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The Impact of Production Characteristics on Capital Structure and Mergers & Acquisitions

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To my family

Abstract

This thesis addresses fundamental questions on the impact of a company's production characteristics on its capital structure and M&A decisions. Three major research areas are empirically addressed: *First*, a positive effect of production flexibility on leverage is shown. *Second*, it is confirmed, by using a consistently defined and direct asset maturity measure, that debt and asset maturity match. Moreover, the finding that a mismatch in debt and asset maturity increases the yield spread of debt at issuance is contributed. *Third*, for a sample of international listed utility companies, no significance for an effect of diversification in production technology on abnormal acquirer returns in horizontal M&A deals is found.

Kurzfassung

Die vorliegende Arbeit untersucht fundamentale Fragestellungen hinsichtlich des Einflusses von Produktionseigenschaften eines Unternehmens auf seine Kapitalstruktur sowie auf Fusions- und Übernahmeentscheidungen. Drei wesentliche Forschungsbereiche werden adressiert: Zunächst wird gezeigt, dass Produktionsflexibilität einen positiven Einfluss auf den Fremdfinanzierungsgrad hat. Des Weiteren wird mit einem konsistent definierten, direkten Maß bestätigt, dass die Fristigkeit von Fremdkapital auf die Fristigkeit des Anlage- und Umlaufvermögens abgestimmt ist. Darüber hinaus wird gezeigt, dass eine Diskrepanz zwischen den Fristigkeiten von Fremdkapital und dem Anlage- und Umlaufvermögen den Zinsaufschlag von Fremdkapitalemissionen erhöht. Abschließend wird für ein Sample von internationalen, börsennotierten Energieversorgern kein signifikanter Einfluss von Diversifikation in den Produktionstechnologien auf abnormale Käufer-Renditen in horizontalen Fusionen und Übernahmen gefunden.

Summary

This thesis addresses fundamental questions on the impact of production characteristics on capital structure and M&A decisions. Even though there are studies hinting at the importance of production characteristics, empirical research on their impact generally is scarce. Besides addressing this research gap, this thesis is relevant for practitioners, as it provides guidance on how production characteristics affect capital structure, debt maturity, yield spreads of debt issues, and acquirer stock market returns in horizontal M&A transactions.

As a basis for my research, I utilize an international sample of listed electric utility companies since their production characteristics can be directly measured by referring to each company's power plants. This sample includes about half of the world's installed electricity generation capacity.

In the following, the research areas addressed in this thesis and the respective findings are briefly summarized: *First*, Mauer and Triantis (1994) discuss in their theoretical paper, that production flexibility increases leverage. Yet, empirical evidence is missing. In his related empirical paper, MacKay (2003) also addresses production flexibility. However, he finds contradicting results. I empirically address and confirm the hypotheses of Mauer and Triantis (1994) using a new dataset which relies on more direct measures of production flexibility. I find that production characteristics are of similar importance to the capital structure compared to the more established "financial" determinants. In addition, I show that there is a substitution effect between production flexibility and financial flexibility.

Second, it seems to be "conventional wisdom" that asset maturity – i.e. the remaining lifetime of assets – determines the maturity of debt. While there is literature addressing this issue, e.g. Stohs and Mauer (1996), Guedes and Opler (1996) and Barclay, Marx and Smith (2003), their measures used for asset maturity are based on the problematic term "Net Property, Plant & Equipment divided by deprecations". I demonstrate mathematically that these established measures can *not* be interpreted as suggested by the literature. Instead, I suggest to use a direct measure of asset maturity. To my best knowledge, there is no empirical proof based on a direct measure of the remaining lifetimes of assets for a sample of non-financial companies. Empirically, I apply such bottom-up measure in order to provide a consistent proof of the matching of debt maturity and asset maturity. Furthermore, I show that a mismatch of debt and asset maturity leads to increased relative yield spreads for new debt at issuance. Such effect on financing costs adds another motivation for debt and asset maturity matching to the debt structure literature.

Consistent with the hypotheses of Benmelech (2009), I show that salability positively affects leverage *and* debt maturity.

Third, mergers and acquisitions might be influenced by production characteristics. While the

effect of industrial diversification on cumulative abnormal returns is studied in detail in the literature, I analyze whether diversification in production technologies affects cumulative abnormal acquirer returns specifically in horizontal deals, i.e. when electricity generating companies buy other electricity generating companies. By simply using SIC codes such horizontal deals would be classified as being non-diversifying, while at the production asset level they can either be diversifying or concentrating with regard to production characteristics.
I find significant positive cumulative abnormal acquirer returns for (horizontal) M&A deals in the utility industry. However, I do *not* find a significant difference in cumulative abnormal acquirer returns between diversifying and concentrating M&A deals with regard to production technologies.

Overall, this thesis demonstrates that production characteristics are relevant determinants in corporate finance decisions.

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List of Abbreviations

2SLS	Two-stage Least Squares
approx.	approximately
avg.	average
bn	billion
CAR	Cumulative abnormal return
CCGT	Combined Cycle Gas Turbine
COD	Commercial Operation Date
DG	Directorate-General
DSCD	Datastream Code
e.g.	example given
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciations, and Amortizations
EC	European Commission
EIA	Energy Information Administration
et al.	et alii
EU	European Union
FASB	Financial Accounting Standards Board
Fig.	Figure
h	hours
i.e.	id est
IAS	International Accounting Standards
IEA	International Energy Agency
IFRS	International Financial Reporting Standards

LCOE	Levelised Cost of Energy
M&A	Mergers and Acquisitions
MSCI	Morgan Stanley Capital International
MW	Megawatt
NEA	Nuclear Energy Agency
O&M	Operations & Maintenance
O&M	Operations and Maintenance
Obs.	observations
OLS	Ordinary Least Squares
perc.	percentile
PP&E	Property, Plant and Equipment
ROA	Return On Assets
SD	Standard deviation
SDC	Securities Data Company
SIC	Standard Industrial Classification
U.S.	United States of America
US-GAAP	United States Generally Accepted Accounting Principles
USD	United States Dollar
VIF	Variance Inflation Factor
vs.	versus
WEPP	World Electric Power Plant

1. Introduction

Capital structure and mergers and acquisitions are broadly discussed topics in corporate finance literature. Nevertheless, there are relevant issues that remain unsolved until today. A vast range of empirical capital structure analyses exists, which mainly focuses on established "financial" firm characteristics. However, recent capital structure research showed that production characteristics are likely to be relevant determinants of the capital structure. Lemmon, Roberts and Zender (2008), Rauh and Sufi (2012) and Leary and Roberts (2013) suggest a relevant impact of production characteristics on the capital structure, while they do not explicitly identify these factors. Overall, capital structure research directly referring to such production characteristics is scarce.

One of these production characteristics is *production flexibility*. Besides a motivation from academic literature, this research is also relevant, e.g., for the utility industry. Today, the transformation of the energy system demands for a flexibilization of utilities' production assets in order to integrate an increasing share of renewable generation assets into the electricity system. Learning about the impact of such developments on the firms' capital structures is relevant for industry practitioners and policy makers.

To date, the impact of production characteristics on capital structure and M&A decisions is largely neglected in empirical research. If considered at all, production asset characteristics are typically parametrized indirectly by established accounting variables. However, using direct "real" data from the level of production assets and linking these fundamental measures to empirical models is applied rarely, potentially because such data is hardly available for large-scale samples. Nevertheless, such analyses provide guidance for companies that change their asset characteristics.

One application that suffers from the non-availability of a direct measure is the missing proof of the theoretical suggestion that *production flexibility* influences the capital structure. Further, several scholars claim to have shown that debt and asset maturity match, while their *asset maturity* measures are inconsistent, as they rely on unreasonably strong assumptions. One of these is that lifetimes of all property, plant and equipment are assumed to be equal. Thus, as scholars can not observe the asset level, their measures become fuzzy and impossible to interpret. Moreover, in M&A transactions, unobserved production characteristics might result in relevant effects on cumulative abnormal acquirer returns. In this thesis, I test whether *diversification in production technology*, derived from the level of production assets, is relevant in order to understand market reactions on M&A deals in the utility industry.

For utility companies, such asset level data regarding the companies production assets is, in principle, available from an international power plant database. Consequently, this data can be used in order to derive direct, bottom-up measures for production asset characteristics. Thereby, effects that derive from the asset level – which can not be observed or parametrized indirectly from accounting measures – can be addressed with direct measures of production asset characteristics. While the empirical analyses included in this thesis are based on a sample of international electric utility companies, it is demonstrated that – regarding their capital structure mechanics– they behave very similar to companies in cross industry samples.

In so far, this thesis generally breaks new ground for the role of non-financial, asset-level variables as relevant determinants in corporate finance.

1.1. Research questions

This section outlines the research questions addressed in this thesis. These questions are separated in three blocks, questions A mainly refer to the influence of production asset characteristics on the capital structure, questions B refer to the impact of production asset characteristics on debt maturity structure, and questions C refer to the influence of diversification at the level of production assets on M&A.

The **major research questions** are:

Question A.1: How does production flexibility influence a firm's leverage ratio?

Question A.2: Do production flexibility and financial flexibility act as substitutes or complements?

Question A.3: Are production asset characteristics of similar importance in comparison to the established "financial" determinants of capital structure?

Question B.1: How does a firm's asset maturity affect its debt maturity? How can a consistent empirical proof of "maturity matching" look like?

Question B.2: How does a mismatch of debt and asset maturity affect the relative yield spread of new debt issues?

Question C.1: Do M&As in the utility industry result in cumulative abnormal acquirer returns? Which are the relevant determinants?

Question C.2: How does diversification in production technology impact cumulative abnormal acquirer returns in horizontal M&As?

Besides these major questions, there are some **additional research questions** also touched in the course of this thesis:[1]

Question A.4: How does asset salability affect leverage?

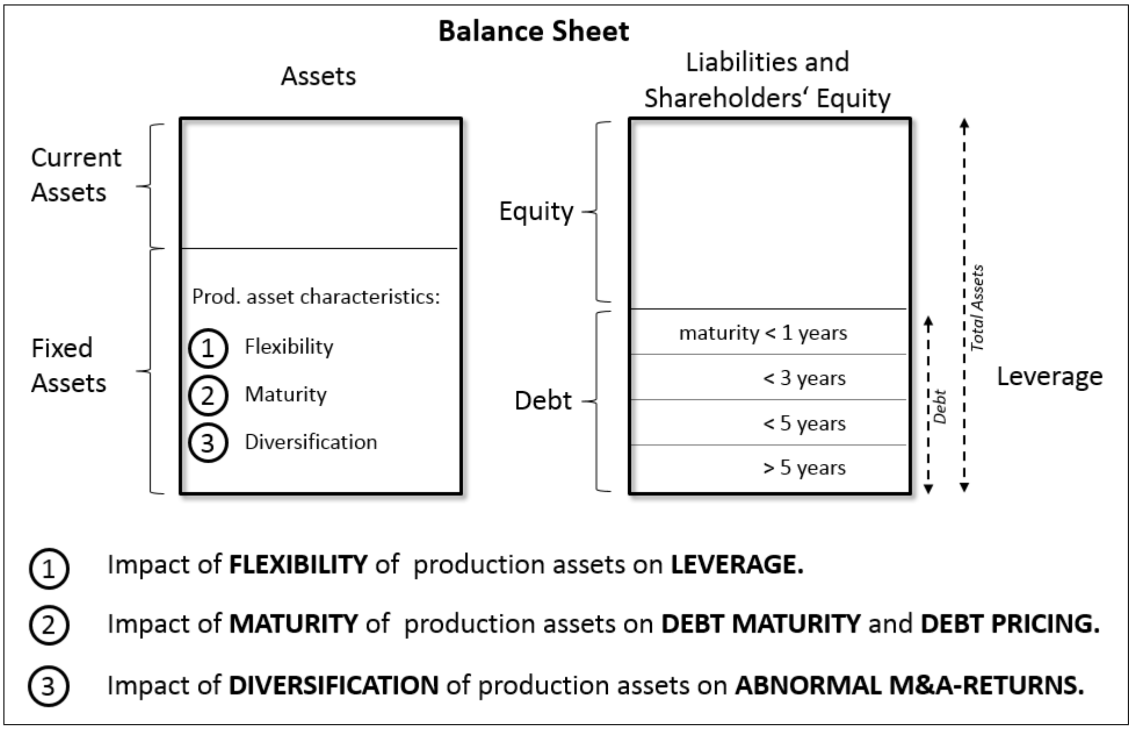
[1] Some of these aspects might have been addressed, at least partially, by the existing literature, as it will be reviewed in the course of this thesis.

Question A.5: How do the average age of production assets and regional diversification influence the capital structure?

Question B.3: How does asset salability influence a firm's debt maturity?

The following Figure 1.1 briefly summarizes the major areas of my research. As pointed out before, I address the effect of production assets characteristics – to be found on the left side of the balance sheet ("Assets") – on the capital structure – to be found on the right side of the balance sheet ("Liabilities and shareholder's equity") – as well as on mergers and acquisitions.

Figure 1.1.: Schematic and illustrative overview of major research areas



1.2. Structure

This thesis should neither be seen as being an exhaustive review of the existing literature on capital structure with regard to leverage and debt maturity, nor as a complete review of the mergers and acquisitions literature. In other words, it should not be understood as a general textbook on capital structure or mergers and acquisitions. Instead, I address specific research gaps in the aforementioned fields that are related to the characteristics of a firm's production assets.

This thesis is structured as follows:

Chapter 2 provides an overview on the literature related to the specific research questions addressed in this thesis. At the beginning, an introduction to the capital structure literature is given, followed by an overview on research concerning financial flexibility. Next, literature assessing the impact of asset characteristics on the capital structure is reviewed. Especially, production flexibility and asset salability are discussed. Furthermore, a review of the literature regarding the matching of debt and asset maturity is given. In addition, the determinants of the yield spread of debt at issuance are reviewed. Also, an overview on the effect of diversification in the context of mergers and acquisitions is provided. This chapter closes with a brief review of findings regarding the capital structure of utility companies in finance research. The literature review addresses those papers that are relevant for my research; it shall not be seen as being exhaustive.

Chapter 3 derives the hypotheses relevant for the further course of this thesis. *First*, the expected effect of production flexibility on leverage is derived. *Second*, it is shown mathematically that the existing measures using "Net Property, Plant and Equipment divided by Annual Deprecations" can *not* be interpreted as an approximation for the remaining lifetime of assets, i.e. the asset maturity. Instead a direct measure is suggested. Furthermore, the hypothesis for the impact of a mismatch of debt and asset maturity on the yield spread of new debt at issuance is presented. Also, the hypotheses for the impact of asset salability on leverage and debt maturity are derived. *Third*, the hypothesis on the impact of diversification in production technologies on cumulative abnormal acquirer returns from M&As is presented.

Chapter 4 explains the construction of the sample, which the further empirical analyses in this thesis are based on. All addressed research questions refer to a sample of international, listed electric utility companies, since their production assets are observable.

Chapter 5 presents the empirical results. *First*, empirical results for the impact of production flexibility on the capital structure are discussed and a causality argument is given. Also, several robustness tests are conducted. *Second*, an empirical proof for the matching of debt and asset maturity – based on a direct measure of asset maturity – is given. Furthermore, empirical results for the impact of a mismatch of debt and asset maturity on the yield spread of new debt issues are discussed. Again, several robustness tests are performed. *Third*, the impact of diversification in production technologies on cumulative abnormal acquirer returns from M&A deals is analyzed.

Chapter 6 summarizes the main findings and discusses their implications. Besides this, the contribution of this thesis to the existing literature is discussed. Furthermore, potential directions for future research are highlighted.

2. Literature Review

This chapter provides an overview on selected aspects of capital structure and mergers and acquisitions research. It intends to familiarize the reader with those aspects that are relevant for the further course of this thesis. This chapter is not intended to give a textbook-like overview neither on capital structure nor on mergers and acquisitions.

First, this chapter addresses the determinants of the capital structure and the concepts of financial flexibility, production flexibility and asset salability. *Second*, it reviews relevant literature on the role of asset maturity as a determinant of debt maturity. *Third*, relevant literature on mergers and acquisitions as well as diversification is reviewed. *Fourth*, to the extent required for my further analysis, I review relevant findings from the finance literature, that are specific to the utility industry, their regulation and their capital structure.

2.1. Capital structure, flexibility and asset characteristics

In this section, literature related to the determinants of leverage is summarized. *First*, a general introduction to the capital structure literature is given, and *second*, the established empirical determinants of the capital structure are presented. *Third*, financial flexibility is discussed as a determinant of the capital structure. *Fourth*, literature relating operational leverage, production flexibility, and asset salability to the capital structure is briefly reviewed.

2.1.1. Established theory and empirical determinants of the capital structure

The "capital structure puzzle"[1] is one of the earliest and most frequently reviewed topics of finance research. Theories have been developed in order to explain capital structure decisions, beginning with the irrelevance statement of Modigliani and Miller (1958) for companies in perfect capital markets. Later, the approaches of *tradeoff theory*, i.e. weighting cost of distress against the tax shield effect of debt, *pecking order theory*[2], *agency* aspects[3] and *market timing theory*[4] were added, when the assumptions of perfect capital markets were relaxed.[5] Since then, scholars aim at differentiating these theories from each other and finally urge to explain the empirically observed corporate capital structure.

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1 Cf. Myers (1984)
2 Cf. Donaldson (1961), Myers (1984), Myers and Majluf (1984) for the general idea and Brounen, De Jong and Koedijk (2006) for survey evidence.
3 Cf. Jensen and Meckling (1979)
4 Cf. Baker, Powell and Veit (2002)
5 Cf. Harris and Raviv (1991) for an overview. Cf. Graham and Leary (2011) for an overview on empirical capital structure research since 2005.

However, classical theories fall short in explaining several empirically observed issues, e.g. the violation of pecking order by frequent equity issues (Fama and French (2005)), forgone tax shield from low leverage (Graham (2000)), stock issuance after exogenous leverage increases (Baker, Powell and Veit (2002), Welch (2004) and Fama and French (2005)), the negative impact of profitability on leverage (Strebulaev (2007)) and several other empirical observations.

Myers (2003) argues, that there is no fundamental capital-structure-theory-of-everything, i.e. a theory explaining all capital structures for each kind of company in every specific situation. The capital structure is rather determined by company specific factors.

2.1.1.1. Optimal target level of leverage

Fama and French (2005) vote for stopping the "horse races [between tradeoff and pecking order model] as stand alone stories for capital structure"[6]. However, one of the frequently addressed questions in capital structure research is still, whether companies adjust their capital structure to an optimal target leverage as expected by the trade-off theory. One of the earlier papers discussing dynamics of the capital structure including transaction costs is Fischer, Heinkel and Zechner (1989). They find that recapitalization costs cause deviations from the target level and that even small recapitalization costs can result in high deviations. Hovakimian, Opler and Titman (2001) argue that such target capital structure may change over time. In their paper, they analyze how the difference between target debt ratio and actually observed debt ratio influences financing decisions. They find that companies tend to move towards their target capital structure, however, the deviation from the target level has stronger influence on repurchase decisions than in issuance decisions. Further, they find that companies tend to move towards their target capital structure when they issue debt or equity. Often they even overcompensate the gap, that derives from accumulated profits and losses.[7]

Graham and Harvey (2001) find mixed evidence for the existence of an optimal target leverage from their survey of 392 CFOs. In total, 81% of the companies have a more or less flexible target leverage. Thereof, 37% of the companies have a flexible target and 34% have a "somewhat tight target or range", while only 10% have a "strict target debt ratio"[8]. In their empirical paper, Fama and French (2005) also argue that there is not a single target level for the financial leverage but more flexible guidelines.

Other survey evidence derives from Brounen, De Jong and Koedijk (2006). They find that companies do have a target leverage ratio and that tax and cost of distress are the major drivers of this target ratio.[9]

Flannery and Rangan (2006), for their 1966-2001 sample period, also find that companies have a target capital structure and they close about one third of the gap between their actual and targeted capital structure per year. They point out that the speed of adjustment depends

[6] Cf. Fama and French (2005), p. 580
[7] Cf. Hovakimian, Opler and Titman (2001), p.22
[8] Cf. Graham and Harvey (2001), p.211
[9] Nevertheless, they confirm that listed companies use stock prices in order to time the market for their new issues.

on adjustment costs and is only relevant in tradeoff theory, as this theory links firm value and capital structure under such market imperfections. In contrast, in pecking order and market timing theory, there is obviously no value explicitly assigned to readjusting to a target capital structure, as Flannery and Rangan (2006) explain. In comparison to Flannery and Rangan (2006), most scholars, e.g. Fama and French (2002), find slower rates of readjustment towards a target capital structure, which is later confirmed by the model of DeAngelo, DeAngelo and Whited (2011), who use new debt issues as the relevant adjustment mechanism.[10]

In contrast to Welch (2004), Flannery and Rangan (2006) find that changes in stock prices only have a temporary effect on the capital structure. Welch (2004) shows that changes of market leverage deriving from changes in the market value of equity are often large and market leverage is usually not rebalanced quickly to the old market leverage. Further, Welch (2004) reports that the issuance of securities does not generally target towards a target capital structure. According to Welch (2004), long-term debt issues can explain about 60% of the variation in leverage.
Similarly, Baker, Powell and Veit (2002) report that "fluctuations in market valuations have large effects on capital structure that persist for at least a decade"[11]. Further, they explain that the capital structure is driven by the managers' attempts to time the market when raising funds, i.e. what they call their *market timing theory* of the capital structure. Finally, they conclude that there is not an optimal capital structure but that a company's capital structure derives from the "past attempts to time the equity market".[12] Consequently, companies do not return to a target leverage ratio in such market timing theory. Brounen, De Jong and Koedijk (2006) provide survey evidence for the importance of market timing in publicly listed – in contrast to privately held – firms.

Kayhan and Titman (2007) again support the relevance of a target debt ratio. Nevertheless, they find that firms can significantly deviate from this target, mainly influenced by cash flow, investment expenditures and historic stock price performance. However, they find that firms slowly move back towards a debt target. Consequently, they explain this deviation by a relatively low cost of being away from the optimum, and instead capital structures being dominated by transaction costs that can temporarily impact the debt/equity choice.

One such paper analyzing the impact of investments on the capital structure is DeAngelo, DeAngelo and Whited (2011). They confirm that the issuance of debt to fund investments is a major driver of deviations from the target capital structure. They consider the opportunity costs of moving away from the target, resulting in a reduced debt capacity for future borrowing of debt, and weight them against the advantage of meeting a given investment opportunity. DeAngelo, DeAngelo and Whited (2011) calls this concept *transitory debt*. According to them, the repayment path of debt in order to move towards the target level "is shaped both by the nature of prospective investment opportunities and by the precise sequence of shock realizations from the firm's stochastic investment opportunity set"[13].

[10] Cf. Flannery and Rangan (2006), p.471 for further literature.
[11] Cf. Baker, Powell and Veit (2002), p.29
[12] Cf. Baker, Powell and Veit (2002), p.29
[13] Cf. DeAngelo, DeAngelo and Whited (2011), p.258

Also, Denis and McKeon (2012) find that companies conduct significant debt issues primarily due to "investment-related capital needs". They find that leverage is driven by "the evolution of the firm's cash flows and its investment opportunities".

Öztekin and Flannery (2012), for their 1991 until 2006 period, find that leverage is also influenced by a company's institutional environment. Öztekin and Flannery (2012) show that the legal and political environment of a company significantly influences its adjustment speed towards the target capital structure.[14]

In a nutshell, literature shows that there is no unique theory accounting for all empirically observed characteristics of the capital structure (Myers (2003)). However, there is significant evidence for the existence of a target capital structure. At the same time, there is significant evidence, that companies can deviate from this target ratio, especially due to investment decisions and especially by the issuance of debt.

2.1.1.2. Established empirical determinants of capitals structure

Numerous empirical papers have analyzed the determinants of the capital structure. The reader is referred to Parsons and Titman (2008), Frank and Goyal (2009) and Graham and Leary (2011) for an overview on empirically relevant determinants of the capital structure. In order to narrow down the variety of capital structure determinants, Frank and Goyal (2009) ask *"Which factors are reliably important?"*. They find that MEDIAN INDUSTRY MARKET LEVERAGE, MARKET-TO-BOOK, TANGIBILITY, PROFITABILITY, SIZE and EXPECTED INFLATION[15] make up this set of "reliably important" factors. In the following, these variables are briefly discussed and rationals for including them in capital structure regressions are given.[16]

MEDIAN INDUSTRY LEVERAGE is a major determinant of the capital structure, as Frank and Goyal (2009) and several other authors argue. Leary and Roberts (2013) observe that a company's capital structure behaves similar to the capital structure of its peers. They find two explanations for such behavior. *First*, they explain the following:

> "As such, firms in the same peer group face similar institutional environments and have similar characteristics, such as production technologies and investment opportunities. The inability to perfectly measure or observe the selection mechanism generates a role for peer firm measures in determining financial policy. This role arises because peer firm measures proxy for latent factors that are both common to firms in a peer group and determine financial policy. In essence, the correlation between firms' financial policies and the actions or characteristics of their peers reflects an omitted variables or measurement error bias.[17]

In other words, by applying the MEDIAN INDUSTRY LEVERAGE as an independent variable, scholars overcome the issue of unobserved characteristics as, e.g., production technology. *Second*, Leary and Roberts (2013) explain that peer firms might "respond to their peers' financial policy"

[14] I later control for such effect – as well as for other country specific effects, e.g. taxes – by introducing country dummies into my equations.
[15] In my empirical analysis, I will capture the effect of expected inflation in country dummies.
[16] For a more complete overview, the reader is referred to Antoniou, Guney and Paudyal (2008), p.88 ff.
[17] Cf. Leary and Roberts (2013), p.2

or their peers' changing characteristics, e.g. risk or profitability.[18] Thereby, Leary and Roberts (2013) justify the MEDIAN INDUSTRY MARKET LEVERAGE as relevant determinant of capital structure. However, Graham and Harvey (2001) find only weak support for the relevance of peer companies' capital structure for managers' capital structure decisions from their survey.

SIZE, usually parametrized by the logarithm of Total Assets, is expected to be a relevant determinant of leverage as large companies are expected to have a lower probability of default.[19] The positive impact of size on leverage was empirically confirmed by, e.g., Hovakimian, Hovakimian and Tehranian (2004), MacKay and Phillips (2005) and Flannery and Rangan (2006).

PROFITABILITY is also expected to be a relevant determinant of the capital structure. It is usually parametrized as EBIT or EBITDA divided by Total Assets. According to the pecking order theory firms prefer their internal funds over external financing.[20] Consequently, one should expect PROFITABILITY to be negatively related to leverage. In contrast, tradeoff theory contrarily argues, that more profitable firms profit more from tax shield effects compared to less profitable firms. Furthermore, the risk of default decreases for more profitable firms. Therefore, according to tradeoff theory, such firms therefore should have a higher leverage, as Jensen (1986) and Hovakimian, Hovakimian and Tehranian (2004) argue. However, empirical studies of, e.g., Titman and Wessels (1988), Rajan and Zingales (1995) and Flannery and Rangan (2006) show that PROFITABILITY is negatively related to leverage.

For TANGIBILITY, a positive relation to leverage is typically expected by scholars. It is usually defined as Net Property, Plant and Equipment divided by Total Assets. According to Rajan and Zingales (1995), tangible assets reduce the costs of distress since they are easier to collateralize and thereby reduce agency costs of debt. Also, such assets, compared to intangible assets, are easier to value from outside the company. Therefore leverage is expected to raise with TANGIBILITY from a theoretical point of view, as it is also confirmed, e.g., by Myers (1977), Titman and Wessels (1988) and Frank and Goyal (2009).

GROWTH OPPORTUNITIES are another "reliable" determinant of leverage. Scholars expect growth to be negatively related to leverage as argued, e.g., by Myers (1977). Myers (1977) explains that highly leveraged companies are more likely to underinvest, and therefore high growth companies should use less debt. Empirical evidence for this negative relation of growth to leverage is found, e.g., by Rajan and Zingales (1995), Hovakimian, Hovakimian and Tehranian (2004) and Flannery and Rangan (2006). Consistently, Lang and Ofek (1996) suggest that managers use leverage to signal their companies' growth opportunities, i.e. companies with higher investment opportunities have lower leverage, which is supported by their empirical findings.

DIVIDEND PAYOUT is not a significant determinant of corporate leverage in the final version of the paper of Frank and Goyal (2009). Chan and Rhee (1990) found a positive relation between dividend payout and leverage. In contrast, Lemmon, Roberts and Zender (2008) find a negative impact of their dividend dummy on leverage for their large sample of non-financial firms between 1965 and 2003. Also Jalilvand and Harris (1984) postulate "[...] that the financial and dividend

[18] Cf. Leary and Roberts (2013), p.1
[19] Cf. e.g. Antoniou, Guney and Paudyal (2008)
[20] Cf. Shyam-Sunder and Myers (1999)

decisions of the corporation should be viewed as part of a simultaneous and interdependent process".[21] However, their empirical evidence is mixed, as it seems to be for the role of dividends in empirical capital structure analysis in general. I note, that Myers (1984) points out that utility companies tend to pay dividends.[22]

In contrast to these *financial factors*, there is little research regarding other *production asset-specific factors* and their impact on the corporate financial structure. Such factors will be reviewed in more detail in the following sections.

2.1.2. Financial flexibility

Graham (2000) finds that companies unexpectedly preserve significant parts of their debt capacity. According to DeAngelo and DeAngelo (2007), financial flexibility explains some of these major unresolved issues in empirical capital structure behavior, e.g. why companies maintain low leverage ratios despite the benefits from the tax shield of debt. They argue that "financial flexibility is the critical missing link for an empirically viable theory".[23]

As mentioned above, Lang and Ofek (1996) study the relation of leverage, investment and firm growth. They find a negative relation between leverage and growth opportunities, implying that, on the one hand, firms with high leverage might not be able to take advantage from these opportunities. In this sense, such companies might underinvest. On the other hand, one of the arguments in capital structure theory is that companies with poor growth opportunities should be prevented from overinvesting, i.e. investing in "bad" projects. Consequently, debt has a disciplining role on managers as it limits their flexibility to invest.[24]

According to Graham and Harvey (2001), financial flexibility is one of the most important determinants of the capital structure, as they found from their survey of U.S. managers. Later, surveys of Bancel and Mittoo (2004) (for listed European companies) as well as Brounen, De Jong and Koedijk (2006) (for listed and unlisted companies from selected countries) confirm this outstanding importance of financial flexibility. However, Brounen, De Jong and Koedijk (2006) find, that pecking order theory, i.e. the preference for internal over external funds, is not the major driver for the CFO's preference for financial flexibility. They show that financial flexibility is more important in countries with target debt ratios (which contradicts the importance of pecking order by definition). They also show that dividend paying companies attribute higher value to financial flexibility[25].

DeAngelo, DeAngelo and Whited (2011) and Denis and McKeon (2012) interpret financial flexibility as unused debt capacity, i.e. such that the "ex ante optimal financial policies preserve the ability to access the capital market ex post in the event of unexpected earnings shortfalls or investment opportunities".[26] In other words, in order to secure financial flexibility in the future, firms preserve parts of their debt capacity in the present. In addition, there are other sources

21 Cf. Jalilvand and Harris (1984), p.128
22 This will later be empirically confirmed for my sample.
23 Cf. DeAngelo and DeAngelo (2007), p.2
24 Cf. Jensen (1986) and Stulz (1990)
25 Cf. Brounen, De Jong and Koedijk (2006), p.1433 f.
26 Cf. Denis and McKeon (2012), p.1900

of flexibility as liquid assets, cash holdings, excess bank credit lines or commercial paper. Such alternative sources of financial flexibility were addressed e.g. by Sufi (2009), who showed that at least for high cash flow firms, revolving credits represent a substitute for cash. Kahl, Shivdasani and Wang (2010) analyze another source of financial flexibility, namely commercial paper. They find, that commercial paper is especially important for firms with high investment needs in order to finance new investments and to bridge gaps to long-term financing.

Faulkender and Wang (2006) find that the marginal value of liquidity is higher for companies with lower liquidity, higher investment opportunities and higher constraints for external financing.

Gamba and Triantis (2008) study the effect of financial flexibility on firm value. They find the following relevant determinants of financial flexibility: costs of external financing, personal and corporate tax rates, growth potential, maturity of the firm, and cash reversibility of capital. Further, they show that companies also retain cash if they have debt outstanding.[27] They see the value of having cash in avoiding issuance costs and financial distress costs, which is traded off against the negative impact from taxes on held cash (as investors have lower tax rates). Gamba and Triantis (2008) find that this value of cash is higher for firms with high volatility in financial flexibility, and is “very small” for companies with low growth opportunities and that “investment and financial flexibility are substitutes to some extent”[28,29].

Further, regarding *production flexibility*, Gamba and Triantis (2008) explain that “the premium [from financial flexibility on the firm value] is also more substantial if the production technology is relatively inflexible, suggesting that financial and investment flexibility are substitutes to some degree”[30]. In their context, production flexibility is understood as the flexibility to reverse an investment in production capacity.[31] Their substitution effect is explained as follows:

> “The reversibility of investment in capital compensates to some degree for the loss in financial flexibility, primarily because the firm can more readily reduce its capital when productivity is low, providing an alternative to holding cash as a buffer to deal with the firm’s debt obligation.”[32]

Denis and McKeon (2012) confirm that financial flexibility “in the form of unused debt capacity, plays an important role in capital structure choices”[33]. They point out that firms’ capital structure is driven by their operating needs, i.e. their cash flows and investment opportunities, even if the resulting capital structures deviate from target levels of leverage. Consequently, “firms do not behave as if managing toward a stationary target leverage ratio is a first-order priority”.[34] Instead, they explain that the capital structure choice is twofold, *first*, a long-term component

[27] This is consistent with Miller and Orr (1966), who argue that – in case of present financing needs – transaction costs for decreasing cash holdings are lower in comparison to transaction costs for selling assets or raising external capital.

[28] Cf. Gamba and Triantis (2008), p.2265

[29] Cf. Gamba and Triantis (2008), p.2266, for further reading regarding the value of cash.

[30] Cf. Gamba and Triantis (2008), p.2293

[31] Gamba and Triantis (2008) do not refer to the flexibility of the production assets itself, i.e. to the possibility to switch production on and off.

[32] Cf. Gamba and Triantis (2008), p.2281

[33] Cf. Denis and McKeon (2012), p.1897

[34] Cf. Denis and McKeon (2012), p.1926

depending on the target levels for the capital structure, *second*, a component depending on the operating needs.

Bancel and Mittoo (2011) find that firms with high financial flexibility, measured by different measures as well as by direct manager-interviews, suffer less from the financial crisis in comparison to less financially flexible firms. They point out that "firms with greater internal financing are likely to have lower leverage, higher cash ratios, and suffer a lower impact from the crisis on their business operation"[35]. According to the survey of Bancel and Mittoo (2011), financial flexibility is closely related to operating flexibility and the overall business model. They argue that financially constrained firms suffer from "more restrictive debt covenants that constrain management's choice of operating, financial and investment policies, and reduce its capacity to respond to changes to the business environment."[36]

2.1.3. Asset characteristics

In this section, production flexibility as well as asset salability are addressed and their relation to the capital structure is reviewed from the literature.

Asset characteristics are of particular interest, as there is first evidence that *asset-specific factors* might be even more important determinants of capital structure than the established *financial factors* (e.g. Lemmon, Roberts and Zender (2008) and Rauh and Sufi (2012)).

Lemmon, Roberts and Zender (2008) point out that significant firm-fixed effects require the identification of time-invariant determinants of leverage. Lemmon, Roberts and Zender (2008) find that leverage ratios are "remarkably stable over time"[37]. Using firm fixed effects, Lemmon, Roberts and Zender (2008) find an adjusted R^2 of 60%, which is much higher than for their cross sectional regressions of between 18% and 29%. Therefore, they conclude that "the majority of variation in leverage in a panel of firms is time invariant and is largely unexplained by previously identified determinants".[38] Further, Lemmon, Roberts and Zender (2008) show, that companies use debt issues, in contrast to equity issues, in order to influence their leverage ratio.

Menichini (2012) uses a structural model in order to explain the capital structure behavior described by Lemmon, Roberts and Zender (2008). He confirms that firm-specific fixed effects explain the behavior of the capital structure, and he states that structural firm characteristics as production technology and the behavior of the management team explain the almost constant part of the leverage.[39]

DeAngelo and Roll (2011) challenge the findings of Lemmon, Roberts and Zender (2008) and argue that their interpretation of leverage stability is not correct also for econometric reasons.[40] One reasons is, that cross-sectional stability is not related to firm-fixed stability of leverage. In their discussion, DeAngelo and Roll (2011) refer to a period of at least 20 years per company. They expound that financial flexibility is one plausible reason, why firms avoid extremely high

[35] Cf. Bancel and Mittoo (2011), p.179
[36] Cf. Bancel and Mittoo (2011), p.182
[37] Cf. Lemmon, Roberts and Zender (2008), p.1576
[38] Cf. Lemmon, Roberts and Zender (2008), p.1576
[39] Cf. Menichini (2012), p.3
[40] Cf. DeAngelo and Roll (2011), p.4 for a more detailed explanation.

leverage ratios, though a company's leverage in general varies widely. DeAngelo and Roll (2011) point out that leverage ratios are mainly unstable and that firm-specific variation of leverage over time is material. At the firm level, they do not find stability within a narrow band around a target leverage. Consequently, DeAngelo and Roll (2011) suggest that leverage is not of high importance for firm valuation, as companies choose widely differing levels of leverage.[41] In contrast to Lemmon, Roberts and Zender (2008), they propose that a theory explaining leverage should potentially concentrate on the funding of investments.[42]

Rauh and Sufi (2012) "suggest that what a firm produces and the assets used in production are the most important determinants of capital structure in the cross section."[43] The findings of Rauh and Sufi (2012) are explained by "asset similarity". They find that the capital structure of companies from the same product market is the most relevant determinant of the capital structure, and show that this effect "is most closely related to the assets used in the production process."[44] Their basic idea is that firms in the same product market have similar assets. Accordingly, they split their sample and use tangibility as the relevant measure to prove the importance of production assets in product market clusters of sample companies. Overall, they thereby also confirm the finding of Leary and Roberts (2013), that peer companies have a major influence on a companies debt ratio.[45]

As mentioned before, Leary and Roberts (2013) find that the capital structure of companies are similar to their peer firms. They argue that this is due to the same institutional environment, similar investment opportunities and production technologies that companies within the same industry are facing. However, the authors do not identify these asset characteristics. For example, Lemmon, Roberts and Zender (2008) state with reference to their stable leverage ratios, as discussed above: "[...] identifying what factors are behind this feature of the leverage data generating process is beyond the scope of this paper [...]"[46]. In this thesis, I address some factors that are potentially relevant in this context, as will be pointed out especially in Section 3 and Section 5.

In the following, I give a brief overview on the influence of production flexibility, operating leverage and asset salability on the capital structure. I do not intent to provide a complete overview. Rather I provide a purposive overview with regard to my later analysis. *First*, I will shortly summarize some of the literature focusing on production flexibility and operating leverage. *Second*, I briefly review the literature on asset salability as a determinant of the capital structure.

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41 This is in accordance with the capital structure irrelevance according to Modigliani and Miller (1958).
42 Cf. DeAngelo and Roll (2011), p.24.
43 Cf. Rauh and Sufi (2012), p.115
44 Cf. Rauh and Sufi (2012), p.119 and p.152
45 For detailed capital structure information with regard to leases, Rauh and Sufi (2012) use data from S&P Capital IQ.
46 Cf. Lemmon, Roberts and Zender (2008), p.1577

2.1.3.1. Production Flexibility, Operating Leverage and the Substitution Effect

In this section it is differentiated, *first*, what scholars typically call “investment flexibility”, i.e. either the flexibility to invest now or later in (production) assets or to reversibility of investments. *Second*, there is what is called “production flexibility” or “operational flexibility”, i.e. the flexibility to continuously switch-on and -off a production asset, to change production processes, production products or production volumes.[47] The reader should be aware that these terms are not always used consistently in the literature.

Production flexibility

MacKay (2003) outlines that the literature differentiates investment and production flexibility. He points out the following kinds of flexibility, which are also reflected in his empirical production and investment flexibility measures:

> “Production flexibility includes switching between inputs and outputs [Kulatilaka (1988), Triantis and Hodder (1990)], varying level of production [He and Pindyck (1992)], and starting or stopping operations [Brennan and Schwartz (1984)]. Investment flexibility includes entry and exit [Dixit (1989)], postponement [McDonald and Siegel (1986)], replacement [Mauer and Ott (1995)], abandonment [McDonald and Siegel (1985)], and the staging of investment [Baldwin (1982)].”[48]

Not complete, however quite intuitive, Hagsiegel, Huisman and Kort (2011) depict different kinds of flexibility as follows: “[...] the firm makes three decisions: choice of investment time, choice of capacity, and choice of production quantity.”[49]

In this section, I briefly review some relevant literature regarding the impact of both of these aspects – *investment flexibility* and *production flexibility* – on the capital structure, while the related concept of *operating leverage* should also be mentioned.

The kind of production flexibility Avazian and Berkowitz (1998) are referring to is related to the questions whether “[t]he firm has the option of producing prior to knowing demand fully or of waiting until demand conditions are revealed”[50]. Avazian and Berkowitz (1998) discuss the impact of their measure of “ex-post production flexibility” and asset specificity on the capital structure in their theoretical paper.[51] They show that production flexibility increases the expected value of the tax shield and decreases the expected costs of distress. In contrast to Mauer and Triantis (1994), they find that for low asset specificity, operating and financial leverage are complements, and becoming even stronger complementary with rising ex post adjustment costs of production capacity. Also, they conclude that in industries with easily redeployable assets, taxes will positively impact investment and financial leverage.[52] A weakness of their model is, that they assume that ex ante production can be financed by debt, whereas

47 Cf. MacKay (2003), p.1140
48 Cf. MacKay (2003), p.1137
49 Cf. Hagsiegel, Huisman and Kort (2011), p.24
50 Cf. Avazian and Berkowitz (1998), p.5
51 An earlier working paper was published under the title “Production flexibility and corporate capital structure”, Aivazian and Berkowitz (1993)
52 Cf. Avazian and Berkowitz (1998), p.18

ex post production is financed by sales of products. Addressing this point in their conclusion, they state that operational and financial leverage might also be substitutes if one accounts for debt maturity structure by allowing ex post production to be financed by debt.[53] As reviewed above, Mauer and Triantis (1994) consider such debt financing in their seminal paper.
Avazian and Berkowitz (1998) also relate their work to the concept of *operating leverage* as follows: "Commitment to ex ante production, or capacity, constitutes what we term operating leverage and a firm with more ex ante production is said to have higher operating leverage than one with less ex ante production."[54] Further, they define ex post production flexibility as the ability to ex post produce a product after additional information on demand and price arrived and insecurity disappeared. In this sense, operating leverage and investment flexibility are related concepts to describe flexibility in production.

Extending former work, the theoretical paper of Mauer and Triantis (1994) included continuous "operating adjustments" in its dynamic model (production flexibility). In contrast, until this time, theoretical models included investment and financing decisions at a discrete point in time, while Mauer and Triantis (1994) also consider recapitalization after the initial investment (investment flexibility). According to Mauer and Triantis (1994), their paper is generally related to the real options literature that analyzes investment flexibility, which determines the optimal exercise of options and their respective value. However, they explain that this literature typically assumes all-equity financing and therefore ignores possible interactions between investments and financing decisions.[55]
In the model of Mauer and Triantis (1994) a single commodity with a stochastic price is produced. Different from earlier research, they allow for the modeled firm to open and shut down its production facilities according to price signals from the market. In order to do so, the company has to pay operating adjustment costs. Furthermore, the modeled firm can change its capital structure over time by issuing equity or debt under consideration of paying recapitalization costs. Their optimal financing policy is calculated – according to tradeoff theory – as a tradeoff of tax advantage and cost of financial distress.[56]

Mauer and Triantis (1994) do not provide closed form solutions, but numerically show that higher *production flexibility* increases a firm's debt capacity, and thereby increases the tax shield value of debt.[57] Their basic idea is to avoid negative margins – and thereby also reduce default risk – by using production flexibility in order to shut down operations at disadvantageous market prices. Therefore, intuitively, the firm value increases with decreasing operating adjustment costs. As they find a similar effect from financial flexibility, they conclude that production flexibility and financial flexibility are substitutes. They explain

> "[...] that when the costs to dynamically manage capital structure are small, the hedging benefit of production flexibility has less of an impact on the net tax shield value of debt

[53] Cf. Avazian and Berkowitz (1998), p.18 f.
[54] Cf. Avazian and Berkowitz (1998), p.2
[55] Cf. Mauer and Triantis (1994), p.1255. I do not provide a review of this strand of literature here. One example of this is Brennan and Schwartz (1984).
[56] Cf. Mauer and Triantis (1994), p.1254
[57] Cf. Mauer and Triantis (1994), p.1253

> financing. This implies that production flexibility and financial flexibility are substitutes, albeit not perfect substitutes."[58]

Consequently, as an effect of increased production flexibility, Mauer and Triantis (1994) find that firms allow for a higher leverage ratio, which is only allowed to vary in a narrower range.

With regard to *investment flexibility*, Mauer and Triantis (1994) find that financing decisions have a minimal effect on the decision whether and when to invest.[59] A priori, one expects that levered companies invest earlier, as their earnings from the investment profit from the tax shield effect. However, Mauer and Triantis (1994) show that this effect is too small to significantly shift investments.

In their working paper, Aivazian and Gu (2002) also allow for debt financing of ex post adjustments, i.e. for ex post contraction by resale and for expansion of capacity by additional investment. Such ex post production is considered to be more expensive as time until products have to be finished is limited. Consequently, capacity adjustment costs are included.[60] In their theoretical models, the authors find that a tax increase supports investment in pre-committed capacity by small firms (while decreasing it for large firms). Also, they find an effect from expandability costs and reversibility costs on financing and investment decisions. Finally, they do not find a clear relationship between operating and financing leverage, "although they are complements for smaller capacity sizes"[61]. They state:

> "The effects of flexibility on debt capacity are complicated, depending on whether operating and financial leverage are complements or substitutes. Finally, optimal operating leverage is positive related to optimal financial leverage for small capital sizes while both may be complements or substitutes for the other sizes."[62]

In his seminal paper, MacKay (2003) *empirically* investigates the effect of different measures of production flexibility and investment flexibility on the capital structure.[63]
For *production flexibility*, MacKay (2003) finds, that production flexibility can facilitate an increased debt capacity "by allowing a firm to adjust its factor intensity, product mix, or production level to changing market conditions, thus lowering the risk of default"[64]. He also argues that an increased redeployability of assets can be interpreted as such flexibility of assets, as will be explained in the next section.
Nevertheless, MacKay (2003) empirically finds, that firms "that can easily adjust their factor intensity, product mix, or level of production generally use less financial leverage, shorter matu-

58 Cf. Mauer and Triantis (1994), p.1272
59 Cf. Mauer and Triantis (1994), p.1272 f.
60 This is somewhat similar to the cost structure of power plants. The ex ante commitment is higher for base load power plants in comparison to peak load power plants. However, there are higher variable production costs for peak load power plants in comparison to base load power plants. This will be empirically addressed in Section 5.1.4.8.
61 Cf. Aivazian and Gu (2002), p.17
62 Cf. Aivazian and Gu (2002), p.4
63 I point out that MacKay (2003) limits his sample, *first*, to manufacturing companies and, *second*, data from the U.S. Department of Commerce.
64 Cf. MacKay (2003), p.1131

rities, and less public debt.[65] He relates this finding – that is somewhat inconsistent with Mauer and Triantis (1994) – to the counter-effect of risk shifting. MacKay (2003) argues that companies that have higher production flexibility tend to apply more risky production strategies[66], which suggests a negative effect of production flexibility on leverage, i.e. an effect in the opposite direction compared to the more direct effect of the reduction of default risk. He explains:

> "These findings suggest that lenders rationally anticipate ex-post opportunism by shareholders and respond to these forms of production flexibility by tightening the terms of credit. This lowers the equilibrium level of financial leverage used by flexible firms and increases their reliance on short-term debt and monitored bank loans."[67]

In other words, MacKay (2003) finds that the counter-effect of opportunistic behavior outweighs the (a priori) expected positive influence of production flexibility on leverage.

For *investment flexibility*, MacKay (2003) argues that debt capacity is increased by allowing firms to expand or contract their production capacity. Thereby distress costs are lowered which suggests a positive effect on leverage. In contrast, he suggests that companies could engage in asset substitution, i.e. substitute assets by more risky ones. Empirically, MacKay (2003) finds that investment flexibility is positively related to financial leverage, which is consistent with Mauer and Triantis (1994). Consequently, the expected positive effect of investment flexibility is not outweighed by the counter-effect of asset substitution. MacKay (2003) relates this to the possibility to mitigate the a priori threat of asset substitution by contractual agreements.
In a nutshell, as pointed out by MacKay (2003), besides mitigating the risk of earning negative margins (production flexibility) or waiting to invest until insecurity about future demand and prices has been reduced (investment flexibility), there are also disadvantages from production and investment flexibility, i.e. especially risk shifting and asset substitution.[68] While for production flexibility, the negative counter-effect from risk-shifting outweighs the direct positive effect of *production flexibility*, in contrast, the negative asset substitution effect does not outweigh the positive effect of *investment flexibility* on leverage, as found by MacKay (2003).

Operating Leverage

The empirical paper of Kuzmina (2012) points out, that empirical evidence on the relation of operating leverage and financial leverage is scarce. She adds to that by analyzing the influence of contractual arrangements with labor on the capital structure of the firm. She finds that "hiring more temporary workers leads firms to have more debt."[69] She argues that "[b]y using flexible contract arrangements with capital and labor, which effectively convert some of the

[65] Cf. MacKay (2003), p.1131
[66] Cf. MacKay (2003), p.1141
[67] Cf. MacKay (2003), p.1132
[68] Cf. the following literature for further reading on the relation between such operating decisions and financial leverage: Mello and Parsons (1992) on the impact of leverage on operating policy, Mello, Parsons and Triantis (1995) on the relation of production flexibility and hedging, and Green and Talmor (1986) on the abovementioned asset substitution and leverage.
[69] Cf. Kuzmina (2012), p.1

fixed operating costs into variable costs, a firm can lower its operating leverage."[70] This is due to the fact that there are lower firing costs for temporary workers that allow for adjustment of workforce levels at lower costs. Thereby the probability of default is reduced, the costs of financial distress decrease and, consequently, leverage increases. Kuzmina (2012) interprets her findings as a substitution effect between operating and financial leverage. She empirically finds that country specific characteristics of the labor market influence leverage ratios.[71]

Mandelker and Rhee (1984) also find a substitution effect between operating leverage and financial leverage, as they explain for their analysis of operating and financial leverage that there is "some evidence of balancing activities between the degrees of two types of leverage".[72]

Kahl, Lunn and Nilsson (2011) analyze the impact of the "operating leverage" on the capital structure. Therefor, they introduce a new measure for the operating leverage based on the importance of fixed costs in a firm's cost structure. Their estimates for operating leverage are derived via regression from ex ante operating costs and sales data. They show that firms with high fixed costs face higher cash flow risks. Consequently, such firms follow more conservative financial policies and retain a lower leverage, as already hypothesized by the leverage trade-off hypotheses of Van Horne (1977). Also, such firms with higher fixed costs, i.e. higher operating leverage, hold more cash. Kahl, Lunn and Nilsson (2011) further show that, if firms are financially unconstrained, they tend to increase cash instead of decreasing leverage when fix costs rise. Kahl, Lunn and Nilsson (2011)interpret the operating leverage to be part of the "permanent component in firms' leverage and cash policies".[73] In summary, the findings of Kahl, Lunn and Nilsson (2011) suggest that a high share of fixed costs might be another explanation for maintaining unused debt capacity, as the authors point out.

Summary

Summing up, there are several papers addressing production and investment flexibility – as well as papers addressing the operating leverage – in the literature.[74] However, their understanding of production flexibility differs. With regard to the further course of this thesis, the *production flexibility* I am referring to relates to costs and the time required for changing the load of the available production capacity. In other words, I assume that the level of production can not be altered neither at zero cost, nor instantaneously. Such costs for switching production levels ("adjustment costs") and the ability to continuously adjust production levels is congruent with the theoretical work of Mauer and Triantis (1994) and somewhat related to the empirical evidence of MacKay (2003) and his more indirect production flexibility measure "volume flexibility".

70 Cf. Kuzmina (2012), p.2
71 In Chapter 5.1, such influence will be captured by country dummies.
72 Cf. Mandelker and Rhee (1984), p.55
73 Cf. Kahl, Lunn and Nilsson (2011), p.5
74 There are other fields of research that also consider production flexibility. For example, in operations research, Hagsiegel, Huisman and Kort (2011) show that firms that can continuously adjust their production up to the installed capacity as an upper bound, invest in more additional capacity and invest earlier in comparison to such inflexible firms, that can only decide to either not produce or produce at full capacity. They argue that this is due to the value of such production flexibility. On the other hand, Hagsiegel, Huisman and Kort (2011) argue that in an uncertain environment flexible firms might invest later as their intention to invest in larger capacities requires more capital, Hagsiegel, Huisman and Kort (2011), p.24.

The concept of *operating leverage* is related to this understanding of *production flexibility* to the extent, the share of fixed and variable costs is related to the time and costs for switching assets on and off, and to *investment flexibility* to the extent a higher share of fixed costs can be interpreted as a pre-commitment to production.
In the following course of this thesis, I do not refer to the concept of *investment flexibility*, as e.g. also addressed by MacKay (2003).

2.1.3.2. Asset salability

Literature includes several terms that are somewhat related to the salability of assets. To name a few, asset marketability, asset redeployability, asset specificity, and asset (il)liquidity (or liquidation value) are related concepts. In this Section, I briefly review from the literature – to the extent required for my later analysis – how asset salability and related concepts impact the capital structure, i.e., *first*, leverage, and *second*, debt maturity.

The basic idea is as follows: firms with assets that can serve as collateral are expected to have higher leverage.[75] Consequently, the better assets can be liquidated, the more debt can be supported (e.g. Shleifer and Vishny (1992)). Yet, scholars point out that this concept differs from *tangibility*, as it is typically used as a determinant in capital structure regressions. Myers (1977) stresses that it is the reduced liquidation value rather than a reduced tangibility of assets that reduces leverage. In the following, I give an overview on the aforementioned related concepts.

Williamson (1988) pointed out that the *liquidation value* of assets effects debt capacity. He explains that redeployable assets have a higher liquidation value.

In contrast to Williamson (1988), Shleifer and Vishny (1992) refer to assets that are designed for a specific application, i.e. they can not be redeployed for different purposes or tasks, e.g. pharmaceutical patents or steel plants.[76] They discuss the determinants of the liquidation value of assets and therefore use the term *asset illiquidity*. Especially for "growth assets" (e.g. high tech companies) and "cyclical assets" (e.g. steel companies), they argue, that if companies are in financial distress, their peer companies are likely to also be in trouble. Also, peer companies might not be able to purchase assets at the same price compared to a purchase price in a situation with less problematic market environment. In this sense, such reduction of the liquidation value can be interpreted as a cost of liquidation. As this liquidation is forced only in the case of financial distress, it can also be interpreted as a cost of leverage.[77] Consequently, leverage is lower for less liquid assets.
Here it becomes obvious that this concept differs from tangibility, as the respective asset might have a high tangibility, while they do not have high liquidity. Further, Shleifer and Vishny (1992) argue that asset liquidity is not constant over time and that believing in high asset liquidity can be "self-fulfilling".[78]

Balakrishnan and Fox (1993) demonstrate that *firm-specific assets* are the most important

[75] Cf. Titman and Wessels (1988), p.3
[76] This obviously also applies to power plants.
[77] Cf. Shleifer and Vishny (1992), p.1345
[78] Cf. Shleifer and Vishny (1992), p.1365

factors influencing capital structure and that such factors are even more important than structural characteristics of the industry.[79] They argue that *asset specificity* reduces leverage due to a lower liquidation value of such assets. Further, they argue that firm-specific assets are harder to evaluate from outside the company and might suffer from the non-existence of a secondary market.[80] Debt contracts become less attractive to the firm as monitoring of firm-specific investments by lenders might be more difficult. This might result in increased underinvestment, as Balakrishnan and Fox (1993) point out.[81] Their paper finally argues that *redeployability* of a company's assets positively influences market leverage. They refer to *asset redeployability* as the opposite of *asset specificity*.

The basic idea of the redeployability measure of Balakrishnan and Fox (1993) is that depreciations are proportional to the value of the physical assets that act as collateral, i.e. net property, plant & equipment. They state that "[t]he ratio of depreciation to total assets is therefore an index of the extent to which the asset of the firm are redeployable."[82] Similarly, they refer to R&D intensity and advertising intensity, in parallel to Bradley, Jarrell and Kim (1984) and Titman and Wessels (1988), as alternative measures for redeployability and intangible firm-specific assets. Their empirical analysis, based on 295 single business firms between 1978 and 1987, shows that "[d]ebt will be the preferred method of financing such assets"[83] and that "unique firm-specific assets and skills are by far the most important determinants of capital structure".[84] Besides referring to *redeployability*, Balakrishnan and Fox (1993) also show that investments in *tangible* assets increase and investments in *intangible* assets decrease leverage.

Williamson (1988) points out that it is exactly those firm-specific assets that require additional investments over their life. And, as explained by Myers (1977), financing such investments by debt might result in underinvestment. Consequently, high firm specificity and low redeployability should reduce firm leverage.

Berger and Ofek (1996) find that certain categories of assets within book value have a more positive effect on the market value, due to their "abandonment option value". They argue that in times of disappointing cash flows, companies have the option to sell *generalizable assets*, which do not loose as much of their value as more specialized assets do.[85] In fact, they compare current assets and fixed assets, and find that "a dollar's book value of current assets adds more market value than a dollar's book value of fixed assets."[86] This classification goes back to Ronen and Sorter (1973), who view current assets as less specific than fixed assets, and similarly, non-inventory assets less specific than inventory, and further, land less specific than other fixed assets.[87]

[79] Balakrishnan and Fox (1993) provide an overview on other papers from the field of business strategy that stresses the aspect of uniqueness of assets, however not necessarily in a capital structure context.
[80] Cf. Balakrishnan and Fox (1993), p.7
[81] This argument seems to be less relevant to utility companies, as their investments can be observed fairly well from outside the firm.
[82] Cf. Balakrishnan and Fox (1993), p.12
[83] Cf. Balakrishnan and Fox (1993), p.12
[84] Cf. Balakrishnan and Fox (1993), p.14
[85] Cf. Berger and Ofek (1996), p.284
[86] Cf. Berger and Ofek (1996), p.259
[87] Cf. Berger and Ofek (1996), p.261

Alderson and Betker (1995) show, consistent with others, that “firms with high liquidation costs use less debt than firms with low liquidation costs”.[88] Also, they find that firms with high liquidation costs tend to have public and unsecured debt, tend to be less constrained by covenants to pay dividends, restrict investment or prohibit corporate restructuring. Overall, companies choose their capital structure such, that future financial distress becomes less probable.[89]

In their working paper, Campello and Giambona (2013) differentiate redeployability and tangibility, as tangible assets only support debt “to the extent that they are redeployable”[90], i.e. those tangible assets that can be sold (referred to as *salability* or *marketability*) with low liquidation cost. Their analysis differentiates assets into three categories and shows that land & buildings have the strongest impact on leverage, in contrast to machinery & equipment and other tangibles. Intuitively, they explain that this is due to the higher *firm specificity* of machines & equipment used in production processes (in comparison to land & buildings).[91]
By the “financing friction argument”[92] of Campello and Giambona (2013), the effect of *redeployability* is limited to those companies that are financially constrained, or in other words “redeployability eases borrowing the most when the supply of credit is tightened”[93]. In contrast, “[f]or unconstrained firms, [...] redeployability is an irrelevant driver of leverage”.[94] By using an instrumental approach, Campello and Giambona (2013) connect the redeployability to asset salability in secondary markets.

Benmelech (2009) not only argues for a link between liquidation value and leverage but, as the first study, also between asset liquidation values and debt maturity. Therefor, he uses a data set on the characteristics of the assets of 19^{th} century railroad companies. Benmelech (2009) explains that the *liquidation value* consists of, *first*, “physical attributes of the assets jointly with the number of its potential users, determine its redeployability – the alternative uses an asset has”, and *second*, “the financial strength of its potential users determine its liquidity – the ease with which it can be sold in its next-best use value”, referred to as “salability”.[95] From the point of view of the buyer, Benmelech (2009) refers to these two dimensions also as the “willingness” of potential users to buy and as the “ability” to afford the asset.
Empirically, Benmelech (2009) finds a strong link between asset salability and debt maturity. While he also hypothesizes a relation for asset salability and leverage, he does not find cross-sectional evidence for this. As proxies for salability, he uses the total track mileage per gauge and state and the number of railroads operated in every state for each gauge.

A less obvious effect of asset salability is described by MacKay (2003). He states: “real flexibility can support financial policy by making assets more marketable (less specific), thus increasing their liquidation value ex post and enhancing their collateral value ex ante”. As a

88 Cf. Alderson and Betker (1995), p.64
89 Cf. Alderson and Betker (1995), p.46 and p.64
90 Cf. Campello and Giambona (2013), p.2
91 This argument does not hold for my later analysis. Though I will refer to (electricity) production, power plants are not a priori firm-specific production assets.
92 Cf. Campello and Giambona (2013), p.5 and p.31
93 Cf. Campello and Giambona (2013), p.31
94 Cf. Campello and Giambona (2013), p.3
95 Cf. Benmelech (2009), p.1546

consequence, MacKay (2003) argues that more marketable (or less specific) assets, support asset substitution by riskier assets which might result in opportunistic behavior of shareholders at the cost of lenders. Consequently, a negative effect of marketability on leverage should be expected. However, MacKay (2003) does not provide a direct measure of asset specificity. Instead, he argues: "Actually measuring asset specificity presents an empirical challenge. [...] Since real flexibility and asset specificity are closely linked, the proposed indicators of real flexibility offer a more structured approach to gauging asset specificity."[96] For his measure of production flexibility, MacKay finds a negative relation to leverage, while he finds a positive relation for his measure of investment flexibility to leverage. He argues that "assets with multiple uses (production flexibility) are more marketable than dedicated production facilities. Assets that are easily redeployable (investment flexibility) are also more marketable".[97] To some extent, there remains some insecurity about the interpretation of his results, i.e. whether the actual effect on leverage is due to production and investment flexibility directly or acts via the channel of marketability. For investment flexibility, he argues that "investment flexibility increases debt capacity by making collateral assets more liquid, while restrictive covenants on asset sales prevent asset substitution."[98] Consequently, it is empirically found that the expected negative effect from marketability on leverage is outweighted by the positive effect of investment flexibility itself. Finally, it seems to be sensible – if possible – to separate effects of marketability – related to asset specificity in the case of production flexibility and related to redeployability in the case of investment flexibility – from the effects of production and investment flexibility itself.

[96] Cf. MacKay (2003), p.1136
[97] Cf. MacKay (2003), p.1136
[98] Cf. MacKay (2003), p.1132

2.2. Asset maturity and yield spread of debt[99]

In this section, literature related to the debt maturity structure is briefly summarized. *First*, I address some general determinants of debt maturity. *Second*, I provide an overview on literature related to asset maturity as a determinant of debt maturity. *Third*, I review the literature on the determinants of the yield spread of debt at issuance. This literature review is not a complete review of the debt maturity literature, but rather concentrates on those aspects that are relevant for my later analysis.

2.2.1. Established determinants of debt maturity

Literature discusses agency costs, asymmetric information and signaling, liquidation risk, tax and flotation costs as determinants of the debt maturity structure. In this section, I briefly review some of the major determinants of debt maturity and give an overview on selected empirical work. As one of these determinants, asset maturity will be discussed in the next section.

By his agency cost argument and the related underinvestment problem, Myers (1977) argues that companies with high *growth options* tend to hold shorter-term debt. Consequently, one expects companies with higher market-to-book ratio to have shorter term debt.

Diamond (1991*b*) argues that debt maturity can be chosen by insiders in order to *signal* the expected future development of a firm's quality. Companies expecting future good news will issue short-term debt as refinancing becomes less costly after the receipt of good news. On the other hand, short-term debt increases the *liquidity risk* of companies if lenders do not allow refinancing at maturity.[100]

According to Whited (1992), collateralizable assets have a positive impact on debt maturity. It is expected that debt maturity rises with increasing *tangibility* of assets.

Stohs and Mauer (1996) argue that *small companies* are short-term financed as they are more likely to face high agency costs. Whited (1992) argues that small companies can not borrow long-term due to their comparably small *tangibility* of assets. In contrast, Elyasiani, Guo and Tang (2002) hypothesize that small companies issue longer-term debt. This is because Fischer, Heinkel and Zechner (1989) argue, that smaller debt issues – usually issued by smaller companies – incur higher proportional transaction costs.

Brick and Ravid (1985) and Brick and Ravid (1991) show that due to a *tax effect* companies issue more long-term debt when the *yield-curve* is upward sloping while they issue shorter debt when the yield curve is downward sloping. Brick and Ravid (1991) demonstrate that this effect is even stronger in case of *interest rate uncertainty.*

MacKay (2003) explains that real flexibility impacts debt maturity. Empirically, he finds shorter debt maturity for higher *production flexibility* and longer debt maturity for increased *investment flexibility*[101], although there is hardly any empirical support for the latter[102]. He

99 This chapter is largely based on Reinartz (2013).
100 We will later discuss this argument in more detail.
101 Cf. MacKay (2003), p.1156
102 Cf. MacKay (2003), p.1150 and p.1155

finds theoretical arguments for both directions: *On the one hand*, he argues that according to Barnea, Haugen and Senbet (1980) and Sharpe (1991), shorter debt "mitigates risk shifting by allowing creditors to either withdraw funding or reset the terms of credit at short, regular intervals".[103] Further, as MacKay's risk shifting argument empirically is positively related to production flexibility (as reviewed in Section 2.1.3.1), he (somewhat indirectly) concludes that companies with a higher production flexibility have shorter debt.[104] *On the other hand*, MacKay (2003) argues that Mauer and Ott (2000) and Mello and Parsons (1992) find lower agency costs of debt for longer term debt, which supports that (investment) "flexible firms will carry longer debt maturities than inflexible firms"[105].

Johnson (2003) shows that "firms trade off the cost of underinvestment problems against the cost of liquidity risk when choosing short maturity"[106]. He finds that the negative effect of *growth options* on leverage is attenuated, when short term debt is used.[107]

In their working paper, Choi, Hackbarth and Zechner (2013) analyze the variety of debt maturities in a companies debt structure. Choi, Hackbarth and Zechner (2013) argue that selling several small assets is less costly than selling one large asset when there is no financing available at maturity of debt. Consequently, companies minimize rollover risks and costs from forced liquidation by holding debt contracts from a wide range of different maturities. According to Choi, Hackbarth and Zechner (2013), especially for companies with higher investment opportunities a more dispersed distribution of debt maturities within these companies' debt structure is found. The same is true for companies that are larger, more mature, higher leveraged and have lower cash flows.

In the following, *first*, I give an overview on the role of asset maturity as a determinant of debt maturity of the balance sheet as well as of single debt issues. *Second*, I address the determinants of the yield spread of debt at issuance.[108]

2.2.2. Relation between debt and asset maturity

In this section, I summarize the relevant literature that related the debt maturity of the capital structure with the maturity of a company's assets.

Besides the aforementioned aspects, *asset maturity* is often seen as a relevant determinant of debt maturity. According to "conventional wisdom"[109] and the work of Myers (1977), companies match the maturities of debt with the maturity of their assets. Myers (1977) explains that "we can interpret matching maturities as an attempt to schedule debt repayments to correspond to the decline in future value of assets currently in place"[110]. Myers (1977) explains that the *agency costs* of debt are thereby reduced.

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[103] Cf. MacKay (2003), p.1135
[104] I will later empirically test the relation between production flexibility and debt maturity.
[105] Cf. MacKay (2003), p.1135
[106] Cf. Johnson (2003), p.209
[107] Cf. Johnson (2003) for a literature review on the relation of debt maturity and leverage.
[108] I also refer to the determination of the yield spread of new debt issues as "debt pricing".
[109] Cf. Benmelech (2009), p.40
[110] Cf. Myers (1977), p.171

Morris (1976) points out that maturity matching is less risky than financing assets either with too long or too short debt. He explains that companies therefore choose their debt to "approximately equal the life of the asset"[111]. Further, Morris (1976) explains that *hedging the variance of net income* is a relevant criterion for the choice of debt maturity.

Diamond (1991*b*) implies that maturity matching leads to a *reduction of liquidity risk*.

Mitchell (1991) explains that maturity matching can be used to *immunize* the "*equity value* against the effects of unexpected interest rate changes".[112]

Hart and Moore (1994) argue in their theoretical paper, that companies match the maturity of their assets to the maturity of their liabilities. They explain the following:

> "We would particularly like to stress that we have provided an explanation for the fundamental maxim: 'assets should be matched with liabilities'. To be precise, [...] we have shown that liabilities [...] should be matched either with the return stream [...] (in the case of the fastest repayment path), or with the rate of depreciation [...] of the collateral (in the case of the slowest repayment path)."[113]

Graham and Harvey (2001), Bancel and Mittoo (2004) and Brounen, De Jong and Koedijk (2006) confirmed this "conventional wisdom" by survey evidence. From surveying 392 CFOs across industries from the U.S., Graham and Harvey (2001) found evidence that *asset maturity* is the most relevant determinant of debt maturity. According to their survey about 63% of the respondents *match debt and asset maturity*.
Similarly, Bancel and Mittoo (2004) find from their survey for listed European companies that approximately 77% of respondents match "the maturity of our debt with the life of our assets".[114] Further, they find that 70% use long-term debt financing in order to reduce refinancing risks in difficult times.

Further, Bancel and Mittoo (2004) find that about one third of the surveyed CFOs issue short-term debt when they *expect long-term interest rates to drop*.[115] They explain that maturity matching is a *hedging instrument* that is even more relevant for companies headquartered in civil-law countries compared to common-law countries.[116]

Bancel and Mittoo (2004) find that only less than 10% of CFOs try to borrow short in order to wait for an expected improvement of their companies' ratings. In such sense, the maturity choice could have been interpreted as a *signal* for the expectations of managers. Another aspect is that companies "borrow short-term so that returns from new projects can be captured by shareholders", and thereby "reduce [...] the chance that [the] firm will want to take on risky projects".[117] In this sense, *overinvestment* is avoided.

Generally, with regard to debt maturity Brounen, De Jong and Koedijk (2006) confirm the findings of Bancel and Mittoo (2004), though absolute numbers vary for their sample of private

[111] Cf. Morris (1976), p.29
[112] Cf. Mitchell (1991), p.204
[113] Cf. Hart and Moore (1994), p.45
[114] Cf. Bancel and Mittoo (2004), p.115
[115] Cf. Bancel and Mittoo (2004), p.112
[116] Cf. Demirgüc-Kunt and Maksimovic (1999) for the influence of legal institutions on debt maturity.
[117] Cf. Bancel and Mittoo (2004), p.115

and public firms. They find that between 32% (France) and 60% (Germany) of the responding companies match "the maturity of [their] debt with the life of [their] assets".[118] However, the "risk management" intention of debt and asset maturity matching remains "the most important factor in the debt maturity decision".[119] Brounen, De Jong and Koedijk (2006) explain that "[a]pparently, firms match the duration of assets and liabilities such that changes in the interest rates have the lowest impact on a firm's operations."[120] As another reason, they point out the intention to reduce refinancing risks as a rational for debt and asset maturity matching, which is in accordance with, e.g., Diamond (1991*b*).

Generally, the empirical debt maturity structure literature can be structured in, *first*, those analyses concentrating on the structure of the balance sheet and, *second*, those analyzing single debt issues. As asset maturity is considered to be one of the major determinants of debt maturity, I can not provide a comprehensive overview on all papers using asset maturity as a relevant determinant. Instead, I concentrate on the most relevant papers that emphasizes this relation. Frequently, the papers of Stohs and Mauer (1996), Guedes and Opler (1996) and Barclay, Marx and Smith (2003) are cited. They find that debt and asset maturity match.[121]

In the following, I briefly summarize the literature linking asset maturity to the debt maturity of the balance sheet. Afterwards, I address the maturity of separate new debt issues.

2.2.2.1. Balance sheet perspective

In this section, I review selected papers that claim to provide empirical evidence for debt and asset maturity matching on the balance sheet.

For a cross-industry sample, Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) analyze the determinants of debt maturity from the balance sheet perspective. They claim to have confirmed the hypothesis that debt and asset maturity match.

Stohs and Mauer (1996) find that debt and asset maturity are positively related. They understand the matching of asset and debt maturity as "a form of corporate hedging that reduces expected costs of financial distress"[122]. In their analysis, they measure asset maturity

118 Cf. Brounen, De Jong and Koedijk (2006), p.1427
119 Cf. Brounen, De Jong and Koedijk (2006), p.1439
120 Cf. Brounen, De Jong and Koedijk (2006), p.1439
121 Also the most recent literature refers to these early papers. For example, Choi, Hackbarth and Zechner (2013), p.4 and MacKay (2003), p.1135, cite Guedes and Opler (1996).
122 Cf. Stohs and Mauer (1996), p.285

as follows:[123]

$$\text{Asset maturity}_{\text{Stohs/Mauer}} = \frac{\text{Current assets}}{\text{Current assets} + \text{Net PP\&E}} \cdot \frac{\text{Current assets}}{\text{Costs of goods sold}} + \\ + \frac{\text{Net PP\&E}}{\text{Current assets} + \text{Net PP\&E}} \cdot \frac{\text{Net PP\&E}}{\text{Depreciation}}. \quad (2.1)$$

Concerning the first term of their measure, they argue:

> "The rationale for this measure is based on the notion that current assets (e.g., inventory) support production, where production is measured by the cost of goods sold."[124]

Further, regarding the second term of their measure, they argue:

> "The maturity of net property, plant, and equipment is that amount divided by annual depreciation expense. The rationale for this proxy is that straight-line depreciation, which is used for balance sheet reporting, provides a better approximation of economic depreciation than do the accelerated schedules that firms use for tax purposes."[125]

Stohs and Mauer (1996) find a positive relation of debt and asset maturity and explain that when the maturity of debt is shorter than the maturity of assets, the firm might not yet have enough cash to pay back the respective debt. In contrast, they explain that, if debt maturity is longer than asset maturity, the cash flow from such assets deceases while debt remains to be repayed.[126] Besides asset maturity, Stohs and Mauer (1996) include the following control variables in their debt maturity regressions: market-to-book, size, change of earnings per share, debt issue rating, debt issue rating squared, rating dummy, tax rate, variance of EBITDA, term spread and leverage. They find significance for the debt issue rating, the debt issue rating squared and for asset maturity. For their Fixed Effects regressions they additionally find significance for all other independent variables except for the term spread.

Barclay, Marx and Smith (2003) also find a positive relation of debt and asset maturity. They perform OLS and 2SLS regressions on debt maturity, including the endogenous variable *leverage*. They define asset maturity equal to the definition of Stohs and Mauer (1996) – later denoted as "Asset maturity$_{\text{Barclay et al.}}$" – and also find a positive relation to the corporate debt maturity structure, both, in their OLS and 2SLS analysis. Their study is based on a large sample of more than 37,000 firm-year[127] observations of industrial firms.

Most of the variables in the set of independent determinants of debt maturity differ compared to those applied by Stohs and Mauer (1996), besides the variables size, market-to-book, and

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123 For purposes of interpretability, I use the sum of current assets and Net PP&E as a denominator for the weights of terms. Stohs and Mauer (1996) are not absolutely clear about whether they construct "the (book) value-weighted average of current assets and net property, plant and equipment" (cf. Stohs and Mauer (1996), p.293) by dividing by the book value of total assets or by the sum of the book values of current assets and Net PP&E. Anyway, both measures can only differ by a constant factor, that is irrelevant in multivariate analysis. However, Barclay, Marx and Smith (2003) are very clear about that and state that "[t]hese ratios are weighted by the relative size of current assets and net property, plant, and equipment" (Barclay, Marx and Smith (2003), p.158).

124 Cf. Stohs and Mauer (1996), p.293

125 Cf. Stohs and Mauer (1996), p.293

126 Cf. Stohs and Mauer (1996), p.285

127 The term "firm-year" refer to the combination of firm and year, e.g. (Company A, 2001), (Company A, 2002), (Company A, 2003), (Company B, 2001), (Company B, 2002) denotes five firm-years.

asset maturity itself. Barclay, Marx and Smith (2003) find significance for market-to-book, a regulation dummy, firm size, commercial paper dummy, and leverage, as determinants of maturity in their OLS and 2SLS regressions. These 2SLS regressions are applied in order to simultaneously solve the leverage and debt maturity decision, that are in fact both influenced simultaneously.

In the following, I briefly mention some other papers addressing the issue of debt and asset maturity matching, though these papers mainly refer to Stohs and Mauer (1996) and do not add much to the measurement of asset maturity. Ozkan (2000) and Ozkan (2002) use Net PP&E divided by annual depreciation expenses as a proxy of asset maturity. These papers empirically confirm the positive relation of their asset maturity measure and the maturity of debt.
The same asset maturity definition is applied by Antoniou (2006). They also find that the maturity of assets matches the maturity of liabilities, which they also referred to as the "immunization hypothesis".[128]

Johnson (2003) uses a different definition. He refers to gross property, plant and equipment instead of net property plant and equipment in the measure of Stohs and Mauer (1996).[129] Nevertheless, he states that "I include the book value-weighted measure of asset maturity, defined by Stohs and Mauer (1996)"[130]. Obviously, this seems to be inconsistent with Equation 2.1. Further, he does not provide a rational for this difference. Johnson (2003) then compares his measure to the measure of Guedes and Opler (1996), who in fact use Gross PP&E, as I will discuss below.

Another paper that empirically addresses debt and asset maturity matching in some more detail is Scherr and Hulburt (2001). Their results confirm the matching of debt and asset maturity for a sample of small U.S. companies with less than 500 employees.[131] A utility industry dummy included in their debt maturity regressions shows no significance. Scherr and Hulburt (2001) point out that

> "Incorrect assumptions in calculating our maturity figures, variation in these maturities from firm to firm, or inappropriate turnover calculations could induce measurement errors in our average debt maturity and the similar asset maturity measure."

However, besides such firm to firm differences, also within-firm differences of maturities might be problematic. Scherr and Hulburt (2001) might have – at least partially – seen this issue, as they mention that the measure of Stohs and Mauer (1996) "does not allow for differences in maturity, which are caused by variations in the fractions of various current assets and assumes straight-line depreciation." They address this issue by aggregating the asset classes cash and marketable securities (0 months), other current assets (12 months), investments, PP&E and intangibles (60 months), land (120 months), and receivables and inventories (based on sales turnover ratio) additively in the general manner of Stohs and Mauer (1996). While such measure

128 Cf. Antoniou (2006), p.189
129 Cf. Johnson (2003), p.216 and p.218
130 Cf. Johnson (2003), p.216
131 Cf. Scherr and Hulburt (2001), p.90 f.

then accounts for different asset categories, they do *not actually measure* asset maturity, but aggregate different balance sheet positions with fixed weights. While on the one hand, this seems to be an improvement, their measure crudely neglects any difference of the asset maturities of their sample companies, which is a disadvantage on the other hand. For example, *for all companies* in their sample, and again *for all assets within a firm's PP&E*, they assume an asset maturity of 60 months. This assumption seems to be inappropriate, e.g. for long-lived assets of utility companies, as I will later show. In this sense, differences in their maturity measures derive from the companies' balance sheet structure instead of from the actual maturity of their assets. Consequently, their measure can not be interpreted as a direct measure of the remaining lifetime of assets. Probably, this might also be the reason for a missing constant shift of debt maturity by the utility industry dummy.

Surprisingly, in contrast to the above mentioned literature, there are papers analyzing the determinants of debt maturity, which do *not at all* include asset maturity as one of its determinants, e.g. Benmelech (2009). He finds that besides his major variable asset salability, the control variables size and tangibility are positively and profitability is negatively related to debt maturity. Also MacKay (2003) does not include asset maturity as a relevant determinant of the share of long-term debt in the overall debt.

Furthermore, the seminal paper of Barclay and Smith (1995) does not include asset maturity as a relevant determinant of debt maturity, while the authors include asset maturity as a determinant in their more recent paper , i.e. Barclay, Marx and Smith (2003). In Barclay and Smith (1995), the authors demonstrate that firms with fewer growth options hold longer-term debt. Further they show, by using a dummy variable for regulated industries, that regulated companies have more long-term debt. They argue, in accordance with Smith (1986), that this is related to the reduced discretion of managers over investment decisions in comparison to managers of non-regulated businesses.[132] Barclay and Smith (1995) explain in their paper:

> "Myers' analysis thus provides a rationale for value-maximizing firms to match the effective maturities of their assets and liabilities. At the end of an asset's life, the firm faces a reinvestment decision. Issuing debt that matures at this time helps to reestablish the appropriate investment incentives when new investment is required. More importantly, however, this analysis indicates that the maturity of a firm's tangible assets is not the sole determinant of its debt maturity. The firm's intangible assets (its growth options) play a critical role as well."[133]

However, empirically they only include growth options in several different specifications, e.g. market-to-book, R&D expenses, depreciation expenses, and earning price ratios. At the same time they leave out any asset maturity measure though they assume asset maturity to be a relevant determinant, which seems to be somewhat contradicting.

In the above mentioned studies, the parametrization of the dependent variable *debt maturity* itself also differs: While Barclay and Smith (1995) and Barclay, Marx and Smith (2003) measure

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132 Cf. Barclay and Smith (1995), p.612
133 Cf. Barclay and Smith (1995), p.611

debt maturity as the fraction of the firm‘s total debt that matures in more than 3 years, Benmelech (2009) – and similar also Stohs and Mauer (1996) – define debt maturity as the "weighted average of the term-to-maturity of all debt instruments outstanding".

In a nutshell, theoretical literature suggests and empirical literature confirms a positive relation of the maturity of debt on the balance sheet and asset maturity. However, control variables applied for debt maturity regressions differ across studies.

2.2.2.2. Debt issue perspective

In contrast to the foregoing section, in this section, I review selected papers referring to the maturity choice of single debt issues.

Guedes and Opler (1996) explain that some debt maturity structure research questions are better addressed by using the balance sheet perspective, while other questions should be addressed from the debt issue perspective. They state that the relationship between a firm's asset and debt maturity should not be addressed from the perspective of single debt issues "because new debt issues may have a maturity that is far from the average maturity of a firm's assets".[134] Nevertheless, in their debt issue analysis Guedes and Opler (1996) include asset maturity as a determinant of debt maturity of single debt issues. I note that they do so without providing a convincing rational for a potential influence. They measure asset maturity as follows:

$$\text{Asset maturity}_{\text{Guedes/Opler}} = \frac{\text{Gross PP\&E}}{\text{Total Assets}} \cdot \frac{\text{Gross PP\&E}}{\text{Depreciation}}, \tag{2.2}$$

where PP&E denotes Property, Plant and Equipment. In fact, Guedes and Opler (1996) also point out, as mentioned earlier, that "these lives should correspond to actual economic lifetimes of plant and equipment"[135]. Guedes and Opler (1996) explain their measure for asset maturity as being intuitive, as "longer maturity assets will be depreciated at a slower rate"[136]. Nevertheless, they omit that national tax regulation influences deprecations: "This measure is very crude, given that allowable depreciation lives are determined by the tax authorities."[137]

Surprisingly, Guedes and Opler (1996) find a positive relationship between the asset maturity of a company's portfolio and the maturity of new debt issues (separately for each issue). Furthermore, they find that this relation of asset and debt maturity is non-linear. Besides asset maturity, as further determinants of this debt maturity of single debt issues they identify the following variables: investment grade rating dummy, market-to-book, size, R&D/ sales, net operating loss carryforwards and income tax/ total assets, as well as further country specific variables and an utility industry dummy. They find highest t-values for the investment grade dummy, size, utility industry dummy, and asset maturity.

Elyasiani, Guo and Tang (2002) also investigate the determinants of the maturity of separate corporate debt issues. In contrast to Guedes and Opler (1996), their analysis does not at all

[134] Cf. Guedes and Opler (1996), p.1810
[135] Cf. Guedes and Opler (1996), p.1813
[136] Cf. Guedes and Opler (1996), p.1813
[137] Cf. Guedes and Opler (1996), p.1813

include the companies' asset maturity as a relevant determinant. Their set of control variables rather significantly differs from the analysis of Guedes and Opler (1996) and includes the following variables: market-to-book, size, debt issue rating, debt issue rating squared, pre-issue leverage, yield spread, earnings change and a call dummy. In a 2SLS analysis, they further include the issue-size ratio as a relevant (endogenous) determinant. For their rather small sample of utility companies,[138] their 2SLS regression finds that debt issue rating and call dummy are positively and debt issue rating squared is negatively related to the maturity of new debt issues. All other control variables remain insignificant. While Guedes and Opler (1996) find an adjusted R^2 of about 15% incl. all debt issues in their analysis, Elyasiani, Guo and Tang (2002) find a R^2 of about 29% for their OLS calculations incl. all firms.

Consequently, there seems to be at least mixed evidence regarding the relevance of asset maturity as a determinant of the debt maturity choice for new debt issues.

In a nutshell, Stohs and Mauer (1996) find, that the maturity of new debt issues matches the maturity of a company's assets without providing a theoretical rational for their finding.[139] However, there are also scholars who do not use asset maturity as a determinant of the maturity of new debt issues. Consequently, empirical evidence on this aspect is at least ambiguous.

2.2.3. Determinants of the yield spread of new debt issues

According to Frank and Goyal (2003), companies typically do not issue debt due to a financial deficit, but instead due to insufficient internal financing when investments need to be financed. According to the pecking order theory, companies prefer internal financing. However, if internal financing is not sufficient, they prefer external debt financing over external equity financing, as information costs are lower for debt issues (Myers (1984), Shyam-Sunder and Myers (1999)).
In this section, I provide an overview on the determinants of the yield spread of such new debt issues. While a broad literature extensively addresses the pricing of debt on the secondary market, there is also some research on primary market pricing, i.e. determining the yield spread of new debt at issuance. In the following, I will briefly summarize research regarding the yield spread at issuance, not comprehensively but to the extent it is relevant for my further discussion in Section 5.2.

Lamy and Thompson (1988) analyze whether the absolute or the relative yield spread between debt issues and the respective treasury bond index with similar maturity is advantageous for understanding the yield spread of primary issues. They find evidence that the more appropriate specification in times of interest rate extremes is the relative yield model, i.e. the yield spread divided by the respective U.S. treasury bond index yield. Lamy and Thompson (1988) consider the following variables as independent determinants of the yield spread: rating, volatility of interest rates on the previous 10 days before the debt issue, issue amount, sinking fund dummy, the level of a 20 year U.S. treasury bond index and a variable parameterizing callability of the debt issue. They find that issue size, callability and interest rate volatility are significant

[138] Their separately reported OLS regression results for utility companies include 423 observations while their 2SLS analysis only includes 31 observations.
[139] I will later point out that the interpretation of their measure is questionable.

determinants of the relative yield spread. While the *rating* is included as a parametrization of default risk, the *interest rate volatility* shall reflect increasing risk premia in times of higher interest rate volatility. The *issue amount* is intended to parametrize the liquidity of the issue, as the market size for an issue increases with its issue size. The latter is hypothesized to have a negative impact on the issuance spread. A right for the issuer to call the debt (i.e. *callability*) is expected to result in an increased yield spread while the expected influence of sinking funds is explained to be a priori unknown. As the dependent variable is calculated as a spread of the debt issue and the U.S. treasury bond index with similar maturity as the debt issue, the *debt issue's maturity* is not assumed to be part of the set of relevant determinants. This is also confirmed by Datta, Iskandar-Datta and Patel (1999).

Allen, Lamy and Thompson (1990) use a similar model and find significance for the sinking funds variable and interest rate volatility.

Fung and Rudd (1986) analyze the yield spread of corporate bonds at issuance by regressing it with the independent control variables debt maturity (i.e. the time to maturity), years to first call, size of issue, debt rating, and a variable controlling for the method of issuance.

Elton et al. (2001) demonstrate that state taxes and factors typically explaining risk premia of common stocks are relevant determinants of the spread at issuance. For the U.S., they explain that the tax effect derives from the taxation of the coupon of corporate bonds, while the coupon of government bonds is not taxed.

This tax effect is accounted for by Gabbi and Sironi (2005) by including the coupon as an independent variable in their regression of the yield spread of new debt issues. However, using the coupon in order to explain the spread of new debt issues is problematic, as - at least for my sample - I find a correlation of >99% between coupon and time-to-maturity of the issue. They explicitly include debt maturity as another independent variable in their regression, although their dependent variable is the difference of the yield to maturity at issuance of debt and the yield to maturity of a treasury bond with similar maturity, which is inconsistent according to the explanations of Datta, Iskandar-Datta and Patel (1999). Besides this, Gabbi and Sironi (2005) include the following variables: rating, seniority level, industry dummies, amount, fees to and number of managers of the respective issuing syndicate and numerous dummy variables.

In contrast, as mentioned before, e.g. Datta, Iskandar-Datta and Patel (1999) leave out debt maturity as a determinant of the yield spread. They state that including debt maturity in their spread measure by choosing the respective treasury bond index yield is sufficient. Datta, Iskandar-Datta and Patel (1999) find that the existence of bank debt is negatively related to the cost of public debt financing. In their analysis they regress the spread between the yield of the debt issue and a corresponding treasury bond of similar maturity with the following independent control variables: rating, relative issue size, call provision, seniority level, sinking dummy, different restriction measures, a parametrization of a company's bank relationship and the firm characteristics age, leverage and firm size.

Summary

To my best knowledge, none of the studies of the determinants of the debt yield spread at issuance has ever addressed the issue of debt maturity and asset maturity matching, while, *first*, according to survey evidence, asset maturity is expected to be the most important determinant of debt maturity structure, and *second*, debt maturity is a determinant of the yield of debt at issuance.

2.3. Mergers and acquisitions and diversification

In this section, I briefly review the rationals of firms to diversify and the impact of industrial diversification on the firm value.[140] This short review of literature is by no means complete. It intends to introduce some of the general arguments regarding diversification and acquirer returns in M&As. I will refer to this review in Sections 3.3 and 5.3. In comparison to the other empirical analysis, Sections 5.3 has a descriptive character.

2.3.1. Rationals for Diversification

Lewellen (1971) argues that the *co-insurance effect* from imperfectly correlated segments increases debt capacity of diversified companies. However, Berger and Ofek (1995) find, that the effect from the increase of the tax shield is comparably small. For example, Comment and Jarrell (1995) argue that the debt level increases from around 33%-34% for almost undiversified companies to about 38%-40% for most diversified companies.

Lewellen (1971) also summarizes some potential operations-related aspects of diversification, that might contribute to an increase in firm value, i.e. *economies of scale of gains in manufacturing efficiency*, *increased market power* and a *more complete product line*, *complementarity in research and technological know-how*, *optimally allocated managerial resources*, and *increased administrative efficiency*.[141]

It is well known that reducing a companies default risk is not a priori a relevant rational from the shareholders' perspective. According to Alberts (1966) and Levy and Sarnat (1970), *shareholders can diversify on their own* in perfect capital markets. Consequently, diversification by conglomerate mergers – i.e. mergers of unrelated businesses – must be driven by other rationals.

Amihud and Lev (1981) suggest that managers "engage in conglomerate mergers to decrease their largely undiversifyable '*employment risk*"'[142]. Meyer, Milgrom and Roberts (1992) also refer to an employment risk, that is explained as follows: They explain that if a single business segment underperforms, such business imposes additional costs on other businesses in the conglomerate. In order to avoid such costs, underperforming businesses are more likely to be divested. Therefore, the jobs of managers of underperforming divisions are threatened. Consequently, such managers are likely to overstate the units' prospects in order to "access corporate resources that can be used to prevent or delay the downsizing".[143] While such behavior influences the access of other business units to corporate resources, such costs can be avoided if the business is separated.[144]

Similarly, Harris, Kriebel and Raviv (1982) argue that information asymmetries influence the allocation of resources within a multi-segment firm via internal capital markets. They argue,

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140 I do not address regional diversification, but concentrate on industrial diversification.
141 Cf. Lewellen (1971), p.521
142 Cf. Amihud and Lev (1981), p.605
143 Cf. Meyer, Milgrom and Roberts (1992), p.11
144 Meyer, Milgrom and Roberts (1992) argue that such distressed businesses are more likely to be acquired by related businesses (in comparison to unrelated businesses), as the threat of layoffs is lower in such related business due to the similarity of skills required within the firm.[145]

that, *first*, "differential information among organizational units" and, *second*, "the potential divergence of goals between subunit managers and headquarters"[146] complicate the allocation of resources via internal capital markets.

Internal capital markets in multi-segment companies might provide another rational for diversification, according to Williamson (1975) and Stein (1997). On the one hand, competition for capital in internal capital markets might at least partly reduce the overinvestment problem by allocation of funds to the most attractive investment opportunity. On the other hand, as Lamont (1997) suggests, financing costs of unrelated segments are interdependent. He analyzes how companies including oil and non-oil business segments reacted to the oil crisis in 1986. He finds that investment in non-oil segments are significantly affected by the decrease in oil prices, while "the same company's nonoil segments should be unaffected if the net present value of nonoil investment is unaffected."[147] Nevertheless, he finds that imperfect internal capital markets reduce investments for all segments.

Teece (1980) argues that *economies of scope* provide a potential rational for diversification into different product markets. He explains that diversification in product markets can be an efficient organizational design if firms can use specialized and indivisible assets or proprietary know-how in order to produce its products.

Lamont (1997) also mentions that besides *product market synergies*, also the *optimal exploitation of managerial talent* is another rational for companies to diversify into different segments.

Stulz (1990) argues that diversification *mitigates the over- and underinvestment problem* by stabilizing cash flows. He explains that companies underinvest when cash flows are low, as managers are unable to credibly claim that low cash flows lead to underinvestment. Further, he explains that managers overinvest when cash flows are high. By diversification and the co-insurance effect, the *variability of cash flows is reduced*, which reduces the costs of managerial discretion due to improved predictability of cash flows.[148] Stulz (1990) argues that thereby "diversification across projects and mergers for diversification purposes can increase shareholder wealth".[149] Moreover, he explains that the value of diversification decreases if investment opportunities become less attractive, as in such case, the cost of underinvestment decreases.

Denis, Denis and Sarin (1997) argue that managers of diversified companies have lower incentives to maximize shareholder value and therefore tend to overinvest ("empire building").

The results of Lamont (1997) are compatible with the hypothesis that "companies tend to subsidize and overinvest in poorly-performing segments."[150] Such *cross-subsidization* behavior is also found in other papers, e.g. Scharfstein and Stein (2000) and Rajan, Servaes and Zingales (2000).

146 Cf. Harris, Kriebel and Raviv (1982), p.617
147 Cf. Lamont (1997), p.85
148 Cf. Stulz (1990), p.4
149 Cf. Stulz (1990), p.18
150 Cf. Lamont (1997), p.84

2.3.2. Impact of Diversification on Firm Value

In the foregoing section, I mainly concentrated on the rationals of diversification. In this section, the impact of diversification on the firm value is discussed. Scholars have discussed whether diversified companies trade at premium or at a discount. In the following, I also review the findings of selected studies.[151] The effect of diversification on firm value can be analyzed by different research designs, especially by using stock returns from M&A announcements or by calculating the sum of stand alone values of segments and compare them to the diversified firm's overall value.

2.3.2.1. Diversification Discount

Wernerfelt and Montgomery (1988) and Lang and Stulz (1994) use Tobin's Q analyses to show that "narrowly diversified firms do better than widely diversified firms"[152].

Berger and Ofek (1995) find that diversified companies on average show diversification discounts of 13% to 15% in comparison to stand-alone values of individual businesses for their sample period from 1986 until 1991. They find that "the value loss is smaller when the segments of the diversification are in the same two-digit SIC code".[153] Further, they show that the arguments of overinvestments and cross-subsidization – as discussed above – explain their findings. They mention that the loss is dampened by a tax advantage that derives from diversification, *first*, due to immediate offsetting of gains and losses from different segments, and *second*, from the higher tax shield resulting from higher debt capacity of diversified companies. However, this tax effect is demonstrated to be small, as already mentioned above. Nevertheless, the authors finally conclude that "if overinvestment and cross-subsidization are properly controlled, a diversification strategy can produce small benefits in the form of increased debt capacity and tax savings".[154]

Comment and Jarrell (1995) find that there is a positive relation between "corporate focus and stock returns". They argue that diversified companies are not successful in realizing benefits from financial economies of scope, from the co-insurance effect, and from internal capital markets.[155]

For firms increasing their focus by divestitures of assets, John and Ofek (1995) find that the remaining assets improve their operating performance in the three years after the divestiture. Consequently, divestitures that are focus-increasing yield positive abnormal event returns to the seller around the announcement date.[156]

Servaes (1996) provides an analysis of corporate focus and diversification and firm performance since the 1960s. He finds that "firms have low valuations during part of the sample period because they are diversified, not because poorly performing firms decide to diversify"[157], which clarifies the direction of causality running from diversification to performance. Further, he finds neither

[151] Later, I will test the impact of diversification in production technology specifically for utility companies.
[152] Cf. Wernerfelt and Montgomery (1988), p.246
[153] Cf. Berger and Ofek (1995), p.39
[154] Cf. Berger and Ofek (1995), p.60
[155] Cf. Comment and Jarrell (1995), p.67
[156] Cf. John and Ofek (1995), p.105
[157] Cf. Servaes (1996), p.1222

evidence for a diversification premium nor a diversification discount for the 1970s, though there is such diversification discount during the earlier 1960s.

Hadlock, Ryngaert and Thomas (2001) analyze the effect of diversification on stock returns when equity is issued. According to Myers (1984), equity issues result in negative abnormal returns due to information asymmetry. Hadlock, Ryngaert and Thomas (2001) find that the issue of information asymmetry is less severe for diversified firms[158], i.e. negative abnormal returns for multi-segment firms equal -2.24% whereas they find -2.82% for single-segment firms.[159] They successfully differentiate these two groups at the 5%-level with a Wilcoxon rank-sum test.[160] Consequently, they conclude that their results are, *first*, *inconsistent* with hypothesis that capital markets expect diversified companies to *allocate capital to less attractive projects*, and *second*, *inconsistent* with the hypothesis that diversified companies are *less transparent*.[161,162] Hadlock, Ryngaert and Thomas (2001) explain the rational for their finding as follows:

> "Our argument is based on the assumption that the errors the market makes in valuing unrelated divisions of a firm are imperfectly correlated. This implies that the absolute value of the percentage error in the market's pricing of a firm's stock will generally be smaller for a diversified firm than it is for a focused firm. Consequently, the adverse-selection problem facing equity issuers should be smaller for diversified firms relative to focused firms."[163]

Campa and Kedia (2002) argue that diversified companies trade at a *discount*, while this is *not a priori a sign that diversification is value destroying.* As for an underperforming company the "opportunity costs of assigning its scarce resources in other industries" are lower.[164] Therefore such companies might be more likely to diversify. Consequently, Campa and Kedia (2002) explain that there is an endogeneity problem, as "a firm's choice to diversify is likely to be a response to exogenous changes in the firm's environment that also affect firm value".[165] Therefore, causality between diversification and firm value is not given. They address this issue by several methods and find that for such companies that already are diversified, there is a value premium from diversification.[166]

Schoar (2002) uses plant level data for manufacturing firms from the Longitudinal Research Database, in order to show that diversified companies are more productive than stand alone firms.[167] However, by further diversifying, companies loose their advantage in productivity. Management attention shifts from the existing segments to the new segments ("new toy effect"). Consequently, performance in the new segments improves and in the existing segments decreases with an overall negative net impact on performance.[168] Schoar (2002) shows that differences in

158 Cf. Hadlock, Ryngaert and Thomas (2001), p.632
159 Cf. Hadlock, Ryngaert and Thomas (2001), p.625 f.
160 Cf. Hadlock, Ryngaert and Thomas (2001), p.626
161 Cf. Hadlock, Ryngaert and Thomas (2001), p.632
162 Transparency refers to the level of detail in annual reports, as explained in Hadlock, Ryngaert and Thomas (2001), p.615
163 Cf. Hadlock, Ryngaert and Thomas (2001), p.614 f.
164 The direction of causality seems to contradict the finding of Servaes (1996).
165 Cf. Campa and Kedia (2002), p.1759
166 Cf. Campa and Kedia (2002), p.1760
167 There are other authors also using plant level data, e.g. Maksimovic and Phillips (2002) and McGuckin and Nguyen (1995) and several later papers.
168 Cf. Schoar (2002), p.2380 and p.2402

transparency can not cause the diversification discount, which is found to equal about 10% on average.

2.3.2.2. Diversification Premium

Denis, Denis and Sahn (1997) find that about 40% of the diversified firms in their sample trade at a premium in comparison to a firm's segments stand alone values.

Graham, Lemmon and Wolf (2002) point out that an implicit assumption that conglomerate segments are comparable to stand alone businesses is not generally true. They find that the diversification discount can, to a large extent, be explained by discounts that have been present before the acquisition of such discounted segments. They conclude that "the distribution of excess values for multi-segment firms should be centered closer to 0, instead of near -15 percent as implied by some previous research."[169]

Later, Villalonga (2004) finds that there is a premium of about 28% for diversified companies, measured by using the "establishment-level database" BITS (Business Information Tracking Series). In contrast, she finds a discount of 18% on average if Compustat data is used.[170] She explains that "it is [...] crucial to measure diversification correctly"[171], as there are some issues related to the frequently used Compustat segment data. I will refer to this in more detail in Section 3.3.

In a nutshell, there are studies finding that diversification leads to significant discounts (e.g. Berger and Ofek (1995), Lang and Stulz (1994) and Servaes (1996)), while other studies find no discount (e.g. Graham, Lemmon and Wolf (2002)) or even a premium (e.g. Villalonga (2004)).

2.3.3. Stock Returns from M&A Deals

One of the major goals in M&A research is to explain the cumulative abnormal returns of stock returns due to M&A events. In this section, I specifically review studies that also address the abnormal acquirer returns from M&A processes, as I will analyze acquirer returns for the utility industry in Section 5.3.3.3.

Generally, M&A markets are driven by economic changes (e.g. Andrade, Mitchell and Stafford (2001), Andrade and Stafford (2004)). In case of unexpected economic changes, companies increase their takeover activities.

For the merging firms – i.e. for the combined return of acquirer and target – scholars overall expect positive combined abnormal returns from productive efficiency gains, collusion and buyer power.[172] Several studies empirically confirmed the positive abnormal returns of the combined merging firms, e.g. Jensen and Ruback (1983), Jarrell, Brickley and Netter (1988), Andrade, Mitchell and Stafford (2001), Fee and Thomas (2004) and Shahrur (2005).

169 Cf. Graham, Lemmon and Wolf (2002), p.719
170 Cf. Villalonga (2004), p.492
171 Cf. Villalonga (2004), p.480
172 Cf. e.g. Fee and Thomas (2004), p.427 or Shahrur (2005), p.65 for tables summarizing the expected effects on merging firms, rivals, customers and suppliers.

Further, many studies find negative abnormal returns for bidder companies only, e.g. Jensen and Ruback (1983), Jarrell, Brickley and Netter (1988), Morck, Shleifer and Vishny (1990), Andrade, Mitchell and Stafford (2001), Fuller, Netter and Stegemoller (2002), and Moeller, Schlingemann and Stulz (2004). For example, Agrawal, Jaffe and Mandelker (1992) find negative abnormal bidder returns from M&A deals of about 10% annually over a period of five years after merger completion.

In their analysis, Fee and Thomas (2004) focus on horizontal M&A deals, identified by SIC codes. They find little evidence for an impact of monopolistic collusion. Instead, they find evidence for a positive effect from increased buying power and productive efficiency. Especially, they find positive abnormal returns for the merging companies with combined positive abnormal returns of about 3.06% for target and bidder. While bidders experience negative cumulative abnormal returns of about -0.58%, targets have a positive abnormal return of 18.77% in a three day event window.[173] Negative abnormal bidder returns are typically seen as an indication that anti-competitive collusion is not the major motivation for such events.[174]

Shahrur (2005) confirm that M&A are "driven by efficiency considerations"[175], or might potentially be driven by collusion or buyer power considerations.[176] They find abnormal returns of 15.89% for target companies and -0.61% for bidder companies for a one day event window. On average, they find a combined abnormal return of 2.25% for the 1 day event window and 3.52% for an event window of 21 days around the event date.[177] Nevertheless, they find a negative combined abnormal return in 39% percent of all cases. According to Mitchell and Mulherin (1996) such negative combined returns indicate the overall negative market expectations with regard to an industry. Shahrur (2005) consistently find that rivals, suppliers and targets experience negative abnormal returns. For the deals with positive combined abnormal returns for acquirer and target, Shahrur (2005) find that the abnormal returns of customers and suppliers are positive, which clearly is inconsistent with the collusion and buyer power theory.[178] In case of collusion positive abnormal returns to acquirer and competitor are expected. Shahrur (2005) state that "horizontal takeover can increase the likelihood of collusion in the takeover industry, which would benefit the merging firms at the expense of their customers and suppliers".[179] Consequently, negative abnormal returns are expected for customers and suppliers.

In contrast, there are studies finding positive returns for acquirers, as will be discussed in the following.

Fuller, Netter and Stegemoller (2002) similarly find negative abnormal acquirer returns for the acquisition of public targets, while in contrast they find positive abnormal acquirer returns

173 Cf. Fee and Thomas (2004), p.440

174 Cf. Fee and Thomas (2004) p.429 and p.440 Also, according to the collusion argument, the gains to rival firms during a horizontal M&A event should be higher than in non-horizontal M&A events.

175 Cf. Shahrur (2005), p.61

176 Cf. Shahrur (2005), p.95

177 These results are in accordance with other research, e.g. Jensen and Ruback (1983) and Andrade, Mitchell and Stafford (2001).

178 Cf. Shahrur (2005), p.63. Eckbo (1983) suggested to analyze the returns of customers and suppliers in discriminate between collusion and efficiency theories of M&A.

179 Cf. Shahrur (2005), p.62

from acquisitions of privately held companies or subsidiaries of listed firms.[180] Chari, Ouimet and Tesar (2010) find significant positive abnormal acquirer returns in takeovers of emerging market targets. Further, they confirm the finding of Fuller, Netter and Stegemoller (2002) that abnormal acquirer returns are higher for acquisitions of privately held targets.

Faccio, McConnell and Stolin (2006) confirm that the listing status of the target company impacts abnormal acquirer returns, although they state that "[p]resumably the listing effect in acquirers' stock returns is a manifestation of some economic phenomenon that our various proxy variables have failed to capture."[181] For unlisted target companies, they find positive abnormal returns to the acquirer (1.48%), whereas they find negative or zero abnormal acquirer return when the target company is listed (-0.38%). As control variables, Faccio, McConnell and Stolin (2006) include the following factors in their empirical analysis of abnormal acquirer returns: acquirer size, method of payment, blockholder created, Tobin's of acquirer, whether acquirer's shares are closely held, pre-announcement leakage, ownership structure of the acquirer, relative market values of target and bidder, whether acquisition is a cross border transaction, whether bidder and target are in the same industry and whether the takeover was hostile. Besides for the listing status, Faccio, McConnell and Stolin (2006) find significance for acquirer size.

Moeller, Schlingemann and Stulz (2004) find that larger acquirers experience significantly smaller cumulative abnormal returns in comparison to smaller acquirers. They argue that this is due to managerial hubris and the fact that large firms offer higher acquisition premia compared to small firms.[182] In their multivariate analysis of abnormal acquirer returns, they control for similar acquirer and deal characteristics as, e.g. Faccio, McConnell and Stolin (2006).

Cai, Song and Walkling (2011) explain that negative or zero abnormal bidder returns are mainly due to not considering anticipation of deals. They point out that M&A announcements are not always surprising, which should generally be accounted for in empirical analysis. As a consequence, they find significant positive abnormal returns for bidders when anticipation is considered correctly.[183] They conclude that this effect helps to understand why firms still conduct M&As. For public target companies, Cai, Song and Walkling (2011) also find significant positive abnormal acquirer returns. Their finding clearly differs from the historical finding of zero or negative abnormal returns for bidder companies.[184]

Kedia, Ravid and Pons (2011) analyze cumulative abnormal returns for vertical mergers. They find positive overall abnormal returns until the late 1990s and negative abnormal returns afterwards. Kedia, Ravid and Pons (2011) argue "that vertical deals between partners with market power, especially in concentrated industries, can be successful."[185] Further, they do not find high abnormal returns for horizontal deals and therefore also conclude that horizontal deals are not conducted for anti-competitive reasons.

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[180] Cf. Fuller, Netter and Stegemoller (2002), p.1792
[181] Cf. Faccio, McConnell and Stolin (2006), p.218
[182] Cf. Moeller, Schlingemann and Stulz (2004), p.226
[183] Cf. Cai, Song and Walkling (2011), p.2243
[184] Cf. Cai, Song and Walkling (2011), p.2282
[185] Cf. Kedia, Ravid and Pons (2011), p.872

Becher, Mulherin and Walkling (2012) test synergy, collusion, hubris and anticipation theory for a sample of M&A deals and focusing on the U.S. utility industry between 1980 until 2004. They find that M&As create value which is mainly consistent with the synergy and collusion hypothesis. In order to differentiate these two hypotheses, they study returns of rivals as well as customer prices. Becher, Mulherin and Walkling (2012) conclude that positive abnormal returns of M&A in the utility industry are caused by synergy rather than by collusion. Therefore, they conclude for the utility industry in the U.S. that the "relaxed antitrust attitude has benefited consumers as well as shareholders".[186]

For the utility companies in their sample, Becher, Mulherin and Walkling (2012) find a mean target return of 13%, an abnormal bidder return of -0.8% and a combined bidder-target return of 2.3%.[187] For horizontal deals vs. non-horizontal deals, they do not find a significant difference in target, bidder and combined returns. Therefrom, they conclude that synergy potentials in horizontal and vertical deals are comparable. As *horizontal*, they classify such deals that are conducted between two electric utilities or between two gas utilities. All other deals (incl. non-utility targets or bidders) are considered *non-horizontal*.

Becher, Mulherin and Walkling (2012) reviews the specific features of utility companies – i.e. high costs for transmission of electricity over long distances, infeasibility of storing electricity, grid capacity constraints and inelastic demand[188] – and argue that "the unique features of electricity [...] make collusion plausible"[189]. However, as mentioned before, there is no empirical evidence for this.

Fan and Goyal (2006) use input-output tables in order to measure vertical relatedness of merging companies. They find that "the wealth effects in vertical mergers are comparable to those in pure horizontal mergers".[190] For future research, Fan and Goyal (2006) suggest that (related) vertical and horizontal deals could be compared to diversifying mergers. They imply that there might be an increased likelihood from organizational talent of the acquirer on one or the other type, i.e. either related or unrelated deals.[191]

186 Cf. Becher, Mulherin and Walkling (2012), p.87
187 Cf. Becher, Mulherin and Walkling (2012), p.70
188 Cf. Becher, Mulherin and Walkling (2012), p.58
189 Cf. Becher, Mulherin and Walkling (2012), p.59
190 Cf. Fan and Goyal (2006), p.877
191 Cf. Fan and Goyal (2006), p.900

2.4. Regulation and the utility industry

In this chapter, I give a brief overview on findings regarding utility companies in finance research, on the consideration of regulation in capital structure research, and on regulation in the utility industry. This overview is not exhaustive and especially does not intend to fully recapture the actual rules of regulation. Instead, this chapter intends to address some hunches or preconceptions regarding the capital structure of utility companies in finance research.

2.4.1. Treatment of utility companies in Finance research

Many recent capital structure papers exclude utility companies, e.g. Kayhan and Titman (2007), Hadlock and Pierce (2010), Kahle and Stulz (2013) and Fama and French (2005). Other studies do *not* explicitly exclude them, e.g. Rajan and Zingales (1995), Graham (2000), Hovakimian, Opler and Titman (2001), Welch (2004), Lemmon, Roberts and Zender (2008) and notably, Öztekin and Flannery (2012), who explicitly analyze the impact of institutional differences on the capital structure. If anything, authors typically state that excluding utility companies is due to the regulated nature of the industry.

Finally, several studies use dummy variables in order to account for utility companies (or regulated companies in general), e.g. Graham, Lemmon and Schallheim (1998), Elyasiani, Guo and Tang (2002), Johnson (2003), Frank and Goyal (2009) and Saretto and Tookes (2013).

The reader shall keep in mind the aforementioned usage of a utility industry dummy variable – as in my context – the acceptance of such dummy variable is already sufficient and will relief some potential doubt regarding the generalizability of my later analyses. A typical dummy variable shifts the leverage ratio by a constant. However, all other factors remain equal as they are for other industries. Obviously, this assumption is even stronger than considering utility companies in separate regressions with the same set of independent variables, as the latter would allow for differing coefficients of the independent variables in comparison to non-utility companies. For example, Elyasiani, Guo and Tang (2002) apply separate regressions for utility companies.[192] However, both types of studies implicitly assume that the mechanics – irrelevant of the absolute level of leverage – are identical, i.e. the same factors drive leverage ratios of utility and non-utility companies in a linear manner.

In the literature, electric utilities and financial institutions are frequently treated separately from other industries. But in such case, for consistency, there are other industries that should then similarly be considered as being regulated to some extent or non-competitive in certain areas of their business or in certain countries, e.g. railways, postal services, telecommunication, gas, air services and maritime transportation, as pointed out in 2001 by OECD (2001).

Further, MacKie-Mason (1990) points at a potential reason for leaving out utility companies from papers in the 1990s in the appendix:

> "Many of the explanatory variables are not reported by COMPUSTAT for electric utilities. Rather than exclude this important sector (utilities undertake a disproportionate share of

[192] Cf. Elyasiani, Guo and Tang (2002), p.361

> public issues), I collected the needed data from Moody's Utilities Manual."[193]

Today, I can not clarify in this review of literature, whether this might be another reason for some other scholars to leave out utilities in their empirical studies. Yet, there are several authors, who do not address the decision to leave out utility companies in great detail. MacKie-Mason (1990) might point out a quite important reason here.

At least since 2003, scholars seem to "follow standard practice" when leaving out "regulated utilities" with SIC codes between 4000 and 4999, as pointed out by Frank and Goyal (2003) for their sample between 1971 and 1998:

> "Following standard practice, financial firms (6000-6999), regulated utilities (4900-4999), and firms involved in major mergers [...] are excluded."[194]

I am not aware of a seminal finance paper, that re-included utility companies arguing with the deregulation of the sector, as will below be reviewed from the literature. Today, scholars might – when they exclude utility companies from their analysis – still be using a "standard argument" that they became used to, without reflecting the changed industry environment in more detail.

The more recent study of Fama and French (2005) also excludes utility companies due to regulation. Their "sample includes NYSE, AMEX, and Nasdaq firms", using data "from CRSP and Compustat".[195] Authors do not clarify the country of the sample companies headquarters, as it is also the case in several other studies.[196] Their sample period reaches from 1973 until 2002.

There remains some doubt that one can not assume that such sample only includes companies based in the U.S. I clearly point out that neither being listed at the NYSE or AMEX nor being included in CRSP or Compustat is a waterproof criterion for the "companies' nationalities" being U.S.-based. For example, the German companies Deutsche Bank AG (since 2001), Siemens AG (since 2001), SAP AG (since 1998) and Fresenius Medical Care AG & Co.KGAA (since 1996), i.e. more than 10% of the companies of the German DAX, and several other international companies are listed at the NYSE, as found from the NYSE listings directory. Especially, the following international utility companies, among others[197], were listed at the NYSE before 2002, according to the NYSE listings directory: Enersis S.A. (since 1993, Chile), Korea Electric Power Corporation (since 1994, South Korea), Endesa Chile (since 1994, Chile), Huaneng Power International, Inc. (since 1994, China) Companhia Paranaense de Energia (since 1997, Brazil), TransAlta Corporation (since 2001, Canada), Veolia Environment (since 2001, France) and Companhia de Saneamento Basico do Estado de Sao Paulo (since 2002, Brazil). Whether nationality of companies is important or is not, if studies discuss the impact from regulation or make use of a regulation argument, there might be some value from controlling for the legal/ regulatory environment, i.e. the country or state, a firm is actually headquartered in. Admittedly,

193 Cf. MacKie-Mason (1990), p.1489
194 Cf. Frank and Goyal (2003), p.225
195 Cf. Fama and French (2005), p.555
196 The reader also does not know whether they limit their sample to primary listings of companies at the NYSE.
197 A list of non-US utilities listed at the NYSE is given in Table A. 1 in the appendix as of March 28^{th}, 2013

as the sample horizon of e.g. Fama and French (2005) is from 1973 until 2002, their sample might include mainly U.S. companies or they might have controlled for it without having specified this in their study. However, there remains some doubt that scholar unintentionally might leave out or include utilities (and banks) from more or less regulated markets and thereby unintentionally bias results for the remaining sample.

Similarly, studies excluding utility companies “due to regulation” and without controlling for “potentially unregulated utility companies” might exclude companies that are less regulated or even unregulated, as they do not consider country specific differences.

Generally, as regulation is country specific, it might be that studies limiting themselves to U.S. data should not be considered as being representative with regard to their statements on regulation for worldwide samples. Therefore, researchers must be careful when they follow “ standard practice” for companies in their international samples.

2.4.2. Findings on utility companies from seminal papers in Finance research

I point out that there is a strand of literature from the 1970s, discussing the effect from regulation especially with regard to the utilities practice. The reader shall consider that this era reaches back to several decades before the sample period addressed in this thesis. In the meantime the industry experienced significant (country-specific) privatization and deregulation.

Early Finance-related research regarding the utility industry

There was an early stream of literature dealing with utility companies due to their characteristics, especially due to regulation imposed on these companies. For example, Hart (1948) and Scott (1954) discussed the specific risks of utility companies in their regulated environment and the impact of nuclear energy for utility companies. Somewhat later, there was an intense discussion on the cost of capital initiated by Miller and Modigliani (1966*a*) with further contributions from, e.g., Miller and Modigliani (1966*b*), Elton and Gruber (1971), Gordon and McCallum (1972), Robichek, Higgins and Kinsman (1972), and Jaffe and Mandelker (1976), all specifically referring to utility companies in their regulated environment of some decades ago in the United States. Miller and Modigliani (1966*a*) choose U.S. utility companies as their sample, since these companies are similar with respect to, e.g., their profitability, (low) growth rates, but also with respect to technologies, products and market environment.[198] They explain that they find “no evidence of sizable leverage or dividends effects”[199] on valuation under perfect market conditions under uncertainty. Further, they found unexpected results for the cost of capital and the cost of equity, that were later discussed extensively in the literature.[200] Later, Carleton, Chambers and Lakonishok (1983) discussed the rate of return regulation and its impact on interest rates, Clarke (1980), evaluated the effect of fuel adjustment clauses on the systematic risk of utility companies.

198 Cf. Miller and Modigliani (1966*a*), p.335, p.337, p.345
199 Cf. Miller and Modigliani (1966*a*), p.386
200 Cf. Miller and Modigliani (1966*a*), p.386

Modern Finance-related research regarding the utility industry

In the following, I provide an overview on findings in more recent, seminal capital structure literature, that are linked specifically to the capital structure of utility companies. In his paper, Myers (1984) explains:

> "However, the regulated firms MM examined had little tax incentive to use debt, because their interest tax shields were passed through to consumers. If a regulated firm pays an extra one dollar of interest, and thus saves T, in corporate income taxes, regulators are supposed to reduce the firm's pre-tax operating income by $T_c/(1-T_c)$, the grossed-up value of the tax saving. This roughly cancels out any tax advantage of borrowing. Thus regulated firms should have little incentive to borrow enough to flirt with financial distress, and their debt ratios could be dispersed across a conservative range."[201]

Myers (1984) also discusses the capital structure of utility companies. He states that

> "regulated firms, particularly electric utilities, typically pay dividends generous enough to force regular trips to the equity market. They have a special reason for this policy: it improves their bargaining position vs. consumers and regulators. It turns the opportunity cost of capital into cash requirements."[202]

Later, Hansen, Kumar and Shome (1994), show that corporate monitoring causes utility companies to pay high dividends and to issue large amounts of equity.[203]

The reader of this thesis should know, that U.S. utility companies were mainly privately owned, though they were acting in a regulated environment, as I will briefly outline below. In this sense, the dividends (Myers, 1984) mentions – at least for their sample firms which might be mainly U.S.-based[204] – do not flow back to a governmental, federal or municipal owner. Whether this argument of Myers (1984) still holds when regulated companies are owned by country, state or city is not discussed. This is especially important, as in most countries, utility companies were not privatized at this point in time, as I will later derive from the literature. Furthermore, this is even more relevant, as Myers (1984) does not explicitly limit the validity of his arguments to the U.S. (which might have led to an application of Myers' arguments by scholars also in international studies in academic research).

Another finding regarding the utility industry is presented by Bradley, Jarrell and Kim (1984), who finds an R^2 of 54% for their analysis of leverage, i.e. that more than half of the variation in leverage is explained by industry dummy variables in cross sectional analysis. Interestingly, when the regulated industries trucking, telephones, utilities and airlines are excluded, their model finds an R^2 of 25%.[205] Their study is based on early data from between 1962 and 1981. They state:

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[201] Cf. Myers (1984), p.578

[202] Cf. Myers (1984), p.585

[203] Another early paper also refers to dividends of the utility industry. Higgins (1974) shows that dividend policy of utility companies does not increase the share price.

[204] Cf. a comment below on the "nationality" of sample companies.

[205] Cf. Bradley, Jarrell and Kim (1984), p.870

> "Regulated firms such as telephone, electric and gas utilities, and airlines are consistently among the most highly levered firms, which raises the possibility that differences between regulated and unregulated firm leverage ratios (for whatever reasons) are primarily responsible for the overall ANOVA results."[206]

Seemingly, Bradley, Jarrell and Kim (1984) were not aware of any reason for the difference in leverage ratios of regulated and unregulated firms.

However, Jensen and Meckling (1976) pointed out that "in industries where the freedom of management to take riskier projects is severely constrained (for example regulated industries such as public utilities) we should find more intensive use of debt financing."[207]

Jensen and Meckling (1976) and Harris and Raviv (1991) point out that regulated utilities, banks and other firms in regulated industries with limited growth opportunities are expected to be higher levered than non-regulated firms. They argue that in such companies lenders are less likely to suffer from asset substitution, i.e. replacing projects or assets by more risky alternatives.[208]

MacKie-Mason (1990) find an important influence of tax in the choice between issuing equity or debt. He analyzes registrations of every publically offered security between 1977 and 1987. As he expects the signaling costs according to Myers and Majluf (1984) to be small – since "the regulatory agency may inform investors of relevant information"[209] – regulated companies are assumed to suffer less from signaling costs at issuance.[210] He finds that utility companies prefer to raise debt. Furthermore, they find that utilities issue equity less frequently, but if they do, raising large amounts of equity. Thereby, they profit from large scale effects in equity flotation costs and reduced transaction costs.[211] Harris and Raviv (1991) confirm that utility companies experience less negative abnormal returns when issuing securities in comparison to industrial firms.[212]

Graham, Lemmon and Schallheim (1998) expect utility companies to have higher debt as they should prefer debt instead of leases. Leases are problematic for utility companies as – depending on regulation of accounting rules – capital leases might not be accepted as part of the capital base[213], which is a relevant lever for the companies' turnover in their regulated part of their business. Operating leases are not counted as being part of the capital base.[214] Also, regulated companies might have higher debt due to more stable cash flows and an implied lower probability for becoming financially distressed, according to Graham, Lemmon and Schallheim (1998). Smith (1986) states that higher debt ratios protect investors from regulators transferring

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206 Cf. Bradley, Jarrell and Kim (1984), p.870
207 Cf. Jensen and Meckling (1976), p.355.
208 Cf. Jensen and Meckling (1976), p.355. Cf. Jensen and Meckling (1976) for a general explanation of the asset substitution argument.
209 Cf. MacKie-Mason (1990), p.1478
210 Cf. Myers and Majluf (1984) and MacKie-Mason (1990) for further details regarding the signaling cost argument.
211 Cf. MacKie-Mason (1990), p.1485 f. and p.1487
212 Cf. Harris and Raviv (1991), p.332
213 Cf. Graham, Lemmon and Schallheim (1998), p.138
214 Cf. Graham, Lemmon and Schallheim (1998), p.138. Graham, Lemmon and Schallheim (1998) refer to a sample of Compustat companies.

wealth to customers.

2.4.3. Developments in privatization and regulation of the industry

The reader should be aware that the (U.S.) utility industry was strongly regulated at the time of publication of the research of Jensen and Meckling (1976), Myers (1984), Bradley, Jarrell and Kim (1984) and Harris and Raviv (1991). However, there was significant deregulation in the 1990s. I can not provide a complete review of regulation for the international utility industry. Nevertheless, as I use an argument that is based on privatization and deregulation in Chapter 5.1, I briefly review relevant facts on both. Jamasb and Pollitt (2001) provide an overview on international incentive regulation in transmission and distribution and give several hints for further reading.

The restructuring of the utility industry is described as a process including three steps by Dewenter and Malatesta (1997): sale of companies, deregulation, and "contracting out of services to private providers".[215] Bacon and Besant-Jones (2001) describe it in a six step process: *First*, commercial principals are introduced to the industry and its companies, *second*, competition is fostered in order to increase efficiency, *third*, the power supply chain is restructured, *fourth*, generators and transmission/ distribution companies are privatized, *fifth*, independent regulator establishes competitive market and balances interests, and *sixth*, government acts as policy maker instead of as owner or operator.[216]

Privatization – besides other goals – aims at "fostering the development of capital market institutions or broadening share ownership, improving the economic performance of privatized enterprises, and raising revenue", according to Dewenter and Malatesta (1997). They point out that the speed of the privatization process differs by country, e.g. for fiscal or cultural reasons. In the appendix to their paper, Dewenter and Malatesta (1997) describe the process of privatization for several countries such as Canada, UK and France, which mainly took place in the 1990's.

Two important exceptions among the most developed states, that I am aware of, are Japan and the United States. Energy utility companies in Japan and the U.S. had been publicly owned much earlier. Edison Electric Institute (1973) finds for the U.S. that "after peaking at 8% in 1900, the share of electrical power generated by municipally owned utilities declined to 5% by 1932, compared to 94% for investor-owned utilities, with the federal and state governments producing the remaining 1%".[217] Moreover, Japan privatized its energy utility companies already in 1951. Until today, regional privately owned electricity utilities are responsible for the power supply in Japan.[218]

Deregulation aims at improving the service level of energy supply and reducing electricity prices compared to prices in monopoly markets by the introduction of competition.[219] Bacon and Besant-Jones (2001) state: "Power reforms are designed to introduce competition where

215 Cf. Dewenter and Malatesta (1997), p.1661
216 Cf. Bacon and Besant-Jones (2001), p.5 f.
217 As cited in Masten (2010), p.605.
218 Cf. Federation of Electric Power Companies of Japan (2012)
219 Cf. OECD (2001)

feasible, which is in the upstream production and downstream supply functions of the industry structure, and to use economic regulation of the wholesale and retail power markets to promote competition and protect consumer interests."[220] A precondition for developing a competitive market design is to grant access to generation, trading, transmission and distribution for all market participants and to dissolve natural monopolies.

In the U.S., there has been federal and state regulation. Retail prices charged by electric utility companies were regulated based on costs by state regulation. At the same time, companies were given regional monopolies, i.e. utilities owning and operating transmission lines in their region were not obliged to grant access to their transmission grid to other utility companies. On the federal level, wholesale prices were regulated. Regulation underwent significant changes in 1992 by the Energy Policy Act and the Order 888 and 889 in 1996, when transmission and distribution grid access was made available to other market participants and the utilities' value chain of generation, transmission and retail was unbundled. Wholesale prices where no longer regulated but priced at marginal costs. Today, in parts of the U.S., there are competitive wholesale and retail electricity markets established such as PJM Interconnection, a large competitive wholesale market with more than 700 market participants (serving all or parts of 13 states[221] of the U.S. plus the District of Columbia), the Electric Reliability Council of Texas and similar markets in New York and New England[222].

In California, the California Public Utilities Commission today regulates utility services incl. electricity prices, as California partially returned from their earlier 1996's deregulation (California Assembly Bill 1890) due to the California Electricity Crisis. During the state's attempt to deregulate the industry, it sold a significant amount of its generation capacity to privately owned independent power producers in 1998. During deregulation an independent system operator of transmission facilities and the California Power Exchange were introduced. Companies were obliged to buy spot electricity instead of entering into bilateral long-term contracts.[223] For further details on regulation in the U.S., the reader is referred to Joskow (2000).

In Japan, independent power producers (IPPs) were introduced in 1995, when the Japanese wholesale generation market was liberalized and a power bidding system was introduced. In 1999, competition was introduced in retail for high-voltage customers. In 2003, the Japan Electric Power Exchange was established, i.e. Japan's wholesale electric power market.

In Europe, directive 96/92/EC of the European Commission increased competitiveness, service quality and efficiency and reached price reductions by further developing rules for the energy markets of European countries in 1996. The process of liberalization went on until the 2000s. While there are some aspects (e.g. grid access, incentive regulation in transmission and distribution) in the industry that are typically "regulated", today wholesale prices are usually set at competitive market places, e.g. the Amsterdam Power Exchange founded in 1999, the Euro-

[220] Cf. Bacon and Besant-Jones (2001), p.4
[221] Delaware, Illinois, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia
[222] Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut
[223] Refer to the FERC chronology http://www.ferc.gov/industries/electric/indus-act/wec/chron/chronology.pdf for more details on the specific situation of the "Western Energy Crisis" in California.

pean Energy Exchange and the Leipzig Power Exchange founded in the 2000, and the Energy Exchange Austria founded in 2001.[224] Due to early liberalization in Scandinavia, the exchange Nord Pool was already established in 1993.

In a nutshell, today the electric utility industry is often considered as being (at least partially) de-regulated, i.e. liberalized from its former restrictions of competition due to natural monopolies.[225] Rules were introduced to foster competition and allow for a non-discriminating, competitive market environment. Very important developments in this direction were the unbundling of generation and transmission/ distribution grids and of retail and transmission/ distribution grids, providing non-discriminating access to these grids to former monopoly owners as well as new player in the market. While grids can be seen as being less competitive areas of the industry[226], generation, retail and trading are usually regarded as being competitive.[227] OECD (2001) gives an international overview of the "Structural Separation in the Electricity Industry" by country.[228]

However, the status of overall deregulation and reforms in the utility industry differs among countries. As deregulation can be considered as a process rather than a single decision, there is not one point in time per country that can be considered as being "the time of deregulation". Generally, the beginning of the 1990s was a time of strong deregulation in the developed countries - however, not necessarily of strong privatization, as I argued for the U.S. and Japan.

In the following, I briefly review the status of regulation in the late 1990s.[229] An overview on the status of regulation is given by Bacon and Besant-Jones (2001) and international benchmarking studies cited therein, especially World Energy Council (1998), Kennedy (2000), Energy Sector Management Assistance Program (1999) and CAEM (2000).[230]

Bacon and Besant-Jones (2001) give an overview on the number of countries that, *first*, substantially liberalized their utility industry, *second*, planned or just started liberalization, and *third*, did not liberalize their utility industry in 1998.[231] In Europe, 20% of the countries already substantially liberalized the utility industry, 43% planned or just started liberalization and 37% did not liberalize the utility industry in 1998. For the worldwide sample of 151 countries, 10% liberalized, 36% plan or just started to liberalize and 54% did not liberalize the utility industry. Mainly Africa and Middle East did not start liberalization to a significant extent in 1998.[232]

The Energy Sector Management Assistance Program (1999) analyzes reforms in the power sector of 115 developing countries. Even for the developing countries, they find that 21% of the

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[224] For an overview on energy legislation in Europe refer to http://europa.eu/legislation_summaries/energy/european_energy_policy/index_de.htm.

[225] Cf. Becher, Mulherin and Walkling (2012), p.59

[226] Consequently, many countries have incentive regulation in place that aims at limiting costs in distribution and transmission by price or revenue cap models, as discussed in detail in Jamasb and Pollitt (2001)

[227] Cf. OECD (2001), p.9 and p.31 ff. for a more detailed discussion.

[228] Cf. OECD (2001), p.67

[229] I choose these years as, *first*, there is quantitative data available, and *second*, as the sample period of my later empirical analysis starts in 2002.

[230] In my later analysis, I capture country specific regulation by using country dummies. As regulation in the U.S. can differ by states, I test robustness of results by also applying separate dummies for each U.S. state.

[231] Bacon and Besant-Jones (2001) derive data form World Energy Council (1998).

[232] Value calculated from data in Bacon and Besant-Jones (2001), p.9.

countries took key reforms steps in privatizing generation, 18% conducted key reform steps in privatizing distribution and 40% granted market access to Independent Power Producers (IPPs). A regulator was established in 29% of the developing states.[233,234]

233 Cf. Energy Sector Management Assistance Program (1999), p.35 ff.

234 A study comparing reforms in OECD and non-OECD countries was conducted by Williams and Ghanadan (2006).

3. Development of Hypotheses

In this chapter, the relevant hypotheses are derived. *First*, the hypothesis for the impact of production flexibility on the capital structure is derived. *Second*, the development of hypotheses for the impact of asset maturity on the maturity of debt are discussed. Further, I develop the hypothesis regarding the impact of a mismatch of debt and asset maturity on relative yield spreads at debt issuance. Also, the hypotheses for the impact of salability on leverage and debt maturity are reflected. *Third*, the hypothesis for the role of diversification in production technologies on cumulative abnormal event returns from mergers and acquisitions is derived.

3.1. Production characteristics and the capital structure decision[1]

3.1.1. Impact Hypothesis

As I showed in Chapter 2, cross-sectional determinants of the capital structure are still a mystery. After literature has extensively discussed the question whether companies adjust towards a target level of leverage, recent literature found that slowly changing production characteristics might explain the empirically observed stability of capital structures over time (e.g. Lemmon, Roberts and Zender (2008), Rauh and Sufi (2012) and Leary and Roberts (2013)).

Mauer and Triantis (1994) theoretically explain that production flexibility increases debt capacity. According to Mauer and Triantis (1994), production flexibility is related to a firm's direct and indirect cost to adjust its production, e.g., to stop and restart a production facility. They provide two theoretical arguments for a positive effect of production flexibility on leverage: *First*, companies with higher production flexibility – which is associated with lower operating adjustment costs – can more quickly react to negative profit margins. For example, they can stop producing instead of earning negative margins, when market prices are unattractive. Equally, more production-flexible companies can start-up production more quickly when margins are positive. This decreases the probability of default by reducing "the negative effect of operating losses on firm value"[2]. Consequently, it is hypothesized that leverage increases with increasing production flexibility. *Second*, besides this, there is a tax effect from the increased value of the tax shield due to higher leverage, which leads to a reduction in the volatility of the firm value.[3] Both effects are expected to increase a firm's leverage in case of higher production flexibility.[4] Consequently, it is hypothesized that leverage increases with increasing production flexibility.

[1] This section is largely based on Reinartz and Schmid (2013).
[2] Cf. Mauer and Triantis (1994), p.1262
[3] Cf. Mauer and Triantis (1994), p.1254
[4] Nota bene: Both effects also have a positive influence on the firm value, according to Mauer and Triantis (1994), p.1262

Thus, I posit:

- **Impact hypothesis**: Higher production flexibility leads to higher leverage ratios.

For the avoidance of doubt, I refer to production flexibility rather than to investment flexibility in the sense of e.g. MacKay (2003).

Surprisingly, MacKay (2003) finds, that higher production flexibility (in contrast to investment flexibility) leads to lower leverage, as already mentioned in Chapter 2. On first view, this contradicts the above hypothesis. However, his empirical results regarding the effect of production flexibility on leverage are relatively weak, as Table 3 and Table 5 of his paper show.

From a theoretical perspective, MacKay (2003) adds a contrasting effect to the effect of production flexibility. MacKay (2003) argues that leverage might decrease due to the threat to lenders that shareholders might apply risk shifting (referring to production flexibility) or asset substitution (referring to investment flexibility). He interprets risk shifting as an opportunity to "risk shift by favoring risky production strategies over low volatility input and output combinations."[5] However, MacKay's risk shifting argument might play a less relevant role in my later analysis, since companies can "acquire reputation capital in the credit market to pre-commit against risk shifting", as MacKay (2003) points out in accordance with Diamond (1991*a*).[6] Also, it is not obvious to what extent risk shifting should influence my sample of international listed utility companies. Therefore, I stick to the hypothesis of Mauer and Triantis (1994).

Further, MacKay's measures of real flexibility are based on the idea that companies adapt their production to a changing economic environment. He uses different dimensions of production flexibility, i.e. process, product and volume flexibility.[7] In contrast, Mauer and Triantis (1994) as well as my empirical analysis, refer to businesses with a single finished product. As measures of production flexibility, MacKay (2003) then uses process flexibility (flexibility to choose between two input factors), product flexibility (flexibility to choose between two output products) and volume flexibility, the latter defined as the sensitivity of cash flows to changes in the output level. This measure of volume flexibility clearly is a derived measure including production adjustment costs, but *not* a direct measure. It includes production adjustment costs in such sense, that these costs cause non-linearity in cash flow sensitivity, as production adjustment costs have to be payed independent of the produced quantity. For volume flexibility he finds significance for a negative impact on total debt divided by total assets at the 5%-level.[8]
In a sense, besides comparing my measure of production flexibility to MacKay's *volume flexibility*, my measures might also be compared to MacKay's *process flexibility*, as I consider a portfolio of power plants that produce electricity from different fuels, i.e. by different power plant technologies.[9] MacKay (2003) not at all finds significance for an impact of process flexibility on

[5] Cf. MacKay (2003), p.1141
[6] Cf. MacKay (2003), p.1135
[7] Cf. MacKay (2003), p.1134
[8] Separating into small and large firms, MacKay (2003) finds slightly stronger significance for the GMM model. I will later show that I find no major differences for my subsample of small and large companies.
[9] The construction of my sample is described in Section 4. The construction of my production flexibility measures is discussed in Section 5.1.

total debt divided by total assets in OLS regression and GMM model. He only finds significance for GMM models referring to the dependent variable long-term debt and public debt divided by total debt (MacKay (2003), Table 3).
MacKay (2003) challenges his results by stating: "Although I take these findings at face value, the reader should keep in mind that my results are only as reliable as the methods I use to derive and estimate the real flexibility proxies".[10] In fact, his measure of production flexibility significantly differs from the measures I am referring to. This statement of MacKay (2003) also underlines the need for a more direct and reliable measure of production flexibility. Finally, MacKay (2003) uses Total Debt divided by Total Assets as a dependent variable.[11]

Again, in my hypothesis, I refer to production flexibility in the sense of Mauer and Triantis (1994), i.e. referring to costs for switching production on and off. *In a nutshell*, I expect to find results that are consistent with Mauer and Triantis (1994) and *not* directly comparable to MacKay (2003).

3.1.2. First-Order Importance Hypothesis

The empirical literature demonstrates that peer effects play a major role in explaining the capital structure (e.g. Frank and Goyal (2009)). However, the reason for this is yet to be clarified. Leary and Roberts (2013) hypothesize that the fact that firms in the same industry have similar production technologies helps to explain this finding. They even show that the *leverage of a firm's peers* is the *most important* determinant of a firm's capital structure.

Lemmon, Roberts and Zender (2008) demonstrate that leverage ratios are very stable over time and that existing empirical models fail to explain this observation. They conclude that the *major determinants* of the capital structure are yet to be identified. However, Lemmon, Roberts and Zender (2008) hypothesize that these factors change slowly over time and explain that they are not affected by IPOs. Hence, production characteristics provide a potential explanation for the empirically observed stability of capital structures over time. Also, production characteristics might explain the abovementioned peer effects. If firms in the same peer group have similar production characteristics, they might choose comparable leverage ratios.

As pointed out before, Rauh and Sufi (2012) find that the capital structure of companies from the same product market is the *most relevant determinant* of the capital structure. They show that this effect "is most closely related to the assets used in the production process."[12] Thus, I hypothesize:

- **First-order importance hypothesis**: Production characteristics are of first-order importance for capital structure decisions.

[10] Cf. MacKay (2003), p.1157
[11] Cf. Section 5.1.3 for a discussion of this leverage measure.
[12] Cf. Rauh and Sufi (2012), p.119 and p.152

3.1.3. Substitution Hypothesis

In line with Denis and McKeon (2012), I define a firm's level of financial flexibility as its unused debt capacity. Empirical evidence indicates that firms preserve more of their debt capacity than expected by "classical" capital structure theories (Graham, 2000). A potential explanation is that unused debt capacity is an important source of financial flexibility, as pointed out by Denis and McKeon (2012). According to Graham and Harvey (2001), Bancel and Mittoo (2004) and Brounen, De Jong and Koedijk (2006), financial flexibility is one of the main considerations of CFOs and an important determinant of the capital structure.

I hypothesize that financial flexibility and production flexibility act as substitutes, which is mainly attributed to a reduced cost of being financially less flexible, if production flexibility is high.

Mauer and Triantis (1994) were first to derive such substitution effect between financial flexibility and production flexibility in their theoretical paper, as explained in detail in Section 2.1.3.1.

MacKay (2003) claims to empirically confirm this substitution effect of financial flexibility and investment flexibility in accordance with Mauer and Triantis (1994) by using his specific measures of investment flexibility. However, he finds almost no or only weak empirical significance for an effect from production flexibility on leverage (MacKay (2003), Tables 3,5 and 6).

Gamba and Triantis (2008) also expect a substitution effect. They conclude "that firms with high levels of financial flexibility should be valued at a premium relative to less flexible firms [...]", which is "[...] more substantial if the production technology is relatively inflexible [...]" (p. 2293).

In accordance with the theoretical suggestion of Mauer and Triantis (1994), I hypothesize:

- **Substitution hypothesis**: Financial flexibility and production flexibility are substitutes.

If this hypothesis holds, the following two approaches should provide an empirical proof: *First*, I approximate a company's financial flexibility by the difference of average net debt of all utility companies in a given year minus net debt of the respective company (as a proxy of the deviation from the target level), and show that it is negatively related to production flexibility.

Second, I proof the substitution effect by demonstrating that companies with higher production flexibility require less financial flexibility in times of decreasing external financing opportunities. In such situation, companies with a lower financial flexibility are shown by Bancel and Mittoo (2011) to suffer more from such crisis. Consequently, if financial flexibility and production flexibility are substitutes – production flexibility should dampen the negative effect of such crisis.

For the Lehman event, I will show that companies with higher production flexibility show positive cumulative abnormal returns around the Lehman crash, i.e. suffer less from the shortening of external financing opportunities in comparison to companies with lower production flexibility. Vice versa, cumulative abnormal returns are positive if external financing opportunities improve for such companies with low production flexibility, as will be demonstrated by exploiting the coordinated central banks action as of Nov. 30^{th}, 2011.

Another view considers the *value* of financial flexibility. This value of being financially flexible might differ across firms. According to Gamba and Triantis (2008), financial flexibility may be less valuable for firms that can adjust their production more quickly and less costly, i.e. that have higher production flexibility. This value of financial flexibility determines the level of financial flexibility – and hence the capital structure – a firm chooses. This view is very much related the cost of deviating from a target leverage, which accounts for financial flexibility, as discussed intensively in Chapter 2.1.1.1. By exploiting their production flexibility, such companies with lower production adjustment time and costs can better react to external shocks. In this view, I hypothesize that production flexibility acts as a substitute for financial flexibility. Consequently, again I expect firms with higher production flexibility to suffer less from the Lehman crash, and to profit less from the coordinated central banks action as of Nov. 30^{th}, 2011.

3.1.4. Asset Salability/ Leverage Hypothesis

Typically, scholars explain that it is hard to measure salability. Therefore, they typically refer to indirect measures. An exception is Benmelech (2009), who uses direct asset salability data.

As a counter-effect to the a priori positive effect of investment flexibility on leverage, as suggested by Mauer and Triantis (1994), MacKay (2003) adds the threat of asset substitution. This counter-effect seems – at least partly – to derive from MacKay's difficulties in separately identifying the effect of asset specificity. MacKay (2003) states that the measurement of asset specificity is challenging and might be related to his measures of investment flexibility.[13] Consequently, difficulties in the interpretation of investment flexibility might arise from his measure, due to the indirect alternative asset specificity channel by which real flexibility effects leverage. He summarizes :

> "Thus positive signs on the real flexibility indicators support the idea that more flexible (less specific) assets promise higher liquidation value ex post and command greater collateral value ex ante. Negative signs on the real flexibility indicators support the idea that by making assets more marketable, real flexibility expands the investment opportunity set and facilitates asset substitution."[14]

Benmelech (2009) also hypothesizes that asset salability influences leverage.[15] Intuitively, Benmelech (2009) explains in accordance with Harris and Raviv (1990) and Williamson (1988), that

> "[...] the right to foreclose on the debtor's assets in the event of default is more valuable when the asset is more redeployable, and thus redeployability increases the debt capacity of an asset."[16]

As asset specificity in this sense may affect leverage ratios, I additionally control for salability *or* specificity in a separate robustness test in order to avoid any potential concerns. Thereby, I

[13] Cf. MacKay (2003), p.1136 f.
[14] Cf. MacKay (2003), p.1137
[15] Cf. Benmelech (2009), p.1548
[16] Cf. Benmelech (2009), p.1548

isolate the effect of salability from the real flexibility channel, which MacKay (2003) is concerned about at least for his investment flexibility variables.
The assets in my empirical analysis are all used in order to produce the same product, namely electricity. For salability *or* specificity of assets, I use an empirical measure based on the number of companies in the same country with the same production technology in their portfolio. However, I will not control for the financial situation of potential buyers. Consequently, depending on the exact definition used for the terms. The reader should understand the terms salability *or* specificity in the sense, as it will be empirically defined in Section 5.1.4.7.

Accordingly, I hypothesize:

- **Asset salability/leverage hypothesis**: Asset salability positively affects leverage.

For the avoidance of doubt, this hypothesis and the empirical proof is not new to the literature. However, I conduct this analysis, since Benmelech (2009) could not empirically confirm this hypothesis, while e.g. Benmelech, Garmaise and Moskowitz (2005) already found significance.

3.1.5. Expected Effects of Asset Age

There are mainly two potential reasons why asset age might be a relevant determinant of capital structure. *First*, asset age controls for the stage of the investment cycle a company is in. In Chapter 2, I reviewed that companies stay below their target leverage to remain financially flexible, i.e. the company saves for investments. Consequently, companies with older assets might be closer to the point of time when they must reinvest. They might prepare therefor by having a lower leverage and preserve additional debt capacity, and therewith the financial flexibility to invest.[17] For making investments, companies can deviate significantly from the target level (e.g. Kayhan and Titman (2007), DeAngelo, DeAngelo and Whited (2011) and Denis and McKeon (2012)). Therefore, when companies build new power plants (i.e. when asset age is low), one might expect that leverage is significantly higher and vice versa. *Second*, there might be an increase in efficiency for younger power plants compared to older power plants of the same production technology due to technological innovation.[18] Consequently, one would expect younger power plants (with higher efficiency and therefore higher profits) to influence leverage. It has to be found empirically which of these two effects dominates.[19] However, as financial flexibility is of highest importance for companies, I hypothesize that the first effect dominates, and consequently, higher asset age negatively impacts leverage.

Regional diversification – as another independent determinant of leverage – might have a positive impact due to a co-insurance effect.

[17] According to Bancel and Mittoo (2004), 73% of managers consider the debt rating to be important for capital structure decisions. Therefore, companies have to limit their overall corporate leverage in order to avoid a decrease in their debt rating.

[18] A relation between efficiency and COD is given, e.g. in Ellersdorfer (2009).

[19] There might be additional structural influences from age, which I do not discuss explicitly, however, the variable asset age controls for them.

3.2. Impact of the remaining lifetime of assets on debt maturity[20]

In this section, I derive my hypotheses, *first*, regarding the impact of asset maturity on debt maturity, and *second*, regarding the impact of a maturity mismatch on the relative yield spread of new debt issues.

3.2.1. Debt/ Asset Maturity Matching Hypothesis

In this section, I address the issue of debt and asset maturity matching on the balance sheet as well as for new debt issues.

3.2.1.1. Balance Sheet

In this section, I hypothesize that debt and asset maturity match. As this hypothesis is in line with the hypotheses and the respective conventional wisdom in the literature, as reviewed in Section 2.2.2, I will not repeat these arguments here. Instead, I explain, why this analysis has in fact not been conducted before, although authors claim to have done so.

Scholars claim that there is a matching of debt maturity to the remaining lifetime of assets or to the future value of assets.[21] Empirically, they rely on measures related to annual depreciations, as reviewed in Section 2.2.2. They provide the impression that the interpretation of Net Property, Plant & Equipment divided by Annual Depreciations is trivial. This is the key term of their measure of the remaining lifetime, e.g. in the cases of Stohs and Mauer (1996) and Barclay, Marx and Smith (2003). While at first sight, this seems to be true, I show by the following calculation that this measure can not be used in order to proof debt and asset maturity matching.

In the following, I show that the imprecision of such measure is large and can not be neglected.[22] In this sense, this section contradicts several important publications. Therefore, in order to be rigorously clear, I provide a mathematical proof in the following.

The abovementioned papers do not provide a detailed discussion regarding the quality of their asset maturity measure. To the best of my knowledge, the following discussion is new to the literature and therefore motivates the relevance of my later empirical analysis of debt and asset maturity matching.

Lemma: *The measure "Net Property, Plant & Equipment divided by Annual Depreciations" can not be interpreted as the remaining lifetime of assets.*

Proof: I assume a portfolio of two assets (V_{A1}, L_{A1}) and (V_{A2}, L_{A2}), where V_{AX} refers to the initial value of an asset (i.e. Gross Property, Plant and Equipment) and L_{AX} refers to the overall lifetime of an asset (also referred to as "time to maturity"). Indices numerate the two assets A1 and A2 included in the asset portfolio.

20 This section is largely based on Reinartz (2013).

21 Cf. Hart and Moore (1994) for a related theoretical discussion.

22 The measure of Scherr and Hulburt (2001) is *not* a measure of the remaining lifetime of assets, as they assume a fixed lifetime per asset class. Therefore, one can a priori expect that debt maturity and asset maturity do not match in terms of absolute values when such measure is used. However, one might still expect to find a correlation of debt and asset maturity in regression analyses using such measure.

Without loss of generality with regard to the Lemma proven here, I *assume* that *both assets are depreciated linearly over their lifetime* (congruency of asset lifetime and depreciation period). Consequently, the Annual Depreciation of the Total Gross Property, Plant and Equipment, which is constant over time in case of linear depreciation, equals

$$\text{Annual Depreciations} = \frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}$$

I.) "Net Property, Plant & Equipment divided by Annual Depreciations":
At the end of the first year, denoted by the respective time $t = 1$[23], the "Net Property, Plant & Equipment divided by Annual Depreciations" equals Gross Property, Plant & Equipment minus Cumulated Depreciations (of the first year only) divided by Annual Depreciations, i.e.

$$\begin{aligned}\frac{\text{Net PP\&E (t=1)}}{\text{Annual Depreciations}} &= \frac{\text{Gross PP\&E} - \text{Cumulated Depreciations (t=1)}}{\text{Annual depreciations}} \\ &= \frac{(V_{A1} + V_{A2}) - \left(\frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}\right)}\end{aligned}$$

II.) Average maturity of assets and a direct measure of average maturity:
In contrast, the average maturity of the asset portfolio is obviously calculated as the value-weighted maturity of the single asset maturities as follows:

$$\text{Direct average asset maturity (t=0)} = \frac{L_{A1} \cdot V_{A1} + L_{A2} \cdot V_{A2}}{(V_{A1} + V_{A2})} \tag{3.1}$$

At the end of the first year, the remaining lifetimes of assets are $(L_{A1} - 1)$ and $(L_{A2} - 1)$. Consequently,

$$\text{Direct average asset maturity (t=1)} = \frac{(L_{A1} - 1) \cdot V_{A1} + (L_{A2} - 1) \cdot V_{A2}}{(V_{A1} + V_{A2})}$$

III.) Interpretation of "Net Property, Plant & Equipment divided by Annual Depreciations":
Now, literature assumes that "Net Property, Plant & Equipment divided by Annual Depreciations" can be interpreted as a measure of asset maturity. Consequently, it is required:

$$\begin{aligned}&\frac{\text{Net PP\&E (t=1)}}{\text{Annual Depreciations}} \overset{!}{=} \text{Direct average asset maturity (t=1)} \\ \Longleftrightarrow\ &\frac{(V_{A1} + V_{A2}) - \left(\frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}\right)} = \frac{(L_{A1} - 1) \cdot V_{A1} + (L_{A2} - 1) \cdot V_{A2}}{(V_{A1} + V_{A2})}\end{aligned} \tag{3.2}$$

[23] For the avoidance of doubt, time t starts at t=0. Consequently, $t = 1$ denotes the end of the first year. The calculation using $t = 0$ is trivial, as then Net PP&E = Gross PP&E and Cumulated Depreciations = 0.

Without loss of generality, I *assume* that the *portfolio is not trivial*, i.e. that asset 1 and asset 2 do not have the same lifetime:

$$L_{A1} \neq L_{A2} \tag{3.3}$$

Further simplification of Equation 3.2 yield

$$\begin{aligned}
\Longleftrightarrow \quad & L_{A1}V_{A1} + L_{A2}V_{A2} - V_{A1} - V_{A2} = \\
&= \frac{V_{A1}^2 + V_{A1}V_{A2} + V_{A2}V_{A1} + V_{A2}^2 - \frac{V_{A1}^2}{L_{A1}} - \frac{V_{A1}V_{A2}}{L_{A2}} - \frac{V_{A1}V_{A2}}{L_{A1}} - \frac{V_{A2}^2}{L_{A2}}}{\frac{V_{A1}}{L_{A1}} + \frac{V_{A2}}{L_{A2}}}
\end{aligned}$$

$$\begin{aligned}
\Longleftrightarrow \quad & V_{A1}^2 + V_{A2}^2 + V_{A1}V_{A2}\left(\frac{L_{A2}}{L_{A1}} - \frac{1}{L_{A1}} + \frac{L_{A1}}{L_{A2}} - \frac{1}{L_{A2}}\right) = \\
& = (V_{A1} + V_{A2})^2 + V_{A1}V_{A2}\left(\frac{-1}{L_{A2}} - \frac{1}{L_{A1}}\right)
\end{aligned}$$

$$\begin{aligned}
\Longleftrightarrow \quad & V_{A1}V_{A2}\left(\frac{L_{A2}}{L_{A1}} + \frac{L_{A1}}{L_{A2}}\right) = 2V_{A1}V_{A2} \\
\Longleftrightarrow \quad & \left(\frac{L_{A2}}{L_{A1}} + \frac{L_{A1}}{L_{A2}}\right) = 2 \\
\Longleftrightarrow \quad & L_{A1}^2 + L_{A2}^2 = 2L_{A1}L_{A2} \\
\Longleftrightarrow \quad & (L_{A2} - L_{A1})^2 = 0 \\
\Longleftrightarrow \quad & L_{A1} = L_{A2}
\end{aligned} \tag{3.4}$$

Nota bene: Equation 3.4 $\lightning$ Equation 3.3.

According to Equation 3.4, Equation 3.2 is *not* fulfilled if the lifetimes of both assets are *not* equal, i.e. if the asset portfolio is non-trivial in the sense of Equation 3.3.

Quod erat demonstrandum, as this contradicts the validity of the assumption made in Equation 3.2, i.e. the interpretability of ‘Net Property, Plant & Equipment divided by Annual Depreciations” as a measure of asset maturity.[24]

By using induction, I show that the requirement of a trivial profile of asset maturities holds at the end of *each* year. Therefore, I show that $n \longrightarrow n+1$:

$$\begin{aligned}
& \frac{\text{Net PP\&E (t=n)}}{\text{Annual Depreciations}} \stackrel{!}{=} \text{Direct average asset maturity (t=n)} \\
\stackrel{!}{\Longrightarrow} \quad & \frac{\text{Net PP\&E (t=n+1)}}{\text{Annual Depreciations}} \stackrel{!}{=} \text{Direct average asset maturity (t=n+1)}
\end{aligned} \tag{3.5}$$

[24] This proof works equally when choosing one debt and one asset portfolio. In such proof one may assume debt and asset maturity matching (as it is to be demonstrated by the respective measure) and one then assumes a trivial matching of debt (“D”) and asset (“A”) portfolio items according to $V_{A1} = V_{D1}$, $L_{A1} = L_{D1}$, $V_{A2} = V_{D2}$ and $V_{A2} = V_{D2}$. Calculation and results are the same as in the proof given above.

Using Formula 3.2 as discussed above, I find:

$$
\begin{aligned}
& \frac{\text{Net PP\&E (t=n)}}{\text{Annual Depreciations}} = \text{Direct average asset maturity (t=n)} \\
\Longleftrightarrow\quad & \frac{(V_{A1}+V_{A2}) - n\cdot\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)} = \frac{(L_{A1}-n)\cdot V_{A1} + (L_{A2}-n)\cdot V_{A2}}{(V_{A1}+V_{A2})} \\
\Longleftrightarrow\quad & \frac{(V_{A1}+V_{A2}) - (n+1)\cdot\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right) + \left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)} = \\
& \qquad = \frac{(L_{A1}-(n+1))\cdot V_{A1} + V_{A1} + (L_{A2}-(n+1))\cdot V_{A2} + V_{A2}}{(V_{A1}+V_{A2})} \\
\Longleftrightarrow\quad & \frac{(V_{A1}+V_{A2}) - (n+1)\cdot\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)} + 1 = \\
& \qquad = \frac{(L_{A1}-(n+1))\cdot V_{A1} + (L_{A2}-(n+1))\cdot V_{A2}}{(V_{A1}+V_{A2})} + 1 \\
\Longleftrightarrow\quad & \frac{(V_{A1}+V_{A2}) - (n+1)\cdot\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)}{\left(\frac{V_{A1}}{L_{A1}}+\frac{V_{A2}}{L_{A2}}\right)} = \\
& \qquad = \frac{(L_{A1}-(n+1))\cdot V_{A1} + (L_{A2}-(n+1))\cdot V_{A2}}{(V_{A1}+V_{A2})} \\
\Longleftrightarrow\quad & \frac{\text{Net PP\&E (t=n+1)}}{\text{Annual Depreciations}} = \text{Direct average asset maturity (t=n+1)}
\end{aligned}
$$

Thereby, it is shown that equality of remaining lifetimes of assets in the portfolio is required at the end of *each* year, since I demonstrated this for the end of the first year[25] and showed $n \longrightarrow n+1$.

■

For the avoidance of doubt, I am *not* aware of any practical issue that is able to heal the problem of the interpretation of the "Net Property, Plant & Equipment divided by Annual Depreciations"-measure as an acceptable proxy. Especially, it seems to be an *invalid* assumption to assume that all companies have only one asset (as in such case the measure would be consistent). Also, it seems to be an *invalid* assumption, that all assets are depreciated over the same time period (i.e. their (same) useful life). For example, RWE reports in their 2012 Annual Report[26], that they assume the useful life of their assets to be, e.g. 10-45 years for thermal power plants and up to 20 years for wind power plants.

By conducting numerical tests[27], I showed that the deviation between a direct measure and the "Net Property, Plant & Equipment divided by Annual Depreciations"-measure can be large. As one numerical example, let us assume the following parameters, which are by no means

25 The proof for the beginning of year 1, i.e. $t = 0$, is trivial and not explicitly shown here.
26 Cf. RWE AG (2013), p.140
27 Results are not explicitly shown here in detail.

"extreme":

$$V_{A1} = \text{US\$}100m, \qquad V_{A2} = \text{US\$}400m$$

and

$$L_{A1} = 10\text{years}, \qquad L_{A2} = 40\text{years}$$

Using Equation 3.2, one finds for "Net Property, Plant & Equipment divided by Annual Depreciations"-value and the "Direct average asset maturity":

$$\frac{500 - \left(\frac{100}{10} + \frac{400}{40}\right)}{\left(\frac{100}{10} + \frac{400}{40}\right)}\text{years} \neq \frac{9 \cdot 100 + 39 \cdot 400}{500}\text{years}$$

$$\iff \qquad 24\text{years} \neq 33\text{years}$$

Obviously, the deviation between the two measures is significant and can not be considered to be negligible.

Table A. 10 in the appendix shows that more than 57% of my sample companies report according to US-GAAP and about 42.8% report according to other standards including IFRS. According to IAS 16, "the depreciation method used shall reflect the pattern in which the asset's future economic benefits are expected to be consumed by the entity"[28]. Further, the accounting standard IFRS IAS 16 requires that companies depreciate their Property, Plant and Equipment for each asset over its "useful life".[29] According to International Accounting Standard 16 - Property, Plant and Equipment (n.d.), "[u]seful life is: (a) the period over which an asset is expected to be available for use by an entity; or (b) the number of production or similar units expected to be obtained from the asset by an entity."[30] Similar rules apply for US-GAAP.

Using their depreciation-based measure, Stohs and Mauer (1996) state that they assume linearity of depreciations.[31] However, this does not have to be the case, e.g. according to IAS 16, § 62 for IFRS.[32] Stohs and Mauer (1996) assume that linearity of depreciations helps to interpret "Net Property, Plant & Equipment divided by Annual Depreciations". According to the above given Lemma, this assumption is incorrect even if linearity is given (as I also assumed liberally in my calculation).

Further, in order to interpret any depreciation-based measure as a proxy for the remaining lifetime, companies would have to depreciate their assets over the complete lifetime, i.e. depreciation period and lifetime have to be congruent (as I also assumed liberally in my calculation). However, according to IAS 16, §57, "[t]he estimation of the useful life of the asset is a matter of judgment based on the experience of the entity with similar assets" and "the useful life of

[28] Cf. International Accounting Standard 16 - Property, Plant and Equipment (n.d.), § 60
[29] Cf. International Accounting Standard 16 - Property, Plant and Equipment (n.d.), § 50
[30] Cf. "Technical Summary" of IAS 38 from http://www.ifrs.org
[31] Cf. Stohs and Mauer (1996), p.293
[32] Nevertheless, it might be an appropriate approximation for the common practice. E.g. RWE points out in their 2012 Annual Report that they generally depreciate linearly and only exceptionally deviate from this.

an asset may be shorter than its economic life". There is "anecdotal evidence" of the "Goldenes Ende" (engl. literally "golden end") of power plants, that is explained by an incongruency between depreciation period and lifetime, e.g.

> "Laut [Wirtschaftsminister Werner] Müller wird die Veag noch für rund acht Jahre defizitär sein. Seien die Kraftwerke dann abgeschrieben, beginne 'das goldene Ende, das dann noch zwanzig Jahre währt'."[33]
> *(English: "According to Müller, Veag will be loss-making for about eight years from now. Afterwards, when power plants are fully depreciated, their "golden end" will last for twenty years."[34])*

Such statements shows that differences between remaining lifetime and depreciation period can not be considered to be negligible.

Consequently, these two aspects, i.e. the linearity assumption and the congruency of depreciation period and asset lifetime assumption, can principally lead to further difficulties in the interpretation of any depreciation-based measure, even if using the "Net Property, Plant & Equipment divided by Annual Depreciations"-measure were meaningful (which I mathematically showed *not* to be the case for assets with differing lifetimes).

Obviously, differences in depreciation between US-GAAP and IFRS are another reason – besides the fundamentally invalid measure – why the depreciation-based measures of Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) can be misinterpreted. In contrast to US-GAAP, IAS 16 requires that companies componentize large assets – e.g. power plants – and separately depreciate major components, i.e. in the example of power plants, turbine, boiler etc. (IAS 16, § 43).
Also, US-GAAP does not allow reversal of impairments, which in contrast is possible under IAS 36. In this context, data availability is another issue. Impairment charges (according to IAS 36) have to be manually corrected by Thomson Reuters (2010) for the Worldscope Database. Thereby the costs of goods sold – which are also included in the measures of Stohs and Mauer (1996) and Barclay, Marx and Smith (2003)[35] – are affected. Thomson Reuters (2010) states:

> "Another example is fixed assets impairment charges. It can be treated by companies as a non-recurring item. Yet other companies may consider it as an operating expense and include it within cost of goods sold. This is only apparent when one sifts through the notes as our analysts are required to do. Worldscope treats fixed assets impairments as non recurring and an adjustment is made to cost of [goods] sold and operating profit when it includes this item."[36]

I consider it to be more likely that such manually corrected data is erroneous in comparison to automatically retrieved data.

Furthermore, major overhauls (e.g. of power plants) and their capitalization as a part of the PP&E are treated differently in US-GAAP and IFRS, which also affects the "Net Property,

33 Webpage of Zeit: http://www.zeit.de/2000/20/Goldenes_Ende/seite-3 on April 22nd, 2013
34 Own translation.
35 Cf. Section 2.2
36 Cf. Thomson Reuters (2010), p.28

Plant & Equipment divided by Annual Depreciations"-measure.[37]

While differences between US-GAAP and IFRS are less relevant for studies concentrating on the US only, they become relevant in the context of an international study as it is conducted in Section 5 of this thesis.[38]

In a nutshell, it is clear that the existing empirical evidence based on annual depreciation-based measures can not be used to proof matching of debt maturity and asset maturity. *First*, this is mainly due to the invalidity of such measures if asset portfolios contain assets with different lifetimes, as shown above. *Second*, although not essential for my argumentation, interpretation can additionally be affected by a potential non-linearity of depreciations and by a potential incongruency of the assets' lifetime and their depreciation period. *Third*, although again not essential for my argumentation, using depreciations and Net PP&E as measures is critical when parts of the sample companies report according to US-GAAP while others do not.

Different from the vague finding of existing papers, I hypothesize more clearly, *however due to the same risk management arguments and "conventional wisdom"*, as summarized in Section 2.2.2:

- **Maturity matching hypothesis (balance sheet):** A firm's real asset maturity (remaining lifetime) has a positive impact on its debt maturity.

In my empirical analysis, I will use a direct measure for the real asset maturity, which is constructed consistent with Equation 3.1, as explained in Section 5.2.2.2. Obviously, this direct measure also is independent of any depreciation issues.[39] Further, it does not require the assumption of linearity and congruency of depreciation period and lifetime. I am not aware of any paper that shows debt and asset maturity matching with such measure.

3.2.1.2. Debt Issuance

In this section, I discuss the relevance of asset maturity as a determinant of the maturity of new debt issues. The measure of Guedes and Opler (1996) – based on the historical Gross PP&E – can not be easily interpreted, either.

As I will find later, the measure of Guedes and Opler (1996) has a mean value which is significantly different from the other asset maturity measures. This might be related to their use of "Depreciation" in their asset maturity measure. As they refer to Gross PP&E, using accumulated depreciations instead of "the depreciation charge [. . .] from the most recent year before a debt issue" (Guedes and Opler (1996), p.1813) seems to be more reasonable (at least before the knowledge of my Lemma as provided in the foregoing section), as they intend to parametrize the actual remaining lifetime of assets. Unfortunately, reading their paper, there

[37] Cf. Deloitte (2009) and PricewaterhouseCoopers (2011) for a discussion of the relevant depreciation rules as applied in the utility industry.

[38] Again, these arguments are not essential for my argumentation, as the depreciation-based measures suggested in the literature are invalid anyway.

[39] In Section 5.2.3.5, I will discuss the effect of current assets on the overall asset maturity.

remains some doubt whether they refer to annual or cumulated depreciations by their term "Depreciations".

Alternatively, Guedes and Opler (1996) test their results for a Net PP&E measure divided by "Depreciations", which supports – as I assume here – that they are actually referring to annual depreciations instead of cumulated depreciations in Equation 2.2. This is also suggested by the above given citation from Guedes and Opler (1996). Moreover, Guedes and Opler (1996) present a second measure, i.e. "(Inventory/Assets) · (Average days in inventory) + (Receivables/Assets) · (Average days receivables in inventory) + (Net PP&E/Assets) · (Net PP&E/Depreciation)".[40] For the avoidance of doubt and any misunderstanding of their paper, I tested both, annual and cumulated depreciations, for both of their measures in my empirical analyzes in Section 5.2. All tables explicitly reported in my paper include results based on annual depreciations for the measure of Guedes and Opler (1996). I find no significance for any of their measures.

As I discussed before, there are other, more recent studies that do not include asset maturity as a determinant of the debt maturity of new debt issues. To my best knowledge, the only top-published study finding significance for an influence of asset maturity on the maturity of new debt issues is Guedes and Opler (1996). However, they do not add a relevant reasoning for this, while they indicate that they expect debt and asset maturity matching for the overall debt structure.[41] Consequently, I expect that asset maturity is not a relevant determinant of debt maturity of single debt issues and I hypothesize in contrast to Guedes and Opler (1996):

- **Maturity matching hypothesis (debt issuance):** There is no significance for an impact of a firm's asset maturity on the time-to-maturity of single debt issues.

3.2.2. Mismatch Premium Hypothesis

In Section 2.2.2, I summarized the rationals for the matching of debt and asset maturities. Another reason might be found in the "pricing" of new debt issues. I hypothesize that relative yield spreads of debt at issuance increase in case of a mismatch between debt maturity and asset maturity. I argue that a mismatch, i.e. either the case that asset maturity is higher or lower than the maturity of debt, leads to a premium in the yield spread of new debt issues.[42]

On the one hand, if debt maturity is higher than asset maturity, the company is running out of collateral with ongoing time. Therefore, I assume a premium on the price of debt. *On the other hand*, and much less obvious, I assume a premium if debt maturity is lower than asset maturity, due to liquidity risk. According to Diamond (1991*b*), "liquidity risk is the risk that a solvent but illiquid borrower is unable to obtain refinancing"[43]. He explains that liquidity risk derives from debt that has shorter maturity than assets, and he explains that in such case lenders' control is increased as they can decide whether to refinance or liquidate. Consequently, Diamond (1991*b*) argues that liquidity risk results in "lost control rents", i.e. in profits that would have been with

[40] Cf. Guedes and Opler (1996), p.1813
[41] Cf. Guedes and Opler (1996), p.1810
[42] I will later show that asset maturity and debt maturity are of similar size. Therefore, I calculate the mismatch as the difference of debt maturity and asset maturity.
[43] Cf. Diamond (1991*b*), p.710

the former owner of the project if it had not been liquidated due to information asymmetries and before profits could be earned. Especially in economically difficult times lenders might fear that liquidation values are limited, as pointed out by Shleifer and Vishny (1992).

We further argue, that in such event, the company might be down-rated and it could become increasingly difficult to convincingly communicate the quality of the companies' projects and the associated returns to other lenders. As lenders face the risk that other (shorter-term) lenders liquidate projects and accept lost control rents, they face the risk of a reduced creditworthiness of the borrower while their lending terms are already fixed. Consequently, lenders should a priori include a premium if debt maturity is shorter than asset maturity. This premium is positively related to the mismatch, because the earlier projects can be liquidated – i.e. the shorter the debt maturity is – the higher are the potentially lost control rents the borrower does *not* receive from such projects.

Morris (1976), in his early theoretical paper, finds arguments supporting a higher risk related to a mismatch of debt and equity maturity. *On the one hand*, he considers debt with a maturity longer than the maturity of assets being risky, "due to the uncertainty of the source and volume of the cash flows which are necessary to service the debt after the asset is retired."[44] *On the other hand*, he explains that if debt maturity is shorter than "asset life", "there is some possibility the asset will not have generated sufficient cash flows by the maturity date".[45] I argue that such risk born by the lender should be reflected in the yield spread of debt at issuance.

Consequently, I hypothesize:

- **Mismatch premium hypothesis:** A mismatch of debt and "real" asset maturity results in higher relative yield spreads for new debt issues. This is true in the case of debt maturity being shorter than "real" asset maturity, and vice versa.

In the foregoing argumentation, I implicitly assume that there is at least one other lender with a shorter debt maturity than the respective debt issue under investigation, as otherwise, there would be almost no risk of lost control rents for the lender of the respective issue under investigation. Further applying the concept of lost control rents it is obvious that the risk for the respective lender and the respective issue under investigation increases with an increasing share of debt being shorter than the respective issue. Consequently, I further *hypothesize* that the higher the time-to-maturity of a debt issue is, the higher is the premium on the rate of the respective debt issue.

In a nutshell, the potential loss of control rents can be increased, *first*, due to earlier liquidation, i.e. when debt maturity is shorter than asset maturity. It can also be increased, *second*, due to an increasing share of debt that is shorter (and potentially leads to liquidation earlier) than the respective debt issue under investigation.

For the avoidance of doubt, the discussed effect should survive controlling for a gap-closing dummy control variable. The effect should still be significant independent of whether compa-

[44] Cf. Morris (1976), p.29
[45] Cf. Morris (1976), p.29

nies close or further extent their debt/ asset maturity mismatch by the respective debt issue. Therefore, I will additionally provide such test in Section 5.2.

3.2.3. Asset Salability/ Debt Maturity Hypothesis

In this section I briefly discuss the expected impact of asset salability on debt maturity.

Shleifer and Vishny (1992) explain that higher liquidation values make long-term debt overhang more attractive.[46]

Hart and Moore (1994) argue that a higher profile of asset values[47] supports long term debt by prolonging the durability of assets.

Benmelech, Garmaise and Moskowitz (2005) find that self-interested managers tend to finance with long-term debt when liquidation values are high. They are first to empirically show that asset salability affects debt maturity. Benmelech (2009) later confirms this finding using asset-level data of 19^{th} century railroad companies.

In accordance with the aforementioned findings, I hypothesize:

- **Asset salability/debt maturity hypothesis:** Asset salability positively affects debt maturity.

For the avoidance of doubt, this is not new to the literature. However, I mainly conduct the respective analysis since I require robustness of my results against including asset salability as an additional independent variable. Therefore, I will present the respective analysis in the robustness section.

[46] Cf. Shleifer and Vishny (1992), p.1347
[47] Cf. Hart and Moore (1994), p.43

3.3. Diversification in Mergers and Acquisitions

In this Section, I briefly derive the hypothesis that will be addressed in Section 5.3. That section has a somewhat descriptive character as it analyzes the acquirer return in M&A transactions specifically for the utility industry.

Section 2.3 presented some of the literature discussing the effect of diversification on segment- and plant-level on cumulative abnormal acquirer returns from M&A transactions. In Section 5.3, I am specifically referring to diversification in production technologies, i.e. a diversification substructure within "horizontal" mergers of companies that include a generation business. In addition there might be diversification along the value chain, i.e. into grid business or sales.[48] Consequently, the respective empirical analysis – which will be descriptive in its nature – is specific to the electric utility industry.

Villalonga (2004) argue that diversification measures in the literature based on segment data are problematic. She explains that, *first*, only segments that meet the 10% materiality condition of the Financial Accounting Standards are reported separately, which results in underestimation of diversification. *Second*, Villalonga (2004) explains that according to Financial Accounting Standards Board (1976), a segment is defined as "a component of an enterprise engaged in providing a product or service or a group of related products and services primarily to unaffiliated customers (i.e., customers outside the enterprise) for a profit"[49]. By this remarkable argument, Villalonga (2004) concludes that "segments, by definition, can be an aggregation of two or more activities, vertically or otherwise related"[50]. She concludes that segments therefore are not comparable across firms. *Third*, over time, there are many changes to the segments reported in COMPUSTAT. E.g. Denis, Denis and Sarin (1997) find that changes in segments are due to reporting changes in about one fourth of all cases, as it is also reviewed by Villalonga (2004). Due to the abovementioned issue deriving from Financial Accounting Standards Board (1976), § 10a, the findings of Villalonga (2004) suggest that there is a "discount to unrelated (conglomerate) diversification, but a premium to related diversification"[51].

Obviously, electricity generation of power plants mainly results in the same finished product, i.e. electricity. Consequently, independent of their technology and independent of the similarity of cash flows from different technologies, all power plants might be reported in the same segment, according to Financial Accounting Standards Board (1976).[52] Nevertheless, as these technologies obviously are related, one might expect a premium from such *related diversification*.

Besides that premium found for related diversification by Villalonga (2004), there are other reasons that might potentially lead to positive effects of diversification within production technologies. Such potentially positive effects might derive from e.g., a co-insurance effect against fuel price volatility, *or* economies of scope from expanding the technical expertise, which opens additional future investment opportunities for the internal capital market into the newly ac-

48 The diversification by these segments will not be controlled for separately.
49 Cf. Financial Accounting Standards Board (1976), § 10a
50 Cf. Villalonga (2004), p.481
51 Cf. Villalonga (2004), p.482
52 In practice, renewable power plants are frequently reported separately from other generation.

quired technologies. Though there are also contrasting effects from diversification, as discussed in Section 2.3, and though operating synergies might be even higher for specializing in production technologies, I finally hypothesize:

- **Related diversification hypothesis:** When electricity generating acquirers diversify their production technology portfolio by M&A transactions, they experience positive cumulative abnormal event returns.[53]

Further, I a priori expect negative cumulative abnormal acquirer returns on average for *all M&A deals in my sample*, as it was found for US utility companies by Becher, Mulherin and Walkling (2012).[54] Also, according to Becher, Mulherin and Walkling (2012), I do *not* expect to find different cumulative abnormal returns for *horizontal* vs. *non-horizontal* deals.[55]

[53] As I will show in Section 5.3, I cannot empirically confirm this hypothesis of a positive premium from diversification. I do not find significance for a discount, either.

[54] In Section 5.3, I will find, that cumulative abnormal acquirer returns are positive.

[55] I will not find a significant difference for cumulative abnormal acquirer returns in Section 5.3.

4. Production Data and Sample Construction[1]

My thesis is based on a sample of international utility companies. While usually obtaining detailed production data on the asset level is challenging, the production assets of utility companies can be observed directly. In this chapter, the origin of the production data used in my empirical analysis in Section 5 is explained. Afterwards, the matching procedure is summarized and the final sample construction is illustrated.

4.1. Origin of Production Data

I obtain data on production characteristics from the WEPP database, which is published by Platts. This is the most comprehensive database on power plants. It contains power plants of all sizes and technologies around the globe. Practitioners such as analysts of energy utilities and management consultants commonly use this database for their analyses. It contains information on single power plants, among others, its specific production technology, its capacity, the geographic location, the start date of its commercial operation, and its owner/operator.[2]

In comparison to the World Energy Outlook – a regular publication of the IEA – the Platts WEPP database includes about 94% to 98% of the total installed capacity worldwide, when solely referring to "operating" capacity. In this sense, the Platts WEPP database can be assumed to be almost complete. The comparison is shown in Table 4.1.

[1] This section is partly based on Reinartz and Schmid (2013) and Reinartz (2013)

[2] A detailed description of the database is provided by Platts (2012). Concerning the coverage of the database, Platts states that "[t]he WEPP Data Base covers electric power plants in every country in the world and includes operating, projected, deactivated, retired, and canceled facilities. Global coverage is comprehensive for medium- and large-sized power plants of all types. Coverage for wind turbines, diesel and gas engines, photovoltaic (PV) solar systems, fuel cells, and mini- and micro-hydroelectric units is considered representative, but is not exhaustive in many countries. Nonetheless, about a quarter of the database consists of units of less than 1 MW capacity. Generating units of less than 1 kW are not included" (p. 5). Thus, I consider the database to be representative for my analysis. With regard to the owner/operator of the power plants, it is argued that "[a]s a general matter, the listed COMPANY is both the operator and sole or majority owner" (p. 10). Although there might be exceptions, I argue that these are small and unlikely to bias my results. However, as for the U.S. detailed ownership data is available, I demonstrate in Section A.2 in the appendix, that most power plant capacity is owned by its operator.

Table 4.1.: Comparison of total installed electrical capacity

Year	Platts Capacity [MW]	WEO Capacity [MW]	Platts/WEO
2009	4,732,739	4,957,000	95%
2008	4,523,533	4,719,000	96%
2007	4,307,153	4,509,000	96%
2006	4,099,429	4,344,000	94%
2005	3,985,039	not available	n/a
2004	3,887,686	4,054,000	96%
2003	3,787,428	not available	n/a
2002	3,662,830	3,719,000	98%

Comparison of installed electrical capacity according to the Platts WEPP database and International Energy Agency (IEA) (2004), International Energy Agency (IEA) (2006), International Energy Agency (IEA) (2008), International Energy Agency (IEA) (2009), International Energy Agency (IEA) (2010) and International Energy Agency (IEA) (2011). The total capacity was not consistently available for 2003 and 2005.

Further, the Platts WEPP database includes – among others – the following plant details: unit name[3], plant name, installed capacity, fuel and other technology details, commercial operation date[4], operational status[5] and country. A full list of columns of the Platts WEPP can be found on the Platts website[6].

We rely on the Platts WEPP database because information on production assets that is reported by the energy utilities on their websites or in annual reports gives rise to several problems. *First*, such information is hardly available since there is no obligation to publish it. More detailed plant level items such as installed capacity, commercial operating date, location of the plant etc. are even more improbable to find for a large scale analysis. *Second*, there is no standardized reporting of such information. Hence, firms may try to engage in selective reporting. One way of such selective reporting might be that firms with many nuclear power plants do not report details on production technologies due to the controversial public debate on this technology, especially after the Fukushima accident. *Third*, even if firms report details on their production assets, the level of detail differs. While some firms aggregate single generation technologies to categories as “thermal” or “fossil”, some companies separately report, coal, gas, oil, etc. *Fourth*, such publically collected data would probably suffer from serious nebulosity regarding the operational status of plants.[7] Consequently, I rely on the WEPP database in order to obtain detailed and unbiased data on the firms’ production assets.

This database is unconsolidated and reports all information for single power plant units. Furthermore, accounting data of power plant owners is *not* included in the database. Hence, it is necessary to match the single power plants to a list of energy utility companies[8] from

[3] The Platts database actually includes data on the unit level of power plants.
[4] The commercial operation date (COD) is the year of the start of operations.
[5] The Platts WEPP database differentiates the following states: *Cancelled*, *under construction*, *deactivated/ mothballed*, *deferred without construction*, *delayed after construction start*, *in commercial operation*, *planned and still in design*, *retired*, *shutdown of standby* and *unknown*.
[6] Cf. http://www.platts.com/Products/worldelectricpowerplantsdatabase
[7] The reader should keep in mind that asset level data is required for my later analyses, i.e. not aggregated portfolio data.
[8] I also refer to electricity producing utility companies as “energy utility companies”.

Thomson ONE and Datastream. I will explain the origin of this list and the construction of the final sample of utility companies in Section 4.4.

4.2. Matching Procedure

We conduct the required matching of single power plants to their respective owners by manually matching the Platts WEPP database items COMPANY or PARENT, i.e. the ultimate parent, to the consolidated list of utility companies from Thomson ONE and Datastream. Both of these Platts WEPP items do not correspond to single power plants, but can include multiple plants and units.

It is important to note that I use the edition of the Platts WEPP database which corresponds to the respective sample year, i.e. a database separate version for each year between 2002 and 2009. Hence, I deploy eight different editions of this database. Using only the most recent version would lead to biased data on production characteristics because the most recent owner reported in the database might not necessarily have been the owner over the whole sample period. For example, the ownership of a power plant can change due to defaults and subsequent asset sales, mergers, or asset deals.

A time-consuming manual matching procedure had to be applied due to several challenges:

- The spelling of company names in Platts WEPP database differs from spelling in Thomson ONE and Datastream.
- Power plants often are not directly owned by the respective Thomson ONE- or Datastream-company but by a subsidiary of those.
- Thomson ONE- or Datastream-companies themselves can be owned by other Thomson ONE- or Datastream-companies included in the company list. Therefore they are not the ultimate parent owning the asset.
- The Platts WEPP database's spelling of names for physically identical power plants occasionally differs over time. Consequently matching has to be conducted separately for each year between 2002 and 2009.

The following manual steps were conducted in order to match the Platts WEPP database to the Thomson ONE and Datastream database:

- Manual matching of Platts WEPP's COMPANY item to the listed Thomson ONE and Datastream utility **parent** companies.
- Manual matching of Platts WEPP's COMPANY item to a Datastream-list of **subsidiaries** of parent companies.[9]

[9] The list of subsidiaries of the Thomson ONE and Datastream utility **parent** companies was downloaded from Datastream in February 2012. It includes 9,559 subsidiaries.

- Manual identification of Thomson ONE and Datastream utility **parent** companies which themselves are subsidiaries of other Thomson ONE and Datastream utility **parent** companies.[10]

In order to improve efficiency in manual matching, matching proposals of Thomson ONE and Datastream-companies to the Platts WEPP COMPANY list were automatically generated as follows:

Step 1: **Matching Thomson ONE/ Datastream parent companies to Platts WEPP item COMPANY using exact short name matching:** For the 1,483 Thomson ONE/ Datastream-parent companies, short names were defined. These short names – as far as possible – pick up the most characteristic string of the company name, e.g. *The AES Corporation* is short-named AES. It was required that this manually given short name to the Thomson ONE/ Datastream utility companies is found in a matching Platts WEPP COMPANY character by character. If so, it was checked manually whether the proposed Thomson ONE/ Datastream company was either a parent of or equal to the respectively matched Platts WEPP COMPANY. If this was true, the match was confirmed, otherwise it was rejected.

Step 2: **Matching Thomson ONE/ Datastream parent companies to Platts WEPP using fuzzy string matching:** In order to allow some deviations in the spelling of company names – e.g. *E.ON*, *E ON*, *EON* or *E-ON* – a so-called *approximate* or *fuzzy matching algorithm* was applied. A fuzzy matching algorithm measures the distance of two strings by valuing permutations and replacements of single characters to convert one string into the other. Such distance – as it is used by the R algorithm AGREP – is the Levenshtein edit distance.[11] Such fuzzy string matching is applied in both cases, *first*, for the full company name according to the Thomson ONE/ Datastream list and, *second*, for the short names list as derived in *Step 1*. Afterwards, it was checked manually whether the proposed Thomson ONE/ Datastream company was either a parent of or equal to the respectively matched Platts WEPP COMPANY. If this was true, the match was confirmed, otherwise it was rejected.

Step 3: **Matching subsidiaries to COMPANYs using fuzzy matching:** In addition to the Platts WEPP's item COMPANY, the fuzzy string matching is also applied to Datastream's list of subsidiaries. Afterwards, it was checked manually whether the proposed subsidiary was either a parent of or equal to the respectively matched Platts WEPP COMPANY. If this was true, the match was confirmed, otherwise it was rejected.[12]

In order to make the outlined procedure less sensitive to legal entity identifiers – e.g. Ltd., AG, GmbH – such terms were deleted from the company names when fuzzy matching was applied.

[10] E.g., due to recent mergers and acquisitions of a majority share, while parent and target remain listed.

[11] Cf. http://stat.ethz.ch/R-manual/R-devel/library/base/html/agrep.html for further explanations regarding agrep and the Levenshtein edit distance.

[12] Cf. Schay (2011) for an introduction to *fuzzy matching* of similar names. There are other scholars in finance using fuzzy matching processes, e.g. Agarwal, Rosen and Yao (2012).

Before, the abovementioned matching procedure was developed, it was intended to match power plants to their owners via a “Bing-matching”. The idea was to count the hits of all possible pairs of power plants and Thomson ONE/ Datastream companies and subsidiaries identified by the search engine Bing when conducting search queries in the Internet. Afterwards certain criteria should have been applied in order to select the actual owner of a plant.[13] The procedure was conducted using the Bing search API[14]. However, checks showed that less than 5% of the proposed matches were correct. Consequently, this approach had to be refused. While the a priori hypothesis was that the number of hits for power plants is significantly higher when combined with the owner company name instead of a third company name, it showed that this is not the case. Potentially, this is mainly caused by the fact that very often, several utility companies are simultaneously mentioned in web articles.

After having matched the Platts WEPP item COMPANY to the Thomson ONE/ Datastream company and subsidiary list, power plants now have to be aggregated to the level of listed parent companies. Therefore, if a Platts WEPP COMPANY item is matched to a subsidiary owned by more than one parent company (according to the Datastream subsidiaries list), such item's installed capacity is allocated to the parent companies at equal parts. Again, such Thomson ONE/ Datastream parent company P^1 can be a listed subsidiary of another listed Thomson ONE/ Datastream ULTIMATE parent company P^U. Consequently, in order to allocate all power plants to the ultimate parent company P^U, such parent companies P^1 have to be further aggregated upwards. At the same time the parent company P^1 remains in the sample, as the company itself is a listed utility company. A list of such parents in the Thomson ONE/ Datastream list that are further aggregated upwards to another ultimate parent is given in Table A. 5 in the appendix.

After having finalized this step, the different production technologies of the power plants included in the Platts WEPP list had to be aggregated to technology classes as given in Table 4.2, column 2, by using the Platts WEPP item FUEL, UTYPE and FUELTYPE for classification.[15]

Finally, a panel structure of the Thomson ONE/ Datastream utility companies including production characteristics per class over time can be constructed.

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13 For example, a criterion might be to order the pairs of a plant “P_1” with all companies $C_1, C_2, C_3, \ldots$ according to the number of Bing hits and then require a certain absolute difference between the first and the second pair, in order to allocate the plant P_1 to the correct company C_X. Several other criteria were tested.

14 Cf. http://code.google.com/p/pybing/

15 Columns 3 and 4 will be addressed in the following chapter.

Table 4.2.: Production technologies

Category	Technology	Run-up time [hours]	Ramp-up costs [€ /MW]
Base-load	Nuclear	40.00^{A}	132.92^{E}
	Non-flexible coal	6.00^{A}	35.75^{E}
	Geothermal	0.00^{Z}	0.00^{Z}
	Biogas	0.25^{B}	46.96^{Z}
	Biomass	2.00^{B}	46.96^{Z}
	Other fossil	3.00^{Z}	46.96^{Z}
Mid-load	Waste	12.00^{B}	46.96^{Z}
	Flexible coal	3.00^{A}	46.96^{E}
	Gas combined-cycle	1.50^{A}	32.22^{E}
	Non-pump storage water	0.00^{Z}	0.00^{Z}
Peak-load	Oil	0.08^{D}	25.45^{E}
	Gas	0.25^{C}	32.22^{Z}
	Pump storage	0.10^{A}	0.00^{Z}
Stochastic	Solar	0.00^{Z}	0.00^{Z}
	Wind	0.00^{Z}	0.00^{Z}

The classification in *base-, mid- and peak-load* is based on the approximate full load hours of a technology. *Run-up times* refer to warm-starts in the case of thermal power plants. They are based on Eurelectric (2011) (marked with ^{A}), Danish Energy Agency (2010) (^{B}) and Swider (2006) (^{C}). The run-up time of oil power plants is based on company websites, e.g. lifecycle power solutions provider Wärtsilä (marked with ^{D}). I also have to make some assumptions (marked with ^{Z}). Other fossil power plants are assumed to have a run-up time of 3 hours, which approximately equals the average of gas and non-flexible coal plants. The run-up time for solar and wind is zero, since such plants are usually not actively dispatched and start generation as soon as sun or wind are available. Similarly, I assume a run-up time of zero for geothermal and non-pump storage water power plants. For nuclear power plants, other sources suggest a run-up time of 25 hours. Using this value does not change my findings. *Ramp-up costs* are partly based on Boldt et al. (2012) (marked with ^{E}). Because they do not report values for all technologies, I have to make some assumptions. I assume that ramp-up costs for gas power plants equal those of CCGT power plants. Further, I assume zero ramp-up costs for geothermal, non-pump storage water, pump storage, solar, and wind power plants. For biomass, biogas, other fossil and waste power plants I assume equal ramp-up costs as for flexible coal power plants.

4.3. Overview on Matched Production Data

This section provides a brief overview on the production data matched according the procedure outlined above. The next section will further narrow down the matched data to the final SAMPLE.

Table 4.3 provides an overview on the data included in the WEPP database. In total, 114,664 power plants are included in the database in 2009. They account for an overall capacity of 4,732 GW. I only consider those plants that are in operation (and hence exclude those under construction/planning or already mothballed) in the respective year.[16] Starting with my complete database of 1,483 Thomson ONE and Datastream companies, I am able to match 52% of the installed capacity and 28% of the number of all operating power plants to energy utilities included in my sample.[17]

The matching of about 50% of the worldwide capacity does not seem implausible. The reason for this is that only listed companies are covered. Hence, privately-owned, municipal or state-

[16] This figure is consistent with the International Energy Agency (IEA) (2011), which reports an “electrical capacity” of 4,957 GW for 2009.

[17] The general sample construction is described in Section 4.4.

owned firms are not included. Consequently, a priori it cannot be expected that all power plants are matched to sample firms.

Table 4.3.: Capacity from Platts WEPP database matched to Thomson ONE/ Datastream list

	Total in database		Matched			
Year	Capacity [MW]	plants [#]	Capacity [MW]		plants [#]	
2009	4,732,739	114,664	2,468,897	52%	31,760	28%
2008	4,523,533	108,960	2,360,368	52%	29,960	27%
2007	4,307,153	103,853	2,276,957	53%	28,597	28%
2006	4,099,429	98,824	2,143,608	52%	26,976	27%
2005	3,985,039	95,541	2,060,653	52%	26,101	27%
2004	3,887,686	93,307	2,008,247	52%	25,146	27%
2003	3,787,428	90,248	1,884,869	50%	23,957	27%
2002	3,662,830	87,220	1,826,514	50%	22,327	26%

This table depicts the total number and capacity of power plants in the edition of the Platts WEPP database in the respective year (columns 2 & 3). The last four columns show these figures only for those power plants which are matched to a firm that is included in the Thomson ONE/ Datastream list.

4.4. Sample Construction

For the empirical analyzes in this thesis, a sample covering listed energy utilities from all over the world is used. In the former sections I illustrated the matching procedure of production data to a combined list of active and inactive utility companies from Thomson ONE and Datastream, both products of Thomson Reuters. This list includes 1,483 listed companies.[18] In this section, this list is further reduced to the final SAMPLE that will be used for later empirical analysis.

The necessary steps to ensure the adequacy of the final sample are as follows: At the beginning, I exclude those companies that can not be matched by using their names, as their company names are almost equal and cannot be differentiated from each other.[19] Next, all firms without a primary security classified as equity are excluded (5 companies). Furthermore, all companies that never were active between 2002 and 2009 are eliminated (138 companies). Also, to ensure that the sample only covers companies focusing on electricity generation, the industry classification of all companies were verified, relying on SIC and ICB codes. Overall, 426 firms that do not fulfill the criteria of an energy utility were eliminated. These removed firms are, among others, utilities specialized in water supply or gas transmission. In a next step, all companies without available market leverage from the Worldscope Database are dropped. Lastly, all companies that have not been assigned any production data are excluded.

Finally, 460 different companies with accounting and production data for a total of 2,449 firm-years remain in the SAMPLE.

18 It is focused on stock market listed utilities since reliable data for unlisted firms is often unavailable.
19 Cf. Table A. 6 in the appendix

4.5. Sample Description

In order to give an overview on the scope of this unique sample, this section adds general descriptive statistics. Further detailed descriptive statistics regarding the production characteristics – e.g. production technologies, run-up time and ramp-up costs of power plants and the remaining lifetime of power plants – are described with their respective definitions in the following chapter. Financial data – as it can now be downloaded by using the matched Datastream identifiers – will also be described in a later chapter.

According to Table 4.4, the companies included in the final sample have a total capacity of, on average, more than 40% of the overall capacity included in the Platts WEPP database.

Table 4.4.: Total installed electrical capacity of sample (narrowed down to 460 companies)

Year	Platts Capacity [MW]	Sample Capacity [MW]	Sample/ Platts
2009	4,732,739	2,050,687	43.3%
2008	4,523,533	1,985,039	43.9%
2007	4,307,153	1,882,726	43.7%
2006	4,099,429	1,770,134	43.2%
2005	3,985,039	1,674,624	42.0%
2004	3,887,686	1,438,676	37.0%
2003	3,787,428	1,318,336	34.8%
2002	3,662,830	1,264,719	34.5%

In Table 4.5, the distribution of sample companies across countries is given. Most companies, i.e. about 18.5% of the 460 companies included in the sample, are headquartered in the United States. However, in comparison to other international studies, the U.S. do not seem to be overrepresented. For example, in Rajan and Zingales (1995) and Öztekin and Flannery (2012), about 64%[20] and about 23.5%[21], respectively, of the sample companies are based in the United States.

[20] Cf. Rajan and Zingales (1995), p.1425
[21] Cf. Öztekin and Flannery (2012), p.90 and p.93

Table 4.5.: Number of companies per country

Country	Number of companies
United States of America	85
Russian Federation	40
China	39
India	22
Canada	21
Brazil	20
Germany	17
United Kingdom	16
Australia	15
Italy	14
France	13
Japan	12
Chile	10
Others	136
Total	460

This table shows all countries in our sample with at least 10 companies headquartered therein.

While the sample is not balanced, it is nevertheless not concentrated to a small fraction of years in the sample period. Table 4.6 shows, that each of the eight years of the sample period includes at least 9% of the sample's firm-years.

Table 4.6.: Number of matched firm-years per year in sample period

Year	No. of firm-years	Share in overall sample
2009	385	15.7%
2008	368	15.0%
2007	353	14.4%
2006	324	13.2%
2005	291	11.9%
2004	265	10.8%
2003	242	9.9%
2002	221	9.0%
Total	2,449	100.0%

5. Empirical Results[1]

In this chapter, the empirical results of my thesis are presented. *First*, I discuss the impact of production characteristics on the capital structure. *Second*, I discuss the influence of asset maturity on debt structure and debt pricing. *Third*, I present my results regarding the effect of diversification in production technologies on cumulative abnormal acquirer returns from "horizontal" M&A deals.

5.1. Production Characteristics, Flexibility and the Capital Structure[2]

In this section, I proceed as follows: At the beginning, I introduce the empirical analysis of production characteristics and their impact on the capital structure. Next, I provide an overview on data and methodology. Afterwards, I discuss my empirical results. Furthermore, I conduct several robustness tests, empirically show causality, and proof a substitution effect of financial and production flexibility. Finally, I conclude this section by summarizing the findings and implications.

5.1.1. Introduction

There is limited empirical evidence on the relation between production flexibility and the capital structure. This might be related to the fact that information on production characteristics are difficult, if not even impossible, to obtain. As derived in Chapter 4, I therefore use detailed information on more than 30,000 single power plants, which enable me to construct different measures for their production flexibility.[3]

In this section, I analyze the impact of production characteristics on the capital structure by using a sample of worldwide energy utilities. Therefor, I construct measures of production flexibility based on electricity generation technologies. I use the firms' overall fraction of base-, mid-, and peak-load capacity (related to the number of full-load hours), run-up time and ramp-up costs as measures of production flexibility. Furthermore, I collect data on the age of production assets and their regional diversification to control for differences in production characteristics not directly related to flexibility. In total, the data set used in this analysis covers 460 listed energy utilities from 57 different countries between 2002 and 2009.

There are additional reasons for using a sample of utility companies for my analysis: *First*, energy utility companies produce mainly one product, i.e. electricity. Thereby, they exhibit

1 Most econometric analyses in this thesis are performed using Stata or R.
2 This section is largely based on Reinartz and Schmid (2013).
3 The matched sample includes about 50% of the world's installed power plant capacity. Because only listed firms are considered in the matching procedure, it is not expected to match 100% of the world's capacity.

a central feature of the assumptions of Mauer and Triantis (1994). The flexibility to produce alternative products, as referred to by the product flexibility of MacKay (2003) can be clearly separated. *Second*, production characteristics are standardized within this industry. This enables me to derive production flexibility measures based on electricity production technologies.[4] *Third*, and finally, I can exploit the exogenous shocks of privatization and deregulation of the industry in the 1990s in order to demonstrate causality. The basic idea is that financing was unlikely to have had a significant influence on production characteristics before deregulation and privatization. Instead, e.g. Peltzman and Winston (2000) explain that production characteristics have been influenced by political preferences.

In this Section, I address the **Impact Hypothesis**, the **First-Order Importance Hypothesis**, the **Substitution Hypothesis** and the **Asset Salability/ Leverage Hypothesis** as derived in Chapter 3.

My main results can be summarized as follows: *First*, I find a positive relation between production flexibility and leverage. By exploiting privatization and deregulation as exogenous shocks, I demonstrate that causality runs from production flexibility to leverage, and not vice versa. *Second*, I do not confirm that production flexibility is of highest importance compared to the established determinants of the capital structure, e.g. size. However, I find that production flexibility is of similar importance compared to these established factors and remains also included in models optimized for parsimony. *Third*, I show that there is a substitution effect between production flexibility and financial flexibility. Therefor, I use two exogenous shocks that changed the availability of external financing opportunities: on the one hand, an event that reduces external financing opportunities, i.e. the 2008 Lehman Brothers collapse, and on the other hand, an event that enhances external financing opportunities, i.e. the coordinated action of international central banks ("central banks' intervention") on November 30^{th}, 2011. As another test, I use the deviation from the target level of leverage (as a measure of financial flexibility) in order to show a substitution of financial and production flexibility. *Fourth*, I demonstrate that asset salability has a positive impact on leverage.

My findings contribute to the literature, as this is the first analysis that uses direct asset-level production characteristics in order to show that production flexibility leads to higher leverage and that production flexibility and financial flexibility are substitutes. Also, I empirically show that asset salability affects leverage – at least for my specific measure – which confirms the hypothesis of Benmelech (2009), who missed the empirical proof in his paper.

5.1.2. Data and Methodology

In this section, I present those variables that enter my first empirical analysis. Further, I present the applied methodology.

[4] This is underlined by the fact that the world market for manufacturing power plant equipment is dominated by very few companies (McGovern and Hicks, 2004).

5.1.2.1. Sample Construction

In Chapter 4, I outlined how production data is constructed. In Section 4.4, I summarized that after matching annual financial data from the Worldscope database, my sample covers 2,449 firm-year observations from 460 firms, located in 57 countries. My final sample data is organized as unbalanced panel and covers the years 2002 to 2009 as this is the period for which I can obtain the necessary data on the firms' production characteristics. I require to have available market leverage ratio and data on production characteristics for all firm-years in my sample.

5.1.2.2. Production Characteristics

Based on these information about single power plants, I construct measures of production flexibility. After that, I build measures of asset age and regional diversification of production across countries to control for other differences in the firms' production characteristics.

Measures of production characteristics

PRODUCTION FLEXIBILITY is *first* measured by a firm's fraction of base-, mid- and peak-load production capacity. The classification into these categories is based on the approximate full load hours of a power plant's generation technology.[5] Since a lower number of full-load hours goes along with more frequent shut-downs and start-ups, production flexibility increases from base- to peak-load. Base-load capacity according to my definition includes nuclear, lignite, biogas, biomass, and other renewable energies except for wind and solar. Mid-load capacity comprises coal, gas combined-cycle, non-pump-storage water, and waste power plants. Gas, oil, and pump storage power plants are classified as peak-load capacities. Furthermore, I calculate the share of stochastic capacities. These include wind and solar power plants. Controlling for stochastic production capacity is important because these production technologies are special in several ways. *First*, country-specific subsidiaries for these technologies are not uncommon. *Second*, and even more importantly, project finance is rather common in this context.[6] Hence, the financing of renewable energy plants might be hardly generalizable. Table 4.2 depicts the classification of the different technologies in base-load, mid-load, peak-load, and stochastic capacities.

As a *second* measure of production flexibility, I make use of differences in the technologies' RUN-UP TIME. I define the average run-up time of company i as follows:

$$\text{Run-up time}_i = \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Run-up time}_k}{\sum_{k=1}^{M} \text{Capacity}_k} \tag{5.1}$$

where k denotes a production technology and M the number of different technologies of the

[5] It should be mentioned that the classification of generation technologies in base-load, mid-load, peak-load, and stochastic can vary across countries. I do not perform a country-specific modeling of the merit order. Such modeling is very complex for an international sample because it requires commodity and electricity market prices, plant specific marginal costs like fuel transportation costs or costs for CO_2 emission allowances, and several country-specific parameters such as time-dependent demand curves, market design parameters, and cross-border transmission capacities. In contrast, I argue that the effect of country-specific merit orders is – at least to some extend – captured by country dummies.

[6] Cf. Wiser (1997), p.16

respective energy utility company. The technology-specific run-up times for warm starts used for the calculation as well as their sources are presented in Table 4.2. As a *third* measure of production flexibility, I use RAMP-UP COSTS.[7] These are the costs for a hot start of a power plant. I define average ramp-up costs of company i as follows:

$$\text{Ramp-up costs}_i = \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Ramp-up costs}_k}{\sum_{k=1}^{M} \text{Capacity}_k} \tag{5.2}$$

As can be seen in Table 4.2, base-load production technologies tend to have longer run-up time and higher ramp-up costs if compared to mid- or peak-load technologies. Nuclear power plants have the highest run-up time and ramp-up costs. By contrast, both measures indicate that oil and gas plants are very flexible.[8] I maintain that RUN-UP TIME and RAMP-UP COSTS are suitable measures of production flexibility in my context. The reason for this is that Mauer and Triantis (1994) argue that production flexibility is mainly determined by start-up and shut-down costs.

For the avoidance of doubt, the flexibility measures are interpreted as follows: Higher run-up times or higher ramp-up costs correspond to lower production flexibility. Also, a higher share of base load power plants' capacity corresponds to a lower production flexibility. In comparison to the base-load capacity share, an increasing share of mid- or peak-load capacity correspond to higher production flexibility.

Furthermore, I calculate two additional variables to control for differences in production characteristics not related to flexibility, i.e. asset age and regional diversification. It is expected that asset age negatively and regional diversification positively impacts leverage, as outlined in Section 3.1.

ASSET AGE is defined as the capacity-weighted average age of the power plant portfolio of a company i, calculated as follows:

$$\text{asset age}_i = \text{Reference Year} - \frac{\sum_{j=1}^{N} \text{Capacity}_j \cdot \text{Year}_j^{Start}}{\sum_{j=1}^{N} \text{Capacity}_j} \tag{5.3}$$

where j denotes the power plants of company i, N the number of different power plants of company i, and Year_j^{Start} the start year of the commercial operation of each power plant.

REGIONAL DIVERSIFICATION measures the production diversification across different countries. It is constructed as a dummy variable that equals one if the energy utility owns power plants in more than one country. It is zero in cases in which the company owns power plants in only one country. Detailed definitions of all variables can be found in Table 5.1. In Appendix A.4, I illustrate the calculation of the production variables by an example.

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[7] It should be mentioned that my results remain stable under varying run-up times and ramp-up costs by ±20%. These tests are not explicitly shown here.

[8] Of course, finding exact values for run-up time and ramp-up costs is very complex. For example, the run-up time of nuclear power plants is difficult to estimate, mainly due to the fact that nuclear operation modes can be affected by legal constraints. Solar and wind power plants are assumed to have zero run-up time and ramp-up costs as they are switched on immediately, without any cost, if sun or wind is available and switched off again without any delay.

Numerical parameters
The number of full-load hours differs significantly among technologies and can differ between countries and over time. The number of full-load hours equals the number of hours a power plant of a given capacity has to run at its full load in order to produce the actually produced energy in a given year. For Germany in 2007, Institut für Energiewirtschaft und Rationelle Energieanwendung und Rheinisch Westfälisches Institut für Wirtschaftsforschung und Zentrum für Europäische Wirtschaftsforschung (2010) find the following numbers for full-load hours by technology: lignite (7,015 full load hours), nuclear (6,507 h), biomass (6,238 h), hard coal (4,649 h), waste (4,013 h), gas (3,277 h), water (2,315 h), oil (784 h), wind (1,781 h) and solar (858 h). During a year's 8,760 hours, plants with a lower average number of full load hours have to be shut-down and ramped-up more frequently than plants with a higher number of full load hours.

According to Table 4.2, ramp-up costs for hot starts[9] are in the range of between 25.45 € /MW for oil and 132.92 € /MW for nuclear power plants. Consequently, ramping-up a nuclear power plant with an assumed capacity of 1,000 MW costs about 132,920.00 € , while ramping-up several oil power plants of the same overall capacity costs 25,450.00 € .
In 2007, energy prices at the wholesales market EEX – i.e. the Phelix Day Base and the Phelix Day Peak – on average were equal 37.99 € /MWh and 48.775€ /MWh, respectively. Phelix Day Base refers to the average price between 0:00 am and 12:00 pm of each day in the delivery period and the Phelix Day Peak refers to the average price between 08:00 am and 08:00 pm from Monday until Friday.[10]
A power plant with 1,000 MW produces 1,000 MWh per hour when running at full load, with an equivalent Phelix Day Base total sales price of 37,990 € per hour (nuclear power plant) or an equivalent Phelix Day Peak total sales price of 48,775€ per hour (oil power plants)[11], the ramp-up costs of the abovementioned fictive power plants are of relevant size in comparison to sales, and even more in comparison to the achieved margins, which are not explicitly assessed here.
Consequently, electric utility companies have to consider ramp-up costs in their resource scheduling.[12]

It is worth mentioning, that the operating expenses of utility companies are to a large extent determined by production, in contrast to other fields of operation. For 180 investor-owned utility companies above a defined minimum size, U.S. Energy Information Administration (2011)[13] provides the average operating expenses structure. The United States Census Bureau aggregates production (48.6%), transmission (2.8%), distribution (1.6%), customer accounts (2.1%), customer service (1.6%), sales (0.1%), and administrative and general (6.5%) to OPERATION. Other

[9] Hot starts are starts with the power plant being less than 12 h offline, warm start are starts with 12 h to 72 h offline and cold starts with the power plant being more than 72 h offline.
[10] I calculated these prices based on daily price data from EEX.
[11] In fact, oil power plants are typically utilized less than 12 hours per day and therefore at somewhat higher market prices per hour.
[12] In an interview with an expert from an international electricity generation company, the interviewee confirmed that ramp-up costs are relevant and, in practice, influence operations. Also, there is a complete strand of literature on resource scheduling for power plants.
[13] Cf. United States Census Bureau (2012)

items of the operating expenses are maintenance (5.8%), depreciation (8.2%), taxes and other (11.9%) and other (non-electric) utility (10.1%). The respective shares in the overall operating expenses for 2009 are provided in brackets. Consequently, production obviously contributes the by far largest fraction of operating costs of an average utility company in the United States.

In contrast to operating expenses, net income or EBITDA are not available from the publication of United States Census Bureau (2012). However, as an indication for Germany, in their 2011 annual reports E.ON and RWE report their highest segment-EBITDA from *Generation*.[14] E.ON reports 28% of EBITDA from *Generation* and 9% of EBITDA from *Renewable Energies*, totaling to 37% of EBITDA. Similarly, RWE reports 38% of EBITDA from *electricity generation* and 4% of EBITDA from *Renewable Energies*, totaling to 42% of EBITDA.[15]

5.1.2.3. Financial Variables

My main leverage measure is MARKET LEVERAGE, defined as total debt divided by the sum of total debt and the market value of a firm's equity.[16] The variables for which I control in the regressions are size, profitability, tangibility, and growth opportunities. Their inclusion is motivated by Frank and Goyal (2009). SIZE is parametrized by the natural logarithm of the firm's total assets. PROFITABILITY is defined as EBIT divided by total assets. I parametrize TANGIBILITY as net property, plant and equipment divided by total assets. To account for differences in growth opportunities, I control for the MARKET-TO-BOOK ratio. Besides these variables, I also include DIVIDEND PAYOUT. This dummy variable equals one if the firm pays a dividend in the respective year and zero otherwise. The interpretation of these variables has been discussed in more detail in Section 2.1.1.2. Detailed definitions can be found in Table 5.1. Furthermore, I include country and year dummies. These account for country- and year-specific effects, e.g. taxes or specific regulations.[17]

5.1.2.4. Methodology

The main estimation methodology is pooled-OLS regression. Additionally, I apply several alternative estimation methodologies as robustness tests in Section 5.1.4.6. My base model is defined as follows:

$$Leverage_{i,t} = \alpha + \varphi \cdot R_{i,t-1}^{\text{production}} + \eta \cdot C_{i,t-1}^{\text{financial}} + \beta \cdot d_i^{\text{country}} + \gamma \cdot d_t^{\text{year}} + \epsilon \tag{5.4}$$

with φ and η being vectors of coefficients and $R^{\text{production}}$ and $C^{\text{financial}}$ being the vectors of the *production-specific* and *financial* regressors. Furthermore, the model includes a constant term

[14] There is no large scale sample of such data available as segmentations differ among companies and over time.

[15] There might be additional EBITDA contributions from generation that are not separately reported. Reported segments are not congruent.

[16] However, I tested for robustness by using book leverage. Results are consistent, although they are not always shown for reasons of parsimony.

[17] Frank and Goyal (2009) further include expected inflation and median industry leverage as "reliably important" determinants of capital structure. I do not include median industry leverage because my sample covers only one industry, i.e. energy utilities. Expected inflation is not explicitly considered because I apply country and year dummies.

α and the dummy variables d_i^{country} and d_t^{year} with their coefficient vectors β and γ. Variables denoted in Greek letters are to be estimated in the regression. While i represents the company index, t is the time index. For causality reasons, all regressors must be in the information set of the dependent variable. Therefore, regressors are lagged by one period. Since my data has a panel structure, standard errors are corrected for the presence of a firm effect (Petersen (2009)). For this, I apply Huber White robust standard errors clustered at the firm-level (White (1980)). In the robustness section, I also present standard errors based on multiway clustering.

Vector R includes my measures of production flexibility. *First*, I include the fraction of mid- and peak-load production capacity. In this specification, I exclude base-load capacity as the reference point of the model. *Second*, I only include base-load capacity and exclude mid- and peak-load capacity as reference point. In both models, I control for the fraction of stochastic production capacity. A higher fraction of mid- and peak-load capacity indicates higher production flexibility while the opposite is true for more base-load capacity. *Third*, I include run-up time as a measure of production flexibility. *Fourth*, ramp-up costs are included instead. Longer run-up time and higher ramp-up costs are expected to reduce production flexibility. Furthermore, I control for other production characteristics. These are asset age and regional diversification, which might have an impact on the firm's risk characteristics.[18]

Vector C includes the financial factors described in Section 5.1.2.3. Obvious data errors are deleted: *First*, I demand that the leverage is between zero and one. *Second*, I require that PROFITABILITY is larger than minus one and, *third*, that MARKET-TO-BOOK is larger than zero. To restrict the impact of outliers, all financial variables are winsorized at the 1% and 99% level.

[18] Asset age controls for differences in the investment cycle between utilities. From the discussion of the capital structure literature in Section 2 it is obvious, that companies adapt their leverage to their operating needs, especially to investment requirements and opportunities. Consequently, asset age might influence the departure of a companies leverage from its actual target level.

5.1.2.5. Definition of Variables

The reader is strongly advised to read through the following definitions of variables in Table 5.1, and not to skip them, as they are relevant for my later analysis.

Table 5.1.: Definition of variables – Capital structure and asset characteristics

Variable	**Description**
Production characteristics	
Base-load capacity [%]	Share of base-load capacities in total capacity
Mid-load capacity [%]	Share of mid-load capacities in total capacity
Peak-load capacity [%]	Share of peak-load capacities in total capacity
Stochastic capacity [%]	Share of stochastic capacities in total capacity
Run-up time [h]	Time it takes to start-up a warm power plant (in h)
Ramp-up costs [USD]	Costs for a hot start of a power plant (in USD)
Asset age [years]	Calculated as the capacity-weighted average age of the firm's assets in the respective year (in years)
Regional diversification	Equals 1 if company has power plants in more than one country, and zero otherwise
Nuclear dummy	Equals 1 if the nuclear power plants are included in the firm-years production portfolio, and zero otherwise
Total capacity [MW]	Sum of installed production capacity (in MW)
Salability	Cf. Section 5.1.4.7
Leverage and control variables	
Total debt [wc03255]	Short term debt & current portion of long term debt [wc03051] + Long term debt [wc03251]
Market leverage	Total debt [wc03255]/ (Total debt + Market value of equity [wc08001])
Book leverage	Total debt/ (Total debt + Common equity [wc03501])
Long-term market leverage	Long term debt [wc03251]/ (Total debt + Market value of equity)
Long-term book leverage	Long term debt/ (Total debt + Common equity)
Net market leverage	(Total debt - Cash and short term investments [wc02001])/(Total debt + Market value of equity)
Net book leverage	(Total debt - Cash and short term investments)/(Total debt + Common equity)
Size	Natural logarithm of the firm's total assets [wc029999] in U.S. dollar
Profitability	Earnings before interest and taxes (EBIT) [wc18191] / Total Assets
Tangible assets ratio	Net Property, plant and equipment [wc02501]/ Total Assets
Market-to-book	Market capitalization [wc08001] / Common Equity [wc03501]
Dividend payout	Equals 1 if the firm pays a dividend, and zero otherwise
Free float [%]	Percentage of total shares available to ordinary investors [noshff]

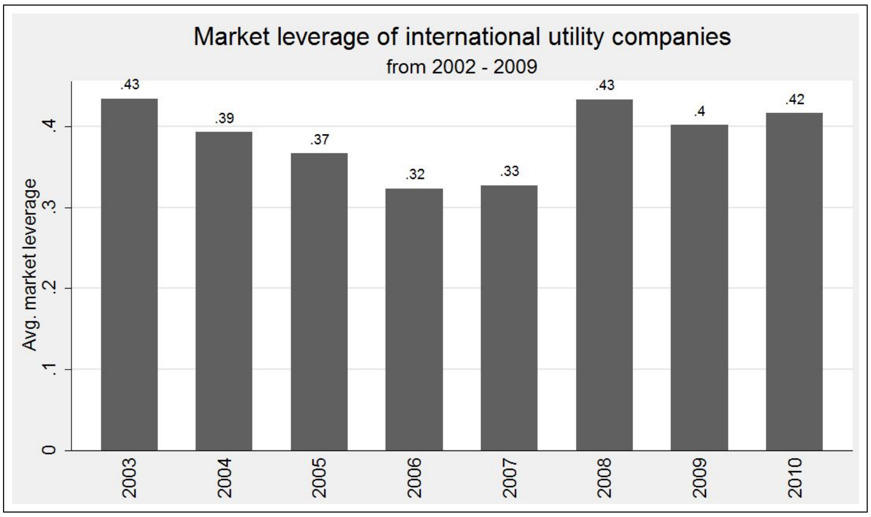
5.1.3. Empirical Results

5.1.3.1. Descriptive Statistics

Table 5.2 depicts descriptive statistics of *financial factors* and *production characteristics*, averaged from 2002 until 2009 for the 2,114 firm-years that enter the regression.[19] For the production related variables, it can be seen that mid-load capacity has the highest average share. Furthermore, the average run-up time is 2.89 hours. I find that the average asset age equals about 20 years. Furthermore, more than two thirds of all companies own power plants in only one

[19] It should be mentioned that all financial variables with a minimum of 0.00 in Table 5.2 are, in fact, larger than zero. However, they are too small to differ when only two digits are displayed.

Figure 5.1.: Average market leverage of firm-years in sample over time



country. Another interesting finding is that nearly 80% of my sample firms pay dividends, which is higher than for multi-industry samples. Lemmon, Roberts and Zender (2008) report that 39% of their sample companies pay dividends. Myers (1984) expected dividends of utility companies to be comparably high.

Table 5.2.: Descriptive sample statistics – Capital structure

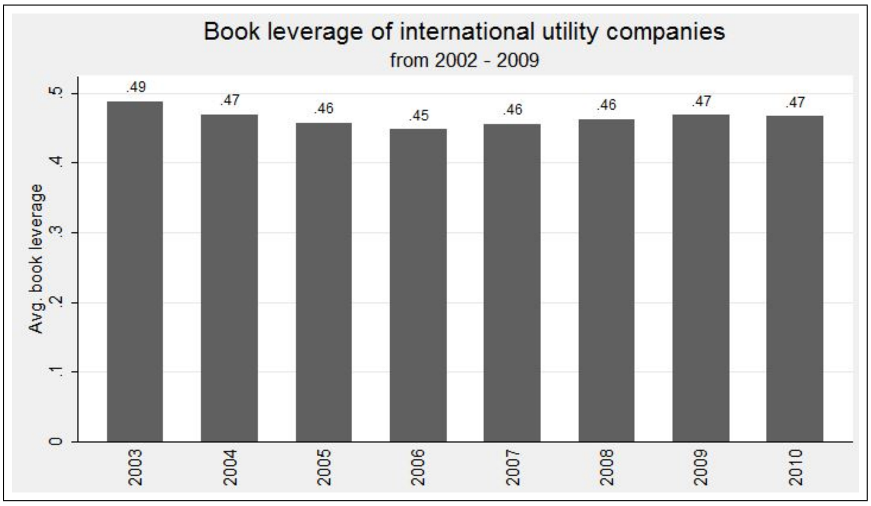
	Obs.	Mean	SD	25% perc.	50% perc.	75% perc.
Market leverage	2114	0.39	0.21	0.23	0.39	0.53
Book leverage	2103	0.46	0.22	0.31	0.50	0.62
Mid-load capacity [%]	**2114**	**0.53**	**0.37**	**0.15**	**0.57**	**0.90**
Peak-load capacity [%]	**2114**	**0.31**	**0.34**	**0.00**	**0.20**	**0.51**
Base-load capacity [%]	**2114**	**0.09**	**0.20**	**0.00**	**0.00**	**0.07**
Run-up time [hours]	**2114**	**3.21**	**4.72**	**0.08**	**1.98**	**3.87**
Ramp-up costs [€ /MW]	**2114**	**30.33**	**19.76**	**17.59**	**32.85**	**41.97**
Stochastic capacity [%]	**2114**	**0.07**	**0.24**	**0.00**	**0.00**	**0.00**
Asset age	2114	19.89	13.57	8.00	19.95	28.10
Regional diversification	2114	0.27	0.45	0.00	0.00	1.00
Size [in $ bn.]	2114	11.70	25.40	0.63	2.79	11.60
Profitability	2114	0.06	0.07	0.04	0.06	0.09
Tangible assets ratio	2114	0.59	0.21	0.48	0.62	0.74
Market-to-book	2114	1.91	1.89	1.08	1.50	2.14
Dividend paying	2114	0.78	0.41	1.00	1.00	1.00

Over time, Figure 5.1 shows that the international utility companies included in the sample had a market leverage of below 40% between 2004 and 2007 and of above 40% before and after that. The average market leverage equals 39%. In contrast, the average book leverage of my sample – as depicted in Figure 5.2 – is more stable over time since it does not depend on the market value of equity and averages to 46%. Consequently, this shows that market leverage can be influenced by stock prices, as Welch (2004) suggested.[20]

As reviewed in Chapter 2, DeAngelo and Roll (2011) finds that while overall sample leverage ratios might be comparably stable, there is less stability on the company level. I address this

[20] Consequently, I later conduct robustness tests regarding the leverage definition.

Figure 5.2.: Average book leverage of firm-years in sample over time



by plotting the market and book leverage of some of the largest sample companies between 1990 and 2010.[21] I find that the companies' individual leverage varies significantly over time, however, variation seems to be correlated for all companies, at least around the years 2006/07. Such effect would later be included in year dummies, when multivariate analyses are conducted. Interestingly, it seems that such effect might also be interpreted as a peer group effect. Market and book leverage are generally highly correlated at the firm level.

In Table 5.3, the averaged (equally weighted) balance sheet of all sample companies is given. Ratios are stable over time. Further, there are significant differences between U.S. and non-U.S. utility companies. For example, U.S. companies hold much less Cash (3.2%) than non-U.S. companies (9.3%) in relation to their Total Assets. Together with lower Receivables, this results in lower Total Current Assets for U.S. companies. Instead, U.S. companies have higher Net Property, Plant & Equipment (65.7%) in comparison to non-U.S. companies (55.7%). Moreover, U.S. companies have higher long-term debt (32.3%) compared to non-U.S. companies (27.5%) with reference to Total Liabilities & Shareholders' Equity. Finally, Total Liabilities are significantly higher for U.S. companies (69.9%) in comparison to non-U.S. companies (55.1%), and consequently, Common Equity is lower for U.S. companies (29.4%) in comparison to non-U.S. companies (42.5%).[22]

In their paper, Rajan and Zingales (1995) also provide a balance sheet for a worldwide cross-industry sample. Their large sample includes about 8,000 companies from 31 countries from 1987 until 1991.[23] On the Assets-side of the balance sheet, they find significantly higher Total Current Assets (48% in the U.S.) in comparison to my utility sample. Instead, Property, Plant & Equipment is much lower (36.3% in the U.S.) in comparison to my sample. On the Liabilities-side of the balance sheet, for the U.S. they find lower long-term debt (23.3%).[24] Total Liabilities

[21] Data is not explicitly reported here.
[22] I will later show that the determinants of leverage are almost equally significant for U.S. and non-U.S. companies.
[23] Cf. Rajan and Zingales (1995), p.1423
[24] Ratios might differ more significantly for other selected countries, e.g. the long-term debt ratio in Germany from Rajan and Zingales (1995) equals 9.8% while Other Liabilities equal 28.7%.

differ moderately between my sample (69.9% for the U.S.) and the cross-industry sample of Rajan and Zingales (1995) (66.1% for the U.S. and, e.g. 72.0% for Germany).

The line item "Total Debt (incl. ST & LT)" in Table 5.3 equals Short Term Debt & Curr. Port. of Long Term Debt plus Long Term Debt divided by Total Liabilities & Shareholders' Equity. This differs from my abovementioned definition of book leverage as Total Debt divided by Total Debt plus Common Equity. For market leverage, I divided by Total Debt plus Market Value of Equity.

However, in the literature, there are other common definitions, especially referring to Book Value of Total Assets for book leverage and to Book Value of Total Assets minus Common Equity plus Market Value of Equity for market leverage. For consistence, the enumerator in the leverage definition should then equal Total Liabilities instead of Total Debt, as otherwise Liabilities are treated equity-like.[25]

These different definitions of leverage result in significant differences of absolute leverage ratios, and therefore in the difference between book leverage in Table 5.2 (approx. 46%) and Total Debt in Table 5.3 (between approx. 32% and 35%), respectively. For my multivariate analyses, I follow Welch (2010) and consistently define book leverage as Total Debt divided by Total Debt plus Common Equity.[26]

Even recent papers use definitions that can be criticized for being somewhat inconsistent with regard to their treatment of Liabilities. E.g. Öztekin and Flannery (2012) define book leverage as Short Term Debt plus Long Term Debt (equals Total Debt) divided by Total Assets. Consequently, Total Liabilities are treated as equity, as they are included in Total Assets, while they are not included in Total Debt.

The leverage ratios use in Lemmon, Roberts and Zender (2008) are questionable in two ways. *First*, the authors define book leverage in accordance with Öztekin and Flannery (2012). *Second*, market leverage is defined as Total Debt divided by Total Debt plus Market Value of Equity. The latter is consistent with my definition, however, this seems to be inconsistent in comparison to their own book leverage as the market leverage measure now *excludes* liabilities in the denominator, while book leverage *includes* it; and in both cases numerators do not include liabilities. This inconsistency is important to note, as Lemmon, Roberts and Zender (2008) find, on average (though not as median), that market leverage is higher than book leverage.

Referring to the line item "Total Debt" in Table 5.3, I find an average of 33.7%[27] for the overall sample. For an international sample covering the years 1991 to 2006, Öztekin and Flannery (2012) report an average book leverage of 24%. Lemmon, Roberts and Zender (2008) report an average book leverage of 27% for a sample of non-financial Compustat firms between 1996 and 2003. Both of these measures are comparable to my line item "Total Debt".

The market leverage measure of Lemmon, Roberts and Zender (2008) (equals 28%) is comparable to my market leverage measure in Table 5.2, which equals 39% for my sample on average.

[25] Cf. Welch (2010), S.19 ff.

[26] I tested my results for both kinds of leverage definitions. Results remain unchanged with regard to their significance.

[27] Average value not reported in table.

Consequently, differences in the absolute level of leverage between my utilities sample and a cross industry sample seem to be significant.

The higher leverage in my sample might be explained by the fact that tangibility and – as a consequence – debt capacity is on average higher in the energy utility industry. While I find a mean value of 59% for the tangibility for my utility sample, Öztekin and Flannery (2012) report a value of only 37%.

Table 5.3.: Balance Sheet of companies in sample

BALANCE SHEET	All	All	All	US	Non-US
Year	2010	2006	2002	2010	2010
	ASSETS				
Cash & Short Term Investments	**8.0%**	**7.8%**	**6.5%**	**3.2%**	**9.3%**
Receivables (Net)	**9.5%**	**9.9%**	**9.1%**	**5.6%**	**10.6%**
Inventories -Total	**2.6%**	**2.8%**	**2.2%**	**2.5%**	**2.6%**
Prepaid Expenses	**0.9%**	**0.9%**	**0.7%**	**1.4%**	**0.8%**
Other Current Assets	**1.4%**	**1.6%**	**2.1%**	**2.3%**	**1.1%**
Current Assets - Total	22.2%	23.0%	20.3%	14.4%	24.3%
Long Term Receivables	**2.4%**	**2.2%**	**2.2%**	**1.1%**	**2.8%**
Investment in Associated Companies	**4.5%**	**3.8%**	**5.5%**	**1.7%**	**5.2%**
Other Investments	**3.2%**	**3.3%**	**3.2%**	**2.4%**	**3.4%**
Property Plant and Equipment - Net	**57.8%**	**59.3%**	**60.2%**	**65.7%**	**55.7%**
Other Assets	**10.8%**	**8.6%**	**9.0%**	**15.2%**	**9.7%**
Total Assets	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
	LIABILITIES				
Current Liabilities - Total	**20.1%**	**20.1%**	**19.0%**	**14.5%**	**21.8%**
Accounts Payable	5.5%	5.6%	4.7%	3.7%	6.0%
Short Term Debt & Curr. Port. of Long Term Debt	7.1%	6.1%	6.9%	3.6%	8.0%
Accrued Payroll	0.6%	0.6%	0.6%	0.6%	0.6%
Income Taxes Payable	0.8%	1.1%	1.0%	0.8%	0.8%
Dividends Payable	0.4%	1.1%	0.8%	0.3%	0.5%
Liabilities Held for Sale - Current	0.5%	0.3%	—	0.5%	0.5%
Liabilities Held for Sale	1.3%	0.1%	—	0.0%	1.4%
Other Current Liabilities	6.1%	6.3%	5.7%	5.1%	6.4%
Long Term Debt	**28.5%**	**26.9%**	**27.8%**	**32.3%**	**27.5%**
Long Term Debt Excluding Capitalized Leases	26.7%	25.2%	27.3%	32.0%	25.3%
Non Convertible Debt	26.7%	25.8%	27.1%	31.0%	25.5%
Convertible Debt	0.7%	0.4%	0.5%	0.3%	0.7%
Capitalized Lease Obligations	0.6%	0.5%	0.4%	0.5%	0.6%
Total Debt	34.9%	32.1%	34.7%	35.3%	34.8%
Provision for Risks and Charges	**3.9%**	**4.7%**	**5.5%**	**5.2%**	**3.5%**
Deferred Income	**1.2%**	**1.3%**	**1.5%**	**1.2%**	**1.2%**
Deferred Taxes	**3.7%**	**4.2%**	**3.6%**	**10.3%**	**1.9%**
Deferred Tax Liability in Untaxed Reserves	**0.0%**	**0.0%**	**0.0%**	—	**0.0%**
Other Liabilities	**4.0%**	**5.0%**	**5.2%**	**8.6%**	**2.7%**
Total Liabilities	58.2%	58.6%	60.3%	69.9%	55.1%
Non-Equity Reserves	**0.3%**	**0.4%**	**0.7%**	**0.0%**	**0.4%**
Minority Interest	**2.1%**	**2.1%**	**1.8%**	**0.4%**	**2.6%**
Preferred Stock	**0.2%**	**0.3%**	**0.3%**	**0.5%**	**0.2%**
Common Equity	**39.7%**	**40.1%**	**36.8%**	**29.4%**	**42.5%**
Total Liabilities & Shareholders' Equity	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

All "Assets-ratios" refer to Total Assets, whereas all "Liabilities-ratios" refer to Total Liabilities & Shareholders' Equity. All ratios were winsorized at the 1% level and averaged over the sample referred to in Table 5.2. Due to winsorizing or missing values, ratios might not add up to 100%. Due to missing values, Short Term Debt & Curr. Port. of Long Term Debt plus Long Term Debt does not equal the reported values for Total Debt. The structure of this balance sheet is taken from the the data provider's manual Thomson Reuters (2010). For data accuracy, ratios smaller than zero and larger than one (on the level of single data points) are excluded from this table.

5.1.3.2. Capital Structure Decisions in the Utility Industry

It could be argued that capital structure decisions of utility companies are systematically different from other industries due to their regulatory environment. Although the utility industry is deregulated in most countries nowadays (Dewenter and Malatesta (1997), Becher, Mulherin and Walkling (2012)), some aspects are still influenced by regulation. For example, grid access fees are often determined by federal or state entities. However, some regulation exists in many industries. For example, the drug admission process in the pharmaceutical industry is regulated by the FDA in the U.S. and car producers have to fulfill safety and environmental requirements. A more comprehensive discussion is given in Section 2.4.3.

Obviously, scholars do not expect substantial differences in the mechanics of the determinants influencing the leverage ratio. Frequently, they simply control for utility companies by introducing a dummy variable. Nevertheless, I analyze in a first step if the factors determining capital structures are systematically different for energy utilities. In order to test whether utility companies behave similar to non-utility firms, I perform a regression only containing financial variables. Results are shown in Table 5.4, model I. As can be seen, signs are in accordance with those reported by Frank and Goyal (2009) for multi-industry samples. Size and tangibility have a positive impact on leverage, while the opposite is true for profitability, the market-to-book ratio, and the dividend dummy. The statistical significance of these results is strong. Hence, I argue that capital structure in the utility industry is determined by similar factors as in other (non-financial) industries. However, as shown in the foregoing section by using descriptive statistics, the absolute level of the leverage ratio differs. Obviously, such constant shift in the overall leverage ratio can be accounted for by a utilities dummy variable in cross industry regressions, as several scholars do.[28]

For the avoidance of doubt, again I point out that regressions are conducted at the firm-year level and that annual, company specific production characteristics are derived bottom-up by aggregation from a database of single production assets.

[28] Cf. Section 2.4.3 for a more detailed discussion.

Table 5.4.: Determinants of the capital structure

Variables	I	IIa	IIb	III	IV
Mid-load capacity [%]		**0.16*****			
		(4.96)			
Peak-load capacity [%]		**0.18*****			
		(5.08)			
Base-load capacity [%]			**-0.17*****		
			(-5.43)		
Run-up time				**-0.0054*****	
				(-4.47)	
Ramp-up costs					**-0.0010****
					(-2.39)
Stochastic capacity [%]		0.20***	0.035		
		(4.79)	(0.93)		
Asset age		-0.0023***	-0.0024***	-0.0025***	-0.0026***
		(-3.49)	(-3.54)	(-3.90)	(-4.10)
Regional diversification		0.047**	0.047**	0.047**	0.047**
		(2.55)	(2.52)	(2.39)	(2.38)
Size	0.027***	0.028***	0.028***	0.030***	0.028***
	(5.27)	(5.33)	(5.33)	(5.09)	(5.00)
Profitability	-0.36***	-0.32***	-0.32***	-0.30***	-0.29***
	(-3.59)	(-3.35)	(-3.36)	(-3.10)	(-3.01)
Tangible assets ratio	0.16***	0.16***	0.16***	0.16***	0.16***
	(3.72)	(3.78)	(3.78)	(3.77)	(3.74)
Market-to-book	-0.014***	-0.014***	-0.014***	-0.014***	-0.015***
	(-3.55)	(-3.35)	(-3.32)	(-3.60)	(-3.66)
Dividend paying	-0.092***	-0.083***	-0.083***	-0.082***	-0.081***
	(-4.76)	(-4.57)	(-4.58)	(-4.49)	(-4.41)
Observations	2,114	2,114	2,114	2,114	2,114
Adjusted R^2	0.38	0.43	0.43	0.42	0.41

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.3.3. Production Flexibility and the Capital Structure Decision

Next, I analyze the relationship between production characteristics and the capital structure. For this, I include different measures of production flexibility. These are mid- and peak-load capacity, base-load capacity, average run-up time, and average ramp-up costs. Base-load (mid- and peak-load) capacity acts (act) as benchmark and is (are) not included in model IIa (IIb), because the share of base-load, mid-load, peak-load, and stochastic generation capacity add up to one. Furthermore, I include asset age and regional diversification. I find that higher mid- and peak-load capacity increase a firm's leverage, whereas base-load capacity has the opposite effect (model II). Thus, more flexible firms choose higher leverage ratios. Next, I use the average run-up time as a measure for production flexibility (model III). Again, higher run-up time, i.e. lower flexibility, leads to lower leverage ratios. Lastly, I also find lower leverage for firms with higher ramp-up costs, i.e. lower flexibility (model IV). Further, I find that asset age and regional diversification influence the capital structure as suggested in Section 3.1, i.e. asset age is negatively and regional diversification is positively related to leverage. All these results are statistically significant at least at the 5%-level, whereby most being significant even at the 1%-level. Interestingly, the adjusted R^2 increases from 38% (model I) to 43% in model II if production-related characteristics are additionally considered.[29] In summary, the outcome is in line with the impact hypothesis, which predicts a positive relationship between production flexibility and leverage.[30]

5.1.3.4. Causality between Production Flexibility and Leverage

So far, I found that production flexibility has a positive impact on leverage. However, showing the causality of this relationship is a priori not trivial. If causality was reversed, firms with better access to finance would choose lower production flexibility. A reason for this could be that there are companies that are better able to finance base-load power plants with high capital expenditures. If better access to finance leads to more equity financing, i.e. lower leverage, causality would run from financing decisions to production flexibility.[31] To investigate the direction of causality, I exploit the privatization of energy utilities and the deregulation of electricity markets in the last decades as exogenous shocks.

There are two reasons why these events help to clarify causality. The *first reason* is based on the fact that energy utilities were mostly publicly owned before privatization. Dewenter and Malatesta (1997) describe that energy utilities in many countries have been publicly owned and were then privatized in the 1980s and 1990s. However, two important exceptions from the general tendency that energy utilities had been publicly owned are the U.S. and Japan.[32] Publicly owned utilities had profited from loan guarantees and access to capital via the state (Dewenter and Malatesta, 2001). Thus, I argue that factors as political preferences rather than financing constraints had determined the production characteristics of publicly owned energy utilities.

The *second reason* exploits the fact that many countries deregulated the energy industry in the 1990s. Before that, even the construction of very expensive power plants, e.g. nuclear plants, was virtually riskless. The reason for this is that markets were not competitive. Hence, the cost could be recovered from costumers by cost-plus pricing based on production costs. In such business environment, financing constraints are very unlikely because future cash-flows are highly predictable. Hence, I argue that the production technology decision in this highly

29 As Table 5.10 shows, R^2 is even higher if book leverage is considered as the dependent variable.

30 I test that the covariance matrix of my regressions has full rank, i.e. that there are no perfect multi-collinearities by testing that variance inflation factors are below a level of 5 – 10, which is usually seen as being problematic. The highest VIF equals 2.30 for size in model III, which shows uncritical collinearity as it is reasonably below a level of 5 – 10, which is typically seen as being problematic. For the avoidance of doubt, such test is conducted for all regressions in this thesis.

31 For a similar argumentation in the context of track gauge and financing decisions, cf. Benmelech (2009).

32 Investor owned energy utilities accounted for the majority of electricity production in the United States since the 19^{th} century (Edison Electric Institute, 1973; Masten, 2010). Moreover, Japan privatized its energy utility companies already in 1951 (Kikkawa, 2006). In contrast, Dewenter and Malatesta mention that France privatized Suez in 1987, the United Kingdom privatized its electric utility companies between 1990 and 1991, and Canada privatized NS Power in 1992. The data appendix of Dewenter and Malatesta (1997) and Jamasb (2006) provide a comprehensive overview on privatization in selected countries.

regulated industry was not driven by financing constraints, but by other factors such as political preferences. In this context, Peltzman and Winston (2000), p. 121, state that "[o]ne of the potential benefits of creating competitive decentralized markets for wholesale power is to bring these politicized resource planning process to an end [...]."

Both reasons support the view that financing had no substantial influence on the production characteristics of (i) state-owned and/or (ii) highly regulated energy utilities. Hence, using before-privatization and deregulation production characteristics to explain the after-privatization capital structure rules out the possibility of reverse causality. In my empirical design, I replace the current production characteristics with those from 1995. This year is chosen because power plants which were in operation in 1995 were largely planned and constructed before the start of the deregulation and privatizations.[33] Technically spoken, I use the production characteristics of 1995 as instruments for production characteristics in later years, while I know that these instruments are not influenced by financing constraints. Because only deregulation, not privatization took place in the U.S. and Japan in the 1990s, I conservatively exclude utilities from these two countries for this test. The empirical model is defined as:

$$Leverage_{i,t} = \alpha + \varphi \cdot C_{i,t-1}^{\text{financial}} + \eta \cdot R_{i,1995}^{\text{production}} + \beta \cdot d_i^{\text{country}} + \gamma \cdot d_t^{\text{year}} + \epsilon \tag{5.5}$$

Results are reported in Table 5.5. As before, higher shares of mid- and peak-load capacity, i.e. higher production flexibility, increase leverage, whereas the opposite is true for base-load capacity (models Ia-Ib). Similarly, higher average run-up time and ramp-up costs, i.e. less flexibility, lead to lower leverage (models II and III). The statistical significance of results is at least 5% for models I and II and 10% for model III. Overall, the results are similar to those reported in Table 5.4. Thus, using the privatization of energy utilities and the deregulation of the energy industry as exogenous shocks allows me to demonstrate that causality runs from production flexibility to capital structure, not vice versa.

[33] Production characteristics for the year 1995 are derived from the 2002 edition of the WEPP database, which is the earliest edition available. All units with a start of commercial operation later than 1995 are excluded. Nevertheless, as argued in Section 5.1.2.2, using ownership information from 2002 for 1995 can cause a bias. Besides that, it is difficult to define the date of the start of privatization and deregulation, especially for an international sample. Although both events often took place at the same time, there were deviations in some countries. Furthermore, deregulation is often a stepwise process towards a desired industry shape, not a one-time shock. I nevertheless decided to follow this approach for this test because I think that the potential bias is small.

Table 5.5.: Direction of causality

Variables	Ia	Ib	II	III
Mid-load capacity$_{1995}$ [%]	**0.11****			
	(1.99)			
Peak-load capacity$_{1995}$ [%]	**0.15****			
	(2.41)			
Base-load capacity$_{1995}$ [%]		**-0.12****		
		(-2.26)		
Run-up time$_{1995}$			**-0.0068*****	
			(-2.94)	
Ramp-up costs$_{1995}$				**-0.0014***
				(-1.84)
Stochastic capacity$_{1995}$ [%]	0.38***	0.26**		
	(3.56)	(2.51)		
Asset age$_{1995}$	-0.0011	-0.00098	-0.0022	-0.0020
	(-0.70)	(-0.61)	(-1.29)	(-1.20)
Regional diversification$_{1995}$	0.092	0.095	0.059	0.074
	(1.58)	(1.64)	(0.98)	(1.18)
Size	0.030***	0.030***	0.025***	0.024***
	(3.78)	(3.78)	(2.84)	(2.81)
Profitability	-0.24*	-0.25*	-0.28**	-0.28**
	(-1.83)	(-1.94)	(-2.01)	(-2.03)
Tangible assets ratio	0.22***	0.22***	0.21***	0.22***
	(3.56)	(3.43)	(3.19)	(3.33)
Market-to-book	-0.0093	-0.0093	-0.012	-0.012
	(-1.24)	(-1.22)	(-1.49)	(-1.42)
Dividend paying	-0.092***	-0.093***	-0.093***	-0.094***
	(-2.78)	(-2.81)	(-2.78)	(-2.85)
Observations	901	901	901	901
Adjusted R^2	0.42	0.42	0.39	0.38

The values of the variables related to production characteristics are replaced with the ones as of 1995 in each sample year. The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.3.5. Substitution Effect between Production and Financial Flexibility

In this section, I provide two empirical tests for the proposed substitution effect.

In the first substitution-test, I approximate a company's financial flexibility from the capital structure and show that it is negatively related to production flexibility. As a measure of financial flexibility, I use the difference between net leverage – as it also controls for Cash and Short Term Investments – and the average net leverage ratio of all utility companies separately for each year. This average net leverage ratio is considered as being a proxy for the target leverage, which itself considers a demand for financial flexibility of companies.[34] I assume that the average net leverage of all companies in the sample is a valid proxy since companies follow the capital structure of their peers, as demonstrated by Leary and Roberts (2013). For the avoidance of doubt, also my results remain robust when I consider the results of companies from the same

[34] This should not be ignored when target leverage is discussed.

country as proxy for the target net leverage.
However, as I discussed in Chapter 2, the actual net leverage may exceed or fall below the target leverage, depending on a company's additional demand for financial flexibility, e.g. due to expected investment opportunities (proxied by market-to-book ratio), external financing opportunities (captured by year dummies and affecting all companies simultaneously) or, as hypothesized, due to a company's production flexibility.

In Table 5.6, I find that companies deviate from the overall target. Results show that companies require higher financial flexibility (higher dependent variable "Average Net Debt minus Net Debt"), if their production flexibility is low, and vice versa. Consequently, at least to some extent, financial flexibility and production flexibility act as substitutes.[35]

In the second substitution-test, I exploit two events that changed the availability of external financing opportunities for all firms. If *financing opportunities deplete*, those firms with *low financial flexibility suffer more*, as found by Bancel and Mittoo (2011). The collapse of Lehman Brothers on September 15^{th}, 2008 represents such exogenous shock. This date is often regarded as the starting point of the 2008/2009 financial crisis in general and the credit crunch in particular (Ivashina and Scharfstein, 2010; De Haas and Van Horen, 2012). In contrast, such firms with *low financial flexibility* are expected to *profit more* from shocks *boosting external financing.* Such event was the coordinated action of international central banks of the U.S., U.K., Japan, Switzerland, Canada, and the Eurozone which took place on November 30^{th}, 2011. Central banks increased market liquidity by lowering the price for U.S. dollar swaps, resulting in cheaper access to dollars for European banks. Thus, this event was seen as an indication that international central banks jointly act to ease the European debt crisis and to avoid frictions in the credit markets. The MSCI World index increased by about 4% after the central banks' intervention, highlighting its global importance.[36]

In a nutshell, if financial flexibility and production flexibility act as substitutes, *more production flexible* companies should *suffer less* if *external financing decreases*, and vice versa should also profit less if external financing is boosted.

As my analysis is performed from the perspective of U.S. investors, I rely on the firms' return indices based on U.S. dollar.[37] For my analysis, I follow a two step approach: *First*, I estimate *normal returns* by using a market model based on MSCI World returns, that are estimated over a 250 trading days estimation window and end right before the event window. *Second*, I calculate *abnormal returns* as the difference of actual event returns minus predicted normal returns in the event window. These abnormal daily returns are aggregated to *cumulative abnormal returns* over the event window. Due to cross sectional dependencies scholars also use JGLS calculations

35 Obviously, I do not explicitly consider that part of financial flexibility that results from the difference between maximal debt capacity and target leverage, which principally adds to the difference between actual leverage and target leverage.

36 Calculated based on data from Datastream.

37 The number of observations is influenced, *first*, by the availability of capital market returns, and *second*, by the fact that firms have to be still listed at the stock market when Lehman Brothers collapsed.

Table 5.6.: Substitution effect between financial and production flexibility

	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Mid-load capacity [%]	**-0.12*** **				**-0.13*** **			
	(-3.30)				**(-3.55)**			
Peak-load capacity [%]	**-0.12*** **				**-0.15*** **			
	(-3.18)				**(-3.90)**			
Base-load capacity [%]		**0.12*** **				**0.14*** **		
		(3.44)				**(3.92)**		
Run-up time			**0.0039*** **				**0.0044*** **	
			(3.24)				**(3.27)**	
Ramp-up costs				**0.00078** **				**0.00095** **
				(2.00)				**(2.35)**
Stochastic capacity [%]	-0.14***	-0.016			-0.16***	-0.017		
	(-3.31)	(-0.53)			(-3.84)	(-0.56)		
Asset age	0.0014*	0.0014*	0.0015**	0.0015**	0.0011	0.0011	0.0012	0.0012
	(1.89)	(1.89)	(2.13)	(2.13)	(1.32)	(1.35)	(1.57)	(1.58)
Regional diversification	-0.016	-0.016	-0.012	-0.013	-0.025	-0.024	-0.020	-0.021
	(-0.93)	(-0.91)	(-0.70)	(-0.71)	(-1.36)	(-1.30)	(-1.07)	(-1.07)
Size	-0.016***	-0.016***	-0.017***	-0.017***	-0.019***	-0.019***	-0.021***	-0.020***
	(-3.17)	(-3.18)	(-3.22)	(-3.09)	(-3.74)	(-3.72)	(-3.74)	(-3.60)
Profitability	0.49***	0.49***	0.48***	0.47***	0.30***	0.30***	0.28**	0.28**
	(4.20)	(4.20)	(4.15)	(4.14)	(2.70)	(2.70)	(2.53)	(2.50)
Tangible assets ratio	-0.16***	-0.16***	-0.16***	-0.16***	-0.19***	-0.19***	-0.19***	-0.19***
	(-3.60)	(-3.64)	(-3.57)	(-3.55)	(-4.36)	(-4.26)	(-4.21)	(-4.16)
Market-to-book	0.0090**	0.0090**	0.010***	0.010***	-0.022***	-0.022***	-0.021***	-0.020***
	(2.33)	(2.32)	(2.63)	(2.70)	(-4.99)	(-4.97)	(-4.80)	(-4.69)
Dividend paying	0.079***	0.079***	0.079***	0.077***	0.049**	0.050**	0.050**	0.048**
	(4.13)	(4.13)	(4.13)	(4.08)	(2.47)	(2.48)	(2.47)	(2.42)
Constant	-0.12	-0.24***	-0.24***	-0.27***	0.14	0.00078	0.0092	-0.024
	(-1.32)	(-3.05)	(-2.88)	(-3.41)	(1.60)	(0.0097)	(0.11)	(-0.30)
Observations	1,842	1,842	1,842	1,842	1,833	1,833	1,833	1,833
Adjusted R^2	0.37	0.37	0.36	0.36	0.41	0.41	0.40	0.40

The dependent variable is the DIFFERENCE OF AVERAGE NET DEBT OF ALL UTILITY COMPANIES IN A GIVEN YEAR MINUS NET DEBT. Models Ia-Id refer to net market leverage ratios, models IIa-IId refer to net book leverage ratios. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in 5.1.

that control for cross sectional dependencies especially in same-industry, same-day event studies (e.g. Malatesta (1986)).

As an alternative approach, according to Malatesta (1986), the abnormal event return for each company i is calculated by the following market model equation:

$$r_{i,t} = \alpha_i + \phi_i \cdot r_t^{\text{MSCI}} + \eta_i \cdot d_t^{\text{event}} + \epsilon_i \tag{5.6}$$

where $r_{i,t}$ denotes the daily returns of firm i, r_t^{MSCI} the daily return of the MSCI world, and d_t^{event} equals one in the event window, and zero otherwise. Consequently, I can interpret the consistent OLS estimator of η_i as the *abnormal return*.[38] As the event occurs contemporaneously for all firms, d_t^{event} has no company index i. The regression is performed over the estimation and the event window.

The cumulated abnormal return (CAR) or the abnormal return (η_i), respectively, are then regressed by firm-specific factors. As firm-specific factors I control for leverage, firm size, percentage of free float shares, and country dummies. Furthermore, I include a measure of production flexibility. For the Lehman event, I use values from the end of 2007 for all explanatory variables to ensure that they are not affected by the event. For the central banks' intervention, I consider financial control variables from the end of 2010, while I include production characteristics from the end of 2009 (as this is the last year for which data are available).[39] Thus, the second-stage regression for the Lehman default (central banks' intervention) event is:

$$\begin{aligned}
&(\textsc{Cumulative})\ \textsc{Abnormal Return} = \\
&\quad = \alpha + \phi \cdot \text{Prod_Flex}_{i,2007(2009)} + \lambda \cdot \text{Lev}_{i,2007(2010)} + \theta \cdot \text{Size}_{i,2007(2010)} \\
&\quad + \kappa \cdot \text{Free_Float}_{i,2007(2010)} + \beta \cdot d_i^{\text{country}} + \epsilon
\end{aligned} \tag{5.7}$$

I analyze both continuous (cumulative) abnormal returns and (cumulative) abnormal return deciles for the simple OLS approach (using CAR) as well as for the second approach according to Malatesta (1986) (using η_i). Both yield very similar results for a one-day event window. Results for both events are reported in Table 5.7.[40] The results support the view that higher production flexibility has a positive impact on the firms' performance during the collapse of Lehman Brothers (models I and II), while the opposite is true for the central banks' intervention (models III and IV). In particular, firms with a higher fraction of mid- and peak-load capacity, i.e. higher production flexibility, perform better after the Lehman collapse, but worse after the central banks' intervention. The opposite is true for firms with high base-load capacities, i.e. lower production flexibility. Results are similar for return deciles (models I and III) and continuous returns (models II and IV).

I additionally calculate results for an alternative time period between September 12^{th} and

[38] Only the t-value of the estimated coefficient η_i might not be consistent in case of cross sectional correlations.

[39] The differing number of observations between both events is caused by differences in matched production data and the availability of financial data for the respective year.

[40] I report results of the simple OLS approach using predicted normal returns. The very similar results of the approach using η_i are not explicitly reported here.

17^{th}, 2008 around the collapse of Lehman Brothers. Results for continuous cumulative abnormal return regressions are reported in Table 5.8. Models Ia-Ib for a symmetric 5 days event window and models IIa-IIb for a symmetric 11 days event window confirm the findings from Table 5.7 for the base/ mid/ peak and stochastic -parametrization. For run-up time and ramp-up costs, results loose some significance potentially due to a small number of observations, as reported in models Ic-Id and models IIc-IId.

For the avoidance of doubt, as the control variable market leverage itself depends on several factors including production characteristics – as discussed above – I also applied 2SLS regressions using the market leverage parametrization of Table 5.4, model III. For such model, results remain mainly unchanged.[41]

To sum up, the results of this event study test indicate that production flexibility dampens the effect of decreasing and increasing availability of external financing. In this sense, this analysis also supports the *substitution hypothesis* predicting a substitution effect between production flexibility and financial flexibility.

[41] Results are not explicitly reported here.

Table 5.7.: Financial crisis performance and reaction to coordinated central banks action (short-term)

Model	Ia	Ib	IIa	IIb	IIIa	IIIb	IVa	IVb
	Lehman: Sep. 15^{th}, 2008				Central banks' intervention: Nov. 30^{th}, 2011			
	CAR deciles		cont. CAR		CAR deciles		cont. CAR	
Mid-load capacity [%]	**3.14*****		**0.035*****		**-1.54****		**-0.013***	
	(3.05)		**(2.71)**		**(-2.08)**		**(-1.80)**	
Peak-load capacity [%]	**3.13*****		**0.041*****		**-1.83****		**-0.019****	
	(2.92)		**(2.71)**		**(-2.42)**		**(-2.35)**	
Base-load capacity [%]		**-3.14*****		**-0.037*****		**1.66****		**0.015****
		(-3.15)		**(-2.79)**		**(2.39)**		**(2.21)**
Stochastic capacity [%]	3.35***	0.22	0.037**	-0.00070	-2.40**	-0.74	-0.022**	-0.0068
	(2.65)	(0.24)	(2.44)	(-0.075)	(-2.59)	(-1.00)	(-2.23)	(-0.89)
Market leverage	-0.19	-0.19	-0.010	-0.0097	1.32	1.33	0.019*	0.019*
	(-0.14)	(-0.14)	(-0.49)	(-0.47)	(1.43)	(1.45)	(1.75)	(1.77)
Size	0.035	0.035	0.0011	0.00100	0.18*	0.18*	0.0019*	0.0020*
	(0.24)	(0.24)	(0.76)	(0.72)	(1.85)	(1.92)	(1.65)	(1.76)
Free float [%]	-1.24	-1.25	-0.0058	-0.0052	-1.33**	-1.33**	-0.013*	-0.013*
	(-1.48)	(-1.48)	(-0.83)	(-0.75)	(-2.15)	(-2.17)	(-1.77)	(-1.78)
Constant	4.01	7.15**	-0.044	-0.0063	4.78***	3.06*	-0.031	-0.048**
	(1.28)	(2.46)	(-1.55)	(-0.27)	(2.66)	(1.88)	(-1.51)	(-2.52)
Observations	237	237	237	237	303	303	303	303
Adjusted R^2	0.17	0.17	0.093	0.095	0.30	0.30	0.54	0.54

The dependent variable is the CUMULATIVE ABNORMAL RETURN. In models I and III, CAR DECILES are used as dependent variable instead of CONTINUOUS CAR (models II and IV). Models I and II refer to the default of Lehman Brothers on Sep. 15^{th}, 2008; models III and IV refer to the central banks' intervention on Nov. 30^{th}, 2011. All models are OLS regressions with T-statistics based on robust standard errors. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in 5.1.

Table 5.8.: Financial crisis performance acound Sep. 15^{th}, 2008

Model	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
		cont. [-2;2] CAR				cont. [-5;5] CAR		
Mid-load capacity [%]	**0.061**				**0.089****			
	(1.41)				**(2.09)**			
Peak-load capacity [%]	**0.10****				**0.12*****			
	(2.13)				**(2.64)**			
Base-load capacity [%]		**-0.074***				**-0.100****		
		(-1.70)				**(-2.34)**		
Run-up time			**-0.0049***				**-0.0033**	
			(-1.69)				**(-1.12)**	
Ramp-up costs				**-0.00088**				**-0.00030**
				(-1.51)				**(-0.51)**
Stochastic capacity [%]	0.062	-0.015			0.050	-0.052**		
	(1.41)	(-0.66)			(1.23)	(-2.12)		
Market leverage	-0.024	-0.021	-0.030	-0.018	0.030	0.032	0.035	0.048
	(-0.44)	(-0.37)	(-0.59)	(-0.33)	(0.60)	(0.64)	(0.74)	(0.96)
Size	0.0018	0.0014	0.0062	0.0045	-0.00044	-0.00078	0.0035	0.0010
	(0.46)	(0.36)	(1.62)	(1.18)	(-0.11)	(-0.19)	(0.85)	(0.26)
Free float [%]	-0.035*	-0.030	-0.032	-0.029	-0.038	-0.034	-0.036	-0.032
	(-1.66)	(-1.42)	(-1.51)	(-1.36)	(-1.62)	(-1.46)	(-1.44)	(-1.33)
Constant	-0.14**	-0.069	-0.12**	-0.092	-0.16*	-0.057	-0.11	-0.083
	(-2.00)	(-1.05)	(-2.17)	(-1.63)	(-1.97)	(-0.70)	(-1.49)	(-1.08)
Observations	237	237	237	237	237	237	237	237
Adjusted R^2	0.11	0.092	0.14	0.100	0.19	0.18	0.16	0.14

The dependent variable is the CONTINUOUS CUMULATIVE ABNORMAL RETURN in the symmetric 5 day and 11 day event window around September 15^{th}, 2008. All models are OLS regressions with T-statistics based on robust standard errors. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.3.6. Economic Importance

All results so far demonstrate that production characteristics have a statistically significant impact on the capital structure. However, the questions arises if this impact is of economic importance as well. To shed light on this, I calculate x-standardized regression coefficients and marginal effects of coefficients based on models I-IV in Table 5.4.

In Table 5.9, the upper number gives the ranking of the economic impact of each coefficient and, the middle number provides the x-standardized regression coefficients, and the bottom number provides the marginal effect as a percentage of the mean market leverage. X-standardized regression coefficients are calculated by using the descriptive statistics from Table 5.2 in combination with the results from Table 5.4.[42] Marginal effects as the percentage change of the dependent variable market leverage are calculated by dividing the unit changes (i.e. the x-standardized regression coefficients) by the mean of the market leverage, i.e. 39% (Table 5.2).

Results read as follows: e.g. market leverage changes by −0.0237 units (model IV) when ramp-up costs change by one standard deviation holding all other variables constant. Consequently, e.g. a change by one standard deviation in run-up time, i.e. by 19.72 €/MW (Table 5.2), changes market leverage by 6.1% of the average market leverage. The given ranking places those regression coefficients first, that induce a higher change in market leverage when the regressor changes by one standard deviation.

One finds that production flexibility is of similar economic importance compared to tangibility, market-to-book and dividend paying dummy, specifically depending on the respective production flexibility measure. Size shows to be the most important determinant of market leverage.

[42] Cf. Long and Freese (2000) for definition and interpretation of standardized regression coefficients. X-standardized coefficients were calculated by multiplying the regression coefficients from Table 5.4 with the standard deviation of each regressor itself.

Table 5.9.: Importance of production flexibility as determinant of market leverage

Model	I	IIa	IIb	III	IV
Mid-load capacity [%]		**3**			
		0.0598			
		15.3%			
Peak-load capacity [%]		**2**			
		0.061678			
		15.8%			
Base-load capacity [%]			**4**		
			0.0338		
			8.7%		
Run-up time				**6**	
				-0.0255	
				-6.5%	
Ramp-up costs					**6**
					-0.0237
					-6.1%
Stochastic capacity [%]		4	9		
		0.0481	0.0084		
		12.3%	2.2%		
Asset age		7	5	3	2
		-0.0312	-0.0326	-0.0339	-0.0353
		-8.0%	-8.4%	-8.7%	-9.0%
Regional diversification		10	8	8	7
		0.0209	0.0209	0.0209	0.0209
		5.4%	5.4%	5.4%	5.4%
Size	1	1	1	1	1
	0.6858	0.7112	0.7112	0.7620	0.7366
	175.8%	182.4%	182.4%	195.4%	188.9%
Profitability	5	9	7	7	8
	-0.0252	-0.0224	-0.0224	-0.0210	-0.0203
	-6.5%	-5.8%	-5.8%	-5.4%	-5.2%
Tangible assets ratio	3	6	3	2	3
	0.0340	0.0340	0.0340	0.0340	0.0340
	8.7%	8.7%	8.7%	8.7%	8.7%
Market-to-book	4	8	6	5	5
	-0.0265	-0.0265	-0.0265	-0.0265	-0.0284
	-6.8%	-6.8%	-6.8%	-6.8%	-7.3%
Dividend paying	2	5	2	4	4
	-0.0378	-0.0341	-0.0341	-0.0337	-0.0333
	-9.7%	-8.7%	-8.7%	-8.6%	-8.5%

Marginal effects are calculated for the empirical specifications presented in Table 5.4, model IIa. The rank of the economic impact shows the relative importance of a variable as a determinant of the dependent variable MARKET LEVERAGE. For each variable, in the first line the rank is given. In the second line, the x-standardized regression coefficients is presented. The third line, shows the percentage change of the dependent variable if the independent variable – all else equal – is changed by one standard deviation. A detailed description of all variables can be found in 5.1.

5.1.3.7. Influence on the Quality of the Model

In order to accept newly introduced factors as relevant regressors, one might care for whether additional variables contribute to the quality of the model or just increase its complexity with a low value added.[43] In order to identify a parsimonious model, I use the Bayesian/Schwarz

[43] Cf. e.g. Frank and Goyal (2009), Lemmon, Roberts and Zender (2008) and Eldomiaty and Ismail (2009) for applications of variable selection criteria in capital structure research.

Information Criterion (BIC) and the Akaike Information Criterion (AIC) according to Schwarz (1978) and Akaike (1974). These criteria allow for the decision whether a regressor should be omitted or included in the final model for market leverage. The criteria are applied by minimizing BIC and AIC while stepwise dropping the regressor with the lowest t-statistics.

I find that BIC and AIC are minimal for the given capital structure models incl. production characteristics, i.e. none of the regressors is dropped from the model when the BIC and AIC criteria are applied. Consequently, all proposed asset characteristics – production flexibility, asset age and regional diversification – are included in my final regressions even if I care about model complexity.[44]

5.1.4. Robustness Tests

One might claim, for example, that variation in production flexibility mainly derives from differences between companies, that are also different along other dimensions, which we not explicitly control for (and that are not already captured by Fixed Effects regressions, i.e. controlling for time-invariant firm fixed effects, as I will do in Table 5.17). Therefore, I apply several additional robustness checks in this section.

Also, one might claim that effects relate to the definition applied for leverage or to the econometric methodology used in the foregoing sections. Therefore, in this section, I investigate the results' robustness with regard to these issues.

First, I show robustness of results for alternative leverage definitions. *Second*, I control for additional asset characteristics, i.e. the number of technologies, the total capacity, the existence of nuclear generation in a production portfolio, and diversification in production technologies. *Third*, I test for robustness in defined sub-samples. *Fourth*, I show that the results are robust to different estimation methodologies. *Fifth*, and finally, I control for differences in salability/ specificity, and thereby I also test my *salability hypothesis*, i.e. that salability is positively related to leverage.

5.1.4.1. General Robustness Tests

In this section, I briefly summarize multiple important robustness tests that I have conducted but which are not explicitly reported in this thesis for reasons of parsimony. Most importantly, excluding the control variables asset age and/or regional diversification from my regressions generally leads to stable results with regard to production flexibility variables.

Results also remain robust if I use several alternative control variables, e.g. EBITDA instead of EBIT or market-to-book total assets ratio instead of market-to-book equity ratio, contemporaneous instead of lagged independent variables or if I do not winsorize the variables. Also, excluding the dividend variable, which is not considered by Frank and Goyal (2009), leads to similarly significant outcomes. The same is true for including research and development divided by turnover as another independent variable. Results are also robust if I replace the single U.S.

[44] Results are not explicitly reported here.

country dummy by separate dummies for each U.S. state. Also, including the year of incorporation for each company leads to unchanged results. Moreover, I found that results remain stable if I vary run-up times or ramp-up costs by ±20%.

Furthermore, results are robust if I additionally include the tax rate for each country, that itself shows to be a significant determinant of the capital structure.[45,46]

5.1.4.2. Leverage Definitions

In this section, I check the results' robustness for alternative leverage definitions. Results for this test are shown in Table 5.10. The dependent variables are *book leverage* in model I, *long-term market leverage* in model IIa, *long-term book leverage* in model IIb, *net market leverage* in model IIIa, and *net book leverage* in model IIIb. Net leverage considers cash and cash equivalents as negative debt. The detailed construction of all leverage variables is explained in Table 5.1. As can be seen, my prior result of a positive relationship between production flexibility and leverage does not depend on the specific leverage definition.[47] In order to limit the number of tables, I additionally report models using run-up time as shown in Table A. 7 in the appendix. For regressions using base and ramp-up costs parametrizations of production flexibility, I find consistent results.

My analysis shows that the independent variables have similarly high explanatory power for book and market leverage. Consequently, the impact from stock value dynamics on the explanatory power of variables seems to be limited. In contrast, Welch (2004) finds that – when including changes in stock prices – the established determinants of leverage have low explanatory power. For book leverage, profitability is not a significant determinant. However, literature also finds different results for the effect of profitability, as mentioned in Section 2.1.1.2.

45 I removed country dummies for this analysis, as tax is otherwise captured by these dummies. International tax rates were taken from Kaserer, Rapp and Trinchera (2012) and Rapp, Schmid and Urban (2012).

46 Reinartz and Schmid (2013), include a dummy, controlling for state-ownership among the three largest shareholders. Results remain unaffected with regard to the effect of production flexibility.

47 Results are also robust when liabilities are included in the definition of leverage, as discussed in Section 5.1.3.1.

Table 5.10.: Robustness test – Leverage definition

	I	IIa	IIb	IIIa	IIIb
	total	long-term		net leverage	
	book	market	book	market	book
Mid-load capacity [%]	**0.16*****	**0.14*****	**0.14*****	**0.12*****	**0.13*****
	(4.38)	**(4.81)**	**(4.31)**	**(3.30)**	**(3.55)**
Peak-load capacity [%]	**0.17*****	**0.15*****	**0.15*****	**0.12*****	**0.15*****
	(4.48)	**(5.00)**	**(4.36)**	**(3.18)**	**(3.90)**
Stochastic capacity [%]	0.21***	0.16***	0.16***	0.14***	0.16***
	(5.00)	(4.52)	(4.16)	(3.31)	(3.84)
Asset age	-0.0023***	-0.0016***	-0.0019***	-0.0014*	-0.0011
	(-3.09)	(-3.11)	(-3.11)	(-1.89)	(-1.32)
Regional diversification	0.061***	0.041**	0.056***	0.016	0.025
	(2.91)	(2.55)	(2.96)	(0.93)	(1.36)
Size	0.036***	0.028***	0.035***	0.016***	0.019***
	(6.54)	(6.80)	(7.42)	(3.17)	(3.74)
Profitability	-0.063	-0.22***	0.013	-0.49***	-0.30***
	(-0.66)	(-3.18)	(0.17)	(-4.20)	(-2.70)
Tangible assets ratio	0.19***	0.15***	0.19***	0.16***	0.19***
	(4.06)	(4.35)	(4.72)	(3.60)	(4.36)
Market-to-book	0.018***	-0.011***	0.011**	-0.0090**	0.022***
	(2.88)	(-3.40)	(2.41)	(-2.33)	(4.99)
Dividend paying	-0.056***	-0.062***	-0.048***	-0.079***	-0.049**
	(-3.19)	(-4.04)	(-3.08)	(-4.13)	(-2.47)
Observations	2,103	2,114	2,110	1,842	1,833
Adjusted R^2	0.48	0.47	0.51	0.39	0.41

The dependent variable is BOOK LEVERAGE in model I, LONG-TERM MARKET LEVERAGE in model IIa, LONG-TERM BOOK LEVERAGE in model IIb, NET MARKET LEVERAGE in model IIIa, and NET BOOK LEVERAGE in model IIIc. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.4.3. Additional Control Variables

Results also remain mainly unchanged when it is controlled for other asset characteristics. As demonstrated in Table 5.11, models Ia-Id, results remain stable when the number of different power plant technologies is included as an additional variable.[48] Further, the natural logarithm of the total capacity is used as an alternative measure of size in models IIa-IId. As it is plausible, it shows to be a significant determinant of the capital structure, i.e. behaves similar as size measured by total assets.

Also, as run-up times and ramp-up costs of nuclear power plants are somewhat different from other production technologies,[49] a nuclear dummy is additionally included as a robustness test. Table 5.12 shows that results are robust when I additionally control for nuclear generation.

[48] I refer to the technologies as given in Table 4.2 in column II.
[49] Cf. Table 4.2

Table 5.11.: Robustness test – Number of technologies and total installed capacity

Model	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Number of technologies	-0.0043	-0.0045	-0.0045	-0.0047				
	(-1.24)	(-1.29)	(-1.24)	(-1.26)				
Size (ln of total capacity)					0.0073**	0.0069*	0.0071*	0.0064*
					(2.06)	(1.95)	(1.95)	(1.72)
Mid-load capacity [%]	**0.16*** **				**0.16*** **			
	(4.80)				**(4.50)**			
Peak-load capacity [%]	**0.17*** **				**0.18*** **			
	(4.88)				**(4.67)**			
Base-load capacity [%]		**-0.16*** **				**-0.17*** **		
		(-5.22)				**(-4.90)**		
Run-up time			**-0.0049*** **				**-0.0036*** **	
			(-4.07)				**(-3.00)**	
Ramp-up costs				**-0.00097** **				**-0.00062**
				(-2.34)				**(-1.39)**
Stochastic capacity [%]	0.19***	0.025			0.17***	-0.0023		
	(4.48)	(0.68)			(3.64)	(-0.062)		
Asset age	-0.0023***	-0.0023***	-0.0024***	-0.0024***	-0.0025***	-0.0025***	-0.0025***	-0.0025***
	(-3.42)	(-3.45)	(-3.73)	(-3.86)	(-3.60)	(-3.64)	(-3.74)	(-3.79)
Regional diversification	0.055***	0.055***	0.055***	0.055***	0.067***	0.068***	0.068***	0.068***
	(2.92)	(2.92)	(2.67)	(2.69)	(3.84)	(3.86)	(3.65)	(3.65)
Size	0.031***	0.031***	0.033***	0.032***				
	(5.01)	(5.01)	(5.03)	(4.99)				
Profitability	-0.32***	-0.32***	-0.30***	-0.30***	-0.29***	-0.29***	-0.27**	-0.26**
	(-3.40)	(-3.41)	(-3.17)	(-3.12)	(-2.77)	(-2.78)	(-2.52)	(-2.50)
Tangible assets ratio	0.17***	0.16***	0.16***	0.16***	0.17***	0.17***	0.17***	0.17***
	(3.86)	(3.87)	(3.87)	(3.87)	(3.68)	(3.66)	(3.72)	(3.78)
Market-to-book	-0.014***	-0.014***	-0.014***	-0.015***	-0.016***	-0.016***	-0.017***	-0.017***
	(-3.34)	(-3.33)	(-3.60)	(-3.64)	(-3.67)	(-3.64)	(-3.94)	(-3.94)
Dividend paying	-0.084***	-0.084***	-0.083***	-0.082***	-0.052***	-0.052***	-0.049***	-0.049***
	(-4.63)	(-4.63)	(-4.55)	(-4.45)	(-2.85)	(-2.85)	(-2.65)	(-2.61)
Constant	0.19**	0.36***	0.35***	0.38***	0.58***	0.75***	0.75***	0.77***
	(1.97)	(3.79)	(3.62)	(4.04)	(10.3)	(16.5)	(17.0)	(17.5)
Observations	2,114	2,114	2,114	2,114	2,114	2,114	2,114	2,114
Adjusted R^2	0.43	0.43	0.42	0.41	0.40	0.40	0.39	0.38

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

Table 5.12.: Robustness test – Nuclear generation dummy

	Ia	Ib	II	III
Nuclear dummy	-0.020	-0.021	-0.018	-0.039*
	(-1.01)	(-1.03)	(-0.76)	(-1.70)
Mid-load capacity [%]	0.15***			
	(4.27)			
Peak-load capacity [%]	0.16***			
	(4.42)			
Base-load capacity [%]		-0.16***		
		(-4.64)		
Run-up time			-0.0047***	
			(-3.09)	
Ramp-up costs				-0.00082*
				(-1.73)
Stochastic capacity [%]	0.19***	0.034		
	(4.27)	(0.91)		
Asset age	-0.0023***	-0.0023***	-0.0025***	-0.0024***
	(-3.38)	(-3.42)	(-3.74)	(-3.77)
Regional diversification	0.048***	0.048**	0.048**	0.048**
	(2.59)	(2.56)	(2.43)	(2.46)
Size	0.030***	0.030***	0.030***	0.031***
	(4.96)	(4.96)	(4.94)	(5.07)
Profitability	-0.32***	-0.32***	-0.30***	-0.30***
	(-3.37)	(-3.38)	(-3.14)	(-3.14)
Tangible assets ratio	0.16***	0.16***	0.16***	0.16***
	(3.78)	(3.78)	(3.76)	(3.76)
Market-to-book	-0.014***	-0.014***	-0.014***	-0.015***
	(-3.35)	(-3.32)	(-3.59)	(-3.61)
Dividend paying	-0.084***	-0.084***	-0.083***	-0.082***
	(-4.60)	(-4.61)	(-4.51)	(-4.47)
Constant	0.21**	0.37***	0.37***	0.38***
	(2.22)	(3.85)	(3.90)	(3.98)
Observations	2,114	2,114	2,114	2,114
Adjusted R^2	0.43	0.43	0.42	0.41

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.4.4. Diversification in Production Technologies

In this section, I also address the potential concern that diversification might influence market leverage.[50]

As a test, I add diversification as an additional determinant of the capital structure. *First*, the technology-based diversification measure is defined as the sum of squares of the capacity of each production technology – according to Table 4.2, column II – divided by the overall production capacity squared (Diversification_tech). *Second*, the base/ mid/ peak/ stochastic-

[50] I will discuss the effect of diversification on mergers and acquisitions event returns in Section 5.3. In order to have a more comprehensive picture of the effects of diversification, I also analyze the effect of diversification on market leverage.[51]

based diversification measure is defined respectively, using the production capacity of each of these classes (Diversification_base).[52] Table 5.13 shows that results for production flexibility remain mainly unchanged, while diversification itself is not a significant determinant of market leverage.

As another test, I address the potential concern that energy utilities that produce electricity with only one single technology lead to biased results. Such firms are highly specialized and might be hardly comparable to “general” energy utilities. I separated the overall sample into such firms with more than one production technology and firms with exactly one production technology. One finds that the impact of production flexibility on market leverage remains significant and consistent with my hypotheses in both sub-samples.[53]

5.1.4.5. Sub-samples

Another potential concern is that my results do not hold true for the U.S. because of their peculiarities with regard to utility regulation. Thus, I first analyze a U.S. sub-sample without considering production characteristics (Table 5.14, model Ia). As can be seen, the impact of the financial factors on the leverage ratio is similar as for the whole sample. Thus, I argue that the main drivers of capital structure are similar for U.S. utilities and the other sample firms. If I include production characteristics, I find, once again, that leverage increases with production flexibility (Table 5.14, model Ib).

Next, I split the sample in small and large companies. For this, I classify a firm-year as being from a large (small) firm if total assets are above (below) the sample median. Results are reported in Table 5.14, model II. As can be seen, mid- and peak-load capacity have a positive impact on the leverage ratio both for small and large firms.

In contrast, I find slightly different results for small companies when I use run-up time and ramp-up costs as measures of production flexibility (Table 5.15). In consistence with the findings of MacKay (2003) (Table 5), I find a stronger influence of production flexibility for large companies in comparison to small companies, which might hint at a non-linear size effect. Consequently, the findings in the overall sample are – at least for the parametrizations of run-up time and ramp-up costs – stronger driven by large companies. However, the reader shall remember, that I do not find the same signs, but exactly the opposite, compared to MacKay (2003). Potential reasons were discussed in Section 3.1.

[52] These measures are also referred to as Herfindahl index.
[53] Results for these subsamples are not explicitly reported here.

Table 5.13.: Robustness test – Diversification

Model	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Diversification_tech	0.0029	0.0039	0.0057	-0.0026				
	(0.087)	(0.12)	(0.16)	(-0.074)				
Diversification_base					-0.0046	-0.0048	0.0099	0.0088
					(-0.12)	(-0.13)	(0.25)	(0.22)
Mid-load capacity [%]	**0.18*** **				**0.18*** **			
	(5.42)				**(5.40)**			
Peak-load capacity [%]	**0.19*** **				**0.19*** **			
	(5.45)				**(5.49)**			
Base-load capacity [%]		**-0.19*** **				**-0.19*** **		
		(-5.87)				**(-5.88)**		
Run-up time			**-0.0058*** **				**-0.0057*** **	
			(-4.74)				**(-4.58)**	
Ramp-up costs				**-0.0014*** **				**-0.0014*** **
				(-3.57)				**(-3.42)**
Stochastic capacity [%]	0.22***	0.027			0.22***	0.029		
	(4.75)	(0.66)			(4.83)	(0.72)		
Asset age	-0.0021***	-0.0021***	-0.0023***	-0.0023***	-0.0021***	-0.0021***	-0.0022***	-0.0023***
	(-3.08)	(-3.11)	(-3.45)	(-3.66)	(-3.12)	(-3.15)	(-3.46)	(-3.67)
Regional diversification	0.045**	0.045**	0.044**	0.043**	0.045**	0.044**	0.044**	0.044**
	(2.36)	(2.35)	(2.12)	(2.08)	(2.30)	(2.28)	(2.11)	(2.12)
Size	0.029***	0.029***	0.031***	0.030***	0.029***	0.029***	0.031***	0.031***
	(4.85)	(4.85)	(4.75)	(4.79)	(4.96)	(4.96)	(4.93)	(5.00)
Profitability	-0.34***	-0.34***	-0.33***	-0.32***	-0.34***	-0.34***	-0.33***	-0.32***
	(-3.60)	(-3.61)	(-3.43)	(-3.38)	(-3.59)	(-3.61)	(-3.44)	(-3.39)
Tangible assets ratio	0.18***	0.17***	0.17***	0.17***	0.17***	0.17***	0.17***	0.18***
	(3.94)	(3.94)	(3.90)	(3.94)	(3.95)	(3.96)	(3.96)	(4.04)
Market-to-book	-0.013***	-0.013***	-0.013***	-0.014***	-0.013***	-0.013***	-0.013***	-0.014***
	(-2.98)	(-2.97)	(-3.21)	(-3.27)	(-2.96)	(-2.95)	(-3.21)	(-3.26)
Dividend paying	-0.078***	-0.078***	-0.078***	-0.076***	-0.077***	-0.078***	-0.078***	-0.077***
	(-3.96)	(-3.96)	(-3.91)	(-3.87)	(-3.95)	(-3.95)	(-3.90)	(-3.87)
Constant	0.18*	0.37***	0.36***	0.41***	0.19*	0.38***	0.36***	0.39***
	(1.69)	(3.59)	(3.33)	(3.90)	(1.80)	(3.67)	(3.37)	(3.79)
Observations	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760
Adjusted R^2	0.43	0.43	0.42	0.42	0.43	0.43	0.42	0.42

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

Table 5.14.: Robustness test – Sub-samples

Model	Ia	Ib	IIa	IIb
Subsample	U.S. only		Firm size	
	Fin.	Full	Large	Small
Mid-load capacity [%]		**0.12****	**0.20*****	**0.14*****
		(2.55)	**(4.21)**	**(3.24)**
Peak-load capacity [%]		**0.16*****	**0.18*****	**0.16*****
		(3.02)	**(3.16)**	**(3.61)**
Stochastic capacity [%]		-0.0034	0.25***	0.18***
		(-0.031)	(4.26)	(3.35)
Asset age		-0.00045	-0.00045	-0.0035***
		(-0.38)	(-0.43)	(-3.94)
Regional diversification		0.0053	0.013	0.094***
		(0.18)	(0.59)	(3.26)
Size	0.032***	0.036***	0.029***	0.020**
	(4.01)	(4.51)	(2.86)	(2.18)
Profitability	-0.47**	-0.51**	-0.62***	-0.18*
	(-2.12)	(-2.29)	(-3.95)	(-1.68)
Tangible assets ratio	0.022	0.028	-0.00034	0.25***
	(0.26)	(0.31)	(-0.0057)	(4.48)
Market-to-book	-0.015**	-0.012*	-0.013*	-0.012**
	(-2.63)	(-1.93)	(-1.90)	(-2.41)
Dividend paying	-0.095***	-0.084***	-0.089***	-0.095***
	(-3.06)	(-2.75)	(-3.59)	(-4.05)
Constant	0.089	-0.090	0.34*	-0.31**
	(0.55)	(-0.47)	(1.76)	(-2.40)
Observations	536	536	1,057	1,057
Adjusted R^2	0.31	0.36	0.52	0.37

The dependent variable is MARKET LEVERAGE in models I and II. Model I only includes observations from the United States. Model IIa (b) only includes firm-years that have higher (lower) total assets as the median. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

Table 5.15.: Robustness tests – Sub-samples – run-up time and ramp-up costs

	Ia U.S. only	Ib Large	Ic Small	IIa U.S. only	IIb Large	IIc Small
Run-up time	**-0.0066***** **(-4.08)**	**-0.0063***** **(-4.48)**	**-0.0025** **(-0.53)**			
Ramp-up costs				**-0.0015**** **(-2.44)**	**-0.0020***** **(-4.80)**	**-0.00020** **(-0.26)**
Asset age	-0.00036 (-0.35)	-0.00088 (-0.90)	-0.0035*** (-4.03)	-0.00049 (-0.44)	-0.0010 (-1.06)	-0.0035*** (-4.03)
Regional diversification	-0.0034 (-0.12)	0.019 (0.86)	0.098*** (3.01)	-0.0054 (-0.18)	0.018 (0.83)	0.099*** (3.06)
Size	0.046*** (5.21)	0.031*** (2.98)	0.022** (2.34)	0.043*** (4.45)	0.029*** (2.79)	0.022** (2.32)
Profitability	-0.43** (-2.12)	-0.62*** (-3.97)	-0.18 (-1.59)	-0.42** (-2.01)	-0.62*** (-3.93)	-0.18 (-1.61)
Tangible assets ratio	0.0056 (0.067)	0.0024 (0.040)	0.25*** (4.39)	0.013 (0.15)	0.011 (0.19)	0.25*** (4.39)
Market-to-book	-0.012** (-2.20)	-0.013** (-2.14)	-0.013** (-2.57)	-0.014** (-2.42)	-0.013** (-2.17)	-0.013** (-2.58)
Dividend paying	-0.088*** (-3.10)	-0.094*** (-4.02)	-0.093*** (-3.96)	-0.089*** (-3.02)	-0.091*** (-3.82)	-0.094*** (-3.98)
Constant	-0.094 (-0.53)	0.51*** (2.92)	-0.20 (-1.52)	-0.0087 (-0.049)	0.60*** (3.57)	-0.20 (-1.49)
Observations	536	1,057	1,057	536	1,057	1,057
Adjusted R^2	0.37	0.52	0.35	0.33	0.52	0.35

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

5.1.4.6. Estimation Methodology

Next, I investigate if the results are robust to different estimation methodologies and standard error calculations. *First*, I use a Tobit regression which accounts for the truncated range of the dependent variable MARKET LEVERAGE from zero to one. Results are reported in Table 5.16, model Ia. *Second*, I apply a between-firm effects estimator that only uses variation across firms, not over time, in model Ib. *Third*, I apply an estimation technique proposed by Fama and MacBeth (1973). In this two-step procedure, a separate regression for every year is performed in step one. In the second step, the coefficient estimates are calculated as the average of the first step estimates. Consequently, this method, known as Fama-MacBeth estimation, has the advantage that it is not biased if a time effect is present (Petersen (2009)). Results are depicted in model Ic.[54] *Fourth*, I apply multiway clustering in model II (Cameron, Gelbach and Miller (2011), Thompson (2011)).

Huber/White robust standard errors are robust in the presence of a firm effect (models Ia and Ib), while the Fama-MacBeth estimator is robust in the presence of a time effect (model Ic). The multiway clustering is robust for errors being correlated within companies, years and countries (model II).

All findings confirm my prior results indicating that higher production flexibility leads to higher leverage ratios. Again, I additionally report models using run-up time in Table A. 8 in the appendix. Calculations using base and ramp-up costs parametrization find consistent results.[55]

Lemmon, Roberts and Zender (2008) also suggests to use Fixed Effects estimation in order to identify “the presence of a significant unobserved permanent component” of the capital structure.[56] Therefore, in Table 5.17, I apply fixed effects regressions and find significance for the run-up time and ramp-up cost parametrizations. In contrast to Lemmon, Roberts and Zender (2008), I find that my overall R^2 decreases for the fixed effects model. Run-up time and ramp-up costs remain significant, while the base/mid/peak and stochastic-parametrization is insignificant for these fixed effects calculations.

Additionally, I tested whether my control variables strongly contribute to the adjusted R^2, as Lemmon, Roberts and Zender (2008) argue. In Table 5.18, I step by step excluded the control variable with the lowest t-value. The tangible assets ratio is excluded first, followed by market-to-book ratio and dividends dummy. Consequently, profitability – and, less surprisingly, size – show to be still more significant than my run-up time measure of production flexibility in Fixed Effects calculations.

However, generally, these Fixed Effects calculations are important, as I thereby control for any unobserved time-invariant firm characteristics that might influence the capital structure. For example, one might claim that measuring generation assets is not sufficient, as transmission and distribution grids also contribute to production flexibility (whatever this means in accordance

[54] With the exception of Fama-MacBeth, all calculations include year and country dummies. In Fixed Effects calculations, country dummies obviously are not included, either.

[55] Results are not explicitly reported here.

[56] Cf. Lemmon, Roberts and Zender (2008), p.1605

with our definition of production flexibility and in the context of grid business).
However, in Section 2.4, I explained that especially the grid business is regulated,[57] while the generation business is less regulated. As regulated businesses are less volatile – principally in all dimensions, e.g. cash flows, value of assets and profitability – the effect of such regulated business segments on the firm's overall control variables in our regression is almost constant over time. In other words, variations in the firms control variables will mainly be driven by those segments with less regulation, i.e. the electricity generation business. Consequently, as my Fixed Effects regression still shows significance, I can exclude grid business as the cause of an omitted variable bias.

Table 5.16.: Robustness tests – Estimation methodology

	Ia Tobit	Ib Between effects	Ic Fama-MacBeth	II Multiway clustering
Mid-load capacity [%]	**0.17*** **	**0.14*** **	**0.12*** **	**0.16*** **
	(5.08)	**(3.02)**	**(7.20)**	**(5.66)**
Peak-load capacity [%]	**0.18*** **	**0.17*** **	**0.14*** **	**0.18*** **
	(5.18)	**(3.72)**	**(6.00)**	**(5.66)**
Stochastic capacity [%]	0.21***	0.16***	0.15***	0.20***
	(4.69)	(3.09)	(11.3)	(3.98)
Asset age	-0.0028***	-0.0036***	-0.0029***	-0.0023***
	(-3.86)	(-4.34)	(-8.97)	(-2.77)
Regional diversification	0.048**	0.057**	0.0040	0.047*
	(2.56)	(2.19)	(0.57)	(1.94)
Size	0.031***	0.025***	0.043***	0.028***
	(5.73)	(4.20)	(20.8)	(4.40)
Profitability	-0.31***	-0.27*	-0.37***	-0.32***
	(-3.20)	(-1.76)	(-7.79)	(-3.73)
Tangible Assets Ratio	0.17***	0.23***	0.16***	0.16***
	(3.95)	(4.79)	(8.68)	(3.90)
Market-to-book	-0.013***	-0.013***	-0.014***	-0.014***
	(-3.24)	(-3.08)	(-4.34)	(-2.70)
Dividend paying	-0.086***	-0.090***	-0.095***	-0.083***
	(-4.78)	(-3.38)	(-5.67)	(-4.30)
Observations	2,114	2,114	2,114	2,114
Adjusted R^2	...	0.39	0.28	0.45

The dependent variable is MARKET LEVERAGE. Model I shows estimates based on a Tobit model with censoring at zero and one. Model II is a between-firm effects estimation. The outcome of a Fama-MacBeth estimation is depicted in model III. Model IV shows OLS estimates with standard errors clustered by firms, years, and countries (Cameron, Gelbach and Miller, 2011). Year and country dummies are included (except for the Fama-MacBeth estimation). All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are used in model I and II. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

[57] Cf. Jamasb and Pollitt (2001) for a study on incentive regulation.

Table 5.17.: Fixed Effects calculations

	Ia	Ib	Ic	IIa	IIb	IIc
Mid-load capacity [%]	**0.013**			**-0.022**		
	(0.24)			(-0.43)		
Peak-load capacity [%]	**0.048**			**0.013**		
	(0.77)			(0.23)		
Run-up time		**-0.0063****			**-0.0094*****	
		(-2.07)			**(-3.57)**	
Ramp-up costs			**-0.0016***			**-0.0020****
			(-1.81)			**(-2.52)**
Stochastic capacity [%]	0.062			0.019		
	(0.91)			(0.31)		
Asset age	-0.0016*	-0.0021**	-0.0022***	-0.00075	-0.0012	-0.0014*
	(-1.93)	(-2.55)	(-2.60)	(-0.97)	(-1.62)	(-1.71)
Regional diversification	-0.016	-0.016	-0.015	0.0090	0.0090	0.0099
	(-1.13)	(-1.23)	(-1.14)	(0.61)	(0.64)	(0.69)
Size	0.10***	0.10***	0.10***	0.095***	0.094***	0.091***
	(5.18)	(5.35)	(5.33)	(5.37)	(5.52)	(5.48)
Profitability	-0.30***	-0.30***	-0.30***	-0.21**	-0.20**	-0.21***
	(-3.18)	(-3.17)	(-3.21)	(-2.57)	(-2.54)	(-2.60)
Tangible assets ratio	0.012	0.012	0.012	0.11*	0.11*	0.11*
	(0.20)	(0.21)	(0.21)	(1.86)	(1.90)	(1.91)
Market-to-book	-0.0035	-0.0037	-0.0037	0.012***	0.012***	0.012***
	(-0.82)	(-0.87)	(-0.87)	(3.06)	(3.10)	(3.07)
Dividend paying	-0.035*	-0.035*	-0.035**	-0.039**	-0.039**	-0.039**
	(-1.96)	(-1.97)	(-1.99)	(-2.33)	(-2.30)	(-2.35)
Constant	-1.06***	-1.00***	-0.94***	-0.96***	-0.93***	-0.85***
	(-3.28)	(-3.24)	(-3.05)	(-3.37)	(-3.42)	(-3.17)
Observations	2,114	2,114	2,114	2,103	2,103	2,103
Adjusted R^2	0.27	0.27	0.27	0.14	0.15	0.15
Within R^2	0.27	0.27	0.27	0.14	0.15	0.15
Between R^2	0.11	0.11	0.11	0.16	0.17	0.16
Overall R^2	0.16	0.16	0.16	0.22	0.23	0.22

The dependent variables are MARKET LEVERAGE in Model Ia - Ic and BOOK LEVERAGE in Model IIa - IIc. All models are Fixed Effects calculations. Year dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in 5.1.

Table 5.18.: Fixed Effects calculations – Sensitivity of R^2

	I	II	III	IV	V
Run-up time	**-0.0063****	**-0.0063****	**-0.0062****	**-0.0063****	**-0.0065****
	(-2.07)	**(-2.07)**	**(-2.02)**	**(-2.08)**	**(-2.17)**
Asset age	-0.0021**	-0.0021***	-0.0021***	-0.0021***	-0.0021***
	(-2.55)	(-2.60)	(-2.62)	(-2.64)	(-2.66)
Regional diversification	-0.016	-0.016	-0.016		
	(-1.23)	(-1.25)	(-1.23)		
Size	0.10***	0.10***	0.11***	0.10***	0.10***
	(5.35)	(4.98)	(5.16)	(5.11)	(5.01)
Profitability	-0.30***	-0.30***	-0.30***	-0.31***	-0.30***
	(-3.17)	(-3.22)	(-3.26)	(-3.26)	(-3.20)
Tangible assets ratio	0.012				
	(0.21)				
Market-to-book	-0.0037	-0.0037			
	(-0.87)	(-0.87)			
Dividend paying	-0.035*	-0.035**	-0.035*	-0.034*	
	(-1.97)	(-1.97)	(-1.94)	(-1.92)	
Constant	-1.00***	-1.00***	-1.04***	-1.03***	-1.02***
	(-3.24)	(-3.22)	(-3.41)	(-3.37)	(-3.33)
Observations	2,114	2,114	2,114	2,114	2,114
Adjusted R^2	0.27	0.27	0.27	0.27	0.26
Within R^2	0.27	0.27	0.27	0.27	0.27
Between R^2	0.11	0.11	0.11	0.11	0.10
Overall R^2	0.16	0.16	0.16	0.16	0.15

The dependent variables are MARKET LEVERAGE. All models are Fixed Effects calculations. Year dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in 5.1.

5.1.4.7. Salability as a Determinant of Leverage

Benmelech (2009) was first to hypothesize that debt maturity *and* leverage are influenced by asset salability. However, in his paper, he did not empirically confirm such effect for leverage. In order to empirically confirm his hypothesis, in this section, I test the impact of salability/ specificity on leverage.

For my analysis, I did not consider the financial situation of the potential buyers in addition, as this would require a thorough discussion of how and under which circumstances power plants can be financed. This is beyond the scope of my thesis. If the reader criticizes that for being too crude, my measure can at least be interpreted as a kind of asset specificity, as it measures how often such assets are found among the companies' competitors. A higher number of companies owning power plants of the same technology in identical geographic regions demonstrates a higher general interest in such plants, i.e. such asset is less specific. However, in comparison to typical measures as tangible assets to total assets (Titman and Wessels (1988) and Rajan and Zingales (1995)) or research and development expenditures (Bradley, Jarrell and Kim (1984)), such asset specificity measure seems to be a good proxy for salability of assets.

Due to the availability of asset level data, I construct a more direct measure of asset salability/

specificity, which is based on the asset level instead of a parametrization based on accounting data. In the sense of Shleifer and Vishny (1992), power plants are assets which are not *redeployable* for other purposes except for generating power. Also the finished product remains the same, i.e. electricity. Consequently, redeployability is not an issue in the sense of Shleifer and Vishny (1992).

I recapitulate that Benmelech (2009) suggests that asset salability consists of the willingness of potential users to buy the asset (determined by asset attributes) and the ability of them to pay (depends on buyers financial strength).[58] However, as he also suggests that salability is understood as "the notion of salability to describe the extent of the value that an asset retains in liquidation"[59], I proxy salability by the number of potential bidders and assume that a higher number of potential bidders is more likely to lead to a higher price in liquidation. Consequently, I expect, that in consistence with Benmelech (2009), a higher salability leads to a higher leverage.

The calculation of my measure of salability is based on the idea that a utility company qualifies for being a potential buyer of a power plant of a specific technology, if it has such power plant in its portfolio, already. The reason is that such company is *able* (from a technical, operations & maintenance and fuel supply resource perspective) and *permitted* (which might be somehow limited e.g. for nuclear power plants) to own the respective power plant technology. Further, I require that a potential buyer comes from the same country as the company owning the power plant. This mirrors the tendency of many electricity generating utility companies to operate as local players, as the mean of the regional diversification dummy variable in my sample (27%) shows. Consequently, my measure of salability should be seen as an asset level related proxy of salability, as of course, for example cross border asset sales are not a priori prevented.

As I calculate salability of the complete portfolio for each company i in my sample, I define my measure of a company's salability as follows:

$$\text{Salability}^i = \frac{1}{\text{Total capacity}} \sum_{tech} (\text{Number of potential buyers}^i_{\text{tech}} \cdot \text{capacity}^i_{tech}),$$

where *tech* denotes the respective technology. Consequently, this bottom-up salability measure is based on annual single power plant data for each company.

In order to empirically proof the *Asset Salability/ Leverage Hypothesis*, I insert asset salability as an additional measure into my leverage regression model. If country dummies are included, I find that variance inflation factors (VIF) of salability equal about 12.5, which is typically considered to be problematic. Therefore, I also calculate the given models without including country dummies.[60] Results excluding country dummies are reported in Table 5.19.[61] The maximal VIF-values (e.g. for models IIc and IIIc) equal an unproblematic level of about 1.65.[62]

58 Cf. Benmelech (2009), p.1548
59 Cf. Benmelech (2009), p.1548
60 Leaving out country dummies might be problematic. Harris and Raviv (1992), p.136, state that bankruptcy law, which is country specific, is implicitly part of a debt contracts. Consequently, leverage might be influenced.
61 Results remain mainly unchanged for book leverage as dependent variable. These results are not reported here. The respective R^2 is higher and equals about 50% when book leverage is used as dependent variable.
62 For the avoidance of doubt, VIFs have been checked continuously throughout all models in this thesis.

This effect of country dummies is likely to derive from my definition of salability, that relies on the number of companies *from the same country.* None of the other models reported before was ever close to a problematic VIF level.

For robustness, I tested the significance of salability when tangibility is included (models IIa-IId) and excluded (models IIIa-IIId), as tangibility is an additional asset- and collateral-related control variable. Results remain mainly unchanged. This test obviously also refers to the statement of Myers (1984), that the reduced liquidation value and not tangibility drives leverage. Actually, I find significance for both variables, tangibility and salability, no matter if both are included or not.[63]

Overall, from Table 5.19, I find the following: *First*, my results for production flexibility are robust and not systematically impacted by salability, which is the case at least for the investment flexibility variable in MacKay (2003).
Second, I find that salability is positively related to leverage, as hypothesized by the *Asset Salability/ Leverage Hypothesis* and in accordance with the hypothesis of Benmelech (2009).

5.1.4.8. Operating Leverage and the Share of Variable Costs

In this section, I test whether the share of variable costs also relates to the capital structure.[64] In accordance with the recent empirical findings of Kahl, Lunn and Nilsson (2011) and Kuzmina (2012), I expect that a higher share of *variable costs in production* – which corresponds to a more *flexible costs structure of production* – leads to a higher leverage. In other words, it is expected that a higher share of fixed costs leads to a lower leverage due to higher future cash flow risks.

As reviewed in Section 2.1.3.1, the *operating leverage* is related to *production flexibility* to the extent the share of fixed and variable costs is related to the costs for switching assets on and off. Also, the operating leverage is related to *investment flexibility* to the extent a higher share of fixed costs can be interpreted as a pre-commitment to production capacity. These interpretations seem to hold for power plants, as such power plants with higher fixed costs, i.e. base load power plants, require a higher number of operating hours and are less flexible. Consequently, I expect that results for this analysis are in line with my foregoing analyses of production flexibility.

This test has been banned to the robustness section, as the parameters I use for the share of variable costs are not only related to the characteristics of the assets, but also to the characteristics of regional markets, which makes this measure less fundamental.[65]

63 The correlation of salability and tangibility equals 0.08, i.e. it is low. All models within the presented table behave similar.

64 Cf. Section 2.1.3.1 for a discussion of operating leverage.

65 The same is – though with lower sensitivity – true for the base/ mid/ peak and stochastic-parametrization. While run-up time and ramp-up costs are related to the asset only, the categorization in base, mid and peak load also depends on the number of full load hours, and therewith principally on the specific market the power plants operates in. Nevertheless, as the ranking of full load hours might probably be similar due to the plants cost structure and international fuel markets, the base/ mid/ peak/ stochastic-parametrization is expected to be less biased.

Table 5.19.: Leverage and Salability

	I	IIa	IIb	IIc	IId	IIIa	IIIb	IIIc	IIId
Asset salability	**0.00070***	**0.00093***	**0.00094***	**0.0010***	**0.0011***	**0.00093***	**0.00095***	**0.0010***	**0.0011***
	(3.43)	**(3.79)**	**(3.95)**	**(4.22)**	**(4.54)**	**(3.67)**	**(3.93)**	**(4.22)**	**(4.49)**
Mid-load capacity [%]		**0.13***				**0.14***			
		(3.89)				**(3.63)**			
Peak-load capacity [%]		**0.14***				**0.15***			
		(3.59)				**(3.45)**			
Base-load capacity [%]			**-0.14***				**-0.14***		
			(-4.06)				**(-3.80)**		
Run-up time				**-0.0033**				**-0.0035***	
				(-2.04)				**(-1.93)**	
Ramp-up costs					**-0.00082***				**-0.00075***
					(-1.96)				**(-1.66)**
Stochastic capacity [%]		0.16***	0.022			0.15***	0.0058		
		(3.25)	(0.53)			(2.86)	(0.14)		
Asset age		-0.0031***	-0.0031***	-0.0033***	-0.0034***	-0.0030***	-0.0031***	-0.0031***	-0.0033***
		(-4.65)	(-4.66)	(-5.05)	(-5.26)	(-4.49)	(-4.53)	(-4.83)	(-4.99)
Regional diversification		0.017	0.017	0.015	0.014	0.0091	0.0090	0.0066	0.0058
		(0.93)	(0.93)	(0.81)	(0.77)	(0.49)	(0.48)	(0.35)	(0.30)
Size	0.034***	0.038***	0.038***	0.038***	0.038***	0.039***	0.039***	0.040***	0.039***
	(7.53)	(8.02)	(8.01)	(7.05)	(7.39)	(7.84)	(7.85)	(7.06)	(7.32)
Profitability	-0.40***	-0.34***	-0.34***	-0.34***	-0.33***	-0.32***	-0.32***	-0.31***	-0.31***
	(-4.08)	(-3.48)	(-3.47)	(-3.38)	(-3.41)	(-3.09)	(-3.10)	(-2.98)	(-2.98)
Tangible assets ratio	0.17***	0.18***	0.18***	0.18***	0.18***				
	(3.65)	(4.24)	(4.21)	(4.11)	(4.25)				
Market-to-book	-0.013***	-0.013***	-0.012***	-0.013***	-0.013***	-0.015***	-0.015***	-0.015***	-0.015***
	(-3.33)	(-3.13)	(-3.12)	(-3.31)	(-3.32)	(-3.39)	(-3.38)	(-3.61)	(-3.61)
Dividend paying	-0.094***	-0.089***	-0.089***	-0.087***	-0.087***	-0.078***	-0.078***	-0.076***	-0.076***
	(-4.39)	(-4.29)	(-4.30)	(-4.16)	(-4.21)	(-3.78)	(-3.79)	(-3.67)	(-3.68)
Constant	-0.11	-0.25***	-0.11*	-0.11	-0.098	-0.17**	-0.031	-0.041	-0.019
	(-1.57)	(-3.33)	(-1.72)	(-1.57)	(-1.42)	(-2.17)	(-0.46)	(-0.55)	(-0.27)
Observations	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760
Adjusted R^2	0.25	0.30	0.30	0.29	0.29	0.27	0.27	0.26	0.26

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year dummies are included. Country dummies are *not* included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1

As Kaplan (2008) points out, gas power plants are assumed to operate as base load power plants in the U.S., while this is not the case, e.g. in Germany. Consequently the following calculation would require the construction of an international merit order model, which is beyond the scope of this thesis. However, I use the parameters of Tidball et al. (2010), p.96, who refers to the data of the Annual Energy Outlook 2009 of the U.S. Energy Information Administration (EIA), in order to test the effect of the cost structure, i.e. the operating leverage, specifically for the U.S. (in order to avoid any bias).

For the calculation of fixed and variable costs, I proceed as follows: In order to obtain the variable costs, I start by calculating fixed O&M (operations and maintenance) costs as the "fixed cost of O&M per installed capacity" (in US$/ kW) multiplied by the installed capacity (in kW). Further, I calculate the variable fraction of O&M costs per MWh as the "variable O&M costs" (in US$/ MWh) multiplied by the number of hours per year multiplied by the capacity factor. Therefrom, I calculate the share of variable and fixed O&M costs per technology.
Further, Tidball et al. (2010) provide fuel costs, total O&M costs and overnight capital costs in US$ per produced MWh by technology.[66] These are used to calculate the overall fixed and variable costs by adding fuel costs per MWh to the variable O&M costs per MWh, the latter defined as the share of O&M (as calculated before) multiplied by the O&M costs per MWh. In parallel, overnight capital costs per MWh are added to the fixed share of the O&M costs per MWh. Finally, therefrom, I calculate the share of fixed and variable costs for producing electricity by technology, i.e. the Levelised Cost of Energy (LCOE) by technology.[67]

I point out, that my results might depend on the parameters given for the United States. Due to the large number of parameters, I do not provide further robustness tests with regard to these parameters.[68] Also, I point out that the capacity factor does not reflect the share of annual full load hours[69] and is given separately for each production technology.

Finally, in order to calculate the variable electricity generation costs for the overall power plant portfolio of each company, I calculate two different measures of the share of variable electricity generation costs. *First*, I weight the variable costs per technology by the installed capacity per technology, *second*, I weight the variable costs per technology by the product of the installed capacity per technology multiplied by the capacity factor.

My results for OLS regressions of the share of variable costs on leverage are shown in Table 5.20. Results show, that the share of variable costs is a relevant determinant of market leverage (Models Ia - Id) and book leverage (Models IIa - IId) with significance at the 5%-level. Models Ia - Ib and Models IIa - IIb use the capacity-weighted variable costs, while Models Ic - Id and IIc - IId use the variable costs weighted be the product of capacity multiplied by the capacity factor. Again, I show robustness for excluding the average asset age and the regional

[66] Cf. Tidball et al. (2010), p.79 ff.

[67] Due to missing data, I assumed as an approximation that the LCOE of oil equal that of gas power plants, the LCOE of Other Fossil equal the average of CCGT, gas and coal power plants, the LCOE of Others, pump storage and waste equal the average of all technologies, and the LCOE of Biogas equal that of CCGT.

[68] As an exception, for gas power plants, the influence of the capacity factor of 0.92 in Tidball et al. (2010) is tested for robustness by changing it to 0.70 as given in Kaplan (2008). I find that results remain robust.

[69] Tidball et al. (2010) defines the capacity factor as follows: "The values shown correspond to maximum availability factors in 2010, or the first year technologies come online" (Tidball et al. (2010), p.96).

diversification variables.

In a nutshell, as hypothesized, there is evidence that a higher share of variable costs, i.e. a lower operating leverage, results in an increased leverage. In other words, companies with a higher share of fixed costs tend to have a lower leverage in order to reduce their increased future cash flow risk. This is consistent with the findings of Kuzmina (2012) and Kahl, Lunn and Nilsson (2011) regarding the influence of operating leverage on the capital structure.

5.1.5. Summary and Implications

In this section, I analyzed the impact of production characteristics on leverage. Especially the influence of production flexibility, parametrized by different measures, was studied.

Recent studies in the capital structure literature suggested that production characteristics had a major impact on leverage (Lemmon, Roberts and Zender (2008), Gamba and Triantis (2008), Rauh and Sufi (2012), Leary and Roberts (2013)). Production flexibility has been identified by Mauer and Triantis (1994), and later MacKay (2003), as a potential reason for this relationship. Mauer and Triantis (1994) argues that production flexibility increases debt capacity and – as a consequence – leverage. Gamba and Triantis (2008) state that the value of being financially flexible decreases for companies that are more flexible in production. In this sense scholars suggest a substitution effect between production flexibility and financial flexibility. However, MacKay (2003), to my best knowledge the only empirical paper referring to production flexibility in a sense similar to mine, confirms the substitution effect of Mauer and Triantis (1994) for his investment flexibility and financial flexibility, but in contrast finds complementarity for production flexibility and financial flexibility.

In my analysis, I find the following, and thereby also confirm the substitution hypotheses of Mauer and Triantis (1994) with regard to production flexibility: *First*, higher production flexibility relates to higher leverage. By exploiting privatization and deregulation as exogenous shocks, I can also show that causality runs from production flexibility to leverage. *Second*, I show that production characteristics are of similar importance as the established determinants of the capital structure. *Third*, I demonstrate that financial and production flexibility act as substitutes. *Fourth*, I prove that, besides production flexibility, also asset salability positively impacts leverage. *Fifth*, I show that the capital structure also behaves consistent with the expected effect from operating leverage (e.g. Kahl, Lunn and Nilsson (2011) and Kuzmina (2012)). I find that a higher share of variable costs supports a higher leverage.

My analysis is based on a sample of 460 international electricity producing utility companies between 2002 and 2009. However, I argue that results are not driven by regulated parts of their business, and that their capital structure is determined by the same factors as for non-utility companies. All data used in my analysis is derived from asset level data, i.e. from data on more than 30,000 different power plants matched to my sample of listed utility companies.

My findings are important to academics and practitioners. *First*, they explain why some companies preserve more of their debt capacity than others. *Second*, they show that production

Table 5.20.: Leverage and share of variable costs

	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Variable costs [%] (capa.)	**0.14****	**0.14****			**0.14****	**0.13****		
	(2.33)	**(2.42)**			**(2.49)**	**(2.32)**		
Variable costs [%] (capa. x load)			**0.15****	**0.14****			**0.14****	**0.13****
			(2.30)	**(2.38)**			**(2.42)**	**(2.25)**
Asset age	0.00018		0.00018		0.00014		0.00013	
	(0.17)		(0.16)		(0.14)		(0.14)	
Regional diversification	0.012		0.012		0.029		0.029	
	(0.39)		(0.41)		(0.94)		(0.96)	
Size	0.033***	0.034***	0.033***	0.034***	0.040***	0.041***	0.040***	0.041***
	(4.53)	(4.43)	(4.53)	(4.44)	(5.26)	(5.41)	(5.26)	(5.41)
Profitability	-0.54**	-0.54**	-0.54**	-0.54**	-0.075	-0.068	-0.076	-0.068
	(-2.57)	(-2.48)	(-2.57)	(-2.48)	(-0.51)	(-0.45)	(-0.52)	(-0.45)
Tangible assets ratio	0.035	0.033	0.036	0.034	0.13	0.13	0.13	0.13
	(0.43)	(0.41)	(0.44)	(0.42)	(1.52)	(1.52)	(1.53)	(1.53)
Market-to-book	-0.014**	-0.014**	-0.014**	-0.014**	0.0097	0.011	0.0096	0.011
	(-2.32)	(-2.42)	(-2.35)	(-2.44)	(1.03)	(1.15)	(1.02)	(1.15)
Dividend paying	-0.088***	-0.091***	-0.088***	-0.092***	-0.050*	-0.059*	-0.050*	-0.059*
	(-2.83)	(-2.96)	(-2.84)	(-2.97)	(-1.75)	(-1.94)	(-1.75)	(-1.95)
Constant	-0.015	-0.013	-0.012	-0.010	-0.14	-0.14	-0.13	-0.14
	(-0.087)	(-0.081)	(-0.069)	(-0.064)	(-0.81)	(-0.86)	(-0.79)	(-0.83)
Observations	536	536	536	536	532	532	532	532
Adjusted R^2	0.35	0.35	0.34	0.35	0.31	0.30	0.31	0.30

The dependent variable is MARKET LEVERAGE in models I and BOOK LEVERAGE in models II. Models only include observations from the United States. All models are pooled OLS regressions. Year dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

capacity dampens external shocks, i.e. both increases and decreases, on financing opportunities, as it was tested by exploiting the Lehman event and the coordinated central banks action on November 30^{th}, 2011. Politicians might think of ways to support production flexibility in order to profit from this buffering effect in times of crises.

5.2. Debt and Asset Maturity Matching and the Yield Spread of Debt[70]

In this section, I address the hypotheses related to the debt maturity structure as derived in Section 3.2.

This section is structured as follows: After a short introduction, I describe my sample and methodology. Thereafter, I provide descriptive statistics, and then present my empirical results. Finally, I conduct some robustness tests and conclude my findings.

5.2.1. Introduction

In this section I address a hypothesis from the early times of capital structure research: the hypothesis of debt and asset maturity matching. Furthermore, I investigate whether a mismatch of debt and asset maturity leads to higher costs of debt. Also, I provide evidence for the effect of asset salability on debt maturity. For these analyses, I refer to explicit asset level data, derived bottom-up from the level of single power plants for a sample of international listed utility companies, as derived in Section 4. In contrast, earlier studies have frequently relied on indirectly derived accounting measures, as discussed in Section 2.2 and Section 3.2.

The remainder of this section is structured as follows: *First*, in Section 5.2.2, I give an overview on data and methodology. *Second*, I empirically address the **maturity matching hypothesis (balance sheet)**, the **maturity matching hypothesis (debt issuance)**, the **mismatch premium hypothesis**, and the **asset salability/debt maturity hypothesis** in Section 5.2.3.

My main results can be summarized as follows: I find, *first*, that firms match their debt maturity to their "real" remaining lifetime of assets, *second*, that the maturity of stand-alone new debt issues is not significantly determined by the maturity of assets, and *third*, that the mismatch between asset and debt maturity is positively related to the yield of new debt issues. For practitioners in the utility industry, I provide formulas for the choice of debt maturity and the pricing of new debt issues.[71] To my best knowledge, these contributions are new to the literature to the extent as explained in detail in Section 3.2.

5.2.2. Data and Methodology

5.2.2.1. Sample Construction

The analyses in this section are based on the same sample of 460 listed energy utility companies from 57 countries for the years between 2002 and 2009 as derived in Chapter 4 and as used in Section 5.1.

Besides the above mentioned accounting data available from Worldscope (as described in Section 5.1.2.1) and production data derived from the WEPP database (as described in Section 4

[70] This section is largely based on Reinartz (2013).

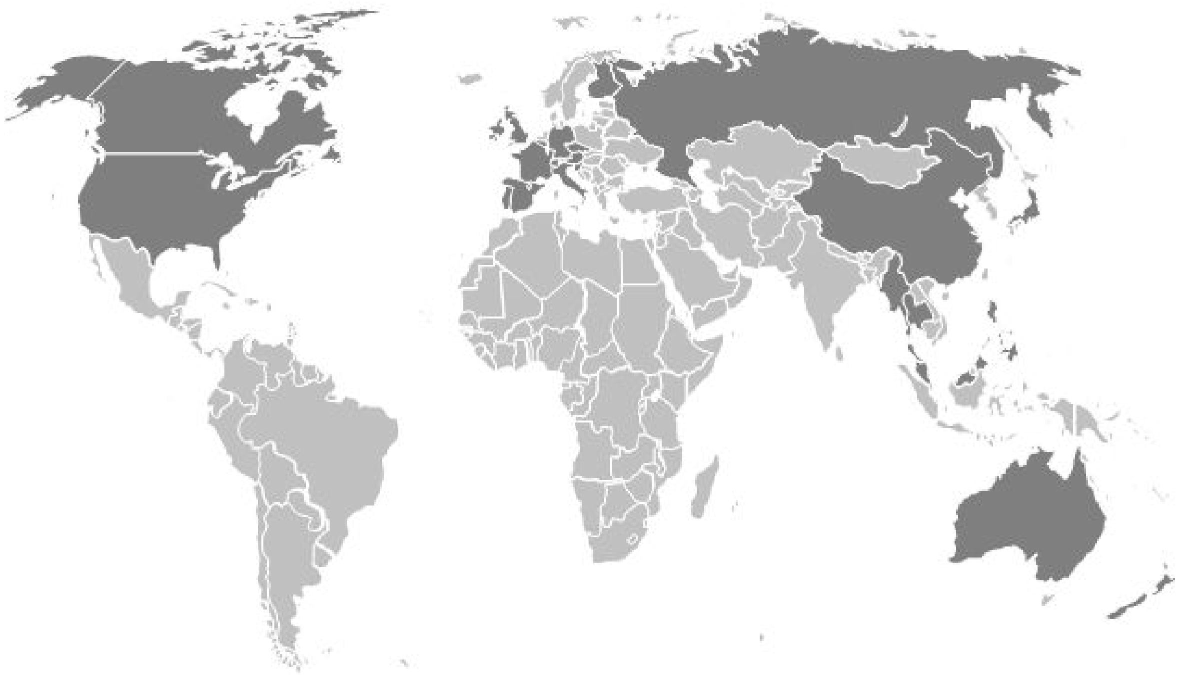
[71] I note that companies making extensive use of project finance for the realization of power plant projects might use different financing rationals to choose leverage and debt maturity. However, my thesis focuses on corporate finance decisions in electric utility companies.

and Section 5.1.2.2), the analysis of the debt maturity structure[72] and the yield spread of debt issues requires additional detailed debt structure data. This data is available from S&P Capital IQ, which had to be manually matched to the Worldscope identifiers of my sample companies.[73] Out of the abovementioned 460 companies, 453 Worldscope identifiers could be manually matched to S&P Capital IQ.

Finally, for the balance sheet perspective, I find debt maturity data on 120 companies from 26 countries.[74] Also, I find data on 6,730 outstanding debt issues between 2002 and 2009, issued by 174 companies in 32 countries.[75]

Figure 5.3 shows the respective countries with headquarters of sample companies domiciled therein. Note that the companies' single assets, that were matched from the WEPP database, might be even wider distributed around the globe.

Figure 5.3.: Countries with headquarters of sample companies domiciled therein (dark gray)



72 For reasons of robustness, I measure the debt maturity structure, *first*, by using balance sheet data, and *second*, by aggregating outstanding debt issues to a "quasi-balance sheet view".

73 As S&P Capital IQ offers detailed debt data, I use this database for debt data while I still rely on Worldscope for other accounting data as in the prior section. I thank A.T. Kearney for access to S&P Capital IQ.

74 Please note that I cannot use all observations in the regressions due to missing financial variables, as I explain later.

75 If I require the existence of an S&P debt issue rating, the number of outstanding debt issues between 2002 and 2009 reduces to 1,417 issues from 99 companies in 21 countries.

5.2.2.2. Production Characteristics

As described in Chapter 4, data on the companies assets derives from the WEPP database.[76] The database – among others – also includes information on generation technology and Commercial Operation Date (COD), i.e. the year of the start of commercial operation. From this plant level data, I derive a "real" measure for the expected asset maturity per company for each firm-year, aggregated from the expected lifetime of the single power plants in a company's portfolio. Therefore, I define the "REAL" ASSET MATURITY – i.e. the remaining lifetime – of a single asset i at time t as follows:

$$\text{Asset maturity}_{\text{single asset,i,t}} = \text{Expected lifetime of asset}_i - \text{Asset age}_{i,t}. \tag{5.8}$$

Furthermore, I calculate asset age as the actual year (here between 2002 and 2009) minus the year of the plant's COD. If a plant is older than its expected lifetime, I assume an asset maturity (i.e. remaining lifetime) of zero.

For the production portfolio of company k including the power plants i, I define the respective asset maturity at time t by two different measures as follows:

$$\text{Asset maturity}_{\text{value-weighted},k,t} =$$

$$= \frac{\sum_i (\text{Asset mat.}_{\text{single asset},i,t} \cdot \text{Capa. of plant}_i \cdot \text{Invest. costs per } kW_e \text{ (tech, country)}_i)}{\sum \text{Capacity of plant}_i \cdot \text{Investment costs per } kW_e \text{ (tech, country)}_i}$$

and

$$\text{Asset maturity}_{\text{capacity weighted},k,t} = \frac{\sum_i \text{Asset maturity}_{\text{single asset},i,t} \cdot \text{Capacity of plant}_i}{\sum \text{Capacity of plant}_i},$$

where kW_e denotes the unit "kilo Watt electric". Consequently, the remaining lifetime of single power plants is aggregated to the asset maturity of a company's portfolio by either weighting it with the respective capacity of each plant or with the investment for each plant, the latter differentiated by technology and country.

While COD and capacity are included in the WEPP database, the *expected lifetime* as well as *investment costs* are not included. According to the IEA/ NEA (2010), expected lifetime and investment costs of a power plant are functions of a plant's technology. Furthermore, investment costs may vary by the location of the plant. As investment costs are not included in the WEPP database, I collect the respective data by technology *and* country from IEA/ NEA (2010) in U.S. dollars. In Table 5.21, column II, an overview of investment costs averaged over countries is given by technology.[77]

One might claim, that investment costs were – besides varying by country and technology – not stable over time. However, there is no data available controlling simultaneously for all

[76] As in the foregoing section, I concentrate on generation assets. And as in the foregoing section, I will demonstrate the robustness of a fixed effects model, that implicitly controls for potential time-constant effects from the regulated, almost time-invariant grid business.

[77] If investment costs were unknown for any relevant country, I considered average investments costs in my calculations (separately for each technology).

three potential influences, i.e. country, technology and time. Therefore, as a test of robustness, I add the second measure of asset maturity that is purely weighted by capacity, rather than by capacity-specific investment costs multiplied by capacity.

Table 5.21.: Power plant lifetimes (calculated bottom-up) and investment costs (averaged from IEA/ NEA (2010))

Technology	Average lifetime (in years)	Average investment costs (in $US\$/kW_e$)
Biogas	30.0	6,142
Biomass	31.7	4,934
Coal non-flex	39.4	4,511
Coal-flex	43.1	2,782
Gas	30.3	1,480
Geothermal	29.8	7,484
Nuclear	33.0	4,757
Oil	30.6	2,295
Solar	25.0	5,350
Waste	20.6	25,486
Water flex	62.1	3,625
Water non-flex	54.8	5,750
Wind	25.0	3,147
Water_tidal-wave	20.0	5,040
Others	37.3	3,785
Average	37.9	3,785

In order to derive the expected lifetimes per asset by technology, as given in Table 5.21, column II, I make use of the WEPP database by calculating historical lifetimes of power plants. The basic idea is to identify such plants that changed their operational status between 2002 and 2009[78] from "in commercial operation" to "retired" or "deactivated/ mothballed". By subtracting the given data item COD, which is included in the WEPP database, from the respective year when the operational status switched to "retired" or "deactivated/ mothballed", the lifetime of such plants is calculated.[79]

In order to perform this calculation, each power plant from the annual WEPP databases between 2002 and 2009 had to be provided with a unique identifier in order to make the operational status of each single plant observable over time. Unfortunately, the annual databases only provide weak "unique" identifiers that cannot be used to match the annual databases. Consequently, *manual matching* of the different annual WEPP databases onto each other was required. For this procedure, I used the WEPP data items "UNIT", "UNITID" or "U", "C" and "L".[80]

[78] The operational status is also included in the WEPP database. It is available for about 99% of the plants and is differentiated in "canceled", "under construction", "deactivated/ mothballed", "deferred without construction start", "delayed after construction start", "in commercial operation", "planned and still in design", "retired", "shutdown or standby" and "unknown".

[79] For example, the WEPP database from 2009 provided the data item COD for about 84% of all power plants in the database, i.e. for 126.375 plants.

[80] Especially for early years, the data items U, C and L from the WEPP database do not represent well defined unique identifiers.

The historical lifetimes of power plants derived by technology from this consolidated database are averaged and given in Table 5.21, column II. They are corrected for a bias of "too young" technologies, if the lifetime for any technology is smaller than 15 years on average, i.e. I manually corrected lifetimes of biogas from 8.5 years to 30.0 years, of solar from 8.0 years to 25.0 years, of wind from 13.4 years to 25.0 years and of tidal/ wave from 13.4 years to 25.0 years, as these technologies are available only for a comparably short period on an industrial scale. The corrected data for lifetimes of solar, wind and tidal/ wave power plants were again taken from IEA/ NEA (2010).[81]

I define these average lifetimes as the a priori expected lifetime of an asset (per technology) which I refer to in Formula 5.8 in order to calculate an assets remaining lifetime, i.e. asset maturity, at a given time t.

While the abovegiven definition only includes production assets when calculating a company's asset maturity, the effect of current assets on the overall asset maturity will be additionally discussed in Section 5.2.3.5. I will show that all results remain robust if I consider the maturity of current assets in the manner of Mauer and Triantis (1994). From Table 5.3, I found that the Net PP&E is high for my sample. Therefore, I expect the abovegiven measure already captures the major part of variations in the overall asset maturity.

5.2.2.3. Debt Data

I rely on debt maturity data from S&P Capital IQ, which provides debt maturity structure data from a balance sheet perspective as well as detailed debt issue data.

I construct two types of parametrizations for analyzing the debt maturity structure from the *balance sheet perspective*. *First*, I derive the share of debt with a maturity larger than three (five) years from S&P Capital IQ.[82]

Second, I add a company's outstanding debt issues per year, and weight their time-to-maturity by their offering amount. Obviously, my second measure is limited to the maturity of public debt issues.[84] The time-to-maturity here equals the year of maturity minus the respective year. In order to calculate the outstanding debt, I not only include debt issued between 2002 and 2009 but significantly older issues as long as they are still outstanding. The oldest debt issue in my sample was offered in 1905. By aggregation of outstanding debt issues, I construct a "quasi-balance sheet perspective". In comparison to the "balance sheet perspective", data in this "quasi-balance sheet perspective" allows for a further differentiation of debt with a maturity

[81] For the avoidance of doubt, I explain the reason for such correction: If a technology is comparably new and one intends to calculate its lifetime, one has to consider that those power plants, that went out of service until today, did never reach the end of their expected lifetime but retired before. In such case, a small number of retired plants could determine the expected lifetime as there are almost no plants of such young technology that already reached their a priori expected end of lifetime.

[82] In order to control for the accuracy of the debt maturity structure data, I added up all long-term debt incl. capital leases that matures within one, two, three, four and five as well as after five years and divided this by the total long-term debt incl. capital leases.[83] I required that the sum of these detailed debt maturity structure items may not deviate more than 10% from the respective total debt value.

[84] In other words, my analysis using this *second parametrization* – based on debt issue data – implicitly assumes that bank debt is of equal (or at least similar) maturity *or* that the amount of bank debt is small in comparison to public debt. However, my first parametrization – based on balance sheet data – includes all types of debt.

larger than five years.

Different from the *debt issue perspective*, debt maturity refers to the time-to-maturity of a single debt issue, i.e. the year of maturity of the issue minus the year of issuance.

S&P Capital IQ provides several other relevant variables for the balance sheet and the debt issue approach. All variables used in my calculations are defined in Table 5.22.

5.2.2.4. Methodology

First, I re-calculate each of the models of Stohs and Mauer (1996), Guedes and Opler (1996), Barclay, Marx and Smith (2003) and Benmelech (2009), as presented in Section 2.2. I include depreciation-based measures as well as my "real" asset maturity measures as a parametrization of asset maturity.

Second, I derive a reliable set of determinants of debt maturity structure by using the Bayesian/ Schwarz Information Criterion (BIC) and the Akaike Information Criterion (AIC) according to Schwarz (1978) and Akaike (1974). I do so because the sets of control variables for determining the debt maturity structure differ significantly across literature.

Third, I analyze the yield spread of new debt issues and the impact from a mismatch of debt and asset maturity via regression analyses.

Fourth, I test the influence of asset salability by referring to the model as derived in the second step.

Since my data for the debt maturity structure has an (unbalanced) panel structure, standard errors are corrected for the presence of a firm effect (Petersen (2009)). For this, I apply Huber/ White standard errors with clustering by firm (White (1980)). All financial variables used in regression analyses were winsorized at the 1%-level. For causality reasons, all regressors must be in the information set of the dependent variable. Therefore, regressors are generally lagged by one period, if not stated differently.

5.2.2.5. Definition of Variables

The reader is strongly advised to read through the following definitions of variables in Table 5.22, and not to skip them, as they are relevant for my later analysis.

Table 5.22.: Definition of variables – Debt maturity and asset maturity

Variable	**Description**
Asset maturity	
Asset maturity "Guedes/Opler"	cf. Section 2.2.2
Asset maturity "Stohs/Mauer"	cf. Section 2.2.2
Asset maturity "Barclay et al"	cf. Section 2.2.2
Asset maturity "capacity weighted" [in years]	cf. Section 5.2.2
Asset maturity "value weighted" [in years]	cf. Section 5.2.2
("Real") asset maturity [in years]	Expected remaining lifetime of assets, cf. Formula 5.8
Debt maturity of debt outstanding [in years]	Amount-weighted average maturity of outstanding debt issues at the respective point in time

Definition of Variables - continued

Variable	Description
Debt maturing > 3 years [%]	Long-term debt (incl. capital leases) due after 4 years ([iq_ltd_due_cy4] + [iq_ltd_due_after_five]) as portion of total long-term debt (incl. capital leases) [iq_total_debt]
Debt maturing > 5 years [%]	Long-term debt (incl. capital leases) due after 5 years [iq_ltd_due_after_five] as portion of total long-term debt (incl. capital leases) [iq_total_debt]
|Guedes/Opler - debt outst. mat.|	Absolute value of difference of asset maturity according to Guedes and Opler (1996) (using annual depreciations) and the "Debt maturity of debt outstanding".
|Barclay – debt outst. mat.|	Absolute value of difference of asset maturity according to Barclay et al. (2003) and the "Debt maturity of debt outstanding".
|Val. weighted – debt outst. mat.| [in years]	Absolute value of difference of the expected, value weighted asset maturity derived from asset level data and and the "Debt maturity of debt outstanding".
|Capa. weighted – debt outst. mat.| [in years]	Absolute value of difference of the expected, capacity weighted asset maturity derived from asset level data and the "Debt maturity of debt outstanding".
|*"Asset maturity"* – debt outst. mat.| >0 [in years]	Absolute value of difference of asset maturity and the "Debt maturity of debt outstanding", if the difference is larger than 0. Otherwise this variable is set to zero. *"Asset maturity"* denotes the different asset maturity measures as given above.
|*"Asset maturity"* – debt outst. mat.| <0 [in years]	Absolute value of difference of asset maturity and the "Debt maturity of debt outstanding", if the difference is smaller than 0. Otherwise this variable is set to zero. *"Asset maturity"* denotes the different asset maturity measures as given above.
Debt structure control variables	
Annual coupon	Offering coupon of debt issue [iq_offer_coupon]
Call dummy	Equals 1 if debt issue is callable, 0 if debt issue is not callable, derived from [iq_callable].
Commercial paper dummy	Equals 1 if share of commercial paper in total debt is >0, otherwise equals 0.
Debt issue rating	S&P issue rating, from 8 ("B+" rating) to 17 ("A+" rating)
Investment grade dummy	Equals 1 if rating is equal or better than BBB-, otherwise equals 0.
Issue-size ratio	Offering amount of debt issue/ Total Assets
Long-term debt rating	S&P long-term debt rating, from 1 ("D+" rating) to 21 ("AAA" rating)
Market leverage	Total debt [wc03255] / Market value of assets = Total debt / (Total debt + Market value of equity [wc08001])
Maturity of issue	Year of maturity minus year of issance of debt
Offering amount	Offering amount of debt issue [iq_offer_amount]
Payment frequency	Equals the number of payments per year, derived from [iq_pmt_freq_num].
Put dummy	Equals 1 if debt issue is putable, 0 if debt issue is not putable, derived from [iq_next_put_date].
(Relative) yield spread	(Offering yield - Yield of U.S. treasury bond index with respective maturity)/ Yield of U.S. treasury bond index with respective maturity
Seniority level of issue	Equals 1 if debt issue is junior/ subordinate, equals 0 if debt issue is senior.
Sinking dummy	Equals 1 if debt issue has sinking funds, 0 if debt issue is not sinking, derived from [iq_next_sink_fund_date].
Rating existence dummy	Equals 1 if company has an S&P rating, otherwise equals 0.
Variation of U.S. treasury bond yield	Standard deviation of the U.S. treasury bond yield in the last 10 days before debt issuance
Absolute yield spread	(Offering yield - Yield of U.S. treasury bond index with respective maturity)
Other financial control variables	
Dividend payout dummy	Equals 1 if the firm pays a dividend and zero otherwise
Δ Profitability	Difference of EBIT/ total assets in year i+1 minus EBIT/ total assets in year i

Definition of Variables - continued

Variable	Description
Firm age (date at issuance)	Year of debt issuance minus year of foundation of company
Income tax paid/ Total assets	Income Tax [wc01451]/ Total Assets
Market-to-book	Market Capitalization [wc08001] / Common Equity [wc03501]
Profitability	Earnings before interest and taxes (EBIT) [wc18191] / Total Assets
R&D expenses	Research & development expense [wc01201]/Total Assets
Size	Natural logarithm of the firm's total assets [wc029999] measured in U.S. Dollar
Tangible Assets Ratio	Net property, plant and equipment[wc02501]/ Total Assets
Tax rate	Total taxes [wc01451]/ Pre-tax Income [wc01401]

5.2.3. Empirical Results

In this section, I will analyze the determinants of the overall debt maturity structure and of the yield spread of new debt issues. First, I start with an overview on the capital and debt maturity structure of international, listed electric utility companies by using descriptive statistics. Thereafter, I address the **maturity matching hypothesis (balance sheet)**, the **maturity matching hypothesis (debt issuance)**, the **mismatch premium hypothesis**, and the **asset salability/debt maturity hypothesis**.

5.2.3.1. Descriptive Statistics and Overview of Debt Structure in the Utility Industry[85]

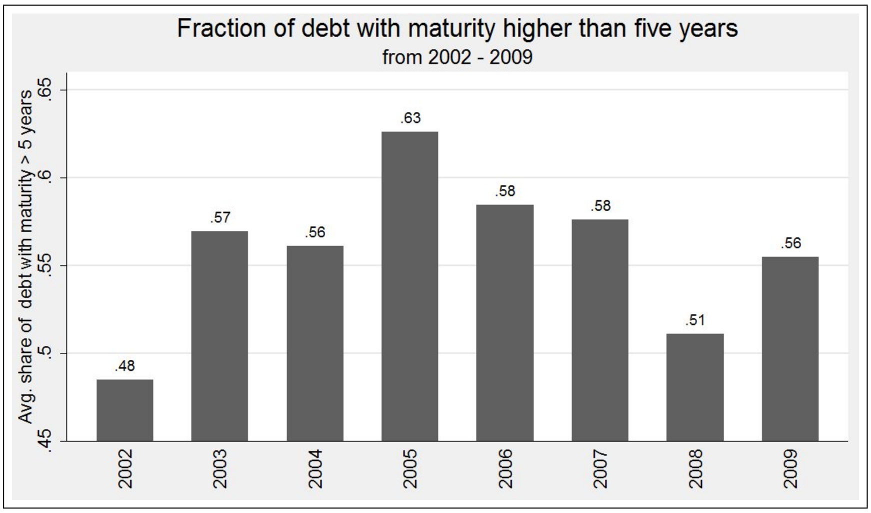
My sample includes debt maturity structure information for 174 companies from the debt issue perspective, i.e. aggregated data on outstanding debt issues, and for 120 companies from the balance sheet perspective, i.e. balance sheet data on debt maturity.[86] Due to the availability of the WEPP database, I focus on the years from 2002 until 2009.

As depicted in Figure 5.4, approx. 50% to 60% of the debt of my sample companies has a maturity longer than *five years*, and about 70% to 75% of their debt has a maturity of longer than *three years*.[87]
In contrast to the cross industry sample of Barclay, Marx and Smith (2003), with a share of 36.6% being longer than five years and 51.7% longer than three years, my sample of utility companies has a higher debt maturity. Adding up outstanding debt issues per company, I find an average maturity of between 11 and 14 years. According to Myers (1977), companies with comparably low growth opportunities – as reflected by a lower market-to-book ratio of utility companies – consistently issue more long-term debt.

The maturity of outstanding debt issues is highest for North America (firm-year average of 14 years), followed by the European Union (9 years) and Asia (7 years).[88]

85 Cf. Rauh and Sufi (2010) for a descriptive debt structure overview on a cross industry sample.
86 Cf. Section 5.2.2.1 for further details regarding the sample construction process.
87 The latter is not explicitly reported here.
88 In a two-sided t-test, for the average market leverage and the maturity of outstanding debt issues, respectively, I found the difference between North America in comparison to the rest of the world is significant at the 1%-level.

Figure 5.4.: Fraction of debt with maturity higher than five years (ordinate) over time (abscissa)



The difference in the maturity of outstanding debt issues between companies with diversified (12.5 years) vs. non-diversified (13.2 years) production technologies is insignificantly small.[89]

The time-to-maturity of debt issues in my sample shows to be significantly higher for callable debt (20 years), while non-callable debt on average has a shorter maturity (12 years).[90]

Analyzing debt issue data after aggregation, i.e. a quasi-balance sheet view, I find that the time-to-maturity of debt issues dropped from 2007 (average time-to-maturity of single debt issues equals 18 years) to 2008 (13 years) and remained mainly unchanged in 2009.

As Figure 5.5 shows for the year 2009, all else equal, the offering yield of new debt issues decreases with an improving debt issue rating.[91]

As Figure 5.6 shows, I find that the maturities of debt issues of utility companies can be rather long-term, i.e. usually up to 35 years, in extreme cases even longer. For my sample, I find that debt issues with longer time-to-maturity tend to have a higher offering yield.[92]

Figure 5.7 compares the different asset maturity measures, as defined in Section 2.2.2, Section 5.2.2 and Section 5.2.3.5, to the maturity of corporate debt (derived from the quasi-balance sheet view, i.e. from the aggregation of outstanding debt issues).[93] The asset maturity measures included in this figure are: the asset maturity measures of Barclay et al. (that equals the measure of Stohs and Mauer (1996)), the measures of Guedes and Opler (1996) using annual and cumulated depreciations, my value-weighted and capacity-weighted asset maturity measures, as well as the value-weighted and capacity-weighted asset maturity measures including current assets,

89 To determine whether a company has a diversified or non-diversified production portfolio, I structured generation technologies into base-load, mid-load, peak-load and stochastic generation. I considered a company to be diversified if its production portfolio includes technologies from at least two of the aforementioned categories. The difference in the maturity of outstanding debt issues is not significant as I found in a t-test.

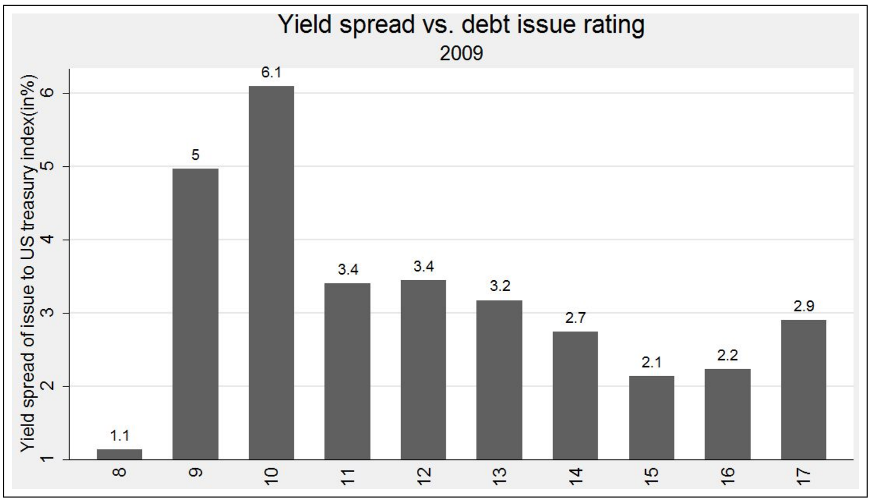
90 In a t-test, I found this difference to be significant at the 1%-level.

91 The offering yield for a debt issue rating of B+ derives from a single debt issue.

92 Results are not explicitly reported here.

93 It is obvious that such statistic can only be derived from outstanding debt issues, because the balance sheet data only provides the share of debt with maturity higher than five years, while it does not further differentiate longer maturities.

Figure 5.5.: Yield spread to U.S. treasury index with similar maturity (ordinate) over debt issue rating (abscissa) for year 2009 - Issue ratings parametrized by numbers (8 = "B+" rating to 17 = "A+" rating) – Debt issue perspective



which will be introduced in Section 5.2.3.5.

I find that the average maturity of public debt on average is similarly distributed compared to my measures of value-weighted and capacity-weighted asset maturity both, as defined above *as well as* including current assets. For these bottom-up asset maturity measures I find a maximum of the distribution at an asset maturity of between 15-20 years and 10-15 years, respectively. The measure as proposed by Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) is distributed similarly to my direct asset maturity measures. In contrast, the measure of Guedes and Opler (1996) differs significantly from the other measures – no matter whether calculated by using annual or cumulated depreciations – and reaches its maximum either at 20-30 years or at 1-3 years, respectively.

The hypothesis that asset and debt maturity match is supported by Figure 5.8. I find indication that the maturity of debt and assets are related positively.[94]

Descriptive summary statistics for my sample are given in Table 5.23 from the balance sheet perspective, and later in Table 5.24 from the quasi-balance sheet perspective, i.e. aggregated data of outstanding debt issues.

[94] The graph is based on 377 firm-years. Thereof, 21 observations have a maturity of more than 35 years.

Figure 5.6.: Frequency distribution (ordinate) of debt maturity at issuance (abscissa) – Debt issue perspective

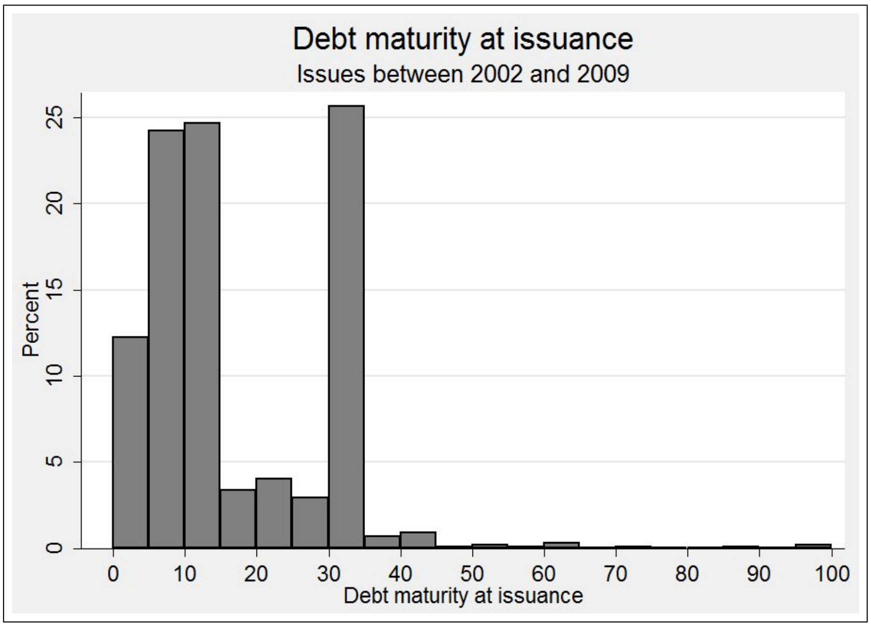


Table 5.23.: Descriptive sample statistics – Debt maturity – Balance sheet perspective

Variables	Number of observations	Mean	Standard deviation	25%-percentile	50%-percentile	75%-percentile
Debt maturity	353	12.49	6.87	8.14	12.05	14.58
% of debt with mat. > 3y	**353**	**0.71**	**0.17**	**0.63**	**0.74**	**0.83**
% of debt with mat. > 5y	**353**	**0.56**	**0.20**	**0.46**	**0.58**	**0.70**
Asset maturity "Guedes/Opler"	**339**	**28.98**	**14.67**	**20.73**	**27.39**	**35.27**
Asset maturity "Barclay et al."	**353**	**15.09**	**5.31**	**11.41**	**14.34**	**18.37**
Asset maturity "value weighted"	**353**	**16.45**	**6.65**	**13.00**	**16.00**	**19.00**
Asset maturity "capacity weighted"	**353**	**17.58**	**6.79**	**14.00**	**17.00**	**22.00**
Long-term debt rating	353	4.56	6.54	0.00	0.00	13.00
Size	353	15.79	1.34	14.98	15.87	16.86
Market leverage	353	0.44	0.14	0.36	0.44	0.53
Tangibility of assets	353	0.63	0.14	0.55	0.64	0.73
Profitability	353	0.06	0.04	0.05	0.06	0.08
Market-to-book	353	1.81	1.17	1.30	1.65	1.98
Commercial paper dummy	353	0.36	0.48	0.00	0.00	1.00
Δ Profitability	353	0.00	0.04	-0.01	0.00	0.01
Tax rate	353	0.32	0.13	0.25	0.34	0.38

Descriptive statistics based on data points as included in Table 5.29, model IV. "Debt maturity" refers to the aggregation of outstanding debt issues.

Figure 5.7.: Frequency distribution (ordinate) of debt maturity and asset maturity measures (abscissa) – Quasi-balance sheet perspective

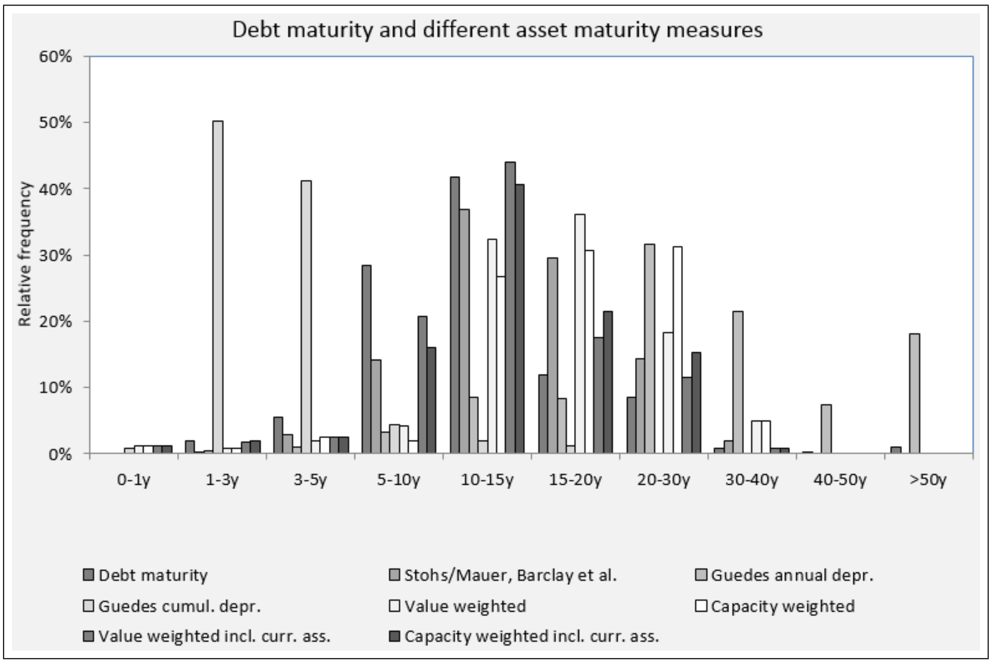


Figure 5.8.: Avg. value-weighted debt maturity (ordinate) over asset maturity (abscissa) – Quasi-balance sheet perspective

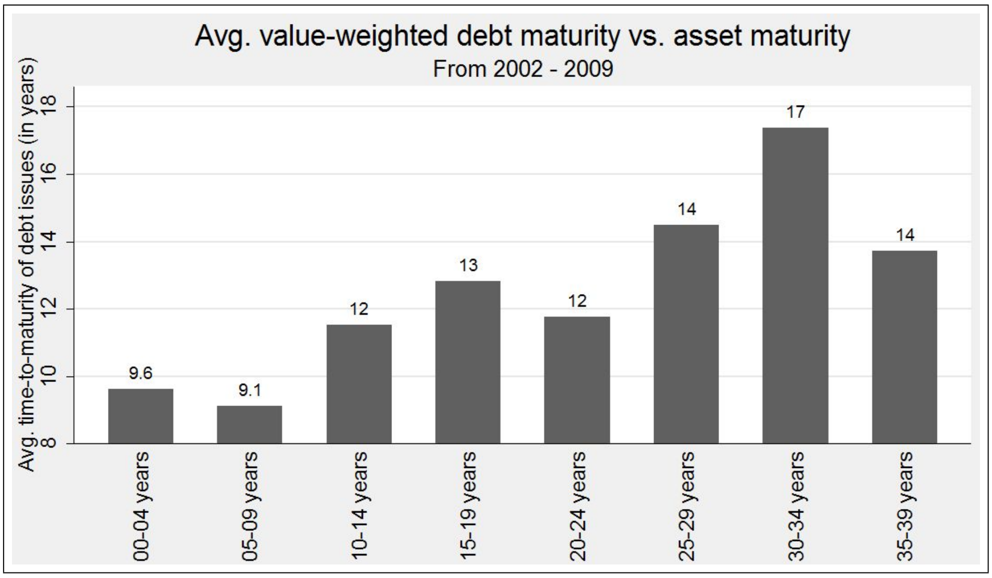


Table 5.24.: Descriptive sample statistics – Debt maturity – Debt issue perspective (single debt issues)

Variables	Number of observations	Mean	Standard deviation	25%-percentile	50%-percentile	75%-percentile
Time-to-maturity	416	16.01	9.55	10.00	10.00	30.00
Relative yield spread	416	0.58	0.53	0.26	0.38	0.65
|Guedes/Opler - debt outst. mat. |	**416**	**15.84**	**9.42**	**9.17**	**15.78**	**21.08**
|Barclay - debt outst. mat.|	**416**	**4.51**	**3.41**	**1.87**	**3.96**	**6.35**
|Value weighted - debt outst. mat.|	**346**	**4.01**	**3.32**	**1.39**	**3.23**	**5.74**
|Capacity weighted- debt outst. mat.|	**346**	**4.73**	**3.90**	**2.07**	**3.51**	**6.79**
|Guedes/Opler - debt outst. mat. | >0	**416**	**15.77**	**9.51**	**9.17**	**15.78**	**21.08**
|Barclay - debt outst. mat.| >0	**416**	**3.57**	**3.70**	**0.00**	**2.46**	**5.90**
|Value weighted - debt outst. mat.| >0	**346**	**2.68**	**3.68**	**0.00**	**0.71**	**3.79**
|Volume weighted - debt outst. mat.| >0	**346**	**3.56**	**4.33**	**0.00**	**2.09**	**5.92**
|Guedes/Opler - debt outst. mat. | <0	**416**	**0.06**	**0.52**	**0.00**	**0.00**	**0.00**
|Barclay - debt outst. mat.| <0	**416**	**0.95**	**2.17**	**0.00**	**0.00**	**0.80**
|Value weighted - debt outst. mat.| <0	**416**	**1.11**	**2.03**	**0.00**	**0.00**	**1.75**
|Capacity weighted - debt outst. mat.| <0	**416**	**0.97**	**2.05**	**0.00**	**0.00**	**0.79**
Firm age (date of issuance)	416	43.29	33.85	14.00	26.00	71.50
Size	416	16.60	1.08	15.78	17.02	17.47
Market leverage	416	0.46	0.11	0.39	0.45	0.52
Bond issue rating	416	14.11	1.80	13.00	14.50	15.00
Offering amount	416	321.78	288.47	140.00	250.00	400.00
Payment frequency	416	2.06	0.71	2.00	2.00	2.00
Sinking dummy	416	0.00	0.05	0.00	0.00	0.00
Put dummy	416	0.00	0.05	0.00	0.00	0.00
Call dummy	416	0.90	0.30	1.00	1.00	1.00
Std of US treasury bond yield	416	0.08	0.04	0.05	0.07	0.09

Descriptive statistics based on data points as included in Table 5.40, model I.

5.2.3.2. Asset Maturity as a Determinant of Debt Maturity

In this section, I address the **maturity matching hypothesis (balance sheet)** and the **maturity matching hypothesis (debt issuance)**.

5.2.3.2.1. Balance sheet perspective

According to my **maturity matching hypothesis**, I expect a positive relationship between asset maturity and debt maturity. As mentioned before, there are two data sources for parameterizing the debt maturity structure on the balance sheet. *First*, there is the balance sheet perspective, i.e. the fraction of debt with maturity higher than three (five) years, i.e. a parametrization derived from balance sheet data, and *second*, debt maturity is parametrized as the weighted average maturity of debt outstanding, i.e. an aggregation to a quasi-balance sheet perspective.[95]

I assume that the former measure of debt maturity might be weaker, because measuring the share of debt with maturity larger than five years does not differentiate the maturity of contracts with long times to maturity. Such measure might be criticized as already the 25% percentile of debt maturity derived from those outstanding debt issues is higher than 8 years for my sample. Consequently, I use both kinds of debt maturity measures in order to demonstrate robustness.

In the following, I discuss the results of re-calculations of Stohs and Mauer (1996), Barclay, Marx and Smith (2003) and Benmelech (2009) in the balance sheet perspective. As these models differ significantly in their set of independent variables, I require all models to consistently show the same results for the relationship of asset and debt maturity. For each of these models, I test the following parametrizations of asset maturity: the depreciation-based measures of Guedes and Opler (1996) and Barclay, Marx and Smith (2003), and my measures of value-weighted and capacity weighted direct asset maturity measures as defined in Section 5.2.2.2. I recall that these measures are not a priori expected to deliver equivalent results, as argued thoroughly in Section 3.2. All calculations presented in this section include country dummies, year dummies if applicable and robust standard errors.

Stohs and Mauer (1996): Applying the model of Stohs and Mauer (1996) shows that the asset maturity measures of Guedes and Opler (1996) and Barclay, Marx and Smith (2003)[96] are significantly and positively related to the average maturity of outstanding debt issues, and similarly, to the share of debt with maturity higher than three (five) years. Applying my measures of value-weighted or capacity-weighted "real" asset maturity also leads to a significant relation with debt maturity. The most significant independent variable is asset maturity. Another significant determinant is the change in profitability. Among others, the S&P long-term debt rating remains insignificant.[97] Results are reported in Table 5.25, using the share of debt with maturity

[95] As mentioned before, I include all debt issues available, the oldest being offered in 1905, in order to also include long living debt contracts.

[96] Their measure equals the measure of Stohs and Mauer (1996).

[97] Instead of the standard deviation of earnings, I use the change of earnings in comparison to the previous year. Due to strong collinearity, I omit the variables debt issue rating squared and the debt issue rating dummy. In accordance with the paper of Stohs and Mauer (1996), I set company ratings to zero, if S&P long-term debt ratings were not available. In contrast, for my later analyses in the debt issue perspective, I require the

higher than three and five years (balance sheet perspective), and Table 5.26, using the average maturity aggregated from outstanding public debt issues (quasi-balance sheet perspective).

Barclay, Marx and Smith (2003): Using the model of Barclay, Marx and Smith (2003) I equally find a positive relation between asset maturity and debt maturity for both parametrizations of debt maturity, i.e. balance sheet perspective and quasi-balance sheet perspective, as reported in Table 5.27 and Table 5.28.

The set of independent variables differs from the model of Stohs and Mauer (1996). Similar to Barclay, Marx and Smith (2003), I use 2SLS regressions and parametrize market leverage as endogenous variable by the instrument variables size, tangibility of assets, profitability, market-to-book and dividend payout. My set of determinants of market leverage is similar to Frank and Goyal (2009) and in accordance with my models in Section 5.1.[98]

Benmelech (2009): Finally, I also re-calculate the model of Benmelech (2009). Again, I confirm the positive impact of asset maturity on debt maturity for both parametrizations of debt maturity. Results are reported in Table A. 11 and Table A. 12 in the appendix. I note that asset maturity was originally not included as a determinant of debt maturity in the models of Benmelech (2009).

existence of a debt issue rating.

98 Adding production flexibility as another independent variable does not change implications from these calculations.

Table 5.26.: Debt maturity – Quasi-balance sheet perspective – according to Stohs and Mauer (1996)

Variables	Ia	Ib	Ic	Id
Asset maturity "Guedes_Opler"	**0.14****			
	(2.52)			
Asset maturity "Barclay et al."		**0.23****		
		(2.39)		
Asset maturity "value_weighted"			**0.51****	
			(2.56)	
Asset maturity "capacity_weighted"				**0.42****
				(2.34)
Market-to-book	-0.54	-0.46	-0.58	-0.48
	(-1.18)	(-1.30)	(-1.64)	(-1.35)
Size	-0.29	-0.26	0.038	-0.11
	(-0.33)	(-0.31)	(0.052)	(-0.14)
Δ Profitability	-5.42	-6.74	-5.41	-5.88
	(-0.64)	(-0.82)	(-0.70)	(-0.73)
Bond rating	0.063	0.074	0.054	0.058
	(0.65)	(0.78)	(0.53)	(0.56)
Tax rate	17.1	14.7	15.6	16.5
	(1.28)	(1.04)	(1.15)	(1.17)
Market leverage	-7.93*	-9.79**	-10.5*	-11.3*
	(-1.70)	(-2.05)	(-1.74)	(-1.85)
Oberservations	451	465	367	367
Adjusted R^2	0.16	0.13	0.20	0.17

The dependent variable is the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF ALL DEBT OUTSTANDING. All models are pooled OLS regressions. Year and country dummies are included in all models. T-statistics based on Huber/White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Interpretation of Empirical Results

In a nutshell, I find that asset maturity is a highly relevant determinant of debt maturity in both parametrizations, i.e., *first*, the fraction of debt with maturity larger than three (five) years, and *second*, the weighted average maturity of outstanding debt issues for all tested models. This finding is largely independent of the differing sets of control variables.

In models using the fraction of debt with maturity larger than three (five) years as a dependent variable, I find highest R^2 for those models measuring asset maturity according to Stohs and Mauer (1996) and Barclay, Marx and Smith (2003). In contrast, for models using the more exact weighted average maturity of outstanding debt issues as a parametrization of debt maturity, I find highest R^2 for models including my "real" asset maturity measures.

As explained before, I expect the latter measure using the weighted average maturity of outstanding debt issues to be more meaningful especially for such companies with a comparably large share of debt longer than three (five) years.

Consequently, I hereby confirm my **maturity matching hypothesis (balance sheet)**. However, the depreciation-based measures – whatever they effectively measure exactly (as discussed

Table 5.25.: Debt maturity – Balance sheet perspective – according to Stohs and Mauer (1996)

Variables	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Ass. mat. "Guedes_Opler"	**0.0028***** **(3.23)**				**0.0048***** **(3.72)**			
Ass. mat. "Barclay et al."		**0.0059***** **(4.15)**				**0.0100***** **(4.45)**		
Ass. mat. "val. weigh."			**0.0030**** **(2.08)**				**0.0043**** **(2.04)**	
Ass. mat. "capa. weigh."				**0.0032**** **(2.07)**				**0.0042**** **(2.15)**
Market-to-book	-0.0015	-0.00083	0.0043	0.0046	-0.019	-0.019	-0.011	-0.011
	(-0.22)	(-0.12)	(0.75)	(0.78)	(-1.28)	(-1.41)	(-0.97)	(-0.92)
Size	-0.0062	-0.0085	-0.0075	-0.0077	-0.0064	-0.010	-0.0072	-0.0079
	(-0.78)	(-1.16)	(-0.95)	(-0.95)	(-0.52)	(-0.92)	(-0.57)	(-0.60)
Δ Profitability	0.32*	0.36**	0.36**	0.36**	0.021	0.092	0.050	0.045
	(1.82)	(2.02)	(2.16)	(2.15)	(0.12)	(0.51)	(0.30)	(0.27)
Bond rating	0.00067	0.0011	0.0013	0.0014	0.0023	0.0029*	0.0028	0.0029
	(0.52)	(0.84)	(0.89)	(0.91)	(1.42)	(1.75)	(1.43)	(1.43)
Tax rate	0.052	0.046	0.054	0.056	0.094	0.080	0.11	0.11
	(1.11)	(0.95)	(0.99)	(1.02)	(1.60)	(1.29)	(1.53)	(1.60)
Market leverage	0.028	-0.0031	0.048	0.040	0.016	-0.040	0.0036	-0.0058
	(0.35)	(-0.039)	(0.52)	(0.44)	(0.13)	(-0.32)	(0.024)	(-0.038)
Oberservations	451	465	367	367	451	465	367	367
Adjusted R^2	0.31	0.31	0.23	0.23	0.40	0.40	0.32	0.32

Dependent variable are the FRACTION OF DEBT WITH MATURITY LARGER THAN THREE YEARS (models Ia-Id) and of that with maturity LARGER THAN FIVE YEARS (models IIa-IId). All models are pooled OLS regressions. Year and country dummies are included in all models. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.27.: Debt maturity – Balance sheet perspective - 2 SLS - according to Barclay et al. (2003)

Variables	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Ass. mat. "Guedes/Opl."	**0.0035***** **(3.92)**				**0.0054***** **(4.62)**			
Ass. mat. "Barclay et al."		**0.0070***** **(4.46)**				**0.011***** **(5.07)**		
Ass. mat. "val. weight."			**0.0036**** **(2.23)**				**0.0048**** **(2.25)**	
Ass. mat. "capa. weight."				**0.0034*** **(1.95)**				**0.0047**** **(2.20)**
Market leverage	0.10	0.0094	0.078	0.024	-0.024	-0.16	-0.16	-0.23
	(0.41)	(0.038)	(0.29)	(0.087)	(-0.080)	(-0.53)	(-0.50)	(-0.72)
Market-to-book	0.0032	0.0035	0.011*	0.010*	-0.021	-0.021	-0.015	-0.015
	(0.45)	(0.51)	(1.80)	(1.67)	(-1.20)	(-1.59)	(-1.33)	(-1.41)
Size	0.0018	0.0014	0.0029	0.0039	0.0017	0.00047	0.0049	0.0063
	(0.16)	(0.12)	(0.22)	(0.29)	(0.11)	(0.029)	(0.27)	(0.34)
Commercial paper	-0.036	-0.033	-0.034	-0.037	-0.030	-0.026	-0.035	-0.039
	(-1.39)	(-1.30)	(-1.32)	(-1.41)	(-0.95)	(-0.85)	(-1.01)	(-1.10)
Constant	0.47**	0.53***	0.48**	0.51**	0.38	0.47**	0.43*	0.48*
	(2.38)	(2.98)	(2.39)	(2.46)	(1.51)	(2.12)	(1.71)	(1.78)
Oberservations	470	483	377	377	470	483	377	377
Adjusted R^2	0.28	0.29	0.22	0.22	0.40	0.39	0.31	0.31
Methodology	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS

Dependent variable are the FRACTION OF DEBT WITH MATURITY LARGER THAN THREE YEARS (models Ia-Id) and of that with maturity LARGER THAN FIVE YEARS (models IIa-IId). All models are 2SLS regressions. Year and country dummies are included in all models. The following instruments were used to parametrize the *market leverage* as endogeneous variable: market-to-book, size, tangibility of assets, profitability and dividend payout. Results of the *market leverage*-part of the 2SLS model are not reported here. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.28.: Debt maturity – Quasi-balance sheet perspective - 2 SLS - according to Barclay et al. (2003)

Variables	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Asset maturity "Guedes/Opler"	**0.15****				**0.14****			
	(2.60)				**(2.30)**			
Asset maturity "Barclay et al."		**0.26****				**0.28*****		
		(2.47)				**(2.76)**		
Asset maturity "value weighted"			**0.43*****				**0.47*****	
			(2.93)				**(3.32)**	
Asset maturity "capacity weighted"				**0.31****				**0.39*****
				(2.26)				**(2.92)**
Market leverage					-16.7**	-20.5**	-19.7**	-27.2***
					(-2.40)	(-2.38)	(-2.37)	(-3.00)
Market-to-book	-0.36	-0.26	-0.33	-0.21	-0.78	-0.83**	-0.84***	-0.91***
	(-0.63)	(-0.58)	(-0.83)	(-0.50)	(-1.58)	(-2.13)	(-2.85)	(-2.93)
Size	0.044	-0.034	0.30	0.12	0.62	0.70	1.01	1.12
	(0.061)	(-0.047)	(0.49)	(0.18)	(0.74)	(0.80)	(1.32)	(1.39)
Commercial paper	1.56*	1.96**	1.89**	2.10**	0.21	0.25	0.26	-0.15
	(1.71)	(2.20)	(1.99)	(2.11)	(0.19)	(0.20)	(0.21)	(-0.11)
Constant	7.95	7.55	-3.04	1.26	13.5	14.5	2.70	8.98
	(0.67)	(0.63)	(-0.34)	(0.13)	(1.20)	(1.35)	(0.31)	(0.93)
Oberservations	472	485	377	377	470	483	377	377
Adjusted R^2	0.18	0.16	0.24	0.18	0.15	0.12	0.20	0.090
Methodology	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS	2SLS

The dependent variable is the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF ALL DEBT OUTSTANDING. Year and country dummies are included in all models. Model Ia-Id denote OLS regressions, while models IIa-IId are 2SLS calculations. The following instruments were used to parametrize the *market leverage* as endogeneous variable: market-to-book, size, tangibility of assets, profitability and dividend payout. Results of the *market leverage*-part of the 2SLS model are not reported here. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

in Section 3.2) – also show significance. Again I point out that this is not trivial. Looking at these fuzzy measures only, significance for debt and asset maturity matching might also result by chance.

Further, I point out that my measures of the remaining lifetime of assets are a priori expected measures. I do not explicitly test whether companies adapt their debt maturity to unexpected changes in the expected remaining lifetime. Instead, I test, whether they match to the a priori expected remaining lifetime of their assets, for which I find high significance. Consequently, companies either do not adapt the debt maturity if there are shocks to the remaining lifetime, or – and maybe more probable – unexpected changes in remaining lifetimes of assets are small, and therefor the a priori expected remaining lifetimes are good proxies of the actual remaining lifetimes.[99]

Parsimonious Debt Maturity Model

In order to derive a model for debt maturity, I aggregate all independent variables from the established debt maturity models presented above in detail and search for an optimal model by using the Bayesian/Schwarz Information Criterion (BIC) and the Akaike Information Criterion (AIC). Therefor, I stepwise minimize BIC and AIC and drop the independent variable with the lowest t-value. For this approach, I focus on the debt maturity of outstanding debt issues.

Table 5.29 demonstrates this procedure, using the value-weighted "real" asset maturity as one of the independent variables. My debt maturity model derived by this procedure finally includes the following factors: value-weighted asset maturity, long-term debt rating, profitability, Δ profitability, commercial paper dummy, tax rate and market leverage. I find once again, that asset maturity – here measured as value-weighted asset maturity – is positively related to debt maturity with significance at the 1%-level.

In Table 5.30, I report x-standardized regression coefficients and marginal effects in order to analyze the importance of the determinants of debt maturity. In Section 5.1.3.6, the interpretation of x-standardized, marginal effects and the given ranking is explained.

I find that asset maturity is the most relevant determinant of debt maturity, i.e. the determinant with the highest economic impact. Thereby, I confirm the finding of the CFO-survey of Graham and Harvey (2001). The column "marginal effect" shows that a change of asset maturity by one standard deviation, i.e. by 6.65 years, changes debt maturity – all else equal – by 20.5% of the average debt maturity.

[99] Finally, another interpretation could also be that such effect averages out over an asset portfolio at least to some extent.

Table 5.29.: Debt maturity – Generation of model using BIC/AIC criteria

Variables	I	II	III	IV	V
Asset maturity "value weight."	**0.39***	**0.40***	**0.39***	**0.39***	**0.39***
	(3.23)	**(3.31)**	**(3.10)**	**(3.10)**	**(2.96)**
Long-term debt rating	**0.095**	**0.099**	**0.10**	**0.11**	**0.13**
	(1.15)	**(1.19)**	**(1.22)**	**(1.25)**	**(1.62)**
Profitability	**12.6**	**13.8**	**15.5**	**17.7**	**21.0**
	(0.87)	**(0.87)**	**(0.93)**	**(1.41)**	**(2.06)**
Commercial paper dummy	**1.30**	**1.29**	**1.49**	**1.52**	**1.67***
	(1.43)	**(1.43)**	**(1.50)**	**(1.54)**	**(1.75)**
Δ Profitability	**-11.9**	**-12.2**	**-13.0**	**-14.7**	**-15.9***
	(-1.40)	**(-1.38)**	**(-1.42)**	**(-2.33)**	**(-2.65)**
Tax rate	**7.66**	**7.62**	**7.46**	**7.56**	**6.88**
	(1.04)	**(1.03)**	**(1.00)**	**(0.99)**	**(0.91)**
Market leverage	**-6.02**	**-6.04**	**-5.05**	**-4.52**	
	(-0.94)	**(-0.95)**	**(-0.76)**	**(-0.78)**	
Market-to-book	-0.22	-0.21	-0.18		
	(-0.58)	(-0.51)	(-0.41)		
Size	0.26	0.23			
	(0.54)	(0.54)			
Tangibility	1.35				
	(0.28)				
Constant	0.78	2.10	4.99	4.25	5.04
	(0.072)	(0.27)	(0.76)	(0.73)	(1.17)
Number of observations	353	353	353	353	359
Adjusted R^2	0.29	0.29	0.29	0.29	0.29

Dependent variable is the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES. All models are OLS regressions. Year and country dummies are included in all models. Model IV represents the model with minimal BIC and AIC values. BIC and AIC values are not explicitly reported here. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.30.: Importance of asset maturity as a determinant of debt maturity

	Rank of economic impact	x-Standardized regression coefficient	Marginal Effect
Asset maturity "value weighted"	**1**	**2.5639**	**20.5%**
Long-term debt rating	5	0.6921	5.5%
Market leverage	6	-0.6536	-5.2%
Profitability	3	0.7438	6.0%
Commercial paper dummy	4	0.7269	5.8%
Δ Profitability	7	-0.6526	-5.2%
Tax rate	2	1.0183	8.2%

Marginal effects are calculated for the empirical model presented in Table 5.29, Model IV. The rank of the economic impact in the second column shows the relative importance of a variable as a determinant of the dependent variable DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES. These ranks are based on the absolute size of the x-standardized regression coefficients, as presented in the third column. The fourth column shows the percentage change of the dependent variable if the independent variable – all else equal – is changed by one standard deviation. A detailed description of all variables can be found in 5.22.

5.2.3.2.2. Debt issue perspective

In this section, I refer to the debt maturity of single debt issues. According to the **maturity matching hypothesis (debt issuance)**, I expect to find no evidence for a significant influence of a company's average asset maturity on the maturity of a single debt issue at issuance.

In fact, applying the model of Guedes and Opler (1996) for my sample of electric utility companies, I find no significant influence for any of the asset maturity measures incl. the measure of Guedes and Opler (1996) itself. Results are presented in Table 5.31. Consequently, my findings contradict the findings of Guedes and Opler (1996). I find no significant relation between asset maturity and the maturity of new debt issues.

The original result of Guedes and Opler (1996) showing significance is surprising for three reasons: *First*, although the authors themselves expect that the issue perspective is *not* well suited to proof a relationship of asset maturity and debt maturity, they find high significance for such relation. *Second*, they do not provide a (solid) theoretical reasoning for this relationship. *Third*, while Guedes and Opler (1996) find that asset maturity is a relevant determinant of the maturity of debt issues, Elyasiani, Guo and Tang (2002) do not at all include asset maturity as a determinant of the maturity of new debt issues.[100]

Using the model of Elyasiani, Guo and Tang (2002) and regressing the maturity of new debt issues, I find that issue-size ratio, market leverage, debt issue rating and call dummy are significant determinants of debt maturity at issuance. In contrast to the model of Elyasiani, Guo and Tang (2002), I dropped the debt issue rating squared as an independent variable from my re-calculation, since I otherwise find variance inflation factors above 200 for both debt issue rating variables.[101]

I find no significance for a relation of asset maturity to the maturity of debt at issuance, when asset maturity measures are added. Results are reported in Table 5.32.

In a nutshell, at least for my sample of utility companies, I conclude that there is no significance for an effect of asset maturity on the maturity of new debt issues. Thereby I confirm the **maturity matching hypothesis (debt issuance)**. For the avoidance of doubt, obviously I do not actively *proof* that this variable does *not* impact new debt issues. Such proof would require to reject an appropriate null hypothesis. Instead, what I actually do is to show, that there is no significance for such impact in my sample (which is consistent with what I claim). The critical reader might for example blame data quality or sample size for this insignificance. However, this seems unlikely, as I use the same data and measures as for other analysis in this section.

Practitioners (from the utility industry) confirmed my findings in interviews:[102] They ex-

[100] In comparison to Guedes and Opler (1996), I use the change in earnings instead of net operating loss carry-forwards and include term premium and rate volatility in year and country dummies.

[101] I can omit the "yield spread" (corresponding to a term spread, not to my "yield spread" in the sense it is used here) from the original model of Elyasiani, Guo and Tang (2002) as explicit variable, as my models instead include dummy variables.

[102] I conducted interviews with four industry experts, *first*, with employees from the finance and controlling department of two different European large integrated utility companies, *second*, with the head of controlling of an international independent power producer, and *third*, with the chief financial officer a specialized renewable energy generation company.

plained to match their overall debt maturity to their portfolio's average asset maturity. They further confirmed that they do not match the maturity of a single new debt issue to the maturity of their asset portfolio. They mentioned risk management considerations as the major driver for their behavior. Especially, they care about fixing margins of projects by fixing the respective financing costs, and about refinancing risk at maturity of debt contracts.

Table 5.31.: Debt maturity – Issue perspective – according to Guedes and Opler (1996)

Variables	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
Asset maturity "Guedes/Opler"	**0.0019**				**0.0017**			
	(0.91)				**(0.81)**			
Asset maturity "Barclay et al."		**0.0058**				**0.0044**		
		(1.42)				**(1.06)**		
Asset maturity "value weighted"			**0.0042**				**0.0018**	
			(0.67)				**(0.30)**	
Asset maturity "capacity weighted"				**0.0027**				**0.0017**
				(0.49)				**(0.32)**
Investment grade dummy	0.14	0.12	0.16	0.17				
	(1.56)	(1.37)	(1.53)	(1.56)				
Issue rating					0.041***	0.039***	0.041***	0.041***
					(3.19)	(3.06)	(3.04)	(3.01)
Market-to-book	-0.012	-0.0095	-0.00017	0.00022	-0.012	-0.0088	-0.0016	-0.0015
	(-0.48)	(-0.40)	(-0.0066)	(0.0087)	(-0.49)	(-0.37)	(-0.065)	(-0.059)
Size	0.021	0.018	0.028	0.026	0.026	0.022	0.029	0.029
	(0.88)	(0.79)	(0.98)	(0.92)	(1.11)	(0.98)	(1.12)	(1.12)
R&D/ total assets	68.5*	67.5*	97.5***	98.1***	74.7*	72.8*	108***	108***
	(1.66)	(1.74)	(2.66)	(2.64)	(1.74)	(1.81)	(2.91)	(2.86)
Δ Profitability	-0.61	-0.80	-0.34	-0.32	-0.64	-0.90*	-0.40	-0.39
	(-1.06)	(-1.63)	(-0.56)	(-0.53)	(-1.14)	(-1.89)	(-0.65)	(-0.62)
Income tax/ Total assets	0.26	0.82	0.58	0.55	0.27	0.90	0.93	0.90
	(0.11)	(0.36)	(0.21)	(0.20)	(0.12)	(0.41)	(0.34)	(0.33)
Constant	1.75***	1.77***	1.46**	1.51**	1.18**	1.23**	1.00*	1.00*
	(3.32)	(3.53)	(2.47)	(2.58)	(2.22)	(2.41)	(1.77)	(1.75)
Observations	1,294	1,333	1,141	1,141	1,294	1,333	1,141	1,141
Adjusted R^2	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20

The dependent variable is the NATURAL LOGARITHM OF THE TIME-TO-MATURITY (AT ISSUANCE). All models are pooled OLS regressions. Year and country dummies are included in all models. Models Ia - Id include - as in Guedes and Opler (1996) - an investment grade dummy, while models IIa - IId include the issue rating. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.32.: Debt maturity – Issue perspective – according to Elyasiani et al. (2002)

Variables	I	IIa	IIb	IIc	IId
Asset maturity "Guedes/Opler"		**0.0041**			
		(0.12)			
Asset maturity "Barclay et al."			**0.051**		
			(0.70)		
Asset maturity "value weighted"				**0.13**	
				(1.27)	
Asset maturity "capacity weighted"					**0.12**
					(1.21)
Issue size ratio	-51.5***	-48.1**	-50.7***	-72.8***	-73.4***
	(-2.76)	(-2.62)	(-2.73)	(-2.99)	(-3.03)
Market-to-book	-0.20	-0.22	-0.20	-0.060	-0.054
	(-0.51)	(-0.57)	(-0.48)	(-0.14)	(-0.13)
Size	-0.23	-0.10	-0.22	-0.33	-0.37
	(-0.41)	(-0.19)	(-0.39)	(-0.50)	(-0.58)
Issue rating	0.21	0.25	0.20	0.12	0.16
	(0.94)	(1.09)	(0.90)	(0.49)	(0.63)
Market leverage	-8.78***	-8.43**	-8.73***	-10.7***	-10.7***
	(-2.90)	(-2.61)	(-2.97)	(-3.21)	(-3.17)
Δ Profitability	-2.60	-0.75	-2.62	7.18	7.78
	(-0.34)	(-0.087)	(-0.35)	(0.82)	(0.90)
Call dummy	3.15**	3.21**	3.15**	3.78**	3.77**
	(2.33)	(2.31)	(2.32)	(2.52)	(2.52)
Constant	20.9*	18.0	20.4*	23.1*	23.4*
	(1.78)	(1.53)	(1.76)	(1.67)	(1.69)
Observations	1,271	1,232	1,271	1,083	1,083
Adjusted R^2	0.17	0.17	0.17	0.17	0.17

The dependent variable is the TIME-TO-MATURITY (AT ISSUANCE). Model IIa-IId denote OLS regressions, while models IIIa-IIId are 2SLS calculations. Year and country dummies are included in all models. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.3. Robustness Tests – Debt and Asset Maturity Matching

In this section, I test the robustness of my results from the balance sheet perspective.

In Table 5.33, I investigate whether my results are robust to applying alternative estimation methodologies. Therefore, I report results for, *first*, a Between Effects estimator that only uses variation across firms, not over time (model I). *Second*, I perform a Fixed Effects calculation, which controls for unobserved, time-invariant effects at the firm level (model II). *Third*, I apply a two-step estimation technique proposed by Fama and MacBeth (1973). In step one, a separate regression for every year is performed. In step two, the coefficient estimates are calculated as the average of the step one estimates. This procedure known as Fama-MacBeth estimation has the advantage of not being biased if a time effect is present (Petersen, 2009) (model III).[103] *Fourth*, I apply multiway clustering by companies, years and countries (Cameron, Gelbach and Miller, 2011; Thompson, 2011) (model IV). The Huber/White robust standard errors used for the main analysis is robust in the presence of a firm effect and the Fama-MacBeth estimator is robust in the presence of a time effect. The multiway clustering is robust for errors being correlated within companies, years and countries.

My prior results regarding the maturity matching hypothesis (balance sheet) are supported for all different estimation methodologies.

In Table 5.34, results for 2SLS regressions with market leverage being the endogenous variable – parametrized by size, market-to-book, profitability, tangibility, dividend payout dummy and debt maturity – are included in model I. Model II additionally includes production flexibility – measured by the run-up time – as another (significant) determinant of leverage. The dependent variable is debt maturity calculated as the *weighted average maturity of outstanding debt issues* in models Ia and IIa, and *market leverage* in models Ib and IIb. I find that asset maturity remains the most significant determinant of debt maturity.

As another test, I tested whether production flexibility, is a relevant determinant of debt maturity, as suggested by MacKay (2003). While MacKay (2003), Table 5 and 6, finds low significance for such effect, I do not find such effect at all. Results are not explicitly reported in this thesis. As explained in Section 2.2.1, MacKay's effect of production flexibility on debt maturity is indirect and acts through the channel of risk shifting, which is a counter-argument that also leads to a negative effect of production flexibility on leverage.[104] Empirically, my results contradict both of MacKay's findings, i.e. for leverage and debt maturity, that both are related to risk shifting in his argumentation.

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[103] With the exception of Fama-MacBeth, calculations are conducted using year and country dummies. Also in Fixed Effects calculations, country dummies obviously are not included either.

[104] The effect of production flexibility on leverage is discussed in Section 2.1.3.1

Table 5.33.: Robustness test – Estimation methodology – I/II

Variables Model	I Between effects	II Fixed Effects	III Fama-MacBeth	IV Multiway clustering
Asset maturity "value weighted"	**0.37*****	**0.20****	**0.20****	**0.39*****
	(3.34)	**(2.32)**	**(3.32)**	**(2.96)**
Market leverage	-4.36	0.42	1.66	-4.52
	(-0.74)	(0.10)	(0.67)	(-0.67)
Long-term debt rating	0.17	-0.0043	0.12*	0.11
	(1.61)	(-0.059)	(2.18)	(1.01)
Profitability	18.3	-13.6	-2.36	17.7
	(1.45)	(-0.87)	(-0.18)	(1.07)
Commercial paper	0.93	0.82	2.00**	1.52
	(0.63)	(0.76)	(3.38)	(1.57)
Δ Profitability	-41.0***	10.5	2.07	-14.7
	(-3.24)	(1.10)	(0.27)	(-1.17)
Tax rate	-2.89	5.56**	11.2	7.56
	(-0.32)	(2.45)	(1.79)	(0.87)
Constant	7.01	6.48**	3.72	4.25
	(0.80)	(2.23)	(1.45)	(0.66)
Observations	353	353	353	353
Adjusted R^2	0.36	-0.32	...	0.36
R^2	0.57	0.10	0.30	0.36

Dependent variable are the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES. Year and country dummies are included (except for Fama-MacBeth). T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.34.: Robustness test – Estimation methodology – II/II

Model	Ia	Ib	IIa	IIb
	2SLS		2SLS	
Asset maturity "value weighted"	**0.39*** **		**0.39*** **	
	(3.11)		**(3.02)**	
Market leverage	-3.32		2.49	
	(-0.51)		(0.36)	
Long-term debt rating	0.11		0.12	
	(1.28)		(1.43)	
Profitability	18.5	-0.94***	22.5*	-0.80***
	(1.55)	(-4.18)	(1.86)	(-3.64)
Commercial paper	1.56		1.80*	
	(1.48)		(1.66)	
Δ Profitability	-14.8**		-15.1**	
	(-2.38)		(-2.46)	
Tax rate	7.50		7.21	
	(0.97)		(0.92)	
Debt maturity		0.00098		-0.0021
		(0.32)		(-0.67)
Run-up time				-0.014**
				(-2.31)
Market-to-book		-0.032***		-0.024***
		(-4.85)		(-3.36)
Size		0.024**		0.034***
		(2.61)		(3.34)
Tangibility		-0.061		-0.024
		(-0.69)		(-0.27)
Dividend payout dummy		-0.12***		-0.10***
		(-3.70)		(-2.86)
Constant	3.14	0.75***	-2.30	0.61***
	(0.55)	(4.04)	(-0.38)	(3.10)
Observations	353	353	353	353
Adjusted R^2	0.29	0.53	0.28	0.57

Dependent variable are the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES in models Ia, IIa and MARKET LEVERAGE in model Ib and IIb. Year and country dummies are included. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.4. Asset Salability as a Determinant of Debt Maturity

In Section 3.1, I discussed the relation of asset salability and the maturity of debt. I hypothesized in my **asset salability/debt maturity hypothesis**, that asset salability has a positive impact on leverage. For my test, I use the asset salability measure as defined in Section 5.1.4.7 and the model derived in Table 5.29 by using the BIC and AIC criteria. As in the case of my leverage regressions incl. asset salability in Table 5.19, I have to leave out country dummies due to high variance inflation factors.[105] I find that the salability of production assets is positively related to the maturity of debt. Asset maturity remains a significant determinant of debt maturity,

[105] Again, leaving out country dummies might be problematic. Harris and Raviv (1992), p.136, state that bankruptcy law, which is country specific, is implicitly part of a debt contracts.

as argued in Section 5.2.3.2. Consequently, a higher salability of assets leads to longer debt maturities. This finding is consistent with the hypothesis of Benmelech (2009) and confirms my **asset salability/debt maturity hypothesis**. In contrast to my other results, I find significance at the 10%-level only.

Table 5.35.: Debt maturity and salability

	I	II
Salability	**0.033***	**0.035***
	(1.68)	**(1.72)**
Asset maturity "value weighted"	**0.37***	
	(1.87)	
Asset maturity "capacity weighted"		**0.33***
		(1.86)
Long-term debt rating	0.044	0.038
	(0.37)	(0.32)
Market leverage	-3.77	-4.84
	(-0.46)	(-0.57)
Profitability	-0.23	1.37
	(-0.014)	(0.087)
Commercial paper dummy	1.44	1.39
	(1.17)	(1.10)
Δ Profitability	-3.44	-4.08
	(-0.36)	(-0.44)
Tax rate	18.2	18.1
	(1.23)	(1.21)
Constant	-0.98	-0.17
	(-0.18)	(-0.034)
Observations	353	353
Adjusted R^2	0.11	0.10

The dependent variable is the debt maturity calculated as the WEIGHTED AVERAGE MATURITY OF ALL DEBT OUTSTANDING. All models are OLS regressions. Year dummies are included in all models. Country dummies are not included. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.5. Measure Robustness Tests – Net PP&E, Fixed Assets and Current Assets

Up to now, asset maturity was approximated by the remaining lifetime of a company's production assets. By using my value-weighted and capacity-weighted asset maturity measures, I showed that the maturity of fixed assets matches the maturity of debt. In comparison to the measures of Stohs and Mauer (1996) and Barclay, Marx and Smith (2003), I assumed for my alternative measures, that the maturity of my direct asset maturity measures outweighs the maturity of current assets.

In Table 5.3, I already showed that Net PP&E of utility companies (about 65% of total assets for U.S. companies and about 55.7% of total assets for non-U.S. companies in 2010), are significantly higher than total current assets (about 14.4% for U.S. companies and about 24.3%

for non-U.S. companies in 2010).[106] In the measures of Stohs and Mauer (1996) and Barclay, Marx and Smith (2003), the maturity of assets is approximated by the weighted maturity of total current assets and Net PP&E.[107]

Up to now – my value-weighted and capacity-weighted measures were independent of current assets, Net PP&E, costs of goods sold or any other items that might be influenced by reporting standards, as discussed in Section 3.2.1. However, in the following I show that results are robust if the maturity of current assets is also included. Therefore, I account for current assets in the same way as Stohs and Mauer (1996) and Barclay, Marx and Smith (2003):

$$\text{Asset maturity (incl. current assets)}_{\text{value-weighted}} =$$

$$= \frac{\text{Current assets}}{\text{Current assets + Net PP\&E}} \cdot \frac{\text{Current assets}}{\text{Costs of goods sold}} + \\ + \frac{\text{Net PP\&E}}{\text{Current assets + Net PP\&E}} \cdot \text{Asset maturity}_{\text{value-weighted}}$$

and

$$\text{Asset maturity (incl. current assets)}_{\text{capacity-weighted}} =$$

$$= \frac{\text{Current assets}}{\text{Current assets + Net PP\&E}} \cdot \frac{\text{Current assets}}{\text{Costs of goods sold}} + \\ + \frac{\text{Net PP\&E}}{\text{Current assets + Net PP\&E}} \cdot \text{Asset maturity}_{\text{capacity-weighted}}$$

The following table provides a descriptive comparison of the maturity mismatch measure before including current assets, i.e. based on the remaining lifetimes of the companies fixed assets, and after including current assets according to the abovegiven formulas:

Table 5.36.: Descriptive comparison – Debt maturity measures (excl. and incl. current assets)

Variables	Obs.	Mean	Standard deviation	25%-perc.	50%-perc.	75%-perc.
Asset maturity						
incl. curr. ass./ val. weigh.	353	13.32	5.95	9.72	12.52	16.30
incl. curr. ass./ capa. weigh.	353	14.16	6.03	10.40	13.23	17.73
excl. curr. ass./ val. weigh.	353	16.45	6.65	13.00	16.00	19.00
excl. curr. ass./ capa. weigh.	353	17.58	6.79	14.00	17.00	22.00

Descriptive statistics based on data points as included in Table 5.29, model IV.

In comparison to the mean maturity of debt of 12.49 years – according to Table 5.23 – the measure incl. current assets is even closer in terms of absolute values. As I already showed in Figure 5.7[108], the capacity-weighted and, especially, the value-weighted asset maturity measures

106 Obviously this is another reason for using a sample of utility companies.

107 A minor share of non-current assets is neglected (incl. long-term receivables, investment in associated companies, other investments and other assets).

108 The reader is advised to again examine this figure.

including current assets seem to best fit the value-weighted maturity of outstanding (public) debt.

In the following, I recalculate my major regressions using these newly defined measures *including current assets* in order to leave no doubt about validity and robustness of my results. These results – given in Tables 5.37, 5.38 and 5.39 – include simple OLS regressions as well as robustness tests of the Tables 5.33, 5.34, and 5.35. There are no relevant changes in results in comparison to the models reported above.
Besides these results, re-calculations of all earlier regressions according to the models of Stohs and Mauer (1996), Barclay, Marx and Smith (2003) and Benmelech (2009) also remain robust and without any significant changes.[109]

Table 5.37.: Measure robustness test – Estimation methodology – incl. current assets – I/II

Variables	I	II	III	IV	V	VI
Model	OLS	OLS	Between effects	Fixed Effects	Fama-MacBeth	Multiway clustering
Asset maturity (incl. current assets)	**0.46*****		**0.47*****	**0.33*****	**0.25*****	**0.46*****
"value weight."	**(3.14)**		**(3.54)**	**(3.33)**	**(3.69)**	**(3.09)**
Asset maturity (incl. current assets)		**0.41*****				
"capacity weight."		**(2.90)**				
Market leverage	-4.05	-5.05	-3.29	0.100	1.50	-4.05
	(-0.69)	(-0.85)	(-0.56)	(0.025)	(0.63)	(-0.63)
Long-term debt rating	0.098	0.093	0.16	-0.0082	0.11*	0.098
	(1.16)	(1.08)	(1.56)	(-0.11)	(2.13)	(0.98)
Profitability	19.2	20.3	21.2*	-12.3	-2.70	19.2
	(1.43)	(1.55)	(1.68)	(-0.79)	(-0.21)	(1.21)
Commercial paper	1.67*	1.64	1.04	0.72	2.09**	1.67*
	(1.72)	(1.64)	(0.71)	(0.68)	(3.49)	(1.80)
Δ Profitability	-17.6**	-17.2**	-47.3***	10.1	0.15	-17.6
	(-2.34)	(-2.40)	(-3.69)	(1.07)	(0.018)	(-1.39)
Tax rate	7.45	7.83	-3.51	5.27**	11.2	7.45
	(0.94)	(0.95)	(-0.40)	(2.34)	(1.83)	(0.82)
Constant	3.53	4.10	6.69	5.43*	3.70	3.53
	(0.58)	(0.69)	(0.77)	(1.91)	(1.45)	(0.55)
Observations	353	353	353	353	353	353
Adjusted R^2	0.30	0.27	0.37	-0.29	...	0.36
R^2	0.363	0.342	0.581	0.123	0.307	0.363

Dependent variable is the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES. Year and country dummies are included (except for Fama-MacBeth). T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

109 Results are not explicitly reported here.

Table 5.38.: Measure robustness test – Estimation methodology – incl. current assets – II/II

Model	Ia	Ib	IIa	IIb
	2SLS		2SLS	
Ass. mat. (incl. current assets) "value weight."	**0.47*** (3.10)**		**0.48*** (3.05)**	
Market leverage	0.54 (0.086)		5.27 (0.78)	
Long-term debt rating	0.11 (1.29)		0.12 (1.41)	
Profitability	22.4* (1.82)	-0.94*** (-4.18)	25.7** (2.11)	-0.80*** (-3.64)
Commercial paper	1.86* (1.78)		2.05* (1.90)	
Δ Profitability	-17.9** (-2.59)		-18.2*** (-2.76)	
Tax rate	7.21 (0.90)		6.96 (0.85)	
Debt maturity		0.00098 (0.32)		-0.0021 (-0.67)
Run-up time				-0.014** (-2.31)
Market-to-book		-0.032*** (-4.85)		-0.024*** (-3.36)
Size		0.024** (2.61)		0.034*** (3.34)
Tangibility		-0.061 (-0.69)		-0.024 (-0.27)
Dividend payout dummy		-0.12*** (-3.70)		-0.10*** (-2.86)
Constant	-0.80 (-0.12)	0.75*** (4.04)	-6.64 (-0.95)	0.67*** (3.48)
Observations	353	353	353	353
Adjusted R^2	0.29	0.53	0.27	0.57

Dependent variable are the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES in models Ia, IIa and MARKET LEVERAGE in model Ib and IIb. Year and country dummies are included. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.39.: Debt maturity and salability – incl. current assets

	I	II
Salability	0.030*	0.032*
	(1.66)	(1.77)
Asset maturity (incl. current assets) "value weight."	**0.42***	
	(1.95)	
Asset maturity (incl. current assets) "capacity weight."		**0.39****
		(2.01)
Market leverage	-3.86	-4.76
	(-0.47)	(-0.56)
Long-term debt rating	0.036	0.034
	(0.30)	(0.28)
Profitability	2.73	3.97
	(0.17)	(0.25)
Commercial paper	1.56	1.55
	(1.29)	(1.27)
Δ Profitability	-5.46	-5.81
	(-0.55)	(-0.60)
Tax rate	18.6	18.5
	(1.22)	(1.20)
Constant	-0.56	-0.16
	(-0.11)	(-0.032)
Number of observations	353	353
Adjusted R^2	0.11	0.11

The dependent variable is the debt maturity calculated as the WEIGHTED AVERAGE MATURITY OF ALL DEBT OUTSTANDING. All models are OLS regressions. Year dummies are included in all models. Country dummies are not included. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.6. *Mismatch of Debt and Asset Maturity as a Determinant of the Yield Spread on Debt at Issuance*

I hypothesized in Section 3.2.2, that a mismatch of debt maturity and "real" asset maturity leads to higher costs for new debt issues.[110] As, to my best knowledge, literature did not yet consider such mismatch as a relevant determinant of the yield spread of new debt issues, I extend a model controlling for the established issue specific factors, that is similar to the models of Lamy and Thompson (1988) and Allen, Lamy and Thompson (1990).

I define my dependent variable *relative debt issuance yield spread* as the spread between the yield to maturity of the debt issue minus the yield of a U.S. treasury bond with similar maturity, divided by the yield of a U.S. treasury bond with similar maturity.[111] Since I thereby implicitly control for time-to-maturity, I consequently leave out the time-to-maturity as an independent variable in accordance with Datta, Iskandar-Datta and Patel (1999). As independent control variables I include the following in accordance with Lamy and Thompson (1988) and Allen, Lamy and Thompson (1990): debt issue rating, offering amount, volatility of the U.S. treasury bond interest rate with similar maturity and the parameters payment frequency, call dummy, put dummy and sinking dummy as parameters of contractual design.

My sample includes public debt issues classified by security type either as "corporate debentures" or "medium term notes".[112] Furthermore, in accordance with the respective treasury bond yield, here I only include U.S. companies in my regressions.[113]

In order to analyze the impact of a mismatching of debt and asset maturity on debt issuance spreads, I add the mismatch as another independent variable. Therefore, I follow a two step approach:

First, I differentiate between those cases when debt maturity is longer than asset maturity and vice versa.

Second, I aggregate both directions of the mismatch to one single variable as a test of robustness, i.e. consider the absolute value of the mismatch as a relevant independent variable.

In this context, obviously, I have to refer to debt maturity parametrized by the *weighted average maturity of outstanding debt issues*. As measures of asset maturity, I apply the depreciation-based measures of Guedes and Opler (1996), Barclay, Marx and Smith (2003) and my volume- and value-weighted direct asset-based measures (excl. the current assets term).

In Table 5.40, I report those results from OLS regressions, that differentiate both directions of mismatch. My calculations show a strong positive influence of the mismatch variables based on my "real" asset maturity measures, some low significance for the mismatch calculated with the Barclay, Marx and Smith (2003) measure and no significance for the measure of Guedes and

110 In this section I will first move on using the value-weighted and capacity-weighted measures of (fixed) asset maturity, again, and show robustness including current assets in the end.

111 For each issue, I chose the U.S. treasury bond with the maturity closest to the issue's maturity. The following U.S. treasury bond maturities were differentiated: 2 years, 3 years, 5 years, 10 years and 30 years.

112 I concentrate on public debt as long term bank debt contracts with a maturity of more than one year are renegotiated in more than 90% of all cases according to Roberts and Sufi (2009).

113 I tested that my model is robust against including or excluding call dummy, put dummy and sinking dummy. I did not use the coupon as one of the independent variables explaining the relative debt issuance yield spread because of its high correlation to the dependent variable.

Opler (1996). Furthermore, I find strong significance for the control variables bond issue rating, interest rate volatility of the U.S. treasury bond yield and put and call dummies.

Note that all mismatch variables are positive (or equal zero) by construction. However, I indicate by "> 0" or "< 0" whether asset maturity is longer than debt maturity ("> 0") or vice versa ("< 0"). If not, the respective variable is set to zero.

However, according to my **mismatch premium hypothesis**, I expect the absolute value of the mismatch to be relevant, as explained in Section 3.2.2. In Table 5.41, I confirm that the absolute value of a mismatch between debt maturity and "real" asset maturity leads to increased costs of new debt issues. This result holds for my "real" asset level measures, however, it does not hold for the measures of Guedes and Opler (1996) and Barclay, Marx and Smith (2003), the latter being equal to the measure of Stohs and Mauer (1996) as pointed out before.[114]

I point out that the results regarding the measures of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) are neither surprising nor unexpected. As due to the discussed insecurity concerning the interpretation of these measures and due to their strong implicit assumptions of equal lifetimes of assets in Net PP&E, linear depreciation and congruency of depreciation period and asset lifetime, I do not hypothesize to find any specific effect on debt pricing when using these measures. This might explain why scholars did not yet empirically address the impact of a mismatch on the relative yield spread of debt in the literature.

[114] I also tested whether a mismatch of asset maturity and the debt maturity of single debt issues, i.e. in contrast to the average maturity of the outstanding debt, is a relevant determinant of the relative debt issuance yield spread. Consistently with the fact that I do not expect such influence, I also do not find significance. Results are not explicitly reported. I mention this test as it is the respective analogy to my discussion in Section 5.2.3.2. There I found an influence of asset maturity on the debt maturity structure while I found no influence on the maturity of single debt issues.

Table 5.40.: Influence of mismatch on relative debt issuance yield spread using splitted maturity mismatches – I/II

Variables	I	II	III	IV
|Guedes/Opler - debt outst. mat.|<0	***omitted***			
|Guedes/Opler - debt outst. mat.|>0	**-0.0014**			
	(-0.84)			
|Barclay - debt outst. mat.|<0		**0.021***		
		(1.71)		
|Barclay - debt outst. mat.|>0		**0.0072**		
		(0.94)		
|Val. weighted - debt outst. mat.|<0			**0.027***	
			(1.99)	
|Val. weighted - debt outst. mat.|>0			**0.013****	
			(2.38)	
|Capa. weighted - debt outst. mat.|<0				**0.024***
				(1.80)
|Capa. weighted - debt outst. mat.|>0				**0.012****
				(2.59)
Bond issue rating	-0.10***	-0.10***	-0.068***	-0.065***
	(-5.97)	(-5.73)	(-6.99)	(-6.06)
Offering amount	-0.025	-0.022	-0.026*	-0.029*
	(-1.15)	(-1.01)	(-1.76)	(-1.98)
Payment frequency	0.0089	0.0096	0.00066	0.00093
	(0.67)	(0.67)	(0.13)	(0.17)
Sinking dummy	0.036	-0.068	0.0081	0.0060
	(0.59)	(-0.79)	(0.24)	(0.18)
Put dummy	0.84***	0.89***	0.76***	0.84***
	(13.2)	(15.5)	(13.0)	(14.3)
Call dummy	0.071	0.051	0.099**	0.11***
	(1.57)	(1.12)	(2.52)	(2.73)
Std. of 10 years U.S. treasury bond yield	-0.38***	-0.35***	-0.47***	-0.46***
	(-8.85)	(-9.99)	(-9.60)	(-9.56)
Constant	4.35***	3.04***	3.48***	3.40***
	(11.3)	(10.2)	(12.9)	(12.3)
Observations	416	453	359	359
Adjusted R^2	0.67	0.65	0.71	0.71

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.41.: Influence of mismatch on relative debt issuance yield spread using aggregated maturity mismatch – II/II

Variables	I	IIa	IIb	IIc	IId
|Guedes/Op. - debt outst. mat.|		**-0.0013**			
		(-0.79)			
|Barclay - debt outst. mat.|			**0.0082**		
			(1.17)		
|Val. weight. - debt outst. mat.|				**0.013****	
				(2.50)	
|Capa. weight. - debt outst. mat.|					**0.012*****
					(2.85)
Bond issue rating	-0.097***	-0.10***	-0.10***	-0.065***	-0.062***
	(-6.32)	(-5.97)	(-5.64)	(-6.39)	(-5.94)
Offering amount	-0.00017	-0.024	-0.022	-0.027*	-0.028*
	(-0.010)	(-1.14)	(-1.00)	(-1.78)	(-1.95)
Payment frequency	0.010	0.0090	0.011	0.0018	0.0025
	(0.71)	(0.67)	(0.76)	(0.40)	(0.54)
Sinking dummy	-0.20**	0.034	-0.092	-0.0012	-0.0028
	(-2.40)	(0.55)	(-1.17)	(-0.038)	(-0.090)
Put dummy	0.81***	0.84***	0.89***	0.79***	0.83***
	(16.8)	(13.2)	(15.7)	(13.5)	(15.2)
Call dummy	0.0029	0.071	0.052	0.10**	0.10***
	(0.075)	(1.56)	(1.11)	(2.59)	(2.75)
Std. U.S. treasury bond yield (10y)	-0.37***	-0.38***	-0.35***	-0.47***	-0.46***
	(-12.1)	(-8.84)	(-9.90)	(-9.58)	(-9.68)
Constant	4.63***	4.34***	3.01***	3.43***	3.35***
	(13.8)	(11.3)	(10.1)	(12.2)	(12.1)
Observations	939	416	453	359	359
Adjusted R^2	0.69	0.67	0.65	0.71	0.71

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

By calculating the x-standardized regression coefficients and the marginal effect, I find that the standard deviation of the 10 years U.S. treasury bond yield and the bond issue rating are even more relevant determinants of the relative debt issuance yield spread than the maturity mismatch ranked third. Results are given in Table 5.42. The marginal effect column shows that a change in the mismatch of debt and asset maturity by one standard deviation (about 2.0 years) changes the average relative yield spread – all else equal – by about 7.7% of the average relative yield spread.[115]

[115] The average yield spread equals 0.554 for the relevant regression sample.

Table 5.42.: Importance of maturity mismatch as a determinant of the relative yield spread

	Rank of economic impact	x-Standardized regression coefficient	Marginal Effect
|Value weighted - debt outstanding maturity|	**3**	**0.0429**	**7.7%**
Bond issue rating	2	-0.1068	-19.3%
Offering amount	6	-0.0252	-4.5%
Payment frequency	7	0.0014	0.3%
Sinking dummy	8	-0.0001	0.0%
Put dummy	4	0.0416	7.5%
Call dummy	5	0.0297	5.4%
Std of 10 years U.S. treasury bond yield	1	-0.3643	-65.8%

Marginal effects are calculated for the empirical model presented in Table 5.41, Model IIc. The rank of the economic impact in the second column shows the relative importance of a variable as a determinant of the dependent variable DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF OUTSTANDING DEBT ISSUES. These ranks are based on the absolute size of the x-standardized regression coefficients, as presented in the third column. The fourth column shows the percentage change of the dependent variable if the independent variable – all else equal – is changed by one standard deviation. A detailed description of all variables can be found in 5.22.

5.2.3.7. Robustness Tests – Debt Yield Spread Premium from Maturity Mismatch

In the prior section, independent variables were limited to debt issue specific independent variables. In this section, I extent the set of independent variables by additional potentially relevant determinants.

5.2.3.7.1. Firm Characteristics as Additional Determinants

First, as a robustness test, I extend the set of control variables by the following firm characteristics, as included in Datta, Iskandar-Datta and Patel (1999): firm size, firm age and market leverage lagged by one year.

I calculate OLS and 2SLS regressions, the latter using market leverage as endogenous variable parametrized by size, profitability, tangibility, market-to-book, and a dividend payout dummy.

As reported in Table A. 13 and Table A. 14 in the appendix, I find that my results are confirmed for my "real" asset-based maturity measures, while the measure of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) remains insignificant in all regressions. As hypothesized, I thereby confirm that the mismatch of debt maturity and "real" asset maturity is positively related to the issue spread of new debt. Again, the fact that the fuzzy measures of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003) yield insignificant results does not contradict my hypotheses and expectations.

5.2.3.7.2. Time-to-maturity as Additional Determinant

Second, as another robustness test, I explicitly add the respective time-to-maturity of an issue as an additional determinant, though it is already controlled for the time-to-maturity by my yield spread measure via the respective U.S. treasury bond yield, as explained above.

In Section 3.2.2, I argued that a higher time-to-maturity leads to a higher yield spread due to an increased potential loss of control rents. The longer the maturity of a debt issue is chosen, the more debt has a shorter maturity, which might potentially force liquidation of projects. Therefore, besides my maturity matching variable, I also introduce the time-to-maturity of the issue as another independent variable in addition.

OLS regressions are reported in Table 5.43 and Table 5.44. I find strong significance for a positive impact of the time-to-maturity on the relative yield spread of the issue.[116] Besides this, my mismatch measures remain significant determinants of the relative yield spread as hypothesized.

As another robustness test, I tested whether a company's diversification in production technologies impacts pricing of new debt issues. I found no significance for such relation, although there is some evidence for such relation in the literature due to coinsurance from diversified business activities, e.g. Hann, Ogneva and Ozbas (2013).

116 Also, this might be regarded as a robustness test for my decision to leave out the time-to-maturity and only include it in the relative yield spread. From an empirical perspective, I can not exclude that both effects overlap. However, theoretically, I expect to already control for the term structure by using the U.S. treasury bond with a similar maturity in my relative yield spread measure.

Table 5.43.: Robustness test – Influence of time-to-maturity and mismatch on relative debt issuance yield spread – I/II

Variables	I	II	III	IV
Time-to-Maturity	0.012***	0.011***	0.012***	0.012***
	(5.58)	(5.66)	(6.92)	(6.75)
|**Guedes annual - debt outstanding matu.**| <**0**	*omitted*			
|**Guedes annual - debt outstanding matu.**| >**0**	-0.0022			
	(-1.15)			
|**Barclay - debt outstanding matu.**| <**0**		0.026**		
		(2.34)		
|**Barclay - debt outstanding matu.**| >**0**		0.0038		
		(0.51)		
|**Value weighted - debt outstanding matu.**| <**0**			0.036***	
			(2.72)	
|**Value weighted - debt outstanding matu.**| >**0**			0.010*	
			(1.78)	
|**Capacity weighted- debt outstanding matu.**| <**0**				0.032**
				(2.46)
|**Capacity weighted - debt outstanding matu.**| >**0**				0.0092**
				(2.02)
Bond issue rating	-0.10***	-0.10***	-0.072***	-0.068***
	(-6.12)	(-5.89)	(-6.99)	(-5.96)
Offering amount	-0.030	-0.024	-0.026	-0.029*
	(-1.40)	(-1.11)	(-1.64)	(-1.74)
Payment frequency	-0.0039	-0.0087	-0.015***	-0.015***
	(-0.32)	(-0.69)	(-2.90)	(-2.77)
Sinking dummy	0.087	-0.0022	0.041	0.037
	(1.41)	(-0.027)	(1.11)	(1.06)
Put dummy	0.83***	0.87***	0.73***	0.83***
	(12.7)	(14.9)	(12.5)	(13.8)
Call dummy	0.059	0.031	0.073	0.082*
	(1.22)	(0.67)	(1.66)	(1.90)
Std. U.S. treasury bond yield (10y)	-0.49***	-0.45***	-0.59***	-0.58***
	(-9.23)	(-10.7)	(-10.2)	(-10.1)
Constant	4.95***	3.41***	4.07***	3.97***
	(11.0)	(11.1)	(12.7)	(12.3)
Observations	416	453	359	359
Adjusted R^2	0.69	0.68	0.74	0.74

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to U.S. companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.44.: Robustness test – Influence of time-to-maturity and mismatch on relative debt issuance yield spread – II/II

Variables	I	IIa	IIb	IIc	IId
Time-to-Maturity	0.011***	0.012***	0.010***	0.011***	0.011***
	(5.69)	(5.61)	(5.60)	(6.49)	(6.56)
|Guedes/Op. - debt outst. mat.|		**-0.0021**			
		(-1.09)			
|Barclay - debt outst. mat.|			**0.0063**		
			(0.89)		
|Val. weight. - debt outst. mat.|				**0.011****	
				(2.09)	
|Capa. weight. - debt outst. mat.|					**0.010****
					(2.33)
Bond issue rating	-0.12***	-0.10***	-0.099***	-0.065***	-0.063***
	(-7.79)	(-6.12)	(-5.65)	(-6.61)	(-5.90)
Offering amount	-0.014	-0.029	-0.024	-0.027	-0.029*
	(-0.59)	(-1.39)	(-1.10)	(-1.62)	(-1.73)
Payment frequency	-0.0087	-0.0039	-0.0055	-0.012**	-0.011**
	(-0.62)	(-0.32)	(-0.47)	(-2.49)	(-2.41)
Sinking dummy	0.0035	0.083	-0.052	0.021	0.019
	(0.083)	(1.35)	(-0.67)	(0.62)	(0.59)
Put dummy	0.86***	0.83***	0.88***	0.78***	0.81***
	(15.3)	(12.7)	(15.0)	(13.3)	(14.2)
Call dummy	-0.033	0.059	0.035	0.083*	0.085**
	(-0.59)	(1.21)	(0.72)	(1.91)	(2.02)
Std. U.S. treasury bond yield (10y)	-0.46***	-0.49***	-0.44***	-0.58***	-0.58***
	(-10.2)	(-9.23)	(-10.5)	(-10.1)	(-10.3)
Constant	5.06***	4.95***	3.32***	3.92***	3.85***
	(15.1)	(11.0)	(10.8)	(12.5)	(12.4)
Observations	499	416	453	359	359
Adjusted R^2	0.70	0.69	0.68	0.74	0.74

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to U.S. companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.7.3. Mismatch-Gap-Closing Dummy as Additional Determinant

Third, as another robustness test, I explicitly add a dummy variable, that controls for whether the gap between debt and asset maturity is further extended or closed by the respective issue.

Obviously, I expect the mismatch of debt and asset maturity to remain a relevant determinant of the relative yield spread. Further, one might expect that issues closing the gap (i.e. the case when the dummy variable equals 1[117]) mitigate the positive effect of the mismatch of debt and asset maturity on the relative yield spread. Consequently, if any, one might expect a decrease of the relative yield spread from this dummy variable.

Results in Table 5.45 show that my "real" asset maturity measures once more remain relevant determinants of the relative yield spread as hypothesized (models III and IV). At the same time, the additional dummy variable remains insignificant. Using the measures of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003), I find that the mismatch-gap-closing dummy becomes significant with an unexpected positive sign. However, due to using the measures of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003), these models are hard to interpret anyway.

Again, as for all yield spread models presented in this section, R^2 of the models relying on my "real" asset maturity measures are higher than for models using the depreciation-based-measures of Guedes and Opler (1996), Stohs and Mauer (1996) and Barclay, Marx and Smith (2003).

[117] Obviously, this dummy variable is specific for the respective mismatch measure.

Table 5.45.: Robustness test – Influence of mismatch-gap-closing dummy and mismatch on relative debt issuance yield spread

	I	II	III	IV
Guedes-mismatch-gap-closing-dummy	0.19***			
	(3.74)			
Barclay-mismatch-gap-closing-dummy		0.089*		
		(1.96)		
Value-weighted-mismatch-gap-closing dummy			0.039	
			(0.98)	
Capa.-weighted-mismatch-gap-closing dummy				0.031
				(0.73)
|Guedes/Op. - debt outst. mat.|	**-0.0026**			
	(-1.53)			
|Barclay - debt outst. mat.|		**0.0078**		
		(1.12)		
|Val. weight. - debt outst. mat.|			**0.012****	
			(2.39)	
|Capa. weight. - debt outst. mat.|				**0.012*****
				(2.86)
Bond issue rating	-0.096***	-0.098***	-0.065***	-0.062***
	(-6.62)	(-5.97)	(-6.30)	(-5.87)
Offering amount	-0.031	-0.018	-0.028*	-0.029**
	(-1.60)	(-0.82)	(-1.92)	(-2.09)
Payment frequency	-0.0028	0.017	0.0036	0.0038
	(-0.23)	(1.10)	(0.67)	(0.81)
Sinking dummy	0.019	-0.12	-0.016	-0.015
	(0.31)	(-1.42)	(-0.46)	(-0.42)
Put dummy	0.86***	0.83***	0.77***	0.85***
	(13.4)	(13.8)	(13.4)	(14.2)
Call dummy	0.079*	0.043	0.10**	0.11***
	(1.82)	(0.96)	(2.68)	(2.85)
Std. U.S. treasury bond yield (10y)	-0.44***	-0.36***	-0.47***	-0.47***
	(-9.02)	(-9.94)	(-9.53)	(-9.70)
Constant	4.46***	2.95***	3.43***	3.34***
	(12.0)	(10.7)	(12.3)	(12.1)
Observations	416	453	359	359
Adjusted R^2	0.69	0.66	0.71	0.71

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.8. Measure Robustness Tests – Net PP&E, Fixed Assets and Current Assets

In this section, in accordance with Section 5.2.3.5, I provide robustness tests for the asset maturity measures explicitly accounting for current assets.

All results for models using a single absolute mismatch variable are given in Table 5.46. The reported models equal those given in Table 5.41, models IIc and IId, Table 5.44, models IIc and IId, and Table 5.45, models III and IV (in this order). Results remain unchanged in comparison to those asset maturity measures not considering current assets as defined in Section 5.2.2.2.

I also recalculate those models using separate mismatch variables and find similar results, as reported in Table 5.47.

Models Ia and Ib in Table 5.46 and Table 5.47 show that a mismatch of debt and asset maturity increases the relative yield spreads of debt at issuance. Further, models IIa and IIb demonstrate that increasing time-to-maturity of a debt issue increases the relative yield spread, which is – at least partially – due to the higher potential loss of control rents due to a higher amount of shorter debt, as explained above. Finally, models IIIa and IIIb show that even if one controls for whether a debt issue closes or further opens the "maturity gap", the effect from the debt and asset maturity mismatch is significant. Remarkably, the adjusted R^2 is higher than 70% for all models.

Table 5.46.: Measure robustness tests – Determinants of relative debt issuance yield spread – incl. current assets – I/II

	Ia	Ib	IIa	IIb	IIIa	IIIb
Time-to-Maturity			0.012***	0.011***		
			(6.63)	(6.51)		
Value-weighted-mismatch-gap-closing dummy					0.036	
					(0.88)	
Capacity-weighted-mismatch-gap-closing dummy						0.020
						(0.46)
|Value weighted - debt outst. mat.|	**0.016****		**0.018****		**0.015****	
	(2.14)		**(2.30)**		**(2.03)**	
|Capacity weighted - debt outst. mat.|		**0.017*****		**0.016*****		**0.016*****
		(2.86)		**(2.74)**		**(2.74)**
Bond issue rating	-0.074***	-0.070***	-0.072***	-0.068***	-0.073***	-0.069***
	(-7.29)	(-6.71)	(-7.57)	(-7.03)	(-7.21)	(-6.63)
Offering amount	-0.030*	-0.029**	-0.029*	-0.028*	-0.031**	-0.030**
	(-1.97)	(-2.02)	(-1.73)	(-1.80)	(-2.12)	(-2.15)
Payment frequency	-0.00068	-0.00084	-0.015***	-0.015***	0.0010	0.000086
	(-0.13)	(-0.17)	(-2.81)	(-2.88)	(0.17)	(0.017)
Sinking dummy	0.010	-0.0035	0.035	0.019	-0.0040	-0.011
	(0.31)	(-0.11)	(0.98)	(0.57)	(-0.11)	(-0.30)
Put dummy	0.74***	0.79***	0.73***	0.78***	0.73***	0.80***
	(13.0)	(14.0)	(12.8)	(14.1)	(12.5)	(13.0)
Call dummy	0.087**	0.096**	0.070*	0.079*	0.088**	0.099***
	(2.33)	(2.68)	(1.71)	(1.97)	(2.42)	(2.70)
Std. U.S. treasury bond yield (10y)	-0.47***	-0.47***	-0.59***	-0.58***	-0.47***	-0.47***
	(-9.66)	(-9.61)	(-10.3)	(-10.2)	(-9.59)	(-9.64)
Constant	3.60***	3.50***	4.07***	3.97***	3.59***	3.50***
	(12.6)	(12.4)	(12.8)	(12.8)	(12.6)	(12.5)
Observations	359	359	359	359	359	359
Adjusted R^2	0.71	0.71	0.74	0.74	0.71	0.71

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.47.: Measure robustness tests – Determinants of relative debt issuance yield spread – incl. current assets – II/II

	Ia	Ib	IIa	IIb	IIIa	IIIb
Time-to-Maturity			0.012***	0.012***		
			(6.71)	(6.78)		
Value-weighted-mismatch-gap-closing dummy					0.034	
					(0.84)	
Capacity-weighted-mismatch-gap-closing dummy						0.020
						(0.47)
|Value weighted - debt outstanding matu.| <0	**0.017***		**0.024****		**0.016***	
	(1.81)		**(2.58)**		**(1.70)**	
|Value weighted - debt outstanding matu.| >0	**0.019***		**0.014**		**0.018**	
	(1.70)		**(1.24)**		**(1.60)**	
|Capacity weighted- debt outstanding matu.| <0		**0.017***		**0.023*****		**0.016***
		(1.95)		**(2.78)**		**(1.90)**
|Capacity weighted - debt outstanding matu.| >0		**0.018****		**0.014**		**0.018****
		(2.16)		**(1.53)**		**(2.06)**
Bond issue rating	-0.072***	-0.067***	-0.077***	-0.072***	-0.072***	-0.067***
	(-7.37)	(-6.26)	(-7.13)	(-6.13)	(-7.40)	(-6.28)
Offering amount	-0.030*	-0.030**	-0.031*	-0.031*	-0.031**	-0.032**
	(-1.99)	(-2.10)	(-1.93)	(-1.93)	(-2.14)	(-2.21)
Payment frequency	-0.00023	-0.00031	-0.017***	-0.016***	0.0014	0.00067
	(-0.040)	(-0.053)	(-2.76)	(-2.76)	(0.21)	(0.12)
Sinking dummy	0.0068	-0.0065	0.052	0.036	-0.0063	-0.015
	(0.18)	(-0.18)	(1.25)	(0.86)	(-0.16)	(-0.37)
Put dummy	0.74***	0.78***	0.70***	0.76***	0.72***	0.79***
	(12.5)	(14.5)	(11.8)	(13.9)	(11.8)	(13.7)
Call dummy	0.092**	0.10**	0.066	0.078*	0.093**	0.11**
	(2.29)	(2.59)	(1.49)	(1.78)	(2.37)	(2.66)
Std. U.S. treasury bond yield (10y)	-0.47***	-0.47***	-0.60***	-0.59***	-0.47***	-0.47***
	(-9.62)	(-9.59)	(-10.4)	(-10.3)	(-9.56)	(-9.61)
Constant	3.55***	3.47***	4.17***	4.07***	3.55***	3.47***
	(12.8)	(12.7)	(12.6)	(12.5)	(13.0)	(12.7)
Observations	359	359	359	359	359	359
Adjusted R^2	0.71	0.71	0.74	0.74	0.71	0.71

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.9. Robustness Test – Offer price

Though it is not included in the other analysis presented in the literature overview in Section 2.2, I additionally control for the relative offer price of a debt issue.[118] Besides the yield spread, such offer price also influences the overall return from such debt issue.

Descriptive statistics regarding the offering yield are given in Table 5.48. The offer price varies in a very narrow range between a minimum of 97.05% and a maximum of 100.53% of the offering amount.

Tables 5.49 and 5.50 show that results regarding the impact of the maturity mismatch on the relative yield spread remain unchanged. All asset maturity measures included in these tables consider the maturity of current assets as described in Section 5.2.3.5.

Table 5.48.: Descriptive statistics – Offer price

Variables	Obs.	Mean	Standard deviation	25%-perc.	50%-perc.	75%-perc.
Offer price	359	99.69	0.395	99.60	99.77	99.93

Descriptive statistics based on data points as included in Table 5.49.

118 Therefore, I use the S&P Capital IQ data item [iq_offer_price].

Table 5.49.: Robustness tests – Offer price as additional determinant of relative debt issuance yield spread – incl. current assets – I/II

	Ia	Ib	IIa	IIb	IIIa	IIIb
Time-to-Maturity			0.011***	0.011***		
			(6.80)	(6.56)		
Value-weighted-mismatch-gap-closing dummy					0.033	
					(0.84)	
Capacity-weighted-mismatch-gap-closing dummy						0.017
						(0.39)
|Value weighted - debt outst. mat.|	**0.016****		**0.018****		**0.015***	
	(2.12)		**(2.28)**		**(2.00)**	
|Capacity weighted - debt outst. mat.|		**0.016*****		**0.016*****		**0.016*****
		(2.85)		**(2.71)**		**(2.72)**
Offer price	-0.13**	-0.13**	-0.11*	-0.11*	-0.13**	-0.13**
	(-2.08)	(-2.11)	(-1.77)	(-1.78)	(-2.11)	(-2.11)
Bond issue rating	-0.069***	-0.065***	-0.069***	-0.064***	-0.069***	-0.065***
	(-7.46)	(-6.64)	(-7.90)	(-7.17)	(-7.29)	(-6.53)
Offering amount	-0.029*	-0.028*	-0.028	-0.028*	-0.031*	-0.029*
	(-1.81)	(-1.85)	(-1.63)	(-1.69)	(-1.94)	(-1.98)
Payment frequency	-0.016	-0.016	-0.027*	-0.026*	-0.015	-0.015
	(-1.22)	(-1.20)	(-1.99)	(-1.96)	(-1.10)	(-1.10)
Sinking dummy	0.052	0.038	0.067	0.052	0.038	0.031
	(1.28)	(1.00)	(1.62)	(1.31)	(0.90)	(0.74)
Put dummy	0.78***	0.82***	0.76***	0.80***	0.76***	0.83***
	(13.2)	(13.8)	(12.9)	(13.7)	(12.9)	(12.8)
Call dummy	0.066	0.075*	0.054	0.063	0.068*	0.078*
	(1.65)	(1.93)	(1.29)	(1.52)	(1.72)	(1.99)
Std. U.S. treasury bond yield (10y)	-0.47***	-0.47***	-0.58***	-0.58***	-0.47***	-0.47***
	(-9.66)	(-9.60)	(-10.4)	(-10.2)	(-9.60)	(-9.64)
Constant	16.8**	16.5**	14.7**	14.5**	16.7**	16.5**
	(2.64)	(2.67)	(2.44)	(2.45)	(2.67)	(2.68)
Observations	359	359	359	359	359	359
Adjusted R^2	0.72	0.72	0.74	0.74	0.72	0.72

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table 5.50.: Robustness tests – Offer price as additional determinant of relative debt issuance yield spread – incl. current assets – II/II

	Ia	Ib	IIa	IIb	IIIa	IIIb
Time-to-Maturity			0.012***	0.011***		
			(6.75)	(6.73)		
Value-weighted-mismatch-gap-closing dummy					0.032	
					(0.78)	
Capacity-weighted-mismatch-gap-closing dummy						0.017
						(0.39)
|Value weighted - debt outstanding matu.| < 0	**0.017***		**0.024****		**0.017***	
	(1.83)		**(2.57)**		**(1.73)**	
|Value weighted - debt outstanding matu.| > 0	**0.019***		**0.015**		**0.018**	
	(1.74)		**(1.27)**		**(1.62)**	
|Capacity weighted- debt outstanding matu.| < 0		**0.017***		**0.022*****		**0.016***
		(1.96)		**(2.75)**		**(1.91)**
|Capacity weighted - debt outstanding matu.| > 0		**0.018****		**0.013**		**0.017****
		(2.20)		**(1.53)**		**(2.09)**
Offer price	-0.13**	-0.13**	-0.11*	-0.11*	-0.13**	-0.13**
	(-2.14)	(-2.13)	(-1.76)	(-1.76)	(-2.16)	(-2.13)
Bond issue rating	-0.067***	-0.063***	-0.073***	-0.069***	-0.067***	-0.063***
	(-7.42)	(-6.05)	(-7.14)	(-5.99)	(-7.39)	(-6.03)
Offering amount	-0.029*	-0.030*	-0.031*	-0.031*	-0.030*	-0.031**
	(-1.83)	(-1.92)	(-1.82)	(-1.82)	(-1.95)	(-2.03)
Payment frequency	-0.016	-0.016	-0.029**	-0.028**	-0.015	-0.015
	(-1.26)	(-1.28)	(-2.24)	(-2.27)	(-1.14)	(-1.16)
Sinking dummy	0.050	0.036	0.084*	0.068	0.037	0.029
	(1.13)	(0.84)	(1.83)	(1.50)	(0.83)	(0.66)
Put dummy	0.77***	0.82***	0.73***	0.79***	0.76***	0.82***
	(12.9)	(14.2)	(11.9)	(13.5)	(12.2)	(13.5)
Call dummy	0.071*	0.082*	0.050	0.062	0.073*	0.085**
	(1.68)	(1.94)	(1.13)	(1.39)	(1.74)	(2.03)
Std. U.S. treasury bond yield (10y)	-0.47***	-0.47***	-0.59***	-0.58***	-0.47***	-0.47***
	(-9.62)	(-9.58)	(-10.4)	(-10.3)	(-9.57)	(-9.61)
Constant	16.9***	16.5***	14.9**	14.7**	16.8***	16.4***
	(2.70)	(2.69)	(2.45)	(2.44)	(2.73)	(2.70)
Observations	359	359	359	359	359	359
Adjusted R^2	0.72	0.72	0.74	0.74	0.72	0.72

The dependent variable is the RELATIVE YIELD SPREAD. All models are OLS regressions. Year dummies are included in all models. The sample is limited to US companies. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

5.2.3.10. Causality between Asset Maturity and Debt Maturity

To my best knowledge, literature exclusively assumes that asset maturity is a determinant of debt maturity. Unfortunately, scholars do not at all address the question whether causality should be the other way round, i.e. that the maturity of debt influences the maturity of assets.

One might argue that asset maturity is – at least to some extent – given by the expected lifetime of a specific power plant technology. Therefore, one might argue that debt and asset maturity matching mainly breaks down to the question whether technology influences debt maturity or vice versa. An influence of debt maturity on technology seems to be less probable, as a significant share of companies is diversified by technology.

However, such diversification effect could be overlapped by another effect, namely that companies, that are limited to shorter debt maturities, buy assets of a long-living technology from other companies at a later stage of the assets' life-cycle. In such case, the plants would have a shorter remaining lifetime.

Consequently, though it seems to be less probable that the available debt maturity is a determinant of asset maturity, it can not be a priori excluded.

Therefore, in the following I propose a causality test, that proves causality running from asset maturity to debt maturity: An appropriate empirical test setting could be to observe the debt structure and the remaining lifetime of assets before and after an exogenous shock on asset maturity.

The nuclear moratorium 2011 in Germany is such an event of a sudden reduction of the remaining lifetimes. However, in such test, one faces the issue that debt maturity cannot be instantaneously adjusted to the shortened maturity of assets as debt contracts are usually fixed for a long term. Thereby such effect might be attenuated due to high transaction costs (as explained before) and might become insignificant for a small sample concentrating only on listed utility companies with nuclear power plants in Germany. Potentially, such shocks – and a resulting maturity debt and asset maturity mismatch – influence maturity decisions for future debt issues. As such test requires debt and asset data as of 2011 and later, I cannot conduct such test today.

Also the unexpected reduction of renewable energy subsidies with retroactive effect in Spain, as announced on December 23, 2010, is a potential exogenous shock for testing causality. Again recent data and a sample of sufficient size is required.

Interestingly, both events are fundamentally different: The first event, i.e. the decision to shut down nuclear power plants earlier than originally planned, is a sudden shortening of the expected remaining lifetime of assets and of the future economic value of these assets. The second event, i.e. the sudden reduction of renewable energy subsidies, is a sudden decrease in the future economic value of an asset while the remaining lifetime remains unchanged. Therefore, these events could be used in order to address causality and the question whether companies actually match debt maturity to the remaining lifetime of assets or to the future economic value.[119]

Due to lacking recent debt and asset data and sample size, these tests cannot be conducted

[119] Also cf. Hart and Moore (1994) for future research.

and are left for future research.

5.2.4. Summary and Implications

This is the first study showing debt and asset maturity matching from a direct bottom-up parametrization using asset-level maturity data. I do not have to rely on measures based on annual depreciations which require strong assumptions, especially the equality of lifetimes of assets in Net PP&E, linearity of depreciations and congruency of asset lifetime and depreciation period. By directly measuring the maturity of the power plants of international electric utility companies, I derive a consistent asset maturity measure and show that companies match their debt maturity to their "real" asset maturity.

In contrast to at least parts of the literature, I demonstrate that there is no significance for an influence of asset maturity on the choice of debt maturity of single debt issues.

Adding to the conventional motivations for maturity matching, I further find that a mismatch between my "real" asset maturity measures and the maturity of debt leads to higher relative yield spreads at debt issuance. I hypothesized that this holds, on the one hand, if debt maturity is higher than asset maturity, i.e. if such company is running out of collateral, and on the other hand, if debt maturity is lower than asset maturity, i.e. if the company faces an increased refinancing risk and potentially suffers from the threat of lost control rents by early liquidation by short-maturity debt holders. These lost control rents increase with increasing time-to-maturity of the respective debt issue.

Also, I find weak significance for an influence of asset salability on debt maturity, which is in accordance with Benmelech (2009).

Further, I provide relevant insights for practitioners in electric utility companies, as I provide formulas for the choice of the debt maturity structure as well as for the relative yield spread of corporate debt issues. Companies may use these formulas to benchmark their debt structure.

Finally, I implicitly provide a reasoning for a stable energy policy design. From this section, politicians and regulators may find that a stable regulatory environment for the assets of utility companies is a relevant lever on the companies' costs of new debt issues, since significant changes in the remaining lifetime of assets can lead to a mismatch of debt and asset maturity and, consequently, to increased financing costs.

5.3. Diversification in Production in Mergers & Acquisitions

In this section, I address the effect of diversification in production technologies on cumulative abnormal returns from M&A events. This study is *specific for the electric utility industry* and *descriptive in its character*. After a short introduction, I describe my sample of international M&A deals in the utility industry as well as the applied methodology. Thereafter, I conduct univariate and multivariate empirical analysis of cumulative abnormal acquirer returns. Finally, I analyze the propensity to acquire and to diversify by applying logit calculations.

5.3.1. Introduction

The impact of diversification on cumulative abnormal returns from M&As has been extensively discussed in the literature. Such studies, as reviewed in Section 2.3, differentiate horizontal vs. vertical or related vs. unrelated deals.

In this section, I address my **diversification effect hypothesis** as motivated in Section 3.3. By M&A deals, companies might generally – even in deals with acquirer and target from the same industry – diversify by such deal, e.g. in production technologies, raw materials used[120], finished products produced or retail channels addressed. This analysis focuses on the question whether acquirers diversify their production technologies by conducting horizontal deals and how the capital market reacts to such diversification. Specifically for an international sample of listed utility companies, I analyze whether diversification within "horizontal deals" – here understood as acquirer and target being electricity generating utility companies – yields cumulative abnormal acquirer returns in M&A transactions. Obviously, such diversification in production technologies would not be reflected in SIC codes, as both, buyer and target, are electricity generating utility companies.

In consistence with the foregoing analyses, I refer to the same sample of listed electric utility companies on the acquirer side, that was the basis for my earlier capital and debt structure analyses. Targets may also include unlisted companies, either from the electric utility industry, from other related or from unrelated industry sectors. Definitions of the terms horizontal, related and unrelated might deviate from common definitions of these classifications and are given in Section 5.3.2.2.

My main results can be summarized as follows: *First*, my **diversification effect hypothesis** will *not* be confirmed, i.e. there will be *no* significant influence from diversification in production technologies on cumulative abnormal returns. This is consistent across different diversification measures, as it will be explained in this section. *Second*, I overall find positive cumulative abnormal returns for M&A deals, as well as specifically for horizontal M&A deals.

The analysis proceeds as follows: *First*, after a short introduction, a sample characterization as well as summary statistics on the M&A market in the utility industry are given. *Second*, the empirical results are presented, and *third*, results are summarized in the summary section.

120 For my sample, production diversification can e.g. be regarded as a way to produce the same finished product based on different fuels.

5.3.2. Data and Methodology

5.3.2.1. Sample Construction

Besides the above mentioned accounting data available from Worldscope and production data derived from the WEPP database, the analysis of M&A requires additional deal specific data. For my analysis in Section 5.3, I refer to the same sample of listed electric utility companies on the acquirer side, that was the basis for my earlier capital and debt structure analyses. My sample includes all deals of sample companies and their subsidiaries, which are included in the SDC Platinum database. In order to conduct M&A event analysis, I further match daily acquirer stock returns from Datastream.

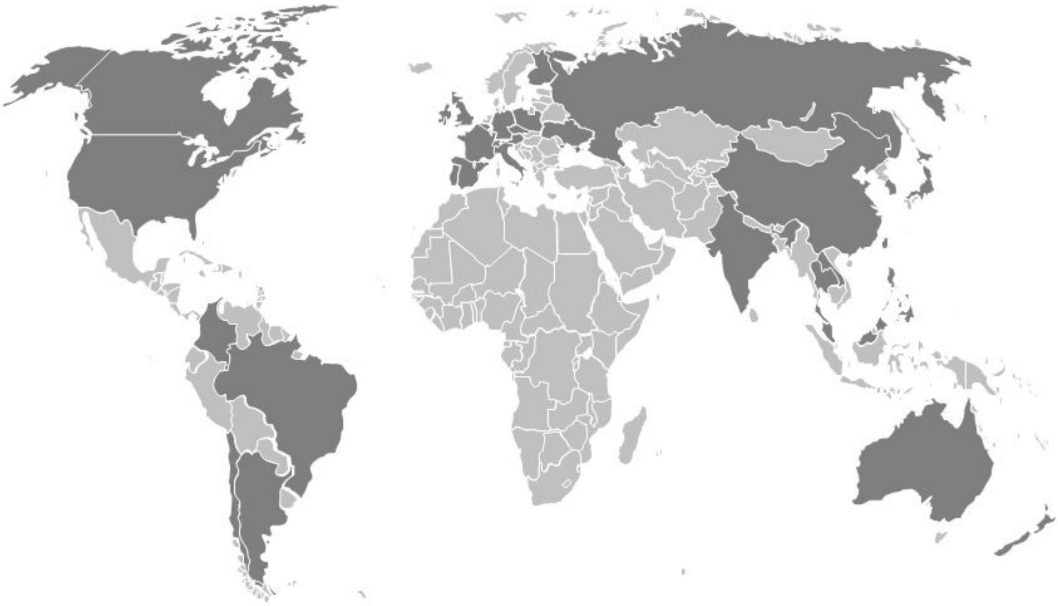
Besides this M&A data (SDC Platinum), my analysis requires production data (Platts WEPP), and accounting data and capital markets return data (Thomson ONE and Datastream) for acquirer companies as well as production data for target companies. While production data is already available for acquirer companies, as described in Section 4 and used in Sections 5.1 and 5.2, it has to be collected for target companies as well. Therefore, I manually match the target companies from the SDC Platinum database to the Platts WEPP database. Different from the steps described in Section 4, there is no list of subsidiary companies of these targets available. This is related to the fact that many of the target companies are private companies or subsidiaries of listed companies, and *not* listed companies.[121] Nevertheless, the remaining steps for building up the dataset are equivalent to those for the production data of acquirer companies, as described in Section 4. Again, extensive manual work is required.

For my sample of 460 acquirer companies, I find acquirer and target production data as well as cumulative abnormal acquirer returns for 257 M&A deals. This sample includes acquirers headquartered in 30 different countries and targets headquartered in 48 countries, as shown in Figures 5.9 and 5.10.

In order to arrive at this sample, I prepared my data as follows:
First, as usual, I exclude all transactions that have *not* been closed. I do so as one can not be sure that SDC Platinum contains all deals that have *not* been closed. In order to avoid any bias, I generally exclude unclosed deals. For example, in such case, one can not be sure that the given transaction value is a sensible value, as the transaction did *not* take place at these conditions.
Second, for the avoidance of doubt, share buybacks are excluded as they would – besides other reasons – lead to trivial correlations between acquirer and target characteristics, which will be relevant in my later analysis. For example, I analyze whether the production asset portfolio of the acquirer is diversified by purchasing the target. In case of a repurchase of shares, these portfolios would be perfectly correlated.
Third, I also exclude such deals that were announced on the same day by one single acquirer company. The reason is that cumulative abnormal returns can not be specifically assigned to one of these deals. Obviously, event studies *not* controlling for such simultaneous deals incorporate causality problems. Such simultaneous deals amount to about 21.7% of all deals in my SDC

[121] For those targets that are themselves included in the list of acquirers, i.e. that are listed electric utility companies, the available subsidiary list was used.

Figure 5.9.: Headquarters of SAMPLE-ACQUIRERS (domiciled in 30 countries; dark gray)



Platinum sample. This share might partially be explained by the fact that some of the targets listed in the raw data themselves are subsidiaries of the same holding company and are sold on the same day. Nevertheless, they are often listed in two separate line items. I point out, that there are several published studies that do not exclude such deals. As the capital market effect can not be attributed to a single target with specific characteristics, such analysis and their implications are highly questionable.[122]

Fourth, I do not correct for other M&A events that happen within the estimation window, as this is typically *not* done in the literature, either. However, I point out that other M&A deals might influence the return regression that is used to estimate normal returns in the estimation window.[123]

Production data is available for the years 2002 until 2009 and will be lagged by one year in my analyses. Therefore, I present the respective deal data for the period between 2003 and 2010.

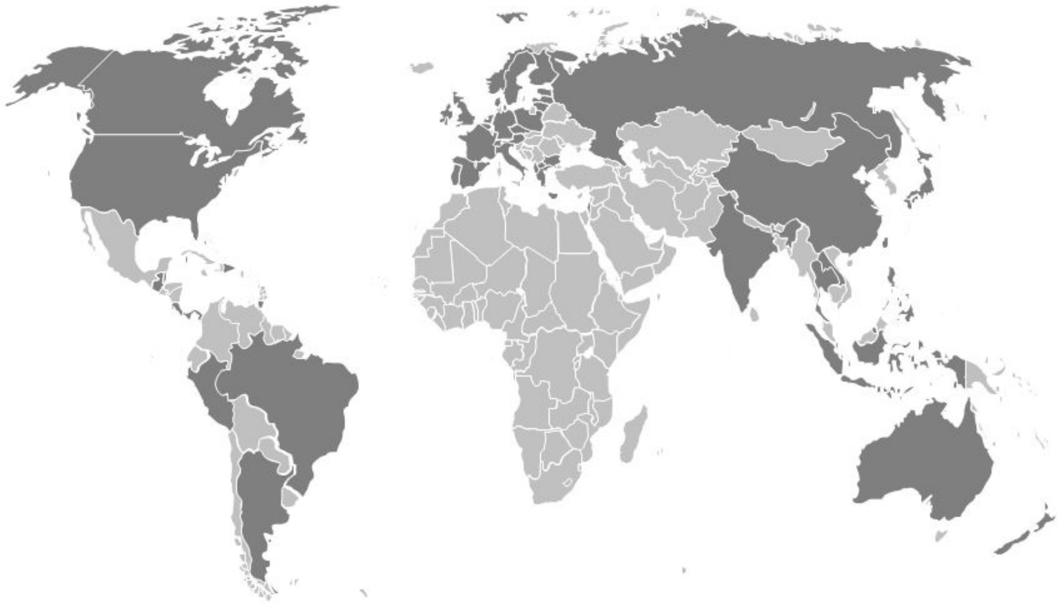
5.3.2.2. M&A Deal Specific Data and Diversification Measures

Besides the abovementioned matching procedure, also a target classification was conducted manually. The aim was to classify targets in order to differentiate "horizontal vs. vertical" deals "and other related vs. other unrelated deals", as described in Table 5.51. Since all acquiring companies produce electricity, all deals involving electricity producing target companies are classified as "horizontal" or "generator" deals. Target and acquirer companies are classified as electricity generating companies if they – besides potential other activities – also generate electricity. As this classification was conducted separately from the matching of production data,

122 An obvious exception would be if the relevant company characteristics are additive and known for all targets acquired at the respective date.

123 In accordance with several well published M&A papers, I ignore this issue. Obviously, controlling for such complication can result in a loss of data points depending on the length of estimation windows.

Figure 5.10.: Headquarters of SAMPLE-TARGETS (domiciled in 48 countries; dark gray)



companies can also be classified as generators (i.e. "horizontal deals") even if there are *no* power plants of the Platts WEPP list successfully matched to it. Though specific generation assets might be unknown, it might be known from, e.g., web-pages that they are electricity generating companies.

The class of "*vertical*" deals includes targets from exploration, mining, transmission, distribution and retail businesses without electricity generation as one of their activities.
District heating, energy services, maintenance, heating, trading, telecommunication/ IT, engineering and manufacturing companies (without electricity generation) are classified as "*other related deals*". "*Unrelated deals*" include such deals that are *not* related to the business of producing electricity, e.g. construction material, real estate, waste, transportation, finance, construction, infrastructure, water and others. This classification was conducted manually via Internet research, mainly from corporate websites and annual reports.

Alternatively, a classification of targets according to SIC codes is used. The classification according to SIC codes is given in Table 5.52.

Table 5.51.: Classification – Manual classification of target companies

Value chain perspective	**Main activity**
Horizontal deals	
	Generator
	Incl. generation assets
Vertical deals	
	Exploration
	Mining
	Transmission
	Distribution
	Retail
Related deals	
	District heating
	Heating
	Trading
	Storage
	Energy services
	Maintenance
	Telecommunication/ IT
	Engineering
	Manufacturing
Unrelated deals	
	Construction/ Construction material
	Real estate
	Water
	Waste
	Transportation
	Finance
	Infrastructure
	Other

Categories are used to classify target companies by their main activities. If targets are owners of power plants, such deals are generally classified as horizontal deals, even if such companies, e.g., are fully integrated along the value chain and include electricity generation as one of their businesses.

Table 5.52.: Classification – SIC classification of target companies

Target-macro-industry	Sub-sample	Industry title	Sub-industry title
Energy and Power	Electric services		
		Electric services	
			Electric services
			Electric & other services combined
			Motors & generators
	Non-electric services though Energy and Power		Power, distribution & specialty transfo
		Natural Gas Transmission Distribution	
			Natural gas transmission
			Natural gas transmission & distribution
			Natural gas distribution
		Upstream	
			Bituminous coal & lignite surface mining
			Crude petroleum & natural gas
			Drilling oil & gas wells
			Oil & gas field exploration services
			Oil & gas field machinery & equipment
			Oil & gas field services, NEC
			Petroleum refining
	Other related utility businesses		
		Refuse	
			Refuse systems
		Water	
			Water supply
			Water, sewer, pipeline, comm & power
		Steam	
			Steam & air-conditioning supply
		Other	
			Gas & other services combined
			Switchgear & switchboard apparatus
			Wholesale-electrical apparatus & equipm
			Wholesale-petroleum bulk stations & ter.
			Wholesale-petroleum & petroleum product
Consumer Products and Services			
Consumer Staples			
Financials			
Government and Agencies			
Healthcare			
High Technology			
Industrials			
Materials			
Media and Entertainment			
Real Estate			
Retail			
Telecommunications			

Categories in the right column refer to primary 4-digit SIC codes of targets as reported in SDC Platinum. The "target-macro-industry" is also reported by SDC Platinum.

Table 5.53.: Overview on diversification measures and their construction

		L1 - "Tech" Production technologies according to Table 4.2	**L2 - "Base"** Base/ mid/ peak and stochastic clusters according to Table 4.2	**L3 - "Cluster"** (Fuel) clusters, i.e. nuclear, coal, gas, green and other
P1	Diversification dummy	*All combinations can be used as measures of diversification, i.e. at levels L1-L3 and with parametrizations P1-P4. Formulas for the calculation of parametrizations are given below.*		
P2	Entropy			
P3	Tech-Relatedness (Jaffe)			
P4	Herfindahl index			

For the analysis of deals, several deal specific variables are required. These are obtained from SDC Platinum. In my later regression analyses, a "tender" dummy is used, describing whether there was a tender offer (dummy equals 1) or not (equals 0). Furthermore, the variable "% of shares acquired" is applied, which refers to that fraction of a target's shares that was acquired. Also, SDC Platinum includes information on the "% of shares owned after transaction", allowing to calculate the toehold, i.e. the "% of shares owned before transaction". From the deal's "announcement date" a "crisis dummy" is constructed, that equals 1 after the Lehman event and 0 before it. Further, I introduce a "headquarters dummy" that equals 1 if acquirer country and target country are the same, and equals 0 otherwise. Besides this and among others, SDC Platinum also includes the "transaction value" and the "number of bidders".

Now, besides these deal related variables, measures of *production diversification* are required. From the production data of acquirer and target, twelve different measures for the deal's diversification effect are calculated. These measures result from four different kinds of parametrizations (i.e. diversification dummy, Entropy, technological relatedness according to Jaffe (1986), and Herfindahl). These parametrizations are calculated based on three different levels of granularity (i.e. production technology, base/ mid/ peak/ stochastic, and technology clusters mainly related by fuel), as summarized in Table 5.53.

For each of these levels $L1$, $L2$ and $L3$, I construct four different parametrizations, $P1$, $P2$, $P3$ and $P4$, of production diversification measures, i.e. a dummy measure, Entropy, technological relatedness (Jaffe), and Herfindahl, as shown in Table 5.53.[124] In detail, these measures can be expected to capture different aspects of diversification. Also, using different levels of granularity for classifying technologies is important because there is no "natural" classification of technologies that can be considered to be special in comparison to other technology classifications.

Granularity levels

First, a diversification measure based on the level of production technologies, i.e. based on the second column in Table 4.2, is constructed. This measure treats each technology differently,

[124] For the avoidance of doubt, this means that the following measures are calculated based on the capacity of the single technology (in MW) $L1_i$, based on base/ mid/ peak/ stochastic capacity (in MW) in $L2_i$, and based on "clusters" (in MW) in $L3_i$.

considering technological differences among all technologies.
Second, a measure based on the level of my base/ mid/ peak and stochastic classification, i.e. the first column in Table 4.2, is constructed. This level aggregates technologies according to their production flexibility (as described in Section 5.1).[125]
Third, production technologies are clustered mainly by fuel: I aggregate production technologies to the clusters "nuclear", "coal", "gas", "green" and "other". While "nuclear" only includes nuclear power plants, I aggregate flexible and non-flexible coal power plants to the "coal" cluster. The "gas" cluster includes gas and gas combined-cycle power plants. I construct the cluster "green" by aggregating the production technologies biogas, biomass, geothermal, non-flexible water, flexible water, solar and wind. "Other" includes the production technologies oil, waste, other fossil and others. These clusters represent similar technologies and – at least for the large groups of nuclear, coal and gas – clusters include technologies with highly related fuel costs within each cluster, i.e. uranium, coal and gas.

In the following, I refer to these different levels as $L1$, $L2$ and $L3$. In the following, I refer to single elements of $L1$, $L2$ and $L3$ as $L1_i$, $L2_i$ and $L3_i$ *or* as *production technology* (e.g. for $L2_1$ = "base", $L2_2$ = "mid", $L2_3$ = "peak" and $L2_4$ = "stochastic").

Parametrizations
First, a dummy measure for diversification by a given deal is constructed. This dummy equals 1, if the target owns a technology $L1_i$, $L2_i$ *or* $L3_i$, respectively, that is not owned by the acquirer *before* acquisition. In contrast, it equals 0 if *no* new technology is added to the acquirer's portfolio by the respective acquisition.

Second, I measure diversification using an entropy measure. Obviously, in order to capture the diversification effect of the deal, the acquirer's change in entropy by the deal, Δ *Entropy*, is the relevant measure. Therefore, I calculate the entropy of the new company, i.e. from the sum of acquirer and target production technologies, minus the entropy of the acquirer's technology portfolio (for the each level $L1$, $L2$ *or* $L3$). The total capacity of the new company is calculated as the sum of target and acquirer production technology as follows:

$$\text{Capacity}_{i,\text{New Company}} = \text{Capacity}_{i,\text{Acquirer}} + \ \% \text{ of shares acquired} \cdot \text{Capacity}_{i,\text{Target}},$$

where i denotes the elements from the respective level $L1$, $L2$ or $L3$. The entropy is calculated, e.g. according to Jacquemin and Berry (1979), as follows:

$$\text{Entropy}_{\text{company}} = \sum_{i=1}^{N} \left(z_i \cdot ln \left(\frac{1}{z_i} \right) \right), \tag{5.9}$$

where z_i equals the capacity-share of production technology i (referring to $L1_i$, $L2_i$ *or* $L3_i$) in the overall production capacity. Further, N denotes the number of elements in the parametrizations (referring to the elements $L1_i$, $L2_i$ *or* $L3_i$). The *more diversified* the production portfolio of

125 The classification into base/ mid/ peak and stochastic is based on approximate full-load hours of power plants.

a company is, the *higher* is its *entropy*. Finally, the diversification effect by a given deal is calculated as

$$\Delta\text{Entropy}_{\text{Deal}} = \text{Entropy}_{\text{New Company}} - \text{Entropy}_{\text{Acquirer}} \tag{5.10}$$

Third, I calculate a measure that captures the relatedness of technology portfolios ("Tech-Relatedness"), as first proposed by Jaffe (1986).[126] As less related production technologies of acquirer and target lead to more diversified new companies, this measure can also be interpreted as a measure of diversification. The Jaffe-measure is computed as follows:

$$\text{Tech-Relatedness}_{\text{Acquirer, Target}} = \frac{\Sigma_{i=1}^{N} Z_i^{\text{Acquirer}} Z_i^{\text{Target}}}{\sqrt{(\Sigma_{i=1}^{N}(Z_i^{\text{Acquirer}})^2)(\Sigma_{i=1}^{N}(Z_i^{\text{Target}})^2)}},$$

where Z_i equals the capacity of production technology i (referring to the single elements $L1_i$, $L2_i$ *or* $L3_i$). Further, N denotes the number of elements $L1_i$, $L2_i$ *or* $L3_i$ in the parametrizations ($L1$, $L2$ *or* $L3$). The measure of Jaffe is *higher* if both technology portfolios are *closer related* to each other.

Fourth, I calculate the change in the Herfindahl measure induced by the deal. In other words, in parallel to the entropy measure, I subtract the Herfindahl of the acquirer before the deal from the Herfindahl of the new company. The Herfindahl measure is defined as[127]

$$\text{Herfindahl} = \sum_{i=1}^{N} \left(z_i^2\right) \tag{5.11}$$

where z_i equals the capacity-share of production technology i (referring to $L1_i$, $L2_i$ *or* $L3_i$) in the overall production capacity. The Herfindal measure is *higher* if a portfolio is *less diversified*, i.e. *more concentrated*.

These twelve measures, according to Table 5.53, are used in order to evaluate the effect of diversification on the acquirer caused by the respective deal.

5.3.2.3. Methodology

There are different empirical strategies used in the course of this section.

First, cumulative abnormal returns of acquirer companies around M&A deals are calculated. All results presented here are calculated for event windows of three days centered around the event date, i.e. [-1;1]. Cumulative abnormal returns are calculated in accordance with the procedure as outlined in Section 5.1.3.5. They are calculated based on U.S.-dollar returns with reference to the *MSCI ACWI Utilities* index using a market model approach.[128]

[126] Cf. Jaffe (1986), p.986

[127] Cf. Jacquemin and Berry (1979) for the definition of the Herfindahl index as well as the inverse Herfindahl index and the entropy measure of diversification. For the avoidance of doubt, several scholars refer to the "inverse Herfindahl index", defined as "1 - Herfindahl index" as "Herfindahl index" as well. I do not follow this definition but instead use the unchanged Herfindahl.

[128] I find similar results when the MSCI World is used as a reference index. For their cross industry and U.S.-focused studies, scholars usually apply a CRSP value-weighted index, e.g. Golubov, Petmezas and Travlos (2012), Bao and Edmans (2011) and Moeller, Schlingemann and Stulz (2004).

Schwert (1996) finds positive returns for acquirer's stocks already 42 days before the event. Consequently, my estimation window – as it is typically done in M&A analyses – ends 43 days before the actual event in order to reduce a potential *anticipation or leakage bias.* In accordance with, e.g. Golubov, Petmezas and Travlos (2012), Lin, Officer and Zou (2011) and Cai and Sevilir (2012), I choose my estimation window to have an overall length of 200 days and an event window of three days symmetric around the event date (i.e. the announcement date of the deal). Recent papers analyzing M&A transactions either choose an event window of three days (e.g. Ferreira, Massa and Pedro (2010), Goel and Thakor (2010), Cai, Song and Walkling (2011), Harford, Jenter and Li (2011) and Bao and Edmans (2011)) or five days symmetric around the event date (e.g. Faccio, McConnell and Stolin (2006), Lin, Officer and Zou (2011), Masulis, Wang and Xie (2007) and Golubov, Petmezas and Travlos (2012)).[129]

Second, univariate tests for subsamples are conducted in order to determine the effect of single variables on cumulative abnormal returns. In my univariate analyses, I conduct one-sided tests (against 0) and two-sided tests (two subsamples against each other).
As one-sided tests, I use non-parametric Wilcoxon signed-rank test and Wilcoxon sign test as well as a parametric t-test. Kolari and Pynnönen (2010) state that most scholars apply non-parametric tests according to Wilcoxon (1945) instead of the more recent tests according to Corrado (1989) and Corrado and Zivney (1992).[130] According to Campbell, Cowan and Salotti (2010), "nonparametric rank and generalized sign test are more powerful than common parametric tests, especially in multi-day windows"[131].
As two-sided tests, I use the unpaired two-sided t-test and the unpaired two-sided Wilcoxon rank-sum test, also frequently referred to as Mann-Whitney test.[132] Scholars frequently report both tests in the literature. While the t-test requires normality of the tested variables, the Wilcoxon rank-sum (Mann-Whitney) test does not.

Third – after calculations of cumulative abnormal returns and univariate testing – cumulative abnormal returns are regressed in order to determine whether diversification is a relevant determinant.

Fourth, logit calculations are conducted in order to test, whether less diversified acquirers acquire diversifying targets and which acquirer characteristics determine the propensity to acquire.

In order to control for heteroscedasticity and within-cluster correlations, my regressions are performed by using cluster-robust standard errors on the acquirer company level according to White (1980). As a robustness test, I further apply double- and multiway-clustering according to Cameron, Gelbach and Miller (2006) and Petersen (2009). All independent variables are winsorized at the 1%-level. Further, all independent variables are lagged by one period for

129 I note that one might also need at least a three day event window as announcement date and return data might be determined at different places of the world for the same event. Consequently, dates of announcement according to SDC Platinum and return data, according to Datastream, might differ by one day, which even manually is hard to control for.

130 The rank test according to Corrado (1989) does not require symmetry of cross-sectional cumulative abnormal returns while the sign test does not require a zero median of cumulative abnormal returns.

131 Cf. Campbell, Cowan and Salotti (2010), p.3078

132 Cf. Wilcoxon (1945) and Mann and Whitney (1947)

causality reasons.

5.3.2.4. Definition of Variables

The reader is strongly advised to read through the following definitions of variables in Table 5.54, and not to skip them, as they are relevant for my later analysis.

Table 5.54.: Definition of variables – M&A and diversification

Variable	**Description**
Diversification measures	
Diversification dummy	cf. Section 5.3.2.2; based either on classes of single production technologies, on base-/mid-/peak-load and stochastic generation or on (fuel) clusters
Entropy	cf. Section 5.3.2.2; based either on classes of single production technologies, on base-/mid-/peak-load and stochastic generation or on (fuel) clusters
Tech-Relatedness	cf. Section 5.3.2.2; based either on classes of single production technologies, on base-/mid-/peak-load and stochastic generation or on (fuel) clusters
Herfindahl	cf. Section 5.3.2.2; based either on classes of single production technologies, on base-/mid-/peak-load and stochastic generation or on (fuel) clusters
Acquirer characteristics	
Market leverage	Total debt [wc03255] / Market value of assets = Total debt / (Total debt + Market value of equity [wc08001])
Market-to-book	Market Capitalization [wc08001] / Common Equity [wc03501]
Profitability	Earnings before interest and taxes (EBIT) [wc18191] / Total Assets
Size	Natural logarithm of the firm's total assets [wc029999] measured in US Dollar
Tangible Assets Ratio	Property, plant and equipment - net [wc02501]/ Total Assets
Deal characteristics	
Relative company equity size acqu./ target	Transaction value [SDC]/ Market value of equity [wc08001] (both in US$)
Tender dummy	Equals 1 if acquirer made a Tender [SDC] offer, otherwise equals 0.
% of shares acquired	% of shares acquired [SDC]
% of shares acquired dummy	Equals 1 if % of shares acquired [SDC] is $\geq$ 50%, otherwise equals 0.
Country of headquarters dummy	Equals one if the Country [DS] of the acquirer equals the target nation [SDC], otherwise equals 0.
Number of bidders	Number of bidders [SDC]
Crisis dummy	Equals 1 if the Date Announced [SDC] was later than September 15^{th}, 2008, otherwise equals 0.
Toehold	Equals 1 if the "percentage of shares acquired" [SDC] does not equal the "percentage of shares owned after transaction" [SDC], otherwise equals 0.

[DS] denotes Datastream
[SDC] denotes SDC Platinum

5.3.3. Empirical Results

In this section, I proceed as follows: *First*, descriptive statistics are presented. *Second*, univariate analyses of the effect of diversification on cumulative abnormal acquirer returns are conducted. *Third*, results of multivariate regressions, and *fourth*, results of logit calculations are shown.

5.3.3.1. Descriptive Statistics and Overview on M&A Activity of Listed Electric Utility Companies

In this section, I provide descriptive statistics on the M&A activity of listed electric utility companies. These statistics should *not* be understood as a description of the industry's M&A activity in general. This is due to the following reasons: *First*, I limited my sample of acquirers (incl. their subsidiaries) to listed electricity producing utility companies, i.e. the sample from the foregoing sections of this thesis. *Second*, I use M&A data from SDC Platinum on *completed deals* that have been announced between 2003 and 2010. In total, for my sample of acquirer companies, the SDC Platinum database includes *3,111 deals* between 2003 and 2010, thereof *1,945 closed deals*.

My later multivariate regression analysis will exclude all deals with a missing data item from either relevant deal data (SDC Platinum), production data (Platts WEPP), accounting data *or* capital market return data (Thomson ONE and Datastream). Differently, for the following descriptive statistics on M&A deals in the utility industry, all deals are included in these statistics, as long as the presented data items are available.

Figure 5.11 shows that most deals in the sample were conducted by acquiring companies from Europe, followed by Asia and North America.

As depicted in Figure 5.12, transaction values in my sample differ significantly over time and were highest in 2006, 2007 and 2010. Unfortunately, transaction values are not available for several deals, also incl. North America.

Figure 5.13 shows in a cumulated diagram that – with regard to the overall transaction value – M&A activities in the electric utility industry are largely dominated by about 75 utility companies worldwide.

I find from Figure 5.14 – according to my manual classification of companies into horizontal, vertical, other related and other unrelated deals – that listed electric utility companies invest most of the overall transaction value into deals classified as "horizontal", i.e. such deals that involve targets that generate electricity (at least as one of their activities).

Figure 5.15 shows that most of the transacted absolute target capacity (in MW) in my sample is coal and gas capacity, followed by renewable capacities. Further, it shows that the transacted capacity by acquirers from Asia is higher compared to Europe and North America. The same is true for renewable generation capacities.

Figure 5.16 depicts average cumulative abnormal acquirer returns between 2003 and 2010, as also given in Table A. 15 in the appendix. Cumulative abnormal acquirer returns are not significantly different from zero, except for 2003 (0.85%) and 2006 (1.02%).

Figure 5.11.: Number of deals by region (2003–2010)

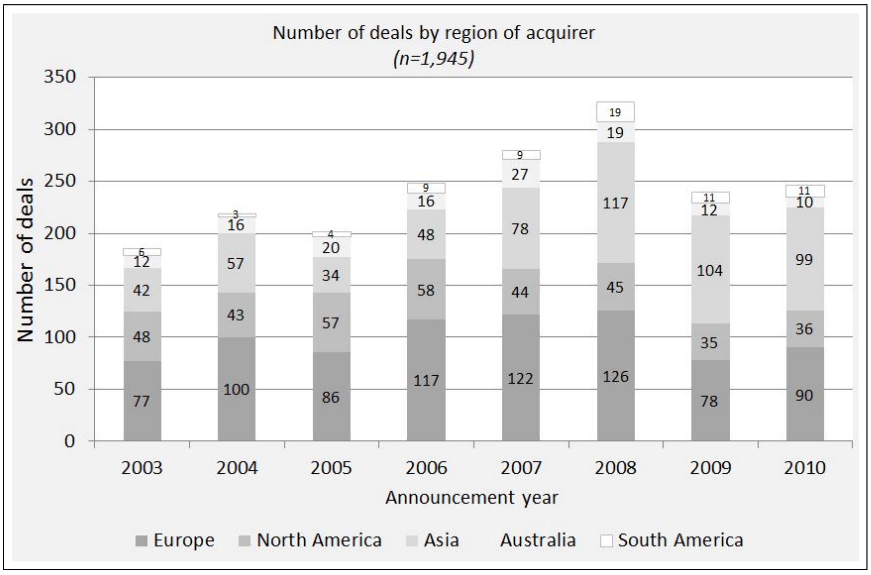


Figure 5.12.: Transaction value by region (2003–2010)

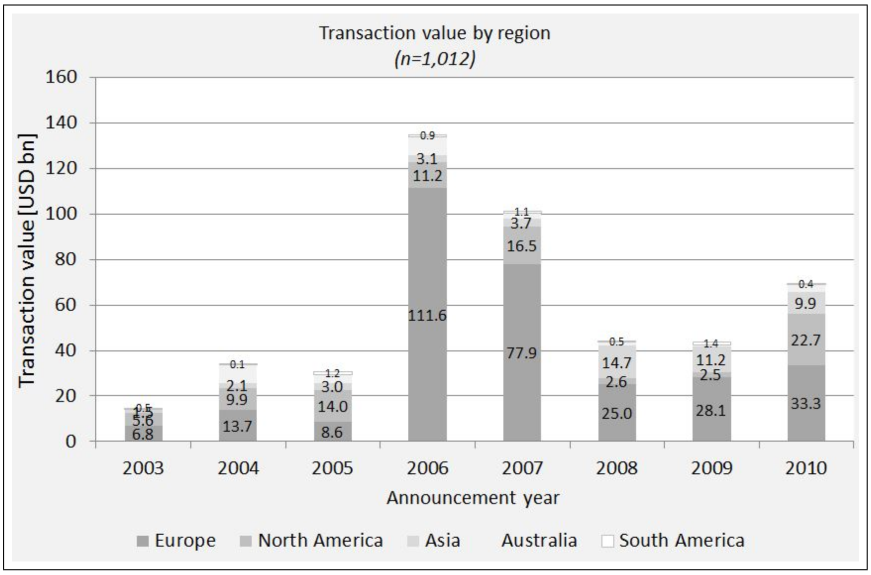


Figure 5.13.: Cumulative transaction value over number of acquirers (2003–2010)

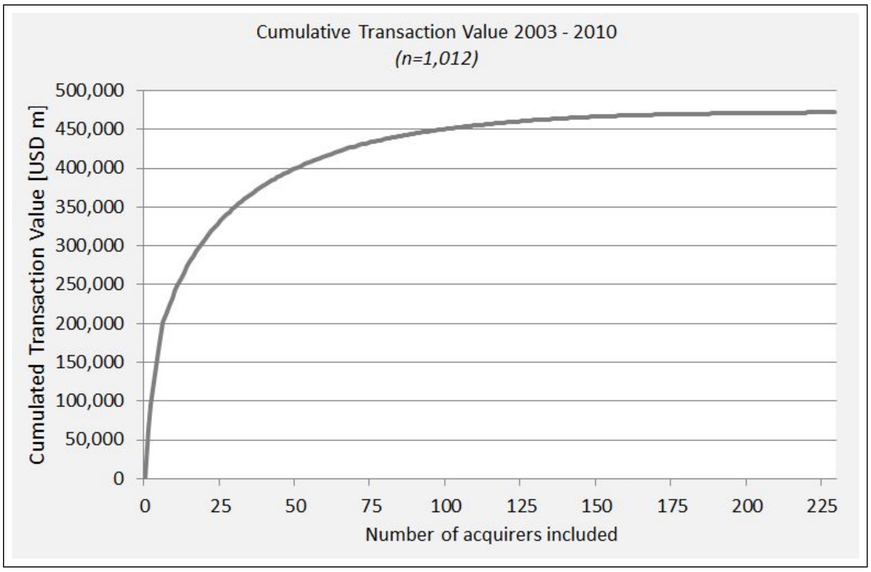


Figure 5.14.: Deal type and transaction value (2003–2010)

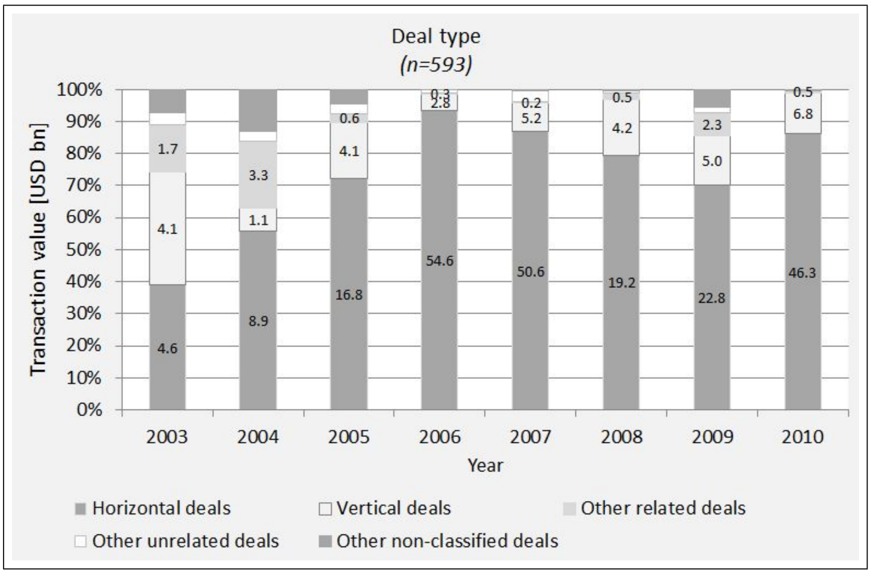


Figure 5.15.: Target capacity by acquirer region as included in sample (2003–2010)

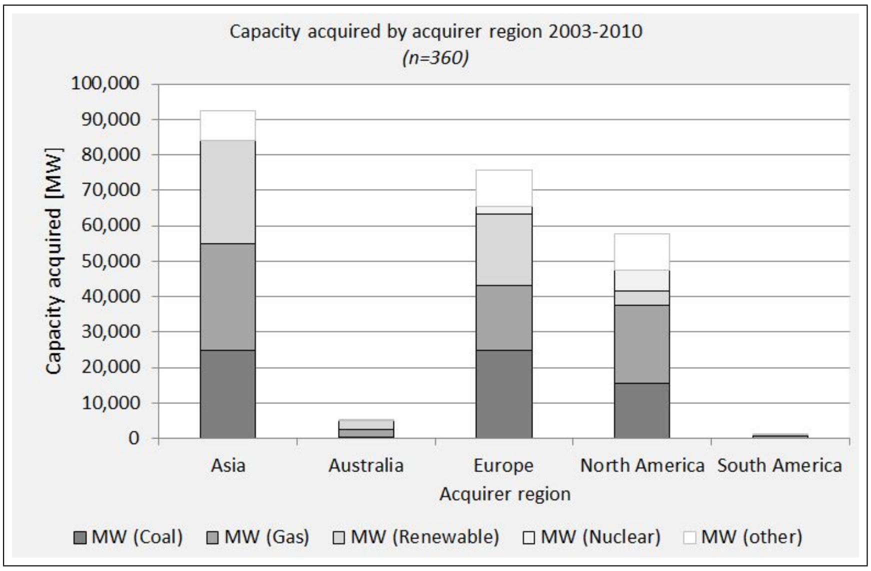
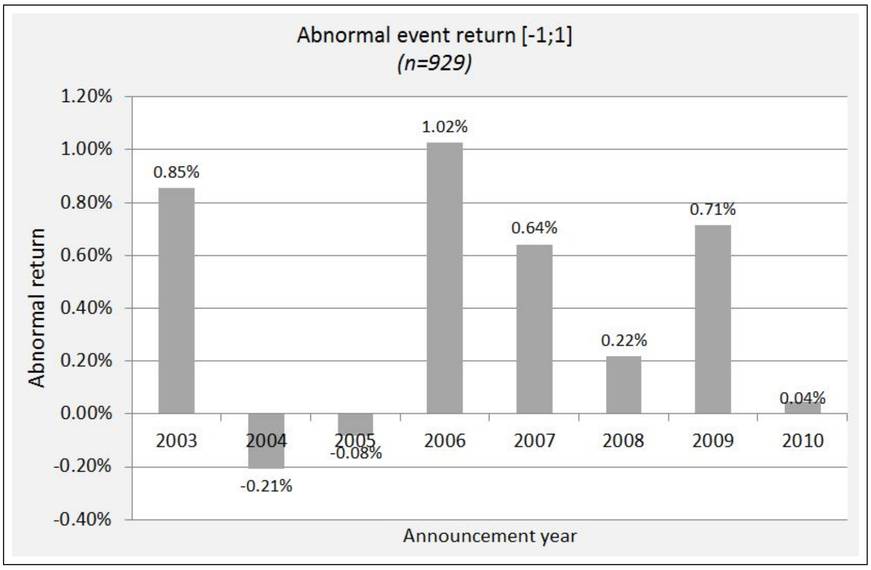


Figure 5.16.: Cumulative abnormal event returns of M&A deals (2003–2010)



The sample for my multivariate analysis is described in Table 5.55. The following is found from my sample of 164 deals with complete data for all independent variables:

- The data shows that only about 3% of the deals are induced by a tender offer.
- The variable "% of shares acquired" indicates that more than 67% of the deals are acquisitions of a majority stakes.
- In about 54% of the deals, acquirers buy target companies headquartered in their own home country.
- Acquirers on average have a toehold of about 29% in the acquired targets.
- About 24% of the deals in the sample were conducted after September 15th, 2008.

Table 5.55.: Descriptive sample statistics – according to the dataset as used in Table 5.61, model IIa

	Obs.	Mean	Std. dev.	25%-perc.	50%-perc.	75%-perc.
Acqu. CAR	164	-0.002	0.033	-0.014	-0.001	0.012
Δ Herfindahl (Tech)	164	-0.036	0.140	-0.118	-0.014	0.057
Δ Herfindahl (Base)	164	-0.029	0.097	-0.019	-0.001	0.002
Δ Herfindahl (Cluster)	164	-0.028	0.092	-0.017	-0.001	0.001
Div. Dummy (tech)	164	0.299	0.459	0.000	0.000	1.000
Div. Dummy (base)	164	0.140	0.348	0.000	0.000	0.000
Div. Dummy (cluster)	164	0.098	0.298	0.000	0.000	0.000
Δ Entropy (Tech)	164	0.090	0.214	0.000	0.013	0.074
Δ Entropy (Base)	164	0.051	0.153	-0.002	0.003	0.031
Δ Entropy (Cluster)	164	0.052	0.155	-0.002	0.001	0.027
Tech. related. (Jaffe) (Tech)	164	0.390	0.383	0.043	0.212	0.801
Tech. related. (Jaffe) (Base)	164	0.576	0.389	0.146	0.688	0.976
Tech. related. (Jaffe) (Cluster)	164	0.585	0.350	0.248	0.674	0.944
Relative company equity size acqu./ target	164	0.128	0.281	0.004	0.021	0.097
Size [acquirer]	164	16.010	1.590	15.361	16.380	17.204
Market leverage [acquirer]	164	0.390	0.178	0.222	0.392	0.514
Market-to-book [acquirer]	164	2.149	1.363	1.416	1.735	2.267
% of shares acquired dummy	164	0.671	0.471	0.000	1.000	1.000
Toehold dummy	164	0.293	0.456	0.000	0.000	1.000
Country of headquarters dummy	164	0.543	0.500	0.000	1.000	1.000
Tender dummy	164	0.030	0.172	0.000	0.000	0.000
Number of bidders	164	1.018	0.134	1.000	1.000	1.000
After Sep. 15th, 2008	164	0.238	0.427	0.000	0.000	0.000

Statistics include data points from Table 5.61.

5.3.3.2. Univariate Cumulative Abnormal Acquirer Return Analyses

In this section, several univariate analyses of cumulative abnormal returns are conducted. I include all deals by the companies in my sample that were announced between 2003 and 2010 and that have finally been *closed*. Also, I require that capital market returns are available.

5.3.3.2.1. One-sided Tests

First, cumulative abnormal returns are calculated for different subsamples, i.e. generators and non-generators, and for horizontal, vertical, other related, other unrelated, and other non-classified deals (referred to as a "value chain perspective") in Table 5.56. Cumulative abnormal returns of these subsamples are tested against zero via one-sided t-test, Wilcoxon signed-rank test, and Wilcoxon sign test.

One finds that overall, the sample of international electricity generating companies experiences cumulative abnormal acquirer returns of 0.389%, which significantly[133] differs from zero. Thereof, the returns of electricity generating (0.308%) and non-generating companies (0.453%) are somewhat less significant[134] and similar in the absolute value. As discussed in Section 2.3.3, there are studies finding negative as well as positive cumulative abnormal returns. The finding of positive cumulative abnormal returns might also be related to the fact that many privately held or subsidiary target companies are included in my sample or due to controlling for anticipation of deals by the choice of the estimation window according to Schwert (1996). Acquisitions of privately held target companies are shown to yield positive cumulative abnormal acquirer returns by Fuller, Netter and Stegemoller (2002) and Faccio, McConnell and Stolin (2006). Cai, Song and Walkling (2011) find positive cumulative abnormal returns as they explicitly control for anticipation of deals.

Using the manual classification along the value chain from Table 5.51, I find positive and significant cumulative abnormal acquirer returns for horizontal deals, insignificant cumulative abnormal returns for vertical deals and significant positive cumulative abnormal returns for other related deals (0.657%).[135]

Further, cumulative abnormal returns are calculated using the SIC classification of targets according to Table 5.52. Results are presented in Table 5.57. I find significantly positive cumulative abnormal acquirer returns for "Energy and Power", "Electric services" and for "other related utility businesses".[136] Returns for both, "Non-electric services" (within "Energy and Power") and the group of Non-"Energy and Power" targets, are found to be insignificant.[137] Positive cumulative abnormal acquirer returns are found for the acquisition of financial institutions, while negative cumulative abnormal returns are found for material businesses.

[133] Shows significance for t-test and Wilcoxon signed-rank test.
[134] Only t-test shows significance for the former group, while t-test and Wilcoxon signed-rank test are significant for the latter.
[135] Shows significance for t-test and Wilcoxon sign test.
[136] Shows significance for t-test and Wilcoxon signed-rank test.
[137] The latter is not congruent with my manually matched classification, as I manually differentiated among Non-"Energy and Power" businesses that are closely and *not* closely related to the core business, e.g. power plant construction services vs. unrelated construction services.

Moreover, Table A. 15 in the appendix presents further univariate statistics for the cumulative abnormal acquirer return. I find that there are positive cumulative abnormal returns for the most developed target home-countries and no significance for the acquirers of targets from less developed countries.[138] For U.S. target companies, cumulative abnormal acquirer returns are not significantly different from zero, while I find positive cumulative abnormal returns for non-U.S. target companies. Highest positive cumulative abnormal acquirer returns are found for acquirers of targets based in Australia and Asia. For several subsamples, cumulative abnormal acquirer returns can not be differentiated from zero, potentially due to their small sample size.

In a nutshell, from the above-mentioned statistics, one finds that horizontal and related deals lead to positive cumulative abnormal returns, while I find insignificant cumulative abnormal acquirer returns in vertical and unrelated deals.

[138] Shows significance for t-test and Wilcoxon signed-rank test. With reference to my sample, the group of most developed countries includes the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom and the Unites States. The group of less developed countries includes all other countries in the sample.

Table 5.56.: Abnormal acquirer returns in M&A with targets classified as generators, non-generators and along the value chain based on manually conducted classification

Category level I	Category level II	Number of observations	Mean abnormal return	t-test clustered by acquirer		Wilcoxon signed-rank test		Wilcoxon sign test
				t	P	Z	P	P
All								
	All deals	929	0.389%	2.97***	0.003	1.90*	0.057	0.131
Generator								
	Generators	407	0.308%	1.66*	0.099	0.92	0.358	0.692
	Non-generators	522	0.453%	2.56**	0.011	1.71*	0.087	0.105
Value chain perspective								
	Horizontal deals	407	0.308%	1.66*	0.099	0.92	0.357	0.692
	Vertical deals	143	0.151%	0.51	0.615	0.39	0.697	1.000
	Other related deals	128	0.657%	1.73*	0.088	1.02	0.307	0.093*
	Other unrelated deals	139	0.199%	0.74	0.465	0.55	0.584	0.349
	Others	112	0.921%	2.14**	0.036	1.42	0.156	0.704

This table reports descriptive statistics for the CUMULATIVE ABNORMAL ACQUIRER RETURN. The reported t-test, Wilcoxon signed-rank test and Wilcoxon sign test all test abnormal returns against zero. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

Table 5.57.: Abnormal acquirer returns in M&A with a target-classification derived from SIC code classification

Category level II	Category level III	Number of observations	Mean abnormal return	t-test clustered by acquirer		Wilcoxon signed-rank test		Wilcoxon sign test
				t	P	Z	P	P
Energy and Power		628	0.477%	2.97***	0.003	2.23**	0.025	0.139
	Electric services (∼ horizontal deals)	383	0.515%	2.48**	0.014	1.80*	0.071	0.443
	Non-electric services though Energy and Power (∼ vertical deals)	96	0.141%	0.4	0.692	-0.08	0.940	0.538
	Other related utility businesses	42	1.052%	1.87*	0.077	1.88*	0.060	0.280
	Others	...						
Non-"Energy and Power"		301	0.207%	0.92	0.359	0.02	0.873	0.645
	Financials	54	1.389%	2.13**	0.04	1.69*	0.091	0.076*
	Industrials	92	-0.212%	-0.89	0.381	-0.65	0.516	0.602
	High technology	32	1.273%	1.18	0.255	1.46	0.145	0.215
	Materials	42	-1.466%	-2.81***	0.009	-2.21**	0.027	0.088*
	Others	...						

This table reports descriptive statistics for the CUMULATIVE ABNORMAL ACQUIRER RETURN. The reported t-test, Wilcoxon signed-rank test and Wilcoxon sign test all test abnormal returns against zero. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

5.3.3.2.2. Two-sided Tests

In the foregoing section, I tested whether the cumulative abnormal acquirer returns of subsamples are different from zero. In this section, I test whether cumulative abnormal acquirer returns for these subsamples are significantly different from each other, i.e. can be separated statistically. Therefore, two-sided tests are required, i.e. a two-sided t-test and a two-sided Wilcoxon rank-sum test (also Mann-Whitney test).[139] I test the subsamples of electricity generating vs. non-generating targets, horizontal vs. vertical deals, “Energy and Power” (SIC classification) vs. Non-“Energy and Power” targets, “Electric services” vs. Non-“Electric services” targets, targets from most vs. less developed countries, and targets from U.S. vs. non-U.S. None of these pairs can be differentiated as reported in Table 5.58, neither by the two-sided t-test nor by the Wilcoxon rank-sum test.

Similarly, Becher, Mulherin and Walkling (2012) also do not find a significant difference for their definition of *horizontal* and *vertical* deals in the utility industry.

5.3.3.2.3. Diversification Effect Hypothesis

My **diversification effect hypothesis** is referring to a diversification effect within the group of horizontal deals, as it has been introduced in Section 3.3. In other words, I hypothesize that there is a substructure within the subsample of horizontal deals[140], that differentiates cumulative abnormal returns for diversifying vs. non-diversifying deals with regard to production technology.

As a test, I conduct univariate analyses applying all diversification measures as defined in Section 5.3.2.2. Obviously, in addition to the foregoing tests, the availability of production data of target and acquirer is required for this analysis. My sample is separated into subsamples at the median for these measures. For all subsamples, cumulative abnormal acquirer returns are tested against 0 and against each other. Finally, I find that these subsamples – independent of the diversification measure – are *not* significantly different from zero in univariate tests. Also, these subsamples can not be differentiated from each other, as Table 5.59 shows. This is in contrast to the **diversification effect hypothesis**. Consequently – at least for univariate tests – my hypothesis can not be confirmed.

Critically, I do not consider this being a proof for the non-existence of an effect of diversification on cumulative abnormal acquirer returns. In order to exclude such effect, the test design would have to be different, in such way that it shows significance for an inverse null-hypothesis.

[139] Before applying these tests, normality of cumulative abnormal returns in my sample was tested. Therefore, a skewness and kurtosis normality test, Shapiro-Wilk and Shapiro-Francia normality tests were used, as suggested by Royston (1993). The reason for testing normality is that the two-sided t-test requires normality, while the Wilcoxon rank-sum test does not.

[140] By “horizontal deals”, I refer to such deals where electricity generating companies buy other electricity generating companies. Acquirer and target companies can additionally be active in non-generating businesses.

Table 5.58.: Two-sided test for significant differences among subgroups

Category level I	Category level II	Category level III	t-test clustered by acquirer		Mann-Whitney test	
			t	**P**	**z**	**P**
Generator						
	Generators Non-generators		0.5554	0.5788	0.435	0.6632
Value chain perspective						
	Horizontal deals Vertical deals		-0.4332	0.665	-0.102	0.9189
Target-macro industry (SIC)						
	Energy and Power Non-"Energy and Power"		-0.9725	0.3311	-1.151	0.2498
	Electrical vs. Non-electrical services					
		Electric services (∼ horizontal deals) Non-electric services	-0.8085	0.419	-0.733	0.4637
Developed country target						
	Most developed countries Less developed countries		0.2591	0.7956	-0.049	0.961
U.S. vs. Non-U.S. target						
	U.S. Non-U.S.		0.2507	0.8021	0.539	0.5898

This table reports descriptive statistics for the CUMULATIVE ABNORMAL ACQUIRER RETURN. The reported test all provide two sided testing of abnormal returns. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

Table 5.59.: Abnormal acquirer returns in M&A in dependence of diversification in production for different diversification measures

		Obs.	Mean abnormal return	t-test clustered by acquirer		Wilcoxon signed-rank test		Wilcoxon sign test	t-test clustered by acquirer		Mann-Whitney test	
				t	P	Z	P	P	t	P	z	P
Δ Herfindahl (Tech)	>= median	121	0.098%	0.29	0.771	0.301	0.763	1.000	0.493	0.623	0.628	0.530
	< median	122	-0.119%	-0.36	0.720	-0.581	0.561	0.651				
Δ Herfindahl (Base)	>= median	121	0.014%	0.04	0.969	0.242	0.809	1.000	0.113	0.910	0.573	0.567
	< median	122	-0.036%	-0.11	0.911	-0.538	0.591	0.786				
Δ Herfindahl (Cluster)	>= median	121	0.151%	0.41	0.683	0.762	0.446	0.363	0.735	0.463	1.367	0.172
	< median	122	-0.171%	-0.60	0.551	-1.171	0.241	0.174				
Div. Dummy (tech)	=1 (Diversifying)	75	-0.214%	-0.40	0.692	-0.570	0.569	0.645	-0.446	0.656	-0.421	0.674
	=0 (Concentrating)	182	-0.007%	-0.03	0.978	-0.248	0.804	0.711				
Div. Dummy (base)	=1 (Diversifying)	45	-0.509%	-0.76	0.452	-1.146	0.252	0.371	-0.963	0.336	-1.201	0.230
	=0 (Concentrating)	212	0.026%	0.11	0.912	0.007	0.995	0.837				
Div. Dummy (cluster)	=1 (Diversifying)	41	-0.785%	-1.07	0.296	-1.665	0.096*	0.060*	-1.484	0.139	-1.613	0.107
	=0 (Concentrating)	216	0.069%	0.31	0.759	0.188	0.851	0.946				
Δ Entropy (Tech)	>= median	123	-0.028%	-0.09	0.928	-0.497	0.619	0.589	-0.080	0.936	-0.427	0.669
	< median	120	0.007%	0.02	0.985	0.139	0.890	0.927				
Δ Entropy (Base)	>= median	123	-0.032%	-0.10	0.919	-0.437	0.662	0.857	-0.096	0.923	-0.440	0.660
	< median	120	0.011%	0.03	0.977	0.165	0.869	0.927				
Δ Entropy (Cluster)	>= median	123	-0.154%	-0.54	0.589	-0.944	0.345	0.279	-0.662	0.509	-1.123	0.262
	< median	120	0.136%	0.38	0.708	0.613	0.540	0.523				
Tech. related. (Jaffe)	>= median	128	-0.043%	-0.13	0.897	-0.243	0.808	0.791	0.113	0.910	0.164	0.869
(Tech)	< median	129	-0.091%	-0.31	0.761	-0.556	0.578	0.598				
Tech. related. (Jaffe)	>= median	128	-0.366%	-1.03	0.309	-1.032	0.302	0.185	-1.412	0.159	-1.049	0.294
(Base)	< median	129	0.229%	0.93	0.354	0.311	0.755	0.725				
Tech. related. (Jaffe)	>= median	128	0.048%	0.14	0.892	0.540	0.589	0.426	0.546	0.586	1.353	0.176
(Cluster)	< median	129	-0.182%	-0.74	0.462	-1.440	0.150	0.078*				

This table reports descriptive statistics for the CUMULATIVE ABNORMAL ACQUIRER RETURN. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

5.3.3.3. Multivariate Cumulative Abnormal Acquirer Return Analyses

In this section, multivariate OLS regressions are conducted in order to identify the determinants of cumulative abnormal acquirer returns from M&A deal announcements. *First*, typical determinants of cumulative abnormal acquirer returns are included as independent variables. *Second*, diversification measures are added as further potentially relevant determinants of cumulative abnormal acquirer returns.

The set of control variables of cumulative abnormal acquirer returns included in my analysis is similar to parts of the literature, as discussed in Section 2.3. However, I do not include any target related accounting data, as such data is not available for my target companies, since they are not necessarily listed.

5.3.3.3.1. Determinants of Cumulative Abnormal Acquirer Returns

In order to identify the relevant determinants of cumulative abnormal acquirer returns by OLS regression analysis, my set of control variables includes the acquirer's size, market-to-book, headquarters dummy, relative company equity size, tender dummy, toehold dummy and % of shares acquired dummy. This is similar to the multivariate analyses of, e.g., Faccio, McConnell and Stolin (2006). Furthermore, I include the acquirer's leverage (e.g. Baker et al. (2012) or Lin, Officer and Zou (2011)). Definitions of all variables are given in Table 5.54.

From my OLS regressions in Table 5.60, I find that acquirer size and tender dummy are relevant determinants of cumulative abnormal acquirer returns. Results remain mainly unchanged when instead of clustering by acquirer (model I), I cluster by acquirer and acquirer country (model II), acquirer and year (model III), acquirer and target country[141] (model IV) and acquirer, acquirer country and year (model V), in order to control for cross-correlations.
Size behaves as expected according to, e.g., Faccio, McConnell and Stolin (2006) and Cai and Sevilir (2012), i.e. cumulative abnormal returns are smaller for larger acquirers.
The tender dummy indicates that cumulative abnormal acquirer returns are negatively affected from deals being induced by a tender offer.

Additionally, I included the number of bidders and a crisis dummy as independent variables in robustness tests. For both variables I find significance for a positive effect on cumulative abnormal returns.[142]

141 Cf. e.g. Ahern, Daminelli and Fracassi (2012)

142 Results are not reported here. I do not include these variables in my standard regression analysis, as they are only infrequently included in M&A cumulative abnormal return regressions. If they are included in the calculations in Table 5.61, these variables become insignificant.

Table 5.60.: Determinants of abnormal acquirer event returns

	I	II	III	IV	V
Relative company equity	1.43	1.43	1.43	1.43	1.43
size acqu./ target	(0.20)	(0.14)	(0.18)	(0.17)	(0.14)
Size [acquirer]	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(-3.88)	(-5.79)	(-4.26)	(-5.07)	(-5.00)
Market leverage [acquirer]	0.013	0.013	0.013	0.013	0.013
	(0.97)	(1.07)	(0.96)	(0.95)	(0.91)
Market-to-book [acquirer]	-0.00029	-0.00029	-0.00029	-0.00029	-0.00029
	(-0.28)	(-0.26)	(-0.23)	(-0.25)	(-0.20)
% of shares acquired	0.0023	0.0023	0.0023	0.0023	0.0023
	(0.51)	(0.75)	(0.41)	(0.61)	(0.45)
Toehold dummy	0.000062	0.000062	0.000062	0.000062	0.000062
	(0.012)	(0.015)	(0.0097)	(0.013)	(0.0090)
Country of headquarters	0.0031	0.0031	0.0031	0.0031	0.0031
dummy	(0.63)	(0.55)	(0.75)	(0.72)	(0.61)
Tender dummy	-0.022***	-0.022**	-0.022**	-0.022***	-0.022*
	(-2.60)	(-2.17)	(-2.08)	(-2.77)	(-1.96)
Constant	0.064**	0.064***	0.064***	0.064***	0.064***
	(2.51)	(3.00)	(3.04)	(3.55)	(3.27)
Observations	605	605	605	605	605
Adjusted R^2	0.17	0.17	0.17	0.17	0.17

The dependent variable is the CUMULATIVE ABNORMAL ACQUIRER RETURN. Models are calculated as OLS regressions. Year and country dummies are included in all models. T-statistics based on standard errors with clustering at the level of acquirer firm (model I), acquirer and acquirer country (model II), acquirer and year (model III), acquirer and target country (model IV) and acquirer, acquirer country, and year (model V) are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.1. The respective event window is has a length of three days symmetric around the event date.

5.3.3.3.2. Diversification as a Determinant of Cumulative Abnormal Acquirer Returns

In order to address the effect of diversification in production, I add the diversification measures as defined in Section 5.3.2.2, which are based on production technology data, as additional independent variables. Results are presented in Table 5.61.

I find that none of the diversification measures – i.e. neither Δ Herfindahl, nor the diversification dummy, nor Δ Entropy nor Technological Relatedness (Jaffe) show any significant effect on the cumulative abnormal return. Results are reported separately for the granularity levels “Tech” (L1) and “Cluster” (L3), however, they are similarly insignificant for “Base” (L2).[143]

Consequently, as for the univariate analyses, I find that the missing effect of diversification on cumulative abnormal acquirer returns does not support the **diversification effect hypothesis**, i.e. the null hypothesis that diversification has no impact on cumulative abnormal acquirer returns can *not* be rejected.

If diversification measures are included, only size shows to be a significant determinant of the cumulative abnormal return with a negative sign, as expected from the literature. All other variables are insignificant.

In order to find an effect from diversification, I conducted several additional tests, e.g. controlling for primary SIC codes of targets in addition to or instead of production diversification measures. None of these settings shows a significant impact of diversification on cumulative abnormal acquirer returns.[144]

As an alternative method to investigate the effect of diversification on market capitalization, I also analyzed the effect of diversification on Tobin’s Q, especially by using Fixed Effects regressions. Significance of diversification in regressions on the market-to-book ratio could indicate an effect of diversification on market value.[145] However, such test based on annual data might be weaker compared to using daily return data in a M&A study. Finally, as in the event study design, also this test based on annual data does *not* show any significance for an influence of my diversification measures on market value.[146]

5.3.3.4. Diversification as Criterion in Target Selection

In this section, I analyze whether acquirers with specific characteristics differ in their propensity to acquire and whether they choose targets with specific characteristics, e.g. with specific production technologies. Especially, I concentrate on the question whether acquirers tend to diversify or concentrate by M&A transactions depending on the a priori diversification of their electricity generation portfolio.

Since for this purpose I conduct logit calculations, the data structure for such analyses needs

[143] Results for L2 are not explicitly reported here.
[144] Results are not explicitly reported here.
[145] Significance in Fixed Effects regressions derives from variation in the longitudinal dimension of data, i.e. from the variation of a company’s diversification over time. Similarly, abnormal returns in an M&A event study derive from the change of the respective determinants at the time of the event.
[146] Results are not explicitly reported here.

Table 5.61.: Impact of diversification on abnormal acquirer event returns

	Ia	Ib	IIa	IIb	IIIa	IIIb	IVa	IVb
Δ Herfindahl (Tech)	-0.015							
	(-0.61)							
Δ Herfindahl (Cluster)		0.033						
		(0.66)						
Div. Dummy (tech)			-0.00061					
			(-0.071)					
Div. Dummy (cluster)				0.0015				
				(0.12)				
Δ Entropy (Tech)					-0.010			
					(-0.47)			
Δ Entropy (Cluster)						-0.014		
						(-0.48)		
Tech. related. (Jaffe) (Tech)							-0.017	
							(-1.61)	
Tech. related. (Jaffe) (Cluster)								-0.014
								(-1.02)
Relative company equity size acqu./ target	-11.3	-8.60	-10.7	-10.9	-9.12	-9.26	-6.52	-7.27
	(-0.87)	(-0.57)	(-0.81)	(-0.79)	(-0.59)	(-0.61)	(-0.59)	(-0.56)
Size [acquirer]	-0.011**	-0.012**	-0.011***	-0.011***	-0.012**	-0.012**	-0.012***	-0.012***
	(-2.51)	(-2.50)	(-2.59)	(-2.58)	(-2.54)	(-2.52)	(-2.67)	(-2.58)
Market leverage [acquirer]	0.037	0.037	0.036	0.036	0.037	0.037	0.033	0.032
	(1.49)	(1.54)	(1.52)	(1.56)	(1.54)	(1.57)	(1.42)	(1.45)
Market-to-book [acquirer]	0.0017	0.0012	0.0016	0.0016	0.0014	0.0014	0.0014	0.0017
	(0.69)	(0.52)	(0.60)	(0.65)	(0.59)	(0.58)	(0.55)	(0.64)
% of shares acquired	0.0043	0.0015	0.0029	0.0033	0.0020	0.0018	0.0043	0.0051
	(0.50)	(0.19)	(0.35)	(0.39)	(0.24)	(0.22)	(0.53)	(0.63)
Toehold dummy	-0.0062	-0.0076	-0.0069	-0.0066	-0.0076	-0.0075	-0.0031	-0.0036
	(-0.62)	(-0.81)	(-0.67)	(-0.68)	(-0.81)	(-0.79)	(-0.29)	(-0.33)
Country of headquarters dummy	-0.014	-0.012	-0.013	-0.013	-0.012	-0.012	-0.015	-0.015
	(-1.40)	(-1.41)	(-1.33)	(-1.44)	(-1.38)	(-1.43)	(-1.62)	(-1.58)
Tender dummy	0.0080	0.0060	0.0079	0.0081	0.0064	0.0066	0.0099	0.0078
	(0.70)	(0.47)	(0.71)	(0.72)	(0.52)	(0.53)	(0.86)	(0.72)
Constant	0.19***	0.20***	0.21***	0.20***	0.20***	0.20***	0.22***	0.21***
	(2.68)	(2.67)	(2.63)	(2.73)	(2.70)	(2.68)	(2.67)	(2.67)
Observations	164	164	164	164	164	164	164	164
Adjusted R^2	0.35	0.36	0.35	0.35	0.35	0.35	0.38	0.37

The dependent variable is the CUMULATIVE ABNORMAL ACQUIRER RETURN. Models are calculated as OLS regressions. Year and country dummies and a constant are included in all models. T-statistics based on Huber/ White standard errors with clustering at the firm level are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.1. The respective event window has a length of three days symmetric around the event date.

to be rearranged in comparison to the aforementioned OLS analysis. For my logit analyses[147], the information on all M&A deals conducted by an acquirer during a given year – including same-date deals of a given company, that had been excluded before – are aggregated to one single acquirer-year observation. Different from foregoing analyses, capital market return data is not required.

First, I analyze which companies are more likely to become an acquirer at least once within a year, i.e. their propensity to acquire. As the basis for this analysis, I refer to the complete sample of listed electric utility companies, i.e. the sample of companies my capital structure analysis is based on.[148] However, I exclude all companies that did *not* conduct at least one deal between 2003 and 2010.[149]

The dependent variable is a dummy variable that equals 1 if the number of deals in a given company-year is larger than zero, and equals 0 if this number of deals equals zero. I control for typical acquirer variables according to the “propensity to acquire”-analysis of Caprio, Croci and Del Giudice (2011), i.e. size, tangible assets ratio, cash holdings, market leverage, return on assets and sales growth. Furthermore, year dummies are included.

Table 5.62 reports results for logit and probit calculations. I find significance for a positive effect from the independent variable company size and a negative effect from market leverage, i.e. the probability that a company conducts at least one acquisition in a given year increases with increasing firm size and decreases with increasing market leverage. For example, Caprio, Croci and Del Giudice (2011) consistently find for their analysis of the propensity to acquire that size is positively linked to the propensity to acquire. Further, they find a negative effect from the tangible assets ratio and a positive effect from return on assets and sales growth.[150]

Second, I measure whether companies – depending on their diversification in production technologies – tend to further diversify or specialize in production technologies by their M&A deals; i.e. the propensity to diversify.[151]

Measuring the decision to diversify or not to diversify is special. A *first* option might be to choose the diversification of the acquirer as an independent variable and the diversification of the target as the dependent variable. However, as the acquirer might be an undiversified nuclear power generator and the target company might be an undiversified wind power generation company, such intra-industry deal would be highly diversifying regarding production technology, while both companies considered separately are undiversified (i.e. specialized).

A *second* and more convincing option is to use the change in the acquirer diversification induced by the deal as the dependent variable, i.e. the diversification effect of the target on the acquirer.[152] The two measures Δ Entropy and Δ Herfindahl are reasonable measures for my

147 Cf. e.g. Baum (2006) for further details on logit and probit analyses.

148 Cf. Section 4

149 I do so in order to make sure that the company was successfully matched to SDC Platinum and that such company’s deals should generally be included in the database. However, if I also include those companies that conducted no deal at all, the size effect, that is reported in Table 5.62, remains significant. Further, I find a positive effect from ROA but no effect from market leverage in such case.

150 Cf. Caprio, Croci and Del Giudice (2011), p.1664

151 For the avoidance of doubt, I point out that I clearly do *not* address whether “more concentrated acquirers tend to acquire more diversified targets”.

152 As explained above, such change in diversification does not equal the diversification of the target itself,

regression analyses, as they can be used for measuring the diversification of the stand-alone acquirer as well as the diversification effect of the target on the acquirer.[153,154]

Table 5.62.: Propensity to acquire (logit and probit models)

	Logit # deals > 0	Probit # deals > 0
Size [Acqu.]	0.17***	0.100***
	(2.65)	(2.69)
Tangibility [Acqu.]	0.25	0.18
	(0.35)	(0.44)
Cash holdings [Acqu.]	2.20	1.35
	(1.42)	(1.47)
Market leverage [Acqu.]	-1.28**	-0.80**
	(-2.02)	(-2.13)
Market-to-book [Acqu.]	-0.010	-0.0059
	(-0.15)	(-0.14)
ROA [Acqu.]	1.95	0.91
	(0.93)	(0.77)
Sales growth [Acqu.]	0.13	0.079
	(0.84)	(0.90)
Constant	-3.54***	-2.05***
	(-3.07)	(-3.14)
Observations	694	694
R^2 (pseudo)	0.033	0.033
Clustering	Acqu.	Acqu.

All models are logit models. Year dummies are included in all models. T-statistics based on Huber/ White standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

Consequently, I derive the dependent variable of my analyses from the average "diversification effect of the target on the acquirer" by separating at its mean value into "more diversifying" and "less diversifying/ concentrating" deals. In addition to the set of independent variables presented above, the (a priori) diversification of the acquirer is used as the respective independent variable.

Empirically, I find significance for all diversification measures. Results imply that acquirers with a higher Herfindahl measure tend to reduce their Herfindahl, while, in contrast, acquirers with a high entropy measure tend to increase their entropy. These results contradict each other.[155] One might claim critically, that the effect of the "diversification of the acquirer" on the "diversification effect of the target on the acquirer" might lead to somewhat trivial results. One may argue, e.g., that a company owning only one production technology is a priori more

but is calculated from difference of the combined company's diversification minus the acquirers a priori diversification.

153 The two measures technological relatedness and diversification dummy can only relate both technology portfolios, while they can not measure the acquirer's diversification separately.

154 My measure for the "diversification effect of the target on the acquirer" is noisy, as I can only aggregate those deals to an average "diversification effect of the target on the acquirer" per firm-year, for which acquirer and target production characteristics are available. If this data is not available for single deals, I excluded such deals but nevertheless calculated the "diversification effect of the target on the acquirer" from all other deals in the firm-year. Although it would be more precise to only include such firm-years with complete acquirer and target production data for all deals, this would significantly reduce the number of observations.

155 Results are not explicitly reported here.

likely to diversify than to concentrate, because while only this one production technology would lead to a specialization, all other production technologies diversify such company. Consequently, there might be a more or less self-fulfilling relation between such acquirers' a priori diversification and the change in diversification in such way, that less diversified acquirers change their diversification more drastically by M&A deals compared to a priori stronger diversified acquirers. Nevertheless, one might hypothesize that an acquirer does not randomly choose its target but still selects consciously. In order to test such effect, I exclude all acquirers with Herfindahl of 1, i.e. fully concentrated acquirers, and I cut all observations from the upper and lower 20% of the entropy measure, separately for each measure. As a consequence, significance for the acquirer's a priori diversification almost completely disappears, though it would still have to hold for this subsample. *In a nutshell*, I find *no* connection between the diversification of an acquirer's generation portfolio and the diversification effect of targets on the acquirer. In other words, there is *no* evidence that acquirers systematically select more or less diversifying targets depending on the acquirer's own diversification in their M&A decisions.[156]

5.3.3.5. Other Related Analyses

Further, I tested whether M&As are closely linked to the capital structure. *First*, I tested whether M&A decisions are relevant determinants of leverage, as defined in Section 5.1. *Second*, I tested whether M&A decisions are relevant determinants of the debt maturity structure, as defined in Section 5.2. For both tests, all M&A deals of each firm-year were aggregated to a single data point per firm-year. None of these analyses showed any significance.[157]

Finally, I conducted logit analyses in order to test whether the acquirers' production characteristics – especially production flexibility and the remaining lifetime of assets – are systematically related to the targets' production flexibility and its remaining lifetime of assets.[158] I found no significance for such relation either.[159]

5.3.4. Summary and Implications

In this section, I studied whether the capital market reacts differently to the announcement of diversifying vs. non-diversifying deals. Further, I analyzed whether companies diversify or concentrate by conducting M&A deals.

Based on a sample of electric utility companies, I found that, overall, M&A transactions in the utility industry result in positive cumulative abnormal acquirer returns. While horizontal deals (here defined as the acquisition of an electricity generating target by an electricity generating acquirer) on average result in positive cumulative abnormal returns of about 0.308%, vertical deals on average show no cumulative abnormal returns significantly different from zero.

[156] Results are not explicitly reported here.
[157] Results are not explicitly reported here.
[158] One could expect that companies buy more flexible assets if they a priori own less flexible assets. Also, one could expect that there are companies that are specialized to construct power plants and others that are specialized to operation and maintenance of older power plants. In such case, one could expect an effect of the remaining lifetime.
[159] Results are not explicitly reported here.

Nevertheless, the acquirers' cumulative abnormal event returns in vertical and horizontal deals finally cannot be differentiated statistically.
Further, no significance was found for a positive effect of diversification in production technologies on cumulative abnormal acquirer returns, though one could have expected a positive effect for several reasons, e.g. from operating synergies, economies of scope and a coinsurance effect (against price peaks in single commodities/fuels).
Further, I also do not find significance for an effect of acquirer diversification on target selection.

6. Conclusion

This chapter summarizes the main findings. Further, the contribution to the existing literature and implications for practitioners and regulators are recapitulated. Finally, avenues for future research are provided.

6.1. Summary of Results

There are three major research areas addressed in this thesis:

First, I analyze the impact of production flexibility on leverage. Theory suggests that production flexibility is positively related to debt capacity, and thereby leverage (Mauer and Triantis (1994)). This is due to two effect: *First*, production flexibility supports debt capacity by allowing to avoid production at negative profit margins, and *second*, there is a tax effect from the increased value of the tax shield due to increased leverage. Further, theory argues that production flexibility and financial flexibility act as substitutes. However, to my best knowledge, there is no direct empirical proof confirming these theoretical suggestions. This thesis closes this gap based on data derived from the production asset level. Further, I applied the exogenous shocks of privatization and deregulation of the utility industry in order to proof causality between production flexibility and the dependent variable leverage. Among others, exogenous shocks on financial flexibility are applied as robustness tests to show the substitution effect of production flexibility and financial flexibility. Moreover, I demonstrate that the behavior of the capital structure is consistent with the expected effect from the operating leverage (e.g. Kahl, Lunn and Nilsson (2011) and Kuzmina (2012)). Empirically, I confirm that a higher share of variable costs supports higher leverage.

Second, I study the impact of the remaining lifetime of production assets on debt maturity, and the effect of a mismatch of debt and asset maturity on the relative yield spread of new debt at issuance. There is "conventional wisdom" that the maturity of a company's debt matches the maturity of its assets. To my best knowledge, there is no study using a consistent, direct measure for the maturity of a company's assets. I theoretically show that the existing "Net PP&E divided by Annual Depreciations"-measures are invalid proxies of asset maturity. Especially these measures assume that all assets included in Net PP&E have equal remaining lifetimes, that these assets are depreciated linearly and that their depreciation period is congruent with the lifetime of assets. I avoid such invalid assumptions and close the gap of a missing empirical proof with a consistent measure by using a direct measure of asset maturity. In accordance with theoretical arguments and the "conventional wisdom", I find that asset maturity and debt maturity match.

Moreover, I contribute to the literature by showing that a mismatch of debt and asset maturity – i.e. either too short or too long debt maturity in comparison to asset maturity – leads to higher relative debt yield spreads at issuance of public debt. This is – in the case of longer debt in comparison to asset maturity – caused by running out of collateral, and – in the case of longer asset maturity in comparison to debt maturity – by liquidity risk and the potential loss of control rents due to liquidation of debt holders with shorter debt maturity.

Further, I show that salability of production assets positively affects leverage and debt maturity, as Benmelech (2009) suggested.

Third, I investigate whether there are cumulative abnormal acquirer returns specifically from diversification in production technologies in horizontal M&A deals. The analysis shows no significance for such effect in horizontal M&A deals, neither in univariate nor in multivariate tests. Analyses were conducted for multiple diversification measures, e.g. relatedness of technology portfolios of acquirer and target, entropy measure, Herfindahl index, and a dummy measure.

6.2. Major Contributions to the Academic Literature

In a nutshell, this thesis demonstrates that production characteristics are relevant determinants in corporate finance decision making. The sample used in this thesis is a hand collected production asset-level database. My analyses break ground for further analysis on the asset level. The strong impact from production characteristics is consistent with recent expectations from the capital structure literature (e.g. Gamba and Triantis (2008), Lemmon, Roberts and Zender (2008), Rauh and Sufi (2012) and Leary and Roberts (2013)). The major contributions to the academic literature are, to my best knowledge, as follows:

First, while there is evidence that production flexibility influences the capital structure and that production flexibility and financial flexibility are substitutes, literature lacks an empirical proof. This thesis provides the missing proof by using direct production flexibility measures derived bottom-up from the asset level. My results confirm the theoretical predictions of Mauer and Triantis (1994). In contrast, they differ from the empirical findings of MacKay (2003) for different reasons.

Second, this thesis is the first to rigorously address the matching of debt and asset maturity. It theoretically and empirically shows, that established measures are invalid proxies of debt maturity, and uses direct asset maturity measures in order to demonstrate that companies match their debt and asset maturity in accordance with the "conventional wisdom".

Third, the empirical result, that the yield spread of debt at issuance increases with a mismatch of debt and asset maturity, is another argument for companies to match maturities. To my best knowledge, this empirical finding is also new to the literature.

6.3. Relevance for Practitioners and Implications for Regulators

6.3.1. Relevance for Practitioners

As mentioned before, this thesis is also relevant to practitioners as it provides them with guidance for their capital structure and M&A decisions in dependence of their production asset characteristics. Especially for practitioners in the utility industry, results can be used as benchmarks in dependence of production flexibility, asset age, regional diversification of assets, remaining lifetime of assets, asset salability, and diversification in production technologies. *First*, formulas for the choice of leverage and debt maturity are given. *Second*, an empirical formula for the yield spread of debt at issuance is provided. *Third*, on average, practitioners in the utility industry should expect positive cumulative abnormal acquirer returns form (horizontal) M&A transactions, however, those seem to be independent of a diversification on the level of production characteristics.

6.3.2. Implications for Regulators

First, regulators might consider to support companies' production flexibility especially in times of financing constraints, since production flexibility and financial flexibility act as substitutes. *Second*, regulators should strive for stable policies with regard to production assets, as unexpectedly shortening the remaining lifetime of assets by regulatory changes might lead to a mismatch between debt and asset maturity, and finally, to increased yield spreads of debt, i.e. to increased financing costs.

6.4. Challenges for Future Research

It was shown that future capital structure research should include production asset characteristics as relevant determinants of capital structure analyses. Future research should discuss whether there are other corporate policy decisions, which are significantly influenced by production characteristics.

Furthermore, the analyses discussed in this thesis could be extended to cross industry samples using detailed production data from the asset level. Though it was shown that the determinants of leverage behave similar to cross industry samples, such direct extension of the sample would even stronger support the generalizability of the findings to other industries.

Concerning the debt maturity choice, future research might contribute an empirically proven causality argument, which could only be suggested in this thesis. Time will presumably provide an opportunity to use these recent events in adequate tests.

Also, future research might show how fast debt maturity adapts to asset maturities that are changed by external shocks on the future economic value or on the remaining lifetime of assets.[1]

Finally, the question, whether cumulative abnormal acquirer returns in horizontal M&As systematically depend on diversification in production characteristics, might be extended to

[1] The theoretical work of Hart and Moore (1994) could be an interesting starting point for such analysis.

non-utility industries. It might also be extended to other non-production steps of the value chain, in order to further analyze the origin of an effect of diversification beyond the company or segment level.

A. Appendix

A.1. Non-U.S. NYSE Utility Companies

Table A. 1.: Non-US utility companies listed at the NYSE sorted by listing date

Name	Listing date	Country of origin
Enersis S.A.	20.10.1993	Chile
Korea Electric Power Corporation	27.01.1994	South Korea
Endesa Chile	27.07.1994	Chile
Huaneng Power International, Inc.	06.10.1994	China
Companhia Paranaense de Energia (COPEL)	30.07.1997	Brazil
TransAlta Corporation	31.07.2001	Canada
Veolia Environnement	05.10.2001	France
Companhia de Saneamento Basico do Estado de Sao Paulo-SABESP	10.05.2002	Brazil
CPFL Energia S.A.	29.09.2004	Brazil
National Grid plc	01.08.2005	United Kingdom
Empresa Distribuidora y Comercializadora Norte S.A.	26.04.2007	Argentina
Companhia Energética de Minas Gerais - CEMIG	12.06.2007	Brazil
Centrais Eletricas Brasileiras S.A. - Eletrobras	31.10.2008	Brazil
Pampa Energía S.A.	09.10.2009	Argentina
China Hydroelectric Corporation	25.01.2010	China
Atlantic Power Corporation	23.07.2010	Canada
Cascal N.V.	— *delisted* —	

Non-US utilities companies listed at the NYSE according to NYSE Euronext (2013) and in contrast to NYSE ARCA, NYSE Euronext and NYSE Alternext.

A.2. Owner- and Operatorship of Power Plants in the U.S.

In this section, the potential inequality of plant owner and operator is discussed. It is argued that the WEPP Platts database item COMPANY can be interpreted as the owner and that a potential error from COMPANY being the operator is small. This is due to the fact, that the owner and the operator of a power plant mostly are – at least as it is shown here for the U.S. – identical companies.

For the U.S., data availability concerning power plants and electricity statistics is comparably good. Besides other information, the name of the plant operator and the ownership shares of all power plant owners are available from the U.S. Environmental Protection Agency[1] in the so-called *Emissions & Generation Resource Integrated Database (E Grid)*. In this section, I calculate several statistics based on this database.

Analyzing the power plant data for the U.S. for 2007, one finds according to table A. 2, that the operator actually is the majority owner in approximately 90% of the power plants. As shown

[1] www.epa.gov

in Table A. 3, these majority owner/ operators hold approximately 84% of the respective power plant capacities.

Consequently, power plant operators are mostly identical with majority owners, holding a high ownership share.

Table A. 2.: Shareholdings of plant operators by number of plants in the US

Share	Number of operator-shareholders	
Majority	4,635	89,6%
Largest minority shareholder	222	4,3%
Small minority shareholder	315	6,1%
Total	5,172	100,0%

Table A. 3.: Shareholdings of plant operators by capacity in the US

Share	Capacity of operator-shareholders (in MW)	
Majority	910,622	83.7%
Largest minority shareholder	86,333	7.9%
Small minority shareholder	91,251	8.4%
Total	1,088,205	100.0%

The available U.S.-data also allows to test the issue of joint plant ownership. It is obvious from Table A. 4, that more than 90% of the plants are owned solely by one company. Small ownership shares are comparably uncommon.

The consideration of generation capacity shows that about 90% of the power plants and approximately 80% of the overall power plant capacity is owned by 100%-owners. Consequently, especially large plants, in contrast to small plants, are more frequently jointly owned by more than one company.

These results show that a potential bias from joint plant ownership in my data, that might not be captured during the matching procedure as described in Section 4.2, is expected to be small.

Table A. 4.: Number of owners and capacity by share of ownership (incl. majority and minority owners)

Ownership share	Number of power plant owners		Capacity (in MW)	
	abs.	rel.		
0,0%	57	1,1%	33.488	3,1%
>10,0%	36	0,7%	25.856	2,4%
>20,0%	30	0,6%	21.353	2,0%
>30,0%	48	0,9%	22.324	2,1%
>40,0%	39	0,8%	20.303	1,9%
>50,0%	168	3,2%	38.344	3,5%
>60,0%	23	0,4%	8.731	0,8%
>70,0%	23	0,4%	17.018	1,6%
>80,0%	35	0,7%	19.416	1,8%
>90,0%	17	0,3%	13.732	1,3%
100,0%	4.696	90,8%	867.639	79,7%
Total	5.172	100,0%	1.088.205	100,0%

The number of power plant owners is counted separately for each plant.

A.3. Sample Construction[2]

Table A. 5.: Companies to be consolidated in the matched sample

Name	Thomson One Banker ID	Entity name
Alinta		
	C000073812	Alinta Limited
	C901875279	Alinta Infrastructure Holdings
	C902430813	Alinta Limited
	C902455657	Alinta Energy Group
Aquila Inc		
	C000004768	Aquila Inc
	C000076548	Aquila Inc
Bergesen D.Y. ASA		
	C901930635	Bergesen D.Y. ASA
	C000043457	Bergesen D.Y. ASA - ADR
British Energy		
	C901460931	British Energy PLC
	C000017169	British Energy Group PLC
YTL		
	C000033099	YTL Power International Berhad
	C000088959	YTL Corp. Berhad
Midamerican Energy		
	C000000859	Midamerican Energy Holdings Company
	C000003080	Midamerican Energy Company
American Water Works Company Inc		
	C902963367	American Water Works Inc
	C902963372	American Water Works Company Inc
Nstar		
	C000000714	Nstar
	C902485900	Nstar Electric Company
Interregional Distribution Grid		
	C902987274	Interregional Distribution Grid Company
	C902996321	Interregional Distribution Grid Company

For these companies matched capacities are aggregated. For some of these companies Thomson Identifiers represent the same company.

2 This section is largely based on Reinartz and Schmid (2013).

Table A. 6.: Companies to be finally excluded from the matched sample

Name	Thomson One Banker ID	Entity name
United Energy		
	C000039195	United Energy A.S.
	C000042794	United Energy Limited
Energy Development		
	C900418825	Energy Development Corp.
	C900609901	Energy Development Company Limited
Edison		
	C000009535	Edison
	C902936946	Edison SPA
Energy		
	C000024828	Energy Inc
	C000041681	Energy Limited
	C000065028	NV Energy Inc
	C901366089	Energy Group PLC (The)

Companies that are excluded since their names can not be differentiated.

A.4. Calculation of Company Specific Production Data[3]

To further clarify how the main variables are constructed, I provide an example. For the following example, I assume the existence of a company X with the following power plant portfolio in the year 2008:

Plant	**Capa**	**Technology**	**COD**	**Category**	**Run-up**	**Ramp-up**
Name	MW	n/a	year [y]	n/a	hours [h]	€/MW
A	6	Wind	2006	Stochastic	0	0
B	100	Biomass	1990	Base-load	2.00	46.96
C	2,000	Nuclear	1980	Base-load	40.00	132.92
D	1,000	Gas	1975	Peak-load	0.25	32.22
E	1,500	Gas	1990	Peak-load	0.25	32.22

First, I calculate the base-load, mid-load, peak-load, and stochastic capacity, as explained in Section 5.1.2. I find the following values for company X in 2008:

[3] This section is largely based on Reinartz (2013).

$$\begin{aligned}
\text{Base-load capacity}[\%]_X &= \frac{\sum_{\text{base}} \text{Capacity}_{\text{base}}}{\text{Total Capacity}} = \frac{(100+2,000)\text{MW}}{4,606\text{MW}} \approx 45,6\% \\
\text{Mid-load capacity}[\%]_X &= \frac{\sum_{\text{mid}} \text{Capacity}_{\text{mid}}}{\text{Total Capacity}} = \frac{0\text{MW}}{4,606\text{MW}} = 0\% \\
\text{Peak-load capacity}[\%]_X &= \frac{\sum_{\text{peak}} \text{Capacity}_{\text{peak}}}{\text{Total Capacity}} = \frac{(1,000+1,500)\text{MW}}{4,606\text{MW}} \approx 54,3\% \\
\text{Stochastic capacity}[\%]_X &= \frac{\sum_{\text{stochastic}} \text{Capacity}_{\text{stochastic}}}{\text{Total Capacity}} = \frac{6\text{MW}}{4,606\text{MW}} \approx 0,0\%
\end{aligned}$$

Second, run-up time is defined as the average run-up time of all power plants in the company's portfolio. Each power plant is weighted by its capacity. The run-up time of each power plant is based on its technology and given in Table 4.2. Thus, the variable run-up time for firm X in 2008 is calculated as follows:

$$\begin{aligned}
\textsc{Run-up time}_X &= \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Run-Up Time}_k}{\text{Total Capacity}}. \\
&= \frac{(6\cdot 0 + 100\cdot 2 + 2,000\cdot 40 + (1,000+1,500)\cdot 0.25)\text{MW}\cdot h}{(6+100+2,000+1,000+1,500)\text{MW}} \\
&= \frac{80,825\text{MW}\cdot h}{4,606\text{MW}} = 17.55h
\end{aligned}$$

Third, ramp-up costs are calculated in the same way as run-up time. The only difference is that ramp-up costs are used in the above formula instead of run-up times.

$$\begin{aligned}
\textsc{Ramp-up costs}_X &= \frac{\sum_{k=1}^{M} \text{Capacity}_k \cdot \text{Ramp-Up Costs}_k}{\text{Total Capacity}}. \\
&= \frac{(6\cdot 0 + 100\cdot 46.96 + 2,000\cdot 132.92 + (1,000+1,500)\cdot 32.22)\text{MW}\cdot €/MW}{(6+100+2,000+1,000+1,500)\text{MW}} \\
&= \frac{351,086\text{MW}\cdot €/MW}{4,606\text{MW}} = 76.22€/MW
\end{aligned}$$

Fourth, I calculate asset age. I average the start year of commercial operation of all power plants. Again, I weight the individual start year of each plant by its capacity. As I require the average asset age for each sample year, I subtract the average start year from the reference year (year of observation). Thus, the variable asset age for firm X in 2008 is calculated as follows:

$$\begin{aligned}
\textsc{asset Age}_X &= \text{Year of observation} - \frac{\sum_{i=1}^{N} \text{Capacity}_i \cdot \text{Year}_i^{Start}}{\text{Total Capacity}} \\
&= 2008y - \frac{(6\cdot 2006 + 100\cdot 1990 + 2,000\cdot 1980 + 1,000\cdot 1975 + 1,500\cdot 1990)y}{(6+100+2,000+1,000+1,500)\text{MW}} \\
&= 2008y - \frac{9,131,036y\cdot \text{MW}}{4,606\text{MW}} = 25,58y
\end{aligned}$$

A.5. Robustness Tests

Table A. 7.: Robustness test – Leverage definition – run-up time

	I	IIa	IIb	IIIa	IIIb
	total	long-term		net leverage	
	book	market	book	market	book
Run-up time	**-0.0060*** **	**-0.0053*** **	**-0.0056*** **	**-0.0039*** **	**-0.0044*** **
	(-3.89)	**(-5.18)**	**(-4.10)**	**(-3.24)**	**(-3.27)**
Asset age	-0.0025***	-0.0018***	-0.0020***	-0.0015**	-0.0012
	(-3.48)	(-3.48)	(-3.38)	(-2.13)	(-1.57)
Regional diversification	0.061***	0.041**	0.056***	0.012	0.020
	(2.83)	(2.43)	(2.89)	(0.70)	(1.07)
Size	0.038***	0.030***	0.037***	0.017***	0.021***
	(6.34)	(6.60)	(7.55)	(3.22)	(3.74)
Profitability	-0.040	-0.20***	0.030	-0.48***	-0.28**
	(-0.41)	(-2.90)	(0.39)	(-4.15)	(-2.53)
Tangible assets ratio	0.18***	0.15***	0.19***	0.16***	0.19***
	(4.01)	(4.40)	(4.76)	(3.57)	(4.21)
Market-to-book	0.017***	-0.012***	0.011**	-0.010***	0.021***
	(2.74)	(-3.62)	(2.33)	(-2.63)	(4.80)
Dividend paying	-0.057***	-0.062***	-0.048***	-0.079***	-0.050**
	(-3.12)	(-4.01)	(-3.04)	(-4.13)	(-2.47)
Constant	0.15	0.23***	0.072	0.59***	0.41***
	(1.63)	(3.36)	(0.97)	(7.09)	(5.04)
Observations	2,103	2,114	2,110	1,842	1,833
Adjusted R^2	0.47	0.46	0.51	0.39	0.41

The dependent variable is BOOK LEVERAGE in model I, LONG-TERM MARKET LEVERAGE in model IIa, LONG-TERM BOOK LEVERAGE in model IIb, NET MARKET LEVERAGE in model IIIa, and NET BOOK LEVERAGE in model IIIc. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

Table A. 8.: Robustness tests – Estimation methodology – run-up time

	I Tobit	II Between effects	III Fama-MacBeth	IV Multiway clustering
Run-up time	-0.0056***	-0.0047**	-0.0029**	-0.0054***
	(-4.61)	(-2.13)	(-2.74)	(-4.35)
Asset age	-0.0030***	-0.0035***	-0.0031***	-0.0025***
	(-4.25)	(-4.36)	(-9.02)	(-2.77)
Regional diversification	0.047**	0.060**	0.0021	0.047*
	(2.40)	(2.29)	(0.27)	(1.76)
Size	0.033***	0.027***	0.044***	0.030***
	(5.51)	(4.40)	(19.3)	(3.87)
Profitability	-0.29***	-0.20	-0.37***	-0.30***
	(-2.95)	(-1.28)	(-6.19)	(-3.36)
Tangible assets ratio	0.17***	0.22***	0.16***	0.16***
	(3.93)	(4.46)	(8.43)	(3.65)
Market-to-book	-0.014***	-0.014***	-0.015***	-0.014***
	(-3.49)	(-3.39)	(-4.37)	(-2.79)
Dividend paying	-0.086***	-0.090***	-0.094***	-0.082***
	(-4.71)	(-3.33)	(-5.65)	(-4.32)
Constant	0.35***	0.27	-0.16***	0.39***
	(3.83)	(1.25)	(-7.08)	(3.77)
Observations	2,114	2,114	2,114	2,114
R^2		0.473	0.265	0.435
Pseudo R^2	-4.15			
Adjusted R^2		0.37		0.43

The dependent variable is MARKET LEVERAGE. Model I shows estimates based on a Tobit model with censoring at zero and one. Model II is a between-firm effects estimation. The outcome of a Fama-MacBeth estimation is depicted in model III. Model IV shows OLS estimates with standard errors clustered by firms, years, and countries (Cameron, Gelbach and Miller, 2011). Year and country dummies are included (except for the Fama-MacBeth estimation). All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are used in model I and II. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

A.6. Accounting Standards applied by Sample Companies

Table A. 10.: Accounting standards used by sample companies

Accounting standard	Number of companies	% of companies
US standards (GAAP)	263	57.2%
Non-US GAAP	197	42.8%
IFRS	50	10.9%
Local standards with some IASC guidelines	50	10.9%
Local standards	61	13.3%
Others	36	7.8%

Table A. 9.: Leverage and salability

	I	IIa	IIb	IIc	IId	IIIa	IIIb	IIIc	IIId
Salability	**0.0020*** **	**0.00085**	**0.00085**	**0.0014** **	**0.0018*** **	**0.00078**	**0.00071**	**0.0013** **	**0.0017*** **
	(3.82)	**(1.21)**	**(1.24)**	**(2.00)**	**(2.90)**	**(1.11)**	**(1.06)**	**(2.00)**	**(3.03)**
Mid-load capacity [%]		**0.16*** **				**0.17*** **			
		(3.78)				**(4.06)**			
Peak-load capacity [%]		**0.16*** **				**0.17*** **			
		(3.26)				**(3.34)**			
Base-load capacity [%]			**-0.16*** **				**-0.17*** **		
			(-3.79)				**(-4.06)**		
Run-up time				**-0.0044*** **				**-0.0047*** **	
				(-2.90)				**(-2.85)**	
Ramp-up costs					**-0.0012*** **				**-0.0012*** **
					(-2.89)				**(-2.72)**
Stochastic capacity [%]		0.20***	0.036			0.19***	0.019		
		(3.97)	(0.86)			(3.77)	(0.45)		
Asset age		-0.0020***	-0.0020***	-0.0022***	-0.0023***	-0.0021***	-0.0021***	-0.0022***	-0.0023***
		(-3.04)	(-3.04)	(-3.39)	(-3.54)	(-3.15)	(-3.15)	(-3.41)	(-3.55)
Regional diversification		0.047**	0.047**	0.047**	0.048**	0.046**	0.046**	0.046**	0.048**
		(2.41)	(2.41)	(2.34)	(2.43)	(2.33)	(2.33)	(2.28)	(2.37)
Size	0.028***	0.029***	0.029***	0.029***	0.030***	0.031***	0.031***	0.032***	0.032***
	(5.33)	(5.30)	(5.31)	(4.86)	(5.12)	(5.34)	(5.37)	(5.11)	(5.33)
Profitability	-0.39***	-0.35***	-0.35***	-0.34***	-0.34***	-0.31***	-0.31***	-0.31***	-0.30***
	(-3.94)	(-3.65)	(-3.65)	(-3.52)	(-3.51)	(-3.13)	(-3.13)	(-3.02)	(-3.00)
Tangible assets ratio	0.18***	0.18***	0.18***	0.17***	0.18***				
	(3.94)	(3.99)	(4.01)	(4.01)	(4.10)				
Market-to-book	-0.012***	-0.012***	-0.012***	-0.013***	-0.013***	-0.013***	-0.013***	-0.014***	-0.014***
	(-2.86)	(-2.86)	(-2.85)	(-2.99)	(-2.98)	(-2.96)	(-2.96)	(-3.12)	(-3.10)
Dividend paying	-0.086***	-0.077***	-0.077***	-0.077***	-0.076***	-0.070***	-0.070***	-0.070***	-0.069***
	(-4.06)	(-3.91)	(-3.91)	(-3.84)	(-3.84)	(-3.47)	(-3.47)	(-3.39)	(-3.39)
Constant	0.42***	0.21**	0.37***	0.37***	0.40***	0.29***	0.46***	0.45***	0.48***
	(4.82)	(2.18)	(4.30)	(4.15)	(4.62)	(2.94)	(5.29)	(4.95)	(5.49)
Observations	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760
Adjusted R^2	0.40	0.44	0.44	0.43	0.43	0.42	0.42	0.41	0.41

The dependent variable is MARKET LEVERAGE. All models are pooled OLS regressions. Year and country dummies are included. All independent variables are lagged by one period. T-statistics based on Huber/White robust standard errors clustered by firms are presented in parentheses. ***, ** and * indicate significance on the 1%-, 5%- and 10%-levels, respectively. A detailed description of all variables can be found in Table 5.1.

A.7. Determinants of Debt Maturity and the Yield Spread of Debt Issues

Table A. 12.: Debt maturity – Quasi-balance sheet perspective – according to Benmelech (2009)

Variables	I	IIa	IIb	IIc	IId
Asset maturity "Guedes/Opler"		**0.22***			
		(1.94)			
Asset maturity "Barclay et al."			**0.29****		
			(2.17)		
Asset maturity "value weighted"				**0.57****	
				(2.22)	
Asset maturity "capacity weighted"					**0.44***
					(1.95)
Size	-0.44	-0.39	-0.41	-0.047	-0.21
	(-0.37)	(-0.34)	(-0.35)	(-0.043)	(-0.18)
Tangibility of assets	2.86	-10.3	-4.29	0.41	1.93
	(0.48)	(-0.98)	(-0.56)	(0.053)	(0.26)
Profitability	13.9	16.8	18.4	20.2*	21.4*
	(1.29)	(1.21)	(1.58)	(1.72)	(1.72)
Constant	17.2	21.1	15.9	0.50	2.81
	(0.79)	(0.93)	(0.74)	(0.030)	(0.16)
Observations	515	497	512	400	400
Adjusted R^2	0.062	0.099	0.078	0.15	0.10

The dependent variable is the DEBT MATURITY CALCULATED AS THE WEIGHTED AVERAGE MATURITY OF ALL DEBT OUTSTANDING. All models are pooled OLS regressions. Year and country dummies are included in all models. T-statistics based on White (1980) standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table A. 11.: Debt maturity – Balance sheet perspective – according to Benmelech (2009)

Variables	I	IIa	IIb	IIc	IId	III	IVa	IVb	IVc	IVd
Asset maturity "Guedes/Opler"		**0.0027****					**0.0039****			
		(2.34)					**(2.15)**			
Asset maturity "Barclay et al."			**0.0055*****					**0.0079*****		
			(3.09)					**(3.44)**		
Asset maturity "value_weighted"				**0.0035****					**0.0041****	
				(2.20)					**(2.00)**	
Asset maturity "capacity_weighted"					**0.0033****					**0.0039****
					(2.03)					**(2.13)**
Size	-0.00096	0.00097	-0.0014	0.0048	0.0041	-0.0045	-0.0013	-0.0050	0.0036	0.0029
	(-0.11)	(0.11)	(-0.16)	(0.51)	(0.44)	(-0.37)	(-0.11)	(-0.44)	(0.30)	(0.24)
Tangibility of assets	0.25***	0.096	0.12	0.25**	0.26**	0.36***	0.14	0.18*	0.40***	0.41***
	(2.91)	(0.88)	(1.21)	(2.46)	(2.56)	(3.62)	(1.17)	(1.83)	(3.41)	(3.52)
Profitability	-0.052	-0.016	-0.0089	-0.13	-0.11	0.012	0.073	0.073	-0.050	-0.024
	(-0.15)	(-0.049)	(-0.025)	(-0.40)	(-0.34)	(0.026)	(0.15)	(0.15)	(-0.11)	(-0.053)
Constant	0.49***	0.50***	0.48***	0.47**	0.47**	0.31	0.33	0.30	0.24	0.23
	(2.77)	(2.92)	(2.83)	(2.41)	(2.27)	(1.38)	(1.47)	(1.38)	(1.03)	(0.95)
Observations	515	497	512	400	400	515	497	512	400	400
Adjusted R^2	0.28	0.29	0.30	0.24	0.24	0.37	0.39	0.40	0.36	0.36

Dependent variables are the FRACTION OF DEBT WITH MATURITY LARGER THAN THREE YEARS (models I-IId) and the FRACTION OF DEBT WITH MATURITY LARGER THAN FIVE YEARS (models III-IVd). All models are pooled OLS regressions. Year and country dummies are included in all models. T-statistics based on White (1980) standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table A. 13.: Influence of maturity mismatch on relative debt issuance yield spread incl. company characteristics – I/II

Variables	Ia	Ib	Ic	Id	IIa	IIb	IIc	IId
|Guedes/Opler - debt outst. mat.|<0	*omitted*				*omitted*			
|Guedes/Opler - debt outst. mat.|>0	**-0.0013**				**-0.00052**			
	(-0.76)				**(-0.25)**			
|Barclay - debt outst. mat.|<0		**0.011**				**0.0071**		
		(1.01)				**(0.69)**		
|Barclay - debt outst. mat.|>0		**0.0031**				**0.0020**		
		(0.40)				**(0.24)**		
|Val. weighted - debt outst. mat.|<0			**0.028***				**0.029***	
			(1.96)				**(1.94)**	
|Val. weighted - debt outst. mat.|>0			**0.011****				**0.0096***	
			(2.18)				**(1.83)**	
|Capa. weighted - debt outst. mat.|<0				**0.024***				**0.023***
				(1.84)				**(1.75)**
|Capa. weighted - debt outst. mat.|>0				**0.0096****				**0.0077***
				(2.08)				**(1.85)**
Market leverage	0.26	0.27	0.22	0.17	0.77	0.83	0.53	0.46
	(1.00)	(1.07)	(1.00)	(0.74)	(1.31)	(1.44)	(1.34)	(1.15)
Firm age (date of issuance)	-0.00010	-0.00016	0.000096	0.000055	-0.00014	-0.00019	0.00011	0.000043
	(-0.17)	(-0.27)	(0.19)	(0.11)	(-0.22)	(-0.28)	(0.20)	(0.084)
Size	-0.033	-0.025	-0.0093	-0.011	-0.026	-0.021	-0.0084	-0.011
	(-1.43)	(-1.05)	(-0.53)	(-0.59)	(-1.03)	(-0.81)	(-0.46)	(-0.58)
Bond issue rating	-0.090***	-0.089***	-0.064***	-0.061***	-0.078***	-0.077***	-0.058***	-0.057***
	(-5.96)	(-5.69)	(-6.36)	(-5.58)	(-4.48)	(-4.48)	(-4.67)	(-4.18)
Offering amount	-0.0014	-0.0044	-0.021	-0.022	-0.0082	-0.013	-0.025	-0.025
	(-0.047)	(-0.15)	(-1.20)	(-1.19)	(-0.28)	(-0.44)	(-1.36)	(-1.29)
Payment frequency	0.0092	0.0093	0.000029	0.00038	0.0076	0.0074	-0.0012	-0.00087
	(0.59)	(0.60)	(0.0052)	(0.061)	(0.46)	(0.45)	(-0.19)	(-0.12)
Sinking dummy	0.0043	-0.053	0.0033	-0.0025	0.0092	-0.014	0.019	0.012
	(0.062)	(-0.65)	(0.090)	(-0.068)	(0.12)	(-0.18)	(0.55)	(0.33)
Put dummy	0.85***	0.86***	0.76***	0.84***	0.86***	0.87***	0.77***	0.84***
	(13.1)	(14.4)	(12.9)	(14.2)	(13.4)	(14.3)	(13.4)	(13.9)
Call dummy	0.059	0.043	0.087**	0.093**	0.050	0.036	0.080**	0.084**
	(1.45)	(0.96)	(2.35)	(2.42)	(1.21)	(0.77)	(2.21)	(2.30)
Variation of 10 years US treasury bond yield	-0.38***	-0.37***	-0.47***	-0.47***	-0.38***	-0.37***	-0.47***	-0.47***
	(-8.85)	(-9.15)	(-9.68)	(-9.65)	(-9.05)	(-9.34)	(-9.81)	(-9.71)
Constant	3.77***	3.59***	3.46***	3.45***	3.93***	3.16***	3.24***	3.28***
	(7.92)	(7.76)	(8.63)	(8.25)	(6.73)	(5.97)	(7.34)	(6.60)
Observations	412	425	359	359	412	425	359	359
Adjusted R^2	0.67	0.66	0.71	0.71	0.66	0.65	0.71	0.70
Methodology	OLS	OLS	OLS	OLS	2 SLS	2 SLS	2 SLS	2 SLS

The dependent variable is the RELATIVE YIELD SPREAD. Models Ia - Id are OLS regressions, Models IIa - IId are 2SLS calculations. Year dummies are included in all models. The sample is limited to U.S. companies. The following instruments were used to parametrize the *market leverage* as endogeneous variable: market-to-book, size, tangibility of assets, profitability and dividend payout. Results of the *market leverage*-part of the 2SLS model are not reported here. T-statistics based on White (1980) standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

Table A. 14.: Influence of maturity mismatch on relative debt issuance yield spread incl. company characteristics – II/II

Variables	I	Ia	Ib	Ic	Id	III	IVa	IVb	IVc	IVd
|Guedes/Opler - debt outst. mat.|		**-0.0013**					**-0.00046**			
		(-0.71)					**(-0.22)**			
|Barclay - debt outst. mat.|			**0.0045**					**0.0031**		
			(0.63)					**(0.38)**		
|Val. weighted - debt outst. mat.|				**0.012****					**0.011****	
				(2.50)					**(2.24)**	
|Capa. weighted- debt outst. mat.|					**0.011****					**0.0094****
					(2.47)					**(2.33)**
Market leverage	0.40**	0.26	0.27	0.20	0.16	0.70**	0.78	0.86	0.48	0.41
	(2.34)	(1.00)	(1.10)	(0.88)	(0.65)	(2.04)	(1.32)	(1.47)	(1.17)	(1.01)
Firm age (date of issuance)	-0.000055	-0.00011	-0.00026	2.8e-06	0.000032	-0.00023	-0.00015	-0.00025	9.8e-06	0.000028
	(-0.14)	(-0.18)	(-0.47)	(0.0051)	(0.059)	(-0.47)	(-0.23)	(-0.41)	(0.018)	(0.053)
Size	-0.038**	-0.033	-0.024	-0.0035	-0.0042	-0.036*	-0.026	-0.020	-0.0019	-0.0040
	(-2.05)	(-1.43)	(-1.02)	(-0.19)	(-0.21)	(-1.87)	(-1.03)	(-0.78)	(-0.097)	(-0.19)
Bond issue rating	-0.068***	-0.090***	-0.087***	-0.061***	-0.059***	-0.062***	-0.078***	-0.075***	-0.055***	-0.054***
	(-6.00)	(-5.95)	(-5.65)	(-5.76)	(-5.39)	(-5.83)	(-4.47)	(-4.49)	(-4.36)	(-4.16)
Offering amount	0.019	-0.0014	-0.0049	-0.026	-0.027	0.015	-0.0083	-0.014	-0.030	-0.030
	(0.88)	(-0.049)	(-0.17)	(-1.43)	(-1.41)	(0.72)	(-0.29)	(-0.47)	(-1.55)	(-1.49)
Payment frequency	0.0081	0.0092	0.0099	0.0013	0.0021	0.0066	0.0075	0.0077	0.00040	0.0012
	(0.54)	(0.58)	(0.64)	(0.25)	(0.40)	(0.42)	(0.46)	(0.47)	(0.066)	(0.20)
Sinking dummy	-0.086	0.0028	-0.069	0.0028	-0.0027	-0.042	0.0076	-0.025	0.017	0.0089
	(-1.58)	(0.040)	(-0.88)	(0.079)	(-0.076)	(-0.84)	(0.10)	(-0.32)	(0.49)	(0.26)
Put dummy	0.81***	0.85***	0.86***	0.79***	0.83***	0.81***	0.86***	0.87***	0.80***	0.83***
	(16.9)	(13.1)	(14.6)	(12.8)	(14.8)	(16.8)	(13.4)	(14.5)	(13.4)	(14.9)
Call dummy	0.0054	0.059	0.043	0.095**	0.097**	0.0041	0.050	0.036	0.091**	0.091**
	(0.15)	(1.45)	(0.94)	(2.56)	(2.57)	(0.12)	(1.21)	(0.74)	(2.47)	(2.48)
Variation of 10 years US treasury bond yield	-0.39***	-0.38***	-0.38***	-0.47***	-0.47***	-0.39***	-0.38***	-0.37***	-0.47***	-0.47***
	(-13.3)	(-8.85)	(-9.11)	(-9.57)	(-9.69)	(-13.4)	(-9.05)	(-9.32)	(-9.68)	(-9.74)
Constant	3.55***	3.77***	3.56***	3.34***	3.31***	3.58***	3.93***	3.11***	3.12***	3.15***
	(9.16)	(7.91)	(7.61)	(7.81)	(7.73)	(9.41)	(6.73)	(5.91)	(6.65)	(6.21)
Observations	745	412	425	359	359	742	412	425	359	359
Adjusted R^2	0.68	0.67	0.66	0.71	0.71	0.68	0.66	0.65	0.70	0.71
Methodology	OLS	OLS	OLS	OLS	OLS	2 SLS	2 SLS	2 SLS	2 SLS	2 SLS

The dependent variable is the RELATIVE YIELD SPREAD. Models Ia - Id are OLS regressions, Models IIa - IId are 2SLS calculations. Year dummies are included in all models. The sample is limited to U.S. companies. The following instruments were used to parametrize the *market leverage* as endogeneous variable: market-to-book, size, tangibility of assets, profitability and dividend payout. Results of the *market leverage*-part of the 2SLS model are not reported here. T-statistics based on White (1980) standard errors with clustering by firms are presented in parentheses. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.22.

A.8. Univariate Statistics for M&A in the Utility Industry

Table A. 15.: Other univariate statistics for M&A with acquirers from the electric utility industry

Category level I	Category level II	Number of observations	Mean abnormal return	t-test clustered by acquirer		Wilcoxon signed-rank test		Wilcoxon sign test
				t	P	Z	P	P
Developed country target								
	Most developed countries	667	0.368%	2.71***	0.008	1.74*	0.082	0.141
	Less developed countries	262	0.443%	1.40	0.165	0.89	0.372	0.666
U.S. vs. Non-U.S. target								
	U.S.	199	0.327%	1.06	0.291	0.46	0.644	0.356
	Non-U.S.	730	0.406%	2.73***	0.007	1.900*	0.057	0.236
Continent of target								
	Asia	207	0.653%	1.74*	0.086	1.38	0.166	0.331
	North America	239	0.305%	1.14	0.258	0.88	0.380	0.105
	South America	46	0.157%	0.34	0.738	0.41	0.682	0.883
	Europe	375	0.206%	1.19	0.239	0.70	0.698	0.796
	Australia	56	1.232%	2.96***	0.008	1.795*	0.073	0.229
	Africa	6	0.030%	0.07	0.951	0.11	0.917	1.000
Announcement year								
	2003	109	0.855%	2.52**	0.014	2.01**	0.045	0.125
	2004	126	-0.209%	-1.00	0.319	-0.55	0.580	0.929
	2005	126	-0.081%	-0.26	0.794	-1.38	0.169	0.130
	2006	120	1.025%	2.72***	0.008	2.47**	0.014	0.035**
	2007	120	0.641%	1.70*	0.093	1.42	0.156	0.315
	2008	121	0.217%	0.45	0.651	0.41	0.685	0.784
	2009	104	0.714%	1.39	0.170	0.67	0.503	0.694
	2010	103	0.045%	0.13	0.899	0.22	0.826	0.694

This table reports descriptive statistics for the CUMULATIVE ABNORMAL ACQUIRER RETURN. The reported t-test, Wilcoxon signed-rank test and Wilcoxon sign test all conduct a test of cumulative abnormal acquirer returns against zero. Significance is indicated by ***, ** and * at the 1%-, 5%- and 10%-level, respectively. A detailed description of all variables can be found in Table 5.54.

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