Essays on Information Problems in Financial Services

Inaugural-Dissertation

zur Erlangung des Grades

Doctor oeconomiae publicae (Dr. oec. publ.)

an der Ludwig-Maximilians-Universität München

2014

vorgelegt von

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Promotionsabschlussberatung:	05. November 2014

Datum der mündlichen Prüfung: 22. Oktober 2014

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Für meine Familie

Danksagung

Zuerst gilt mein ganz herzlicher Dank meiner Erstbetreuerin Monika Schnitzer. Ihre Unterstützung und fachliche Betreuung machten diese Dissertation erst möglich. Der rege Austausch, die kritischen Fragen und Ratschläge halfen mir sehr in meiner Forschung. Außerdem möchte ich mich bei meinem Zweitgutachter Dietmar Harhoff für die Beratung und Unterstützung während meiner Zeit am Max-Planck-Institut bedanken. David Florysiak danke ich für hilfreiche Kommentare und die Bereitschaft, als Drittgutachter dem Dissertationskommittee beizuwohnen.

Meinen Kollegen am Max-Planck-Institut für Innovation und Wettbewerb sowie an der volkswirtschaftlichen Fakultät der Ludwig-Maximilians-Universität München möchte ich danken für die wertvollen Diskussionen, die gemeinsame Arbeit, das nette Arbeitsklima und die vielen Ratschläge. Mein Dank gilt auch den Kollegen der Europäischen Kommission für den Einblick in die EU-Finanzmarktpolitik und die Zusammenarbeit, aus der ein Kapitel für diese Dissertation entwachsen ist. Insbesondere danke ich hierbei meinem Koautor Harald W. Stieber.

Für die finanzielle Unterstützung durch die Max-Planck-Gesellschaft in Form meines Promotionsstipendiums bin ich sehr dankbar.

Mein größter Dank gilt Freunden und der Familie, die mich auf meinem Weg begleitet und unterstützt haben. Ich bin sehr glücklich über den Rückhalt. Das bedeutet mir sehr viel. Ich widme ihnen diese Arbeit.

Fabian Kühnhausen, November 2014

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Introduction

A well-functioning financial cycle is a prerequisite for effective competition and innovation in the real economy. Because of the interconnectedness of financial markets and the real economy, financial crises lead to serious adverse real effects if the financing of households, the real economy and governments is impaired. One fundamental reason for why financial crises arise throughout economic history is that financial risks to the real economy, contagion risks and default risks of single financial instruments can only be imperfectly assessed. Hence, information asymmetries between investors and financial institutions, between investors and non-financial companies - basically between suppliers and buyers of financial services - are an inevitable part of financial markets.[1]

The recent financial crisis has caused a growing lack of faith in both effective self-regulation and competitive forces in financial markets. Public intervention in terms of competition policy and financial regulation has so far not kept pace with increasing financial risks and developments of new financial instruments. However, financial risks need to be monitored because they can have large negative impacts on the functioning of the EU *Single Market* and other parts of the global real economy.[2]

A further question particularly relevant to Europe is whether an aspired financial market integration is best served by competition or regulation. While an adequate level of competition among financial institutions is necessary for a sufficient level of EU financial market integration, a clear supervisory and regulatory framework is needed to maintain trust in the well-functioning of financial markets. The European Central Bank and the

[1] Compare Böheim (2009), Campello, Graham, and Harvey (2010) and Lüderssen (2011).
[2] Compare Gros and Alidi (2010) and Beck, Chen, Lin, and Song (2012).

European Commission continuously observe and analyze market and policy developments relevant to both EU financial market stability and integration.[3]

Important to note is that financial regulation is only effective when policy makers know what determines the demand for financial services and what drives financial institutions to supply certain kinds of financial instruments. It is hence important to understand how financial institutions conduct their business and how incentive structures of different stakeholders in financial markets can be aligned. The goal is to determine a financial market structure more robust to external shocks and to introduce conduct among financial institutions which is less prone to adverse selection and moral hazard.

This dissertation is a microeconomic investigation of information problems in financial markets. Specifically, we analyze what impact information asymmetries have with regard to the supply of financial services by financial institutions and the demand for financial services from other firms. In the first chapter, we investigate empirically how financial innovations affect the stability of financial institutions in the USA. In the second chapter, we investigate the capital structure choice of non-financial companies in an empirical setup. In the third chapter, we propose an economic analysis of a European Commission regulation to improve competition and quality in the market for auditing services. The chapters are self-contained and can be read independently.

In Chapter 1, 'Financial Innovation and Fragility', we evaluate the impact of innovative activity of financial agents on their stability in a competitive framework. Both theoretical and empirical literature provide strong evidence for why financial crises exist and why financial institutions engage in producing financial innovations. A recent strand of research[4] tries to combine both areas and argues that a competitive financial system and the non-patentability of financial innovations can cause a financial crisis. These papers analyze the incentives to innovate and the relation to financial distress. Particularly, this literature predicts that innovative activities negatively affect firm stability. Hence,

[3] See Zeitler (2008), European Central Bank (2013) and European Commission (2014).
[4] Starting with Bhattacharyya and Nanda (2000).

there exist a vast array of concerns about the interconnection of financial innovations, financial distress of firms and financial crises. Despite the plentiful theoretical work, only a few empirical studies on that relation exist. This chapter provides insight into the empirical relationship between innovation and stability in financial markets at the firm level.

We follow the *innovation-fragility view*[5] and explore whether more innovative financial systems are more prone to financial crises. We use a unique data set on financial innovations in the USA between 1990 and 2002. This data set is provided by Lerner (2006) and counts micro-level financial innovations in newspaper articles, databases and patents. We augment the data with performance and stability measures. Our analysis relates firm-level variations in innovative activity to the risk of insolvency, profit volatility and other stability measures of financial institutions while controlling for firm characteristics and time trends.

We show that a larger degree of innovation negatively affects firm stability of financial institutions. A couple of extensions to the initial model show the robustness of our results. We find that the relationship is stronger firstly, for larger firms but only for innovative activity captured through patenting and secondly, when financial institutions are more leveraged. We also confirm the robustness of our results against modifications of the innovation measures and different fragility parameters measuring profitability, capitalization, activity risk and risk of insolvency. In addition, we analyze the impact of pre-crisis innovative activity on profitability in times of financial distress. We find that more innovative firms face higher losses during a period of crisis. Overall, our analyses support the *innovation-fragility view*.

This chapter expands the recent strand of literature on the relationship between incentives to innovate and financial instability. Our contribution is the empirical connection between financial innovations and instability of financial agents. There exist only few empirical analyses focusing either on particular innovations[6] or on cross-country com-

[5] See Beck, Chen, Lin, and Song (2012).
[6] E.g. Henderson and Pearson (2011).

parisons[7] so far. To the best of our knowledge, this chapter is the first quantitative assessment of the *innovation-fragility view* at the firm level. We provide insights into the driving forces behind the supply of financial services and show how information problems between financial institutions and investors are exploited to reap profits from misunderstandings, negligence and misperceptions of the risk-return profile of financial instruments. Although we focus here on the USA, this firm-level analysis offers general insights into the incentives to innovate and dynamics in a competitive financial system.

In Chapter 2, 'Determinants of Capital Structure in Non-Financial Companies', we evaluate firm-, industry- and country-specific factors determining a firm's capital structure.[8] A recent comprehensive review of structural issues related to corporate finance and economic activity for the Euro Area has pointed to the potential impact of capital structure choices for the financial stability and economic performance of the economy as a whole.[9] However, the empirical validity of several capital structure theories has been ambiguous so far. A stylized fact that further motivates our inquiry is the pronounced cross-country variation in leverage ratios of non-financial companies. In this context, we find it intriguing that among the two major theories that try to explain capital structure choices of non-financial companies, the pecking order theory seems to better allow for country heterogeneity along the leverage dimension as compared to the trade-off theory.

In this chapter, we follow similar empirical research in conducting a series of panel analyses to determine the most important factors that drive leverage ratios. We append previous work in drawing on a variety of different parameters and indices on firm-, industry- and country-level to explain a greater portion of variation in the data. We use a short panel data set with a very large European cross-section. Then, we build on Rajan and Zingales (1995) and subsequent empirical studies[10]. We investigate how a large group of firm-specific, industry-specific and macroeconomic factors affect capital structure choices over the past decade with an emphasis on Europe.

[7] E.g. Beck, Chen, Lin, and Song (2012).
[8] This chapter is based on joint work with Harald W. Stieber, European Commission.
[9] See European Central Bank (2013).
[10] Frank and Goyal (2009), Fan, Titman, and Twite (2012), Köksal, Orman, and Oduncu (2013) and European Central Bank (2013).

We show that firm size, industry leverage, industry growth and tax shield positively affect leverage ratios, while profitability and liquidity have negative impacts. Furthermore, tangibility has a positive impact on leverage for those firms that use long-term debt financing. In contrast to capital structure theories and most empirical studies, we find a negative impact of tangibility on total and short-term leverage ratios. We would argue that this comes from the composition of our data set, namely the large majority of small firms. In addition, we find a strong impact of international capital flows. Our model is an improvement over previous empirical capital structure models in terms of explaining data variation and cross-country differences.

This chapter extends the literature on capital structure choice. Our contribution is twofold. First, we deal with the sample selection problem by analyzing a data set with a very large European cross-section, i.e. in the number of firms, of industries and of countries, with respect to firm size and the inclusion of USA and Japan as comparisons. Second, we augment the existing capital structure analyses with firm-, industry- and country-specific variables that can explain more of the variation in the data on capital structure. In this chapter, we focus on the demand-side of financial markets and analyze how information problems between investors and non-financial companies influence capital costs of these firms and as such, have an impact on the capital structure choice. Our study provides strong indications that corporate taxation needs to be part of macro-prudential policy for international capital markets in view of the strong effects of national tax codes on leverage ratios. Furthermore, our very representative estimates can be seen as an input for future research on the quantification of international intra-group capital mobility and tax-base shifting.

In Chapter 3, 'Auditing Quality in Regulatory Regimes', we evaluate the impact of regulatory interventions on the quality of auditing services. During the recent financial crisis, it has become apparent that a positive auditing result of a firm's financial statements does not necessarily reflect a financially robust situation for that company. The European Commission thus plans to create a *Single Market for Statutory Audits* with standardization and voluntary quality certification measures among others. The goal is to introduce more competition, and to improve the transparency in the market and the reliability of the signaling of audit results' quality to potential investors of companies.[11]

This chapter investigates the impact of the European Commission proposals on social welfare and the well-functioning of the market for auditing services. We set up a theoretical model based on Stahl and Strausz (2011) that illustrates the relationship between an auditor, a firm and a regulator. By utilizing a signaling framework we show differences between standardization and certification. While standardization introduces the possibility to train and to invest into quality and leads to homogeneous price competition among auditors, certification segments the market such that a separating equilibrium with prices equal to productivities is sustained.

We can show that it matters which market side initiates the verification of quality for firstly, the regulator's profits and secondly, social welfare. The regulator's interests and social efficiency are not aligned, however. The welfare analysis reveals that standardization of audit services is optimal if the costs for verifying quality are sufficiently low for the regulator. On the other hand, voluntary quality certification leads to a separating equilibrium where only high-quality auditors certify. This regime maximizes social welfare whenever verification costs are large. The results are robust against a number of extensions introducing renegotiations, quality choice, imperfect verification technologies, excessive supply and demand, and asymmetric cost structures.

This chapter contributes to the literature by providing an economic analysis of a proposed European Commission regulation concerning auditing services. We focus again on the supply-side of financial markets and analyze how information problems between firms and auditors can be resolved. We compare a harmonization of the quality of the service provided by standardization against supply-side certification. A signaling of the quality of the audit service provided by the auditor through seller-induced certification can successfully dissect the market into different quality segments allowing for a more efficient allocation of audit mandates according to the buyers' willingness to pay, the respective

[11] See European Commission (2010, 2011a,b,c).

need for a certain quality level and the ability of a respective auditor to provided such demanded quality. Standardization may allow low-quality audit firms to catch up and thus, allow the European Commission to raise the average audit quality provided in the market. The respective regulatory regime which maximizes social welfare depends on the structure of the verification costs for the regulator.

Taking these three chapters together, this dissertation shows that information problems are important obstacles to the efficiency of financial markets. While the first two chapters provide positive analyses of the supply and demand of financial services, the third chapter turns to a normative approach. In particular, we provide insights into how public intervention can be approached in order to increase the efficiency of financial markets. We hope to contribute to the ongoing discussion about financial regulation, competition policy and financial market integration.

Chapter 1

Financial Innovation and Fragility

1.1 Introduction

Numerous researchers have analyzed the causes for distress of financial agents during the recent financial crisis starting in 2007. Through both theoretical and empirical analyses, they came up with a variety of reasons. These include panics of bank customers and major investors, shocks to money supply, to debt financing and to the real economy, as well as the interconnectedness of banks and their complexity. A recent strand of literature[1] tries to argue, however, that a competitive financial system and the non-patentability of financial innovations (FI) can cause a financial crisis. These papers analyze the incentives to innovate and the relation to financial distress. Despite the plentiful theoretical literature, only a few empirical studies on that relation exist. These have provided evidence on the drivers for product development and competition in financial markets. This work provides additional insight into the empirical relationship between innovation and stability in financial markets.

In this chapter, we follow the *innovation-fragility view*[2] and explore whether more innovative financial systems are more prone to financial crises. To do so, we analyze the

[1] Starting with Bhattacharyya and Nanda (2000). A more detailed literature review is given in Section 1.2. This also provides the theoretical underpinnings for the empirical analysis in Section 1.4.

[2] See Beck, Chen, Lin, and Song (2012).

proposed causal and positive relationship between FI and incidents of financial distress in an empirical setup with US data on the firm level. The precipitating question is who innovates in the financial market? Is the degree of innovativeness positively related to an firm's profit volatility? Does innovative activity increase the risk of insolvency? In other words, is competition through innovation negatively related to stability?

We utilize count data and patents to measure FI on a micro level from Lerner (2006) and relate firm-level variations in innovativeness to profit volatility of financial institutions while controlling for firm characteristics and time trends. Based on an empirical setup that corresponds to Hasan, Schmiedel, and Song (2009), Demirgüç-Kunt and Huizinga (2010), Beck, Chen, Lin, and Song (2012), and Lepetit and Strobel (2012), we investigate the link between profit volatility and FI in a dynamic panel model. We find a significant positive relation which implies a negative impact on the stability of the financial system. Furthermore, we check the results against a number of different extensions. While regressions with interactions between firm characteristics and FI provide ambiguous results, our findings are confirmed with different innovation measures and different fragility measures. In addition, more innovative firms face higher losses during a period of crisis.

The chapter is structured as follows. First, we discuss previous literature in the area. In Section 1.3 we introduce the data while in Section 1.4 we present the empirical analysis. In Section 1.5 we discuss the results and extend our analysis, while Section 1.6 concludes the chapter.

1.2 Literature Review

This chapter draws on literature from two distinct research areas: (i) micro- and macroeconomic research on the existence of financial crises and (ii) investigations into the foundations of FI.[3]

[3] General surveys about research on financial agents with particular focus on asymmetries of information and security design are given by Allen and Winton (1995) and Duffie and Rahie (1995).

1.2.1 Financial Crises

The first field of research pertains to the origins and persistence of financial crises, or more particularly, the investigation of causes for financial distress of single agents providing any kind of financial services. In their seminal paper, Allen and Gale (2000) investigate possible contagion and bubbles in financial networks. They build a model of contagion with perfectly competitive banking and show that a first-best allocation of risk-sharing is possible, but fragility still persists. Subsequently, Upper and Worms (2004) confirm Allen and Gale's (2000) model by empirically evaluating the risk of contagion and credit risk in the German interbank lending market.[4] Their analysis provides two results: First, credit risk may trigger a domino effect in that there exists considerable scope for contagion even with safety mechanisms. Second, more concentrated structures can lower the threshold for contagion.[5]

Furthermore, Allen and Gale (2004) analyze the relation between competition and financial stability. Here, they find a negative trade-off between both while considering a variety of different settings such as general equilibrium models, agency models, Schumpeterian competition and contagion. In a three-period model with risky and standard assets as well as timing incongruity, they show that greater competition is good for efficiency, but bad for financial stability. Additionally, Allen, Babus, and Carletti (2009) provide a thorough review on financial crises. They find that most financial crises arise from panics, business cycle fluctuations or contagion, and derive from this evidence a common sequence of events: With surging money supply, asset prices and credit volumes increase which inevitably lead to a price bubble bound to burst. A banking crisis is then followed by an exchange-rate crisis and a substantial drop in real output.[6]

[4] They use balance sheet data of German banks to estimate bilateral credit relationships.

[5] Many more papers can be found which empirically analyze the causes for financial crises both at a micro- and macro-level. Since we want to focus on the distinct relationship between FI and financial health, an extended overview on that area of literature would be beyond the scope of this chapter.

[6] Brunnermeier (2009) presents an overview on the development of the recent financial crisis and uses micro- and macro-level data to suggest reasonable policy interventions.

1.2.2 Financial Innovations

A second strand of literature looks at the origins and existence of financial innovations.[7] The seminal definition of FI is given by Tufano (2003): It is the creation of financial instruments (both product and process) by invention or diffusion of products, services or ideas. He states that FI exists because of the incompleteness of markets, for managing risk, for pooling of funds and because of regulation. Frank and White (2004, 2009) review the technological changes and innovations in commercial banking over the last 25 years. They employ the same definition of FI as Tufano (2003) and argue that FI reduce costs and risks, pool funds and provide a tool to serve demands of investors. In addition, they survey the literature to illustrate innovation patterns over the investigated period.

From a theoretical perspective, numerous papers provide arguments for the existence of innovations in financial markets. Most recently, Michalopoulos, Laeven, and Levine (2011) link FI to the endogeneous growth theory while Carvajal, Rostek, and Weretka (2012) examine innovations in frictionless financial markets with short selling. They find incomplete markets even with costless innovation and competition. Ferreira, Manso, and Silva (2014) argue that the form of equity financing determines FI incentives. In their model, they suggest to go public for exploiting existing ideas and go private for exploring new, risky ideas. Song and Thakor (2010) and Shen, Yan, and Zhang (2012) provide arguments for collateral-motivated FI and link possible innovation cycles in financial markets to government regulation such as *Basel III*.

Empirical assessments of innovations in financial markets have started with research in the 1980s and 1990s.[8] In his early contribution, Tufano (1989) argues that FI provide first-mover advantages. He assesses the dynamics of innovations and competition by analyzing data on 58 publicly offered FI in the years 1974 to 1987 which raised USD 280 billion and providing cross-sectional regressions of the underwriting spread on firm

[7]Tufano (2003), Frank and White (2004, 2009) as well as Lerner and Tufano (2011) provide overviews on innovations in financial markets.
[8]See e.g. Miller (1986, 1992), Merton (1992), Frank and White (2004, 2009).

characteristics.[9] He finds that 20% of new securities being issued in 1987 have not been in existence in 1974 and that new product ideas diffuse rapidly across competitors so that banks do not enjoy monopoly pricing with innovations, but rather capture a larger market share with lower prices than their imitators.

Lerner (2002) looks at financial patents during the period 1971 to 2000 and analyzes the impact of the *State Street* decision[10] on the degree of innovation observable in the market. He uses the classification of the US Patent and Trademark Office and the Delphion IP Network to identify 445 financial patents and finds a surge in patenting filed mostly by large corporations. In addition, Lerner (2006) investigates the origins of innovations by developing a new measure for FI. His regressions show that small, less profitable firms are more innovative with an additional agglomeration effect. More recently, Lerner (2010) inquires about litigation of patents on FI.[11] He analyzes financial patent awards by the US Patent and Trademark Office between 1976 and 2003 in combination with firm-level data from public records. He finds that first, patents on FI are litigated more often than normal patents; second, litigated patents are mostly owned by small firms or individuals and have more claims and citations than other financial patents; and third, large firms are more often defendants in litigation.

Finally, Boz and Mendoza (2010) examine the interaction of FI, learning and collateral constraints in a stochastic equilibrium model of household debt and land prices. They use an experimental setup with switching between high- and low-leverage regimes according to Bayesian learning and find that innovations in financial markets lead to boom-bust cycles.

[9] Tufano (1989) relied on three data sources: first, a literature search using ABI-Inform and Business Periodical Index; second, interviews with investment bankers; third, company data from SDC and IDDIS.

[10] *State Street Bank vs. Signature Financial Group* was a 1998 decision by the US Court of Appeals for the Federal Circuit (CAFC) regarding the patentability of business methods. Herein, the CAFC rejected the notion of a *business method exception* and allowed the protection of an invention if it involved some practical application and some tangible result, which with regards to financial patents was deemed the pricing. However, the 2008 CAFC decision *In re Bilski* rejected the tangible result test as inadequate. The US Supreme Court affirmed this judgement in *Bilski vs. Kappos.* This leaves companies with great uncertainty over the patentability of financial innovations.

[11] This again draws on Lerner (2002).

The financial innovations considered here differ from innovations in product markets in several important ways. In general, consumers of financial services face opacity about the portfolio of financial agents and their quality provided in financial services. Also, research has not yet produced any structural model with which to estimate both supply and demand of FI. Frank and White (2004) survey empirical studies on FI and point to the general scarcity in research in that field. Lerner and Tufano (2011) also show some differences between FI and manufacturing innovations, most notably stressing different dynamics and agency structures. They point out the problems of assessing FI due to the rarity of R&D spending by financial agents, the infrequency or non-existence of financial patents and the opacity of FI by private firms.

1.2.3 Incentives to Innovate and Financial Crises

This chapter makes use of a new strand of literature combining both aforementioned research fields. Most work focuses on the *innovation-fragility view* coined by Beck, Chen, Lin, and Song (2012) that innovations may have adverse effects on competition and stability. It begins with early theoretical work by Bhattacharyya and Nanda (2000). Their paper is the first to connect incentives to innovate and the analysis of financial crises in a theoretical setup. Because client characteristics, market structure and volatility affect switching costs and costs of delayed adoption, banks with greater market power and more secure relationships with customers are more likely to innovate. Empirical assessments of the causal link between innovations and financial instability have been scarce.

Most recently, two lines of argumentation have emerged. The first one focuses on incentive structures and volatility in financial markets. Thakor (2012) analyzes the relation between incentives to innovate and financial crises. He makes use of Allen and Gale's (2004) model with three periods where the distinction is not between standard and risky assets, but now between standard and innovative assets. Financial agents then face the trade-off between making profits from innovation and refinancing risks. In his model, the degree of innovativeness is positively related to the refinancing risk which makes imitation less likely and drives up profits. Reasons for financial distress are then the competitive financial system and the non-patentability of FI because of the correlation of default risks if FI can be imitated.

Beck, Chen, Lin, and Song (2012) evaluate the respective relationships between FI and real sector growth, real sector volatility and bank fragility using bank-, industry- and country-level data from 32 countries during the period 1996 to 2006. Approximating Tufano's (2003) definition of FI by financial R&D intensity obtained from the OECD, they analyze the *innovation-fragility view*. Namely, they relate country-level variation in FI to bank-level variation in profits and volatility. Their results show that innovativeness leads to increasing fragility, risk taking, profit volatility and bank losses during crises. Herein, smaller, fast growing banks are more fragile in countries with more FI while smaller, less leveraged banks are more effected by agglomeration effects.

A second line of argumentation focuses on investors' behavior. Shleifer and Vishny (2010) set up a behavioral finance model where they assume optimism of investors as stimulus for demand for new securities and pessimism as a shock leading to financial crises. Mispricing occurs because financial agents profit from investors' misperceptions. Depressed securities then have adverse welfare effects ex post as they cut off lending to new instruments. Overall, securitization raises the level of investment and cyclicality. Henderson and Pearson (2011) show that investors can be exploited by innovative financial products. Their event study proposes that issuers innovate to sell new securities at a risk-adjusted premium to uninformed investors because innovativeness increases complexity and ambiguity. Subsequently, issuers exploit investors' misunderstandings of financial market. The authors provide reasons for excess demand in overconfidence, framing and loss aversion of investors.

Jeon and Nishihara (2012) extend Shleifer and Vishny's (2010) model and allow agents to securitize risky assets with leverage and asymmetric information. They find that risk retention requirements imposed by governments reduce welfare. Concurrently, Gennaioli, Shleifer, and Vishny (2012) argue that FI cause crises because of neglected risks. Their research is also an extension of Shleifer and Vishny's (2010) paper whereby agents engineer securities perceived to be safe but exposed to neglected risks which leads to excessive security issuance. They apply a model of belief formation to relate FI, security issuance, risk perception and financial fragility.

This chapter follows the recent strand of new literature on the relationship between incentives to innovate and financial instability. The chapter's contribution is the empirical connection between financial innovations and instability of financial agents. There exist only a few empirical analyses focusing either on particular innovations (Henderson and Pearson (2011)) or on cross-country comparisons (Beck, Chen, Lin, and Song (2012)) so far. To the best of our knowledge this is the first quantitative assessment of the *innovation-fragility view* at the agent level. We employ a data set by Lerner (2006) and augment it with performance and stability measures so that we can study the effect of firm-level variation in FI on the stability of financial agents. Although we focus here on the USA, this firm-level analysis can offer insights into the incentives to innovate and dynamics in a competitive financial system.

1.3 Data

The data set measures financial innovations in the USA from 1990 until 2002 via a unique counting mechanism.[12] Lerner (2006) investigates the origins of innovations and develops a new FI measure based on news stories from the Wall Street Journal during the period 1990 to 2002 which he merges with additional information from the SEC, Compustat, finance journals and the US Patent and Trademark Office to establish a link between innovative ability, firm characteristics and patenting.[13] The sample consists of firms with either at least one innovation observed by the measure during the time period or being active in the SIC codes 60 through 64 and 67. These SIC codes include firms operating in the financial services business such as insurance, banking, financial advisory and so on except for real estate.

[12]The data were kindly provided by Josh Lerner, Harvard Business School.
[13]See also Lerner (2002) for his aforementioned earlier work on financial patents.

The data set consists of four different groups of variables:[14] First, we use firm characteristics to control for firm-specific effects. In accordance with Lerner (2006), we use the logarithm of total assets to measure firm size. Profitability ($Opprof$) is defined as earnings before interest, taxes, depreciation and amortization ($EBITDA$) divided by revenues, and leverage is defined as the ratio of the book value of a firm's long-term debt to total capitalization. Further control variables include firm age, cash equivalents, employees, shareholders' equity, long-term debt, common market value and revenues.

Second, the data set includes performance measures like EBITDA, net income, retained earnings as well as return on assets (ROA) and return on equity (ROE) which are used to derive the stability measures and provide information about the competitive nature.

Third, we measure stability of financial institutions with the Z-score. The Z-score is a measure of bank solvency and corresponds to $(ROA + CAR)/\sigma(ROA)$. It "indicates the number of standard deviations that a bank's rate of return on assets can fall in a single period before it becomes insolvent. A higher Z-score signals a lower probability of bank insolvency" (Beck, Chen, Lin, and Song (2012)).[15] For robustness checks, we later also use other stability measures such as the capital-asset ratio (CAR), standard deviations of returns, and the Sharpe ratio which is defined as $ROE/\sigma(ROE)$.

Fourth, innovation is measured by the count of patent applications, patents issued and stories on innovations per year and firm. We also include a measure for the agglomeration effect by counting the number of innovations by other firms within the same two-digit ZIP code area as a firm.

All financial data is in million 2002 US Dollars. Financial and company data comes directly from Compustat or is calculated from its pool of variables. The count data on innovations comes from articles issued in the Wall Street Journal or the Factiva database

[14]For complete descriptions of the variables used here, see Table A.1 in the Appendix.

[15]See Lepetit and Strobel (2013) for more information on firm's insolvency risk and different approaches to time-varying Z-score measures. They provide a derivation of the Z-score and discuss several ways to estimate means and standard deviations of the variables used to calculate the measure. We follow their recommended specification.

on technological inventions. Patent data comes from the US Patent and Trademark Office. For a comprehensive explanation of the data set, see Lerner (2006). We clean the data from coding errors and outliers, and perform some plausibility checks. Any observations with implausible values for balance sheet items (e.g. negative revenues) are dropped. We also exclude observations with negative Z-scores. The final sample is an unbalanced panel of 3,042 firms with 19,895 firm-year observations.

Like any other measure of FI, the count measure used here also has its limitations. It necessarily excludes private firms not listed in Compustat. Furthermore, the time period is rather limited and the methodology to source the counts of innovations from the articles is based on stylized facts of FI. Also, problems in assessing FI exist due to the rarity of R&D spending by financial institutions, the infrequency of financial patents and the opacity of FI by private firms as discussed by Tufano (2003), Frank and White (2004, 2009) and Lerner and Tufano (2011). Therefore, the count measure introduced by Lerner (2006) and applied here to analyze financial fragility is a promising first start to assess empirically the connection between financial innovations and instability of financial agents.

1.4 Empirical Analysis

This section explores the relationship between FI and financial agents' fragility empirically. We first provide a description of the data and then present the empirical model specification.

1.4.1 Descriptive Statistics and Properties

Table 1.1 provides an overview of the summary statistics of the variables. It shows that there exists great heterogeneity among firms in terms of size and profitability. Because we include all firms active in financial services, leverage ratios are comparably low. Stability measures are constructed from the firm characteristics to capture a firm's insolvency risk and activity risk. Higher numbers for the Sharpe ratio and the Z-score reflect less fragility. Moreover, the count data on FI includes a lot of zeros as indicated by the low means.[16] Generally, variances of the variables are quite large. For most variables, mean values are larger than the median because these variables exhibit right-skewed distributions with a lot of values close to zero.

Table 1.1: Summary Statistics of Key Variables

Variable	**Mean**	**Median**	**Std. Dev.**	**Min.**	**Max.**
Age	9.550	6.000	11.971	0	77
Assets	12806.760	604.177	57441.090	0	1097190
Cash Equiv.	1348.839	28.258	8608.241	0	316206
Leverage	0.278	0.213	0.263	0	0.999
Long-term Debt	1698.329	36.057	11639.600	0	468570
Market Value	2939.847	138.685	15583.860	0	535947
Pref. Stock	38.948	0.000	223.152	0	5712
Revenues	2607.716	78.583	11729.980	0	186857
Sh. Equity	1306.896	91.860	5115.215	-515.745	153738
Opprof	0.077	0.291	6.850	-587.544	19.483
Ret. Earnings	776.869	24.195	3527.743	-15801	81210
ROA	0.050	0.011	1.723	-16.444	235.667
ROE	0.835	0.104	49.136	-125.869	4787.999
CAR	0.226	0.127	3.231	-441	3.414
HHI	0.014	0.014	0.002	0.011	0.019
σ(ROA)	0.142	0.008	4.875	0	650.898
σ(ROE)	1.557	0.046	45.011	0	2194.872
Sharpe	3.702	2.211	8.642	-103.399	346.778
Z-score	42.926	22.897	194.269	0	12381.450
Innovations	0.016	0.000	0.165	0	6
Patents	0.033	0.000	0.416	0	15
Applications	0.031	0.000	0.432	0	21
R&D	45.594	0.000	436.137	0	9845
FI by Others	2.442	0.000	3.441	0	12

Notes: N=19,895. The list is ordered according to the four different groups of variables mentioned above. See Table A.1 in the Appendix for definitions of the variables. All financial data is in million 2002 US Dollars and comes from Compustat. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006).

[16] In total, the data set includes only 588 incidents of financial innovation.

Observations are evenly distributed over the time period and firm characteristics exhibit a high degree of persistence. About 11% of firms in the sample have observations for the entire time period. About 26% of firms have 8 or more consecutive observations. On average, the data set has 6 observations per firm.

Figure 1.1 displays firm characteristics over time. There exists a general increase in the absolute values of these firm-specific variables. Similar to Figure 1.1, Figure 1.2 presents the evolution of a firm's performance and stability measures over the time period. There is no clear trend in rising or falling profitability of financial institutions. While retained earnings and the Sharpe ratio increase over time, operational profitability, the capital-asset ratio and returns on assets and equity decline.

Figure 1.1: Firm Characteristics

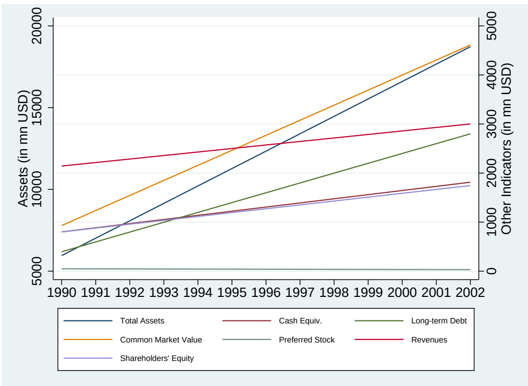


Figure 1.2: Profitability and Stability Measures

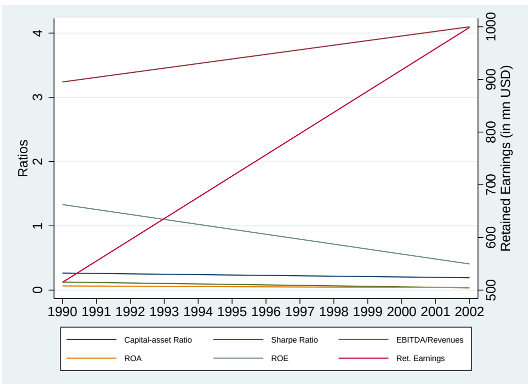


Figure 1.3 presents how the count of FI has developed over time. The notable peak towards the late 1990s is due to the aforementioned *State Street* decision. Observations

for patents lag behind applications because the average time period between applying for a patent and granting patents is about two to three years. Only applications for patents granted during the time period are included in the data set. Overall, the number of observed innovations is rather low in comparison to the overall size of the data set so that this is one point of caution.

Figure 1.3: Evolution of Innovative Activity

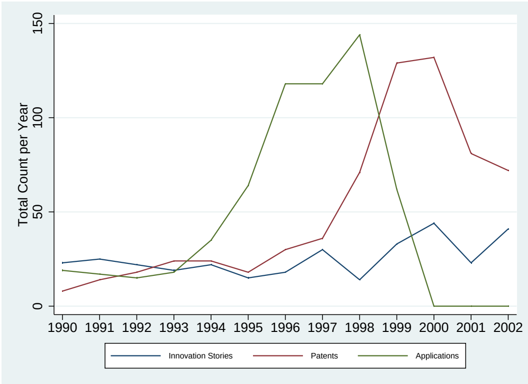
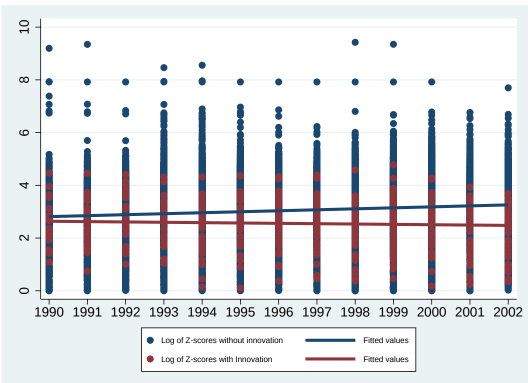


Figure 1.4 presents a comparison of fragility by grouping firms with measured innovation and with no count, respectively, and by plotting the evolution of both sets. In accordance with our hypothesis, linear predictions of Z-scores of firms without innovation are slightly higher than those with counts of innovation. Additionally, a time trend indicates that the relation becomes stronger.

Figure 1.4: Evolution of Z-scores



Following the descriptives, a variety of univariate analyses provide a first glance at the variables' behavior and properties. Firm characteristics are correlated with each other and over time. This also drives autocorrelation in Z-scores by construction. Including lagged dependent variables in the regressions captures most of the autocorrelation. While the FI measures are significantly correlated with each other, a F-test also shows joint significance. Also, fragility (Z-scores) and FI measures are significantly positively (negatively) correlated.[17] Mann-Whitney U tests show that the mean and variance of Z-scores are significantly different with and without innovation. A series of panel-based unit root tests reject the hypothesis that the Z-scores are first-order integrated ($I(1)$).[18] Control variables are carefully selected to avoid problems of multicollinearity. A robust version of the Wu-Hausman test by Wooldridge (2002) shows that fixed effects modeling is preferred over a random effects setup. Furthermore, Breusch-Pagan and White tests show that error terms are heteroskedastic, while Arellano-Bond and Breusch-Godfrey tests show that the error terms are correlated with each other.

1.4.2 Empirical Strategy

Based on the micro-level database on FI in the US between 1990 and 2002 presented above, we relate agent-level variations in innovativeness to profitability and profit volatility of financial institutions while controlling for firm characteristics and time trends. For our empirical setup we build on Hasan, Schmiedel, and Song (2009), Demirgüç-Kunt and Huizinga (2010), Beck, Chen, Lin, and Song (2012), Lepetit and Strobel (2012) and Bertay, Demirgüç-Kunt, and Huizinga (2013). They analyze profits and fragility of financial institutions with a variety of different setups and also assess the reliability of the Z-score.[19] Because of the data properties presented above, our baseline model specification is as follows.

$$Z_{i,t} = \rho Z_{i,t-1} + \beta X_{i,t} + \gamma Y_{i,t} + \alpha_i + \delta_t + \epsilon_{i,t} \tag{1.1}$$

[17]See Table A.2 in the Appendix.

[18]We use augmented Dickey-Fuller and Phillips-Perron tests to analyze cointegration. If Z-scores were really $I(1)$, then their time series would be a random walk with drift. In fact, the data is trend stationary and we use a time trend in our regression models to account for that.

[19]Their work shows that the Z-score is a feasible indicator to measure financial stability of firms and is commonly used in the literature.

where indices i, t stand respectively for firm and time. Z is the Z-score per firm and period.[20] Including lagged dependent variables allows us to account for the persistence of firm characteristics which also reflect in the Z-scores by construction and the general persistence over time. X is the vector of firm characteristics for which data are available while Y is the vector of different financial innovation indicators. To account for firm heterogeneity and skewness, we use ratios of balance sheet items relative to asset size for the control variables and employ the logarithm of all independent variables that are not ratios. The regression model also includes α_i and δ_t to account for omitted firm-specific and time fixed effects, respectively. The Newey-West-type robust error term ϵ is clustered at firm-level and allowed to be heteroskedastic, autocorrelated and spatially correlated.

1.5 Results

In this section, we discuss the main results and perform a number of robustness checks. We also extend the model to further investigate the *innovation-fragility view* in more detail.

1.5.1 Baseline Model

We compare different versions of the dynamic panel model set up in Section 1.4.2 which enhances the static linear fixed effects model by including autoregressive coefficients for fragility. This allows us to capture feedback from current or past shocks to current values of the dependent variable. This specification is adequate in the presence of autocorrelated error terms and high persistence in the dependent variable which we have shown earlier.

Table 1.2 provides the overview of the different model specifications. Baseline innovative capacity in firms is captured by firm size, profitability and leverage which Lerner (2006) has shown to be important drivers of incentives to innovate. In all regressions, we include firm characteristics, year fixed effects and a constant but suppress their coefficients in the

[20] Because the Z-score is highly skewed and to avoid truncation, we use $ln(1+Z\text{-}score)$ in the regressions.

tables.

Column 1 to 4 provides the Driscoll and Kraay (1998) estimator with firm fixed effects and lagged dependent variables interchangeably. Column 4 depicts the full model specification presented in Section 1.4.2. Even though firm fixed effects cover average innovative ability of a firm while lagged dependent variables capture time trends, the γ coefficients to measure FI remain negative and statistically significant. Once accounting for firm differences and time trends, patenting becomes sufficiently less important for firm stability.

Column 5 presents the results for the period 1990 until 1998 only. Remember the *State Street* decision by the CAFC in 1998.[21] This has provided firms with legal certainty about what kind of FI can be legally protected. Hence, more technology spillovers should theoretically be observed in the pre-1998 period because of the legal uncertainty prior to the CAFC decision. Given these spillovers from FI, we expect to observe a stronger relation between firm instability and innovative activity. We split the data sample into pre-*State Street* and post-*State Street* periods. Analyzing the first subsample indeed shows larger γ coefficients of the FI measures prior to 1998 and hence confirms that spillover effects of FI further decrease stability.

Moreover, we analyze the impact of competitive pressure on the proposed positive relationship between FI and fragility. We thus include the Herfindahl-Hirschman Index (HHI) in column 6. Because an increase in the HHI signals rising market power and weakening competition, the positive regression coefficient for the HHI indicates that competition and stability are negatively correlated which is the same conjecture Allen and Gale (2004) made. Controlling for competition does not change the γ coefficients of the FI measures or the agglomeration effect.

[21] We already mentioned this in the Literature Review (Section 1.2) and it is discussed in Lerner (2002).

Table 1.2: Variants in the Model Specification

	static ln(1+Z-score$_t$)	**firm FE only** ln(1+Z-score$_t$)	**LDV only** ln(1+Z-score$_t$)	**full specification** ln(1+Z-score$_t$)	**pre-1998** ln(1+Z-score$_t$)	**competition** ln(1+Z-score$_t$)
ln(1+Z-score$_{t-1}$)			0.794***	0.013	-0.005	0.012
			(0.060)	(0.008)	(0.008)	(0.007)
ln(assets)	0.382***	-0.133***	0.111***	-0.139***	-0.166***	-0.138***
	(0.027)	(0.011)	(0.032)	(0.009)	(0.008)	(0.009)
EBITDA/revenues	0.016***	-0.000	0.005***	-0.000	0.000	-0.000
	(0.002)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Leverage ratio	0.144	-0.266***	-0.085*	-0.257***	-0.246***	-0.254***
	(0.162)	(0.026)	(0.051)	(0.020)	(0.025)	(0.020)
HHI						0.162
						(0.435)
FI by others	-0.010	0.003***	-0.003*	0.001*	0.000	0.001*
	(0.008)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Innovations	-0.211***	-0.028**	-0.075*	-0.029**	-0.058*	-0.027**
	(0.034)	(0.012)	(0.042)	(0.012)	(0.031)	(0.012)
Patents	-0.074***	-0.006	-0.016*	-0.004	0.015	-0.004
	(0.012)	(0.006)	(0.009)	(0.005)	(0.009)	(0.005)
Applications	-0.023**	-0.003	0.002	-0.001	-0.003	-0.002
	(0.012)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Controls	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	N	Y	N	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y
Observations	16,717	16,717	14,770	14,770	7,934	14,770
Number of firms	2,715	2,715	2,660	2,660	2,022	2,660
R-squared	0.293	0.594	0.551	0.633	0.629	0.633

Notes: See Table A.1 in the Appendix for definitions of the variables. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). All financial data is in million 2002 US Dollars and comes from Compustat. Column 1 does not include a lagged dependent variable or firm fixed effects. Column 2 includes only firm fixed effects. Column 3 includes only a lagged dependent variable. Column 4 includes the full model specification presented in Section 1.4.2. Column 5 includes data for 1990 until 1998 only. Column 6 includes data for the full period from 1990 until 2002 with the HHI controlling for firm-level competition. In all regressions, we include firm characteristics as controls, year fixed effects and a constant but suppress their coefficients in the tables. Control variables include firm age, cash equivalents, employees, retained earnings, shareholders' equity, preferred stock and long-term debt (all as ratios relative to assets or logarithms). Driscoll and Kraay (1998) robust standard errors are clustered at firm-level and presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Overall, results show that indeed there exists a significant positive relation between FI and fragility (negative relation between FI and Z-scores) albeit small, but patenting seems to be no factor. The size of the coefficients however corresponds to the correlations from the univariate analyses in Section 1.4.1. Surprisingly, the agglomeration effect as measured in *FI by others* is very weak.

1.5.2 Robustness

We check the robustness of our results. Foremost, the results in Table 1.2 are robust against including or excluding different firm-specific control variables. We also use data on revenues and common market value instead of total assets to control for firm size but the results do not change. If we include a dummy variable for incidences of FI instead of the three different count measures, the coefficient is negative but not significant.

In order to check whether our results are due to a particular econometric specification, we run different panel estimators. We compare our baseline model specification to a pooled feasible GLS estimator with a panel-specific AR(1)-disturbance, a Prais-Winsten regression to account for autocorrelated error terms, and a Newey-West heteroskedasticity- and autocorrelation-consistent (HAC) estimator. We find qualitatively similar results. The advantage of Driscoll and Kraay (1998) standard errors is that they expand Newey-West HAC estimators to include correlation between panels and that the estimator does not place restrictions on the limit behavior of the number of panels.

We also run dynamic panel data estimators. We use the Arellano and Bond (1991) estimator by instrumental-variables (IV) estimation of the parameters of the first-difference model using lags of regressors as instruments.[22] Additionally, we use the Blundell and Bond (1998) estimator because the Arellano and Bond (1991) estimator performs poorly

[22]We have shown earlier that the data is trend stationary. Because the Arellano and Bond (1991) estimator relies on first differences, it consumes most of the variation between observations for innovation indicators since their within-variation (variation over time) is larger than their variation between panels. Thus, coefficients for the innovation indicators turn out smaller and not significant in the regression.

with large autoregressive disturbances.[23] We find qualitatively similar results.

In any estimation of fixed effects models for short panels when lagged dependent variables are present, coefficients may be downwardly biased. This is called *Nickell (1981) bias* whose size is relative to the time period T of the data set. It is given here by $1/T = 1/13 = 0.07$. Thus, as $T \to \infty$ the bias disappears.[24] That's why we compare the Driscoll and Kraay (1998) estimator with the aforementioned dynamic panel data estimators which are consistent. Two caveats arise from dynamic panel data estimators in this case, namely that the IV estimation greatly increases the mean squared error and that errors are assumed to not be serially correlated. On the other hand, the Driscoll and Kraay (1998) estimator works with great precision although potentially biased. Thus, a trade-off between correcting biases against decreases in efficiency is inherent. Fundamentally, trading a small reduction in the bias for a large decrease in efficiency sounds questionable. Assuming the *Nickell (1981) bias* is negligible since $T = 13$ is a reasonable time period and given the small coefficient for lagged Z-scores from Table 1.2, we further pursue the Driscoll and Kraay (1998) estimator with fixed effects and lagged dependent variables in our analysis.

1.5.3 Extensions

We extend the baseline model with a couple of features. First, we want to explore the relationship between innovation and fragility across firms with different characteristics. Thus, we generate interaction terms of the FI measures with assets, profitability and leverage.[25] Table 1.3 provides the piece-wise inclusion of these interactions into the regression with the Driscoll and Kraay (1998) estimator assessed above. Column 1 and 4 show the effect of FI on fragility with heterogeneous firm size. The relationship is stronger for

[23] The Blundell and Bond (1998) estimator is a system GMM estimation method which enhances the Arellano and Bond (1991) estimator with additional moment conditions. Both estimators are consistent, but they assume that there exists no autocorrelation in the error terms, that panel-level effects are uncorrelated with the first differences and that good instruments are available.

[24] Compare Behr (2003) for a discussion on dynamic panel data estimators and their application to financial data.

[25] For the interaction terms, we multiply our FI indicators with assets, profitability and leverage, respectively.

larger firms but only for innovative activity captured through patenting. Overall, patenting decreases stability significantly. Column 2 and 4 show that the different profitability levels have no impact on the effect of FI on fragility as expected. Finally, column 3 and 4 display the effect of FI on fragility with different leverage ratios. The relationship is stronger when firms are more leveraged and the impact of innovation increases with the leverage ratio. Across all models, the positive (negative) relation between innovation and fragility (stability) prevails, while the size of the coefficients differs across specifications.

Second, we investigate the robustness of our results from Section 1.5.1 against modifications of innovation measures as depicted in Table 1.4. Column 1 provides the regression results with the Driscoll and Kraay (1998) estimator from Table 1.2. Subsequently, column 2 uses a weighting mechanism to account for sole or collaborative inventions while column 3 uses only highly innovative activities as classified by a three-part scheme introduced by Lerner (2006). Column 4 provides a combination of 2 and 3 and finally, column 5 introduces R&D expenditures as a further control.[26] Results are confirmed. The positive relation between innovation and fragility is persistent while patenting has no effect.

[26]See Table A.1 in the Appendix for a description of the exact modifications.

Table 1.3: Interaction with Firm Characteristics

	Firm Size	**Profitability**	**Leverage**	**Compound Model**
	ln(1+Z-score$_t$)	**ln(1+Z-score$_t$)**	**ln(1+Z-score$_t$)**	**ln(1+Z-score$_t$)**
ln(1+Z-score$_{t-1}$)	0.013*	0.013*	0.013*	0.013*
	(0.008)	(0.008)	(0.008)	(0.008)
ln(assets)	-0.155***	-0.155***	-0.154***	-0.154***
	(0.013)	(0.013)	(0.013)	(0.013)
EBITDA/revenues	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage ratio	-0.228***	-0.227***	-0.227***	-0.227***
	(0.024)	(0.024)	(0.025)	(0.025)
FI by others in 2-digit zip code	0.002*	0.002*	0.002*	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Innovations	-0.016	-0.010***	-0.103**	-0.097***
	(0.019)	(0.004)	(0.043)	(0.034)
Patents	-0.042***	0.002	-0.036*	-0.035**
	(0.012)	(0.005)	(0.020)	(0.017)
Applications	-0.016	-0.008*	-0.044	-0.060*
	(0.012)	(0.005)	(0.033)	(0.035)
Innovations * ln(assets)	-0.048			0.191
	(0.158)			(0.195)
Patents * ln(assets)	-0.402***			-0.672***
	(0.111)			(0.195)
Applications * ln(assets)	-0.136			-0.029
	(0.091)			(0.081)
Innovations * EBITDA/revenues		0.001		0.001
		(0.001)		(0.001)
Patents * EBITDA/revenues		-0.001***		-0.002***
		(0.000)		(0.000)
Applications * EBITDA/revenues		-0.001		-0.001*
		(0.000)		(0.000)
Innovations * leverage ratio			-0.117**	-0.139**
			(0.052)	(0.054)
Patents * leverage ratio			-0.035	0.027
			(0.022)	(0.020)
Applications * leverage ratio			-0.046	-0.055
			(0.033)	(0.041)
Controls	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Constant	Y	Y	Y	Y
Observations	14,770	14,770	14,770	14,770
Number of firms	2,660	2,660	2,660	2,660
R-squared	0.634	0.634	0.634	0.634

Notes: See Table A.1 in the Appendix for definitions of the variables. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). All financial data is in million 2002 US Dollars and comes from Compustat. All columns incorporate the baseline model from column 4 of Table 1.2. Column 1 includes interaction terms between firm size and FI measures. Column 2 includes interaction terms between profitability and FI measures. Column 3 includes interaction terms between leverage ratio and FI measures. Finally, column 4 includes all interaction terms. In all regressions, we include firm characteristics as controls, firm and year fixed effects, and a constant but suppress their coefficients in the tables. Control variables include firm age, cash equivalents, employees, retained earnings, shareholders' equity, preferred stock and long-term debt (all as ratios relative to assets or logarithms). Driscoll and Kraay (1998) robust standard errors are clustered at firm-level and presented in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 1.4: Robustness against FI Measures

	base	weighted	major	weighted and major	R&D
	ln(1+Z-score$_t$)	**ln(1+Z-score$_t$)**	**ln(1+Z-score$_t$)**	**ln(1+Z-score$_t$)**	**ln(1+Z-score$_t$)**
ln(1+Z-score$_{t-1}$)	0.013	0.013	0.013	0.013	0.013
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
ln(assets)	-0.139***	-0.139***	-0.139***	-0.139***	-0.143***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
EBITDA/revenues	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage ratio	-0.257***	-0.257***	-0.258***	-0.258***	-0.248***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.018)
FI by others in 2-digit zip code	0.001*	0.001*	0.001*	0.001*	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Innovation parameters	-0.029**	-0.046***	-0.028*	-0.051*	-0.027**
	(0.012)	(0.017)	(0.015)	(0.027)	(0.012)
Patent parameters	-0.004	-0.012	-0.005	-0.014	-0.006
	(0.005)	(0.014)	(0.005)	(0.014)	(0.005)
Application parameters	-0.001	-0.004	-0.001	-0.004	-0.001
	(0.005)	(0.015)	(0.005)	(0.015)	(0.005)
R&D/assets					-0.489***
					(0.144)
Controls	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y
Observations	14,770	14,770	14,770	14,770	14,770
Number of firms	2,660	2,660	2,660	2,660	2,660
R-squared	0.633	0.633	0.633	0.633	0.634

Notes: See Table A.1 in the Appendix for definitions of the variables. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). All financial data is in million 2002 US Dollars and comes from Compustat. Column 1 incorporates the baseline model from column 4 of Table 1.2. Column 2 includes a weighting mechanism to account for sole or collaborative inventions. Column 3 includes only highly innovative activities as classified by a three-part scheme introduced by Lerner (2006). Column 4 is a combination of 2 and 3. It includes a weighting mechanism to account for sole or collaborative inventions of only highly innovative activities as classified by Lerner (2006). Finally, column 5 includes R&D expenditures as a further control. In all regressions, we include firm characteristics as controls, firm and year fixed effects, and a constant but suppress their coefficients in the tables. Control variables include firm age, cash equivalents, employees, retained earnings, shareholders' equity, preferred stock and long-term debt (all as ratios relative to assets or logarithms). Driscoll and Kraay (1998) robust standard errors are clustered at firm-level and presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Third, we further explore the robustness of results by investigating the components of the Z-score and alternative measures for firm fragility in Table 1.5.[27] Thus, we keep the right-hand side variables the same and compare different left-hand side variables. We respectively use ROA, ROE and the capital-asset ratio to assess profitability and capitalization, the volatility of ROA and volatility of ROE to measure a firm's activity risk, and finally, the Sharpe ratio as an alternative measure for the risk of insolvency. Specifically, the Sharpe ratio describes how well the return compensates the investor for the risk taken. Column 2 and 3 show that profitability is positively affected by patenting behavior, but surprisingly, the innovation coefficient is significantly negative although small. Capitalization of firms in column 4 is negatively affected by FI on a small scale, but only in patenting. Unusually, activity risk is not affected by a firm's degree of innovation as depicted in columns 5 and 6. Lastly, innovation continues to positively relate to risk of insolvency although the coefficient becomes insignificant whereas unexpectedly patenting positively affects excessive returns as shown in column 7.

Fourth, another investigation looks at the impact of FI on profitability during a financial crisis. Did FI hurt financial institutions during a period of financial market breakdown? In a cross-sectional setting where independent variables from 1999 only are used, we analyze whether firms make larger losses during financial distress when innovating. Table 1.6 provides an overview of the summary statistics of the variables for 1999. The cross-sectional sample has 1,781 observations. For most variables, mean values are larger than the median indicating a few large firms drive up average values. Values for most differences in profitability are negative. Variances in general are large.

[27]Because the different measures are highly skewed and to avoid truncation, we use the logarithm for the dependent variables in the regressions, except for standard deviations.

Table 1.5: Robustness against Fragility Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ln(1+Z-score$_t$)	**ln(1+ROA$_t$)**	**ln(1+ROE$_t$)**	**ln(1+CAR$_t$)**	**σ(ROA)**	**σ(ROE)**	**ln(1+Sharpe$_t$)**
ln(1+Z-score$_{t-1}$)	0.013						
	(0.008)						
ln(1+ROA$_{t-1}$)		0.042					
		(0.022)					
ln(1+ROE$_{t-1}$)			0.024				
			(0.015)				
ln(1+CAR$_{t-1}$)				0.327***			
				(0.004)			
ln(1+Sharpe$_{t-1}$)							0.033***
							(0.009)
ln(assets)	-0.143***	0.004	-0.152***	-0.048***	-0.020	-0.083	-0.297***
	(0.008)	(0.007)	(0.022)	(0.005)	(0.017)	(0.066)	(0.024)
EBITDA/revenues	0.000	0.000***	0.001***	0.000	0.000	-0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Leverage ratio	-0.248***	0.005	0.091***	0.100***	-0.011	-0.158	0.166***
	(0.018)	(0.013)	(0.015)	(0.006)	(0.014)	(0.132)	(0.055)
FI by others in 2-digit zip code	0.001*	0.001	0.003	0.001	0.009	0.002	0.000
	(0.000)	(0.001)	(0.002)	(0.001)	(0.007)	(0.001)	(0.003)
Innovations	-0.027**	-0.003**	-0.004	-0.002	-0.001	-0.037	-0.026
	(0.012)	(0.001)	(0.006)	(0.003)	(0.004)	(0.042)	(0.027)
Patents	-0.006	0.003	0.009**	-0.003***	-0.002	0.001	0.018**
	(0.005)	(0.002)	(0.004)	(0.001)	(0.002)	(0.003)	(0.009)
Applications	-0.001	0.003**	0.007**	-0.002**	-0.002	0.002	0.018***
	(0.005)	(0.001)	(0.003)	(0.001)	(0.002)	(0.002)	(0.006)
R&D/assets	-0.489***	-0.449	-0.498***	0.073	0.159	0.002	-0.253**
	(0.144)	(0.504)	(0.136)	(0.055)	(0.152)	(0.085)	(0.124)
Controls	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y
Observations	14,770	14,770	14,754	14,824	14,770	14,505	13,960
Number of firms	2,660	2,660	2,658	2,714	2,660	2,659	2,630
R-squared	0.634	0.103	0.071	0.519	0.004	0.002	0.082

Notes: See Table A.1 in the Appendix for definitions of the variables. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). All financial data is in million 2002 US Dollars and comes from Compustat. Lagged dependent variables are included in the regressions except for standard deviations of returns. We keep all other independent variables the same and only change the dependent variables from column to column. Column 1 incorporates the baseline model from column 4 of Table 1.2. Column 2 and 3 measure the impact of FI on profitability where returns on assets and equity are the dependent variables, respectively. Column 4 measures the impact of FI on capitalization of firms. Here, the capital-asset ratio is the dependent variable. Column 5 and 6 measure the impact of FI on activity risk by including the standard deviations of the returns on assets and equity, respectively. For these two regressions coefficients are scaled by 1,000. Finally, column 7 includes the Sharpe Ratio as dependent variable as another stability measure. In all regressions, we include firm characteristics as controls, firm and year fixed effects, and a constant but suppress their coefficients in the tables. Control variables include firm age, cash equivalents, employees, retained earnings, shareholders' equity, preferred stock and long-term debt (all as ratios relative to assets or logarithms). Driscoll and Kraay (1998) robust standard errors are clustered at firm-level and presented in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 1.6: Summary Statistics of Cross-Section (1999)

Variable	**Mean**	**Median**	**Std. Dev.**	**Min.**	**Max.**
Age	9.226	5.000	11.699	0	74
Assets	15381.500	614.032	65763.220	0	893649
Cash Equiv.	1503.317	27.252	9642.401	0	205371
Leverage	0.326	0.293	0.276	0	0.997
Long-term Debt	1954.220	51.799	12102.890	0	339221
Market Value	4597.746	116.612	26350.170	0.062	535947
Pref. Stock	33.535	0.000	183.772	0	3375
Revenues	2802.985	79.385	12301.180	0	184589
Sh. Equity	1496.865	87.944	5640.443	-44	83397
Δ(Opprof)	-0.533	0.014	16.200	-523.908	130.719
Δ(ROA)	-0.096	-0.001	1.382	-41.827	1.671
Δ(ROE)	0.195	-0.004	6.999	-51.006	230.774
Innovations (avg.)	0.012	0.000	0.075	0	1.200
Patents (avg.)	0.024	0.000	0.219	0	5.000
Applications (avg.)	0.040	0.000	0.352	0	7.000
R&D	48.874	0.000	457.900	0	7502.168
FI by others	1.002	0.000	1.713	0	4.000

Notes: N=1,781. See Table A.1 in the Appendix for definitions of the variables. All financial data is in million 2002 US Dollars and comes from Compustat. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). FI measures are averaged over the period 1990 to 1999.

For the cross-sectional analysis, we use as the dependent variable $\Delta(Opprof)$, $\Delta(ROA)$ and $\Delta(ROE)$, respectively, where $\Delta(\centerdot) = (\centerdot)_{2002} - (\centerdot)_{1999}$.[28] We expect that the difference will be negative for most firms and should be larger for more innovative firms. The model specification for the three regressions is as follows.

$$\Delta(\centerdot)_i = \beta X_i + \gamma Y_i + \epsilon_i \tag{1.2}$$

where index i stands for the firm and the dependent variable is the performance change between 2002 and 1999 calculated as the difference in $Opprof = EBITDA/revenues$, ROA, ROE, respectively, between the values in the respective years. Again, X is the vector of firm characteristics in 1999 while Y is the vector of different financial innovation

[28] The year 1999 has the most observations per year in the data set and the NASDAQ had its ten-year peak then, while in 2002 the NASDAQ considerably dropped because of the burst of the ICT bubble.

indicators. We use feasible GLS estimation with heteroskedastic error terms ϵ in the regressions. FI measures are averaged over the period 1990 to 1999 because this captures overall innovative activity per firm. Table 1.7 provides the results which suggest that more innovative firms face higher profitability declines during distress. The significantly negative sign on γ is consistent with the *innovation-fragility view* and suggests that firms with higher pre-crisis FI suffered more during a crisis.

Table 1.7: Comparison of Profitability Changes

Variables	(1) **Δ(ROA)**	(2) **Δ(ROE)**	(3) **Δ(Opprof)**
ln(assets)	0.044***	-0.329***	-0.279***
	(0.002)	(0.008)	(0.019)
EBITDA/revenues	0.010***	-0.008	
	(0.003)	(0.011)	
Leverage ratio	-0.152***	1.190***	0.675***
	(0.004)	(0.029)	(0.047)
FI by others in 2-digit zip code	-0.040***	0.041***	-0.150***
	(0.005)	(0.002)	(0.016)
Innovations (avg.)	-0.087***	-0.315***	-1.634***
	(0.006)	(0.021)	(0.178)
Patents (avg.)	-0.511***	0.366***	-1.696***
	(0.028)	(0.060)	(0.543)
Applications (avg.)	0.249***	-0.223***	0.751**
	(0.018)	(0.037)	(0.302)
Controls	Y	Y	Y
Constant	Y	Y	Y
Observations	1,202	1,201	1,196
Number of firms	1,202	1,201	1,196
R-squared	0.044	0.048	0.023

Notes: See Table A.1 in the Appendix for definitions of the variables. Count data on innovations comes from the Wall Street Journal, the Factiva database or the US Patent and Trademark Office, collected by Lerner (2006). FI measures are averaged over the period 1990 to 1999. All financial data is in million 2002 US Dollars and comes from Compustat. In column 1, we use the change in ROA as dependent variable, in column 2, we use the change in ROE as dependent variable, and finally, in column 3, we use the change in operational profitability as dependent variable. In all regressions, we include firm characteristics as controls and a constant but suppress their coefficients in the tables. Control variables include firm age, cash equivalents, employees, retained earnings, shareholders' equity, preferred stock and long-term debt (all as ratios relative to assets or logarithms). Robust standard errors are clustered at firm-level and presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

1.6 Conclusion

In this chapter, we evaluate the relationship between financial innovations and the fragility of financial institutions. Theoretical literature provides strong evidence for why financial crises exist and why firms engage in producing financial innovations. A recent strand of research tries to combine both areas and analyzes the impact of innovative activity of financial agents in a competitive framework. Particularly, this mostly theoretical literature links profit volatility to innovative activities and predicts a positive relationship. That is, the degree of innovation negatively affects firm stability.

We base our analysis on a unique data set that counts financial innovations in the USA between 1990 and 2002 provided by Lerner (2006) and augment it by performance and stability measures. Then, we build on empirical frameworks by Beck, Chen, Lin, and Song (2012) and others to quantitatively assess the so called *innovation-fragility view* on a firm level. We show that a larger degree of innovation positively (negatively) affects firm fragility (stability) after controlling for the underlying firm characteristics. A couple of extensions to the initial model show that our results are quite robust. Different modifications of the innovation measures yield the same outcomes. Furthermore, we use different fragility parameters measuring profitability, capitalization, activity risk and risk of insolvency and find that the results support our argumentation. In addition, firms with higher pre-crisis FI face higher losses during a period of financial crisis. Overall, our analyses support the *innovation-fragility view*.

Chapter 2

Determinants of Capital Structure in Non-Financial Companies*

2.1 Introduction

A recent comprehensive review of structural issues related to corporate finance and economic activity for the Euro Area has pointed to the potential impact of capital structure choices for the financial stability and economic performance of the economy as a whole.[1] In the present study, using a large set of data, we investigate the determinants of funding choices of firms in order to create a solid starting point for further research into access to finance and financial stability questions. In doing so, we take the view that analyzing capital structure choice can inform macro- and micro-prudential policies despite the fact that empirical evidence supports both main capital structure theories (pecking order theory and trade-off theory). We find very similar econometric results as in European Central Bank (2013) as to which firm-specific factors determine (i) the potential use of external funding by non-financial companies (NFCs) and (ii) its degree (leverage), but we extend the discussion by analyzing the impact of additional industry- and country-specific factors.

*This chapter is based on joint work with Harald W. Stieber, European Commission.

[1]See European Central Bank (2013).

A stylized fact that motivates our inquiry is the pronounced cross-country variation in NFCs' leverage ratios. Apparently different models of funding structure are compatible with comparable levels of economic activity and well-being. However, leverage ratios within an industry sector seem to follow strong path dependence. At the end of the 1980s the bank-financed German and Japanese models were considered the most sustainable, where banks took important stakes in non-financial (manufacturing) industries and thus had their incentives aligned with the long-term funding needs of R&D-intensive sectors. During the 1990s the Japanese model became infamous for its "zombie" banks[2] while Germany's costly re-unification created a structural break in the economic data for a number of years. At present a new mantra of a well-diversified funding structure is developed in light of the recent financial crisis. However, Germany and some other European economies have done well with NFCs using mainly financing intermediated by banks rather than capital markets.[3] In this context we find it intriguing that among the two major theories that try to explain NFCs' capital structure choices, the pecking order theory seems to better allow for country heterogeneity along the leverage dimension as compared to the trade-off theory.

We build on Rajan and Zingales (1995) and subsequent empirical studies. In addition to the firm-specific factors they have identified, we further investigate which other industry-specific and institutional factors affect capital structure choices. Based on a short panel with a very large cross-section, we can show that firm size, industry leverage, industry growth and tax shield positively affect leverage ratios, while profitability and liquidity have negative impacts. Furthermore, tangibility has a positive impact on leverage for those firms that use long-term debt financing. In addition, we find a strong impact of international capital flows. The results are robust against different panel estimators, decompositions and in yearly cross sections.

The chapter is structured as follows. First, we discuss previous literature in the area. In

[2] A zombie bank is a financial institution with negative net worth. They continue to operate as a result of government support that allow these banks to meet debt obligations and avoid bankruptcy.

[3] Accordingly, Aoki and Nikolov (2012) identify this possibility of a stable bank-financed economy and a possible increase in systemic risk as capital markets expand and diversify.

Sections 2.3 we introduce the data and variables used in our empirical study. Section 2.4 presents the empirical analysis. In Section 2.5 we discuss the analytical results, while Section 2.6 concludes the chapter.

2.2 Literature Review

The determinants of differences in capital structures have been the subject of theoretical as well as empirical research over the past few decades.

2.2.1 Capital Structure Theories

Theoretical underpinnings go back to Modigliani and Miller (1958) who propose that the capital structure does not affect firm value in a tax-free, full-information, no-agency world. However, given more realistic assumptions about the market in which firms compete for external financing, theoretical papers in the recent literature on capital structure suggested a vast number of dynamics and intuitions.[4] Two main theories prevail. First, the trade-off theory by Kraus and Litzenberger (1973) assumes that an optimal capital structure exists for every firm at any point in time. It postulates that firms trade off tax advantages from debt against refinancing risk where the optimal debt-equity mix depends on tax and bankruptcy codes.

Second, the pecking order theory by Myers and Majluf (1984) and Myers (1984) is based on information asymmetries between companies and investors. Here, firms do not have target leverage ratios but instead consider capital costs and access to finance in order to determine their leverage. Given increasing costs with rising information asymmetries, firms first make use of internal funds such as retained earnings before acquiring debt and

[4]For an overview of capital structure choice theories including trade-off theory, pecking order theory, market timing theory, cash flow theory and agency theory see Myers (1977, 2001), Goldstein, Ju, and Leland (2001), or Bhamra, Kuehn, and Strebulaev (2010).

lastly, new equity. Bertomeu, Beyer, and Dye (2011) further show that both a firm's present capital structure and its disclosure policy determine its capital costs.[5]

2.2.2 Empirical Evidence

Empirical assessments of capital structures have started with research into firm characteristics by Rajan and Zingales (1995). In a cross-sectional study of G7 countries they find four relevant firm level-drivers for leverage - firm size, firm growth opportunities, tangibility and profitability. Moreover, they show that inter-country differences are small. Faulkender and Petersen (2006) and Brav (2009) add to that list two other important factors, firm age and access to finance. The former examine US firms over two decades and show that access to finance is positively related to leverage while the latter analyzes UK firms over one decade to find that private firms are more levered and leverage restructuring is closer related to firm performance. One intuition is that private equity is more costly than public equity due to information asymmetries.[6]

More recently, studies have also included industry drivers of leverage. Almazan and Molina (2005), MacKay and Phillips (2005), Faulkender and Petersen (2006), Brav (2009), Frank and Goyal (2009) and Degryse, de Goeij, and Kappert (2012) find that inter- and intra-industry effects are important determinants of individual leverage ratios for Dutch, UK and US firms.[7] They are able to show that the effects of firm characteristics on capital structures significantly differ across industries. Chen and Yu (2011)

[5] A series of studies test the aforementioned two main capital structure theories. Shyam-Sunder and Myers (1999) and Frank and Goyal (2003) specifically analyze projections from both theories and find evidence in favor of a dynamic trade-off theory in line with Goldstein, Ju, and Leland (2001) but most of the statistical tests employed have weak power. De Jong, Verbeek, and Verwijmeren (2011) point out that the pecking order theory better explains levels of debt while the trade-off theory predicts debt issuance and repurchase decisions.

[6] Bharath, Pasquariello, and Wu (2009), Brav (2009), Huang and Ritter (2009) and Bharath and Dittmar (2010) analyze the implications of information asymmetries on capital structure choice and discuss the decision on security issuance in discrete choice models. For US and UK firms, they find that larger information asymmetries drive leverage and that macroeconomic conditions, market timing and the speed of adjustment towards target leverage ratios are important in a firm's decision to issue securities. Whited and Wu (2006) build a structural model to construct an index for financial constraints of firms based on how information asymmetries impact certain firm characteristics.

[7] Some of these studies make use of a very detailed level of data where they use factors such as CEO tenure and compensation, and industry-specific risk hedging for which we do not have data.

investigate multinational corporations and find significant industry-fixed effects, export intensity, and foreign direct investment which drive capital structure choice. In their study on small Italian firms, La Rocca, La Rocca, and Cariola (2011) find that capital structure choice also depends on a firm's business life cycle and subsequently, on growth patterns within industries. Including industry-specific factors in the analysis can also serve as proxy for target leverage ratios and account for correlated but omitted variables.

A third group of studies analyzes the effects of institutional and country factors on capital structure choices. Antoniou, Guney, and Paudyal (2008), Psillaki and Daskalakis (2009), Frank and Goyal (2009), Fan, Titman, and Twite (2012), Öztekin and Flannery (2012) and Köksal, Orman, and Oduncu (2013) include a country's legal and financial traditions, inflation, GDP and capital flows in their analyses of G5 countries, Southern Europe, 39 developing and developed countries, and Turkey, respectively. They find that differences in capital structures reflect differences in the economic environment, specifically varying degrees of exposure to capital markets, tax systems, institutions, macroeconomic conditions and corporate governance practices. Whenever such country-specific factors are common, firms determine their capital structure in similar ways.

Two caveats arise from previous empirical research with respect to capital structures. First, a series of papers shows that in order to thoroughly assess time-series patterns in leverage ratios, a long time dimension (typically a couple decades) in a dynamic panel model is needed and a common GMM estimator is outperformed by a long-differencing estimator.[8] However, this very much restricts the longitudinal dimension of the data employed, to few industries or few countries. Second, different results from empirical analyses have often been attributed to sample selection bias.[9] Most studies restrict themselves to only a handful of countries or only a few industries. To our knowledge, only recent papers have investigated and compared the impact of industry and country

[8]Compare Antoniou, Guney, and Paudyal (2008), Huang and Ritter (2009), Denis and McKeon (2012), and Öztekin and Flannery (2012).

[9]While Faulkender and Petersen (2006), Fan, Titman, and Twite (2012) and Köksal, Orman, and Oduncu (2013) support the trade-off theory, Brav (2009), La Rocca, La Rocca, and Cariola (2011) and Degryse, de Goeij, and Kappert (2012) support the pecking order theory.

characteristics.[10] However, the industry composition within countries as well as institutional factors vary a lot and can explain the different findings.

Our contribution is thus twofold. First, we tackle the sample selection problem by analyzing a data set with a very large European cross-section, i.e. in the number of firms, of industries and of countries, with respect to firm size and the inclusion of USA and Japan as comparisons. Second, we augment the existing panel analyses with firm-, industry- and country-specific variables that can explain more of the variation in the data on capital structure. Because we only have a short panel data set, we cannot analyze the aforementioned dynamic aspect of capital structure choice, but we show that for the short time period we analyze the data is stationary and our results are robust in yearly regressions. Our study provides strong indications that corporate taxation needs to be part of macro-prudential policy for international capital markets in view of the strong effects of national tax codes on leverage ratios.

2.3 Data

This section explains the (i) data set as well as (ii) definitions and hypotheses to be tested in our empirical analysis.

2.3.1 Sample

The data set measures capital structures in Europe, Japan and the USA from 2003 until 2012. For firm-level data, we use the ORBIS database[11] which contains company information for unlisted and listed companies. We include firms with either revenue above EUR 1 million, assets above EUR 2 million, or more than 15 employees. Macroeconomic

[10] Compare Psillaki and Daskalakis (2009), Frank and Goyal (2009), Degryse, de Goeij, and Kappert (2012), Fan, Titman, and Twite (2012) and Köksal, Orman, and Oduncu (2013). They are able to show that the importance of capital structure determinants goes from firm-specific to country to industry-specific effects. They show this with (i) the goodness-of-fit of their models and (ii) the size of coefficients of the regressors in their models.

[11] The data were kindly provided by the European Commission under a license agreement with Bureau van Dijk.

data comes from the World Development Indicators of the World Bank. We identify different industries by using the two-digit industry codes of the European NACE Rev. 2 classification.[12]

We clean the data from coding errors and outliers, and perform some plausibility checks. Any observations with missing data or implausible values for variables (e.g. negative revenues) are dropped. We adjust the data to keep only observations with leverage ratios in the interval [0,1], profitability within [-1,1], tangibility and liquidity in [0,1].[13] Firm growth is capped at 100%, i.e. a doubling of revenues from year to year. The final sample is an unbalanced panel of 1,189,708 firms with 6,365,842 firm-year observations. We do not have 10 years of data for all firms because each year some firms enter or exit the sample.

2.3.2 Variables and Hypotheses

We use three different measures for the capital structure of firms in our analysis: short-term, long-term and total debt over total assets, respectively, determined with book values.[14] Rajan and Zingales (1995) demonstrate that ratios of liabilities to assets are an appropriate measure widely adopted for financial leverage of companies as they serve as a proxy for what is left for shareholders in case of liquidation.[15] On the other hand, the data set consists of three different groups of independent variables: firm characteristics, industry-specific parameters and country-specific variables.[16]

[12] We exclude firms with missing industry codes and firms operating in agriculture, mining, financial services, public services, education, health, entertainment and other services which constitute NACE Rev. 2 classification sections A, B, K, O, P, Q, R, S, T, and U.

[13] Section 2.3.2 provides definitions and shows why these are reasonable boundaries.

[14] In accordance with common nomenclature, short-term debt is any debt payable within one year. Long-term debt is any liability exceeding one year in maturity.

[15] Subsequent studies have followed this approach while other definitions include market values of equity or assets in the denominator (e.g. Shyam-Sunder and Myers (1999), Welch (2004), Faulkender and Petersen (2006), Antoniou, Guney, and Paudyal (2008), Frank and Goyal (2009)) as a result of the critic against book measures being backward looking. In addition, some studies have used interest coverage or debt maturity to measure leverage of firms (Rajan and Zingales (1995), Welch (2004), Frank and Goyal (2009), Fan, Titman, and Twite (2012)).

[16] See Table B.1 in the Appendix for complete descriptions of the variables used here. All financial data is in thousand EUR. Table B.2 provides an overview of the distribution of data along several dimensions.

2.3.2.1 Firm-specific Factors

Firm Size One of the aforementioned key determinants of leverage is firm size (Rajan and Zingales (1995)). Larger firms are usually more established in their markets, diversified and less likely to fail. Therefore, it has been argued that size can be seen as an inverse measure of bankruptcy risk. To avoid problems of multicollinearity we use the logarithm of revenues to measure firm size since several of the ratios used in our analyses are in terms of assets. Revenues and total assets are highly correlated.[17] The pecking order theory is ambiguous but the trade-off theory postulates that leverage is positively affected by firm size as shown in most of the empirical studies.

Firm Growth Future business prospects of a company represent another important leverage factor (Rajan and Zingales (1995)). How firms react to investment opportunities determines their profitability and status in their respective markets. In order to mitigate problems of multicollinearity we use growth rates in revenues to measure firm growth since several of the ratios used in our analyses are in terms of assets.[18] While the pecking order theory predicts a positive relation to leverage, the trade-off theory assumes a negative relation. Results from previous literature are mixed.[19]

Profitability More profitable firms usually generate more cash flows and firms generally prefer to finance projects with internal funds. Since retained earnings increase with higher profits, the need for debt financing decreases with higher profitability.[20] In line with Frank and Goyal (2009), Psillaki and Daskalakis (2009), and Chen and Yu (2011) we define profitability as earnings before interest and taxes (EBIT) over total assets. While

[17]While Rajan and Zingales (1995), Psillaki and Daskalakis (2009), and Köksal, Orman, and Oduncu (2013) use revenues as a proxy for size, Frank and Goyal (2009), La Rocca, La Rocca, and Cariola (2011), Degryse, de Goeij, and Kappert (2012) and Fan, Titman, and Twite (2012) use data on assets.

[18]Although Brav (2009), La Rocca, La Rocca, and Cariola (2011) and Köksal, Orman, and Oduncu (2013) use percentage changes in sales, Frank and Goyal (2009), Chen and Yu (2011) and Degryse, de Goeij, and Kappert (2012) use growth in terms of assets.

[19]Brav (2009) and Degryse, de Goeij, and Kappert (2012) find a positive coefficient, while Rajan and Zingales (1995), Faulkender and Petersen (2006) and Fan, Titman, and Twite (2012) find a negative coefficient in their respective analyses.

[20]Causality may vary, however, with younger firms or otherwise financially constrained firms being required to achieve higher profitability in order to access external finance. Still, informational asymmetries where firms have private knowledge about the true value of their assets and firm growth opportunities could explain a wide range of cases.

the trade-off theory is ambiguous, the pecking order theory predicts a negative relation as is the consensus in the literature.

Tangibility We define tangibility as the share of fixed assets to total assets. The larger the fraction of fixed assets on a firm's balance sheet, the more assets it can pledge as collateral against debt which diminishes the agency costs borne by the investor. Also, liquidation values ought to be higher and easier to determine. Thus, it should be easier for a firm with more tangible assets to acquire loans. Both capital structure theories predict a positive relation between tangibility and leverage.

Liquidity Firms with less liquidity may find it harder to attract debt as costs of contract enforcement (including during possible insolvency proceedings) increase. Numerous definitions exist. We use cash equivalents over total assets as a proxy for firms' capacity to demand payments from their debtors while holding off on their creditors. Both theories are ambiguous about the expected relation to leverage but Brav (2009) and Köksal, Orman, and Oduncu (2013) have found a negative coefficient.

Nickell Criterion This factor comes from Nickell and Nicolitsas (1999) and measures financial stress of a company in terms of how much of its cash flow is spent to cover debt expenses. Specifically, this flow measure allows us to capture the impact of interest rate changes on debt[21].

2.3.2.2 Industry-specific Factors

Industry Leverage In accordance with Frank and Goyal (2009), Degryse, de Goeij, and Kappert (2012) and Köksal, Orman, and Oduncu (2013), we measure industry trends with median leverage ratios by grouping firms with the same two-digit industry classification codes. Early work by Harris and Raviv (1991) already suggests a strong relationship between industry affiliation and leverage ratios and highlights existing differences across

[21] While this ratio is potentially interesting from a monetary policy and macro-prudential point of view, it does not have explanatory power in our model.

industries but consistency within them. The trade-off theory supposes that inter-industry effects exist as the optimal leverage ratio may differ across industries. Also, the effects of aforementioned firm characteristics may vary across industries. The pecking order theory does not offer a clear prediction. Moreover, intra-industry effects can arise from competition and agency conflicts within a market. Firms may face higher pressure to assert to the optimal leverage ratio in more competitive situations while increasing leverage might deter takeover attempts or signal firm stability. Empirical evidence shows a strong positive relation between industry and individual firm leverage.

Industry Growth To account for industry-specific demand shifts, we also measure the development of an industry with median growth rates across groups of firms with the same two-digit industry classification codes. La Rocca, La Rocca, and Cariola (2011) find a positive relationship with leverage ratios.

2.3.2.3 Macroeconomic Factors

Taxation We also measure the impact of a country's fiscal treatment of debt financing.[22] Taxes affect the size of the tax shield for debt financing and they can impact the amount of retained earnings and the dividend policy of a firm. These impacts tend to favor higher leverage ratios. Faulkender and Petersen (2006), Degryse, de Goeij, and Kappert (2012), Fan, Titman, and Twite (2012), Köksal, Orman, and Oduncu (2013) and Feld, Heckemeyer, and Overesch (2013) have shown that an effective debt interest tax shield is positively related to leverage. The pecking order theory is ambivalent about taxation, while the trade-off theory predicts a positive relation between tax shield and leverage ratios. As a proxy for the tax shield per country we compute the actual tax savings for firms with long-term debt compared to firms without long-term debt.

Inflation Following Frank and Goyal (2009), Fan, Titman, and Twite (2012) and Köksal, Orman, and Oduncu (2013) we include changes in consumer prices.[23] Rising

[22]Data on tax payments per firm comes from the ORBIS database.

[23]Data for this factor and subsequent macroeconomic factors comes from the World Development Indicators, World Bank.

inflation decreases the relative value of debt. Also, tax deductions from debt financing are more valuable when inflation is expected to be higher. Frank and Goyal (2009) and Köksal, Orman, and Oduncu (2013) find a positive relation between inflation and leverage which is in line with the trade-off theory.

GDP Growth The business cycle also has a profound impact on capital structures. During times of economic prosperity collateral values increase and debt financing becomes easier. Agency problems between firms and investors become more severe in economic downturns. However, internal funds of firms generally increase in economic expansion so that according to the pecking order theory firms might make less use of debt financing. Whited and Wu (2006) find that financially constrained firms' cost of financing decreases with the duration of the economic upswing. Thus, leverage could be either pro-cyclical or counter-cyclical. Frank and Goyal (2009) find a positive relation while Köksal, Orman, and Oduncu (2013) find a negative one.

Capital Flows Antoniou, Guney, and Paudyal (2008), Fan, Titman, and Twite (2012) and Köksal, Orman, and Oduncu (2013) argue that developments in capital markets are important to determine firm-level capital structures. Hereby, the size and structure of national capital markets depends heavily on the international allocation and dispersion of capital. Thus, we include a measure for capital flows in our analysis. This takes on positive values whenever money is flowing into a country, effectively representing an increase of foreign ownership of domestic assets. The factor is negative whenever money is flowing out of the country suggesting that a country increases its ownership of foreign assets. Antoniou, Guney, and Paudyal (2008) and Köksal, Orman, and Oduncu (2013) find a positive relation between capital flows and leverage.

Unemployment As another business cycle indicator and to account for developments in labor markets, we include the fraction of work force that is unemployed by drawing from World Bank accounts.

Stock Prices We also want to take into consideration how expensive equity for public firms is. Thus, we include data on Standard & Poor's Global Equity Indices collected by the World Bank which measure the performance of various stock exchanges around the world. Welch (2004), Antoniou, Guney, and Paudyal (2008) and Frank and Goyal (2009) argue that the effect of changing stock prices on capital structure may reflect overall growth prospects, relative price changes in asset classes or differences in agency costs. Firms may take advantage of mispricing in stock markets to reduce their capital costs. Thus, the pecking order theory predicts and empirical analyses confirm that stock price development and leverage ratios are negatively related.

2.4 Empirical Analysis

This section explores the determinants of capital structures of NFCs empirically. We first provide (i) a description of the data and then (ii) present the empirical model specification.

2.4.1 Descriptive Statistics and Properties

Observations are evenly distributed over the time period investigated here. About two thirds of the companies in our sample have between five to eight observations while 25% of firms have eight or more consecutive observations. Some countries like France, Italy and Spain have a large number of data points while we cautiously also include countries with few observations in our sample, like Cyprus, Liechtenstein, Lithuania, Montenegro and Malta. Figure 2.1 shows the three leverage ratios and their behavior over time. Weak time trends are visible. Long-term leverage seems to increase continuously, while short-term leverage seems to decrease over our sample period which covers after all a full business cycle from trough to trough.

Figure 2.1: Leverage Ratios over Time

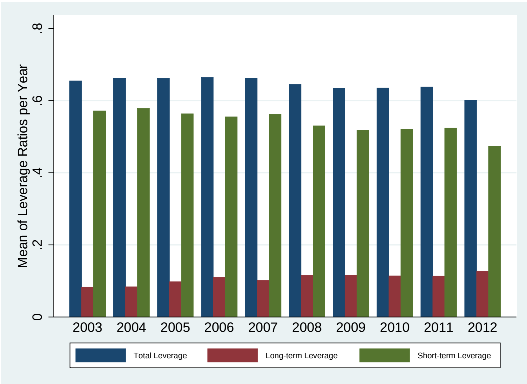


Table 2.1 provides an overview of the summary statistics of the variables introduced in Section 2.3.2. It shows that there exists great heterogeneity among firms in terms of size, growth and profitability as well as large differences across industries and countries. Generally, variances of our variables are quite large. Industry- and country-specific factors are less volatile. Across the sample, firms hold on average 65% debt in terms of total assets. Notably, we find that 40% of the firms in our sample do not hold any long-term debt and subsequently, short-term debt accounts for approximately 84% of total debt. For most variables, mean and median are close, except for firm-level growth and liquidity where we have only a few high-growth companies and only a few firms with large cash reserves.

We can also compare leverage measures, our explanatory variables as well as balance sheet data and items from the profit-and-loss statement (P&L) across countries. Table 2.2 depicts the differences for eight major countries in our sample. We find substantial variation in overall capital structure choice, e.g. Italy versus the USA, and in debt maturity, where e.g. Italy and Poland have very small shares of long-term debt to total debt. For our explanatory variables, differences are substantial across countries. While large firms are located in Japan and the USA, Southern European firms have the highest growth rates.

Table 2.1: Summary Statistics of Variables

Variable	**Mean**	**Median**	**Std. Dev.**	**Min.**	**Max.**
Total LR	0.650	0.696	0.249	0	1
Lt LR	0.105	0.005	0.181	0	1
St LR	0.545	0.561	0.267	0	1
Firm Size	7.824	7.681	1.808	0	20.457
Firm Growth	0.393	0.058	3.048	-1	1
Profitability	0.080	0.056	0.127	-1	1
Tangibility	0.329	0.249	0.282	0	1
Liquidity	0.127	0.059	0.164	0	1
Nickell	0.293	0.059	43.068	-18505	83094
St Ind. LR	0.548	0.579	0.108	0.164	0.745
Lt Ind. LR	0.020	0.006	0.029	0	0.325
Total Ind. LR	0.693	0.694	0.053	0.381	0.821
Ind. Growth	0.058	0.065	0.057	-0.288	0.244
Tax Shield	0.005	0.005	0.005	0	0.063
Inflation	2.807	2.166	2.789	-4.480	25.296
GDP Growth	1.359	1.725	3.089	-17.955	12.233
Capital Flows	0.003	0.001	0.005	-0.020	0.042
Unemployment	8.806	8.400	3.479	2.300	37.300
Stock Prices	9.072	13.076	35.392	-82.190	189.230

Notes: N=6,365,842. See Table B.1 in the Appendix for definitions of the variables. All variables are ratios, growth rates or logarithms.

Table 2.2: Cross-country Comparison of Variables

	Germany	UK	France	Italy	Spain	Poland	USA	Japan
Leverage Measures								
Total LR	0.683	0.605	0.638	0.752	0.608	0.538	0.468	0.542
Lt LR	0.241	0.115	0.057	0.077	0.165	0.071	0.142	0.115
St LR	0.441	0.489	0.582	0.675	0.442	0.468	0.325	0.428
Explanatory Variables								
Firm Size	9.534	9.621	7.914	7.609	7.478	8.582	11.534	12.209
Firm Growth	0.242	0.191	0.207	0.442	0.485	0.289	0.418	0.078
Profitability	0.099	0.080	0.095	0.057	0.062	0.108	-0.007	0.046
Tangibility	0.337	0.358	0.253	0.297	0.365	0.409	0.471	0.441
Liquidity	0.115	0.123	0.190	0.080	0.124	0.108	0.222	0.179
Nickell	1.123	0.386	0.039	0.467	0.314	0.093	0.129	-0.239
Total Ind. LR	0.680	0.683	0.696	0.693	0.703	0.684	0.639	0.669
Lt Ind. LR	0.018	0.019	0.016	0.024	0.021	0.020	0.012	0.014
St Ind. LR	0.538	0.541	0.572	0.534	0.547	0.542	0.516	0.543
Ind. Growth	0.058	0.061	0.060	0.054	0.059	0.055	0.068	0.066
Tax Shield	0.009	0.007	0.004	0.004	0.007	0.004	0.002	0.009
Inflation	1.583	2.638	1.725	2.093	2.740	2.983	2.508	-0.127
GDP Growth	1.331	1.349	1.124	0.100	1.661	4.504	1.594	0.821
Capital Flows	-0.001	0.002	0.001	0.001	0.006	0.013	0.001	-0.001
Unemployment	8.481	6.093	8.716	7.576	13.158	11.738	6.615	4.523
Stock Prices	12.191	6.399	5.617	-1.458	11.807	11.465	5.969	6.775
Balance Sheet Items								
Cash Equivalents	8068.503	11702.990	2047.225	946.198	1256.842	1508.315	218442.600	168741.100
Fixed Assets	60300.030	96672.770	12213.010	8161.040	9431.051	11214.540	1473932.000	875690.600
Total Assets	109880.300	216787.300	21981.900	16159.260	16731.570	18411.120	2179010.000	1543776.000
Short-term Debt	54035.410	126398.900	11882.790	8756.929	6814.443	7626.083	843778.800	681131.500
Long-term Debt	22638.130	35025.690	3285.930	2507.065	4303.499	1741.117	479997.300	301391.200
Shareholders' Equity	33206.710	55362.690	6813.181	4895.263	5613.629	9043.921	855233.800	561253.500
P&L Items								
Revenue	142291.500	145428.500	20566.370	12709.050	12576.800	22002.590	1937623.000	1365154.000
EBITDA	108796.740	14736.450	2014.106	1550.000	1468.947	2270.105	295891.000	146243.300
EBIT	6157.123	9343.033	1233.255	700.344	944.808	1377.137	199215.600	75171.620
Interest	1370.790	6.085	198.418	169.235	131.706	143.710	23221.590	9429.621
Tax Payments	1600.950	2445.634	295.732	258.056	208.171	237.148	56685.990	28232.310
Net Income	3043.198	6891.314	739.105	273.053	605.034	996.280	119308.000	37509.690

Notes: Mean values per country. See Table B.1 in the Appendix for definitions of the variables. Factors used in regression analyses are ratios, growth rates or logarithms. Balance sheet and P&L items are in thousand EUR.

Profitability is generally low.[24] Tangibility and liquidity are highest for US firms while industry-specific factors are similar. Macroeconomic conditions differ as well, naturally. The composition of firms' balance sheets and P&L statements shows that considerable differences in levels exist. We also find that large firms from Japan and the USA are over-represented in our sample as country-average levels of balance sheet items vastly exceed those of European firms. This may also explain the significantly lower leverage ratios for US and Japanese firms in the data set.

A decomposition of Rajan and Zingales' (1995) four main firm-level drivers of leverage reveals great differences across industries and countries.[25] Large firms exist predominantly in Russia, USA, Japan and Switzerland, while most small firms exist in Southern and Eastern Europe. Large firms are mainly operating in the industry clusters electricity, gas and water supply as well as manufacturing. Firms with high growth rates are located in Eastern Europe and active in electricity, gas and water supply as well as ICT and research. The most profitable firms exist in Northern Europe and respectively, in industry clusters ICT and research and services. Most firms show low profitability. About 98% of observations lie within the interval [-0.5,0.5] and about 83% of the data points are within one standard deviation away from the overall mean (0.080). Finally, firms with the largest share of fixed assets are located in Switzerland, Cyprus and Denmark and are active in accommodation and food as well as electricity, gas and water supply.

Notably, the tax shield differs significantly among countries as depicted in Figure 2.2 with Iceland, the Netherlands and Russia providing the highest tax incentives for debt financing.[26] Because we compute both the tax shield and the firm-specific factors relative to total assets, we can compare level effects of our variables. Remarkably, the level of most tax shields is much smaller than those of the firm-specific factors. While e.g. profitability, tangibility and liquidity have overall means 0.080, 0.329 and 0.127, respectively,

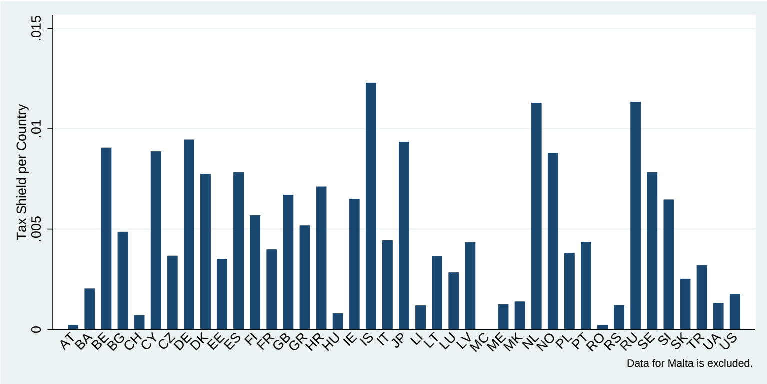
[24] For the USA, some firms experience significant losses over our sample period which explains the negative average profitability, but the median of profitability for US firms in our sample is 0.057.

[25] For brevity we relegate these Figures B.1, B.2, B.3, B.4, B.5, B.6, B.7 and B.8 to the Appendix.

[26] We exclude Malta from this figure because it has only 221 observations and is considered a tax haven within the EU. Hence, its average tax savings per firm are far above that from other countries. For Monaco we do not have data on taxation so we cannot compute the tax shield for this country.

tax shield has a mean value of 0.005 as indicated in Table 2.1. Hence, already small changes in the tax shield can have big impacts on firms' funding structure.

Figure 2.2: Tax Shield across Countries



Following the descriptives, a variety of univariate analyses provide a first glance at the variables' behavior and properties. Our explanatory variables are all correlated with the leverage ratios.[27] A F-test confirms joint significance. Furthermore, firm characteristics are correlated with each other and over time. We have carefully selected and computed our explanatory indicators with relatively low correlations from the vast group of available variables in the ORBIS database to avoid problems of multicollinearity. We find weak time trends given the data is stationary as indicated in unit root tests. Mann-Whitney U tests and t-tests show that the mean and variance of leverage ratios are significantly different across countries and industries. European firms hold more debt and in particular, firms located in the Euro Area. Investigating capital structure choice across industries, especially firms in trade and transportation have significantly different debt holdings from firms pursuing other economic activities. A robust version of the Wu-Hausman test by Wooldridge (2002) shows that fixed effects modeling is preferred over a random effects setup. Furthermore, Breusch-Pagan, Jarque-Bera and Breusch-Godfrey tests respectively show that the error terms are heteroskedastic, asymptotically normal and correlated with each other within panels.

[27]See Tables B.3 and B.4 in the Appendix.

2.4.2 Empirical Strategy

We regress firms' leverage ratios on firm characteristics and other controls following the approach of Rajan and Zingales (1995) who have identified four relevant factors for leverage (firm size, firm growth, profitability, tangibility) and that of related empirical studies such as Faulkender and Petersen (2006), Brav (2009), Frank and Goyal (2009), Psillaki and Daskalakis (2009), Degryse, de Goeij, and Kappert (2012), Fan, Titman, and Twite (2012) and Köksal, Orman, and Oduncu (2013). They analyze similar questions and provide valid frameworks to assess capital structure choices.

Subsequently, we test the predictions of the pecking order vs. trade-off theory with a series of fixed effects panel regressions. Because of the data properties presented above, our baseline model specification is as follows.

$$L_{i,t} = \alpha_z + \beta X_{i,t-1} + \gamma Y_{s,t-1} + \rho Z_{k,t-1} + \delta_t + \epsilon_{i,t} \tag{2.1}$$

where indices i, s, k represent firms, industries and countries, respectively, and t stands for time. L is the leverage ratio per firm and period. We use here three measures that accordingly reflect short-term, long-term and total debt over total assets. X is the vector of firm characteristics while Y is the vector of industry-specific factors and Z is the vector of country factors. To reduce problems with endogeneity and to include all factors in the information set, we lag our independent variables by one time period. To account for firm heterogeneity and partial skewness in the data of some factors, we use only ratios or logarithms of our variables. The regression model also includes α_z with $z = \{i, s, k\}$ and δ_t to account for omitted firm-, industry- and country-specific effects and year fixed effects, respectively. As suggested by Petersen (2009), we employ two-dimensional clustering of our robust error term ϵ at firm-level and year-level. The asymptotically normal robust standard errors then account for heteroskedasticity and within-panel serial correlation.

2.5 Results

In this section we discuss the main results and perform a number of robustness checks. We also investigate subsamples and different industry and country characteristics.

2.5.1 Full Sample

In a first step, we assess the validity of our model specification to account for the data properties presented in Section 2.4.1. To do so, we compare the panel model set up in Section 2.4.2 with the three different leverage ratios. Table 2.3 provides the overview for that. In all regressions we include firm and year fixed effects as well as a constant but suppress their coefficients in the tables. In column 1 of Table 2.3 we analyze total leverage ratios, in column 2 we look at long-term leverage ratios and in column 3 we apply short-term leverage ratios as the dependent variable.[28] In separate analyses we employ industry and country fixed effects and find that the results do not change. We also run the regressions with the entire sample and with differences of firm leverage from industry median leverage as dependent variables and find qualitatively same results.[29]

For total leverage ratios we discover positive impacts on leverage from firm size, industry leverage, industry growth and tax shield, while profitability and liquidity have negative impacts. Industry-specific factors and capital flows turn negative for long-term leverage ratios. It seems that the business cycle affects long-term capital structure choice differently. On the other hand, tax shield turns negative for short-term leverage ratios, but we have had no prediction for that relation here since the tax shield is zero for all firms with short-term debt only, and it only applies to firms with long-term debt. The variables firm size, profitability and liquidity provide consistent results across the three different leverage ratios.

[28]In column 2 we only include firms that have long-term debt > 0 and in column 3 we only include firms that have short-term debt > 0.

[29]For brevity, we relegate these regressions to Tables B.5, B.6 and B.7 in the Appendix.

Table 2.3: Baseline Results for Three Leverage Ratios

	(1) **Total Leverage**	(2) **Long-term Leverage**	(3) **Short-term Leverage**
Firm Size	0.005***	0.001***	0.003***
	(0.000)	(0.000)	(0.000)
Firm Growth	0.001***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)
Profitability	-0.159***	-0.062***	-0.128***
	(0.001)	(0.002)	(0.001)
Tangibility	-0.028***	0.103***	-0.103***
	(0.001)	(0.002)	(0.001)
Liquidity	-0.080***	-0.003**	-0.075***
	(0.001)	(0.002)	(0.001)
Nickell	0.000	0.000***	-0.000
	(0.000)	(0.000)	(0.000)
Total Ind. LR	0.144***		
	(0.008)		
Lt Ind. LR		-0.094***	
		(0.013)	
St Ind. LR			0.158***
			(0.007)
Ind. Growth	0.008***	-0.025***	0.031***
	(0.002)	(0.002)	(0.002)
Tax Shield	1.097***	1.504***	-0.421***
	(0.020)	(0.088)	(0.025)
Inflation	0.001***	-0.000	0.002***
	(0.000)	(0.000)	(0.000)
GDP Growth	0.001***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)
Capital Flows	0.226***	-0.209***	0.465***
	(0.033)	(0.044)	(0.039)
Unemployment	-0.002***	0.002***	-0.002***
	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
Constant	Y	Y	Y
Observations	3,265,810	1,794,355	3,263,935
Number of firms	887,514	596,868	887,197
R-squared	0.099	0.136	0.204

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

In contrast to capital structure theories and most empirical studies, we also find a negative impact of tangibility on total and short-term leverage ratios. We would argue that this comes from the composition of our data set, namely the large majority of small firms.[30] The dominance of short-term debt in our data may reflect that especially small firms use only short-term debt instruments and that asset specificity makes it harder for firms to obtain cash against fixed assets. We hence argue that the trade-off between liquidity and fixed assets as well as the fact that cash equivalents cover short-term debt financing more adequately and reliably in the eyes of investors lead to the negative β coefficient for tangibility for total leverage ratios.[31] For long-term leverage ratios, we find the expected positive coefficient. This is obvious as firms holding long-term debt use fixed assets as collateral against their long-term external financing.[32]

Surprisingly, financial stress, individual and country-specific growth potential as well as stock market developments do not play a role in capital structure choice. The coefficients for the Nickell criterion are not significant and the coefficients for firm-level and country-level growth as well as for Standard & Poor's Global Equity Indices are significant but economically not relevant.

In summary, we find that firm size, industry leverage, industry growth and tax shield positively affect leverage ratios, while profitability and liquidity have negative impacts. Our results are quite robust. We compare our regression model to different specifications with an estimator incorporating panel-specific AR(1)-disturbances, the Newey-West heteroskedasticity- and autocorrelation-consistent (HAC) estimator as well as the Driscoll and Kraay (1998) estimator accounting for heteroskedasticity, autocorrelation and spatial

[30] Remember that about 40% of the firms in our sample do not hold any long-term debt and that short-term debt constitutes most of total liabilities held by firms. Firms that hold short-term debt only do not make use of capital markets, but rather employ overdraft and cash facilities for their external financing. Hence, tangibility is negatively correlated with size, growth, profitability, liquidity and positive related to country-level factors in our sample.

[31] As a robustness check, we also run a regression with an interaction term between firm size and tangibility and find the expected positive and significant coeffient. That is, a larger size allows firms to pledge more fixed assets as collateral against debt financing.

[32] Köksal, Orman, and Oduncu (2013) find the same dynamics.

correlation and find similar results in terms of signs of coefficients and significance.[33] Our results also do not change for piecewise exclusion of data from USA, Japan, Norway and Switzerland.[34]

Year-by-year regressions show that the size of coefficients changes, but not the signs or significance, except for industry growth (changing signs) and capital flows for which the sign of the ρ coefficient turns negative in 2007, more so in 2009 and 2010. This reflects the reversal in international capital flows during this period. Tax shield coefficients become larger over time.[35] With our definition of tax shield as a share of total assets, we also capture valuation effects in balance sheets of firms. Overall, the yearly regressions indicate that our model is quite robust over time.

We can compare our results to the capital structure theories and previous empirical studies on that matter. This is depicted in Table 2.4. We find similarities especially with Frank and Goyal (2009), Psillaki and Daskalakis (2009) and Köksal, Orman, and Oduncu (2013). Moreover, our model is an improvement over the Rajan and Zingales (1995) four-factor core model and subsequent specifications from other empirical studies in terms of explaining data variation.[36] We would argue that our findings, which are based on a much larger cross-section and on a much larger scale in terms of firm characteristics, ought to be more representative of the capital structure choices the average firm in a developed country makes.

[33] We also run dynamic panel models and find qualitatively similar results in terms of significance and signs of coefficients although the goodness-of-fit of theses models is worse given that we have stationary data and that we work with a short panel with small T and very large N.

[34] These countries exhibit particular structural differences to the majority of the countries in our sample, i.e. a large group of MNEs in the US, the Japanese loose monetary policy, a large sovereign wealth fund owned by the Kingdom of Norway, or the large Swiss financial industry. Our results are not driven by influences of these particularities.

[35] This growing tax distortion merits future research in our view given the possible implications for macro-prudential policies.

[36] For brevity, we relegate the comparison of the different empirical capital structure models to Table B.8 in the Appendix. We include in Table B.8 only major changes between model specifications.

Table 2.4: Comparison of Theories and Empirical Studies regarding Determinants of Total Leverage Ratios

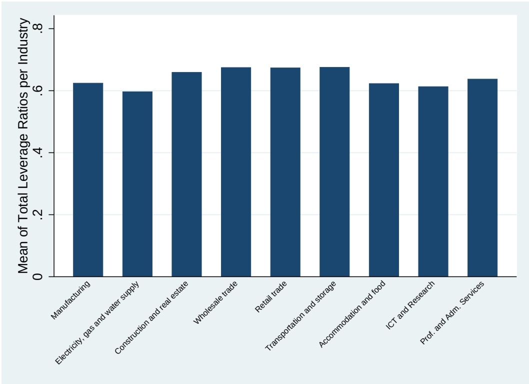
	Pecking Order Theory	**Trade-off Theory**	**Rajan and Zingales (1995)**	**Faulkender and Petersen (2006)**	**Antoniou, Guney and Paudyal (2008)**	**Brav (2009)**	**Frank and Goyal (2009)**	**Psillaki and Daskalakis (2009)**	**Chen and Yu (2011)**	**La Rocca, La Rocca and Cariola (2011)**	**Degryse, de Goeij and Kappert (2012)**	**Fan, Titman and Twite (2012)**	**Köksal, Orman and Oduncu (2013)**	**Our Data**
Firm Size	?	+	+	-	+	+	+	+	-	+	+	+	+	+
Firm Growth	+	-	-	-	-	+	-	?	?	+	+	-	?	+
Profitability	-	?	-	-	-	-	-	-	-	-	-	-	-	-
Tangibility	+	+	+	+	+	+	+	-	+	+	+	+	+	-
Liquidity	?	?	n.a.	-	?	-	-	?	?	-	?	?	-	-
Nickell	n.a.	n.a.	n.a.	n.a.	-	n.a.	-	n.a.	n.a.	n.a.	+	n.a.	n.a.	?
Total Ind. LR	?	+	n.a.	+	n.a.	n.a.	+	n.a.	n.a.	n.a.	+	n.a.	+	+
Ind. Growth	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	+	n.a.	n.a.	n.a.	+
Tax Shield	n.a.	+	n.a.	+	+	n.a.	?	n.a.	n.a.	n.a.	+	+	+	+
Inflation	n.a.	+	n.a.	n.a.	n.a.	n.a.	+	n.a.	n.a.	n.a.	n.a.	-	+	+
GDP Growth	+	n.a.	n.a.	n.a.	n.a.	n.a.	+	n.a.	n.a.	n.a.	n.a.	+	-	+
Capital Flows	n.a.	n.a.	n.a.	n.a.	+	n.a.	n.a.	n.a.	+	n.a.	n.a.	+	+	+
Unemployment	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-
Stock Prices	-	n.a.	n.a.	-	-	n.a.	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	?

Notes: +/- = sign of significant coefficients in respective regressions where total leverage ratio is the dependent variable, ? = theories are ambivalent or results are inconclusive (either coefficient is not significant or switching signs), n.a. = factor was not included in study

2.5.2 Industry Analysis

Furthermore, we check the robustness of our results for industry dynamics by analyzing industry sectors separately. In accordance with the European Central Bank (2013), we cluster the two-digit industry codes of the European NACE Rev. 2 classification by their respective economic activity to nine different groups.[37] We then want to disentangle different industry dynamics by analyzing capital structure choice according to economic activity. Figures 2.3 and 2.4 show cross-sectional and time-series behavior of capital structures across industry clusters.

Figure 2.3: Leverage Ratios across Industries



We find trade and transportation sectors with the highest leverage ratios on average, while electricity, gas and water supply use the least amount of debt. Over time, there is strong persistence in the capital structure choice within an industry, except for firms active in electricity, gas and water supply for which average total leverage ratios sharply increase over our sample period.

[37] "Manufacturing" encompasses all firms from NACE Rev. 2 classification section C, "Electricity, gas and water supply" includes all firms from NACE Rev. 2 classification sections D and E, "Construction and real estate" groups all firms from NACE Rev. 2 classification sections F and L, "Wholesale trade" encompasses those firms from NACE Rev. 2 classification section G with two-digit industry codes 45 and 46, "Retail trade" includes those firms from NACE Rev. 2 classification section G with two-digit industry code 47, "Transportation and storage" groups all firms from NACE Rev. 2 classification section H, "Accommodation and food" encompasses all firms from NACE Rev. 2 classification section I, "ICT and research" includes all firms from NACE Rev. 2 classification section J and those from section M with two-digit industry code 72, and finally, "Professional and administrative services" groups all firms from NACE Rev. 2 classification sections M and N except those with two-digit industry code 72.

Figure 2.4: Leverage Ratios across Industries and Time

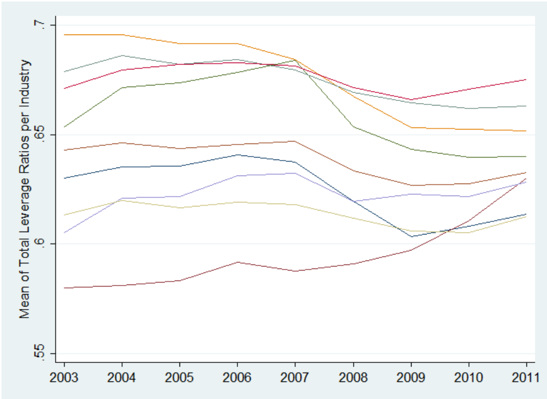


Table 2.5 provides the results of our model specification presented in Section 2.4.2 with the sample decomposed into the nine different industry segments. Here, we leave out industry median leverage in the regressions because this is just a level effect in an inter-industry analysis. We also run regressions with differences of firm leverage from industry median leverage as dependent variables and find qualitatively same results.[38] The variables firm size, firm growth, profitability, liquidity, tax shield, inflation and unemployment provide consistent results across the nine different industry groups. While firm size, firm-level growth, tax shield and inflation have positive impacts on leverage ratios, profitability, liquidity and unemployment have negative impacts. Coefficients for capital flows are positive except for retail trade. Tangibility decreases leverage except for the two sectors retail trade and transportation. Considerable differences in capital structure choice across industries then arise from varying demand in markets and from different levels in the relevant explanatory variables.

[38]For brevity, we relegate these regressions to Table B.9 in the Appendix.

Table 2.5: Results for Total Leverage Ratio across Industries

	Manufacturing Total Leverage	**Electricity Total Leverage**	**Construction Total Leverage**	**Wholes. trade Total Leverage**	**Retail trade Total Leverage**	**Transportation Total Leverage**	**Accom. & food Total Leverage**	**ICT & res. Total Leverage**	**PAS Total Leverage**
Firm Size	0.004***	0.011***	0.003***	0.008***	0.004***	0.010***	0.003	0.004***	0.006***
	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Firm Growth	0.001***	0.001**	0.000***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.187***	-0.174***	-0.136***	-0.165***	-0.177***	-0.166***	-0.169***	-0.128***	-0.130***
	(0.003)	(0.010)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.005)	(0.003)
Tangibility	-0.038***	0.002	-0.054***	-0.025***	0.011***	0.012**	-0.004	-0.028***	-0.017***
	(0.002)	(0.009)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)	(0.004)
Liquidity	-0.101***	-0.063***	-0.085***	-0.073***	-0.079***	-0.080***	-0.060***	-0.064***	-0.065***
	(0.002)	(0.010)	(0.002)	(0.002)	(0.004)	(0.005)	(0.006)	(0.005)	(0.003)
Nickell	0.000***	0.000***	-0.000	0.000***	0.000***	0.000	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ind. Growth	0.030***	-0.022**	-0.034***	-0.040***		-0.174***	-0.075*	-0.084***	0.052***
	(0.003)	(0.010)	(0.007)	(0.009)		(0.029)	(0.043)	(0.024)	(0.008)
Tax Shield	1.140***	1.198***	1.248***	0.910***	0.890***	0.999***	1.364***	1.175***	1.166***
	(0.039)	(0.162)	(0.047)	(0.039)	(0.063)	(0.095)	(0.134)	(0.127)	(0.071)
Inflation	0.002***	0.001***	0.002***	0.000***	0.000**	0.002***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP Growth	0.001***	-0.002***	0.001***	0.001***	0.001***	0.001***	-0.000	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Flows	0.304***	1.110***	0.149*	0.029	-0.055	0.422***	0.200	0.436**	0.421***
	(0.062)	(0.240)	(0.084)	(0.063)	(0.107)	(0.145)	(0.191)	(0.201)	(0.136)
Unemployment	-0.001***	-0.005***	-0.002***	-0.002***	-0.001***	-0.002***	0.000	-0.001***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	0.000***	0.000***	0.000***	-0.000	0.000	0.000	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	778,647	58,756	709,282	719,252	295,702	161,189	115,135	111,451	316,396
Number of firms	199,457	16,231	204,332	187,186	79,622	45,485	32,492	31,499	91,210
R-squared	0.094	0.051	0.125	0.110	0.090	0.062	0.051	0.059	0.081

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. The nine industry clusters in the columns are 'Manufacturing', 'Electricity, gas and water supply', 'Construction and real estate', 'Wholesale trade', 'Retail trade', 'Transportation and storage', 'Accommodation and food', 'ICT and research' and 'Professional and administrative services'. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

2.5.3 Geographic Analysis

We also analyze whether location is an important parameter that affects the way our explanatory variables impact capital structure choice and that accounts for any unobserved effects given geographic characteristics.

2.5.3.1 Regions

First, we investigate broad geo-political aspects. To do so, we compare firms located in the European Union[39] and within the Euro Area[40] to a control group. We define this control group as all EFTA states and the two non-European countries in our sample. Thus, this group includes Iceland, Liechtenstein, Norway, Switzerland, Japan and the USA.

Initially, we find that mean and variance of leverage ratios when clustered into the aforementioned three groups are significantly different. Firms in the Euro Area have on average higher leverage ratios than firms located in the European Union and more so, than firms in the control group. Table 2.6 depicts the regression results for the three groups. Higher leverage ratios in the European Union and Euro Area are driven by taxation effects and capital flows. Tangibility and unemployment positively affect debt financing of firms in our control group, while the coefficients remain negative for the other two groups. All other factors have similar effects on capital structure choice of firms. Differences between firms located in the European Union and those in the Euro Area are predominately driven by effects from the internal capital market. Firms outside the Euro Area experience exchange rate risks and face tougher lending and reserve requirements, while the common supranational monetary policy within the Euro Area insures firms against illiquidity and country-specific risks.

[39] We only have 27 countries for the European Union instead of 28 because Croatia acquired membership on July 1, 2013, but our data set ends in 2012.

[40] We exclude Latvia from the Euro Area because it adopted the currency on January 1, 2014 but our data set ends in 2012. However, we include Monaco and Montenegro because the former shares a monetary union with France and the latter is an unilateral adopter of the Euro.

Table 2.6: Results for Total Leverage Ratio across Regions

	Control Group[§] **Total Leverage**	**EU27**[†] **Total Leverage**	**Euro Area**[‡] **Total Leverage**
Firm Size	0.005***	0.006***	0.006***
	(0.001)	(0.000)	(0.000)
Firm Growth	0.000**	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Profitability	-0.096***	-0.173***	-0.179***
	(0.004)	(0.001)	(0.001)
Tangiblity	0.026***	-0.026***	-0.032***
	(0.005)	(0.001)	(0.001)
Liquidity	-0.059***	-0.081***	-0.083***
	(0.004)	(0.001)	(0.001)
Nickell	0.000	0.000	0.000***
	(0.000)	(0.000)	(0.000)
Total Ind. LR	0.159***	0.091***	0.066***
	(0.021)	(0.008)	(0.009)
Ind. Growth	0.067***	0.009***	0.008***
	(0.007)	(0.002)	(0.002)
Tax Shield	0.693***	1.098***	1.066***
	(0.065)	(0.021)	(0.022)
Inflation	0.001	0.001***	-0.000
	(0.001)	(0.000)	(0.000)
GDP Growth	-0.001**	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Capital Flows	-9.900***	0.126***	1.151***
	(1.117)	(0.034)	(0.050)
Unemployment	0.012***	-0.002***	-0.002***
	(0.001)	(0.000)	(0.000)
Stock Prices	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
Constant	Y	Y	Y
Observations	197,398	2,959,093	2,547,956
Number of firms	46,064	809,574	674,827
R-squared	0.079	0.108	0.113

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. § includes EFTA states (Iceland, Liechtenstein, Norway, Switzerland), USA and Japan. † excludes Croatia. ‡ includes Monaco and Montenegro, excludes Latvia. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

2.5.3.2 Countries

Second, we disclose the importance of macroeconomic conditions by analyzing cross-country differences in leverage ratios. This heterogeneity is more profound than among industries. Figures 2.5 and 2.6 show cross-sectional and time-series behavior of capital structures across countries.[41]

Figure 2.5: Leverage Ratios across Countries

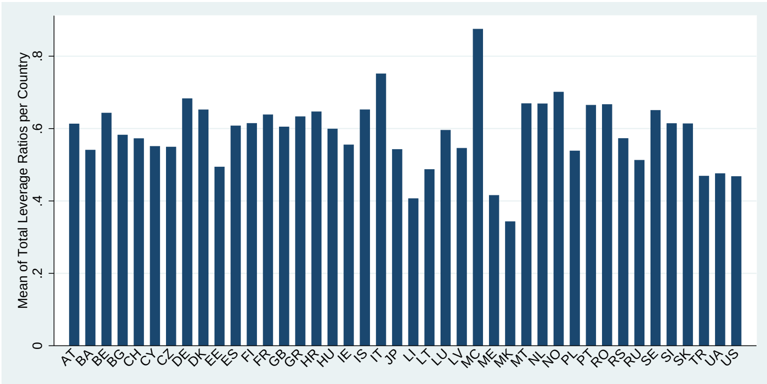
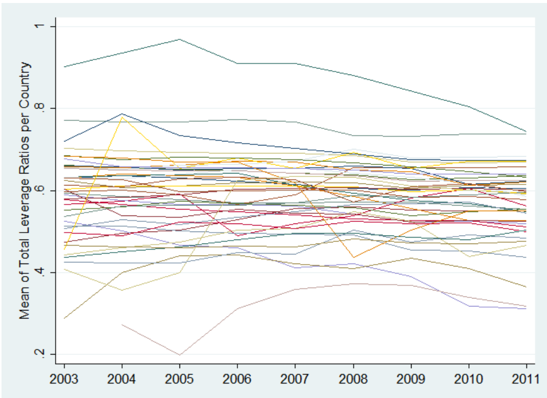


Figure 2.6: Leverage Ratios across Countries and Time



Among the countries with the highest average leverage ratios, we find Germany, Italy, Monaco and Norway, while firms with the least amounts of debt per firm are located

[41] We have firm-level data from 42 different countries. Tables and Figures make use of the ISO 3166-1 two-digit country codes. These are: AT = Austria, BA = Bosnia and Herzegovina, BE = Belgium, BG = Bulgaria, CH = Switzerland, CY = Cyprus, CZ = Czech Republic, DE = Germany, DK = Denmark, EE = Estonia, ES = Spain, FI = Finland, FR = France, GB = United Kingdom, GR = Greece, HR = Croatia, HU = Hungary, IE = Ireland, IS = Iceland, IT = Italy, JP = Japan, LI = Liechtenstein, LT = Lithuania, LU = Luxembourg, LV = Latvia, MC = Monaco, ME = Montenegro, MK = Macedonia, MT = Malta, NL = Netherlands, NO = Norway, PL = Poland, PT = Portugal, RO = Romania, RS = Serbia, RU = Russia, SE = Sweden, SI = Slovenia, SK = Slovakia, TR = Turkey, UA = Ukraine, US = USA.

in Liechtenstein, Macedonia, Montenegro, Turkey, Ukraine and the USA. Over time, cross-country differences also vary considerably. While most average leverage ratios per countries run in a band between 40 to 80%, yearly differences are significant which do not suggest a strong path dependence.

Table 2.7 then provides an overview of the results from our country-by-country regressions.[42] We include the three countries with the highest average leverage ratios, namely, Germany, Italy and Norway, as well as the three countries with the lowest average leverage ratios, being Turkey, Ukraine and the USA. In particular, the results suggest that cross-country differences are mainly driven by differences in industry structure and composition within a country.

Firm size has a significant positive impact on leverage ratios for high-leverage countries while it has no effect in low-leverage countries. Profitability and liquidity are consistently negatively related to leverage ratios, while tangibility decreases leverage ratios except in Germany and Norway. The degree of tangibility affects country-specific capital structures through the sectoral distribution of economic activity which precisely has such a large degree. Coefficients for industry median leverage are positive except for firms in Italy whereas tax shields consistently drive debt financing in all countries. Results for firm-level and industry growth, GDP growth, the Nickell criterion, unemployment and stock prices are inconclusive.

We also run regressions for the eight major countries that we previously investigated in Table 2.2. Profitability and liquidity consistently negatively affect capital structures, while tax shields regularly drive leverage ratios positively. Coefficients for tangibility are positive except for Italy, Japan and the USA. Results are inconclusive for firm size and firm-level growth, the Nickell criterion, industry-specific factors, and business cycle indicators.

[42] We exclude Liechtenstein, Macedonia, Monaco and Montenegro from the cross-country study due to lack of observations.

Table 2.7: Results for Total Leverage Ratio across Countries

	high-leverage Countries			**low-leverage Countries**		
	Germany	**Italy**	**Norway**	**Turkey**	**Ukraine**	**USA**
	Total Leverage	**Total Leverage**	**Total Leverage**	**Total Leverage**	**Total Leverage**	**Total Leverage**
Firm Size	0.006***	0.005***	0.008***	-0.017	-0.002	-0.004
	(0.002)	(0.000)	(0.001)	(0.015)	(0.001)	(0.003)
Firm Growth	0.000*	0.000***	0.000***	-0.005	0.001***	-0.001*
	(0.000)	(0.000)	(0.000)	(0.012)	(0.000)	(0.001)
Profitability	-0.116***	-0.199***	-0.090***	-0.128	-0.112***	-0.135***
	(0.007)	(0.003)	(0.004)	(0.116)	(0.005)	(0.012)
Tangibility	0.017**	-0.101***	0.028***	-0.155	-0.095***	-0.044**
	(0.008)	(0.002)	(0.005)	(0.113)	(0.007)	(0.022)
Liquidity	-0.056***	-0.087***	-0.051***	-0.311***	-0.072***	-0.193***
	(0.006)	(0.002)	(0.004)	(0.086)	(0.008)	(0.021)
Nickell	0.000	0.000***	0.000	-0.001*	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Total Ind. LR	0.256***	-0.057***	0.185***	1.510***	0.597***	0.047
	(0.026)	(0.013)	(0.023)	(0.551)	(0.050)	(0.076)
Ind. Growth	-0.000	-0.022***	0.094***	0.012	-0.010	0.015
	(0.007)	(0.003)	(0.008)	(0.092)	(0.014)	(0.019)
Tax Shield	0.730***	0.997***	0.740***	1.374	2.504***	3.721***
	(0.111)	(0.033)	(0.068)	(5.925)	(0.225)	(0.943)
Inflation	0.003***	0.015***	0.000		0.000**	0.008
	(0.001)	(0.000)	(0.001)		(0.000)	(0.006)
GDP Growth	-0.000***	0.002***	0.002	0.001	0.000***	-0.002
	(0.000)	(0.000)	(0.003)	(0.001)	(0.000)	(0.002)
Unemployment		0.016***	0.012***			-0.009***
		(0.000)	(0.003)			(0.001)
Stock Prices	0.000***	0.001***	0.000***	0.000	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y
Observations	97,139	840,289	164,352	401	108,735	16,759
Number of firms	33,904	207,442	38,335	193	31,606	3,933
R-squared	0.065	0.168	0.087	0.208	0.176	0.111

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. Capital flows are excluded for collinearity reasons as are inflation and unemployment for some countries. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

2.5.4 Firm Characteristics

Finally, we explore in more detail how different firm characteristics impact the effects of our explanatory variables on capital structure choice. That is, we make refinements to our subsampling in order to capture (i) the impact of information asymmetries between investors and firms through dissecting firms according to their legal status and (ii) how well our model explains the respective capital structure choices of firms of different size. This may indicate whether a firm's position in the life cycle or industry benchmarks have an effect on capital structure choice because large firms tend to be well-established industry leaders.

2.5.4.1 Public vs. Private Firms

We investigate information asymmetries by subsampling our data set into two groups, publicly traded companies and private firms, respectively.[43] Private firms should encounter greater difficulties in acquiring external financing and in particular, debt, as potential investors incur higher agency costs and the problem of adverse selection is bigger. Not surprisingly, mean and variance of leverage ratios between both groups are significantly different. We find that private firms have higher leverage ratios on average than public firms. This may stem from the fact that private firms do not have access to many equity or equity-like financial instruments that publicly traded companies may make use of.

The majority of public firms in our sample is located in France, Greece, Italy and Spain, while Finland, Iceland, Ireland and Spain have the highest share of public companies to total amount of firms in the sample. Most countries have a large share of private firms.

Table 2.8 provides the overview of our model for the subsamples into public and private firms. Results for both groups are the same as in the baseline model in Table 2.3 for firm-level and macroeconomic factors, except for capital flows which are positively related

[43] For 162,250 firms with 864,026 firm-year observations, the legal status could not be accurately identified so they are not included in either group.

to debt financing for public firms only. Also, public firms experience larger effects from industry-specific factors on their leverage ratios. This indicates that public firms adhere more to market pressures in setting leverage targets due to increased transparency and visibility of their business operations. On the other hand, private firms have financing models that are less affected in their capital structure choice by changes in international capital flows. This may arise from the fact that foreign ownership disproportionally increases in publicly traded companies due to better capital market liquidity.

2.5.4.2 Small vs. Large Firms

Another inquiry with respect to information asymmetries, transactions costs and the range of available funding instruments analyzes the effect of firm size on capital structure choice. To do so, we divide our sample in deciles and investigate the lowest and highest groups, namely, the 10% firms in our data set with the smallest firm size and the 10% with the largest firm size. Mean and variance of leverage ratios for small firms are significantly lower than otherwise. On the other hand, average leverage for large firms is close to that of the overall sample. The smallest firms in our data set are located in Italy, Spain and the Ukraine, while the largest firms are located in France, Germany and the United Kingdom.

Table 2.9 provides the results for both deciles. For most of the explanatory variables, the effects on capital structure choice are the same in both deciles and as in Table 2.3. Firm size obviously affects only large firms. Industry-specific factors drive down debt financing only for small firms, while it is positively related for large companies. Macroeconomic factors affect large firms to a lesser degree. Overall, it seems that large firms are bound by higher market pressure in concentrated segments within their respective economic activity and benefit overly from industry trends and demand. On the other hand, small firms are more affected by changes in foreign ownership of domestic assets than large firms.

Table 2.8: Results for Total Leverage Ratio due to Firms' Legal Status

	public firms **Total Leverage**	**private firms** **Total Leverage**
Firm Size	0.009***	0.004***
	(0.001)	(0.000)
Firm Growth	0.000***	0.001***
	(0.000)	(0.000)
Profitability	-0.183***	-0.155***
	(0.004)	(0.001)
Tangibility	-0.045***	-0.025***
	(0.003)	(0.001)
Liquidity	-0.095***	-0.075***
	(0.003)	(0.001)
Nickell	0.000**	0.000**
	(0.000)	(0.000)
Total Ind. LR	0.230***	0.064***
	(0.018)	(0.009)
Ind. Growth	0.011***	0.003
	(0.004)	(0.002)
Tax Shield	1.771***	1.009***
	(0.057)	(0.024)
Inflation	0.002***	0.001***
	(0.000)	(0.000)
GDP Growth	0.001***	0.001***
	(0.000)	(0.000)
Capital Flows	0.929***	-0.033
	(0.062)	(0.042)
Unemployment	-0.002***	-0.002***
	(0.000)	(0.000)
Stock Prices	0.000***	0.000***
	(0.000)	(0.000)
Year FE	Y	Y
Firm FE	Y	Y
Constant	Y	Y
Observations	533,609	2,280,129
Number of firms	135,724	634,245
R-squared	0.166	0.115

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Results for Total Leverage Ratio according to Firm Size

	small firms **Total Leverage**	**large firms** **Total Leverage**
Firm Size	-0.001	0.007***
	(0.001)	(0.001)
Firm Growth	0.000**	0.001***
	(0.000)	(0.000)
Profitability	-0.085***	-0.180***
	(0.006)	(0.004)
Tangibility	-0.066***	-0.013***
	(0.005)	(0.004)
Liquidity	-0.069***	-0.067***
	(0.007)	(0.004)
Nickell	0.000*	0.000
	(0.000)	(0.000)
Total Ind. LR	-0.051*	0.277***
	(0.029)	(0.019)
Ind. Growth	-0.067***	-0.004
	(0.012)	(0.004)
Tax Shield	1.821***	1.020***
	(0.141)	(0.061)
Inflation	0.004***	0.001***
	(0.000)	(0.000)
GDP Growth	0.001***	0.000
	(0.000)	(0.000)
Capital Flows	2.192***	0.505***
	(0.208)	(0.111)
Unemployment	0.001***	-0.001***
	(0.000)	(0.000)
Stock Prices	0.000***	0.000***
	(0.000)	(0.000)
Year FE	Y	Y
Firm FE	Y	Y
Constant	Y	Y
Observations	230,489	358,206
Number of firms	109,319	103,892
R-squared	0.035	0.108

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

2.6 Conclusion

Capital structure choice is a highly relevant topic for a firm's prosperity and to deduce the right economic and competition policies, especially given the economic development and turmoil over the last decade. Both theoretical and empirical literature has dealt with a number of mechanisms and factors that firms consider and encounter in their financing decisions. In this chapter, we follow similar empirical research in conducting a series of panel analyses to determine the most important factors that drive leverage ratios. We append previous work in drawing on a variety of different parameters and indices on firm-, industry- and country-level to explain a greater portion of variation in the data.

We base our analysis on a large cross-sectional data set to mitigate problems of selection and survival biases. Then, we expand empirical frameworks by Frank and Goyal (2009), Fan, Titman, and Twite (2012), Köksal, Orman, and Oduncu (2013) and the European Central Bank (2013) to quantitatively assess capital structure choices over the past decade with an emphasis on Europe. We show that firm size, industry leverage, industry growth and tax shield positively affect leverage ratios, while profitability and liquidity have negative impacts. Furthermore, tangibility has a positive impact on leverage for those firms that use long-term debt financing. For small firms that mostly make use of short-term debt only, we find a negative relationship due to the trade-off between tangibility and liquidity to serve debt obligations to investors. In addition, we find a strong impact of international capital allocation due to the size of coefficients for our capital flows variable. The results are robust against different panel estimators, decompositions and in yearly cross sections.

Our study makes a deliberate choice in favor of a highly representative sample with a very large cross-section while a majority of empirical studies has previously used much smaller samples of larger (listed) firms. Hence, an important contribution of our work is to provide a check to what extent previous results may have suffered from a small sample bias, or rather from a selection bias that ignored financial constraints of the vast majority of NFCs. Indeed, we find that previous studies neglected the different capital structure choice of small firms, cross-country differences as well as the effects of the business cycle and the size of national capital markets on leverage. This explains differences in empirical results. Second, our study provides strong indications that corporate taxation needs to be part of macro-prudential policy frameworks in view of the important effects of national tax codes on leverage ratios. Furthermore, our very representative estimates can be seen as an input for future research on the quantification of international intra-group capital mobility and tax-base shifting.

Chapter 3

Auditing Quality in Regulatory Regimes

3.1 Introduction

As is well known, the market for audit services is dominated by four large oligopolistic firms.[1] A stylized fact that motivates this chapter is that especially large industrial companies rely on these four auditors and rarely change their mandates with them. The four oligopolistic audit firms argue that only they are capable of auditing large companies. Additionally, the financial crisis has shown that a positive auditing result does not provide clear signaling of financial robustness because financially distressed companies received positive statements far too often.[2] It has hence been argued that insufficiently low average audit quality exists in the market. However, robust audit is key to investor confidence as one crucial part in the investors' decision-making process. This is why the European Commission (EC) has proposed regulatory interventions to introduce more competition, and to improve the transparency in the market and the reliability of the signaling of audit results' quality to potential investors of companies.

[1]Since 2002, the wave of subsequent mergers among firms providing auditing services has left four large, dominant firms in the market: Deloitte Touche Tohmatsu, Ernst & Young, KPMG, Pricewaterhouse-Coopers. The additional small- and medium-sized audit firms can be regarded as the competitive fringe.

[2]Examples include Enron and most recently, Lehman Brothers and AIG.

After the EC introduced the *Statutory Audit Directive* in 2006[3], the recent financial crisis has shown immediate need to improve the regulatory framework for audits. Thus, a *Green Paper on Audit Policy* was produced in 2010 and discussed with major stakeholders.[4] Subsequently, in November 2011 EC proposals were drafted for an amended directive and new regulation on mandatory rotation, mandatory tendering, separation of non-audit services, European supervision, competitive aspects[5] and proportionality.[6] With these actions, the EC aims at creating a *Single Market for Statutory Audits* by introducing a mobility measure (*European Passport*) to foster cross-border competition among auditors, a quality measure (voluntary quality certification) to improve the average quality of the service provided in the market and thirdly, a standard measure (*International Standards of Auditing*) to harmonize accounting frameworks and to increase transparency over the differences in service quality[7]. The EC argues that its proposals are beneficial for a variety of reasons. These include the enhanced independence of audit firms, better quality of audits, improved stability and confidence in the financial market as well as increased confidence in the robustness of financial statements. This may lead to lower cost of capital for audited companies and to better access to financing opportunities for firms (European Commission (2011a)).

However, two caveats arise from the EC's approach to create a *Single Market for Statutory Audits*: Firstly, the proposed formal standardization may impose a market entry barrier, whereas weaker standards or non-mandatory certification may be ineffective. Indeed, economic theory suggests that both certification and standards actually increase barriers to market entry. However, the EC proposals are intended to allow small audit firms to compete with the four large oligopolistic audit firms which arguably is not possible now. Hence, while in particular small auditors are in favor of regulatory interventions by national authorities or the EC, the *Big Four* have continuously opposed any

[3]See European Commission (2006).
[4]See European Commission (2010).
[5]The focus of this chapter is solely on this point although the other also deserve attention in economic analyses. This would be beyond the scope of this work.
[6]See European Commission (2011b,c).
[7]That is, the distribution of quality levels provided by the agents within the market.

additional regulation.[8] Secondly, it is unclear how effective formal regulation is - whether on national or EU level - to improve competition and market conduct against persistent informal standards applied by e.g. banks in their lending practices.[9]

In this chapter, we evaluate the impact of regulatory intervention on the quality of auditing services. Do the EC proposals improve the reliability of the signaling of the audit reports' quality? We also investigate the effects of costly signaling. The difference between certification and standardization lies with who initiates the verification of quality. If the demand-side does, the less informed party (regulator, buyer) standardizes quality of the auditing service provided in the market. If the supply-side does, the more informed party (auditor) may signal their quality to the market by certification. Is it then more profitable for the regulator to certify the auditor or to standardize? More importantly, who should initiate verification of quality from a welfare perspective? Based on a theoretical model of an auditor-firm-regulator-relationship we can show that voluntary quality certification leads to a separating equilibrium where only high-quality auditors certify. This is optimal for social welfare whenever verification costs are large. On the other hand, standardization of audit services is optimal if the costs for verifying quality are sufficiently low.

The chapter is structured as follows. First, we discuss previous literature in the area. In section 3.3 we explain the intuition of the proposed EC regulatory changes. In section 3.4 we set up a model to present the differences between standardization and certification and the respective outcomes from playing a signaling game. Section 3.5 includes the welfare analysis. Section 3.6 summarizes the results which are checked for their robustness in section 3.7. Section 3.8 concludes the chapter.

[8]See e.g. the public statements and reactions to the proposed EC regulation in the media (Frankfurter Allgemeine Zeitung (2011)).

[9]Compare DeAngelo (1981), European Commission (2011a). Evidence from studies suggests that companies intending to go public switch their auditor to one of the *Big Four*. Dye (1993) finds that banks require companies which ask for debt instruments for their corporate financing to first acquire an audit on their financial statements from one of the *Big Four* before submitting an application for e.g. a loan. Subsequently, these discriminatory clauses have been called "Big4-laws".

3.2 Literature Review

In order to explore the impact of the EC proposals on audit quality through certification and standardization, this chapter builds on two strands of research.

First, Accounting and Law & Economics literature focuses on pricing and concentration as well as the incentivization of auditors to provide sufficient quality by legal regimes. One group of papers focuses on audit quality differences. This starts by DeAngelo (1981) providing the definition of audit quality as the joint probability that an auditor uncovers financial distress if the firm is indeed financially unhealthy. Empirical work by Deis and Giroux (1992) finds a number of factors explaining audit quality differences: Audit quality decreases as auditor tenure increases, and is also negatively related to size and financial health of a firm. However, audit quality increases with the number of firms whose mandates one auditor has. Finally, there exists a strong relationship between effort and audit quality.

Dye (1993) and Schwartz (2007) also utilize DeAngelo's definition and examine the effect of auditor's liability on the audit quality provided in various legal regimes. Palmrose (1986), Magee and Tseng (1990), Kanodia and Mukherji (1994), and Lawrence, Minutti-Meza, and Zhang (2011) find a significant correlation between auditor size and her fees where the *Big Four* set distinct higher prices for their services than the competitive fringe. Moreover, they find that predatory pricing by auditors is persistent even when all bargaining power lies with the buyer. However, the independence of the auditor in evaluating the financial situation of a firm might be compromised by less rigid standards. Ecchia and Lambertini (1997) examine the impact of minimum quality standards in a vertically differentiated duopoly and find that the standard impairs the stability of price collusion. Ye and Simunic (2013) analyze the preferences for auditing standards if they are vague or tough. They find that both firm and auditor prefer strict standards, but if the toughness of standards is set at a non-optimal level, both prefer vaguer standards.

Second, Industrial Organization literature looks at the respective strategic interactions between auditor and investor, auditor and third-party regulator as well as auditor and audited firm game-theoretically. In this research, the impacts of costly certification and asymmetric information about the true quality of the audit service provided are addressed. A rich literature on asymmetric information and in particular, signaling, exists.[10] Chaney, Jeter, and Shaw (2003) and Zhang (2007) analyze the effect of aggressive competition on the provision of auditing services and the impact of the public's expectations on audit quality. They find that regulators should ensure the independence of auditors by decreasing the likelihood of cheating by auditors, either through increased scrutiny or increased fines upon discovery. Causholli, Knechel, Lin, and Sappington (2013) argue that an incumbent auditor has an informational advantage and thus, may provide under-auditing and gather substantial rent from its clients. The information asymmetry makes it also difficult for auditors with superior quality to acquire the auditing mandate.

This chapter introduces certification and standardization of audit quality in a signaling setup. Work by Fasten and Hofmann (2010) focuses on the asymmetries of information disclosure when certification is demanded by both seller and buyer. Stahl and Strausz (2011) examine costly certification via inspection and signaling games but allow both buyer and seller to determine whether they want to verify the quality of the service provided. Since a company or investor as potential buyers of the audit service know less about the true audit quality provided by the auditor with the mandate, they impose too much regulation on auditors if they are anxious or too little restrictions if they are lenient in an inspection game (Stahl and Strausz (2011)).

We build on the framework by Stahl and Strausz (2011) but deviate in that we only allow the seller to decide over certification and otherwise impose a harmonization of the quality of the service provided by standardization. A signaling of the quality of the audit service provided by the auditor through seller-induced certification can successfully dissect the market into different quality segments allowing for a more efficient allocation of audit mandates according to the buyers' willingness to pay, the respective need for a certain quality level and the ability of a respective auditor to provided such demanded

[10] See Akerlof (1970), Spence (1973, 1974), Wilson (1977) and Tirole (1988).

quality. Standardization may allow low-quality audit firms to catch up and thus, allow the EC to raise the average audit quality provided in the market. Is it not clear however, whether the results for different forms of certification shown in earlier research also hold in comparison to the EC proposed standardization. This is the aspect this work tackles.

3.3 Single Market for Statutory Audits

Among the proposed regulatory changes issued by the European Commission at the end of 2011, it suggests the creation of a *Single Market for statutory* (i.e. required by law) *audits* by introducing competitive measures to the audit profession. It goes on to state that it wants to "allow audit firms to provide services across the EU and to require all statutory auditors and audit firms to comply with international auditing standards when carrying out statutory audits"[11].

Previous legislation on this issue is predominantly based on the *Statutory Audit Directive*[12] introduced in 2006 (European Commission (2011a)). Since then, the Commission has recognized the need for improved public intervention to tackle the weaknesses of the audit market for competitors and consumers alike. Therefore, it initiated research on audit firms prior to implementing any new legislative procedure.[13] Based on these insights, the Commission drafted a green paper[14] regarding its audit policy and subsequently, proposed a new EC regulation[15] and the amendment of the *Statutory Audit Directive*[16] to appropriately account for concerns raised by audit firms, investors and further stakeholders as well as for its own goals in the public interest.[17]

[11]See European Commission (2011a) and the respective proposals European Commission (2011b) and European Commission (2011c).

[12]See European Commission (2006).

[13]Two main studies have to be noted here: Oxera Consulting (2007) and ESCP Europe (2011).

[14]See European Commission (2010).

[15]EC proposal for a *Regulation to increase the quality of audits of financial statements of public-interest entities*, COM(2011) 779.

[16]EC proposal for a *Directive to enhance the single market for statuory audits*, COM (2011) 778.

[17]The EC has recognized that it needs more detailed rules for large listed companies of public interest and hence, drafted a separate proposal for regulation. Thus, the amendment of the Statutory Audit Directive (COM (2011) 778) shall coexist with new regulation (COM (2011) 779) targeting large listed entities (European Commission (2011b)).

Table 3.1 provides a summary of the framework proposed by the EC.[18] In this chapter, we focus on the fifth point under Actions which stresses the importance of competition. This is about creating a *Single Market for Statutory Audits* in the EU by means of a *European Passport*, quality certification, prohibition of discriminatory clauses and introducing *International Standards on Auditing*.

Table 3.1: Framework of EC Audit Policy

Objectives	• improve credibility and reliability of financial statements • facilitate cross-border competition among auditors • take into account capabilities of small audit firms • improve supervision • secure sufficient auditor independence and competition
Actions	• mandatory rotation of audit firms • mandatory tendering • separation of non-audit services • European supervision of auditors • creation of a Single Market for statutory audits • proportionality regarding small audit firms

3.3.1 Policy Action 1 - European Passport

First, a possibility to foster effective competition for auditing mandates is the harmonization of rules and the creation of a single European market for auditing services through introducing a *European Passport* (European Commission (2010)). Hence, the EC proposed such a passport for audit firms. This would lead to mutual recognition of statutory auditors approved in one EU member state to facilitate cross-border mobility of auditors which would particularly benefit small audit firms (European Commission (2011a)). In detail, the EC suggests a change from single-state approval and an aptitude test under the old *Statutory Audit Directive* to a single European market for auditing services by harmonization and introduction of this passport for auditors. Hence, a European-wide registration with common professional qualification requirements would be created which fosters harmonization on ownership and independence rules (European Commis-

[18]For a summary, see European Commission (2011a). The proposals include the six different elements and their respective specifications at length (European Commission (2011b,c)).

sion (2010)). The proposal for the amended directive allows auditors approved in one EU member state to also provide statutory audits in another member state. No multiple approval process would be necessary anymore.[19]

The EC argues that administrative costs for authorities and auditors would decrease, but basic requirements on organization and sufficient resources for performing quality audits would persist (European Commission (2011a,c)). Because many barriers to cross-border competition among auditors exist, the EC proposal encourages more competition for auditing mandates and potentially lowers costs in compliance to rules regulating the provision of auditing services (European Commission (2010)). Especially small audit firms would benefit from the reduction of entry barriers to the market and from cross-border opportunities to compete (European Commission (2011a)).

The EC proposal to introduce a *European Passport* can thus be seen as unconditionally beneficial to improve competition in the market for auditing services. Hence, we do not include this aspect in the model presented in Section 3.4.

3.3.2 Policy Action 2 - Quality Certification

Second, the Commission wants to foster the selection of auditors by firms based primarily on audit quality. Since audit quality depends on independence, professional scepticism and technical competence, the EC proposes European-wide voluntary quality certification of audit firms. This certificate would recognize their ability to perform high quality audits of companies and would work against the argument of the four oligopolistic audit firms that only they have the capabilities to provide high quality in their auditing services.[20] Certificates would be issued by the European Securities and Markets Authority (ESMA)[21]. Stakeholders, auditors and companies would then benefit from improved audit quality and restored credibility of financial information (European Commission

[19]Similar to the *one-stop-shop principle* applied by the Commission in its merger control under Article 21 of the EC Regulation 139/2004.

[20]The problem here lies with the fact that in practice, one encounters only positive or rarely failed audit reports. Thus, there is no quality differentiation with respect to the outcome of such audit report.

[21]The ESMA was established in 2009 by EC Regulation COM(2009) 503.

(2011a,c)).

The EC argues that direct costs would affect both auditors and public authorities in obtaining and administrating the certification. The European quality certification would provide a mechanism for quality verification in auditing services. To obtain the certificate, there exist administrative and fee requirements (European Commission (2011c)). We present a model for this voluntary quality certification in Section 3.4.4.

3.3.3 Policy Action 3 - Prohibition of Discriminatory Clauses

A further aspect is the EC's proposal for prohibition of "Big Four-laws". Academics, auditors and policy makers have recognized that there exist contractual clauses limiting listed companies in search of a suitable auditor for their financial statements in their selection. This practice reflects the problem of asymmetric information regarding the soundness of financial statements on behalf of investors and creditors. The clauses require audits of financial statements undertaken by *Big Four*-firms only.[22] In essence, a company will face higher costs of capital or will not even be able to make use of debt financing if it does not acquire an auditing mandate from one of the four large auditors. In addition, part of the market for auditing services is foreclosed to small audit firms who are not able to provide tenders for auditing mandates to in particular large listed companies (DeAngelo (1981), Deis and Giroux (1992), European Commission (2011a)). The EC's proposed directive and regulation prohibit any contractual clauses requiring audit reports from a specific audit firm, in particular, any *Big Four*-firm (European Commission (2011b,c)).

The EC proposal to prohibit discriminatory clauses against small audit firms can thus be seen as unconditionally beneficial to improve competition in the market for auditing services. Hence, we do not include this aspect in the model presented in Section 3.4.

[22] Subsequently, these clauses are termed "Big Four-laws", "Big Four only"-bias, "Big Four is Best"-bias, etc. and are applied e.g. by banks in their lending processes.

3.3.4 Policy Action 4 - International Standards on Auditing

The fourth aspect of the creation of the *Single Market for statutory audits* is the proposed introduction of *International Standards of Auditing* (ISAs)[23] on the EU level to improve the accountability and reliability of auditing procedures and results (European Commission (2010)). It requires compliance with the ISAs by all statutory auditors. Hence, audits would be performed based on a harmonized framework. Applicable rules for audit reports would be streamlined (European Commission (2011a,b)). Regulators, standard setters and auditors would then benefit from these harmonized requirements, legislation and standards. Firms would benefit from lower cost of capital, improvements to audit quality and potential savings in audit fees. In total, the introduction of ISAs leads to recurring net benefits in EU estimated at 2bn EUR per year (European Commission (2011a), Köhler (2009)). However, the Commission estimates the increased costs of applying ISAs roughly at 90t to 150t EUR annually for listed companies with a balance sheet of 100mn EUR and more and at approximately 10t EUR annually for small firms. This is equivalent to a 6% to 10% increase in recurring audit costs. Since the ISAs would be compulsory for all active audit firms, they would face both direct costs from adaptation and compliance to ISAs and indirect costs from lower fees. In addition, public authorities have to incur direct costs of establishing guidance and monitoring of proportional application of the new accounting rules (European Commission (2011a)). We present a model for this standardization in Section 3.4.3.

3.4 Model

This section looks at the theoretical implications of such EC legislation by assessing the effects of standardization and certification in a signaling framework. The important aspect about the market for auditing services is the fact that there exists asymmetric information about the audit quality.

[23] ISAs are professional standards for the performance of audits of financial statements. They are issued by the International Assurance and Auditing Standards Board which operates under the realm of the International Federation of Accountants.

Verification of audit quality can be done in two ways depending on who initiates verification. If it is the demand-side, the less informed party verifies quality. We model this by standardization imposed by the EC. If it is the supply-side, the more informed party verifies quality if it decides to acquire a certificate. Two questions arise from this setting: First, is it more profitable for the regulator to provide certification or standardization? Second, who should initiate verification from a welfare point of view? Henceforth, we follow Stahl and Strausz (2011) to set up two signaling games of costly standardization and certification alongside a baseline model. We then compare the equilibria with regards to social welfare.

3.4.1 Agents, Strategies and Payoffs

The model has three agents. In a simple auditor-firm-regulator-relationship, the seller is the auditor. She offers her auditing services, i.e. an audit report, at price p_a with quality being known to her but unobservable to the buyer. Quality q_i can either be high, q_h, with ex ante probability λ or it can be low, $q_l > 0$, with probability $1-\lambda$ where $\Delta q \equiv q_h - q_l > 0$ and λ is bounded away from 1. A high-quality auditor has production cost $c_h > 0$, while $c_l = 0$. Furthermore, we assume there exist economic rents from auditing such that $q_h - c_h > q_l - c_l = q_l > 0$. Then, the high-quality auditor receives $\Pi_h = p_a - c_h$ when auditing the firm and zero otherwise, while the low-quality auditor receives $\Pi_l = p_a - c_l$ when providing audit services and zero otherwise.

The second agent is the buyer of the auditing service, i.e. the firm that is in need of an audit as a signal of its financial health to investors for future external financing of its business operations. After observing p_a, the buyer's possible actions are $\sigma_b \in \{s_n, s_b\}$, where s_n = buyer does not buy good, s_b = buyer buys good. The quality of the auditing service is identified with the buyer's maximum willingness to pay. A risk-neutral buyer is then willing to pay $p \leq \bar{q} \equiv \mathbb{E}[q] = \lambda q_h + (1-\lambda) q_l$. His reservation payoff is zero if he is not buying, $\Pi_b(s_n|p_a) = 0$. Otherwise, he receives $\Pi_b(s_b|p_a) = q_i - p_a$.

The third agent is the regulator. She is the institution verifying the quality of the auditing service. This could be the ESMA as proposed by the EC. We assume an honest, single and profit-maximizing regulator because Strausz (2005) shows that bribing hurts reputation and that honest certification constitutes a natural monopoly.[24] The regulator exists because there exists demand for verifying the audit quality from both sides of the market.[25] A regulator can verify the auditor's quality at cost c_v. She initially decides whether to certify the auditor (supply-side verification) or standardize (demand-side verification) and then sets a price p_v at which certification or standardization is available. That is, revealing the quality of the auditing services is costly to the auditor and the buyer, respectively. The regulator has all bargaining power as she initially sets p_v to retrieve all economic rents from both auditor and firm. Her payoff from verification is thus $\Pi_r^t = x^t(p_v - c_v)$ where the probability of verification is $x^t, t \in \{s, c\}$, with $s =$ standardization and $c =$ certification. If not verifying quality, the regulator's reservation payoff is zero.

3.4.2 Baseline Regime without Verification

Without any regulatory regime present in the market for auditing services, we face the typical lemon's problem by Akerlof (1970) because we additionally assume that production costs of high-quality audits exceed average quality, $c_h > \bar{q}$. A high-quality auditor does not offer her auditing services and the market outcome is inefficient. Information asymmetries lead to the following equilibrium: Suppose the buyer expects average quality and pays a single price $p = \bar{q}$ because he cannot differentiate quality levels. He then receives $\Pi_b(s_b|p) = q_l - \bar{q} < 0$. The low-type auditor sells at $p = \bar{q}$ and makes profits $\Pi_l = \bar{q} - c_l = \bar{q} > 0$ while the high-type auditor does not sell because $p = \bar{q} < c_h$ and $\Pi_h = \bar{q} - c_h < 0$. After Bayesian updating, the buyer would pay at most $p = q_l$ such that $\Pi_b(s_b|p) = 0$ and $\Pi_l = q_l$. Thus, auditors of high quality are crowded out of the market.

[24] In a setting with oligopolistic certification which differs horizontally, sellers with unobservable quality would self-select according to the strictness of the tests applied. Hence, sellers are segmented across the distribution of certifiers relative to their quality and stricter tests imply higher fees (Hvide (2004)).

[25] We will show this in section 3.4.2.

Given these results from the initial equilibrium, there exists demand for quality verification from both sides of the market. In a market without information asymmetries, a high-quality auditor could sell her auditing services for $p_a = q_h > c_h$. Therefore, she has demand for some form of verification that allows her to credibly signal her quality to the buyer. The high-type auditor is willing to pay the regulator at most her maximum benefit from providing auditing services, i.e. $q_h - c_h$. Yet there also exists demand for quality verification from the demand-side. Whenever a buyer faces an auditor offering her services at any $p_a > q_l$, the buyer may demand some form of quality verification to identify higher quality of the auditing services offered. Hence, from now on we assume that a regulator can perfectly verify the auditor's quality at cost $c_v \in [0, q_h - c_h]$ and makes the results publicly observable.

3.4.3 Standardization

In the first signaling game, the three players buyer, auditor and regulator engage in a market where quality is standardized by the regulator at $\tilde{q}$.[26] because the regulator wants to raise average audit quality in the market. This means that only one type of audit quality, i.e. $\tilde{q}$, can be provided by the auditor and is available to the buyer. Audit quality is hence homogeneous in the market. Note that we refer here to a formal standard driven by the regulator similar to those formal standards implied by standard-setting organizations.[27]

Furthermore, the auditor has the opportunity to invest in order to raise the quality of her auditing services offered. The idea is that auditors are able to train and reach $\tilde{q}$ by investment, e.g. through a learning process, in particular the low-type auditors. We assume that quality is additively separable so that the investment allows the auditor to acquire additional audit quality above her existing level. Hence, the auditor's investment is simply a cost component such that $i_k + c(q_i) = c(\hat{q})$ where $c(\hat{q})$ is the auditor's total

[26]This could be in the form of compulsory certification, mandatory norms or introducing laws regulating minimum quality standards or compatibility.

[27]To illustrate this, one can think of e.g. the European Commission proposing a new directive to standardize mobile phone chargers.

costs to acquire a quality target $\hat{q}$.

The game has the following structure and timing:[28]

t=1	regulator sets p_v as the price for standardizing audit quality in the market and sets $\tilde{q} = q_h$
t=2	nature selects quality $q_i, i \in \{l, h\}$, of the audit service provided and the auditor learns her type of quality
t=3	auditor offering audit report of quality q_i at cost c_i decides about investment level i_a to attain quality threshold: $q(i_a) + q_i = \tilde{q}$
t=4	auditor sets price p_a for her service
t=5	buyer decides whether or not he buys the good (audit report)

In the initial stage, the regulator verifies the quality from demand-side through standardization. She receives $\Pi_r^s = x^s(p_v - c_v)$ where verification always takes place so that $x^s = 1$.

Since quality is standardized at $\tilde{q} = q_h$, the auditor's quality target that she wants to attain becomes $\hat{q} = \tilde{q} = q_h$. Then, the auditor sets her investment level according to $i_k = c(\tilde{q}) - c(q_i)$ where $i_k \in [0, c_h]$. Also, the auditor chooses her price p_a from a continuous set of prices. Then the strategy profile of an auditor of quality q_i is given by $\sigma_i : \mathbb{R}_+ \to [0,1]$ where each σ_i incorporates choosing both a price p_a and an investment level i_a.

After observing p_a, the buyer's possible actions are: s_n = buyer does not buy good, s_b = buyer buys good. To fix ideas, we assume that the standardization costs p_v are paid by the buyer. The respective payoffs for the buyer are: $\Pi_b(s_n|p_a) = 0$ and $\Pi_b(s_b|p_a) = q_h - p_a - p_v$. Hence, the maximum price that the auditor can then charge to the buyer and still sell the good is $p_a \leq q_h - p_v$.

[28]It does not change the outcome of the analysis if the steps in t=3 and t=4 occur sequentially or simultaneously.

Lemma 3.1 *The analysis of the game does not depend on who pays for the standardization costs. The only difference are the cut-off values for the minimum and maximum price p_a the auditor can charge to the buyer and still sell the service and subsequently, how the total surplus is distributed among the agents.*

Proof See the Appendix. ■

With the game's structure and timing and the agents' strategies presented, we derive an equilibrium of the game of standardization in Proposition 3.1. Note that since the regulator sets p_v in t=1, she can extract all rents from both buyer and auditor.

Proposition 3.1 *There exists a unique equilibrium outcome where*

$$\textit{Auditor's strategy } \sigma_i^* : \begin{cases} p_a^* = q_h - p_v & \textit{if } \; p_v \leq q_h - p_a \\ \textit{any } p_a \geq c(\tilde{q}) & \textit{if } \; p_v > q_h - p_a \end{cases}$$

For the q_h auditor, $i_h^* = 0$ while the q_l auditor needs to invest $i_l^* = c_h$.

$$\textit{Buyers's strategy } \sigma_b^* : \begin{cases} s_b & \textit{if } \; p_v \leq q_h - p_a \\ s_n & \textit{if } \; p_v > q_h - p_a \end{cases}$$

$$\textit{Regulator's strategy } \sigma_r^* : p_v^* = q_h - c_h.$$

Then, $p_a^* = c_h$ so that $\Pi_b^*(s_b|p_a) = \Pi_h^* = \Pi_l^* = 0$ and the regulator's profit is

$$\Pi_r^s = q_h - c_h - c_v.$$

Proof See the Appendix. ■

The regulator sets p_v such that she can extract all rents from both buyer and auditor by charging a price equal to the economic rent from high-quality auditing, $p_v = q_h - c_h$.

3.4.4 Certification

In the second signaling game, the buyer and seller play a game where the seller (auditor) can ascertain her quality of the audit report by seller-induced quality verification. She can choose to acquire a costly quality certificate from the regulator. With certification the auditor's quality becomes observable. Audit quality is now heterogeneous in the market.

In contrast to the standardization game described in section 3.4.3, we now leave the regulator to set only her price for certification p_v and allow the auditor to choose both her price p_a as well as the option to acquire a costly certificate which reveals her audit quality to the buyer.

The game has the following structure and timing:[29]

t=1	regulator sets p_v as the price for acquiring quality certification
t=2	nature selects quality $q_i, i \in \{l, h\}$ of audit service provided and the auditor learns her type of quality
t=3	auditor offering audit report of quality q_i at cost c_i decides about price p_a for her service
t=4	auditor decides whether or not to demand certification at price p_v
t=5	buyer decides whether or not he buys the good (audit report)

We focus on the *Perfect Bayesian Equilibria* (PBE)[30] of the game described above.[31] Here, a PBE specifies three components: firstly, the auditor's pricing strategy; secondly,

[29] It does not change the outcome of the analysis if the steps in t=3 and t=4 are reversed or occur simultaneously.

[30] As described by Kreps and Wilson (1977) as a refinement of Bayesian Nash equilibria and subgame perfect Nash equilibria.

[31] These criteria limit the out-of-equilibrium beliefs such that any information set reached off the equilibrium path shall be assigned probability zero if the strategy to reach that node is equilibrium-dominated. In a two-type model like the one employed here these refinements lead to unique equilibria in both certification and standardization regimes. If more types or recurrences exist, more stringent refinements are needed. One such is presented by Rabin and Sobel (1993) who show which equilibria may survive repeated interaction because they are frequently deviated to. Another is a more sophisticated set of contracts offered by the seller of the good Maskin and Tirole (1992).

the buyer's belief after observing prices; and thirdly, the buyer's behavior.

In the initial stage, the regulator verifies audit quality whenever the auditor chooses to do so and receives $\Pi_r^c = x^c(p_v - c_v)$ where the probability of verification is x^c.

The auditor chooses her price p_a from a continuous set of prices. Also, she decides whether or not she wants to obtain certification from the regulator at price p_v. The strategy profile of an auditor of quality q_i is given by $\sigma_i : \mathbb{R}_+ \rightarrow [0,1]$ where each σ_i incorporates choosing both a price p_a and the decision to buy certification $\sigma_i(c)$.

The buyer sets beliefs $\mu_b(p_a)$ on what quality the auditor offers where $\mu_b : \mathbb{R}_+ \rightarrow [0,1]$, i.e. after observing p_a and possible certification, the buyer believes that the auditor is of type q_h with probability $\mu_b(p_a)$. After observing p_a and possessing belief μ_b, the buyer's possible actions are: s_n = buyer does not buy good and receives $\Pi_b(s_n|p_a, \mu_b) = 0$, s_b = buyer buys good and receives $\Pi_b(s_b|p_a, \mu_b) = \mu \cdot q_h + (1-\mu)q_l - p_a$. Hence, the maximum price that the auditor can then charge to the buyer and still sell the good is $p_a \leq \mu_b(p_a)\Delta q + q_l$.

Lemma 3.2 *Only the high-type auditor acquires certification.*

Proof See the Appendix. ■

With the game's structure and timing and the agents' strategies presented, we derive an equilibrium of the game of certification in Proposition 3.2. Note that since the regulator sets p_v in t=1, she can extract all rents from both the buyer and the certifying auditor.

Proposition 3.2 *There exists a unique equilibrium outcome where*

$$\textit{Auditor's strategy } \sigma_h^* : \begin{cases} p_a^* = q_h;\ \sigma_h^*(c) = 1 & \textit{if } \ p_v \leq q_h - c_h \\ \textit{any } p_a \geq c_h;\ \sigma_h^*(c) = 0 & \textit{if } \ p_v > q_h - c_h \end{cases}$$

$$\textit{Auditor's strategy } \sigma_l^* : \begin{cases} p_a^* = q_l;\ \sigma_l^*(c) = 0 & \textit{if } \ p_v \leq q_h - c_h \\ \textit{any } p_a \geq c_l;\ \sigma_l^*(c) = 0 & \textit{if } \ p_v > q_h - c_h \end{cases}$$

$$\textit{Buyers's belief } \mu_b^* : \begin{cases} \mu_b^* = 1 & \textit{if } \ p_a = q_h \quad \wedge \quad \sigma_i^*(c) = 1 \\ \mu_b^* = 0 & \textit{if } \ p_a < q_h \quad \vee \quad \sigma_i^*(c) = 0 \end{cases}$$

$$\textit{Buyers's strategy } \sigma_b^* : \begin{cases} s_b & \textit{if } \ p_a \leq \mu_b(p_a)\Delta q + q_l \\ s_n & \textit{if } \ p_a \geq \mu_b(p_a)\Delta q + q_l \end{cases}$$

$$\textit{Regulator's strategy } \sigma_r^* : p_v^* = q_h - c_h.$$

Then, $p_a^*(\mu_b^*(p_a), q_h) = q_h$ *and* $p_a^*(\mu_b^*(p_a), q_l) = q_l$ *so that* $\Pi_b^*(s_b|p_a, \mu_b) = 0$, $\Pi_h^* = 0$, $\Pi_l^* = q_l$ *and the regulator's profit is* $\Pi_r^c = \lambda(q_h - c_h - c_v)$.

Proof See the Appendix. ■

3.4.5 Regulator's Profits

The regulator obtains a higher profit under standardization than with voluntary certification: $\Pi_r^s \geq \Pi_r^c \Leftrightarrow q_h - c_h - c_v > \lambda(q_h - c_h - c_v)$ since $\lambda < 1$ by definition. Therefore, the regulator will always prefer standardization over certification. We now check whether these preferences are aligned with social efficiency.

3.5 Welfare

Who should initiate verification of quality from a welfare perspective? A normative answer demands investigation into buyer's demand and verification costs. Social efficiency is improved because both types of verification by the regulator allow the q_h auditor to sell her services. From an efficiency perspective, the differences between both regulatory regimes and the initial environment without verification relate to the different probabilities with which the high-quality audit is provided and sold as well as the frequency at which costly verification arises.

3.5.1 Welfare Measurements

As usual, social welfare is defined as the three agents' surplus. Here this is the economic rents from auditing for the auditor, firm and regulator. Henceforth, we calculate four different welfare measures according to the environments presented in the model in section 3.4. In the initial setting where verification by a regulator is not possible, welfare amounts to $\overline{W} = (1-\lambda)q_l$ because in the inefficient regime where quality verification is not possible and quality is unobservable, only the low-quality auditor sells her services.

With standardization, the auditing service with q_l is never sold. The q_l auditor has to invest $i_l = c_h$ in order to attain quality threshold $\tilde{q} = q_h$. Additionally, expected verification costs are $x^s \cdot c_v$ where the probability of verification is $x^s = 1$. Hence, social welfare under standardization is $W^s = q_h - c_h - x^s \cdot c_v = q_h - c_h - c_v$ since always and only high-quality audits are provided and sold, but verification costs also always apply.

With certification, the auditing service with q_l is always provided and sold. Furthermore, expected certification costs are $x^c \cdot c_v$ where the probability of verification is $x^c = \lambda$. Then, social welfare under voluntary certification is $W^c = \lambda(q_h - c_h) + (1-\lambda)q_l - x^c \cdot c_v = \lambda(q_h - c_h - c_v) + (1-\lambda)q_l$. Both types of audits are provided and sold with their respective a priori probabilities and verification costs apply whenever the q_h auditor engages in the market.

Finally, if - for some reason - there would exist no information asymmetries in the audit market, the audit reports would always be sold at prices equal to productivities without any regulatory intervention. Hence, social welfare with observable quality is $W = \lambda(q_h - c_h) + (1-\lambda)q_l$.

3.5.2 Thresholds for c_v

As can easily be noted, the ranking of the aforementioned four welfare measurements depends on the verification costs c_v the regulator has to bear if she takes action. Thus, we compare the four welfare measures and determine the thresholds of c_v for which one is larger than another. This is provided in the following Lemma.

Lemma 3.3 *i) With regard to standardization,*

$$W^s > W \text{ iff } c_v < (1-\lambda)(\Delta q - c_h) \text{ and}$$

$$W^s > \overline{W} \text{ iff } c_v < \lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h).$$

ii) With regard to certification,

$$W > W^c \text{ iff } \lambda \cdot c_v > 0 \text{ and}$$

$$W^c > \overline{W} \text{ iff } c_v < q_h - c_h.$$

iii) When comparing both regulatory regimes,

$$W^c > W^s \text{ iff } c_v > \Delta q - c_h.$$

iv) When comparing both non-regulatory regimes with and without information asymmetries,

$$W > \overline{W} \; \forall \; c_v.$$

Proof See the Appendix. ■

The thresholds for c_v are necessary for ranking the four different welfare measurements. Remember that the regulator can verify the auditor's quality at cost $c_v \in [0, q_h - c_h]$. Each such threshold is an interval of values for c_v for which a clear ranking of the different welfare measures is possible. Comparing the thresholds for verification costs in the different scenarios, we derive the following Lemma.

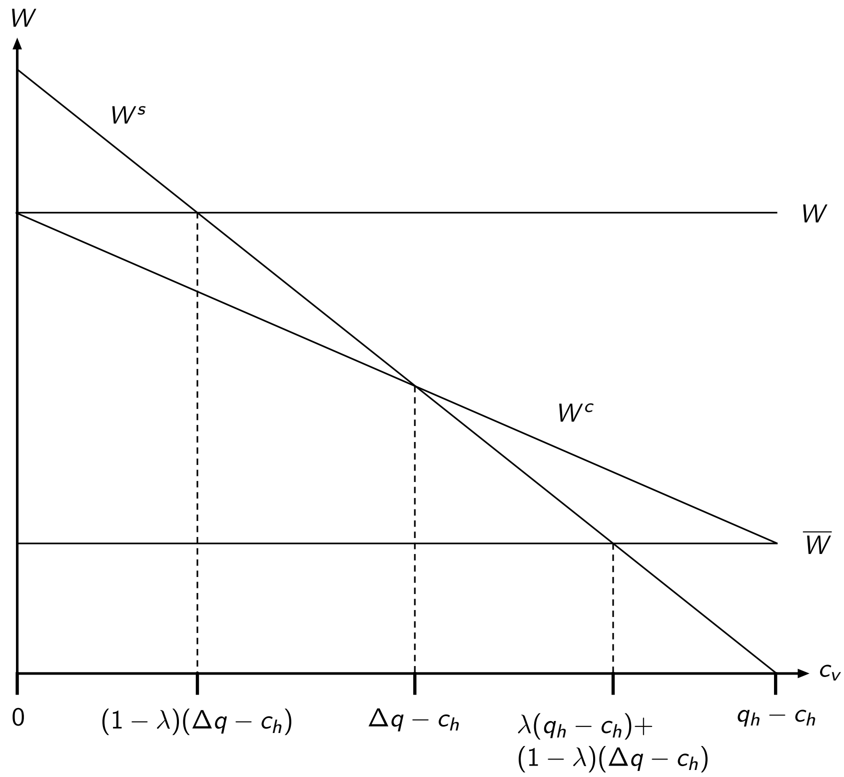
Lemma 3.4 *The thresholds for c_v can be uniquely ranked:*

$$0 < (1-\lambda)(\Delta q - c_h) < \Delta q - c_h < \lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h) < q_h - c_h.$$

Proof See the Appendix. ■

Figure 3.1 is a graphical representation of the four welfare measures as a function of verification costs c_v. Note that both non-regulatory regimes which yield W and $\overline{W}$, respectively, are independent of c_v and hence, are horizontal straight lines. On the other hand, both regulatory regimes providing W^s and W^c, respectively, dependent on c_v. Hereby, the slope of the welfare function in the case of standardization is $x^s = 1$ which is steeper than the slope of the welfare function in the case of certification which is $x^c = \lambda$. Note that the cut-off value $c_v = \Delta q - c_h$ derived in Lemma 3.3 determines the intervals for which $W^s \lesseqqgtr W^c$ and reflects the difference in economic benefits from high-quality and low-quality audits.

Figure 3.1: Welfare Functions



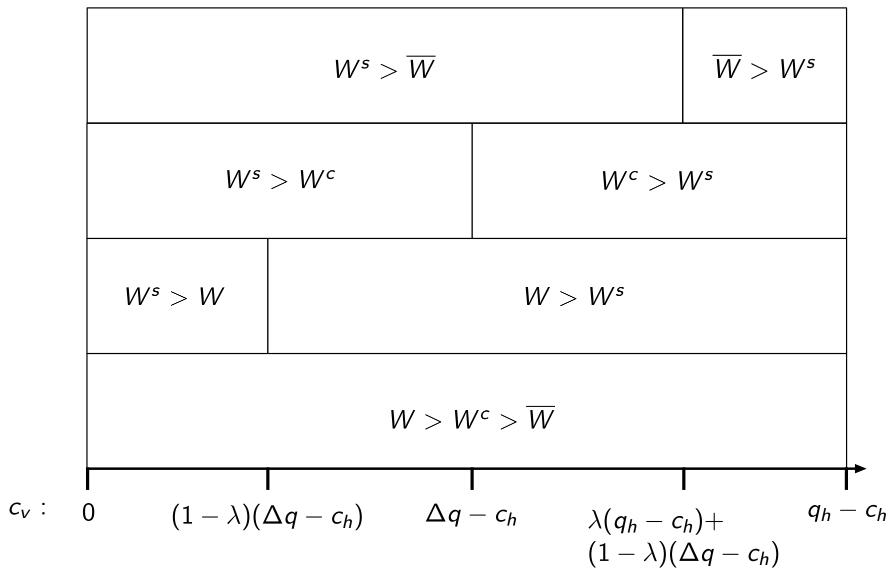
Furthermore, whenever $c_v = 0$, welfare from certification coincides with welfare from a situation without information asymmetries, i.e. $W^c = W$, and welfare from standardization yields the maximum economic rent from auditing, i.e. $W^s = q_h - c_h$.

If maximum verification costs $c_v = q_h - c_h$ are incurred by the regulator, then welfare from certification coincides with welfare from the initial scenario with information asymmetries which exposes the Lemon's problem, i.e. $W^c = \overline{W}$. Welfare from standardization then is zero, i.e. $W^s = 0$.

3.5.3 Welfare Analysis

By bringing the five cut-off values of c_v in order, intervals are established such that the four aforementioned welfare measures can be ranked. We can graphically show in Figure 3.2 how Lemmata 3.3 and 3.4 lead to a ranking of the four welfare measurements.

Figure 3.2: Ranking of Welfare Measures



Hence, regulator's preferences and social efficiency are not always aligned because the regulator would always prefer standardization to maximize her profits. Normative implications can be deduced from this analysis: $\forall\, 0 < c_v < (1-\lambda)(\Delta q - c_h)$, $W^s > W > W^c > \overline{W}$ so that standardization yields the social optimum. The low verification costs make it worthwhile for the regulator to introduce high-quality audits only through standardization. The gains from improving average audit quality in the market through formal standards (norms, training, etc.) for the share of low-type auditors outweigh the costs of introducing such regime.

$\forall\ (1-\lambda)(\Delta q - c_h) < c_v < \Delta q - c_h$, $W > W^s > W^c > \overline{W}$ so that a market without information asymmetries is optimal and standardization is second-best. In this lower intermediate interval, verification costs already outweigh the benefits from the increased probability of high-quality audits, i.e. $1-\lambda$. Yet, verification costs are still not large enough to induce a credible signal for the high-quality auditor through voluntary certification.

$\forall\ \Delta q - c_h < c_v < \lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h)$, $W > W^c > W^s > \overline{W}$ so that again, a market with observable quality is optimal and certification is now second-best. In this upper intermediate interval, verification costs are large enough so that the high-quality auditor can credibly signal her audit quality to the buyer through voluntary certification. Hence, welfare from certification is larger than from standardization. However, these costs from verifying quality outweigh the benefits from observable quality so that a market without information asymmetries would be first-best.

$\forall\ \lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h) < c_v < q_h - c_h$, $W > W^c > \overline{W} > W^s$ so that once more, a market with observable quality is optimal and certification is second-best. Now verification costs are so large that even the inefficient market equilibrium with unobservable quality, no verification and only low-quality audits sold yields higher welfare than the standardization regime.

3.6 Results

From a theoretical model based on a simple relationship between an auditor, firm and a regulator, we are able to draw some clear results which are not, however, obvious at first. On the one hand, because standardization costs always apply, the regulator's profit under standardization is higher than with certification. Also, standardization is optimal for social welfare if verification costs covered by the regulator are sufficiently low. On the other hand, certification enables a differentiation in the product space available in the audit market. In the separating equilibrium, only the q_h auditor certifies and sells her good at $p_a = q_h$ while the q_l auditor never certifies and sells her good at $p_a = q_l$. Here, the audit report is always sold. Also, certification is optimal for social welfare if verification costs are sufficiently large.

Thresholds for which $W^s \lesseqgtr W^c$ depend on the cut-off value $c_v = \Delta q - c_h$ derived in Lemma 3.3 which represents the difference in economic rents from high-quality and low-quality audits. Hence, the larger the difference in benefits from both types of audit, the larger the interval for c_v for which $W^s > W^c$.

In any case, an environment without any information asymmetries yields the social optimum whenever $c_v > (1-\lambda)(\Delta q - c_h)$. That is, the costs for a standardization regime (c_v), which allows auditors to obtain the ability to provide high-quality audits through investment, outweigh the increased benefits from high-quality audits. This increase is the difference in economic rents from high-quality audits $(q_h - c_h)$ over low-quality audits $(q_l - c_l)$ whenever nature draws low-type auditors (with probability $1-\lambda$). Note that the threshold value for $c_v \to 0$ as either the share of high-quality auditors increases $(\lambda \to 1)$ or the difference in economic benefits decreases $(q_h - c_h - (q_l - c_l) = \Delta q - c_h \to 0)$. No regulatory intervention is never optimal.

3.7 Extensions

We now introduce some additional features to extend the initial model and check the robustness of our results. We analyze seven different amendments.

First, are the results obtained from the signaling games renegotiation-proof? Suppose renegotiations are costless. With standardization, all auditors sell their report with q_h at some $p_a \leq q_h - p_v$. With certification, prices charged by the respective types of auditors equal productivities so that pricing is efficient. Thus, renegotiations do not change the incentives to quote another price $p'_a \neq p_a$.

Second, we previously assumed that the quality provided by an auditor is exogeneously given by nature in t=2. Now we let the high-type auditor be able to choose between q_h and q_l when producing an audit report. Subsequently, the q_h auditor can produce q_h and certify ($\Pi_h = q_h - c_h - p_v \geq 0$) or she can produce q_l and deny verification ($\Pi_h = q_l > 0$). Hence, her outside option improves from zero to q_l and this limits the exploitation by regulator: Certification occurs iff $\Pi_h = q_h - c_h - p_v \geq q_l \Leftrightarrow p_v \leq q_h - c_h - q_l = \Delta q - c_h$. The regulator still extracts all rents from verification but the rents are now smaller: $\Pi_r^c = \lambda(\Delta q - c_h - c_v) < \lambda(q_h - c_h - c_v)$, whereas Π_r^s is unchanged.

Third, we investigate the regulator's imperfection in verification. So far, we assumed that the regulator perfectly observes quality once called upon for verification. Consider now a verification technology that reveals the true quality only with $\frac{1}{2} < \eta < 1$ and the wrong quality with $1 - \eta$. Then, in standardization this ambiguity leads to an equilibrium where $p_v = \eta q_h - c_h$. Any $\eta > \frac{1}{2}$ thus reduces the profitability from verification to $\Pi_r^s = \eta q_h - c_h - c_v$. In the case of certification, an equilibrium exists where again $p_v = \eta q_h - c_h$. Hence, a q_h auditor certifies and has $p_a = q_h$ such that $\Pi_h = p_a - c_h - p_v$ $= (1 - \eta)q_h \geq 0$ while a q_l auditor never certifies and has $p_a = q_l$ such that $\Pi_l = p_a - c_l$ $= q_l > 0$. The buyer (firm) only buys the good if it is certified as q_h and only believes that the good is q_h if it is certified and $p_a = q_h$. Therefore, the equilibrium outcome in the certification regime remains separating and the regulator receives $\Pi_r^c = \lambda(\eta q_h - c_h - c_v)$.

A fourth extension is the case of a monopoly. We consider one seller who can sell n units of the service to n identical buyers. Then both standardization and certification games are unchanged except that equilibrium outcomes are multiplied by n. Let us assume a capacity constraint such that one seller can sell $n - 1$ units to n identical buyers. In standardization, equilibrium outcomes are unchanged since all $n - 1$ units of the audit service provided are of quality q_h and homogenous price competition among buyers leads to $p_a = q_h - p_v$. Profits of the auditor and regulator are multiplied by $n - 1$. One buyer drops out. With certification, the $n - 1$ units can either be of q_h or of q_l. Equilibrium outcomes are again unchanged. A q_h auditor always certifies while a q_l auditor never certifies. Profits of the auditor and regulator are multiplied by $n - 1$. One buyer drops out. Hence the capacity constraint has no bite since all bargaining power lies with the seller (auditor) anyhow.

A fifth extension looks at the implications of a monopsony. We now consider m auditors competing to sell one good to one buyer. Then competition between sellers reduces seller's demand for quality verification. With standardization, auditors compete down to price equal marginal costs, i.e. $p_a = c_h \ \forall \ i$. The m auditors irrespective of the quality provided make $\Pi_i = p_a - c_h = 0$. The buyer gets $\Pi_b(s_b|p_a) = q_h - p_a - p_v \geq 0$ while the regulator receives $\Pi_r^s = p_v - c_v = q_h - c_h - c_v$. Again, equilibrium outcomes are unchanged and all rents are extracted by the regulatory authority. In certification, q_h auditors charge the lowest possible price $p_a = c_h$ but cannot cover sunk costs p_v. Hence, we arrive at an asymmetric equilibrium where only one q_h auditor certifies such that $p_a = q_h$ and thus $\Pi_h = p_a - c_h - p_v \geq 0$.[32] If no other agent certifies, then $\sigma_h(c)$ yields a credible signal for one q_h auditor. If $y \in (1, m]$ certify, then a recoupment of p_v is not possible and $\Pi_h(c) = \frac{q_h - c_h}{y} - p_v \leq 0$ because $p_v = q_h - c_h$. Meanwhile, q_l auditors charge their lowest possible price $p_a = c_l = 0$ and again never certify so that $\Pi_l = p_a - c_l = 0$. The regulator receives $\Pi_r^c = \lambda(q_h - c_h - c_v)$.

Sixth, we analyze production heterogeneity. We can assume an asymmetric cost structure in the sense that catching up is more expensive for a q_l auditor. Remember that initially, $i_k = c(\tilde{q}) - c(q_i)$ where $i_k \in [0, c_h]$. Now let $c(\tilde{q}) = c(q_i) + \beta i_k$ where $0 < \beta < 1$ so that $i_k \in \left[0, \frac{c_h}{\beta}\right]$. A q_h auditor still has $i_h^* = 0$ so that $\tilde{q} = q_h$ is attained. A q_l auditor needs to invest $i_l = \frac{c(\tilde{q}) - c(q_l)}{\beta}$ to attain $\tilde{q} = q_h$ so that $i_l^* = \frac{c_h}{\beta} > c_h$. If $c_h \leq p_a \leq \frac{c_h}{\beta}$, then we find a crowding out of q_l auditors as they will not invest and hence not attain the quality threshold $\tilde{q}$, and only q_h auditors sell the audit service. This result is independent of which agent pays for standardization costs as shown earlier. However, as long as the bargaining power lies with the auditors, cost differences do not matter because the price p_a asked for by the auditor always attains the maximum willingness to pay of the buyer, which is $\{q_h - p_v; q_h - \alpha p_v; q_h\}$, respectively, depending on who pays for standardization costs.

[32] This is for the case where the auditor is still the price setter and the buyer decides on buying after observing prices. We refrain from an analysis with bilateral bargaining power.

Cost differences only matter if we have m agents on the sell-side as in the monopsony case.

Finally, as a seventh extension we consider a multilateral framework with n buyers, m auditors and an asymmetric cost structure. Like before, each auditor can sell one unit of the service to one seller. In the standardization game, homogeneous price competition among auditors leads to $\lambda \cdot m$ auditors of type q_h offering their services at $p_a = c_h$, while $(1-\lambda)m$ auditors of type q_l procure their services at $p_a = \frac{c_h}{\beta}$. If $n < \lambda \cdot m$, then all demand is satisfied by q_h auditors with $p_a = q_h - p_v$ and $p_v = q_h - c_h$ and subsequently, $p_a = c_h$. Hence, we encompass the crowding out of q_l auditors as envisioned with production heterogeneity and a competitive supply-side earlier. The buyer then receives $\Pi_b(s_b|p_a) = q_h - c_h > 0$. If $n > \lambda \cdot m$, then $\lambda \cdot m$ of the demand is served by q_h auditors at $p_a = c_h$ whereas $n - \lambda \cdot m$ of the demand is satisfied by q_l auditors at $p_a = \frac{c_h}{\beta}$ and so the supply function is a step function. Whether $n - \lambda \cdot m \lesseqqgtr (1-\lambda) \cdot m$ depends on $n \lesseqqgtr m$, i.e. if excess demand or excess supply exists in the market. As before, the receives regulator receives $\Pi_r^s = q_h - c_h - c_v$.

In the certification game, both q_h and q_l auditors supply their services at prices equal to productivities, i.e. $p_a = \{q_h; q_l\}$. If we have excess demand with $n > m$, then q_h auditors certify and receive $\Pi_h = q_h - c_h - p_v \geq 0$ while q_l auditors never certify and receive $\Pi_l = q_l - c_l = q_l > 0$. The buyer receives $\Pi_b(s_b|p_a, \mu_b) = 0$. This is the same outcome as in the initial model of certification. If we have excess supply with $n < m$, q_h auditors charge the lowest possible price $p_a = c_h$ but cannot cover sunk costs p_v. Hence, we arrive at an asymmetric equilibrium where only one q_h auditor certifies such that $p_a = q_h$ and thus $\Pi_h = p_a - c_h - p_v \geq 0$. The remaining $\lambda(m-1)$ auditors of type q_h do not certify. If no other agent certifies, then $\sigma_h(c)$ yields a credible signal for one q_h auditor. If $y \in (1, m]$ certify, then a recoupment of p_v is not possible and $\Pi_h(c) = \frac{q_h - c_h}{y} - p_v \leq 0$ because $p_v = q_h - c_h$. Meanwhile, $(1-\lambda)m$ auditors of type q_l charge their lowest possible price $p_a = c_l = 0$ and again never certify since $\Pi_l(c) = p_a - c_l - p_v < 0 = p_a - c_l = \Pi_l(p_a)$. In total, $\lambda(m-1) + (1-\lambda)m = m - \lambda$ auditors do not certify. Then, $\lambda(m-1) + (1-\lambda)m - n = m - \lambda - n$ auditors cannot sell their service and go empty-handed. This result is similar to the monopsony case. Moreover, the regulator receives $\Pi_r^c = \lambda(q_h - c_h - c_v)$.

3.8 Conclusion

In this chapter, we evaluate the impact of regulatory interventions on the quality of auditing services. The recent financial crisis has shown that a positive auditing result does not provide clear signaling of financial robustness because financially distressed companies received positive statements far too often. The EC thus wants to create a *Single Market for Statutory Audits*. Herein, the EC plans to introduce measures aimed at competition, standardization and certification in order to introduce more competition, and to improve the transparency in the market and the reliability of the signaling of audit results' quality to potential investors of listed companies.

Based on a theoretical analysis of an auditor-firm-regulator-relationship we utilize a signaling framework to show the differences between standardization and certification. While standardization leads to homogeneous price competition among auditors where all rents are collected by the regulator, certification segments the market such that a separating equilibrium with prices equal to productivities is sustained. We can show that it does matter which market side initiates the verification of quality for firstly, the regulator's profits and secondly, social welfare. The regulator's interests and social efficiency are not aligned, however.

In our analysis, we find that voluntary quality certification is obtained only by high-quality auditors. Important to note is that the cut-off values for verification costs c_v determine the welfare ranking. Hence, certification is optimal for social welfare whenever verification costs are sufficiently large. Standardization is optimal whenever the costs for verifying quality are low for the regulator. However, a regime without information asymmetries would be optimal for welfare in almost all cases.

A couple of extensions to the initial model show that our results are quite robust. While renegotiations, quality choice, imperfect verification technologies and a competitive demand-side do not change equilibrium outcomes, a competitive supply-side leads to firstly, an asymmetric equilibrium with only one q_h agent certifying and secondly, a crowding out of q_l auditors in case of an asymmetric cost structure. A multilateral framework gives the same results.

Appendices

Appendix A

Appendix to Chapter 1

Table A.1: Overview of Variables, Definitions and Sources

Variables	Definitions	Sources[1]
Financial innovation measures		
Applications	Patent applications counted per firm in a year.	US PTO[2], collected by Lerner (2006)
Weighted Applications	Weighted patent applications per firm in a year where the sum of 1 (count) is divided among the firms mentioned in the article about the innovation.	US PTO, collected by Lerner (2006)
Innovations	Count of stories from newspaper articles and databases on innovations per firm in a year.	WSJ[3] and FD[4], collected by Lerner (2006)
Weighted Innovations	Weighted count of innovations (as above).	WSJ and FD, collected by Lerner (2006)
Major Innovations	Count of only major innovations where Lerner (2006) applies a three-part classification scheme (A,B,C).	WSJ and FD, collected by Lerner (2006)
Weighted Major Innovations	Weighted count of major innovations (as above).	WSJ and FD, collected by Lerner (2006)

[1]We make use of the data set constructed by Lerner (2006) for which he draws on various data sources. In addition, we define and compute additional factors, which were previously not used, for our empirical investigation. All financial data is in million 2002 US Dollars.
[2]US Patent and Trademark Office
[3]Wall Street Journal
[4]Factiva database

Financial innovation measures (cont'd)		
FI by Others	Number of financial innovations in the same year by other firms with headquarters in the same two-digit zip code as the firm.	WSJ and FD, collected by Lerner (2006)
Patents	Count of patents granted to a firm in a year with respect to the financial services area.	US PTO, collected by Lerner (2006)
Weighted Patents	Weighted count of patents (as above).	US PTO, collected by Lerner (2006)
Financial Institution's performance measures		
EBIT	Earnings before interest and taxes per firm and year.	Compustat
EBITDA	Earnings before interest, taxes, depreciation and amortization per firm and year.	Compustat
Net Income	Net income of a firm in million 2002 USD per year.	Compustat
Opprof	Operational profitability constructed as EBITDA / revenues (opprof = EBIT / revenues, whenever EBITDA is unavailable).	computed from Compustat data
Ret. Earnings	Retained earnings in million 2002 USD per firm in a year.	Compustat
ROA	Return on assets constructed as net income / assets.	computed from Compustat data
ROE	Return on equity constructed as net income / shareholders' equity.	computed from Compustat data
Financial Institution's stability measures		
CAR	Capital-asset ratio constructed as shareholders' equity / assets.	computed from Compustat data
Δ(Opprof)	Difference between operational profitability in 2002 and 1999.	computed from Compustat data
Δ(ROA)	Difference between return on assets in 2002 and 1999.	computed from Compustat data
Δ(ROE)	Difference between return on equity in 2002 and 1999.	computed from Compustat data
σ(ROA)	Standard deviation of ROA for each agent calculated over the sample period.	computed from Compustat data
σ(ROE)	Standard deviation of ROE for each agent calculated over the sample period.	computed from Compustat data

Financial Institution's stability measures (cont'd)		
Sharpe	Sharpe ratio constructed as ROE / σ(ROE). Larger values imply less excessive risk for a certain return.	computed from Compustat data
Z-score	Index of bank solvency constructed as (ROA+CAR) / σ(ROA). Higher Z-score implies lower probability of failure.	computed from Compustat data
Other agent-level variables		
Age	Age of firm in relation to its foundation or IPO.	Compustat
Assets	Total assets of each financial institution in million 2002 USD per year.	Compustat
Cash equiv.	Cash equivalents in million 2002 USD per firm in a year.	Compustat
Emp.	Employees per firm and year.	Compustat
HHI	Herfindahl-Hirschman Index defined as the sum of squared shares of revenues per firm to total revenues per year, i.e. HHI = $\Sigma_i^N(\text{revenues}_i/\text{total revenues})^2$ per year.	computed from Compustat data
Leverage	Ratio of the book value of a firm's long-term debt to total capitalization (book value of long-term debt and preferred stock and the market value of common stock).	Compustat
Lt. Debt	Long-term debt in million 2002 USD per firm in a year.	Compustat
Market Value	Common market value in million 2002 USD per firm in a year.	Compustat
Pref. Stock	Preferred stock in million 2002 USD per firm in a year.	Compustat
R&D	Expenditures per firm for research and development in million 2002 USD in a year.	Compustat
Revenues	Revenues in million 2002 USD per firm in a year.	Compustat
Sh. Equity	Shareholders' equity in million 2002 USD per firm in a year.	Compustat

Table A.2: Spearman Correlation Coefficients of FI measures and Z-scores of firms

	Log of Z-score	**Innovations**	**Weighted counts of innovations**	**Only major innovations**	**Weighted major innovations**	**Patents**	**Weighted counts of patents**	**Applications**	**Weighted counts of applications**	**R&D ratio**	**FI by others**
Log of Z-score	—										
Innovations	-0.0417***	—									
Weighted count of innovations	-0.0417***	1.0000***	—								
Only major innovations	-0.0338***	0.8397***	0.8390***	—							
Weighted major innovations	-0.0338***	0.8397***	0.8390***	1.0000***	—						
Patents	-0.0707***	0.1459***	0.1458***	0.1272***	0.1272***						
Weighted count of patents	-0.0707***	0.1459***	0.1458***	0.1272***	0.1272***	1.0000***	—				
Applications	-0.0561***	0.1213***	0.1212***	0.1087***	0.1088***	0.4428***	0.4428***	—			
Weighted count of applications	-0.0561***	0.1213***	0.1212***	0.1087***	0.1088***	0.4428***	0.4428***	1.0000***	—		
R&D ratio	-0.2158***	0.1004***	0.1003***	0.0818***	0.0818***	0.3431***	0.3431***	0.2953***	0.2953***	—	
FI by others	-0.0187***	-0.0336***	-0.0337***	-0.0270***	-0.0271***	-0.0168	-0.0168	-0.0083	-0.0083	-0.0208***	—

Notes: *** p<0.01

Appendix B

Appendix to Chapter 2

B.1 Data Description

Table B.1: Overview of Variables, Definitions and Sources

Variables	**Definitions**	**Sources**[1]
Leverage Ratios		
Total Leverage	(long-term debt + short-term debt) / total assets per firm in a year.	ORBIS
Long-term Leverage	Long-term debt / total assets per firm in a year.	ORBIS
Short-term Leverage	Short-term debt / total assets per firm in a year.	ORBIS
Firm-specific Factors		
Firm Size	Logarithm of revenues per firm in a year.	ORBIS
Firm Growth	Percentage change in revenues per firm in a year.	ORBIS
Profitability	Earnings before interest and taxes (EBIT) / total assets per firm in a year.	ORBIS

[1]We define and compute the factors used in the empirical investigation according to common literature. The data for the individual variables is drawn from the respective sources. All financial data is in thousand EUR.

Firm-specific Factors (cont'd)		
Tangibility	Fixed assets / total assets per firm in a year.	ORBIS
Liquidity	Cash equivalents / total assets per firm in a year.	ORBIS
Nickell Criterion	Interest paid / cash flow per firm in a year.	computed from ORBIS data
Industry-specific Factors		
Industry Leverage	Median of (short-term, long-term, total) leverage per year and industry.	computed from ORBIS data
Industry Growth	Median percentage change in revenues per year and industry.	computed from ORBIS data
Macroeconomic Factors		
Tax Shield	If firms make use of long-term debt: average (taxation / total assets) per country of firms financed without long-term debt – average (taxation / total assets) per country of firms financed with long-term debt; zero otherwise.	computed from ORBIS data
Inflation	Annual percentage change in consumer prices per country.	WDI[2], World Bank
GDP Growth	Annual percentage change in GDP per country.	WDI, World Bank
Capital Flows	Net capital account / GDP per country in a year.	WDI, World Bank
Unemployment	Total unemployment as percentage of total labor force per country in a year.	WDI, World Bank
Stock Prices	Annual percentage change in Standard & Poor's Global Equity Indices per country.	WDI, World Bank

[2]World Development Indicators, World Bank (2013)

Table B.2: Data along different Dimensions

Dimensions	Observations
Full Sample	6,365,842
EU27†	5,744,127
Euro Area‡	4,859,829
Industries	
Manufacturing	1,484,855
Electricity, gas and water supply	117,474
Construction and real estate	1,418,791
Wholesale trade	1,375,798
Retail trade	563,192
Transportation and storage	321,420
Accommodation and food	225,965
ICT and research	219,725
Professional and administrative services	638,622
Countries*	
Germany	298,347
United Kingdom	212,695
France	1,321,317
Italy	1,452,641
Spain	1,018,082
Poland	94,890
USA	29,556
Japan	25,738
Legal Status	
public	1,016,853
private	4,484,963
n.a.	864,026

Notes: † excludes Croatia; ‡ includes Monaco and Montenegro, excludes Latvia; ∗ includes only eight major countries

Table B.3: Spearman Correlation Coefficients of Leverage Ratios and Firm- and Industry-level Variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
St LR	(1)	—												
Lt LR	(2)	-0.3514***	—											
Total LR	(3)	0.7524***	0.1865***	—										
Firm Size	(4)	0.1264***	0.0064***	0.0479***	—									
Firm Growth	(5)	0.1075***	-0.0209***	0.1047***	0.0519***	—								
Profitability	(6)	-0.0626***	-0.1176***	-0.1825***	0.1036***	0.2342***	—							
Tangibility	(7)	-0.3925***	0.3526***	-0.1774***	-0.1354***	-0.0428***	-0.1728***	—						
Liquidity	(8)	-0.0845***	-0.1931***	-0.2413***	-0.0001	0.0548***	0.3110***	-0.2553***	—					
Nickell	(9)	0.1533***	0.2190***	0.3056***	0.0256***	0.0482***	0.0585***	0.0480***	-0.2444***	—				
St Ind. LR	(10)	0.2468***	—	—	0.1101***	0.0750***	0.1513***	-0.3510***	0.1482***	0.0049***	—			
Lt Ind. LR	(11)	—	0.2120***	—	-0.1481***	-0.0683***	-0.1469***	0.2829***	-0.1503***	0.0373***	-0.6944***	—		
Total Ind. LR	(12)	—	—	0.1563***	-0.0140***	0.0529***	0.0591***	-0.2182***	0.0626***	0.0274***	0.7019***	-0.2094***	—	
Ind. Growth	(13)	0.0964***	-0.0785***	0.0334***	0.0653***	0.2275***	0.1225***	-0.0923***	0.0704***	-0.0130***	0.3578***	-0.3454***	0.1901***	—

Notes: *** p<0.01

Table B.4: Spearman Correlation Coefficients of Leverage Ratios and Macroeconomic Variables

		(1)	(2)	(3)	(14)	(15)	(16)	(17)	(18)	(19)
St LR	(1)	—								
Lt LR	(2)	-0.3514***	—							
Total LR	(3)	0.7524***	0.1865***	—						
Tax Shield	(14)	-0.1911***	0.8211***	0.1489***	—					
Inflation	(15)	-0.0665***	-0.0141***	-0.0524***	0.0010	—				
GDP Growth	(16)	-0.0337***	-0.0375***	-0.0566***	-0.0975***	0.2783***	—			
Capital Flows	(17)	-0.1125***	0.0493***	-0.0903***	-0.0217***	0.2577***	0.0792***	—		
Unemployment	(18)	-0.2190***	0.1208***	-0.1988***	0.0006	-0.0711***	0.0503***	0.3835***	—	
Stock Prices	(19)	0.0045***	-0.0483***	-0.0081***	-0.0614***	-0.3096***	0.2462***	-0.0569***	0.0242***	—

Notes: *** p<0.01

B.2 Supplementary Regressions

Table B.5: Model Specification with different Fixed Effects

	(1) Total Leverage	(2) Total Leverage	(3) Total Leverage	(4) Long-term Leverage	(5) Long-term Leverage	(6) Long-term Leverage	(7) Short-term Leverage	(8) Short-term Leverage	(9) Short-term Leverage
Firm Size	0.005***	0.006***	0.008***	0.001***	0.001***	-0.004***	0.003***	0.004***	0.009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm Growth	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.159***	-0.184***	-0.182***	-0.062***	-0.056***	-0.052***	-0.128***	-0.164***	-0.165***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	-0.028***	-0.103***	-0.095***	0.103***	0.118***	0.120***	-0.103***	-0.238***	-0.215***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Liquidity	-0.080***	-0.152***	-0.139***	-0.003**	-0.026***	-0.035***	-0.075***	-0.157***	-0.133***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Nickell	0.000	0.000	0.000	0.000***	0.000*	0.000*	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Total Ind. LR	0.144***	0.136***	0.467***						
	(0.008)	(0.008)	(0.004)						
Lt Ind. LR				-0.094***	-0.005	0.513***			
				(0.013)	(0.008)	(0.006)			
St Ind. LR							0.158***	0.150***	0.424***
							(0.007)	(0.007)	(0.002)
Ind. Growth	0.008***	0.008***	-0.011***	-0.025***	-0.017***	-0.032***	0.031***	0.027***	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Tax Shield	1.097***	1.827***	1.810***	1.504***	1.881***	1.919***	-0.421***	-0.372***	-0.343***
	(0.020)	(0.019)	(0.019)	(0.088)	(0.045)	(0.055)	(0.025)	(0.066)	(0.066)
Inflation	0.001***	-0.003***	0.001***	-0.000	-0.002***	-0.000***	0.002***	-0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP Growth	0.001***	-0.001***	0.001***	0.001***	0.001***	0.000***	0.000***	-0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Flows	0.226***	-1.276***	0.250***	-0.209***	0.229***	-0.093***	0.465***	-1.756***	0.496***
	(0.033)	(0.029)	(0.033)	(0.044)	(0.024)	(0.031)	(0.039)	(0.032)	(0.039)
Unemployment	-0.002***	-0.005***	-0.002***	0.002***	0.001***	0.000***	-0.002***	-0.007***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	-0.000***	0.000***	0.000***	-0.000***	-0.000***	0.000***	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	N	N	Y	N	N	Y	N	N
Industry FE	N	Y	N	N	Y	N	N	Y	N
Country FE	N	N	Y	N	N	Y	N	N	Y
Constant	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	3,265,810	3,265,810	3,265,810	1,794,355	1,794,355	1,794,355	3,263,935	3,263,935	3,263,935
Number of firms	887,514	887,514	887,514	596,868	596,868	596,868	887,197	887,197	887,197
R-squared	0.099	0.174	0.208	0.136	0.252	0.272	0.204	0.259	0.305

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include year fixed effects and a constant but suppress their coefficients in the tables. All columns incorporate the baseline model specification introduced in Section 2.4.2. Columns 1, 4 and 7 include the same regressions as in Table 2.3 with firm fixed effects. Columns 2, 5 and 8 include industry fixed effects in regressions for total, long-term and short-term leverage, respectively. Columns 3, 6 and 9 include country fixed effects in regressions for total, long-term and short-term leverage, respectively. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.6: Sample Selection for Long-term and Short-term Leverage Ratios

	full sample **Long-term Leverage**	**long-term debt > 0** **Long-term Leverage**	**full sample** **Short-term Leverage**	**short-term debt > 0** **Short-term Leverage**
Firm Size	0.002***	0.001***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Firm Growth	0.000***	0.001***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.031***	-0.062***	-0.128***	-0.128***
	(0.001)	(0.002)	(0.001)	(0.001)
Tangibility	0.075***	0.103***	-0.103***	-0.103***
	(0.001)	(0.002)	(0.001)	(0.001)
Liquidity	-0.005***	-0.003**	-0.075***	-0.075***
	(0.001)	(0.002)	(0.001)	(0.001)
Nickell	0.000***	0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Lt Ind. LR	-0.023***	-0.094***		
	(0.008)	(0.013)		
St Ind. LR			0.158***	0.158***
			(0.007)	(0.007)
Ind. Growth	-0.023***	-0.025***	0.031***	0.031***
	(0.001)	(0.002)	(0.002)	(0.002)
Tax Shield	1.532***	1.504***	-0.423***	-0.421***
	(0.021)	(0.088)	(0.025)	(0.025)
Inflation	-0.000***	-0.000	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP Growth	0.000***	0.001***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Capital Flows	-0.258***	-0.209***	0.482***	0.465***
	(0.031)	(0.044)	(0.039)	(0.039)
Unemployment	-0.002***	0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Constant	Y	Y	Y	Y
Observations	3,265,810	1,794,355	3,265,810	3,263,935
Number of firms	887,514	596,868	887,514	887,197
R-squared	0.211	0.136	0.203	0.204

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. All columns incorporate the baseline model specification introduced in Section 2.4.2. Columns 2 and 4 include the same regressions as in Table 2.3 for long-term and short-term leverage ratios, respectively. Columns 1 and 3 include regressions for long-term and short-term leverage ratios, respectively, with the full sample. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

Table B.7: Baseline Results for Leverage Differences

	(1) **Total Difference**	(2) **Long-term Difference**	(3) **Short-term Difference**
Firm Size	0.005***	0.001***	0.005***
	(0.000)	(0.000)	(0.000)
Firm Growth	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Profitability	-0.158***	-0.064***	-0.158***
	(0.001)	(0.002)	(0.001)
Tangibility	-0.026***	0.103***	-0.026***
	(0.001)	(0.002)	(0.001)
Liquidity	-0.080***	-0.002	-0.080***
	(0.001)	(0.002)	(0.001)
Nickell	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)
Ind. Growth	0.002	-0.031***	-0.021***
	(0.002)	(0.002)	(0.002)
Tax Shield	1.082***	1.674***	1.098***
	(0.020)	(0.088)	(0.020)
Inflation	0.001***	-0.000*	0.001***
	(0.000)	(0.000)	(0.000)
GDP Growth	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Capital Flows	0.147***	-0.210***	0.129***
	(0.033)	(0.044)	(0.033)
Unemployment	-0.002***	0.002***	-0.002***
	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
Constant	Y	Y	Y
Observations	3,265,810	1,794,355	3,263,935
Number of firms	887,514	596,868	887,197
R-squared	0.097	0.102	0.182

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. All columns incorporate the baseline model specification introduced in Section 2.4.2. The dependent variables are differences of firms' total leverage from total industry median leverage in column 1, differences of firms' long-term leverage from long-term industry median leverage in column 2, and differences of firms' short-term leverage from short-term industry median leverage. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

Table B.8: Comparison of Empirical Capital Structure Models

	our model Total Leverage	Rajan and Zingales (1995) Total Leverage	Faulkender and Petersen (2006) Total Leverage	Frank and Goyal (2009) Total Leverage	Köksal, Orman and Oduncu (2013) Total Leverage
Firm Size	0.005***	0.009***	0.008***	0.0008***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm Growth	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.159***	-0.179***	-0.165***	-0.166***	-0.157***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tangibility	-0.028***	-0.006***	-0.028***	-0.028***	-0.028***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Liquidity	-0.080***		-0.087***	-0.088***	-0.078***
	(0.001)		(0.001)	(0.001)	(0.001)
Nickell	0.000			0.000	
	(0.000)			(0.000)	
Total Ind. LR	0.144***		0.190***	0.188***	0.159***
	(0.008)		(0.008)	(0.008)	(0.007)
Ind. Growth	0.008***				
	(0.002)				
Tax Shield	1.097***		1.140***	1.169***	1.083***
	(0.020)		(0.020)	(0.020)	(0.020)
Inflation	0.001***			0.003***	0.002***
	(0.000)			(0.000)	(0.000)
GDP Growth	0.001***			0.001***	0.001***
	(0.000)			(0.000)	(0.000)
Capital Flows	0.226***				0.476***
	(0.000)				(0.032)
Unemployment	-0.002***				
	(0.000)				
Stock Prices	0.000***		-0.000*	0.000***	
	(0.000)		(0.000)	(0.000)	
Year FE	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y
Observations	3,265,810	3,265,810	3,265,810	3,265,810	3,265,810
Number of firms	887,514	887,514	887,514	887,514	887,514
R-squared	0.099	0.072	0.082	0.084	0.087

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. Column 1 incorporates the baseline model specification introduced in Section 2.4.2 for total leverage ratios. Columns 2 includes Rajan and Zingales' (1995) model. Originally, they run a cross-sectional study on G7 countries in 1991. Column 3 includes Faulkender and Petersen's (2006) model. In their study, they analyze US firms from 1986 to 2000. Column 4 includes Frank and Goyal's (2009) model specification based on an analysis of public US firms from 1950 to 2003. Column 5 includes the model by Köksal, Orman and Oduncu (2013). They originally analyze Turkish firms from 1996 to 2009. In order to compare the different model specifications, we use the same sample for all regressions based on our model specification from Section 2.4.2 and the data set explained in Section 2.3. Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B.9: Results for Leverage Differences across Industries

	Manufacturing Total Difference	**Electricity Total Difference**	**Construction Total Difference**	**Wholes. trade Total Difference**	**Retail trade Total Difference**	**Transportation Total Difference**	**Accom. & food Total Difference**	**ICT & res. Total Difference**	**PAS Total Difference**
Firm Size	0.005***	0.012***	0.003***	0.009***	0.005***	0.011***	0.002	0.004***	0.006***
	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Firm Growth	0.001***	0.001**	0.000***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.186***	-0.195***	-0.137***	-0.165***	-0.178***	-0.165***	-0.169***	-0.127***	-0.130***
	(0.003)	(0.010)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.005)	(0.003)
Tangibility	-0.036***	0.003	-0.054***	-0.025***	0.011***	0.013**	-0.002	-0.027***	-0.017***
	(0.002)	(0.009)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.005)	(0.003)
Liquidity	-0.099***	-0.056***	-0.086***	-0.073***	-0.079***	-0.080***	-0.060***	-0.064***	-0.065***
	(0.002)	(0.010)	(0.002)	(0.002)	(0.004)	(0.005)	(0.006)	(0.005)	(0.003)
Nickell	0.000***	0.000**	-0.000	0.000***	0.000***	0.000	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ind. Growth	0.017***	0.040***	0.046***	0.050***		-0.043	-0.086**	0.016	0.060***
	(0.003)	(0.010)	(0.007)	(0.009)		(0.029)	(0.043)	(0.024)	(0.008)
Tax Shield	1.133***	1.484***	1.258***	0.895***	0.890***	0.997***	1.364***	1.170***	1.140***
	(0.039)	(0.163)	(0.047)	(0.039)	(0.063)	(0.095)	(0.134)	(0.127)	(0.071)
Inflation	0.002***	0.001**	0.002***	0.000***	0.000***	0.002***	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP Growth	0.000***	-0.001**	0.000***	0.001***	0.001***	0.001***	-0.000	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Flows	0.285***	0.592***	-0.011	0.024	-0.053	0.417***	0.195	0.438**	0.387***
	(0.062)	(0.246)	(0.084)	(0.063)	(0.107)	(0.145)	(0.192)	(0.202)	(0.136)
Unemployment	-0.001***	-0.006***	-0.002***	-0.002***	-0.001***	-0.002***	0.000	-0.001***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Stock Prices	0.000***	0.000	0.000***	0.000***	-0.000	0.000	-0.000	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	778,647	58,756	709,282	719,252	295,702	161,189	115,135	111,451	316,396
Number of firms	199,457	16,231	204,332	187,186	79,622	45,485	32,492	31,499	91,210
R-squared	0.104	0.049	0.128	0.129	0.066	0.038	0.026	0.076	0.084

Notes: See Table B.1 in the Appendix for definitions of the variables. Firm-level data and taxation comes from the ORBIS database. Data for macroeconomic factors comes from the World Bank. The dependent variables are differences of firms' total leverage from respective total industry median leverage. All variables are ratios, growth rates or logarithms. In all regressions, we include firm and year fixed effects and a constant but suppress their coefficients in the tables. All columns incorporate the baseline model specification introduced in Section 2.4.2. The nine industry clusters in the columns are "Manufacturing", "Electricity, gas and water supply", "Construction and real estate", "Wholesale trade", "Retail trade", "Transportation and storage", "Accommodation and food", "ICT and research" and "Professional and administrative services". Following Petersen (2009), we employ two-dimensional clustering of robust standard errors at firm-level and year-level. *** p<0.01, ** p<0.05, * p<0.1

B.3 Illustrations

Figure B.1: Firm Size across Countries

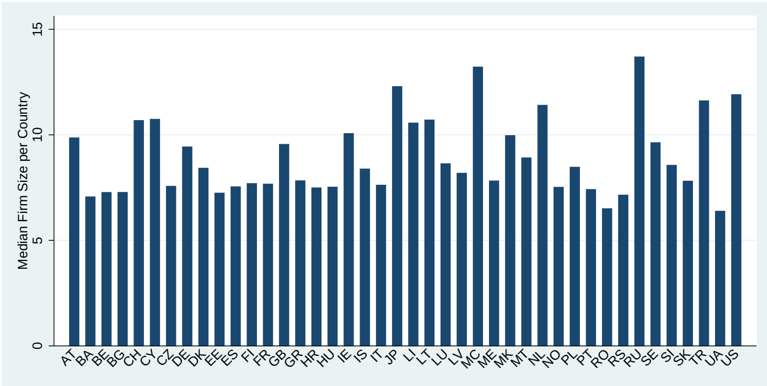


Figure B.2: Firm Size across Industries

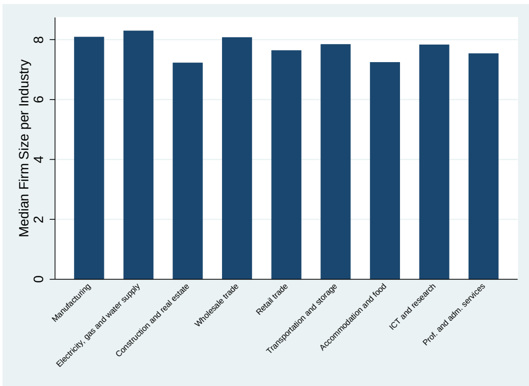


Figure B.3: Growth Rates across Countries

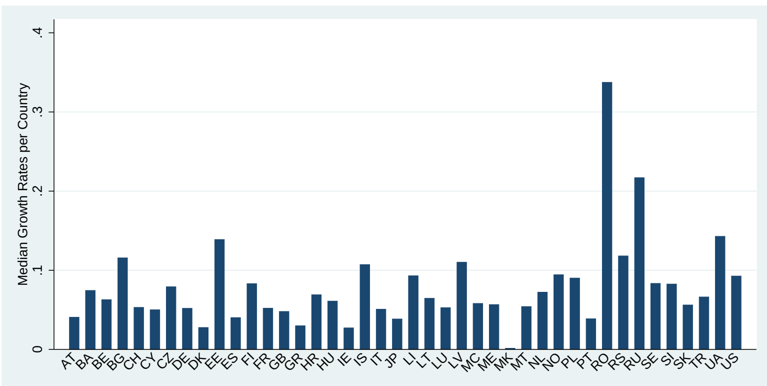


Figure B.4: Growth Rates across Industries

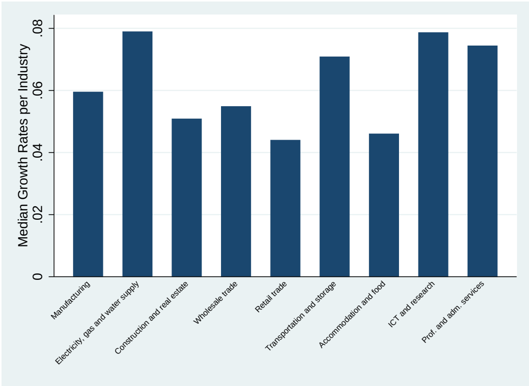


Figure B.5: Profitability across Countries

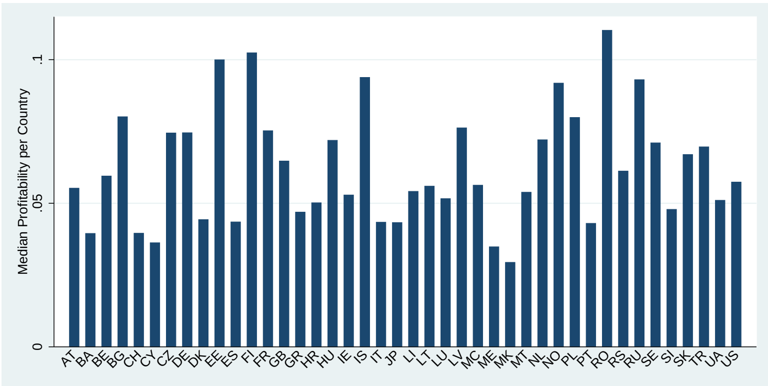


Figure B.6: Profitability across Industries

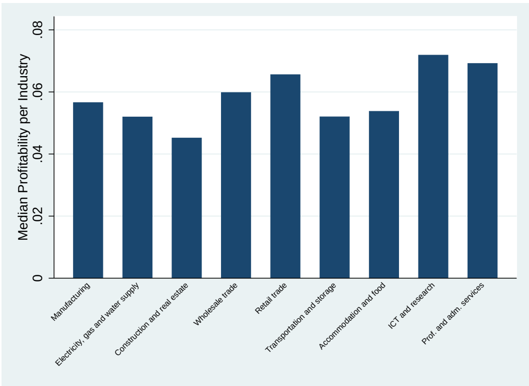


Figure B.7: Tangibility across Countries

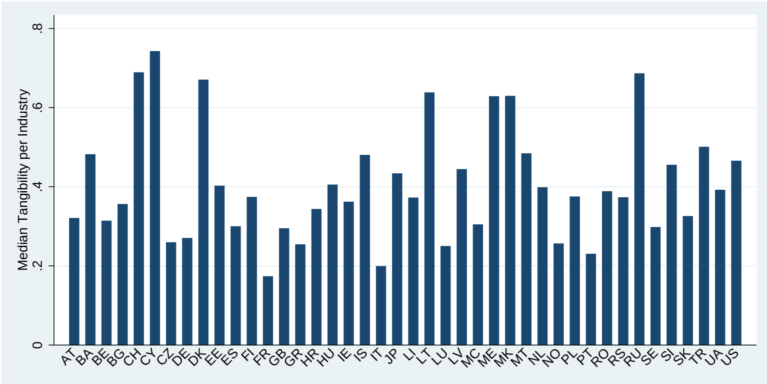
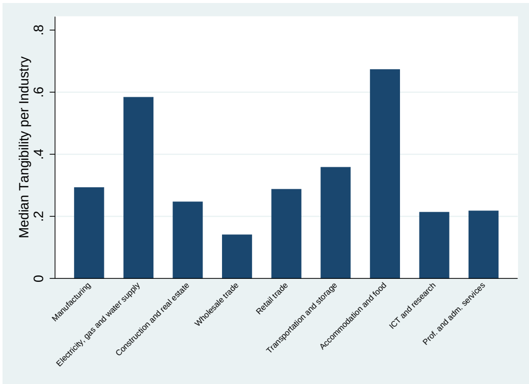


Figure B.8: Tangibility across Industries



Appendix C

Appendix to Chapter 3

Proof of Lemma 3.1

Verification of quality by introducing standardization is costly. We can distinguish three cases. Initially, We assume that the buyer pays the standardization costs solely. However, they can also be borne by the seller or shared among both agents without changing the equilibrium outcome of the game. We illustrate this in the following.

Case I The buyer pays for standardization. This is explained in the text.

Case II The auditor pays for standardization. The respective payoffs for the buyer are then: $\Pi_b(s_n|p_a) = 0$ and $\Pi_b(s_b|p_a) = q_h - p_a$. Hence, the maximum price that the auditor can then charge to the buyer and still sell the good is $p_a \leq q_h$.

The equilibrium depends on the range of p_v: For any $p_v \leq p_a - c_h \leq q_h - c_h$, buyer acquires the good with q_h at $c_h + p_v \leq p_a \leq q_h$. He then receives $\Pi_b(s_b|p_a) = q_h - p_a \geq 0$. The q_h auditor will not invest ($i_h = 0$) and have $\Pi_h = p_a - c_h - i_h - p_v = q_h - c_h - p_v \geq 0$ while the q_l auditor will invest ($i_l = c_h$) and also have $\Pi_l = p_a - c_l - i_l - p_v = q_h - c_h - p_v \geq 0$.

For any $p_v > q_h - c_h > p_a - c_h$, the buyer cannot buy the good irrespective of the quality because it is not supplied. The q_h auditor and q_l auditor would make losses

$\Pi_h = \Pi_l = p_a - c_h - p_v \leq q_h - c_h - p_v < 0$.

Case III Both agents pay for standardization. Let $0 < \alpha < 1$ denote the share of standardization costs covered by the buyer and $1 - \alpha$ the respective share covered by the auditor. Then payoffs for the buyer are: $\Pi_b(s_n|p_a) = 0$ and $\Pi_b(s_b|p_a) = q_h - p_a - \alpha p_v$. Hence, the maximum price that the auditor can then charge to the buyer and still sell the good is $p_a \leq q_h - \alpha p_v$.

Again, the equilibrium depends on the range of p_v: For any $p_v \leq \frac{p_a - c_h}{1-\alpha}$, the buyer acquires the good with q_h at $c_h + (1-\alpha)p_v \leq p_a \leq q_h - \alpha p_v$. He then receives $\Pi_b(s_b|p_a,) = q_h - p_a - \alpha p_v \geq 0$. Inserting p_v leads to $\Pi_b(s_b|p_a) = q_h - p_a - \alpha\left(\frac{p_a - c_h}{1-\alpha}\right) = \frac{(1-\alpha)q_h - (1-\alpha)p_a - \alpha p_a + \alpha c_h}{(1-\alpha)} = \frac{(1-\alpha)q_h - p_a + \alpha c_h}{(1-\alpha)} \geq 0$. This holds iff $(1-\alpha)q_h + \alpha c_h \geq p_a$. Because the regulator charges $p_v \leq \frac{p_a - c_h}{1-\alpha}$, the condition simplifies to $p_v \leq \frac{(1-\alpha)q_h + \alpha c_h - c_h}{1-\alpha} = \frac{(1-\alpha)(q_h - c_h)}{1-\alpha} \Leftrightarrow p_v \leq q_h - c_h$. This is always fulfilled since $q_h - c_h$ is the full economic rent from auditing. The q_h auditor will not invest ($i_h = 0$) and have $\Pi_h = p_a - c_h - i_h - (1-\alpha)p_v$ $= q_h - \alpha p_v - c_h - i_h - (1-\alpha)p_v = q_h - c_h - p_v \geq 0$ while the q_l auditor will invest ($i_l = c_h$) and also have $\Pi_l = p_a - c_l - i_l - (1-\alpha)p_v = q_h - \alpha p_v - c_l - i_l - (1-\alpha)p_v = q_h - c_h - p_v \geq 0$.

For any $p_v > \frac{p_a - c_h}{1-\alpha}$, the buyer cannot buy the good irrespective of the quality because the service is not provided. The q_h auditor and q_l auditor make losses $\Pi_h = \Pi_l = p_a - c_h - (1-\alpha)p_v < p_a - c_h - \frac{(1-\alpha)(p_a - c_h)}{1-\alpha} = 0$.

From the three cases illustrated above, we derive the price ranges the auditor can make use of because of her respective bargaining power against the buyer:

- case I - $c_h \leq p_a \leq q_h - p_v \Rightarrow q_h - c_h \geq p_v$
- case II - $c_h + p_v \leq p_a \leq q_h \Rightarrow q_h - c_h \geq p_v$
- case III - $c_h + (1-\alpha)p_v \leq p_a \leq q_h - \alpha p_v \Rightarrow q_h - c_h \geq p_v$

Hence, the equilibrium strategy of the regulator σ_r^* is unaffected by the shifting in p_a which determines the equilibrium outcome of the game of standardization independent of who pays the standardization costs. Q.e.d.

Proof of Proposition 3.1

The game is solved by backward induction. In t=5, the buyer buys the auditing service iff $\Pi_b(s_b|p_a) \geq 0$:

$$\sigma_b^* : \begin{cases} s_b & \textit{if } \ \Pi_b(s_b|p_a) \geq 0 \Leftrightarrow \tilde{q} - p_a - p_v \geq 0 \Leftrightarrow p_a \leq \tilde{q} - p_v = q_h - p_v \\ s_n & \textit{if } \ \Pi_b(s_b|p_a) < 0 \Leftrightarrow \tilde{q} - p_a - p_v < 0 \Leftrightarrow p_a > \tilde{q} - p_v = q_h - p_v \end{cases}$$

In t=4, the maximum price the auditor can charge to the buyer and still sell the auditing service is $p_a \leq \tilde{q} - p_v$ since $\tilde{q} - p_a - p_v \overset{!}{\geq} 0$ in order to have $\Pi_b(s_b|p_a) \geq 0$. The auditor solves

$$\max_{p_a} \Pi_i = p_a - c_i - i_k$$
$$s.t. \ 1) \ c(\tilde{q}) \leq p_a \leq \tilde{q} - p_v$$
$$2) \ \Pi_i \geq 0$$

Then,

$$\frac{\partial \Pi_i}{\partial p_a} = 1$$
$$\Pi_i|_{p_a=0} = 0 - c_i - i_k < 0$$
$$\Pi_i|_{p_a=\tilde{q}-p_v} = q_h - p_v - c_i - i_k \geq 0$$

Hence,

$$\textit{Auditor's strategy } \sigma_i^* : \begin{cases} p_a^* = \tilde{q} - p_v & \textit{if } \ p_v \leq q_h - c_i - i_k \\ \textit{any } p_a \geq c(\tilde{q}) & \textit{if } \ p_v > q_h - c_i - i_k \end{cases}$$

In t=3, the auditor chooses her investment level to attain the quality threshold set by the regulator in standardization. Since quality is standardized at $\tilde{q} = q_h$, the auditor's quality target that she wants to attain becomes $\hat{q} = \tilde{q} = q_h$. Then, the auditor sets her investment level according to $i_k = c(\tilde{q}) - c(q_i)$ where $i_k \in [0, c_h]$. For the q_h auditor, any

$i_k \geq 0$ attains $\tilde{q} = q_h$ so that $i_h^* = 0$.[1] The q_l auditor needs to invest $i_l = c(\tilde{q}) - c(q_l)$ to attain $\tilde{q} = q_h$. Since $c(q_l) = c_l = 0$, I find $i_l = c(\tilde{q})$ and since $c(\tilde{q}) = c_h$, I find $i_l^* = c_h$.[2]

In t=2, nature moves and allocates audit quality q_i.

In t=1, given the auditor's and buyer's strategies, the regulator sets $\tilde{q} = q_h$ and solves

$$\max_{p_v} \Pi_r^s = x^s(p_v - c_v)$$
$$s.t.\ 1)\ i_h^* = 0, i_l^* = c_h$$
$$2)\ p_a^* = q_h - p_v$$
$$3)\ p_v \leq q_h - c_h$$
$$4)\ c_v \in [0, q_h - c_h]$$
$$5)\ \Pi_r^s \geq 0$$
$$6)\ x^s = 1$$

Then,

$$\frac{\partial \Pi_r^s}{\partial p_v} = 1$$
$$p_v^* = q_h - c_h$$
$$p_a^* = c_h$$

Hence, $\Pi_b^*(s_b|p_a) = \tilde{q} - p_a - p_v = q_h - c_h - (q_h - c_h) = 0$, $\Pi_h^* = p_a - c_h - i_h = c_h - c_h = 0$, $\Pi_l^* = p_a - c_l - i_l = c_h - c_h = 0$ and the regulator's profit is $\Pi_r^s = x^s(p_v - c_v) = q_h - c_h - c_v$ because the probability of verifying quality in standardization is $x^s = 1$ by assumption.

Q.e.d.

[1] Any $i_h > 0$ only increases costs but not profits.

[2] Any $i_l > c_h$ only increases costs but not the quality, by definition. Any $i_l < c_h$ does not attain $\tilde{q}$.

Proof of Lemma 3.2

Note that certification yields the auditors $\Pi_h(c) = q_h - c_h$ and $\Pi_l(c) = q_l$, respectively. For any $p_v \leq q_h - c_h$, certifying will get the q_h auditor a payoff of $\Pi_h(c) = q_h - c_h - p_v \geq 0$ so that $\sigma_h(c) = 1$ while the q_l auditor makes $\Pi_l(c) = q_l - p_v < q_l$ so that $\sigma_l(c) = 0$. For any $p_v > q_h - c_h$, certification would give the q_h auditor a negative payoff: $\Pi_h(c) = q_h - c_h - p_v < 0$ and yield the q_l auditor a payoff of $\Pi_l(c) = q_l - p_v < q_l$ which is guaranteed if no certification occurs. Q.e.d.

Proof of Proposition 3.2

The game is solved by backward induction. In t=5, the buyer buys the auditing service iff $\Pi_b(s_b|p_a, \mu_b) = \mu \cdot q_h + (1-\mu)q_l - p_a \geq 0$:

$$\sigma_b^* : \begin{cases} s_b & \textit{if} \;\; \Pi_b(s_b|p_a, \mu_b) \geq 0 \Leftrightarrow p_a \leq \mu_b(p_a)\Delta q + q_l \\ s_n & \textit{if} \;\; \Pi_b(s_b|p_a, \mu_b) \leq 0 \Leftrightarrow p_a \geq \mu_b(p_a)\Delta q + q_l \end{cases}$$

He buys the good ($\sigma_b = s_b$) if $\mu_b(p_a)\Delta q + q_l \geq p_a$. Then $\mu_b \geq \frac{p_a - q_l}{q_h - q_l}$ so that $\mu_b = 1$ iff $p_a = q_h$ and $\mu_b = 0$ iff $p_a = q_l$. The buyer believes that the good is q_h if it is certified and $p_a = q_h$. Hence,

$$\mu_b^* : \begin{cases} \mu_b^* = 1 & \textit{if} \;\; p_a = q_h \quad \wedge \quad \sigma_i^*(c) = 1 \\ \mu_b^* = 0 & \textit{if} \;\; p_a < q_h \quad \vee \quad \sigma_i^*(c) = 0 \end{cases}$$

In t=4, the auditor decides whether or not she wants to obtain certification of her quality. From Lemma 3.2, we know that

$$\sigma_h^* : \begin{cases} \sigma_h^*(c) = 1 & \textit{if} \;\; p_v \leq q_h - c_h \\ \sigma_h^*(c) = 0 & \textit{if} \;\; p_v > q_h - c_h \end{cases}$$

$$\sigma_l^*(c) = 0 \;\; \forall \;\; p_v$$

For $p_v \leq q_h - c_h$, the q_h auditor always certifies while the q_l auditor never certifies. For $p_v > q_h - c_h$, any equilibrium involves no certification.

In t=3, the maximum price the auditor can charge to the buyer and still sell the auditing service is $p_a \leq \mu_b(p_a)\Delta q + q_l$ since $\mu_b(p_a)\Delta q + q_l \overset{!}{\geq} p_a$ in order to have $\Pi_b(s_b|p_a, \mu_b) \geq 0$. If $\mu_b = 1$, the maximum price that the auditor can then charge to the buyer and still sell the good becomes $p_a \leq \mu_b(p_a)\Delta q + q_l \Leftrightarrow p_a \leq q_h$, whereas if $\mu_b = 0$, then $p_a \leq q_l$. The high-type auditor solves

$$\begin{aligned} \max_{p_a} \ \Pi_h &= p_a - c_h - p_v \\ s.t. \ 1) \ & c(q_h) \leq p_a \leq \mu_b(p_a)\Delta q + q_l \\ 2) \ & \sigma_h^*(c) \\ 3) \ & \mu_b^* \\ 4) \ & \Pi_h \geq 0 \end{aligned}$$

Then,

$$\begin{aligned} \frac{\partial \Pi_h}{\partial p_a} &= 1 \\ p_a^* &= q_h \end{aligned}$$

The low-type auditor solves

$$\begin{aligned} \max_{p_a} \ \Pi_l &= p_a - c_l \\ s.t. \ 1) \ & c(q_l) \leq p_a \leq \mu_b(p_a)\Delta q + q_l \\ 2) \ & \sigma_l^*(c) \\ 3) \ & \mu_b^* \\ 4) \ & \Pi_l \geq 0 \end{aligned}$$

Then,

$$\frac{\partial \Pi_l}{\partial p_a} = 1$$
$$p_a^* = q_l$$

In any separating equilibrium, prices equal productivities, i.e. $p_a^*(\mu_b^*(p_a), q_h) = q_h$ and $p_a^*(\mu_b^*(p_a), q_l) = q_l$.[3] Hence,

$$\textit{Auditor's strategy } \sigma_h^* : \begin{cases} p_a^* = q_h;\ \sigma_h^*(c) = 1 & \textit{if } \ p_v \leq q_h - c_h \\ \textit{any } p_a \geq c_h;\ \sigma_h^*(c) = 0 & \textit{if } \ p_v > q_h - c_h \end{cases}$$

$$\textit{Auditor's strategy } \sigma_l^* : \begin{cases} p_a^* = q_l;\ \sigma_l^*(c) = 0 & \textit{if } \ p_v \leq q_h - c_h \\ \textit{any } p_a \geq c_l;\ \sigma_l^*(c) = 0 & \textit{if } \ p_v > q_h - c_h \end{cases}$$

In t=2, nature moves and allocates audit quality q_i.

In t=1, given the auditor's and buyer's strategies, the regulator solves

$$\begin{aligned} \max_{p_v} \ & \Pi_r^c = x^c(p_v - c_v) \\ s.t. \ & 1)\ \sigma_h^*(c), \sigma_l^*(c) \\ & 2)\ p_a^*(\mu_b^*(p_a), q_h) = q_h \text{ and } p_a^*(\mu_b^*(p_a), q_l) = q_l \\ & 3)\ p_v \leq q_h - c_h \\ & 4)\ c_v \in [0, q_h - c_h] \\ & 5)\ \Pi_r^c \geq 0 \\ & 6)\ x^c = \lambda \end{aligned}$$

[3]If $p_a > q_i$, the buyer makes losses from contracting the auditor. If $p_a < q_i$, then another buyer can offer $p_a' \equiv p_a + \epsilon < q_i$ and contract the auditor profitably for any $\epsilon > 0$.

Then,

$$\frac{\partial \Pi_r^c}{\partial p_v} = \lambda$$
$$p_v^* = q_h - c_h$$

Hence, $\Pi_b^*(s_b|p_a, \mu_b) = \mu_b^*(p_a)\Delta q + q_l - p_a = 0$, $\Pi_h^* = p_a - c_h - p_v = q_h - c_h - (q_h - c_h) = 0$, $\Pi_l^* = p_a - c_l = q_l$ and the regulator's profit is $\Pi_r^c = x^c(p_v - c_v) = \lambda(q_h - c_h - c_v)$ because the probability of verifying quality in certification is $x^c = \lambda$. Certification cannot yield any higher payoff than $\lambda(q_h - c_h - c_v)$ because this would require either $p_v > q_h - c_h$ or that the low-quality auditor certifies with strictly positive probability ($\sigma_l(c) > 0$). The regulator can only acquire $\lambda\,(q_h - c_h - c_v)$ with $p_v = q_h - c_h$ and $\sigma_h(c) = 1$. Q.e.d.

Proof of Lemma 3.3

The comparisons of the four different welfare measurements are calculated in the following.

Standardization In comparison to welfare with observable quality, $W^s > W$ iff

$$q_h - c_h - x^s \cdot c_v > \lambda(q_h - c_h) + (1 - \lambda)q_l$$
$$\Leftrightarrow (1 - \lambda)(q_h - c_h) - (1 - \lambda)q_l - c_v > 0$$
$$\Leftrightarrow c_v < (1 - \lambda)(\Delta q - c_h).$$

In comparison to welfare without verification of quality, $W^s > \overline{W}$ iff

$$q_h - c_h - x^s \cdot c_v > (1 - \lambda)q_l$$
$$\Leftrightarrow q_h - c_h - (1 - \lambda)q_l > c_v$$
$$\Leftrightarrow c_v < \lambda(q_h - c_h) + (1 - \lambda)(\Delta q - c_h).$$

Certification In comparison to welfare with observable quality, $W > W^c$ iff

$$\lambda(q_h - c_h) + (1 - \lambda)q_l > \lambda(q_h - c_h) + (1 - \lambda)q_l - x^c \cdot c_v$$
$$\Leftrightarrow \lambda \cdot c_v > 0$$

which is always given since $0 < \lambda < 1$ and $c_v \in [0, q_h - c_h]$.

In comparison to welfare without verification of quality, $W^c > \overline{W}$ iff

$$\lambda(q_h - c_h) + (1-\lambda)q_l - x^c \cdot c_v > (1-\lambda)q_l$$
$$\Leftrightarrow \lambda(q_h - c_h) > \lambda \cdot c_v$$
$$\Leftrightarrow c_v < q_h - c_h$$

which is always given since $c_v \in [0, q_h - c_h]$.

Comparison between regulatory regimes When comparing both regulatory regimes, $W^c > W^s$ iff

$$\lambda(q_h - c_h) + (1-\lambda)q_l - x^c \cdot c_v > q_h - c_h - x^s \cdot c_v$$
$$\Leftrightarrow (\lambda - 1)(q_h - c_h) + (1-\lambda)q_l + (x^s - x^c)c_v > 0$$
$$\Leftrightarrow (1-\lambda)(q_l + c_v) > (1-\lambda)(q_h - c_h)$$
$$\Leftrightarrow c_v > \Delta q - c_h.$$

Comparison between non-regulatory regimes When comparing both non-regulatory regimes with and without information asymmetries, $W > \overline{W}$ $\forall$ c_v because

$$\lambda(q_h - c_h) + (1-\lambda)q_l > (1-\lambda)q_l$$
$$\Leftrightarrow \lambda(q_h - c_h) > 0$$

which is always given since $0 < \lambda < 1$ by definition and $q_h - c_h > 0$ by assumption.Q.e.d.

Proof of Lemma 3.4

The thresholds for c_v are necessary for ranking the four different welfare measurements. Remember that the regulator can verify the auditor's quality at cost $c_v \in [0, q_h - c_h]$. Each such threshold is an interval of values for c_v for which a clear ranking of the different welfare measures is possible. The intervals are established by bringing the five cut-off values of c_v in order such that $\underbrace{0}_{min} < \underbrace{(1-\lambda)(\Delta q - c_h)}_{T^1} < \underbrace{\Delta q - c_h}_{T^2} < \underbrace{\lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h)}_{T^3} < \underbrace{q_h - c_h}_{max}$.

First, $0 < T^1$ since $(1-\lambda) > 0$ and $\Delta q > c_h$ by assumption.

Second, $T^1 < T^2$ since $0 < \lambda < 1$ by definition.

Third, $T^2 < T^3$ since $T^2 = \Delta q - c_h \Leftrightarrow \lambda(\Delta q - c_h) + (1-\lambda)(\Delta q - c_h)$ so that $T^2 < T^3 \Leftrightarrow \lambda(\Delta q - c_h) < \lambda(q_h - c_h)$ which obviously holds by $\Delta q = q_h - q_l < q_h$.

Finally, $T^3 < q_h - c_h$ since $\lambda(q_h - c_h) + (1-\lambda)(\Delta q - c_h) < q_h - c_h \Leftrightarrow (1-\lambda)(\Delta q - c_h) < (1-\lambda)(q_h - c_h)$ which obviously holds by $\Delta q = q_h - q_l < q_h$.

Q.e.d.

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