leverage I mean, more generally, the amount of external financing used to finance a bank's assets.

The hypothesis that I test in this study is the following: lenders' leverage has a positive effect on the leverage of their borrowers because debt benefits originate only at the lenders' level and higher leverage of lenders leads to more debt benefits and higher leverage of borrowers.

In this empirical model, at time t a borrower makes a decision on his capital structure by trading off the distress costs and tax benefits of his own debt and the distress costs and tax benefits of his banking network by analysing the information available at time *t-1*. The borrower does not observe the distress costs and tax benefits of the banking network directly but rather makes decisions based on the financing terms that his banking network provides. The financing terms that the banking network provides depend on the level of bank leverage. Banks with higher leverage are able to provide their clients with lower interest on loans, because such banks pay less tax on their income and have a higher surplus, which they can pass on to borrowers through better financing conditions. If the banking network charges high interest rates due to its low leverage, I expect a borrower to prefer equity financing.

This empirical model assumes that the leverage ratio of borrower k at time t (Z_{kt}) linearly depends on the weighted leverage of his lenders' leverage (Y^*_{kt-1}) at time *t-1*. I focus on the linear specification of the model to emphasize the intuition; later on I allow for non-linearity by testing whether the relation between borrowers' and lenders' leverages differs for high and low levels of lenders' leverage.

The empirical model is as follows:

$$Z_{kt} = \beta_0 + \beta_1 Y^*_{kt-1} + \boldsymbol{\beta_2} \boldsymbol{X}^B_{kt-1}, \qquad (5)$$

where Z_{kt} is the leverage of borrower *k* at time *t* computed as the ratio of total debt to total assets, and I expect coefficient β_1 to have a positive sign; Y^*_{kt-1} is the weighted average of lenders' leverages for borrower *k*; and $\boldsymbol{X}^B_{kt-1}$ is the matrix of borrower-specific control variables. Section 2.4 describes how Z_{kt} is defined and what is included in $\boldsymbol{X}^B_{kt-1}$.

2.4 Econometric model

To test for the borrower–lender relation, I construct a panel of borrower–year observations and estimate fixed-effect panel data regressions of the borrowers' leverage on the weighted average of the lenders' leverage and a number of control variables. The model that I estimate is as follows:

$$Z_{kt} = \beta_0 + \beta_1 Y^*_{kt-1} + \beta_2 \boldsymbol{X}^B_{kt-1} + \beta_k + \beta_t + u^B_{kt} , \qquad (6)$$

where Z_{kt} is the leverage of borrower k at time t, β_0 is constant, Y^*_{kt-1} is the weighted average of lenders' leverages as described in section 2.3.3, $\boldsymbol{X}^B_{kt-1}$ is a matrix of borrower-specific control variables that I describe in the next paragraph, β_k is the borrower's fixed effect, β_t is the time fixed effect and u^B_{kt} is a borrower-specific error term. I define the dependent variable Z_{kt} in two different ways:

book leverage=the book value of debt (long-term debt plus debt in current liabilities) divided by the total assets;

market leverage=the book value of debt divided by the market value of assets (market value of equity plus book value of debt).

In my definition of leverage, I follow numerous studies from the literature on firms' capital structure (see for example Korajczyk and Levy, 2003). I use three different measures of lenders' leverage: debt to book assets, total liabilities to assets and deposits to assets. Bank debt includes: short-term borrowings; the current portion of long-term debt; the current portion of capital leases; long-term debt; federal home loan bank debt; capital leases; and trust preferred securities. It does not include deposits.

The control variables in matrix $\boldsymbol{X}^B_{kt-1}$ are the borrower-specific determinants of the capital structure according to previous studies (Fama and French, 2002; Jandik and Makhija, 2001; Korajczyk and Levy, 2003; Leary and Roberts, 2014). I summarize the control variables, their definitions and their expected signs in Table 1.

Table 1 Control variables for borrower–lender regression: Proxies, expected sign and rationale for the predictions

Determinant of Capital Structure	Proxies Used in this Study	Expected Sign	Rationale for the Expected Sign
Profitability	Operating income before depreciation, tax and interest expenses	+/-	More profitable firms have more book leverage (trade-off model); controlling for investment opportunities, firms with more profitable assets have less market leverage (pecking order model)
Investment Opportunities	Market value of the firm/book value of the firm	-/+	Controlling for profitability, firms with larger investments have lower book and market leverage (trade-off model); given the profitability, firms with more investments have more book leverage (pecking order model)
Collateral	Net property plant and equipment/total assets	+	More collateral allows firms to issue more debt and increase their leverage
Size	Natural logarithm of sales	+	The expected costs of financial distress are likely to be lower for large (arguably older and more stable) firms (Weiss, 1990) and hence larger firms can issue more debt
Risk	Volatility of earnings computed as a standard deviation of earnings for the past five years	-	Higher volatility of earnings can signal an unstable environment and debt providers can be reluctant to issue debt

2.5 Data and empirical results

2.5.1 Description of the data and summary statistics

To relate borrowers to lenders, I use DealScan, a database that provides historical information on the terms and conditions of syndicated loans in the global commercial market. DealScan provides information on the amount, maturity, payment schedule and participants of each loan, but it lacks data on the financial statements of the firms. To include financial statements' information in the analysis, I link DealScan with Compustat North America and S&P Capital IQ. I download most of the information for the borrowers from Compustat North America using the matching provided by Chava and Roberts (2008).[11] I perform hand matching of lenders with S&P Capital IQ, because this database allows the information to be found easily, even if the firm has been renamed or merged. I match lenders by their name, country and state (for the United States), SIC code and parent's firm name. The sample period is from 1995 to 2014, because most of the information in DealScan is available for this period. The sample with non-missing data for all the variables consists of around 952 borrowers,[12] with an average of 3.7 observations per borrower and around 1000 lenders. To use all the available information, I apply an unbalanced panel approach. Furthermore, as the number of observations varies from variable to variable, the number of observations differs for different specifications throughout the analysis.

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans. The upper panel of Figure 1 illustrates that the majority of the sample consists of North American firms (66.41% of

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[11] This sample is much smaller than the sample of Chava and Roberts (2008), because they match only borrowers in DealScan with Compustat. In my case, in addition to information on the borrower's financial statement, I need information on his bank's financial statement; I also need to know the amount that each lender allocates to a borrower within a syndicate. These two additional restrictions on the inclusion in the sample reduce the sample considerably relative to the sample of Chava and Roberts (2008).

[12] The number of borrowers and lenders differs depending on whether the dependent variable is book or market leverage.

the sample); Asian and European firms comprise 20.96% and 9.45%, respectively. Around 66% of the North American firms are from the USA; the majority of the Asian firms are from Taiwan (3.51%) and Hong Kong (4.19%). The European firms are mostly from countries that are members of the European Union. Appendix 2 lists the frequencies of observations for different countries in our sample. This study is the first to analyse firms from different regions in one sample. Data from different regions allow the investigation of the differences in capital structure in general rather than the differences in capital structure within a particular region or country. To account for the heterogeneity of firms from different countries, I control for time-invariant, firm-specific characteristics using fixed-effect panel regression.

The lenders are financial companies that are identified in DealScan as lenders and that provided loans for the borrowers in our sample. The lower panel of Figure 1 illustrates the geographical distribution of the lenders; the majority of the sample consists of North American companies (41.28%) and Asian companies (32.31%). The majority of the lenders are banks: commercial banks (SIC 602) constitute 61% of the sample, foreign banking and branches and agencies of foreign banks (SIC 608) account for 17% and business credit institutions make up around 6%. The rest of the sample is distributed among 23 different financial industries.

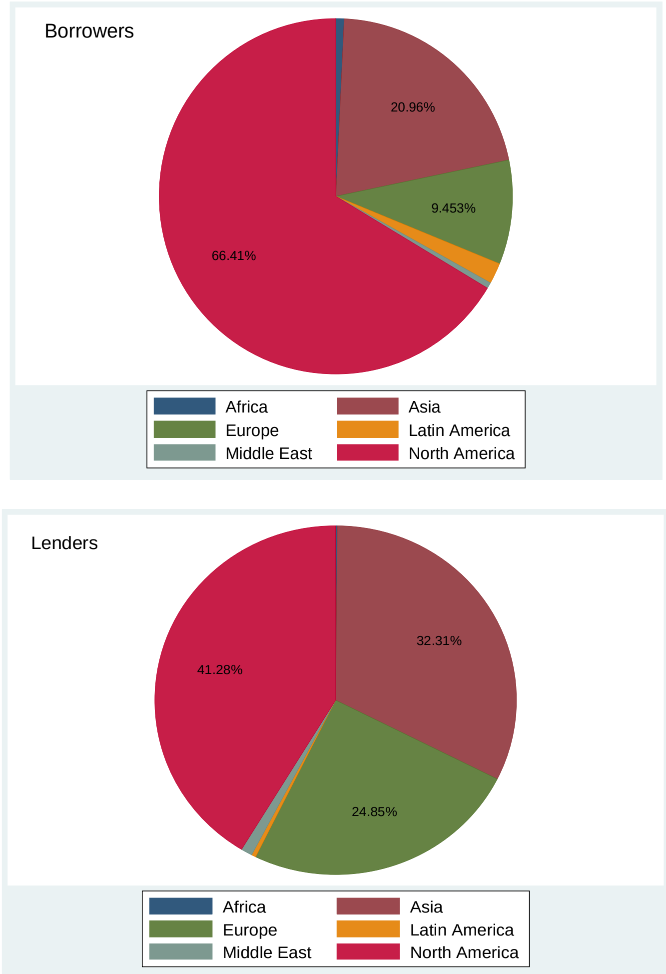


Figure 1 Distribution of the borrowers and lenders over the geographical regions

The industry distribution of the borrowers in the sample is diverse. The sample includes 58 industries as measured by the standard industry classification (SIC) with two-digit codes. Figure 2 presents a histogram of the borrowers' industry distribution. As the histogram illustrates, none of the industries dominate the sample considerably: the percentage of the most frequently observed industry (SIC 48 “Communications”) is around 11%. The second most frequent industry is SIC 36 (“Electronic and Other Electrical Equipment and Components, except Computer Equipment”) with 7.2%, and the third most frequent industry is SIC 73 (“Business Services”) with 5.6%. As similar factors affect the financial policies of the firms within an industry, we exclude financial firms from the sample of borrowers to avoid potential endogeneity.

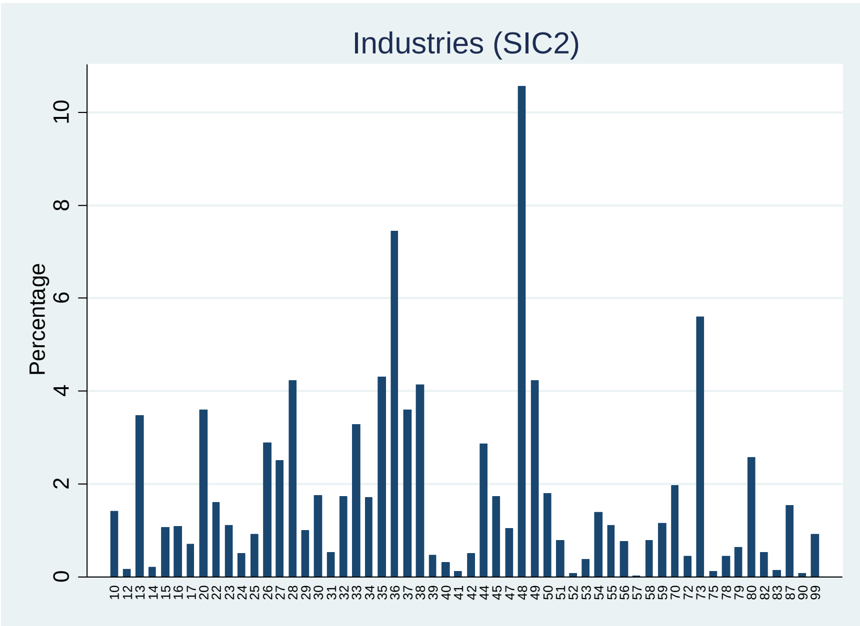


Figure 2 Industry distribution of the borrowers in the sample

Table 2 presents the descriptive statistics. To mitigate the influence of extreme observations, I Winsorize all the variables at the first and ninety-ninth percentiles. The upper part of Table 2 shows the descriptive statistics for the dependent variables and borrower-specific control variables; the lower part of the table shows the statistics for the lender-specific regressors. Similar to previous studies (see for example Frank and Goyal, 2009; Jandik and Makhija, 2001), the non-financial firms in our sample finance with debt around 38% of the book value and around

42% of the market value of assets. The average profitability (EBITDA to assets), market to book, tangibility and size are similar to those found in previous studies. These similarities indicate that this sample is an unbiased selection from a population. Similar to Jandik and Makhija (2001), I measure risk as the standard deviation of the percentage change in firms' operating income for the past five years, including the year of interest. Some authors (Frank and Goyal, 2009) measure risk as the variance of stock returns, but I prefer to use the standard deviation in operating income because more data are available for the latter measure. The lower part of Table 2 presents the descriptive statistics for the weighted averages of lenders' leverages (section 2.3.3 explains the computation of the weighting). In contrast to borrowers, lenders have a large proportion of liabilities on their balance sheets: they finance around 70% of their assets with liabilities (deposits and non-deposit liabilities). On average, the proportion of deposits to total assets is 47.17%, while the proportion of debt to total assets (lenders' leverage) is only around 18.57%. Appendix 3 presents the correlation matrix for all the variables. To use all the available information, I apply an unbalanced panel approach. As the number of observations varies from variable to variable, it differs for different specifications throughout the analysis.

Table 2 Descriptive statistics

The table presents the number of observations, means, standard deviations (Std Dev.), minimums (Min.) and maximums (Max.) for the variables used in the analysis. The sample of borrowers consists of non-financial firms identified as borrowers and the sample of lenders consists of financial firms identified as lenders in DealScan. Size is measured as the natural logarithm of sales. All the sales are converted into US dollars by the exchange rate as of the end of the corresponding year. Appendix 1 provides the definitions of the variables. All the variables, except the macroeconomic variables, are Winsorized at the first and ninety-ninth percentiles. The upper part of this table shows the dependent variables and borrower-specific control variables; the lower part of the table shows the lender-specific regressors and macroeconomic variables. All the variables except risk and size are in percentages. The number of observations and values of descriptive statistics are for the baseline regression. The number of observations can vary for different specifications in the analysis, because I analyse an unbalanced panel and the number of observations differs from variable to variable.

	Mean	Std Dev.	Min.	Max.
Borrower-Specific Factors				
Book Leverage	37.465	23.493	0.001	117.710
Market Leverage	42.612	29.475	0.001	100.000
EBITDA to Assets	11.215	8.677	-20.699	38.124
Size	6.781	1.855	-0.356	11.050
Market to Book	121.923	101.680	0.638	781.329
Tangibility	32.889	23.376	0.016	89.368
Risk	1.650	4.542	0.039	37.055
Lender-Specific Factors				
Lenders’ Book Leverage	18.570	12.146	0.002	49.301
Lenders’ Liabilities to Assets	70.089	21.334	0.639	95.403
Lenders’ Deposits to Assets	47.169	16.129	0.127	78.376
Macroeconomic Variables				
GDP Growth	1.878	2.021	-5.579	14.162
LIBOR	2.724	2.231	0.198	6.464
N	3558			

A crucial assumption of the empirical model is that deductibility of interest expenses from taxable income plays an important role in firms’ capital structure decisions. The sample is international and corporate tax rates can vary between different countries, but interest on debt is normally deductible from taxable income in all the countries around the world. For more details on tax rules in different countries, see for example Spengel and Zöllkau (2012, p. 79) and Blouin et al. (2014). As I describe in section 2.6.1, to capture the differences in tax policies and institutional settings among different countries, I include the region dummies in the model. Including country dummies would capture the differences among the countries even better, but the number of observations in the sample does not allow the inclusion of an additional 1000 dummies in the model. I reckon that region dummies are able to capture the differences in tax policies among the countries, because the tax policies in the same economic regions are usually similar. For example, the member states of the European Union are closely connected by trade activities, and in most cases the tax policies on the national level take into account the tax policies in other member states. Moreover, the European Commission is actively working to determine the rules for a common consolidated tax base for the EU-wide activities of multinational companies. In addition, the majority of the sample consists of American companies, and I define a separate dummy for the USA. I create the following regions and corresponding dummies for them: the USA; Asia (the Asia region includes Indonesia, South Korea, the Marshal Islands, Malaysia, the Philippines, Singapore, Thailand, Taiwan and Vietnam); China; Hong Kong; the European Union (EU); and the South of the EU (Italy, Spain, Portugal and Greece).

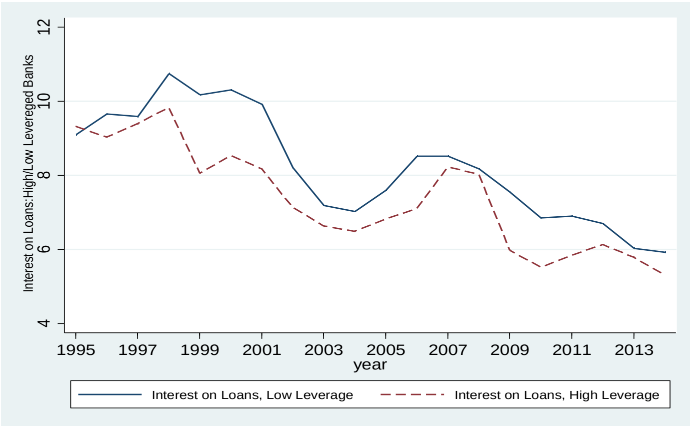
I also want to emphasize that in this study I do not focus on the direct effect of changes in tax policies on the borrowers' leverage. The main purpose is to explore the effect of lenders' leverage on the leverage of their borrowers, and I use the tax argument only to justify the existence of this effect, following the discussions in Gornall and Strebulaev (2015), who use tax benefits and bankruptcy costs to develop their model of financing as a supply chain. However, as Gornall and Strebulaev (2015) note, their framework of risk reduction and supply chain mechanism is general and valid in the presence of other incentives to issue debt. In their model any alternative debt benefits should also be passed on from lenders to borrowers.

2.5.2 Leverage and interest on loans

In this study I test the empirical hypothesis about the positive effect of lenders' leverage on the leverage of their borrowers. This positive relationship is justified by the theoretical discussion that banks with higher leverage charge lower interest on loans. High leverage allows banks to deduct more interest expenses and increase the surplus, which they can pass on to the borrowers. The lower interest on loans allows banks' customers to borrow more; hence, higher leverage of banks corresponds to higher leverage of their borrowers. As the assumption of low interest on loans in highly leveraged banks creates the ground for a relationship between lenders' and borrowers' capital structures, I start the empirical analysis by testing whether the data confirm the negative relationship between leverage and interest on loans. I define interest on loans as the ratio of interest income from loans to gross loans. I divide the sample of lenders into two groups: lenders with high leverage (with liabilities to assets above the median) and lenders with low leverage (with liabilities to assets below the median).

The upper part of Figure 3 shows the graphs of the interest on loans (average over time) for these two groups for the entire sample, and the lower part of the figure shows graphs only for the USA, because American banks constitute the largest part of our sample. As the upper part of Figure 3 demonstrates, banks with high leverage on average charge lower interest rates on their loans. The lower part of Figure 3 demonstrates a similar pattern for the sample of American firms, and the gap between the interests on loans for banks with high and low leverage is even larger here. To make sure that the means of interest on loans are statistically different for banks with high and low leverage, I also perform a statistical mean difference test for the whole sample. Table 3 presents the results of the *t* test on the equality of the means of interest on loans for banks with high and low leverage. The null hypothesis of this test is that the difference between the means of the two groups is equal to zero. I reject the null hypothesis at the 95% confidence interval, since the *p*-value of the test is smaller than the 5% significance level.

The lower interest on loans that highly leveraged banks charge their borrowers is one of the important prerequisites for a positive effect of lenders' leverage on the leverage of their borrowers in this study. As the sample confirms that highly leveraged banks charge lower interest on their loans, I can proceed with the analysis of the main hypothesis of the study and test whether the leverage of lenders affects the leverage of their borrowers positively.



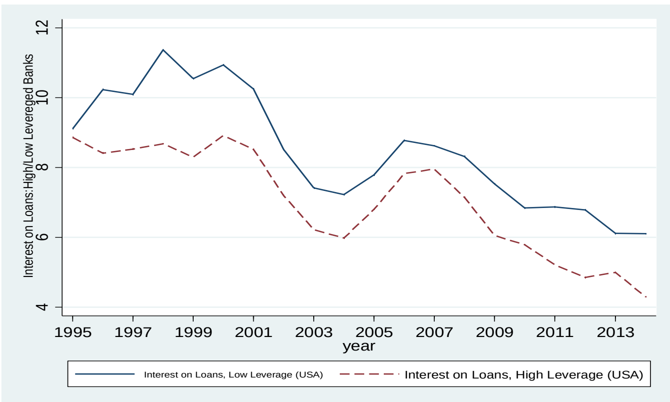


Figure 3 Average interests on loans for the entire sample of lenders and lenders from the USA, grouped by high and low leverage levels

Table 3 Mean difference test for banks with high and low leverage

The table presents the means, standard deviations (Std Dev.), standard errors (Std Err.), 95% confidence interval, t statistics and p-value for the mean difference test for the banks with high and low leverage. Banks are lenders for the non-financial companies in our sample for which information on the interest income on loans is available. The null hypothesis for this test is that the difference in means between the two groups is equal to zero.

Group	Observations	Mean	Std Err.	Std Dev.	[95% Confidence Interval]	
High Leverage	9162	7.678	0.062	5.949	7.556	7.800
Low Leverage	8927	8.042	0.057	5.473	7.929	8.156
Combined	18089	7.858	0.042	5.722	7.775	7.941
Difference		-0.363	0.085		-0.530	-0.197

Difference=mean (high leverage)–mean (low leverage); Ho: difference=0; Ha: difference≠0

t=-4.5135, degrees of freedom=18036, Pr(|T|>|t|)=0.0000

2.5.3 Effect of the lenders' leverage on the leverage of their borrowers

Previous research on banks' leverage uses total liabilities to assets as the main variable of interest (see for example Gropp and Heider, 2010). I use lenders' leverage (total debt to total assets) as the main regressor, because it is best suited to testing the hypotheses of this study for the following two reasons. Firstly, lenders' leverage defined as total debt to total assets is consistent with the definition of borrowers' leverage. Secondly, if lenders' and borrowers' leverages are related through the tax benefits of debt, the use of total liabilities is not appropriate, as they also include non-interest-bearing liabilities and deposits. Non-interest-bearing liabilities do not provide tax benefits, and banks do not choose deposits solely because of tax benefits; rather, the deposits reflect the traditional functions of banks. Borrowers' total debt is the sum of long-term debt and debt in current liabilities. Long-term debt includes all the obligations that require interest payments, mortgages and similar debt, and debt in current liabilities includes different types of bank loans. However, both long- and short-term debt include non-bank debt as well, and that is why the effect of lenders' leverage on the leverage of their borrowers can be underestimated.

Table 4 Estimation of the effect of lenders' leverage (book leverage) on the leverage of their borrowers

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans by DealScan. The lenders are financial firms, mostly banks. All the independent variables except for risk are lagged by one year. Risk is the standard deviation of the percentage change in the operating income for the past five years and already reflects the information on the past activities of a firm. In Panel A the dependent variable is debt scaled by total assets, and in Panel B the dependent variable is total debt scaled by the market value of assets. Appendix 1 provides definitions of the variables. The standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. All the variables are Winsorized at the first and ninety-ninth percentiles. The table shows the results of estimating the following equation, with $\mathrm{Y}^*_{\mathrm{kt}-1}$ as lenders' average debt to assets and Z_{kt} as borrowers' debt to book assets (Panel A) and borrowers' debt to market value of assets (Panel B):

$$Z_{kt} = \beta_0 + \beta_1 Y^*_{kt-1} + \beta_2 \boldsymbol{X^B_{kt-1}} + \beta_k + \beta_t + u^B_{kt}$$

	(1)	(2)	(3)	(4)	(5)
Panel A: Book Leverage					
Lenders' Book Leverage	0.139**	0.136*	0.128*	0.122*	0.120*
	(0.068)	(0.070)	(0.070)	(0.073)	(0.068)
Size		-0.319	0.018	-0.051	1.830*
		(0.757)	(0.785)	(0.829)	(0.950)
Tangibility			0.205***	0.191***	0.109
			(0.057)	(0.060)	(0.068)
Market to Book				-0.004	0.006
				(0.005)	(0.006)
EBITDA to Assets					-0.360***
					(0.069)
Risk					0.016
					(0.143)
Constant	36.390***	38.446***	29.344***	30.384***	29.965***
	(1.300)	(5.303)	(6.367)	(6.898)	(6.817)
Observations	4402	4332	4320	4140	3558
R^2	0.003	0.003	0.018	0.016	0.079
Adjusted R^2	0.003	0.003	0.017	0.015	0.073
Panel B: Market Leverage					
Lenders' Book Leverage	0.028	-0.006	-0.009	-0.021	0.059
	(0.105)	(0.102)	(0.103)	(0.087)	(0.083)
Size		2.043*	2.354*	1.249	5.668***
		(1.221)	(1.212)	(1.035)	(1.051)
Tangibility			0.256***	0.239***	0.140*
			(0.090)	(0.082)	(0.076)
Market to Book				-0.071***	-0.056***
				(0.012)	(0.017)
EBITDA to Assets					-0.508***
					(0.106)
Risk					-0.157
					(0.212)
Constant	45.203***	32.009***	21.236**	37.994***	17.168**
	(1.990)	(8.208)	(9.335)	(8.357)	(8.664)
Observations	3962	3914	3911	3882	3479
R^2	0.000	0.018	0.034	0.076	0.258
Adjusted R^2	0.000	0.017	0.033	0.075	0.253
Borrower Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	No	No	No	Yes

Panel A of Table 4 presents the results of the estimation of equation (6) with the dependent variable equal to total debt to total assets. The standard errors in all the estimations in this study are adjusted to heteroskedasticity and within-borrower dependence and are in parentheses. Columns (1)–(5) present the estimation results for different specifications. The specification in the first column has only one regressor (lenders' book leverage), and the fifth column presents the model with all the control variables as described in Table 1. The coefficient on lenders' book leverage is positive and significant in all the specifications. Keeping the effect of size, tangibility, market to book, profitability and risk fixed, a 1 percentage point increase in the average of lenders' leverage corresponds to an increase of 12 basis points in borrowers' leverage.[13] Combined with the descriptive statistics in Table 2, it is possible to say that a 1 standard deviation (12.15%) increase in lenders' average leverage corresponds to a 1.5% increase in their borrowers' leverage. This result confirms the main hypothesis of the study about the positive effect of lenders' leverage on the leverage of their borrowers. It is necessary to keep in mind that this coefficient might be underestimated due to the measurement error in the dependent variable and the regression attenuation bias. Moreover, by using the weighted average of lenders' leverage, only part of the lender–borrower relation observed through syndicated lending is measured, and exhaustive information is not observed on the relation between borrowers and lenders.

The magnitude of the coefficient on lenders' leverage is comparable to the magnitude of the firm-level control variables, and the coefficients of the control variables confirm some findings from previous studies. For example, the positive effect of size and the negative effect of profitability are similar to the results obtained by Frank and Goyal (2009) and Leary and Roberts (2014). In this case a 1% increase in size, measured as the logarithm of total sales, corresponds to a 1.82% ((ln(1.01)*1.83)*100) increase in borrowers' leverage. The effect of size is non-linear and economically more significant for smaller firms. Consider, for example, firm k_1 with sales of 50 million and firm k_2 with sales of 1000 million,

[13] A basis point is equal to 1/100th of 1% or 0.01% (0.0001); 1%=100 basis points.

both of which increase their sales by 10 million. The increase of 10 million for firm k_1 corresponds to a 20% increase in its sales, and the 10 million increase for firm k_2 corresponds to a 1% increase in its sales. Correspondingly, the increase in leverage for firm k_1 is 33% ((ln(1.2)*1.83*100) and for firm k_2 is 0.33 % (ln(1.01)*1.83*100). The coefficient for profitability (-0.36) is negative and significant, which implies that a 1 standard deviation increase in profitability (8.68%) leads to a 3.12% decrease in firms' leverage. One of the explanations for the negative effect of profitability is that firms passively accumulate profits that they can use to finance investment instead of issuing debt (Kayhan and Titman, 2007).

Considering the results for market leverage as the dependent variable (Panel B of Table 4), the coefficient of lenders' leverage is statistically and economically insignificant. One of the explanations for this insignificance is the way in which market leverage is defined. Similar to previous research, market leverage is defined as the ratio of the book debt to the market value of assets. The market value of assets is the sum of market capitalization and the book value of debt. Remarkably, in contrast to the regression using book leverage, the coefficient of market to book is highly significant as well as the effect of size and profitability being much higher. Market to book, profitability and size have a substantial effect on the stock price. Since the market value of assets is a function of stock prices, it is ambiguous whether the coefficients in the regression explain the variation in market leverage or whether they capture the factors that determine the stock prices.

Table 5 illustrates the results of the estimation of equation (6) with two alternative measures of lenders' leverage: total liabilities to assets and deposits to assets. As expected, the coefficients of both alternative measures of leverage are statistically and economically insignificant. The explanation for this insignificance is that the total liabilities also include non-interest-bearing liabilities, which do not provide debt benefits for borrowers. We also doubt whether deposits provide tax benefits of debt, because deposits reflect traditional banking operations, rather than banks choosing deposits solely because of tax benefits.

Table 5 Estimation of the effect of lenders' leverage (total liabilities to assets and deposits to assets) on the leverage of their borrowers

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans by DealScan. The lenders are financial firms, mostly banks. All the independent variables except for risk are lagged by one year. As risk is the standard deviation of the percentage change in the operating income for the past five years, it already reflects the information on the past activities of a firm. In columns (1)–(2) the dependent variable is debt scaled by total assets, and in columns (3)–(4) the dependent variable is total debt scaled by the market value of assets. Appendix 1 provides definitions of the variables. The standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses. All the variables, except for the macroeconomic variables, are Winsorized at the first and ninety-ninth percentiles. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. The table shows the results of estimating the following equation, with Y^{*}_{kt-1} as lenders' average liabilities to assets or deposits to assets:

$$Z_{kt} = \beta_0 + \beta_1 Y^{*}_{kt-1} + \beta_2 \boldsymbol{X^{B}_{kt-1}} + \beta_k + \beta_t + u^{B}_{kt}$$

	(1) Book Leverage	(2) Book Leverage	(3) Market Leverage	(4) Market Leverage
Lenders' Liabilities to Assets	-0.005		-0.043	
	(0.034)		(0.031)	
Lenders' Deposits to Assets		0.012		-0.075
		(0.048)		(0.052)
Size	1.938*	1.973*	1.938*	1.973*
	(1.003)	(1.015)	(1.003)	(1.015)
Tangibility	0.099	0.122*	0.174**	0.203***
	(0.068)	(0.068)	(0.070)	(0.071)
Market to Book	0.002	0.004	-0.047***	-0.045***
	(0.007)	(0.007)	(0.013)	(0.014)
EBITDA to Assets	-0.318***	-0.335***	-0.491***	-0.516***
	(0.072)	(0.074)	(0.095)	(0.099)
Risk	-0.018	0.048	-0.018	0.048
	(0.140)	(0.137)	(0.140)	(0.137)
Constant	32.330***	30.927***	32.330***	30.927***
	(6.987)	(6.952)	(6.987)	(6.952)
Observations	3679	3505	3601	3427
R^2	0.072	0.070	0.256	0.257
Adjusted R^2	0.066	0.064	0.251	0.251
Borrower Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes

The results presented in Table 4 confirm the existence of a linear effect of lenders' leverage on the leverage of their borrowers. However, the borrower–lender capital structure relationship can be non-linear depending on different levels of lenders' indebtedness. For example, if a lender has too many debt obligations, a borrower might not be willing to issue more debt from this lender because of the high riskiness of this lender and the implied distress costs. On the other hand, if the lender's leverage is too low, the borrower would not issue due debt because of the higher interest on loans that such a lender would charge. The next section presents the tests for the presence of non-linearity in the lender–borrower relationship.

2.5.4 Non-linearity in relation of the financing decisions of borrowers and lenders

This section moves beyond the linear specification of the baseline model and tests for the presence of a non-linear relationship in the financing decisions of lenders and their borrowers. It first discusses the theoretical background behind the non-linear relationship and then presents the empirical test.

According to Gornal and Strebulaev (2015), banks' and borrowers' financing decisions are both strategic complements and strategic substitutes. The strategic complementarity implies that banks with lower leverage pay higher taxes and charge higher interest on loans to make up for the tax burden. Borrowers' interest payments generate net tax benefits only to the extent that their banks avoid paying taxes on the interest payments received from borrowers. For example, if a bank cannot pass any tax benefit on to a borrower (all-equity bank) and the firm's interest deductions are effectively the bank's taxable income, the presence of distress costs implies that the borrower does not issue debt at all. For relatively low bank leverage, this strategic complementarity effect dominates and reduces the total indebtedness of the economy.

The strategic substitution effect is connected to the distress costs arising from having debt. Higher bank leverage increases the risk of the bank's failure and increases its distress costs. The strategic substitution effect dominates for banks with relatively high leverage, but extremely high leverage translates into instability and higher borrowing costs and decreases borrowers' incentives to issue more debt.

To summarize, the strategic complementarity and substitution effects imply a non-linear effect of lenders' leverage on the leverage of their borrowers. For moderate levels of bank leverage, higher leverage of lenders corresponds to higher leverage of borrowers, because higher leverage of banks implies cheaper financing for borrowers due to the tax benefits. If a bank's leverage is too high, borrowers issue less debt due to the increased probability of bank failure and the implied higher costs of borrowing for a firm. If a bank's leverage is too low, the borrower issues less debt due to the higher costs of borrowing that the bank charges a borrower due to the bank's own tax burden.

The remainder of this section presents an empirical test for the presence of non-linearity in the relation between banks' and borrowers' financing decisions. Following the predictions of Gornall and Strebulaev (2015), we expect to find a negative effect of lenders' leverage on the leverage of their borrowers for extremely high or extremely low levels of banks' leverage.

In section 2.3.3 I formulate an empirical hypothesis about the positive effect of lenders' leverage on the leverage of their borrowers and test this hypothesis for all the lenders in the sample. In this section I split the entire sample into two groups: lenders with low leverage and lenders with high leverage. In contrast to the empirical hypothesis from section 2.3.3 and the results presented in section 2.5.3, in this section I expect to find a negative effect of lenders' leverage on the leverage of their borrowers according to the arguments presented at the beginning of this section.

To distinguish between lenders with high and low leverage, I introduce into the model an extreme leverage dummy (D_{kt}) for high- and low-leveraged banks. I define banks as having low leverage if the values of total liabilities to assets for these banks fall below the twenty-fifth percentile, and I define banks as highly leveraged if the values of their total liabilities to assets are above the seventy-fifth percentile. Dummy D_{kt} takes the value of 1 if the bank's ratio of total liabilities to assets in the sample is lower than 0.57 (the value at the twenty-fifth percentile) and the value of 0 if the bank's ratio of liabilities to assets takes the value of 0.89 (the value at the seventy-fifth percentile). I include D_{kt} and its interaction with the debt-to-assets ratio or total liabilities-to-assets ratio in the baseline model and estimate the following equation:

$$Z_{kt} = \beta_0 + \beta_k + \beta_1 Y^*_{kt-1} + \boldsymbol{\beta_2} \boldsymbol{X}^B_{kt-1} + \beta_3 D_{kt} + \beta_4 D_{kt} Y^*_{kt-1} + \beta_t + u^B_{kt}\,. \quad (7)$$

Columns (1) and (2) of Table 6 present the results of the estimation of equation (7). In column (1) - Y^*_{kt-1} is the lenders' liabilities-to-assets ratio, and in column (2) - Y^*_{kt-1} is the lenders' book leverage (debt-to-assets ratio). As the estimation results illustrate, the extreme leverage dummy and its interaction terms with Y^*_{kt-1} are statistically insignificant. This implies that lenders with extremely high and low leverage do not differ statistically in their impact on the borrowers' leverage and the data do not confirm empirically the presence of non-linearity in the financing decisions of borrowers and their lenders.

Table 6 Testing for non-linearity in the effect of lenders' leverage on the leverage of their borrowers

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans by DealScan. The lenders are financial firms, mostly banks. All the independent variables except for risk are lagged by one year. Risk is the standard deviation of the percentage change in the operating income for the past five years and already reflects the information on the past activities of a firm. Appendix 1 provides the detailed definitions of the variables. The standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses. All the variables are Winsorized at the first and ninety-ninth percentiles. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. The dependent variable is borrowers' book value of the debt-to-assets ratio. Columns (1) and (2) present the results of the estimation of equation (7), column (1) shows the results with lenders' liabilities to assets as the main variable of interest and column (2) shows the results with lenders' book leverage as the main variable of interest; the extreme leverage dummy equals 1 if the bank's ratio of total liabilities to assets is lower than 0.57 (twenty-fifth percentile) and the value of 0 if the bank's ratio of liabilities to assets takes the value of 0.89 (seventy-fifth percentile).

	(1) Book Leverage	(2) Book Leverage
Lenders' Liabilities-to-Assets	-0.026	
	(0.057)	
Lenders' Liabilities-to-Assets*Extreme Leverage Dummy	0.086	
	(0.079)	
Lenders' Book Leverage		0.021
		(0.094)
Lenders' Book Leverage*Extreme Leverage Dummy		0.167
		(0.197)
Extreme Leverage Dummy	4.717*	5.387
	(2.845)	(4.194)
Size	1.376	1.353
	(1.099)	(1.064)
Tangibility	-0.038	-0.028
	(0.112)	(0.114)
Market to Book	0.012*	0.011
	(0.007)	(0.007)
EBITDA to Assets	-0.376**	-0.377**
	(0.150)	(0.147)
Risk	0.092	0.123
	(0.232)	(0.235)
Constant	33.852***	32.302***
	(9.684)	(9.299)
Observations	1405	1333
R^2	0.095	0.099
Adjusted R^2	0.078	0.082

2.6 Robustness tests

2.6.1 Effect of the money market and macroeconomic conditions on leverage

The money market conditions, such as the level of interbank rates, have a substantial impact on the costs of banks' debt. Many banks around the world use the LIBOR (London Interbank Offered Rate) as a benchmark for the pricing of different types of products, such as loans and deposits. The LIBOR presents the costs of banks' borrowings as well as banks' concerns about potential defaults on interbank markets. The LIBOR also reflects the general macroeconomic conditions, and during normal times it can closely follow the short-term interest rates determined by central banks, but in times of financial crisis the two rates can diverge to reflect the credit risk that banks expect in their borrowings.

One of the concerns in our analysis is that interbank rates, such as the LIBOR, explain all the variation in the interest on loans that banks charge to their clients. Consequently, a bank's leverage does not affect its interest on loans or its borrowers' leverage. To control for the impact of the money markets' pricing on the borrowers' leverage, I include the LIBOR in the baseline equation (6). Following the intuition described in section 2.3.3, I lag the LIBOR by 1 year. In general, the LIBOR is based on 5 different currencies for 7 different maturities. As I average the characteristics of several loans and cannot control for different types of the LIBOR for each particular loan, I use the LIBOR for USD with a maturity of 2 months, because it is one of the most quoted rates. The sample confirms that the interest on loans for lenders in different regions and the LIBOR-USD-2 months are indeed correlated. The correlation coefficient between the interest on loans and the LIBOR for North American companies is positive and quite high (0.34). The correlation coefficients for European and Asian lenders are about 10% smaller in magnitude (0.19 and 0.18, respectively) but still indicate a predictive relation between the interest on loans and the LIBOR-USD-2 months.

The macroeconomic conditions of borrowers' country of incorporation affect borrowers' financing decisions as well. For example, in times of economic boom, the supply for a firm's product encourages the firm to expand and invest. Increased investments require funding and encourage the firm to increase its leverage. On the contrary, during economic downturns, firms invest less and borrow less. As the real GDP growth, among other things, reflects the changes in consumer spending and industrial investment, I include its lagged level in the baseline model to control for macroeconomic fluctuations, which affect the demand for debt and leverage. By including the GDP growth in the analysis, I capture some of the macroeconomic fluctuations, but some country-specific characteristics, such as the institutional framework, are not observable.

The countries in the sample might also have different tax policies. To control for country-specific characteristics, empirical models often include the interaction term between country dummies and time dummies in the model. As the sample contains around 50 countries and 19 years, the inclusion of around 1000 dummies is difficult because of the collinearity problem.[14] To decrease the number of dummies, I combine several countries into regions, which might have similar macroeconomic conditions due to their geographical closeness and the interconnectedness of their monetary and fiscal policies. I create the following regions: the USA; Asia (Indonesia, South Korea, the Marshal Islands, Malaysia, the Philippines, Singapore, Thailand, Taiwan and Vietnam); China; Hong Kong; the European Union (EU); and the South of the EU (Italy, Spain, Portugal and Greece). In the regression with regions, I do not include countries that have too few observations and cannot be combined into bigger regions (for example African and Middle Eastern countries, Israel, India, Japan, Canada and Australia).

I reckon that region dummies capture the difference in such important country characteristics as tax policies. Countries in the same region have close ties due to common trade and other economic activities and often adjust their national tax policies to those of their trade partners to make the process of taxation easy. Member states of economic unions (such as the European Union) even aim to determine a common consolidated tax

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[14] Even in the regression with the region–time dummy, I drop the dummy for the year 2014 because of collinearity.

base for the taxation of activities of multinational companies within the union.

Table 7 Estimation of the effect of lenders' leverage (book leverage) on the leverage of their borrowers, controlling for the effect of macroeconomic variables

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans by DealScan. The lenders are financial firms, mostly banks. All the independent variables except for risk are lagged by one year. Risk is the standard deviation of the percentage change in the operating income for the past five years and already reflects the information on the past activities of a firm. Appendix 1 provides definitions of the variables. The standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses. All the variables are Winsorized at the first and ninety-ninth percentiles. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. Columns (1)–(2) of the table present the results of the estimation of the baseline equation (6) with lagged LIBOR and GDP growth; columns (3)–(4) present the results of the estimation of the baseline regression with region–time dummies. The dependent variables are shown in the top row of the table.

	(1) Book Leverage	(2) Market Leverage	(3) Book Leverage	(4) Market Leverage
Lenders' Book Leverage	0.121*	0.064	0.092*	0.055
	(0.068)	(0.080)	(0.052)	(0.061)
Size	1.842*	5.613***	2.735***	5.231***
	(0.945)	(1.034)	(0.853)	(1.004)
Tangibility	0.112	0.111	0.111*	0.133*
	(0.068)	(0.079)	(0.062)	(0.068)
Market to Book	0.005	-0.056***	0.006	-0.052***
	(0.006)	(0.017)	(0.005)	(0.008)
EBITDA to Assets	-0.362***	-0.479***	-0.368***	-0.483***
	(0.069)	(0.108)	(0.066)	(0.077)
Risk	0.000	-0.153	-0.187	-0.285**
	(0.138)	(0.188)	(0.126)	(0.135)
Libor	2.005***	2.350***		
	(0.703)	(0.673)		
GDP Growth	0.569**	0.319		
	(0.260)	(0.314)		
Constant	16.685**	3.597	24.172***	-7.371
	(7.719)	(8.307)	(8.874)	(9.261)
Observations	3558	3715	3369	3517
R^2	0.081	0.245	0.861	0.873
Adjusted R^2	0.074	0.239	0.802	0.819
Borrowers' Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Region–Time Fixed Effect	No	No	Yes	Yes

Columns (1)–(2) of Table 7 present the results of the regression with the LIBOR and GDP growth with the dependent variable equal to the book or market leverage; columns (3)–(4) present the results with region dummies. Similar to section 2.5.3, the second and fourth columns show that lenders' book leverage does not have a significant effect on the market leverage of borrowers, while the effects of market-to-book ratios, profitability and size are remarkably significant. As these factors are important determinants of stock prices and market leverage is a function of the stock price of a firm, it is ambiguous whether the coefficients in the regressions with market leverage capture the determinants of leverage or stock market prices. Column (1) demonstrates, similarly to the results of the previous section, that lenders' leverage has a positive effect on the leverage of their borrowers. Controlling for money market conditions (LIBOR), GDP growth and firm-specific characteristics, I obtain the same economic and statistical effect of lenders' leverage on the leverage of their borrowers: ceteris paribus, a 1% increase in the average lenders' leverage leads to an increase of 12 basis points in the leverage of their borrowers. Remarkably, the coefficients of the LIBOR and GDP growth are also significant. This implies that the LIBOR and GDP growth explain some of the variation in the leverage ratios of non-financial firms, but their effect does not diminish the effect of lenders' leverage. A 1 standard deviation (2.23%) increase in the LIBOR leads to a 4.5% increase in borrowers' leverage and a 1 standard deviation increase in the GDP growth (2.02%) leads to a 1.18% increase in borrowers' leverage. The LIBOR often closely follows the short-term interest rates determined by central banks, which are moderately high during economic booms and low during economic downturns. The correlation coefficient between the LIBOR and the GDP growth is around 0.2, which also indicates that the LIBOR reflects the general macroeconomic conditions. The LIBOR's positive sign in the regression of the leverage of non-financial companies suggests that the LIBOR captures the effect of economic cycles on leverage rather than the direct effect of the pricing of loans. The significant effect of macroeconomic variables on leverage is similar to the findings of Graham et al. (2014), who argue that macroeconomic uncertainty and financial sector development play a more prominent role in changes in leverage than firm-specific characteristics.

In the regression with region–time dummies (column 3), the coefficient of lenders' leverage on the leverage of their borrowers still remains positive and significant; ceteris paribus, a 1% increase in lenders' average leverage leads to an increase of 9.2 basis points in borrowers' leverage.

2.6.2 Equally weighted lenders' leverage

As section 2.3.3 describes, the weight of each lender in the weighted average of lenders' leverage depends on the amount that lender *j* allocates to borrower k at time *t*. Weighting lenders' leverage by the amount of lenders' allocation within a syndicate means that a lender with greater allocation has a greater impact on a borrower. Such a lender is most concerned about the solvency of a borrower and has greater incentives to adjust the terms of financing such that a borrower is able to repay the loan. As I do not observe in the data the total value of the loan portfolio of each borrower, it is possible that the lender with the greatest impact within a syndicate does not have the greatest impact on the borrower in practice. To test for the robustness of the results, I compute the alternative weighting – the equally weighted average of lenders' leverage, in which all the lenders have similar weights independently of the amount that they are allocated within a syndicate. The computation of the weighted average of lenders' leverage (Y_{jt}^{*}) is similar to that described in section 2.3.3. The only difference is that in section 2.3.3 I obtain the allocation of each lender *j* for borrower *k* from DealScan (s_{ijt}) but in this section I use the equally weighted allocation. s_{ijt} in this section equals the total amount of syndicate *i* divided by the number of participants (*n*) in the syndicate:

$$s_{ijt} = \frac{L_{ikt}}{n}/100,$$

where L_{ikt} is the amount of loan *i* that borrower *k* received at time *t*.

Table 8 presents the results of the estimation of the baseline equation (6) with the equally weighted average of lenders' leverage. Columns (1)–(3) present the results of the estimation using borrowers' book leverage as the dependent variable and lenders' leverage measured as debt to total assets, total liabilities to total assets and deposits to total assets, correspondingly. Column (4) of Table 8 shows the estimation results with market leverage as the dependent variable and lenders' average debt to assets as the explanatory variable.

Table 8 Estimation of the effect of lenders' leverage (book leverage) on the leverage of their borrowers: Equally weighted lenders' leverage

The sample of borrowers consists of non-financial firms identified as borrowers in syndicated loans by DealScan. The lenders are financial firms, mostly banks. All the independent variables except for risk are lagged by one year. Risk is the standard deviation of the percentage change in the operating income for the past five years and already reflects the information on the past activities of a firm. Appendix 1 provides detailed definitions of the variables. The standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses. All the variables are Winsorized at the first and ninety-ninth percentiles. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. This table shows the results of estimating the following equation, with $\mathrm{Z_{kt}}$ as borrowers' debt-to-assets ratio and $\mathrm{Y^{*}_{kt-1}}$ as lenders' average debt-to-assets ratio (columns 1 and 4), lenders' liabilities to assets (column 4) and lenders' deposits to assets (column 3). The average lenders' leverage is weighted equally by the number of participants in a syndicated loan:

$$Z_{kt} = \beta_0 + \beta_1 Y^{*}_{kt-1} + \beta_2 \boldsymbol{X^{B}_{kt-1}} + \beta_k + \beta_t + u^{B}_{kt}$$

	(1) Book Leverage	(2) Book Leverage	(3) Book Leverage	(4) Market Leverage
Lenders' Book Leverage (Equally Weighted)	0.144**			0.167*
	(0.073)			(0.089)
Lenders' Liabilities to Assets (Equally Weighted)		0.024		
		(0.030)		
Lenders' Deposits to Assets (Equally Weighted)			0.002	
			(0.041)	
Size	1.833*	1.967**	1.984*	5.601***
	(0.940)	(0.996)	(1.013)	(1.025)
Tangibility	0.106	0.096	0.110	0.105
	(0.068)	(0.068)	(0.068)	(0.079)
Market to Book	0.006	0.002	-0.001	-0.055***
	(0.006)	(0.007)	(0.007)	(0.017)
EBITDA to Assets	-0.359***	-0.320***	-0.240***	-0.478***
	(0.069)	(0.072)	(0.080)	(0.108)
Risk	0.020	-0.017	0.048	-0.138
	(0.144)	(0.141)	(0.137)	(0.192)
Constant	29.614***	30.186***	30.142***	16.599**
	(6.751)	(6.880)	(6.809)	(8.280)
Borrower Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	3558	3679	4421	3715
Adjusted R^2	0.073	0.066	0.049	0.241

Similar to the results obtained with the value-weighted average (Table 4), the coefficients of lenders' book leverage is positive and significant, implying that a 1 percentage point increase in lenders' book leverage leads to an increase of 14.4 basis points in borrowers' book leverage. The coefficient of lenders' leverage in the regression with market leverage is also positive and significant, but since the same coefficient is insignificant in previous specifications, I cannot argue about any effect of the average lenders' leverage on the market leverage of borrowers. Consistent with the results from Table 4, columns (2)–(3) show that the coefficients of lenders' liabilities to assets and deposits to assets are insignificant.

To summarize, the robustness tests, which account for the effect of macroeconomic conditions and use equally weighted lenders' leverage, confirm the main result. I argue that lenders' leverage (measured as debt to assets) has a positive and significant effect on borrowers' leverage (debt to assets). Leverage, as measured by banks' total liabilities to assets or deposits to assets, does not have a significant effect on borrowers' leverage. I explain the difference in significance of different measurements of leverage by different reasons that drive lenders' decision to issue one or another type of liability. One of the reasons why banks prefer to issue debt is tax benefits; if borrowers and lenders are related through tax benefits of debt, this relation should be reflected in the coefficients of debt to assets. The coefficients on total liabilities and deposits to assets are not significant, because it is not clear whether these liabilities transfer the tax benefits of debt to a borrower.

2.7 Conclusions

In this study I present empirical tests of the relationship between borrowers' and lenders' capital structures. To test whether the capital structure of lenders affects the capital structure of their borrowers, I construct a panel of borrower–year observations and estimate fixed-effect panel data regressions of borrowers' leverage on the weighted average of lenders' leverage and a number of control variables. I demonstrate that lenders' leverage (measured as debt to assets) has a positive and significant effect on borrowers' leverage (debt to assets). Leverage measured by banks' total liabilities to assets or deposits to assets does not have a significant effect on borrowers' leverage.

The regulation of the financial sector has recently led to its deleveraging, but non-financial sectors still use debt intensively. The positive effect of lenders' leverage on the leverage of their borrowers implies that further deleveraging of the financial sector may lead to less indebtedness and vulnerability of the economy. The effect of lenders' leverage on the leverage of their borrowers in this study might be underestimated due to measurement error in the dependent variable and regression attenuation bias. By using the weighted average of lenders' leverage, I measure only part of the lender–borrower relation observed through syndicated lending; I do not observe exhaustive information on the relation between borrowers and lenders.

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Appendix 1 Notation and definition of variables

Risk=standard deviation of the percentage change in firms' operating income for the past five years, including the year of interest. Operating income is *oibdp* from Compustat and *IQ_OPER_INC* from Capital IQ.

Book leverage=total book debt/total book assets

Total debt is the sum of total long-term debt, which is defined as debt obligations due more than one year from the company's balance sheet date, *plus* debt in current liabilities, which is defined as the total amount of short-term notes and the current portion of long-term debt (debt due in one year).

Long-term debt includes: purchase obligations and payments to officers (when listed as long-term liabilities); notes payable, due within one year and to be refunded by long-term debt when carried as a non-current liability; long-term lease obligations (capitalized lease obligations); industrial revenue bonds; advances to finance construction; loans on insurance policies; indebtedness to affiliates; bonds, mortgages and similar debt; all obligations that require interest payments; publishing companies' royalty contracts payable; timber contracts for forestry and paper; extractive industries' advances for exploration and development; production payments and advances for exploration and development; and redeemable preferred stock and similar securities that the company is classifying as a liability under the guidelines of SFAS 150. (This definition of long-term debt is from the Compustat database).

Debt in current liabilities includes: bank acceptances and overdrafts; loans payable to the officers of the company; loans payable to stockholders; loans payable to parents and consolidated and unconsolidated subsidiaries; notes payable to banks and others; instalments on a loan; sinking fund payments; and brokerage companies' drafts payable. (This definition of debt in current liabilities is from the Compustat database).

Market leverage=total book debt/market value of assets

Market value=market capitalization+total book debt

Market capitalization is defined as the monthly closing price as of

December of the corresponding year times the actual number of common shares outstanding, excluding dilution (conversion of convertible preferred stock, convertible debentures, options and warrants).

EBITDA to assets=operating income before depreciation/total assets

Size=ln (total revenue); the total revenues are converted into US dollars by the exchange rate as of the end of the corresponding year.

Market to book=market value of assets/total book assets

Tangibility=net property plant and equipment/total book assets

Lenders' leverage=weighted average of lenders' total debt/total book assets; the computation of the weights is described in section 3.3.

Total bank debt includes: short-term borrowings; current portion of long-term debt; current portion of capital leases; long-term debt; federal home loan bank debt; and capital leases.

Trust preferred securities, which do not include deposits.

Lenders' liabilities to assets=weighted average of lenders' total liabilities/total book assets; the computation of the weights is described in section 3.3.

Lenders' deposits to assets=weighted average of lenders' total deposits/total book assets; the computation of the weights is described in section 3.3.

LIBOR=yearly average of monthly LIBOR-USD (2 month)

GDP growth=GDP real growth, year-to-year change, %

Appendix 2 Geographical distribution of borrowers

Country	Frequency	Percentage
Argentina	6	0.17
Australia	18	0.51
Bermuda	49	1.38
Brazil	1	0.03
Canada	22	0.62
Switzerland	12	0.34
Chile	11	0.31
China	42	1.18
Cayman Islands	21	0.59
Germany	52	1.46
Spain	48	1.35
Finland	2	0.06
France	53	1.49
United Kingdom	66	1.85
Greece	21	0.59
Hong Kong	149	4.19
Indonesia	87	2.45
India	18	0.51
Ireland	25	0.70
Israel	20	0.56
Italy	42	1.18
Japan	14	0.39
Korea (South)	36	1.01
Liberia	10	0.28
Luxembourg	1	0.03
Macau	2	0.06
Mexico	27	0.76
Marshall Islands	24	0.67
Malaysia	19	0.53
Netherlands	15	0.42
New Zealand	6	0.17
Peru	2	0.06
Philippines	18	0.51
Portugal	3	0.08
Russia	16	0.45
Singapore	9	0.25
Sweden	22	0.62
Thailand	24	0.67
Turkey	3	0.08
Taiwan	125	3.51
USA	2,399	67.43
South Africa	18	0.51
Total	3558	100

Appendix 3 Correlation matrix for the variables used in the study

	Book Leverage	Market Leverage	Size	Tangibility	Market to Book	EBITDA to Assets	Risk	Lenders' Book Leverage	Lenders' Liabilities to Assets	Lenders' Deposits to Assets
Book Leverage	1									
Market Leverage	0.583	1.000								
Size	-0.074	-0.060	1.000							
Tangibility	0.186	0.199	-0.113	1						
Market to Book	0.026	-0.490	-0.090	-0.053	1					
EBITDA to Assets	0.014	-0.336	0.103	0.007	0.386	1				
Risk	-0.001	0.043	-0.045	0.045	-0.020	-0.150	1			
Lenders' Book Leverage	0.006	0.063	0.074	0.035	-0.051	-0.050	0.037	1		
Lenders' Liabilities to Assets	-0.161	-0.105	-0.027	0.018	-0.024	-0.037	-0.001	0.467	1	
Lenders' Deposits to Assets	-0.192	-0.183	-0.058	0.008	0.040	-0.001	-0.032	-0.334	0.489	1

3. Bank debt and risk taking

3.1 Introduction

Banks finance around 90–95% of their assets with debt, which can take the form of deposits or non-deposit liabilities. A high level of indebtedness of the financial sector makes it fragile, especially during times of financial downturn, when a large number of customers withdraw their deposits and the funds on the interbank markets are limited. A fragile financial system increases the probability of system-wide crisis, and an obvious question that arises is what determines banks' decision to issue debt. One potential determinant of bank debt issuance is excessive risk taking due to deposit insurance and implicit government guarantees. However, academic studies do not confirm that deposit insurance plays a decisive role in determining bank leverage (hereafter by leverage I mean the proportion of assets financed with debt). For example, Gropp and Heider (2010) show that deposit insurance and capital regulation are of second-order importance in determining the capital structure of banks. They also demonstrate that buffers in excess of the regulatory minimum do not explain the variation in bank capital. Indeed, banks keep the level of regulated capital much higher than regulators require. For example, in the past 19 years, the average Tier 1 capital ratio (banks' core equity capital to risk-weighted assets) in Asian, European and North American banks was around 10.3 %.[15] Meanwhile, according to regulators, banks are well capitalized if their Tier 1 ratio is equal to 6%.

Deposit-taking activities do not provide an exhaustive explanation of why banks issue a large amount of debt, because banks usually take on additional unsecured debt on the top of their deposit base. Thakor (2014) demonstrates that, even though the deposits are the factor of production

[15] These are the author's estimates. The sample is described in Section 3.5.

in banks, this fact alone does not allow the argument that banks hold a high level of debt only due to the presence of deposits on their balance sheet. Standard corporate finance variables fail to explain much of the variation in bank leverage as well. Most of the models of industrial firms' capital structure rely on Modigliani and Miller's (1958) irrelevance theorem. However, as DeAngelo and Stulz (2013) note, the debt–equity neutrality principle is inapplicable to banks and it is an inappropriate baseline for assessing whether the leverage ratio of banks is too high.

In this paper I analyse the asset-side determinants of bank leverage and investigate whether the riskiness of bank's assets has an effect on the bank's debt issue. I define leverage as the ratio of bank debt to bank assets, and hereafter by debt I mean the portion of liabilities that banks issue in excess of their deposit rate (non-deposit liabilities). I use a novel approach to assessing the riskiness of a bank by analysing the leverage of its borrowers. Using the data on syndicated loans, I compute the weighted average of borrowers' leverage for each bank. The advantage of using borrowers' characteristics for assessing banks' risk in comparison with accounting measures of risk is that borrowers' characteristics are not derived directly from the balance sheet of the bank and hence the analysis is less subject to the endogeneity problem.

Despite the existing literature lacking a convincing explanation of the determinants of bank leverage, relatively few studies investigate this topic in general and even fewer focus on the riskiness of a bank. Among the existing studies is that by Shrieves and Dahl (1992), who demonstrate a positive relation between changes in banks' risk and banks' capital and conclude that changes in banks' capital are risk-based rather than determined by regulatory pressure. This study covers the period of 1983–1987, but in the recent decades empirical researchers have paid surprisingly little attention to the relation between the quality of a bank's assets and the bank's debt issue. Several theoretical models emphasize the importance of this relationship. For example, Inderst and Mueller (2008) argue that the leverage of banks invariably leads to excessive risk taking, because banks do not own the project that they finance and cannot extract all the profits. Their theory of optimal bank leverage shows that higher bank leverage is not explained by the mechanical linkage to their deposit-taking role, but it is rather explained by the banks' function as loan providers. They show that the riskiness of banks' borrowers is negatively related to the leverage of the banks and that banks' leverage ratio increases when their borrower pool becomes safer.

This paper provides recent evidence regarding the relation between the riskiness of a bank's assets and the bank's debt issuance. In contrast to the previous literature, which derives the measures of bank riskiness from the bank-specific characteristics, I analyse how the riskiness of a bank's loan portfolio affects the bank's debt issuance. I use a novel approach to assessing banks' risk by focusing on the leverage of their borrowers. I find that a decrease in the safety of banks' borrowers today decreases the probability of the banks' debt issuance tomorrow. This result demonstrates more rational behaviours of banks and does not confirm the presence of moral hazard. The moral hazard of banks (due to deposit insurance and government guarantees) can lead to excessive risk taking. For example, if a bank expects a bailout in the case of a default, it issues too much risky debt even when the portfolio of existing loans is already highly risky. In this paper I demonstrate that the probability of debt issuance tomorrow decreases with an increase in the riskiness of the loan portfolio today. This means that banks' decision to issue debt depends on the riskiness of their assets and that banks do not take excessive risks due to moral hazard. However, it is worth noting that the banks in my sample are on average less subject to moral hazard because they are relatively small banks, which rely on bailouts to a lesser extent than big, systemically important banks.

3.2 Related literature

3.2.1 Determinants of banks' capital structure

Traditionally, banks provide loans to customers with a shortage of funds by borrowing from customers with excessive funds. In other words, banks fulfil the role of an intermediary between companies and investors by granting loans and receiving deposits. Figure 1 illustrates the yearly changes in the liabilities structure of American banks. As the figure shows, the total bank liabilities have not changed substantially over the years, while most of the changes have happened in the proportion between deposit and non-deposit liabilities.

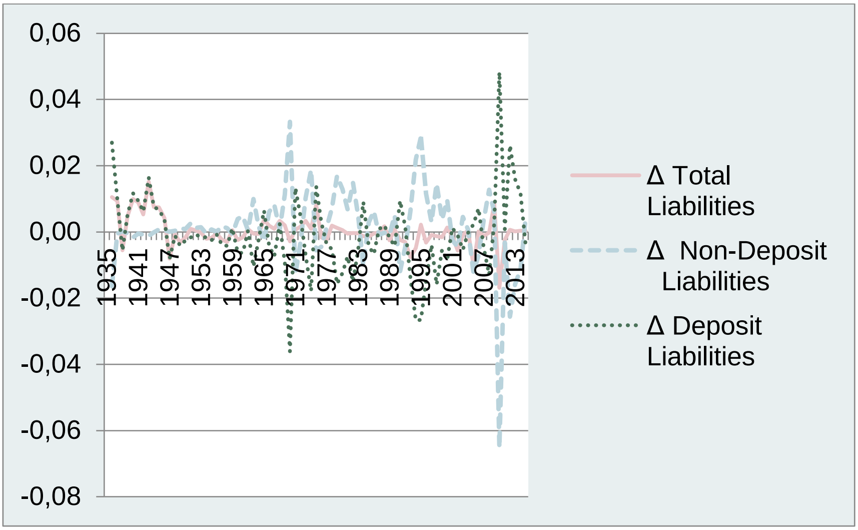


Figure 1 Historical changes in total liabilities, total non-deposit liabilities and deposit liabilities for the sample of US banks, 1935–2011

Receiving deposits represents one of the core banking activities, and deposits contain a large part of the total bank liabilities. At the same time, the proportion of deposits is not the only determinant of the bank debt, because banks usually hold debt in excess of their deposit rate. Moreover, as Figure 1 illustrates, the proportion of deposit and non-deposit liabilities is negatively related. For example, when the proportion of deposit liabilities decreased in 1970, the proportion of non-deposit liabilities increased, and a similar pattern appeared in the late 1970s, 1990s and around 2010. The existing studies also question the argument that the deposit rate explains why banks prefer to have a large amount of debt compared with equity. For example, Acharya et al. (2012) note that, given the limited supply of core deposits, it is not obvious why banks do not add a large amount of equity to whatever deposits they issue. Thakor (2014) notes that deposits are both a factor of production and a liability of banks, but this fact alone does not explain why the banking sector should have high leverage.

Another strand of the literature advocates the tax benefits of debt as the determinants of bank leverage. For example, Schepens (2013) documents the impact of the tax shield on Belgian banks and demonstrates that reducing the relative tax advantage of debt increases the bank equity ratio. However, the tax benefits of debt are also an important determinant of the capital structure of non-financial firms (see for example Heider and Ljungqvist, 2015). Financial firms on average have higher leverage than industrial firms, and since they both enjoy the same tax benefits, it is unclear why financial firms have higher leverage. Acharya et al. (2012) also name the disciplinary role of leverage as its important determinant. Debt induces creditors to monitor managers' risk taking more closely, and debt's price increases in the event of bankruptcy, when the loss absorption capacity of equity shrinks. The disciplinary effect of debt is valid for non-financial firms as well, but this effect for banks is unique because of uninsured demand deposits, which can be withdrawn at any time.

Some studies analyse the leverage of banks in a standard framework of non-financial firms. The determinants of the capital structure from the pecking order or the trade-off theory explain some of the variation in banks' capital structure (see for example Gropp and Heider, 2010), but both theories ignore important characteristics of banking industries (deposits, deposit insurance and government guarantees). Some studies argue that government guarantees and deposit insurance have a positive effect on bank leverage (see for example Juks, 2010). However, Gropp and Heider (2010) find that mispriced deposit insurance and capital regulation have second-order importance in determining the capital structure. They find that only the bank fixed effects are important determinants of banks' capital structure and that the leverage converges to bank-specific, time-invariant targets.

Allen et al. (2011) develop a model that demonstrates that banks' incentives to hold capital can arise not only from the side of banks' liabilities but also from the side of banks' assets. They argue that, in the competitive markets, banks use capital as a tool to commit to monitoring and attracting borrowers. Given that the monitoring of customers is costly, banks are subject to the moral hazard problem when they choose the monitoring effort. Higher equity capital forces banks to internalize the costs of their default and provides greater incentives to monitor their borrowers. Another tool for improving banks' incentive to monitor is the loan rate, because a marginal increase in the loan rate gives banks a greater incentive to monitor as they receive higher pay-offs if the borrower's project succeeds and the loan is repaid. Holding more capital increases the direct costs for banks, but a higher loan rate has a negative impact only on the borrower's return from the project.

3.2.2 Bank leverage and risk taking

The existing theoretical and empirical literature provides mixed evidence about the relationship between banks' leverage and their risk taking. Some studies illustrate a positive relation; for example, the theoretical model of Gennotte and Pyle (1991) considers assets' risk–leverage trade-off and shows that deposit guarantees lead to a decrease in a bank's investment but increase the per-unit asset risk.

Few empirical studies investigate the relation between banks' capital and the riskiness of their assets. Shrieves and Dahl (1992) demonstrate a positive association between changes in banks' risk and banks' capital and conclude that the changes in bank capital over the period of 1983–1987 were risk-based rather than determined by regulatory pressure. Inderst and Mueller (2008) argue that banks have higher leverage than non-financial institutions because high leverage ensures that banks have first-best incentives to make new risky loans. They show that all-equity banks are too conservative in their credit decisions and high leverage is a necessary condition for banks to take on new loans. Inderst and Mueller (2008) analyse the relation between banks' leverage and their access to borrowers with different risk profiles. They show that an increase in the safety of the pool of a bank's borrowers leads to an increase in the bank's optimal debt level.

Numerous studies investigate the relation between bank capital and asset risk in connection to the changes in capital regulation. Blum (1999) shows in a dynamic framework that capital regulation may lead to an increase in the riskiness of banks. He demonstrates that, under the binding capital requirements, an additional unit of capital tomorrow is more expensive for banks, and if issuing equity tomorrow is too expensive, the only possibility to increase the equity tomorrow is to increase the risk today. Gersbach (2013) shows that without capital regulation banks may not obtain a socially efficient level of equity. Due to the competition for the equity resources, banks have to provide a high return to their equity holders. However, if banks managed to issue a large amount of equity, they would not have incentives to take excessive risks.

3.3 Measures of risk

3.3.1 Measures of risk in previous studies

This section describes the measures of bank risk used in the previous literature as well as discussing the advantages and disadvantages of the methods used. It also reviews the literature that relates the capital structure of banks and borrowers.

Previous studies (e.g., Shrieves and Dahl, 1992; Jokipii and Milne, 2011; Rime, 2001) mostly measure bank risk using an index constructed from the accounting data or simply the ratio of non-performing loans to assets. The advantage of using a risk index is that it corresponds to the risk-weighting methodology applied by the regulation. However, the use of the accounting data on the left-hand side and right-hand side of the empirical model leads to the endogeneity problem, because the dependent and explanatory variables are determined simultaneously. Studies that use the accounting measures of risk often provide contradictory conclusions about the relation between the bank risk and the bank capital adjustments. For example, Rime (2001) finds a positive relationship between changes in risk and changes in capital to total assets for a sample of Swiss banks, but such a relationship is insignificant for the ratio of capital to risk-weighted assets. This finding indicates that Swiss banks improve their capital adequacy by issuing more equity or increasing their retained earnings but not by decreasing their risk taking. Jokipii and Milne (2011) find a positive relation between short-term capital buffers and portfolio risk adjustments. They also demonstrate that this relationship was negative after the crisis of 1991–1992 and positive before 1991 and after 1997. Jacques and Nigro (1997), on the contrary, find a negative relationship between changes in capital and risk levels. They argue that this negative relationship may be attributable to methodological flaws in the risk-based framework, in which the weights assigned to specific categories of assets are not able to reflect the true risk. Given the controversial findings of the previous studies, this study needs another measure of bank risk, which is not determined simultaneously with the bank capital.

Several theoretical studies demonstrate the importance of borrowers' characteristics for the bank capital structure. Diamond and Rajan (2000) model the optimal capital structure of banks using the interaction between the depositors, the equity (debt) holders and the borrowers of a bank. They show that trade-offs between liquidity creation, credit creation and bank stability determine the optimal capital structure. Diamond and Rajan (2000) argue that banks' capital structure also determines the nature of banks' customers, because different customers rely to different extents on liquidity and credit. Gornall and Strebulaev (2015) develop a model of joint capital structure decisions of banks and their borrowers. In their model the capital structures of banks and their borrowers are determined jointly. Given the importance of borrowers' characteristics for banks' capital structure and the weaknesses of the risk measures used in the previous literature, I use borrowers' leverage as a measure of risk in this study. I discuss the computation of this risk measure in the next section.

3.3.2 Computation of the weighted average of borrowers' leverage

In this paper I use a novel approach to assessing banks' risk, and this approach aims to reduce the endogeneity problem in the empirical model. I assess the riskiness of banks by characteristics of their loan portfolio, and I focus in particular on the leverage of the banks' borrowers. The advantage of this measure is that it is not derived from the banks' balance sheet, and this feature minimizes the problems of simultaneity and omitted variables. If both the debt and the riskiness of a bank are computed directly from the balance sheet, the same institutional, managerial and infrastructural conditions of the bank determine the measures of debt and riskiness. Conversely, the leverage of borrowers is less endogenous to the leverage of their banks, because the leverage of borrowers is determined by completely different managers in different financial conditions. I also exclude financial companies from the sample of borrowers, and their exclusion ensures that banks' and borrowers' financing policies are determined by different economic conditions. I measure banks' risk by the weighted average of their borrowers' leverage. I assume that higher average leverage of the borrowers corresponds to a higher risk of the bank's loan portfolio.

Identifying a bank's loan portfolio characteristics is a challenge, because the information on bank loan contracts is confidential. To identify multiple borrowers of each particular lender and the weight of each borrower in a bank's loan portfolio, I use syndicated loan contracts (the only publicly available information on loan contracts). This measure does not provide the entire composition of a bank's loan portfolio; rather, it identifies the most important borrowers of a given bank. Syndicated loans are usually large loans for large borrowers, and banks' risk depends to a great extent on the solvency and resilience of such borrowers. Banks issue a large proportion of their total loans through syndication. For example, according to the survey conducted by the Board of Governors of the Federal Reserve System, as of August 2015, 47% of commercial and industrial loans in the USA were made under participation or syndication.[16] According to Bloomberg's Global Syndicated Loans Review,[17] the volume of syndicated loans in Europe and Asia is also quite large. For example, the Asian (excluding Japan) volume of syndicated loans in the first part of 2015 was 205.6 billion US dollars of closed deals from 612 transactions, and the volume of syndicated lending in Europe, the Middle East and Africa reached 519.4 billion USD in the same period.

In a syndicated loan contract, the participating lenders share the total amount of the loan and the corresponding risk. Each lender is allocated a certain proportion of the total loan. The amount allocated to a lender

[16] Survey of Board of Governors of the Federal Reserve System, released on 2 October 2015 and available at http://www.federalreserve.gov/releases/e2/current/#fn7.

[17] Available at http://share.thomsonreuters.com/general/PR/Loan-2Q15-(E).pdf.

within a syndicated loan allows me to quantify the importance of all the observed borrowers of a lender. I assume that changing a lender is costly for a borrower and that terminating a loan contract and changing a borrower is costly for a lender. Therefore, during the period of loan maturity, lenders and borrowers would rather adjust their financing policies to each other than terminate the loan contract. Previous research on relationship lending supports this assumption. For example, Dahiya et al. (2003) show that the termination of loan contracts negatively affects the value of a borrower. Bharath et al. (2007) demonstrate that the past lending relationship increases the probability of securing loans and investment banking business in the future. Banks with an established lending relationship have a probability of 40% of providing future loans to a borrower, while banks without a prior lending relationship have only a 3% probability of issuing future loans.

Given that both banks and lenders have an interest in the long-term lending relationship and borrowers from the syndicated loans are the most important borrowers for a given bank, I construct a portfolio of bank loans issued through syndicates. Using the amount of the outstanding loan for each borrower allows me to construct a value-weighted loan portfolio. A value-weighted loan portfolio assigns the largest weight to the borrowers who received the largest amount from a particular bank and whose financial conditions can have the most influence on this bank. The subsequent paragraphs introduce the notation and describe the computation of the weights for the syndicated loan portfolio.

Hereafter, I use the following notation:

D_{ikt}≡outstanding debt of firm *k* within syndicated loan contract *i* at time *t* (debt of firm *k* to all banks);

D_{jkt}≡outstanding debt of firm *k* to bank *j* at time *t* (debt of firm *k* to a specific bank *j*);

s_{ijt}≡allocation of bank *j* within syndicate *i* at time *t*.

Based on the observed amount of syndicated loan i, I define the matrix **D** of outstanding debt of firm *k* at time *t*. Each element of the debt matrix is written as follows:

$$D_{ikt} = \begin{cases} L_{ikt} \; if \; t < t^p \\ L_{ikt} - p_{ikt} \; if \; t \geq t^p \end{cases}, \tag{1}$$

where t^p is the start date of the loan's repayment, L_{ikt} is the amount of loan *i* that borrower *k* received at time *t* and p_{ikt} is the payment instalment repaid in period *t*. As syndicated loans imply multiple lenders, it is necessary to consider the allocation of each lender *j* in the total amount of the firm's debt received through syndicated loans. To define the outstanding debt of firm *k* to bank *j* at time *t*, I multiply the total amount of the syndicated loan by each bank's allocation (s_{ijt}) within the syndicate:

$$D_{jkt} = \sum_i D_{ikt} s_{ijt}, \tag{2}$$

where D_{ikt} is the amount of outstanding debt of firm *k* at time *t* and s_{ijt} is lender *j*'s allocation within syndicate *i* at time *t*. I obtain the allocation s_{ijt} from the terms of each syndicated contract. I compute weight w_{jkt} as follows and interpret this weight as the measure of importance of each borrower in the bank's loan portfolio:

$$w_{kjt} = \frac{D_{jkt}}{\sum_{k'} D_{jk't}}, \tag{3}$$

where index k' denotes all the borrowers of bank *k* at time *t*.

After computing the weight of each borrower in the bank's loan portfolio, I define the leverage of a borrower as the debt-to-assets ratio and compute the weighted average of borrowers' leverage for each lender *j* at time *t* (z_{jt}) as follows:

$$z_{jt} = \sum_{k=1}^{K} w_{kjt} \, z_{kt}, \tag{4}$$

where w_{kjt} is the weight of borrower k in the loan portfolio of bank j and z_{kt} is the leverage of each borrower k at time t.

3.4 Model

The research question of this study concerns how banks' decision to issue debt is related to the riskiness of their assets. If a bank is not subject to a moral hazard problem, I expect to observe a negative relation between the debt issued tomorrow and an increase in the riskiness of the assets today. Inderst and Mueller (2008), in their theoretical model, show that bank leverage can adjust optimally and is neither hard-wired to deposits nor too costly to change. They demonstrate that, if a bank is able to make less risky loans because of cross-sectional variation in its pool of borrowers or because its ability to screen borrowers changes, one should expect a negative relationship between lending and risk taking. Inderst and Mueller (2008) argue that "as the bank's borrower pool becomes safer, the bank's optimal debt level and leverage ratio increase". This negative relation is related to the lower risk premium that the bank's debtholders demand as the bank's own debt becomes less risky and hence the bank is able to issue more debt.

Using the theoretical arguments of Inderst and Mueller (2008), in this study I test empirically whether the increase in the safety of the pool of banks' borrowers today corresponds to a higher probability of debt issuance tomorrow. Higher borrowers' leverage signals higher riskiness of the bank loan portfolio, and I expect to find a negative relationship between borrowers' leverage today and the probability of the bank issuing debt tomorrow. If the bank's debtholders reckon that the loan portfolio of a bank is already too risky, the probability of issuing new debt for this bank decreases.

To test the empirical predictions, I estimate the following logit model:

$$P(y_{jt}=1 \,|\, \alpha_j, z_{jt-1}, \boldsymbol{x}_{jt-1}, \lambda_t)=L\big(\alpha_0 + \alpha_j + z_{jt-1}\gamma + \boldsymbol{x}'_{jt-1}\boldsymbol{\beta} + \lambda_t\big), \tag{5}$$

where y_{jt} is a binary variable that equals 1 if bank *j* issues debt at time *t* and 0 otherwise, *j* is individual banks' fixed effects, z_{jt-1} is the main variable of interest representing the risk of a bank loan portfolio (described in the previous section), $\boldsymbol{x}_{jt-1}$ is the matrix of the bank-specific control variable (described below), λ_t is a time effect and *L* is the logistic distribution function.

y_{jt} is defined as follows:

$$y_{jt} = \begin{cases} 1 \; if \; \left[\left(debt_{jt}^{long} + debt_{jt}^{short}\right) - \left(debt_{jt-1}^{long} + debt_{jt-1}^{short}\right)\right] > 0 \\ 0 \; if \; \left[\left(debt_{jt}^{long} + debt_{jt}^{short}\right) - \left(debt_{jt-1}^{long} + debt_{jt-1}^{short}\right)\right] \leq 0 \end{cases} \qquad (6)$$

where $debt_{jt}^{long}$ denotes the long-term debt of bank *j* at time *t*, $debt_{jt}^{short}$ is debt in current liabilities; subscripts *t* and *t-1* denote the corresponding time periods. Hence, I assign the value of 1 to the variable y_{jt} if the net debt issuance in a given period is greater than zero (the bank's debt increased relative to the previous period), and y_{jt} is equal to 0 if the net debt issuance is negative or zero (the bank decreased or did not change the value of debt relative to the previous period). If the bank issued (repaid) debt in the same period as it issued (repurchased) equity, I exclude such an observation from the sample. By doing this, I ensure that I analyse how the bank's riskiness affects its decision to issue debt but not debt and equity at the same time. Banks can have different types of liabilities in their balance: deposits, commercial papers, loans from the inter-bank market and so on. In this paper I focus on the portion of debt that banks issue in excess of their deposit rate. I do not analyse changes in the bank deposit rate in this study; because deposits are also factors of production for banks, their determinants are much more complex and beyond the scope of this study.

Studies on the debt–equity choice usually use both the debt choice and the equity choice of banks for the analysis (see for example Hovakimian et al., 2001). In this sample there are too few events of equity issuance, which do not coincide with the debt issuance, and I cannot use equity issuance as a dependent variable.

The matrix of control variables $\boldsymbol{x}_{jt-1}$ includes well-established determinants of leverage, such as size, growth opportunities, collateral and profitability (see for example Fama and French, 2002; Gropp and Heider, 2010; Jandik and Makhija, 2001; Korajczyk and Levy, 2003; Leary and Roberts, 2014). I present the definitions of the variables in Appendix 1. To diminish the simultaneity problem, I lag all the variables by one year. I measure the size of a bank as a logarithm of the bank's total revenues. I expect size to have a positive effect on debt issuance, because larger firms are usually older firms and can negotiate better financing conditions for their debt contracts. Similar to the previous literature, I measure growth opportunities as the market-to-book ratio. The expected sign for growth opportunities is ambiguous. On the one hand, growth can have a negative effect on debt issuance because growing firms are younger firms without an established reputation and thus might have difficulties in obtaining debt. On the other hand, growth opportunities require funding and growing firms might have a greater demand for debt, which implies a positive relation between growth and debt issuance. I expect to find a positive effect of collateral on debt issuance, because more collateral allows firms to secure and receive a greater amount of debt. For the case of non-financial firms, collateral is usually defined as the ratio of net property plant and equipment to total assets, but, due to the essence of their activities, banks do not own many buildings, land or machinery; however, they can use securities and cash as collateral for short-term borrowings. I define collateral as the sum of mortgage-backed securities, investment securities, net property plant and equipment and cash scaled by total assets. The expected effect of profitability on debt issuance is also ambiguous. On the one hand, I expect profitability to have a positive sign on the probability of debt issuance, because higher profitability sends signals to lenders about the good financial conditions of a bank. On the other hand, banks with higher profitability have more internal financing due to the accumulated retained earnings, and such banks have a lower demand for debt. I also control for time-invariant, bank-specific characteristics by including borrowers' fixed effect in the analysis as well as controlling for time-varying economic conditions using time dummies.

I use a binary specification because I want to analyse the changes in the probability of bank debt issuance in relation to changes in riskiness rather than analysing the determinants of the bank debt level. My purpose is to identify how banks react to an increase in the riskiness of their assets in the presence of capital regulation. In particular, I want to see how banks react to an increase in the riskiness of their loan portfolio. If a bank issues more debt tomorrow in response to higher risk today, it signals its moral hazard behaviours, but if the bank does not issue debt or equity in response to the increase in the risk, it signals its more rational behaviours.

To account for the time-invariant heterogeneity of each bank, I use a fixed-effect logit model as the main specification, but I also present the results from a random-effect logit model.

The baseline specification is the logit model, because it is designed to model a choice between the binary outcomes. The model describes the probability that y_{jt} equals one or the probability that a bank issues debt at time *t*, given the riskiness of its loan portfolio and other bank-specific characteristics at *t-1*. In addition to logit, I estimate a linear probability model (LPM). As LPMs for a binary response often give good estimates of the average marginal response probability (Wooldridge, 2003, p. 243), I also estimate the fixed-effect OLS. To estimate the linear probability model, I set:

$$L(\alpha_0 + \alpha_j + z_{jt-1}\gamma + \boldsymbol{x}'_{jt-1}\boldsymbol{\beta} + \lambda_t) = \alpha_0 + \alpha_j + z_{jt-1}\gamma + \boldsymbol{x}'_{jt-1}\boldsymbol{\beta} + \lambda_t \tag{7}$$

and specify LPM for binary response y_{jt} as follows:

$$P(y_{jt}=1 \,|\, \alpha_j, z_{jt-1}, \boldsymbol{x}_{jt-1}, \lambda_t) = \alpha_0 + \alpha_j + z_{jt-1}\gamma + \boldsymbol{x}'_{jt-1}\boldsymbol{\beta} + \lambda_t + \varepsilon_{jt}, \tag{8}$$

where α_j, $\boldsymbol{x}_{jt-1,}$, z_{jt-1} and y_{jt} are the same as defined above.

The empirical model assumes that the observed leverage of bank *j* at time *t* is an optimal leverage. I make this assumption because theoretical research has still not provided conclusive arguments on whether companies have a predetermined target capital structure or whether they adjust their capital structure according to the current economic and financial conditions. Moreover, I derive my empirical hypothesis from the theoretical predictions of Inderst and Mueller (2008), who presume that leverage can be adjusted optimally and that it is not costly to change. Given the presumption of Inderst and Mueller (2008), I assume that the observed leverage of banks is optimal and that banks do not deviate from any predefined target. The existing empirical literature provides ambiguous evidence on the existence of the optimal capital structure as well as on its determinants. The target capital structure in empirical studies is often estimated with the help of various statistical models, and the estimated target capital structure is sensitive to the choice of explanatory variables and the method of estimation.

3.5 Data

To relate borrowers to lenders and to compute the weighted average of borrowers' leverage, I use DealScan, a database that provides historical information on the terms and conditions of syndicated loans in the global commercial market. DealScan contains information on the amount, maturity, payment schedule and participants of each loan, but it lacks data on the financial statements of the companies. To include information from financial statements in the analysis, I link DealScan with Compustat North America and S&P Capital IQ. Data on borrowers' debt and assets are downloaded from Compustat North America using the DealScan–Compustat matching provided by Chava and Roberts (2008). I perform hand matching of lenders with S&P Capital IQ, because this database allows me to find the information easily even if the firm has been renamed or merged. I match lenders by their name, country and state (for the United States), SIC code and parent's company name. The sample period is from 1995 to 2014, because most of the information in DealScan is available for this period. The sample with non-missing data for all the variables consists of around 150 financial firms, mostly banks and other depositary institutions, with an average of 5.5 observations for a firm. The sample is international; both borrowers and lenders are European, Asian or American firms. The industries' distribution of borrowers in the sample is diverse, but the sample of borrowers excludes financial companies. Figure 2 presents the geographical distribution of lenders in the sample. To account for the heterogeneity of companies from different countries, I control for time-invariant, firm-specific characteristics using the fixed-effect panel regression and fixed-effect panel logit.

Table 1 presents the descriptive statistics of the variables used in the analysis. To mitigate the influence of extreme observations, I Winsorize all the variables at the first and ninety-ninth percentiles. The descriptive statistics demonstrate that on average the values of the variables in this study are similar to those in previous studies. For example, borrowers' risk, measured as the average of borrowers' leverage (0.375), is similar to the average leverage of industrial firms in previous studies (see for example Jandik and Makhija, 2001). Banks' average profitability and collateral are similar to the average values reported by Gropp and Heider (2010). The similarities in the averages of this study's variables and those of previous studies indicate that this study's sample represents an unbiased selection from the population. Market to book is defined as the ratio of the market value of assets to the book value of assets. The market value of assets is the sum of the market capitalization and book value of debt. The average market-to-book ratio is usually greater than one for non-financial firms and big banks from developed countries. As this sample includes relatively small banks from developing countries, the average market-to-book ratio is smaller than one and the maximum value is just slightly greater than one, because all the variables are Winsorized and extreme observations are replaced by the values from the first and ninety-ninth percentiles. To use all the available information, I apply an unbalanced panel approach. As the number of observations varies from variable to variable, it differs for different specifications throughout the analysis.

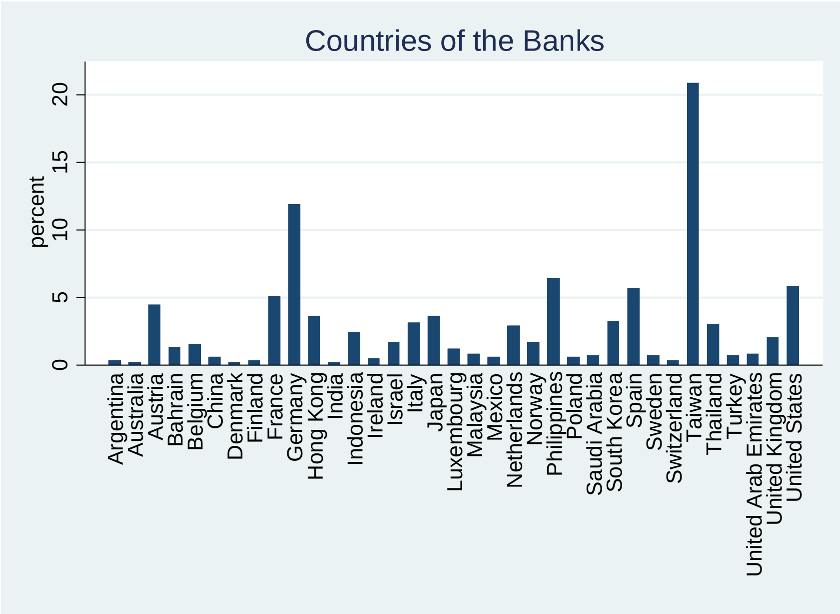


Figure 2 Geographical distribution of the banks in the sample

Debt issuance equals 1 if a bank's debt increased at time *t* relative to *t-1* and 0 if the bank's debt decreased or did not change at time *t* relative to *t-1*. If the bank's debt increased (decreased) in the same period as the bank's equity increased (decreased), I exclude such observations from the sample. By doing this, I ensure that I analyse how banks' riskiness affects their decision to issue debt but not debt and equity at the same time. According to the definition provided by Capital IQ, bank debt consists of short-term borrowings, the current portion of long-term debt, the current portion of capital leases, long-term debt, federal home loan bank debt, capital leases and trust preferred securities, but it excludes deposit liabilities. Appendix 1 presents the definitions and Appendix 2 presents the correlation matrix of all the variables.

Table 1 Descriptive statistics

The table presents the number of observations, means, standard deviations (St. Dev.), minimums (Min.) and maximums (Max.) for the fixed-effect logit. All the variables are Winsorized at the first and ninety-ninth percentiles. The sample includes financial companies identified as lenders by DealScan and non-financial companies identified as borrowers by DealScan. The sample consists of American, Asian and European companies for the period 1995–2014. Appendix 1 contains the definitions of all the variables. The last two rows in this table show the proportion of zeros and ones in the dependent variable.

		Mean	St. Dev.	Min.	Max.
Borrowers' Risk		0.375	0.162	0.000	0.810
Size		6.694	1.905	1.507	13.967
Market to Book		0.240	0.226	0.000	1.019
Collateral		0.258	0.130	0.009	0.775
Profitability		0.090	0.168	-0.800	0.495
Loans to Assets		0.623	0.164	0.027	0.922
Debt Issue=0	47.94%				
Debt Issue=1	52.06%				
N	824				

3.6 Results

First two columns of table 2 present the results of the estimation of equation (5) and third column presents the results of estimation of equation (8). Hence, the first column displays the results of the fixed-effect panel logit, the second column presents the random-effect panel logit and the third column shows the results from the estimation of the linear probability model. I include time dummies in all the estimations. The number of observations for the fixed-effect logit is smaller (824 compared with 1097), because for this model I drop the observations for the banks for which the dependent variable equals one in all the observed periods (the bank was issuing debt in each period) or for which the dependent variable always equals zero (the bank was repurchasing or not issuing debt in that period). I exclude from the analysis the time periods when the data on debt issuance are missing.

As columns (1)–(3) of Table 2 illustrate, borrowers' risk – the main variable of interest – is negative and significant, indicating that an increase in the riskiness of banks' loan portfolio, as measured by the weighted average of borrowers' leverage, has a negative effect on the banks' probability of issuing debt.

Among the control variables, profitability has a positive and significant effect on the probability of issuing debt in all the specifications. Higher profitability increases the probability of bank debt issuance because higher profitability signals to the bank's creditors that the bank is a reliable borrower.

Table 2 Effect of borrowers' risk on bank debt issuance

First two columns of table 2 present the results of the estimation of equation (5) and third column presents the results of estimation of equation (8). The first column displays the results of the fixed-effect panel logit, the second column presents the random-effect panel logit and the third column shows the results from the estimation of the linear probability model. The sample consists of American, Asian and European financial companies for the period 1995–2014. Appendix 1 presents the definitions of the variables. All the variables are Winsorized at the first and ninety-ninth percentiles. Standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses (columns 1 and 3); the standard errors in parentheses of column (2) are conventional standard errors. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. All the independent variables are lagged by one year.

	(1) Debt Issue	(2) Debt Issue	(3) Debt Issue
Borrowers' Risk	-1.903**	-0.833*	-0.315*
	(0.879)	(0.459)	(0.176)
Size	-0.247*	-0.035	-0.033
	(0.135)	(0.046)	(0.024)
Market to Book	-4.752***	-0.592	-0.646***
	(1.416)	(0.381)	(0.222)
Collateral	-0.390	-0.258	-0.027
	(1.985)	(0.843)	(0.375)
Profitability	2.731***	2.485***	0.363***
	(0.803)	(0.526)	(0.101)
Loans to Assets	0.441	0.323	0.110
	(1.882)	(0.707)	(0.408)
Constant	6.727**	0.577	1.064***
	(2.727)	(0.946)	(0.368)
Time Dummies	Yes	Yes	Yes
Fixed Effect	Yes	No	Yes
Random Effect	No	Yes	No
Log-Likelihood	-481.633	-716.82	
Observations	824	1097	1097
Number of Banks	150	295	295
Pseudo R^2	0.156	0.041	
Adjusted R^2			0.034

As the pseudo R^2 illustrates, the fixed-effect logit model predicts the probability of bank debt issue better than the random-effect model. Moreover, Table 3 presents the cross-tabulation of the actual and predicted outcomes for the fixed-effect logit model. The outcome is classified as correctly specified if the estimated correct probability is greater than 50%. As the table demonstrates, the model correctly specifies the probability in 68.89% of cases. This proportion indicates that the model has good predictive power, and in the further analysis I will focus on this model and discuss its results in greater detail below.

Table 3 Cross-tabulation of the actual and predicted outcomes for the fixed-effect logit model

The table presents the cross-tabulation of the actual and predicted outcomes for the fixed-effect logit model. An outcome is classified as correctly specified if the estimated correct probability is greater than 50%.

	Actual		
Predicted By Model	Debt Issued: y_{it}=1	Debt Not Issued: y_{it}=0	Total
$\hat{y}_{it} = 1$	303	132	435
$\hat{y}_{it} = 0$	126	263	389
Total	429	395	824
Correctly Predicted			68.89%

Apart from their signs, the coefficients from the binary choice models are not easy to interpret directly. One of the ways to interpret the coefficients is to compute the marginal effects of the changes in the explanatory variables. For continuous variables, the marginal effects are partial derivatives of the response function. Two methods of estimating marginal effects exist. The first method is to compute the marginal effects at specified values of the independent variables. The second method is to compute the partial changes for all the values of the independent variables and then compute their average (average marginal effects). The advantage of using the first method is that it allows the estimation of the marginal effects for specific values of independent variables, determined by a researcher. The advantage of the second method is that it provides a more general and more realistic interpretation of the results. In this paper

I present the marginal effects computed by both methods. I start with a graphical presentation (Figure 3) of the marginal effects of borrowers' leverage for specified values of borrowers' leverage, and then I present the average marginal effect of all the variables in Table 4.

Figure 3 plots the predictive probabilities of a bank issuing debt for specific values of borrowers' risk as well as 95% confidence intervals. These margins are computed from the predictions of the previously fitted model ($P(y_{jt}=1 \mid \alpha_j, z_{jt-1}, \mathbf{x}_{jt-1}, \lambda_t) = \widehat{\alpha_0} + \widehat{\alpha_j} + z_{jt-1}\hat{\gamma} + \mathbf{x}'_{jt-1}\,\widehat{\boldsymbol{\beta}} + \widehat{\lambda_t},$) at specified values of borrowers' leverage and by fixing the values of other explanatory variables at their average values. I present the probabilities of debt issuance for the range from 0 to the maximum value of borrowers' leverage (0.8) with the interval of 1 standard deviation (0.16). Figure 3 illustrates a negative relationship between the probability of debt issuance and the borrowers' risk: keeping other covariates at their means, the probability of bank debt issuance decreases with the value of borrowers' leverage. For instance, a 1 standard deviation increase in the value of borrowers' leverage from 0.16 to 0.32 leads to a 4 percentage point decrease in the probability of debt issuance (the probability decreases from 60% to 54%).

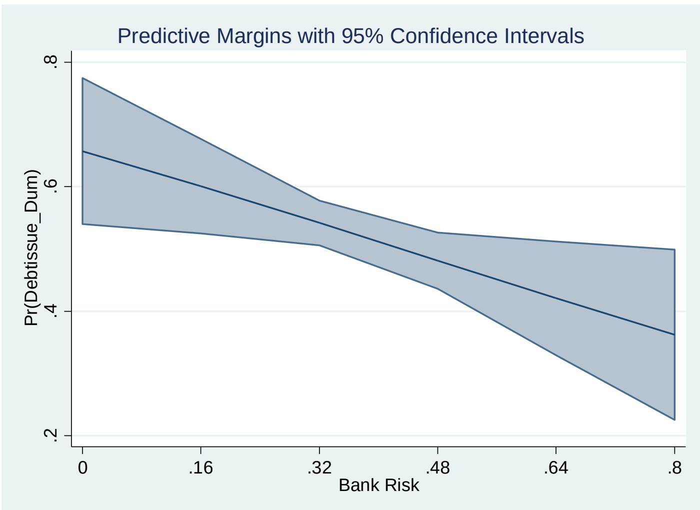


Figure 3 Predicted probabilities of bank debt issuance for different levels of bank borrowers' risk

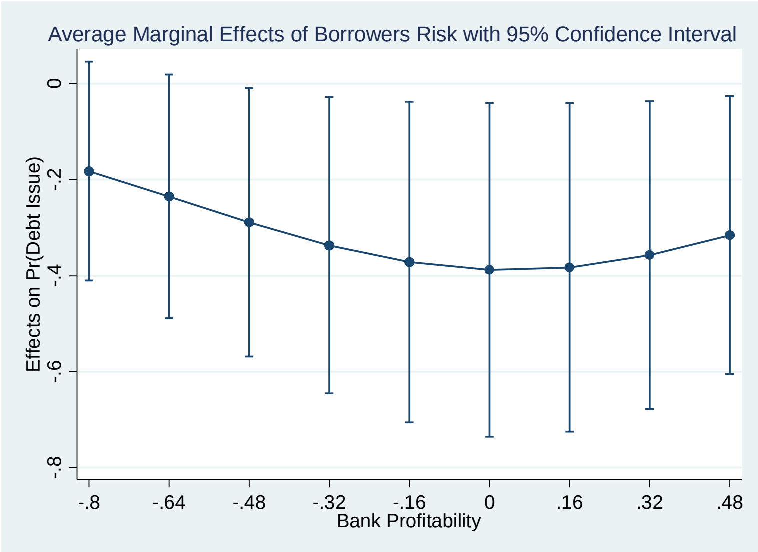
Table 4 presents the average marginal effect for the fixed-effect logit. The average marginal effect is the average value of the marginal effects for all the observations in the sample. To estimate the average marginal effect, I compute the marginal effect (the estimated coefficient times the derivative of the response function with respect to the variable of interest) for each observation in the database and then find their average value. If I assume that the sample is a good representation of the population, the average marginal effect can be interpreted as the marginal effect for the population. The average marginal effect of the borrowers' risk of the magnitude of -0.381 implies that, by keeping all the other covariates constant, a 1 unit increase in the average borrowers' leverage corresponds to a decrease in the probability of a bank issuing debt by 0.381. If, for example, borrowers' average leverage increases by 1 standard deviation of 0.16, the probability of issuing debt will decrease by 0.06. Given that the total proportion of bank debt issuance is equal to 0.521, the economic effect of an increase in borrowers' risk on the probability of debt issuance is moderate. A 1 standard deviation increase would decrease the proportion of debt issuance only to 0.461; however, the effect can be stronger for higher increases in risk. For example, a 2 standard deviation increase in risk (0.32) can decrease the proportion of debt issuance to 0.4 (0.521-0.32*0.381=0.4).

Table 4 Average marginal effects

The table presents average marginal effects for the fixed effect logit estimated from equation (5). The first column displays average marginal effect, second column presents standard errors, third column shows presents p-valus and 95% confidence interval is at the last two columns.

	dy/dx	Std. Err.	P>z	[95% Confidence	Interval]
Borrowers' Risk	-0.381	0.174	0.029	-0.723	-0.039
Size	-0.050	0.027	0.065	-0.102	0.003
Market-to-Book	-0.952	0.273	0.000	-1.487	-0.418
Collateral	-0.078	0.398	0.844	-0.857	0.701
Profitability	0.547	0.157	0.000	0.240	0.854
Loans-to-Assets	0.088	0.377	0.815	-0.651	0.828

As regards the relative economic importance of the other control variables, similar to Hovakimian et al. (2001), I find that the market-to-book ratio is one of the most important determinants of the debt versus equity issue choice. The relative economic importance of the riskiness of the loan portfolio for the debt issuance is in the third place after the market-to-book ratio (-0.952) and profitability (0.547). Figure 4 presents the average marginal effects of borrowers' risk for different levels of profitability and the market-to-book ratio as well as 95% confidence intervals. The average profitability of banks in the sample is 0.09, and, as the upper part of Figure 4 illustrates, the marginal effect of borrowers' risk at this level of profitability is around 0.4. When the profitability moves from zero either to the losses or to the profits side, the effect of borrowers' leverage becomes less negative; in other words, it becomes economically less significant. If the profitability increases, the bank accumulates more retained earnings, which it can use as an internal source of financing and thus demand less debt. On the other hand, if the profitability moves from zero to the losses sides, the borrowers' risk is no longer so relevant, because large losses are the strongest signal for creditors that the bank cannot receive more debt. Remarkably, for a high level of losses, the effect of borrowers' risk is not significant. The lower part of Figure 4 demonstrates that a higher market-to-book ratio corresponds to a less negative effect of borrowers' risk, which implies that a higher market valuation of a bank is more important for the creditors than the quality of the bank's loan portfolio.



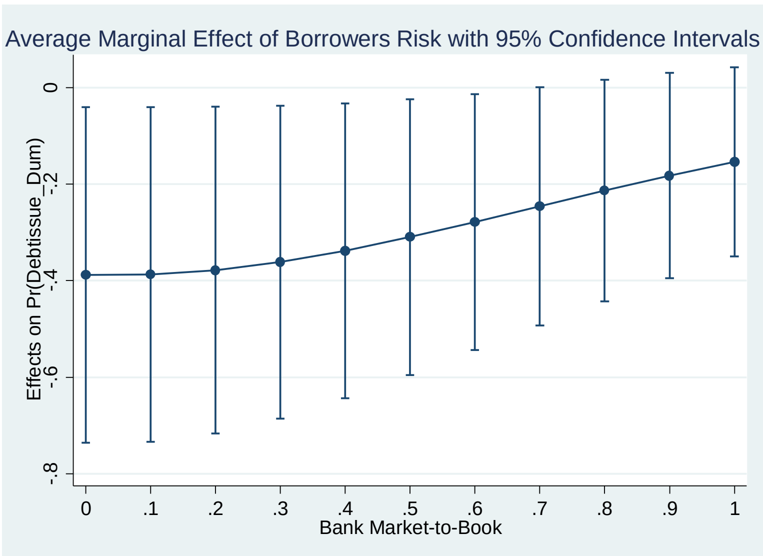


Figure 4 Average marginal effects of borrowers' risk on the probability of debt issuance for different levels of profitability (upper figure) and the market-to-book ratio (lower figure)

The results are in line with those of Gropp and Heider (2010), who find a negative effect of risk on the book and market leverage of banks. They are also in line with the predictions of Shrieves and Dahl (1992), who find a positive relation between the change in risk and the issuance of capital by banks. As discussed in section 3.2.2, issuing more debt tomorrow as a response to higher risk today sends signals about the moral hazard of a bank. This analysis indicates a negative relation between the risk today and the debt issuance tomorrow, which might suggest more rational behaviours of banks and does not confirm the presence of moral hazard. The finding also supports the arguments proposed by Inderst and Mueller (2008), who question the presumption that without regulation positive leverage leads to excessive risk taking by banks. The result confirms their theoretical proposition that a bank's leverage increases when its borrower pool becomes safer (the riskiness of the borrowers decreases).

3.7 Robustness tests

3.7.1 Exogenous shocks

In contrast to previous studies, this study does not derive its risk measure directly from the balance sheets of banks; by doing so, it diminishes the endogeneity problems. However, since borrowers and lenders operate under similar economic conditions, similar factors may affect borrowers' and lenders' decisions to issue debt. An even more severe identification problem can arise if the lenders' decision to issue debt affects the borrowers' leverage. The fact that banks and companies operate in similar economic environments implies that they can affect each other's financing decisions. Such simultaneity implies that borrowers' risk is an endogenous regressor and the parameters of the equation cannot be identified. To identify the parameters correctly, I can add one more variable to the equation, which is exogenous to the borrowers' risk but endogenous to the banks' decision to issue debt.

Such a variable is difficult to find, especially if one uses accounting measures of banks' risk. Similar to Leary and Roberts (2014), I use idiosyncratic returns for each bank as exogenous equity shocks. An advantage of this risk measure is that it allows me to find a variable that is endogenous to the banks' debt issuance but exogenous to the borrowers' leverage. This approach has similarities to the event studies, which aims to identify shocks that are exogenous to the variable of interest. Exogenous events are difficult to find, and Leary and Roberts (2014) use the equity shocks of a specific firm as an additional exogenous variable. Several studies show that stock returns are important determinants of the capital structure (see for example Myers, 1984). Moreover, stock returns reflect most of the value-relevant news, but this news usually affects the idiosyncratic and common (affecting both borrowers and banks) components of stock returns. My aim is to disentangle the variation in the returns that are specific to a particular bank. Accordingly, I run the traditional capital asset pricing model (CAPM) and regress banks' excess returns on the market excess returns.[18] I then use the residuals from the CAPM as the measure of bank-specific equity shocks. As this equity shock is specific to a particular bank but has little or no variation with the market, this shock also has little or no variation with the borrowers' financing decisions (the banks and borrowers in my sample are from different industries).

I compute the idiosyncratic equity shock for each bank j at time t as follows:

$$\hat{\eta}_{jt} = \bar{r}_{jt} - \hat{\alpha}_{jt} - \hat{\beta}_{jt}\bar{r}_{m_j t}, \tag{9}$$

where $\bar{r}_{jt}$ is average over the monthly excess returns for each bank j, $\bar{r}_{m_j t}$ is the annual average over the monthly market excess returns for a given year and for a market of bank j, $\hat{\eta}_{jt}$ are residuals and $\hat{\alpha}_{jt}$ and $\hat{\beta}_{jt}$ are the intercept and slope from the following model:

$$r_{js} = \alpha_{jt} + \beta_{jt} r_{m_j s} + \eta_{js}, \tag{10}$$

[18] I estimate equity shocks similarly to Leary and Roberts (2014), but I do not use an industry component in the computation of the returns because the banks and borrowers in my sample are from different industries.

with $s = 1,\ldots,12$ for each $t = t\text{-}5,\ldots,t\text{-}1$, r_{js} is the monthly excess return of bank j and $r_{m_j s}$ is the monthly market excess return for each bank's country. To compute $\hat{\alpha}_{jt}$ and $\hat{\beta}_{jt}$ for each bank at time t, I use the monthly excess returns for this bank for the previous five years. For example, to compute $\hat{\alpha}_{jt}$ and $\hat{\beta}_{jt}$ for 1995, I use the historical monthly excess returns from January 1990 to December 1994.

Table 5 Average values for excess returns, excess market returns and average alfas and betas used for computation of equity shock

This table presents average values for excess returns, excess market returns and average alfas and betas used for computation of equity shocks.The sample consists of monthly returns for financial firms in our sample. Returns are for the period from January 1990 to December 2014; alfas and betas are on the yearly basis from 1995 to 2014. To compute $\hat{\alpha}_{jt}$ and $\hat{\beta}_{jt}$ for each bank, I use monthly excess returns for each bank for five previous years. I estimate standard capital assets pricing model (CAPM) of monthly excess returns for each bank on monthly excess market returns on a rolling 5-years window, using historical monthly returns. For example, to compute $\hat{\alpha}_{jt}$ and $\hat{\beta}_{jt}$ for 1995, I use historical monthly excess returns from January 1990 to December 1994. Equity shocks ($\hat{\eta}_{jt}$) are the residuals from the CAPM.

Variable	Mean	Std. Dev.
Excess Returns, r_{js}	0.006	0.061
$\hat{\alpha}_{jt}$	0.006	0.035
$\hat{\beta}_{jt}$	0.063	0.534
Equity Shocks, $\hat{\eta}_{jt}$	-0.0001	0.068
Average number of observation per regression	20	

We lag the idiosyncratic shocks $\hat{\eta}_{jt}$ by one year and include them in the baseline equations (5) and (8). By doing this, we include in the analysis one more regressor, which exogenous to our measure of bank risk (borrowers' average leverage), but endogenous to bank debt issue.

Table 6 presents the results of the estimation of equations (5) and (8) with the exogenous shocks. The table demonstrates that the significance and sign of the main coefficient of our interests (Borrowers' Risk) is similar to the main results presented in the previous section.

Table 6 Effect of borrowers' risk on bank debt issuance (controlling for equity shocks)

The table presents the results of the estimation of equation (5) and (8). The first column displays the results of the fixed-effect panel logit, the second column presents the random-effect panel logit and the third column shows the results from the estimation of the linear probability model. The sample consists of American, Asian and European financial companies for the period 1995–2014. Appendix 1 presents the definitions of the variables. Equity shock is the residual from the CAPM for each bank. All the variables are Winsorized at the first and ninety-ninth percentiles. Standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses (columns 1 and 3); the values in parentheses in column (2) are conventional standard errors. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. All the independent variables are lagged by one year.

	(1) Debt Issuance	(2) Debt Issuance	(3) Debt Issuance
Borrowers' Risk	-5.720**	-1.971**	-0.815**
	(2.265)	(0.889)	(0.353)
Size	-0.331	-0.045	-0.043
	(0.229)	(0.079)	(0.029)
Market to Book	-6.372**	-1.029	-0.637**
	(2.694)	(0.722)	(0.258)
Collateral	2.047	-0.756	0.134
	(4.595)	(1.519)	(0.489)
Profitability	2.618**	2.121***	0.297***
	(1.207)	(0.763)	(0.097)
Loans to Assets	4.274	0.267	0.723
	(4.541)	(1.295)	(0.626)
Equity Shock	1.012	-0.113	0.115
	(3.307)	(2.064)	(0.562)
Constant	1.309	0.749	0.738
	(4.271)	(1.623)	(0.507)
Time Dummies	Yes	Yes	Yes
Fixed Effect	Yes	No	Yes
Random Effect	No	Yes	No
Log-Likelihood	-153.219	-257.681	
Observations	275	382	382
Adjusted R^2			0.099
Pseudo R^2	0.261	0.007	

3.7.2 Alternative measures of risk and the continuous dependent variable

Several empirical studies (see for example Shrieves and Dahl, 1992; Rime, 2001; Fiordelisi et al., 2011) use non-performing loans to assess the effect of banks' risk on their efficiency and capital. To test for the robustness of my risk measure, in this section I use the lagged ratio of non-performing loans to total assets instead of the weighted average of borrowers' leverage. Moreover, in this section I apply alternative definitions of the dependent variables: the debt-to-assets ratio and the first difference in the debt-to-assets ratio. Columns (1)–(3) of Table 7 present the estimation results of the panel logit, random-effect panel logit and linear probability model with the risk, measured as the ratio of non-performing loans. The last two columns of Table 7 present the results of the estimation of the fixed-effect linear regression model with a continuous dependent variable. In column (4) the dependent variable is the debt-to-assets ratio,[19] and in column (5) the dependent variable is the first difference in the debt-to-assets ratio.

As columns (1)–(3) of Table 7 illustrate, the use of non-performing loans as the risk measure confirms the main results of the study and shows a negative and significant effect of bank risk on the probability of debt issuance. The use of the debt-to-assets ratio as the dependent variable produces the same sign as the risk coefficient, but it becomes statistically and economically insignificant. The use of the first difference in the debt ratio produces a negative, statistically significant coefficient, which is in line with the main results. The fact that the difference in the debt ratio is significant, in contrast to the level of debt to assets, suggests that the riskiness of the loan portfolio affects banks' decision to issue or repurchase debt, but it does not affect the level of issued debt per se.

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[19] I use only the book values of debt and assets in this study.

Table 7 Effect of borrowers' risk on bank debt issuance: Alternative measures of risk and the continuous dependent variable

The table presents the results of the estimation of equation (5) and (8). The first column displays the results of the fixed-effect panel logit, the second column presents the random-effect panel logit and the third column shows the results of the estimation of the linear probability model. The last two columns of the table present the results of the estimation of the fixed-effect linear regression model with a continuous dependent variable. In column (4) the dependent variable is the debt-to-assets ratio, and in column (5) the dependent variable is the first difference in the debt-to-assets ratio. The sample consists of American, Asian and European financial companies for the period 1995–2014. Appendix 1 presents the definitions of the variables. All the variables are Winsorized at the first and ninety-ninth percentiles. Standard errors, robust to heteroskedasticity and within-borrower dependence, are in parentheses (columns 1,3 , 4,5); the values in parentheses in column (2) are conventional standard errors. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. All the independent variables are lagged by one year; the names of the dependent variables are in the top row.

	(1) Debt Issuance	(2) Debt Issuance	(3) Debt Issuance	(4) Bank Leverage	(5) Dif. in Bank Leverage
Non-performing Loans	-14.905***	-5.236***	-2.589***		
	(3.234)	(1.775)	(0.630)		
Borrowers' Risk				-0.036	-0.025*
				(0.022)	(0.014)
Size	-0.210***	-0.043	-0.032**	-0.002	-0.001
	(0.070)	(0.027)	(0.013)	(0.004)	(0.003)
Market to Book	-2.650***	-0.492**	-0.428***	0.316***	-0.275***
	(0.565)	(0.221)	(0.104)	(0.066)	(0.044)
Collateral	-0.708	0.438	-0.106	0.049	-0.010
	(0.958)	(0.500)	(0.181)	(0.055)	(0.043)
Profitability	2.384***	2.788***	0.367***	-0.040***	0.025**
	(0.500)	(0.327)	(0.077)	(0.014)	(0.011)
Loans to Assets	0.760	1.062**	0.143	0.027	0.034
	(0.960)	(0.422)	(0.196)	(0.057)	(0.042)
Constant	1.112	-0.431	0.809***	0.199***	0.067
	(1.517)	(0.660)	(0.225)	(0.057)	(0.045)
Time Dummies	Yes	Yes	Yes	Yes	Yes
Fixed Effect	Yes	No	Yes	Yes	Yes
Random Effect	No	Yes	No	No	No
Log-Likelihood	-1431.324	-1880.520			
Observations	2508	2952	2952	2310	2303
R^2			0.049	0.168	0.131
Adjusted R^2			0.042	0.159	0.122
Pseudo R^2	0.160	0.006			

3.7.3 Conditional fixed effect model

In section 3.6 I presented the results of the estimation of the fixed-effect panel data model, with the dummies for each individual bank. An alternative way to estimate equation (5) is to use the conditional fixed-effect logit, in which, in contrast to regular logistic regression, the data are grouped and the likelihood is calculated relative to each group. In this model only banks that change their status (issue debt or do not issue debt) are included in the estimation. The difference between the observations in two subsequent periods ($x_{j1} - x_{j2}$) is used as the explanatory variable and the change in y_{jt} as the dependent variable (it takes the value of 1 for a positive change and 0 for a negative change).

Table 8 presents the results of the estimation of equation (5) with the conditional fixed-effect logit. Column (1) presents the estimated coefficients and column (2) presents the average semi-elasticities[20] of the probability of a bank issuing debt given the explanatory variables. As I do not include in the estimation dummies for individual fixed effects, I cannot compute the predicted values and individual marginal effects for each bank. Instead I compute the marginal effect on the average probability. As Table 8 illustrates, the model estimated with the conditional fixed-effect logit produces results similar to the logit with fixed effects with the dummies for each bank. The market to book, profitability and borrowers' risk are significantly important for the probability of bank debt issuance. According to the estimated semi-elasticities, the effect of borrowers' risk on the probability of debt issuance is also negative, and it implies that a 1 unit increase in borrowers' leverage corresponds to a 0.7% decrease in the average probability of debt issuance.

[20] I thank Professor Joao Santos Silva from the University of Surrey for providing the code for computing the marginal effects in the conditional fixed-effect logit.

Table 8 Effect of borrowers' risk on bank debt issuance: Conditional fixed-effect model

This table presents the results of the estimation of equation (5) with the conditional fixed-effect logit. Column (1) presents the estimated coefficients, and column (2) presents the average semi-elasticities of the probability of bank debt issuance given the explanatory variables. The sample consists of American, Asian and European financial companies for the period 1995–2014. Appendix 1 presents the definitions of the variables. All the variables are Winsorized at the first and ninety-ninth percentiles. Standard errors are in parentheses; statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively. All the independent variables are lagged by one year; the definitions of the dependent variables are provided in Appendix 1.

	(1) Debt Issuance	(2) Debt Issuance
Borrowers' Risk	-1.514**	-0.704**
	(0.747)	(0.348)
Size	-0.203	-0.095
	(0.129)	(0.060)
Market to Book	-3.941***	-1.832***
	(1.082)	(0.507)
Collateral	-0.327	-0.152
	(1.473)	(0.685)
Profitability	2.250***	1.046***
	(0.743)	(0.347)
Loans to Assets	0.359	0.167
	(1.534)	(0.713)
Time Dummies	Yes	Yes
Average of Debt Issue Dummy	0.535	0.535
Observations	824	824
Pseudo R^2	0.070	0.070

3.8 Conclusions

The research question of this study concerns how banks' decision to issue debt is related to the riskiness of their assets. Given the importance of borrowers' characteristics for banks' capital structure and the weaknesses of the risk measures used in the previous literature, I employ a novel approach to assessing bank risk and use borrowers' leverage as a measure. The analysis indicates a negative relation between the risk today and the debt issuance tomorrow. In other words, the riskiness of assets negatively affects banks' decision to issue debt, and banks are less likely to issue more debt if their loan portfolio became more risky in the preceding period. This finding suggests more rational behaviours of banks, which do not take excessive risks in anticipation of bailouts. The finding also supports the arguments proposed by Inderst and Mueller

(2008), who question the presumption that without regulation positive leverage leads to excessive risk taking by banks. This result confirms their theoretical proposition that banks' leverage increases when their borrower pool becomes safer (the riskiness of the borrowers decreases).

Appendix 1 Definition of the variables

Debt issuance equals 1 if the bank issues debt in a given period and zero otherwise.

Bank debt consists of short-term borrowings; the current portion of long-term debt; the current portion of capital leases; long-term debt; federal home loan bank debt; capital leases; and trust preferred securities. It does not include deposits.

Market value of assets=market capitalization+total book debt

Market capitalization is defined as the monthly closing price as of December of the corresponding year times the actual number of common shares outstanding, excluding dilution (the conversion of convertible preferred stock, convertible debentures, options and warrants).

Collateral=(mortgage-backed securities+investment securities+net property plant and equipment+cash)/total book assets

Loans to assets=total loans/total book assets

Market to book=market value of assets/total book assets

Non-performing loans=total non-performing loans/total book assets

Profitability=operating income before depreciation/total book assets

Size=ln(total revenue); total revenues are converted into US dollars by the exchange rate valid for the corresponding year

Borrowers' book leverage=weighted average of borrowers' total debt/total assets

Borrowers' total debt is the sum of total long-term debt, which is defined as debt obligations due more than one year from the company's balance sheet date, *plus* debt in current liabilities, which is defined as the total amount of short-term notes and the current portion of long-term debt (debt due in one year).

Equity shocks are the residuals from the regression of monthly excess returns of each bank on the monthly excess market returns in a rolling five-year window, using historical monthly excess returns.

Appendix 2 Correlation matrix for the variables used in the analysis

	Debt Issuance	Borrowers' Risk	Size	Market to Book	Collateral	Profitability	Loans to Clients
Debt Issuance	1						
Borrowers' Risk	-0.031	1.000					
Size	-0.005	-0.117	1.000				
Market to Book	-0.052	-0.014	-0.103	1			
Collateral	-0.006	-0.049	-0.008	-0.060	1.000		
Profitability	0.142	-0.125	0.180	-0.036	0.041	1	
Loans to Clients	0.017	0.107	-0.162	0.050	-0.691	-0.058	1

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4. The impact of the financial crisis on innovation and growth: Evidence from technology research and development

with Emanuel Alfranseder

4.1 Introduction

In this paper we assess the impact of the financial crisis of 2007–2009 on corporate investment, particularly research and development (R&D) expenditures. We measure firms' financial constraints and financial distress and investigate whether those variables have a significant predictive value on R&D during the financial crisis. We argue that reduced investment due to financial constraint is more detrimental to economic growth and a sign of a credit supply shock. In contrast, reduced investment due to financial distress signals a credit demand shock and is a sign of intensified creative destruction during the crisis.

Changes in corporate investment are a crucial driver of macroeconomic fluctuations. In general, firms can use internal funds (cash flow and retained earnings) and external funds (debt or equity) to finance their investment projects. Financial innovation has made financial systems as a whole increasingly complex and, as some argue, more vulnerable to crises (Beck et al., 2014). This development increases the odds that turbulence in the financial system is not a result of a downturn in the real economy; on the contrary, financial crises cause recessions in the real economy. Many argue that the recession of 2008 was indeed caused by the financial crisis starting in 2007 (Tong and Wei, 2008; Reinhart and Rogoff, 2009). An essential question is thus how the financial crisis affects real economic activities, such as corporate investments and technological development.

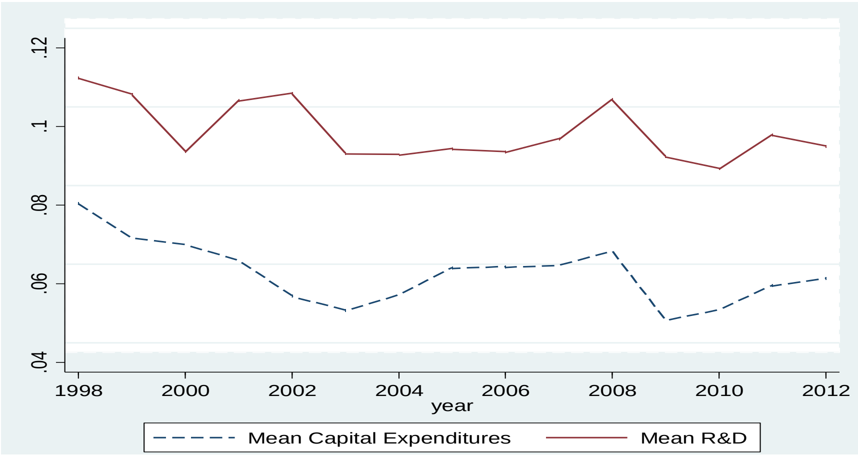
To this end, a large and growing literature examines whether the supply frictions on the credit market are relevant to corporate investment during financial turbulence. Some studies show theoretically and empirically that financial market fluctuations affect non-financial companies' growth. For example, Duchin et al. (2010), Almeida et al. (2012), and Campello et al. (2010) show that firms reduce their capital expenditures due to the negative credit supply shock (a bank lending supply shock or a general credit supply shock). Other researchers (e.g., Kahle and Stulz, 2013; Hetland and Mjos, 2012) find contrasting evidence that a lending supply shock was not necessarily a dominant causal factor for investment policies during the crisis. They show that financially constrained firms' level of investment was not more affected than unconstrained firms' level of investment. Thus, given the current state of research, it is unclear whether non-financial firms' investment is affected by the fluctuations in the credit supply or by the availability of viable investment opportunities. This paper contributes to the discussion on corporate investment, in particular R&D, and the effect of the financial crisis on the real economy.

The Schumpeterian idea of creative destruction (Schumpeter, 1939) and the basic economic theory on competitive markets predict that recessions provide an opportunity to drive weak and obsolete firms out of business. Thus, a recession should affect businesses that are already in distress prior to the recession: "weak" businesses. A more negative impact on the economy plays out when a recession negatively affects healthy firms. Economic growth is lost if firms that have viable investment opportunities cannot invest due to a lack of financing. We identify financially "weak" businesses using non-financial firms' degree of financial distress based on Altman's Z-scores (Altman, 1968) and firms' financial constraint using the Whited–Wu index (Whited and Wu, 2006). R&D financing is a critical input factor for innovation and growth in modern economies. According to the National Science Foundation survey

(National Science Board, 2012), as of 2009, the US R&D growth outpaced its GDP growth in the past 20 years. Despite several periods of spending slowdown (including the period of the 2007–2009 financial crisis), the rate of R&D to GDP rose from about 0.6% of the GDP in 1953 to about 2% in 2009. As the National Science Foundation notes, this increase reflects the growing role of business (privately funded) R&D in the United States and the growing prominence of R&D-derived goods and services in national and global economies.

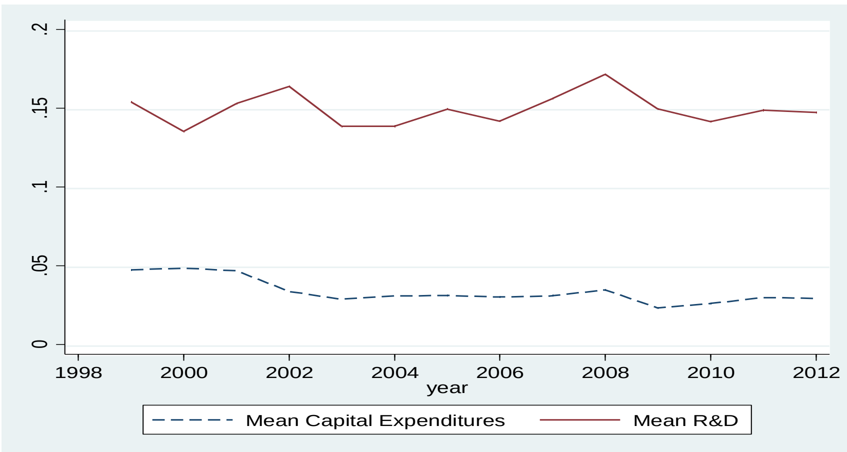
We focus on high-technology industries that are more R&D intensive. The reason for focusing on R&D expenditures instead of capital expenditures is twofold. First, according to the endogenous growth theory, R&D investments provide new knowledge and increase productivity (Romer, 1990). Thus, R&D spending has a longer-term effect on economic growth and is a more meaningful measure in the framework of our question of how damaging the financial crisis has been to the real economy. Second, since the 1980s, R&D spending has become increasingly important compared with capital investment (Borisova and Brown, 2013). Figure 1 illustrates[21] that the average R&D expenditures are more than double the average capital expenditures.

[21] Remarkably, both R&D and capital expenditures were at their peaks in 2008 and then radically dropped in 2010. As we are scaling all the series by total assets, overvaluation of assets before the crisis or undervaluation of assets after the crisis can potentially explain such high volatility in the series of average investments. To check how the dynamics of the series appear without scaling, we also plot the logarithms of R&D and capital expenditures without scaling by total assets, and the pattern looks similar to the series presented in Figure 1.



Panel A: Whole sample

The figure contains all non-financial firms available in the Compustat US database. The dashed line plots the yearly average capital expenditures, and the solid line plots the yearly average R&D expenditures. Both variables are scaled by total assets and Winsorized at the 1% level.



Panel B: Technology firms

The dashed line plots the yearly average capital expenditures, and the solid line plots the yearly average R&D expenditures. The figure contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. Both variables are scaled by total assets and Winsorized at the 1% level.

Figure 1 Average expenditures for research and development vs. capital expenditures

Our main question is how the financial crisis of 2007–2009 affected non-financial firms' investment behaviour. Our framework offers an insight into the question of whether the financial crisis was transmitted through the decreased credit supply or rather through the decreased demand for products. This paper contributes to the discussion on corporate investment, particularly R&D, and the effect of the financial crisis on the real economy. Our work is distinguished from previous work in the field by the approach that we use to test the interdependence between the financial crisis and the firms' investment behaviour. To the best of our knowledge, there is no direct comparison between the two groups of firms: financially constrained and distressed. We also contribute to the discussion on whether the supply or demand for funds is the dominant causal factor determining firms' investment policies during the crisis.

We find that financial distress played a minor role, if any, as a determinant of R&D expenditures during the financial crisis. Financial constraints had a substantial impact on R&D expenditures during the crisis. Everything else being equal, more constrained firms invested more during the crisis period.

We explain the higher level of investment of financially constrained firms during the crisis by the three following reasons. The first reason is connected with our definition of financial constraints: among other things, a higher ratio of long-term debt to assets corresponds to higher financial constraints. In our sample financially constrained firms have very low leverage, which implies that they rely less on external financing and are less affected by its scarcity during the crisis. Moreover, as the financially constrained firms in our sample are also young and growing, their R&D investments are likely to be determined by broader economic fundamentals than just a negative supply of external funds. The second reason behind the high R&D expenditures during the crisis is that our paper analyses only large public firms. Times of bank distress can be associated with the shift away from high-risk R&D projects of private firms to relatively safe projects of public firms (see for example Nanda and Nicholas, 2014). Such a shift might explain the increase in R&D investment of public firms during the crisis. As we do not observe the R&D expenditures of private firms, we unfortunately cannot test for the relative change in R&D investments between public and private firms. The third reason behind the increased R&D investments during the crisis is connected with the technological growth cycles. The discussion on whether R&D expenditures are pro-cyclical or counter-cyclical is still ongoing in the literature on economic growth, and it is beyond the scope of this paper. We argue that the R&D expenditures were not negatively affected during the crisis in 2008–2009 and that they were determined by broader economic fundaments than a negative supply shock.

Our result is consistent with the observation that the average R&D expenditures increased during the financial crisis and is in line with the findings of Kahle and Stulz (2013) and Hetland and Mjos (2012), who question whether firms' investment behaviour is affected by a credit supply-side shock. From a macroeconomic perspective, it is evident that the financial crisis did not negatively affect listed technology firms' R&D investment. This finding is evidence that the financial crisis did not significantly damage innovation and future growth proxied by R&D expenditures in the long term. Remarkably, our results are also similar to the results of Nanda and Nicholas (2014), who find that the aggregate effect of banks' distress on innovation during the Great Depression was weak for publicly traded firms, especially for industries that were less dependent on external financing. Similar to the recent financial crisis, the effect of bank distress on innovation during the Great Depression was strongest immediately after the collapse of the banking sector, but the effect attenuated as the depression years progressed.

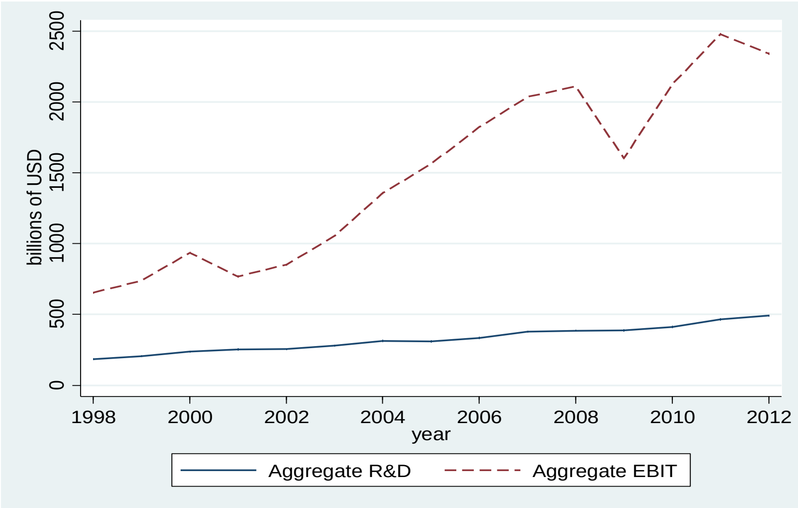
4.2 Financing of technology firms: Financial constraints and distress

4.2.1 Financing of technology firms

As mentioned in the introduction, the share of R&D expenditures is more than double that of capital expenditures in the non-financial firms included in the Compustat US database. In addition, 70% of the aggregate R&D expenditures in the US are concentrated in seven high-tech industries: drugs (SIC 283), office equipment and computers (SIC 357), electronic components (SIC 366), communication equipment (SIC 367), scientific instruments (SIC 382), medical instruments (SIC 384) and software (SIC 737). Following Brown et al. (2009), we use only these seven industries in our analysis.

In Figure 2 we present the aggregate R&D and earnings before interest and taxes (EBIT) for our sample.[22] The graph reflects the upward trend in the aggregate value of R&D expenditures. Moreover, the earnings of high-tech firms, measured by EBIT, are constantly increasing even during the financial crisis; they drop only in 2010, when the financial crisis was arguably over. This initial finding casts doubt on the hypothesis that the slowdown in R&D investment was due to firms' financial constraints in receiving external funds for their investments. Solely based on these findings, we would rather assume that the slowdown in R&D growth is driven by the decreased demand during the economic recession. The economy was already in recession in 2010; thus, production and sales could have already been negatively affected.

[22] Figure 2 presents the aggregate series without scaling them by the number of firms, because we want to demonstrate the importance of R&D expenditures for the economy in total rather than the increase in R&D expenditures for each particular firm.



The dashed line plots the yearly sum of earnings before interest and taxes (EBIT), and the solid line plots the yearly sum of R&D expenditures. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification.

Figure 2 Total research and development expenditures and EBIT over time

Our data show that high-tech firms were able to finance their R&D investment despite the crisis in the financial sector. This means they were able to borrow externally or had enough internal funds to finance their projects. Academic researchers agree that external financing, especially debt, can be more difficult to obtain for R&D-intensive firms, because R&D investments are more difficult to collateralize and monitor. For example, Hall (2002) notes, "Although leverage may be a useful tool for reducing agency costs in the firm, it is of limited value for R&D-intensive firms. Because the knowledge asset created by R&D investment is intangible, partly embedded in human capital, and ordinarily very specialized to the particular firm in which it resides, the capital structure of R&D-intensive firms customarily exhibits considerably less leverage than that of other firms." Our data confirm this statement. Table 1 shows that the mean leverage in the high-tech sample (0.107) differs considerably from the mean of the entire sample (0.219) in the Compustat US database for the period 1998–2012. This finding suggests that, in our sample, R&D-intensive firms do indeed rely on external financing to a lesser extent than the average firm in the sample.

Table 1 Descriptive statistics of leverage

Panel A reports the percentiles and descriptive statistics for the aggregate value of the leverage for the entire sample of the Compustat US database for the period 1998–2012. Panel B reports the descriptive statistics for the aggregate value of leverage for seven high-tech industries (SIC 283, 357, 366, 367, 382, 384 and 737) and the average value of leverage for each high-tech industry for 1998–2012. The variables are Winsorized at the 1% level.

Panel A. Leverage: Entire Sample

Descriptive Statistics	
Observations	24,253
Mean	0.219
Std Dev.	0.186
Min.	0
Max.	0.934

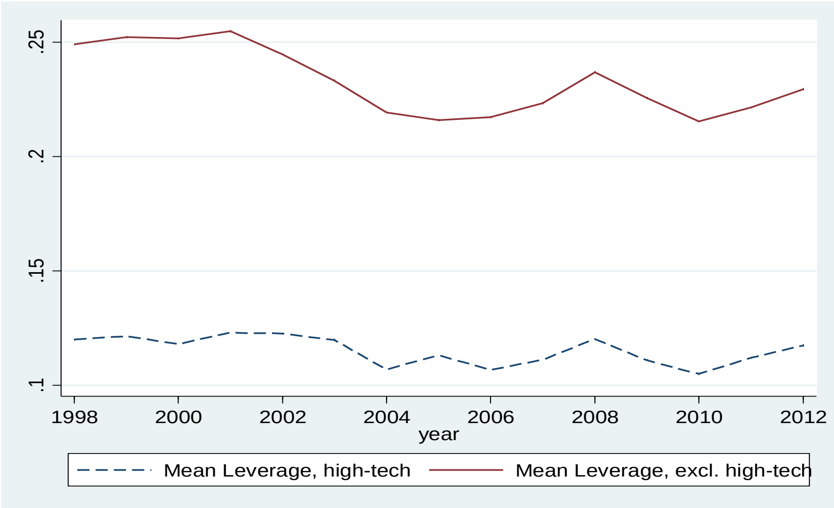
Percentiles	Leverage (Average)
25%	0.048
50%	0.198
75%	0.338
95%	0.574
99%	0.721

Panel B. Leverage: High-Tech Firms

Descriptive Statistics	
Observations	9898
Mean	0.107
Std Dev.	0.148
Min.	0
Max.	0.861

SIC	Leverage (Average)
283	0.127
357	0.087
366	0.111
367	0.126
382	0.106
384	0.111
737	0.081

At the same time, as Figure 3 illustrates, the leverage ratio for the whole sample in general and high-tech firms in particular did not sharply decrease during the 2007–2009 financial crisis, suggesting that firms were able to borrow during the downturn. The considerable decrease in the average leverage ratio happened only in 2010.



The solid line plots the yearly average leverage (total debt/total assets) for the sample of high-tech firms (with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification), and the dashed line plots the yearly average leverage for all the other firms, excluding high-tech. The figure contains all the firms available in the Compustat US database for the period 1998–2012 excluding financial firms and utilities. The variables are Winsorized at the 1% level.

Figure 3 Average leverage for the sample of high-tech industries and industries excluding high-tech

4.2.2 Financial constraints

With perfect capital markets, firms' investment decision is independent of their financial condition, which means that investment decisions depend only on the demand for investment. However, in the presence of asymmetric information, moral hazard and tax considerations, external and internal capital are not perfect substitutes and their costs differ. Adverse selection can also limit the ability of firms with certain characteristics to receive external financing. For example, small, young firms have less chance of obtaining funding for the same project than mature, large firms, because the creditor has more information about the latter and thus considers their projects to be less risky. Even among established firms, R&D investments can be disadvantaged due to the uncertainty associated with their output and higher adjustment costs (Hall, 2002).

A plethora of research develops different approaches to testing for financial constraints. Extensive literature is built on the test of the investment equation for liquidity constraints. Thus, Fazzari et al. (1988) address the problem using investment–cash flow sensitivities. They demonstrate that financial constraints matter for investment decisions; building on their findings, they argue that financial constraints contribute to macro-investment fluctuations. Building on the work of Kaplan and Zingales (1997), Lamont et al. (2001) propose what is commonly referred to as the KZ index. They estimate ordered logit models to determine which balance sheet items optimally predict financial constraints. Although the KZ index has been a popular measure of financial constraint, the recent literature casts certain doubts on its validity. Whited and Wu (2006) and Hadlock and Pierce (2009) provide evidence of the weaknesses of the KZ index and propose alternative measures. Rajan and Zingales (1998) construct a simple ratio for the dependence on external finance at the sector level, measuring a different but related phenomenon. In their work they take the ratio of capital expenditure minus cash flow to cash flow and compare the individual dependencies on the median sector level to determine the demand for external financing. Whited and Wu (2006) develop their WW index by optimizing the present discounted value of future dividends (Tong and Wei, 2008) and incorporate inequality constraints with respect to dividend payouts and the stock of debt in every period. Parameterizing the model and estimating it with the generalized method of moments (GMM), they identify the best fit for predicting financial constraints. We use the WW index in our baseline regression with an alternative measure of financial constraints as a robustness check. We compare the results of our baseline regression with the results using the work of Hadlock and Pierce (2009) as an alternative measure. Hadlock and Pierce (2009) carefully read the financial filings of a sample of US firms to preclassify them into five categories of constraints. Essentially replicating the analysis of Lamont et al. (2001), they find age, size, cash flow and leverage to be the only significant predictors of financial distress. To avoid endogeneity issues, they propose an index, the SA index, focused solely on age and size. The WW index correlates closely with the SA index, and Hadlock and Pierce (2009) report a simple correlation coefficient of 0.8 in their underlying sample.

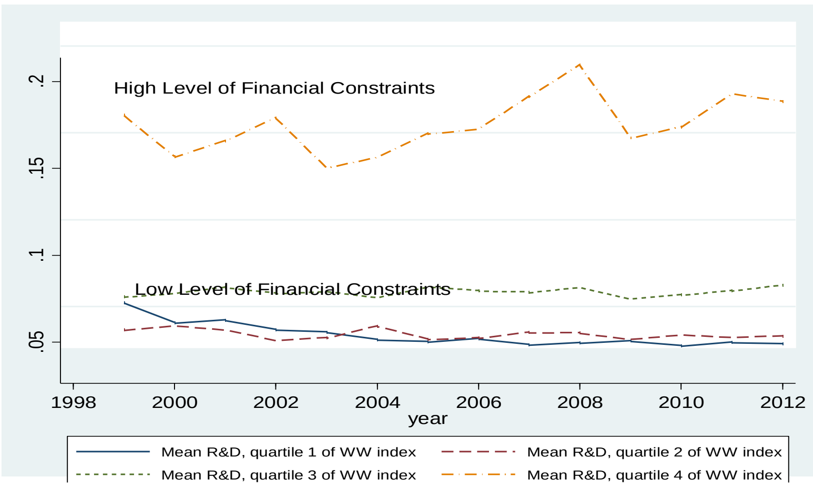
To test whether the WW and Hadlock and Pierce (2009) indexes make the same predictions for financial constraints in our sample, we divide the whole high-tech sample into small, young firms and large, mature firms. Small firms are firms with total assets below the median value, and young firms are firms aged less than 15 years. Large and mature firms are respectively firms with total assets above or equal to the median and aged 15 years or older. The definition of “young” and “mature” firms is based on the number of years for which the firm is listed in Compustat. We compute descriptive statistics for the WW index and its components and present them in the first two columns of Table 2. According to Hadlock and Pierce (2009), large and mature firms should be less constrained in receiving external financing than small and young firms. Indeed, the average value of the WW index for the sample of large, mature firms is smaller (-0.958) than the value for the sample of small, young firms (-0.737). Hence, large, mature firms are less financially constrained than small, young firms. If we also compare each component of the index between the two groups, we can see that the small, young firms’ average ratio of cash flow to total assets is negative (-0.303), while the average cash flow to assets for large and mature firms is positive (0.083). Moreover, as we would expect, small, young firms pay lower dividends but have higher sales growth and greater R&D expenses than large, mature firms.

Table 2 Investment, the WW index and its components grouped by small, young and large, old firms

Descriptive statistics for different groups of firms. The first two columns present the mean, standard deviation and number of observations for R&D expenditures, capital expenditures, the WW index and its components for the sample of high-tech firms (SIC 283, 357, 366, 367, 382, 384 and 737) grouped by small and young versus large and mature firms. Small firms are firms with total assets below the median value, and young firms are firms aged 15 years or less. Large and mature firms are, respectively, all the other firms: those with total assets greater than the mean and older than 15 years. Column three presents the same statistics for high-tech firms in total.

Variable	Large and Mature	Small and Young	High-Tech
Research and Development			
Observations	2337	2889	9898
Mean	0.082	0.221	0.144
St. Dev.	0.070	0.213	0.162
Capital Expenditures			
Observations	2329	2880	9860
Mean	0.034	0.030	0.032
St. Dev.	0.031	0.041	0.038
Whited and Wu Index			
Observations	2337	2889	9898
Mean	-0.958	-0.737	-0.838
St. Dev.	0.094	0.091	0.126
Cash Flow/Total Assets			
Observations	2337	2889	9898
Mean	0.083	-0.303	-0.083
St. Dev.	0.116	0.554	0.351
Long-Term Debt to Total Assets			
Observations	2337	2889	9898
Mean	0.113	0.046	0.080
St. Dev.	0.132	0.099	0.130
Total Assets (ln)			
Observations	2337	2889	9898
Mean	14.162	10.112	11.958
St. Dev.	1.721	1.037	2.225
Sales Growth			
Observations	2337	2889	9898
Mean	0.184	0.889	0.478
St. Dev.	2.863	12.029	8.255
Dividends (Paid=1, Not Paid=0)			
Observations	2337	2889	9898
Mean	0.348	0.018	0.125
St. Dev.	0.476	0.135	0.330

Figure 4 plots the R&D expenditures according to four quartiles of their level of financial constraints as measured by the WW index. The solid line represents the first quartile and the dotted–dashed line represents the firms with the highest level of financial constraints. At first glance, the figure suggests counterintuitive results: the firms with the highest level of financial constraints have the highest level of R&D. However, these findings are consistent with the discussion above in that R&D investment might not be directly affected by the shock in the financial sector, but the slowdown in the growth of R&D investment is due to the recession in the whole economy. Hence, financially constrained firms might not necessarily reduce their R&D expenditures due to financial constraints, but they would be affected by other broader economic fundamentals. Furthermore, according to the WW index, a firm is considered to be more financially constrained if it is small and has a high level of sales growth. This means that small, growing firms are generally more financially constrained. At the same time, these firms tend to invest most in the development of new goods and services.



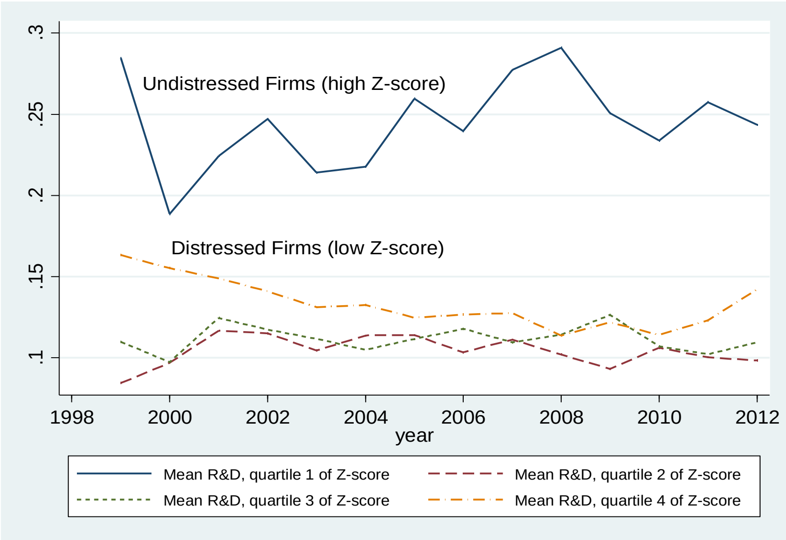
Yearly averaged R&D expenditures grouped by four quartiles of financial constraint. Financial constraints are measured according to Whited and Wu (2006), and the firms in the first quartile are the least constrained. R&D is scaled by total assets and Winsorized at the 1% level. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification.

Figure 4 Research and development expenditures by four quartiles of financial constraints

4.2.2 Financial distress

Parts of the literature distinguish between purely financial and economic distress (Andrade and Kaplan, 1998). Differentiating these two types of distress is not straightforward, so we will not draw this distinction. Altman (1968) assesses a firm's probability of defaulting on its liabilities from a ratio analysis of accounting-based balance sheet data. Ohlsson (1980) proposes a similar indicator derived from a conditional logit model also employing accounting-based measures. In his seminal contribution, Merton (1974) proposes an alternative approach by describing a firm's equity as a call option on the value of its assets. Current equity prices help to determine the probability of default by incorporating market evaluations into the financial distress assessment. Subsequent research attempts to improve on the accuracy of both accounting- and market-based measures or partly combines them (Campbell et al., 2008).

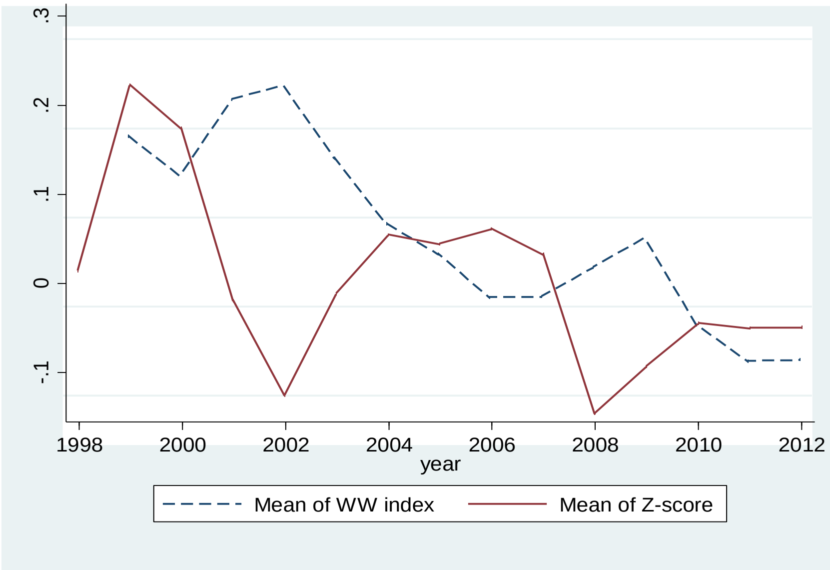
To measure the financial distress of firms in this study, we employ Altman's Z-score, a linear combination of five financial ratios computed from firms' financial statements that are often used in the academic literature because they are intuitive and easy to compute. The exact specification of the Z-score is noted in the appendix. By measuring financial distress, we investigate whether the 2007–2009 financial crisis contributed to creative destruction. That is, did it drive weak businesses and poorly performing firms out of the market? These firms are expected to have been unable to find projects with positive net present values during the crisis. Therefore, the theory predicts that they will have reduced their investment during the crisis. In Figure 5 we plot the R&D expenditures according to the four quartiles of firms' level of financial distress measured by Altman's Z-score. The graphs show that the least financially distressed firms (the fourth quartile of Altman's Z-score index) tend to have the highest level of R&D expenditures. However, the pattern for the three lower quartiles does not allow for preliminary conclusions, so we will explore the effect of firms' financial distress on their investment further.



The figure plots the yearly average R&D expenditures grouped by four quartiles of financial distress. Financial distress is measured according to Altman (1968), and the firms in the first quartile are the most distressed. R&D is scaled by total assets and Winsorized at the 1% level. Altman's Z-scores are also Winsorized at the 1% level. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification.

Figure 5 Research and development expenditures by four quartiles of financial distress

In Figure 6 we plot our indicators of financial distress and financial constraints over time. Both indicators develop according to intuition in 2008 and 2009, and firms are on average more financially distressed and constrained during the crisis. The simple correlation of the Winsorized measures for financial constraints and financial distress is −0.144. A negative correlation is to be expected, as increasing constraints are reflected in an increasing value of the WW index while increasing distress is reflected in a decreasing Z-score.



The figure plots the yearly average Altman's Z-score and the Whited and Wu (2006) index. The solid line plots Altman's Z-score, and the dashed line plots the WW index. Both indicators are normalized and Winsorized at the 1% level. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification.

Figure 6 Financial distress and financial constraint indicators over time

4.3 Related literature

The huge-scale governmental interventions in the financial sector during the 2007–2009 crisis raise some questions: is it worth spending taxpayers' money to save big banks and are the fluctuations in the financial sector strongly connected to the performance of the non-financial sector? The theories of impaired access to capital built the foundation for a wide range of policy interventions during the crisis, including the Troubled Asset Relief Program implemented in 2008. Some studies indeed show theoretically and empirically that fluctuations in financial markets affect the growth of non-financial companies. For example, Duchin et al. (2010), Almeida et al. (2012) and Campello et al. (2010) show that firms reduce their capital expenditures in the face of negative shocks to the credit supply (bank lending supply shocks or credit supply shocks in general). Contradicting these results, other researchers (e.g., Kahle and Stulz, 2013; Hetland and Mjos, 2012) find evidence that a lending supply shock was not necessarily the dominant causal factor for financial and investment policies during the crisis and that the investment levels of financially constrained firms were not more affected than the investment levels of financially unconstrained firms. Below, we describe the aforementioned research in greater detail. First, we present evidence supporting the notion that a credit supply shock directly harms the investment of firms. Subsequently, we describe contrary findings.

A branch of research finds evidence that corporate investment, especially of small, bank-related firms or financially constrained firms, declines significantly following the onset of a crisis. This type of study uses Stiglitz and Weiss's (1981) model of credit rationing as the theoretical background for its empirical hypothesis. According to this model of credit rationing, prices on the loan markets are not cleared through the simple price mechanism; rather, equilibrium in loan markets is characterized by credit rationing. Credit rationing occurs when, among identical loan applicants, some of the applicants receive a loan and others do not. Moreover, the rejected applicants would not receive a loan even if they were ready to pay a higher interest rate. Alternatively, in identical groups of individuals with a given credit supply, some are unable to obtain a loan even though they would be able to do so in the case of a larger credit supply. Stiglitz and Weiss (1981) emphasize in their conclusion that "in a rationing equilibrium, to the extent that monetary policy succeeds in shifting the supply of funds, it will affect the level of investment, not through the interest rate mechanism, but rather through the availability of credit". These findings are quite plausible: a decrease in the credit supply cannot increase the price (the interest rate) of the loan until the supply is equal to the demand, because increasing interest rates or collateral requirements would increase the riskiness of banks' loan portfolios by inducing the borrowers to invest in riskier and potentially more profitable projects.

Several empirical studies base their hypotheses on the model of credit rationing and are able to confirm it. For example, Duchin et al. (2010) assess the impact of the crisis on investment by regressing firm-level quarterly investment (both capital expenditures and R&D) on a crisis indicator variable, on the interaction of this indicator variable with the firm's cash reserves and on controls for firm fixed effects, Q, and cash flow. They find that corporate investment declined significantly after the onset of the crisis, especially for firms that had low cash reserves or high net short-term debt, faced financial constraints and operated in industries that are dependent on external finance. Almeida et al. (2012) use a matching approach to compare the evolution of capital expenditures of treated firms relative to their control group during the crisis. They test whether firms with a large fraction of long-term debt maturing during the crisis decreased their corporate investment more than firms that did not need to refinance a large amount of their debt during the crisis. Almeida et al. (2012) find that firms with long-term debt maturing immediately after the third quarter of 2007 cut their quarterly investment rates by 2.5 percentage points more than firms with debt due after the crisis. An earlier empirical paper by Hoshi et al. (1991) confirms the theory of impaired access to capital. They study a sample of Japanese industrial firms and show that investment by a set of firms that are closely tied to large banks is less sensitive to liquidity constraints than investment by firms with weak bank relationships.

However, recent studies question the empirical findings listed above and the idea that a credit supply shock was the dominant factor for investment policies during the crisis. For instance, Kahle and Stulz (2013) use cross-sectional variation in changes in firm investment and financing policies to investigate whether the credit supply shock is a first-order determinant of firms' changes in investment policy during the crisis. They consider four channels through which firms' investment levels change during the crisis: 1) a bank lending supply shock, which predicts that net debt issuance should fall more for bank-dependent firms; 2) the supply of credit in general, which predicts that not just bank-dependent but credit-dependent firms were affected more during the crisis; 3) a demand shock, which suggests that the losses of housing wealth, decreases in consumer credit and panic after the failure of Lehman Brothers in September 2008 led to firms' demand for funding investment; and 4) the collateral channel or balance sheet multiplier effect, which suggests that firms' capital expenditures decreased due to the fact that during the crisis the value of the assets fell and hence the firms had less collateral against which to borrow. To assess these four channels empirically, Kahle and Stulz

(2013) use the Almeida et al. (2012) matching approach and the Duchin et al. (2010) methodology. They compare highly leveraged, bank-dependent firms with firms with similar leverage but no bank loan or revolver two years prior to the crisis. Likewise, they compare a sample of firms with zero leverage two years prior to the crisis (firms that are not dependent on credit) with a sample of firms with consistently high cash holdings. They find no support for the view that bank lending or credit supply shocks played a major role in decreasing firms' capital expenditures in the last two quarters of 2007 and the first two quarters of 2008. Moreover, they do not support the collateral channel or balance sheet multiplier effect on capital expenditures. However, they emphasize that, during the crisis, pervasive effects across firms irrespective of their leverage did exist: a common shock to the demand for firms' products and uncertainty about the future demand could lead to a general decrease in capital expenditures independent of firms' financial characteristics.

Hetland and Mjos (2012) empirically show that financially constrained firms' investment levels were not more affected during the crisis. They assess the impact of the 2008–2009 crisis in Norway on unlisted small and medium-sized firms. In contrast to Duchin et al. (2010), they find that changes in credit availability affect investments most for the least financially constrained firms. They explain their finding by stating that financially constrained firms tend to use more cash holdings and other types of crisis-hedging instruments than financially unconstrained firms. Hence, in the crisis, unconstrained firms experience the largest shock to their investment policies and the effect of financial constraints on real investment is more complex than is generally assumed in the literature.

Given the current status of research in the area, it is ambiguous whether non-financial firms decrease their investment due to a decrease in the credit supply or due to the fact that the economy is in recession and the investment opportunities are limited. We contribute to the literature and examine the effect of the financial crisis on the real economy.

4.4 Data and empirical approaches

4.4.1 Empirical model

Numerous researchers demonstrate that external and internal financing are not perfect substitutes in the presence of informational asymmetry, costly monitoring and contract enforcement problems (Myers and Majluf, 1984; Stiglitz and Weiss, 1981; Jensen and Meckling, 1976). External finance is shown to be costlier than internal finance. The gap between external and internal finance widens with increasing interest rates, leading to adverse effects on investment. During bank lending supply shocks, some borrowers may be constrained from receiving external funds due to their dependence on banks. Empirical tests of the importance of financial constraints for investment commonly use two approaches: 1) testing for financial constraints using Q-models or 2) directly estimating the Euler equation for capital stock.

Fazzari et al. (1988) introduce the approach using Q-models. They add proxies for the availability of internal funds to the investment equation and thus assume that the investment rate should not depend on any variables other than the average Q (the market value of the firm relative to the replacement value of the capital stock). The cash flow usually proxies for the availability of internal funds in this approach. However, this approach is subject to criticism, as the cash flow may contain information about future profitability and hence can be correlated with the investment demand (opportunities).

The main alternative to using Q-models of investment to test for financial constraints is the direct estimation of the Euler equation for the capital stock. The main advantage of this approach is that it does not rely on unobservable measures, such as the market value of the firm. The structural model by Bond and Meghir (1994) and Bond et al. (2003) is commonly used in this framework. In this model current investment is positively related to expected future investment and a current average profit term and negatively related to the user cost of capital. In the empirical work, the unobserved expected future investment is replaced by the realized investment rate plus a forecast error. The cost of the capital term is replaced by time and firm-specific effects. The output/capital ratio can also be introduced into the model to account for the cost of other factors of production, and the debt term can be used to control for non-separability between investment and borrowing decisions.

Following Bond et al. (2003) and Brown et al. (2009), the empirically operational investment equation takes the form

$$RD_{i,t} = \alpha_i + \alpha_1 RD_{i,t-1} + \alpha_2 RD_{i,t-1}^2 + \alpha_3 CF_{i,t-1} + \alpha_4 Sales_{i,t-1} + d_t + \epsilon_{it}, \qquad (1)$$

where $RD_{i,t}$ is the lagged R&D expenditures for firm i in period t, $RD_{i,t-1}^2$ is the quadratic adjustment costs and $CF_{i,t-1}$ is the lagged gross cash flow accounting for the cost of other factors of production under the assumption of constant returns to scale. $Sales_{i,t-1}$ stands for the firm's lagged sales, which proxy for the output of the firm. All the variables are scaled by the firms' beginning-of-period assets. Bond and Meghir's (1994) structural model implies that firm investments should be scaled by the physical capital stock, but it is hard to determine this value in the case of R&D due to the absence of a long time series of R&D expenditures and their rate of depreciation. Thus, we follow Brown et al. (2009) and use a firm's total assets as a scale factor in the regression.

Following Brown et al. (2009) and their basic approach, we include contemporaneous sales, $Sales_t$, in the model as an additional control for demand; we also include measures of financial constraints (Whited and Wu, 2006) and financial distress (Altman, 1968) and their interaction with the crisis dummy in investment equation (1). The exact specification of the measures is noted in the appendix.

$$RD_{i,t} = \alpha_i + \alpha_1 RD_{i,t-1} + \alpha_2 RD_{i,t-1}^2 + \alpha_3 CF_{i,t-1} + \alpha_4 Sales_{i,t-1} + \alpha_5 Sales_t + \alpha_6 Dum_{\text{Crisis}} + \gamma FD_{it-1} + \gamma_1 Dum_{\text{Crisis}} FD_{it-1} + \beta FC_{it-1} + \beta_1 Dum_{\text{Crisis}} FC_{it-1} + ind_j + \epsilon_{it}, \qquad (2)$$

where Dum_{Crisis} is an indicator variable that is one during the crisis period and zero otherwise. FC_{it-1} stands for the lagged measure of financial constraints, and FD_{it-1} is the lagged measure of financial distress. To control for movements in the aggregate cost of capital and tax rates, Bond and Meghir (1994) include time dummies, and Brown et al. (2009) use industry-level time dummies to control for industry-specific changes in technological opportunities. Since we are only interested in the effect of the crisis period (2008–2009) on investment, we use only the crisis time dummy. To control for the industry-specific changes, we include industry (ind_j) dummies in our model.

Moreover, the structural theoretical model implies that, under the null hypothesis of no financial constraints, α_1 is positive and slightly larger than one and α_2 is slightly less than minus one. The coefficient of the lagged cash flow (α_3) is expected to have a negative sign, since it proxies for other factors of production. The coefficient of lagged sales (α_4) is expected to be positive, since lagged sales proxy for output and should positively affect firms' investment opportunities. We also expect α_5 (the coefficient for contemporaneous sales) to be positive, because it proxies for the demand for firms' goods or services.

4.4.2 Data

All the data are taken from the Compustat US database. We use annual data starting from 1998, and our last observation is from 2012. Brown et al. (2009) identify seven high-tech industries in which R&D investment is concentrated: drugs, office equipment and computers, electronic components, communication equipment, scientific instruments, medical instruments and software. We follow Brown et al. (2009) and use these seven industries (SIC 283, 357, 366, 367, 382, 384 and 737) and drop firms from all other industries. The total sample of all high-tech and non-high-tech firms consists of 2,446 firms, but in the regression analysis we analyse only the sample of 1,219 high-tech firms. To use all the available information, we apply an unbalanced panel approach.

A descriptive overview of all our variables is displayed in Table 3. To mitigate the influence of extreme observations and following the practice in the existing literature, we Winsorize all the variables at the 1% level.

We also exclude observations with negative sales, negative total assets and negative equity.

Table 3 Descriptive statistics for the sample of high-tech firms

The descriptive statistics for all the variables used in the regressions (SIC 283, 357, 366, 367, 382, 384 and 737). All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets.

Variable	Mean	Std Dev.	Min.	Max.
Research & Development (RD)	0.144	0.162	0	0.954
Cash Flow (CF)	-0.083	0.351	-1.981	0.432
Sales	0.790	0.557	0	4.220
Z-Scores (FD)	5.439	13.010	-26.868	120.731
Whited and Wu Index (FC)	-0.838	0.126	-1.209	-0.545
Total Assets (in Million USD)	2135.238	8755.249	0.579	88900
N	9898			

4.5 Empirical results

4.5.2 Dynamic panel estimation

According to Bond and Meghir's (1994) structural model of investment, current investment is positively related to expected future investment. This implies that our empirical specification includes the lagged value of the dependent variable. This leads to endogeneity issues in the panel data regression. Additionally, due to the inclusion of a contemporaneous term ($Sales_t$), simultaneity can cause OLS estimates to be biased and inconsistent. Since our panel is characterized by a large N and small T, autocorrelation remains a problem in our regressions. The most commonly used estimators designed to overcome the described problems are those of Arellano and Bond (1991) and Arellano and Bover (1995).

We use the Arellano and Bover (1995) system GMM estimator as our primary approach. We treat RD_{t-1}, RD_{t-1}^2 and $Sales_t$ as potentially endogenous.

In the following we estimate the model as described in equation (2). We report both OLS fixed-effect and OLS random-effect results and the Arellano and Bover (1995) estimation results with two different choices of instruments. Table 4 displays the estimates. The Hausman test confirms that the random effects are inconsistent, so the results are reported for completeness. The two specifications following Arellano and Bover (1995) differ in the choice of instruments. In the first specification, we choose to use instruments only for the dynamic part of the equation and contemporaneous sales; the second specification includes instruments for all the variables. We use the third lag in both specifications. While we encounter problems with overidentification – in particular when using instruments for all the explanatory variables – the main variables of interest are consistently significant across the different estimations. The problem of overidentification is less severe when we use only lags of three variables ($RD_{i,t-1}, RD_{i,t-1}^2$ and $Sales_t$) as instruments. The p-value of the Hansen test in this regression does not reject the null hypothesis (at the 1% confidence level) that the instruments are valid and uncorrelated with the error term. Thus, we use the results from this regression as the baseline in our analysis.

The estimated coefficient of the financial constraints, FC_{t-1}, is insignificant in all the specifications, meaning that the financial constraints measured by the WW index do not affect the R&D expenditures during normal times. However, the coefficient for the interaction term between the financial constraints and the crisis dummy is positive and significant, suggesting that firms with higher financial constraints invested more during the financial crisis. This result is significant in all four specifications presented in Table 4. Moreover, the result is in line with our initial predictions based on the descriptive statistics: Figure 4 shows that the firms with the highest financial constraints have the highest level of investment. One of the potential explanations for this result is that the R&D expenditures of firms are not directly affected by frictions in the financial sector; rather, the R&D expenditures might be sensitive to the dynamics of demand during economic cycles. Below, we present some arguments to support this explanation.

4.5.3 Discussion of the results

First, we discuss the results presented in Table 4 further and then present the explanation of our main results. The estimated coefficients conform reasonably well to the Euler equation predictions under the null hypothesis of no financial constraints. In particular, the dynamic effect of lagged R&D is in line with the theoretical predictions discussed in section 4.4, and the coefficient α_1 from equation (2) is highly significant and greater than one. The structural model also suggests that the coefficient of quadratic adjustment costs should be smaller than minus one. In all our regressions, the coefficients for the adjustment costs are negative and highly significant, but they are never smaller than minus one. The only result that contradicts the theoretical predictions is the negative sign for the coefficient of the lagged sales. According to the theory, this coefficient should be positive, since the output of a firm should be positively related to its expected future investment. Bond and Meghir's (1994) investment equation is derived under the null hypothesis of no financial constraints, and the estimated coefficients mainly conform to the theoretical predictions. This may suggest that the firms in our sample are not severely financially constrained, and that is why the WW index is even positive during the crisis.

Second, the results are similar to those of Kahle and Stulz (2013). They investigate access to capital and capital expenditures during the 2007–2009 financial crisis for bank-dependent firms and firms that were highly leveraged before the crisis. These firms should be more financially constrained during the financial crisis due to the negative supply shock, but Kahle and Stulz (2013) find that highly leveraged firms decreased their capital expenditures during the crisis as much as unleveraged firms. Bank-dependent firms did not decrease their capital expenditures more than firms that were not dependent on banks in the first years of the crisis and in the two quarters after the Lehman collapse. Thus, they argue that a bank lending shock or a credit supply shock were not the first determinants of firm investment and financial policies during the crisis and rather support the demand shock theory. Kahle and Stulz contradict Brown et al.'s (2009) finding that access to internal and external finance has a significant effect on young firms' R&D investment but has no impact on mature firms. Together with the fact that there was no boom in R&D for mature firms, Brown et al. (2009) explain their findings with a shift in the finance supply and argue that it is difficult to explain them with a demand-side story. Thus, our results support Kahle and Stulz's (2013) findings, and we argue that a demand shock during the recession has a greater impact on R&D expenditures. As we saw in Figure 1, the R&D expenditures were not considerably affected in 2008 when a possible negative supply shock occurred, but they were more affected in 2009 when the economy had already been in recession. (The real GDP growth in the USA dropped to −2.78% in 2009, while it was −0.29% in 2008 according to the data from the Bureau of Economic Analysis.) Moreover, the coefficient of contemporaneous sales (a proxy for the firms' demand) is positive and significant throughout all four specifications. This result suggests that the demand had a significant impact on high-tech firms' R&D investment during the period of our study.

In addition, our findings are in line with those of Hetland and Mjos (2012), who show that, for their sample of unlisted Norwegian firms, the credit availability affected investments most for the least financially constrained firms. The suggested explanation is that financially constrained firms used their cash holdings and other means to hedge against future credit market distractions to a greater extent than generally less constrained firms that rely more on external financing.

Our results are also similar to those of Nanda and Nicholas (2014), who use micro-data on corporate R&D to study the effect of the financial sector's distress on technological development during the Great Depression. They find that the R&D of public firms was not severely affected relative to the R&D of private companies and that bank distress was associated with the shift away from high-risk R&D projects of private firms to relatively safe projects of public firms. They conclude that the aggregate effect of banks' distress on innovation during the Great Depression was weak for publicly traded firms, especially in industries that were less dependent on external financing. Interestingly, similar to the recent financial crisis, the effect of bank stress on innovation during the Great Depression was strongest immediately after the collapse of the banking sector, but the effect attenuated as the depression years progressed.

Our sample consists of high-tech publicly traded firms, which on average rely on external financing to a lesser extent than other firms,[23] and, similar to Nanda and Nicholas (2014), we also find that R&D expenditures of public firms were not negatively affected by the recent financial crisis.

Moreover, according to the index of financial constraints that we use, financially constrained firms are less dependent on external financing. As Table 2 demonstrates, small and young firms (which are also classified as more constrained by the WW index) have a ratio of long-term debt to assets that is more than 2.5 times smaller than large and mature firms (0.046 and 0.113, correspondingly). Independence from external financing and hence from shocks in its availability explains why the financially constrained firms in our sample were not negatively affected. In addition to a low long-term debt-to-assets ratio, the financially constrained firms in our sample have quite high sales growth compared with the unconstrained firms. High sales growth is usually associated with young, expanding firms, which invest more intensively than large and mature firms. Our results indicate that the R&D investments in our sample were not affected by the shocks in the financial sector but rather that R&D investments follow the cycle, which is not directly related to the supply of external financing.

The discussion on whether R&D expenditures are pro-cyclical or counter-cyclical is still ongoing in the literature on economic growth. For example, Rafferty (2003) notes that R&D can have counter-cyclical behaviours due to the opportunity cost effect: the return to inventive activity is stable over the business cycle, but the return to productive activity is high during expansion periods and low during recessions. Fatas (2000) presents empirical and theoretical evidence that R&D expenditures are pro-cyclical and the trend of research and development

[23] As Table 1 demonstrates, the average leverage (debt-to-assets ratio) of high-tech firms is almost two times smaller than the average ratio of the entire sample of Compustat firms, excluding financial firms and utilities.

growth is similar to that of GDP growth. The discussion of pro-cyclicity and counter-cyclicity of R&D are beyond the scope of this paper. However, we argue that the R&D expenditures in our sample were not affected directly by the negative shocks in the financial sector but rather followed their own cycle.

Similar to the coefficient of financial constraints, we find a statistically significant impact of our financial distress measure during the financial crisis, but it is economically very small. Thus, financially distressed firms are substantially similar to undistressed firms, both during normal times and during the financial crisis. This result indicates that the financial distress measured by Altman's Z-scores does not have an economically substantial impact on R&D expenditures. While we initially expected to see some effect, we may explain these results with the fact that Altman's Z-scores cannot measure purely financial distress. Rather, they are a mixed measure of economic and financial distress. As we already control for demand effects, our measure of financial distress might not capture enough of the purely financial distress to play a significant role.

Table 4 Panel estimation results – Research and development

Estimation of the model described in equation (2). The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($RD_{i.t-1}, RD_{i.t-1}^2$ and $Sales_t$) and use all the other variables directly as instruments. All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
RD_{t-1}	1.084***	0.813***	1.607***	1.509***
	(0.039)	(0.055)	(0.318)	(0.130)
RD_{t-1}^2	-0.621***	-0.519***	-0.812***	-0.886***
	(0.055)	(0.066)	(0.267)	(0.166)
$\mathrm{Dum}_{\mathrm{Crisis}}$	0.015***	0.014***	0.012**	0.010***
	(0.003)	(0.003)	(0.005)	(0.002)
FD_{it-1}	0.000***	0.000**	0.000**	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
$\mathrm{Dum}_{\mathrm{Crisis}}\mathrm{FC}_{t-1}$	0.000	0.001*	0.001*	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)
FC_{t-1}	0.038*	0.004	0.042	0.061
	(0.021)	(0.030)	(0.077)	(0.093)
$\mathrm{Dum}_{\mathrm{Crisis}}\mathrm{FC}_{t-1}$	0.016***	0.014***	0.014***	0.012**
	(0.003)	(0.003)	(0.004)	(0.005)
Sales_{t-1}	-0.079***	-0.060***	-0.104***	-0.066***
	(0.007)	(0.007)	(0.013)	(0.025)
Sales_{t}	0.075***	0.087***	0.090***	0.065**
	(0.007)	(0.007)	(0.013)	(0.027)
CF_{t-1}	0.020***	0.014	0.129***	0.047
	(0.007)	(0.009)	(0.036)	(0.042)
357.SIC3	-0.062***		0.113	0.026
	(0.008)		(0.194)	(0.060)
366.SIC3	-0.063***		-0.162	-0.060
	(0.007)		(0.162)	(0.044)
367.SIC3	-0.059***		0.025	-0.016
	(0.007)		(0.128)	(0.036)
382.SIC3	-0.064***		-0.237	-0.084*
	(0.007)		(0.151)	(0.048)
384.SIC3	-0.056***		0.016	-0.044
	(0.008)		(0.135)	(0.043)
737.SIC3	-0.061***		-0.097	-0.063**
	(0.007)		(0.108)	(0.028)
Constant	0.106***	0.033	0.050	0.055
	(0.021)	(0.029)	(0.122)	(0.096)
Observations	9898	9898	9898	9898
Adjusted R^2	0.203	0.226		
Instruments			48	145
Hansen Test			0.006	0.000

4.5.3 Robustness

As much of the literature uses capital expenditures to measure corporate investment, we also use capital expenditures as the dependent variable and apply the model described in equation (2). The results reported in Table 5 confirm our previous analysis. The analysis also shows that the dynamic part of the model is not statistically significant in Arellano and Bover's (1995) dynamic panel estimation. It is not surprising that capital investment is less persistent; adjustment costs are usually much less important. The results illustrate that the result of relatively higher investment of more constrained firms also holds for capital investment during the financial crisis.

We additionally extend the crisis period to 2010 as the descriptive statistics show that the average R&D continued to decline in 2010. Although the financial crisis was arguably over in 2010, it could be argued that the effects might only transmit with a larger delay than we account for when limiting the crisis period to 2008–2009. This analysis shows similar results.

Firms from the pharmaceuticals sector (SIC 283) have a substantially higher level of average R&D expenditures in our sample and might drive the results. We thus perform the same analysis excluding all firms with SIC 283. Table 7 shows that the main results are unaffected.

Table 5 Panel estimation results – Capital expenditures

Estimation of the model described in equation (2) replacing R&D expenditures with capital expenditures as the dependent and lagged explanatory variables. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($CE_{i.t-1}, CE^2_{i.t-1}$ and $Sales_t$) and use all the other variables directly as instruments. All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
CE_{t-1}	0.663^{***}	0.430^{***}	-0.348	0.359^{*}
	(0.047)	(0.047)	(0.253)	(0.194)
CE^2_{t-1}	-1.159^{***}	-0.891^{***}	2.733^{**}	0.255
	(0.270)	(0.213)	(1.280)	(1.142)
$\mathrm{Dum}_{\mathrm{Crisis}}$	-0.002^{**}	-0.002^{**}	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
FD_{it-1}	0.000^{***}	0.000^{***}	0.000^{**}	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
$\mathrm{Dum}_{\mathrm{Crisis}}\mathrm{FC}_{t-1}$	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
FC_{t-1}	-0.005	-0.009	-0.021	0.065^{**}
	(0.004)	(0.008)	(0.013)	(0.027)
$\mathrm{Dum}_{\mathrm{Crisis}}\mathrm{FC}_{t-1}$	0.006^{***}	0.007^{***}	0.009^{***}	0.004^{***}
	(0.001)	(0.001)	(0.001)	(0.001)
Sales_{t-1}	-0.011^{***}	-0.007^{***}	-0.005^{*}	-0.020^{**}
	(0.002)	(0.002)	(0.003)	(0.008)
Sales_{t}	0.013^{***}	0.014^{***}	0.014^{***}	0.020^{***}
	(0.002)	(0.002)	(0.003)	(0.007)
CF_{t-1}	0.008^{***}	0.007^{***}	0.013^{***}	0.030^{**}
	(0.001)	(0.002)	(0.005)	(0.013)
357.SIC3	-0.003^{**}		0.016	-0.010
	(0.001)		(0.067)	(0.019)
366.SIC3	-0.006^{***}		-0.071	-0.037^{**}
	(0.001)		(0.071)	(0.018)
367.SIC3	0.007^{***}		0.022	0.007
	(0.002)		(0.020)	(0.010)
382.SIC3	-0.003^{**}		-0.060	0.010
	(0.001)		(0.056)	(0.015)
384.SIC3	0.001		0.006	0.018
	(0.001)		(0.046)	(0.018)
737.SIC3	-0.002^{**}		-0.032	0.004
	(0.001)		(0.048)	(0.010)
Constant	0.008^{**}	0.007	0.028	0.075^{***}
	(0.004)	(0.007)	(0.022)	(0.026)
Observations	10930	10930	10930	10930
Adjusted R^2	0.104	0.115		
Instruments			48	145
Hansen Test			0.012	0.013

Table 6 Panel estimation results – Extended crisis period

Estimation of the model described in equation (2) with Dum_{Crisis} for years 2008–2010. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($RD_{i.t-1}, RD^2_{i.t-1}$ and $Sales_t$) and use all the other variables directly as instruments. All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
RD_{t-1}	1.083***	0.815***	1.706***	1.537***
	(0.040)	(0.056)	(0.309)	(0.130)
RD^2_{t-1}	-0.621***	-0.521***	-0.901***	-0.892***
	(0.056)	(0.066)	(0.264)	(0.166)
Dum_{Crisis}	0.008***	0.008***	0.007*	0.004*
	(0.002)	(0.002)	(0.004)	(0.002)
FD_{it-1}	0.000***	0.000**	0.001**	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
$Dum_{Crisis}FC_{t-1}$	0.000	0.000	0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
FC_{t-1}	0.034*	-0.001	0.022	0.048
	(0.021)	(0.030)	(0.076)	(0.094)
$Dum_{Crisis}FC_{t-1}$	0.010***	0.011***	0.012***	0.006
	(0.003)	(0.003)	(0.004)	(0.004)
$Sales_{t-1}$	-0.079***	-0.061***	-0.107***	-0.074***
	(0.007)	(0.007)	(0.013)	(0.025)
$Sales_t$	0.075***	0.087***	0.090***	0.072***
	(0.007)	(0.007)	(0.013)	(0.027)
CF_{t-1}	0.021***	0.015*	0.134***	0.057
	(0.007)	(0.009)	(0.034)	(0.040)
357.SIC3	-0.063***		0.151	0.025
	(0.008)		(0.200)	(0.060)
366.SIC3	-0.063***		-0.142	-0.060
	(0.007)		(0.158)	(0.045)
367.SIC3	-0.060***		-0.002	-0.015
	(0.007)		(0.129)	(0.036)
382.SIC3	-0.065***		-0.197	-0.079*
	(0.007)		(0.148)	(0.048)
384.SIC3	-0.056***		0.035	-0.042
	(0.008)		(0.133)	(0.044)
737.SIC3	-0.061***		-0.088	-0.058**
	(0.007)		(0.107)	(0.029)
Constant	0.104***	0.029	0.017	0.040
	(0.021)	(0.029)	(0.119)	(0.097)
Observations	9898	9898	9898	9898
Adjusted R^2	0.189	0.224		
Instruments			48	145
Hansen Test			0.004	0.000

Table 7 Panel estimation results – Excluding pharmaceuticals

Estimation of the model described in equation (2) excluding pharmaceuticals. The sample contains all the firms available in the Compustat US database with SIC 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($RD_{i.t-1}, RD^2_{i.t-1}$ and $Sales_t$) and use all the other variables directly as instruments. All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
RD_{t-1}	1.030***	0.762***	1.220***	1.187***
	(0.048)	(0.074)	(0.196)	(0.111)
RD^2_{t-1}	-0.489***	-0.345***	-0.676*	-0.603***
	(0.093)	(0.108)	(0.354)	(0.217)
Dum_{Crisis}	0.007***	0.005**	0.010***	0.008***
	(0.002)	(0.002)	(0.004)	(0.002)
FD_{it-1}	0.000**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
$Dum_{Crisis}FC_{t-1}$	-0.000	-0.000	0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
FC_{t-1}	-0.002	-0.077*	0.025	0.125**
	(0.021)	(0.041)	(0.057)	(0.057)
$Dum_{Crisis}FC_{t-1}$	0.007***	0.005*	0.006*	0.001
	(0.002)	(0.003)	(0.003)	(0.003)
$Sales_{t-1}$	-0.067***	-0.052***	-0.072***	-0.076***
	(0.008)	(0.009)	(0.009)	(0.019)
$Sales_t$	0.072***	0.084***	0.073***	0.082***
	(0.008)	(0.008)	(0.008)	(0.019)
CF_{t-1}	0.012	0.005	0.044**	0.055**
	(0.008)	(0.010)	(0.018)	(0.026)
366.SIC3	-0.000		0.046	-0.033
	(0.005)		(0.105)	(0.045)
367.SIC3	0.004		0.117	-0.017
	(0.005)		(0.105)	(0.042)
382.SIC3	-0.001		0.006	-0.036
	(0.005)		(0.107)	(0.036)
384.SIC3	0.007		0.082	-0.050
	(0.006)		(0.088)	(0.037)
737.SIC3	0.002		0.019	-0.021
	(0.004)		(0.086)	(0.033)
Constant	0.006	-0.056	-0.033	0.122**
	(0.023)	(0.039)	(0.106)	(0.058)
Observations	7711	7711	7711	7711
Adjusted R^2	0.321	0.334		
Instruments			48	145
Hansen Test			0.000	0.000

As described in section 4.2.2, an active body of literature discusses how best to measure financial constraints. Hadlock and Pierce (2009) argue that a very simple measure of firm age and size (the so-called SA index) captures financial constraints best. They report a correlation of 0.8 with the WW index that we use as our primary indicator. In our sample the correlation is much lower (0.3). However, as we show in the first two columns of Table 2, firms are less financially constrained according to the WW index in the sample of large and mature firms. This suggests that the WW and SA indexes give the same prediction about the level of financial constraints in our sample. The exact specification of the SA index is presented in the appendix. Table 8 shows the results of replacing the WW index with the SA index and estimating our regression as before. The main results remain unchanged.

We also perform two other robustness tests. First, to confirm that our results are not affected by the changes in the value of total assets, we use the natural logarithm of all the balance sheet variables instead of the ratios in the regressions. The results are consistent with our baseline regression, even though we lose some observations as the natural logarithm of a negative value is undefined and many of our variables have negative values (cash flow for example). Second, we test the sensitivity of our results to the magnitude of the coefficients in the WW index. We replace the WW index in our regressions with the equally weighted index. Namely, we replace the coefficients estimated by Whited and Wu (2006) with equal weights of 0.17. The signs of the coefficients are kept from the original index. Even though the choice of the weights is quite arbitrary, the results of the estimations are in line with the ones presented previously. However, the magnitude of the main variable of interest is slightly smaller. We present the results of these two robustness checks in the Internet appendix.

Table 8 Panel estimation results – Alternative measure of financial constraints

Estimation of the model described in equation (2) replacing the WW index with the SA index. The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($RD_{i.t-1}$, $RD^2_{i.t-1}$ and $Sales_t$) and use all the other variables directly as instruments. All the variables are Winsorized at the 1% level. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
RD_{t-1}	1.091***	0.815***	1.667***	1.488***
	(0.039)	(0.055)	(0.283)	(0.120)
RD^2_{t-1}	-0.628***	-0.521***	-0.848***	-0.888***
	(0.055)	(0.066)	(0.238)	(0.153)
Dum_{Crisis}	0.015***	0.013***	0.011**	0.009***
	(0.003)	(0.003)	(0.005)	(0.002)
FD_{it-1}	0.000***	0.000**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
$Dum_{Crisis}FC_{t-1}$	0.000	0.000	0.001*	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
FC_{t-1}	0.010**	-0.005	-0.045	0.001
	(0.005)	(0.007)	(0.028)	(0.012)
$Dum_{Crisis}FC_{t-1}$	0.003***	0.003***	0.004***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
$Sales_{t-1}$	-0.078***	-0.060***	-0.106***	-0.047*
	(0.007)	(0.007)	(0.015)	(0.026)
$Sales_t$	0.076***	0.087***	0.092***	0.058**
	(0.007)	(0.007)	(0.012)	(0.027)
CF_{t-1}	0.016**	0.013	0.125***	0.005
	(0.007)	(0.009)	(0.040)	(0.028)
357.SIC3	-0.062***		0.187	0.020
	(0.007)		(0.216)	(0.056)
366.SIC3	-0.062***		-0.210	-0.079*
	(0.007)		(0.164)	(0.044)
367.SIC3	-0.059***		-0.005	-0.024
	(0.007)		(0.119)	(0.034)
382.SIC3	-0.062***		-0.329**	-0.087*
	(0.007)		(0.156)	(0.049)
384.SIC3	-0.055***		-0.022	-0.081*
	(0.008)		(0.139)	(0.041)
737.SIC3	-0.062***		-0.023	-0.070***
	(0.007)		(0.090)	(0.027)
Constant	0.110***	0.011	-0.159	0.006
	(0.019)	(0.027)	(0.137)	(0.054)
Observations	9898	9898	9898	9898
Adjusted R^2	0.192	0.226		
Instruments			48	145
Hansen Test			0.035	0.000

4.5.4 Delayed effect of the crisis

R&D expenditures are often planned well in advance. Figure 1 illustrates that the drop in the average R&D expenditures only started in 2009 and continued in 2010. This period does not match the financial crisis, as few would argue that the financial was still ongoing in 2010. This delay can be explained by two factors: 1) changes in R&D expenditures are not directly affected by the turbulence in the financial sector and 2) R&D expenditures are affected by the financial crisis but with a time lag, due to certain peculiarities of planning and accounting. To test this issue, we use a time dummy for 2009–2010 instead of 2008–2009 in our regressions. If the first explanation holds, we expect our main variable of interest, $FC_{t-1} * Dum_{\text{Crisis}}$, to be insignificant. In this case the argument for a demand-side scenario would be further strengthened. If the second factor is more important, we expect $FC_{t-1} * Dum_{\text{Crisis}}$ to be negative and significant, and we have more evidence to advocate the supply of funds as a determinant of firms' investment decisions.

Table 9 shows that the effect of financial constraints is no longer statistically significant when using 2009–2010. This suggests that financial constraints were not a determinant of the R&D investments in 2009–2010.

Table 9 Panel estimation results – Delayed effect of the crisis

Estimation of the model described in equation (2). The sample contains all the firms available in the Compustat US database with SIC 283, 357, 366, 367, 382, 384 and 737 as the primary industry classification. For Arellano and Bover's (1995) dynamic estimation, we use the third lag in both specifications and apply system GMM. In column 3 we only instrument for the dynamic part and contemporaneous sales ($RD_{i.t-1}$, $RD_{i.t-1}^2$ and $Sales_t$) and use all the other variables directly as instruments. All the balance sheet variables are scaled by total assets. Standard errors, robust to heteroskedasticity and within-firm serial correlation, are reported in parentheses. The dummy variable for the financial crisis comprises 2009 and 2010. The last row presents the p-values for Hansen's test for overidentification restrictions.

	OLS – Random Effects	OLS – Fixed Effects	AB – Dynamic Part Instrumented	AB – All Instrumented
RD_{t-1}	1.084***	0.815***	1.672***	1.537***
	(0.040)	(0.056)	(0.296)	(0.126)
RD_{t-1}^2	-0.621***	-0.520***	-0.898***	-0.903***
	(0.056)	(0.067)	(0.259)	(0.162)
Dum_{Crisis}	-0.006***	-0.003	-0.008*	-0.006**
	(0.002)	(0.002)	(0.005)	(0.003)
FD_{it-1}	0.000***	0.000**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.001)
$Dum_{Crisis}FC_{t-1}$	-0.001*	-0.001**	-0.001	-0.002**
	(0.000)	(0.001)	(0.001)	(0.001)
FC_{t-1}	0.037*	-0.000	0.030	0.025
	(0.021)	(0.029)	(0.074)	(0.093)
$Dum_{Crisis}FC_{t-1}$	-0.005	-0.005	-0.004	-0.018**
	(0.004)	(0.004)	(0.005)	(0.008)
$Sales_{t-1}$	-0.080***	-0.061***	-0.106***	-0.077***
	(0.007)	(0.008)	(0.013)	(0.024)
$Sales_t$	0.076***	0.088***	0.089***	0.084***
	(0.007)	(0.008)	(0.012)	(0.026)
CF_{t-1}	0.021***	0.015*	0.127***	0.033
	(0.007)	(0.009)	(0.033)	(0.039)
357.SIC3	-0.063***		0.141	0.025
	(0.008)		(0.197)	(0.061)
366.SIC3	-0.063***		-0.112	-0.074*
	(0.007)		(0.156)	(0.045)
367.SIC3	-0.060***		-0.002	-0.017
	(0.007)		(0.131)	(0.037)
382.SIC3	-0.065***		-0.181	-0.068
	(0.007)		(0.151)	(0.048)
384.SIC3	-0.056***		0.028	-0.037
	(0.008)		(0.129)	(0.045)
737.SIC3	-0.061***		-0.114	-0.056*
	(0.007)		(0.102)	(0.029)
Constant	0.107***	0.031	0.033	0.010
	(0.021)	(0.028)	(0.114)	(0.098)
Observations	9898	9898	9898	9898
Adjusted R^2	0.221	0.224		
Instruments			48	145
Hansen Test			0.000	0.003

4.6 Conclusions and discussion

This paper explores the effect of the 2007–2009 financial crisis on the R&D expenditures of 1,219 publicly traded high-tech firms from 1998 to 2012. In particular, we explore the effect of financial constraints and distress on firms' R&D investments. We measure financial constraints by the WW index and distress by Altman's Z-score. Using a GMM procedure to estimate a dynamic R&D model, we find that financial distress played a minor role, if any, as a determinant of R&D expenditures during the financial crisis. Financial constraints had a substantial impact on R&D expenditures during the crisis. Everything else being equal, more constrained firms invested more during the financial crisis. The result is robust to extending the crisis period, excluding the dominant industry and using an alternative measure of financial constraints. Furthermore, the investment patterns for capital expenditures are similar. The significance of the results only disappears if we shift the crisis period to 2009–2010, when the financial crisis itself was arguably already over.

While at first sight surprising, our result is consistent with the observation that the average R&D expenditures increased during the financial crisis. Moreover, the outcome is consistent with Kahle and Stulz's (2013) and Hetland and Mjos's (2012) findings, which question whether firms' investment behaviour was affected by a supply-side shock during the financial crisis. Our analysis also only takes into account listed firms, which tend to have better overall access to financing and on average rely on debt to a lesser extent than other firms. One plausible argument for the initially surprising result that financially constrained firms invested more during the crisis is that they are more experienced in overcoming such constraints than unconstrained firms.

Interpreting the results from a macroeconomic perspective, it becomes evident that the financial crisis did not negatively affect listed technology firms' R&D investment. This finding is evidence that not much long-term damage resulted from the financial crisis for innovation and future growth proxied by R&D expenditures. It also supports the argument that the financial crisis was transmitted through a demand-side shock rather than a supply-side shock.

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Appendix

Altman Z-scores

$$Z = 0.012WC_{it} + 0.014RE_{it} + 0.033EBIT_{it} + 0.006MVTL_{it} + 0.999SA_{it}$$

Here WC_{it} is the ratio of working capital to total assets. RE_{it} represents the ratio of retained earnings to total assets. $EBIT_{it}$ stands for the ratio of earnings before interest and taxes to total assets. $MVTL_{it}$ represents the ratio of market value equity to book value of total liabilities, and SA_{it} stands for the ratio of sales to total assets.

$WW\ Index$

$$-0.091CF_{it} - 0.062DIVPOS_{it} + 0.021TLTD_{it} - 0.044LNTA_{it} + 0.102ISG_{it} - 0.035SG_{it}$$

Here CF_{it} is the ratio of cash flow to total assets. $DIVPOS_{it}$ is one if a firm pays cash dividends and zero otherwise. $TLTD_{it}$ is the ratio of long-term debt to total assets. $LNTA_{it}$ is the natural log of total assets. ISG_{it} is the firm's three-digit-industry sales growth and SG_{it} is the firm's sales growth.

$SA\ Index$

$$SA = -0.737Size_{it} + 0.043Size_{it}^2 - 0.040Age_{it}$$

Here Size is the log of inflation-adjusted book assets. Age is the number of years for which the firm is listed without missing data in Compustat. Size and age are Winsorized.