Identification and Treatment of Risk:
Recent Empirical Evidence from Selected Topics

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Matthias Walter

(Diplom-Kaufmann Univ., Bachelor of Science)

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Erstgutachter:	Prof. Dr. Hans Ulrich Buhl
Zweitgutachter:	Prof. Dr. Yarema Okhrin
Vorsitzender der mündlichen Prüfung:	Prof. Dr. Axel Tuma
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„There is nothing more risky than not taking any risks."

Josep “Pep” Guardiola

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Index of Research Papers

This doctoral thesis contains the following four research papers, of which two are already published or accepted for publication, and two are under review for publication:

Research Paper 1 (RP 1):

Geyer-Klingeberg J, Hang M, Rathgeber A, Stöckl S, Walter M (2015). What do we really know about corporate hedging? A multimethod meta-analytical study. Working paper.

Research Paper 2 (RP 2):

Walter M (2015). How do soccer matches and competitions really influence stock markets? A review of recent empirical evidence. Working paper.

Research Paper 3 (RP 3):

Walter M, Häckel B, Rathgeber A (2015). Market pricing of Credit Linked Notes - the influence of the financial crisis. *Journal of Credit Risk* 12(1):43-74.

VHB-JOURQUAL 3: category B
Impact Factor 2014: 0.310

Research Paper 4 (RP 4):

Stepanek C, Walter M, Rathgeber A (2013). Is the convenience yield a good indicator of a commodity's supply risk? In *Resources Policy* 38(3):395-405,
doi: 10.1016/j.resourpol.2013.06.001

Impact Factor 2014: 2.053

I Introduction

What is the scope of this thesis?

In past decades, risk management has been implemented in a majority of companies across all sectors. The main reason for this is that risk management directly contributes to shareholder value (Gay and Nam 1998; Bartram 2000; Beasley 2005), and thus, supports the basic idea of value-based management, which can be attributed to Rappaport (1986). In addition, risk management is driven by a number of regulatory requirements. For instance, in the United States, the New York Stock Exchange requires the audit committee of each listed company to "discuss policies with respect to risk assessment and risk management" (Ittner and Keusch 2015). In Germany, the "Gesetz zur Kontrolle und Transparenz im Unternehmensbereich (KonTraG)" requires every listed company to implement an early risk warning system and to include a statement regarding its risk structure within their financial statements. In addition, companies within the financial sector are obligated to fulfill the requirements of the "Mindestanforderungen an das Risikomanagement (MaRisk)". Thereby, MaRisk also requires the implementation of a risk management process. Such a risk management process is also proposed by various contributors in economic research (Bandyopadhyay et al. 1999; Stoneburner et al. 2002; Huther 2003; Wolf 2003; Hallikas et al. 2004; Merna and Al-Thani 2010; Beech and Chadwick 2013; and PMI 2013). Other than small differences in denominations and delimitation, there is a broad consensus (e.g., Bandyopadhyay et al. 1999; Harland et al. 2003; Hallikas et al. 2004) that the risk management process is a continuous loop rather than a linear process, and that it can be subdivided into four separate phases, similar to the basic idea of the strategic management process: (1) risk identification, (2) risk assessment, (3) risk treatment, and (4) risk monitoring. Each of the process phases is essential for a holistic risk management within a company and thus for an increase in corporate value. Nevertheless, the phases of *"risk identification"* and *"risk treatment"* are of particular interest, as – at least for German companies – these two phases contain the biggest potential for risk management optimization (BDI 2011). This empirical finding is strengthened by Wolf (2003), who characterizes the risk identification phase as the basis of the risk management process, thus determining its efficiency. This is in line with Wolz (2001), who shows that in practice, risk identification is one of the major challenges for firms with respect to risk management. In addition, Hallikas et al. (2004) describe risk identification as a "fundamental phase in the risk management practice". The relevance of risk treatment is emphasized by Aebi et al.

(2012), who denote the improvement of the treatment of risks as the main focus in quantitative risk management. Consequently, this doctoral thesis focuses on the identification and treatment of risks and provides empirical evidence regarding both phases. Figure I-1 displays the aforementioned risk management process as a cycle, and the content-related focus of the doctoral thesis at hand:

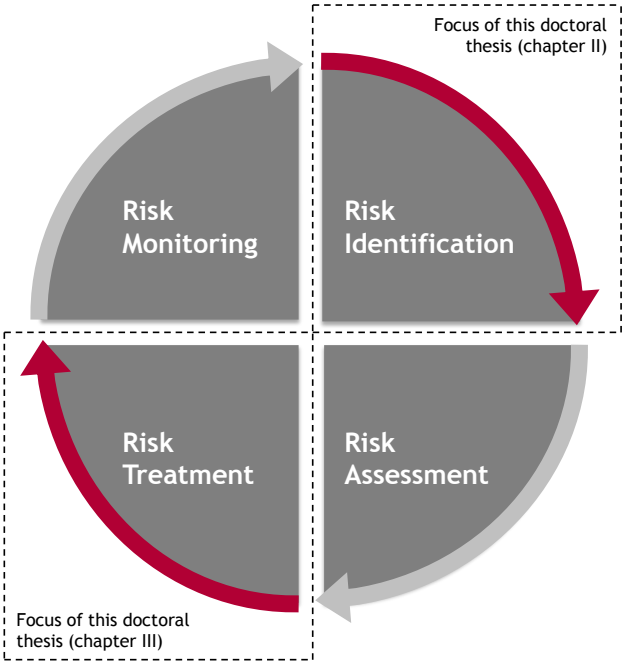

Figure I-1: Risk management process and focus of the doctoral thesis

Risk is a very broad field of research, and risk in economics in particular. This starts with the definition of risk and does not end with the classification of various types of risk. Therefore, the aim of this thesis is not to provide a comprehensive and detailed overview of risk management, but rather to address selected topics from distinct areas within risk management.[1] However, in order to achieve a common understanding for this thesis, some basic definitions are provided briefly hereafter.

What is "risk"?

This thesis follows the generally accepted definition of risk as an uncertain positive or negative outcome (e.g., return, credit repayments, or availability of a commodity) by simultaneously available subjective or objective probabilities for this outcome (Huther 2003; Hull 2010). This is in line with the definition of risk in classical decision theory, which conceives risk as "reflecting variation in the distribution of possible outcomes, their

[1] For a detailed overview of risk management, please refer to the respective standard literature on risk management; e.g., Wolf (2003), Gleißner and Romeike (2005), Albrecht and Maurer (2008), Gleißner (2008), Wolke (2008), Hull (2010), Merna and Al-Thani (2010), and Rejda and McNamara (2014).

likelihoods, and their subjective values" (March and Shapira 1987). In this context, risk can be measured by (1) nonlinearities in the revealed utility for money or (2) by the variance of the probability distribution of possible profits and losses related to a particular alternative (Pratt 1964; Arrow 1965).[2]

How can different types of risk be classified?

Risk can be classified in different categories. Regarding the classification of risks, this thesis follows the widely accepted classification scheme of, e.g., Albrecht and Maurer (2008) or Hull (2010), who subdivide risk as: (1) credit risk, (2) market risk, (3) liquidity risk, and (4) operational risk. Thereby, *credit risk* includes all risks associated with a potential default of a borrower, bond issuer, or counterparty in a derivative transaction (Hull 2010). In other words, credit risk is the risk that one of the aforementioned counterparties is unable, or unwilling, to make required payments; e.g., coupon payments or redemption payments. Credit risks can be related to private, institutional, and sovereign borrowers or investors. *Market risk* includes all kinds of risks that occur due to movements in market prices. This includes, for instance, the volatility of stock prices, or equity risk, but also currency risks and interest rate risks. In addition, market risks also include commodity risks, i.e., the risk that arises from the volatility of commodity prices. *Liquidity risks* can be subdivided into liquidity funding risks as well as liquidity trading risks. While the former comprises the inability of a financial or non-financial firm to service its liabilities, i.e., to meet its cash needs as they arise (Hull 2010), the latter relates to the inability to trade an asset at a fair price with immediacy due to a lack of liquidity in the market (Nikolaou 2009; Hull 2010). In case a liquidity risk becomes striking on a firm level, and particularly a liquidity funding risk, this may lead to illiquidity and finally to insolvency. Both types of liquidity risks are co-related, as funding is the prerequisite of trading, which is in turn the prerequisite of market liquidity. However, funding depends on an asset's market liquidity (Brunnermeier and Pedersen 2009). While the three aforementioned types of risk primarily refer to the "financial risk" category, the fourth type of risk, *operational risk*, comprises all risks occurring in daily business. According to the widely accepted definition of operational risk provided by the Basel Committee, operational risk is "the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events" (BIS 2001). Consequently, this includes, among others, IT risks (e.g. system

[2] In addition (and in contrast to the introduced definition of risk), uncertainty exists in case probabilities for uncertain outcomes are not available at all (e.g., Merna and Al-Thani, 2010). Uncertainty will not be in the scope of this thesis. For a detailed description of risk and uncertainty, please refer to Perridon et al. (2012).

failures), process risk (e.g., inadequate reporting arrangements), or personnel risks (e.g., fraud). In addition, beyond the financial sector, operational risk also comprises supply chain-related risks (such as the risk that a specific commodity is not available for the production process) or several risks regarding the success of research and development (R&D) activities – such as the risk that the product fails to achieve the projects' technical objectives or risks occurring due to insufficient project planning.

Why does this thesis focus on credit risk and operational risk?

This thesis examines credit risks and operational risks for the following reasons: the need for managing credit risks has strongly increased in the course of the 2007-2009 financial crisis, which was primarily caused by a lack of *credit risk* management such as insufficient credit assessments, particularly in the financial sector (Sabato 2010). Due to spillover effects and the increasing globalization of supplier networks, the financial crisis escalated to a worldwide economic crisis (Claessens et al. 2012). According to Soin and Collier (2013), the financial crisis further unveiled the consequences that may arise in case *operational risks*, arising from the actions of people, systems, and processes, are ignored. Against the particular assertion that operational risks are difficult to hedge (Nocco and Stulz 2006), the management of operational risks (such as the development of appropriate early warning indicators) is of major importance. Consequently, the focus in modern managerial practice has shifted to operational risk management (EY 2013). For instance, in manufacturing firms, a relevant operational risk topic is the availability of scarce commodities, or the management of commodity risks. This is justified by both increased industrial metal production and consumption in the past decade, especially caused by rapid growth in emerging markets, as well as an increased commodity price volatility. The latter results from a growing financialization of commodity markets (Creti et al. 2013; Henderson et al. 2014) and an increasing cross-linkage of production processes (e.g., Harland et al. 2003). The effect of this is that the availability risk of economically very important industrial metals can easily increase to a critical level in the future (European Commission, 2010) and, in a worst case scenario, cause further economic crises. Hence, appropriate tools for the management of operational commodity risks are required.

What is "risk identification" and how can risks be identified?

The risk identification phase as the first phase of the continuous risk management process primarily aims to determine which internal and external risks are likely to affect a company at its whole or a particular project (Bandyopadhyay et al. 1999; Merna and Al-Thani 2010).

Risk identification should provide a holistic, consistent, and systematic overview of potential risks before they occur. In other words, "the focus of risk identification is to recognize future uncertainties [and] to be able to manage these scenarios proactively" (Hallikas et al. 2004). Risks should be identified not only as "stand-alone" but also with consideration of the interdependencies among different risk factors. In addition, risks should be identified "bottom-up" and "top-down"; i.e., risks should be derived from the business' objectives (Wolf 2010). Adequate tools for risk identification are, for instance, SWOT analyses, portfolio analyses, scenario analyses, or early warning systems.[3]

One major research strand that can be related to the identification of risks examines the determinants of corporate hedging behavior. But *why* does this particular research strand contribute to risk identification? In line with similar learning spillover effects, for instance in terms of investment decisions (e.g., Foucault and Fresard 2014; Dougal et al. 2015; Raff and Verwijmeren 2015) or capital structure choice (e.g., Leary and Roberts 2014), the knowledge about why other firms hedge their risks makes it possible to draw conclusions about risk factors within one's own company. For instance, numerous existing studies provide evidence that firms tend to increase their hedging activities with increasing expenses for research and development (R&D) activities. There are several reasons for this correlation. First, R&D activities are risky as they are characterized by high expenses and low cash inflows in the present, as well as uncertain benefits in the future (Hall 2002; Carlsson et al. 2007). Second, another widely accepted explanation for this correlation is the underinvestment problem (Nance et al. 1993; Gay and Nam 1998), which occurs when external financing for a company is expensive and internally generated cash flows are not sufficient to finance value-adding projects with a positive net present value. Therefore, the company must reduce its investment spending. R&D activities may enforce the presence of this phenomenon in several ways. Among others, as aforementioned, R&D activities may not generate sufficient internal cash flow. Further, information asymmetries may exist between managers and lenders regarding the quality of new projects, leading to high costs for external financing. Consequently, conducting risk management in a situation with high R&D activities adds value, as it provides the company with sufficient funds in order to take advantage of attractive investment opportunities with a positive net present value. Less obvious examples are the number of institutional investors or the number of intangible assets.[4] To express this concept differently, the knowledge about why other firms may hedge

[3] For a detailed description of the various risk identification tools, please refer to, e.g., Wolf (2003).
[4] For a detailed overview, please refer to section II-1.

helps to identify potential risks in one's own firm in terms of a bottom-up identification. Nevertheless, the sheer number of studies analyzing corporate hedging behavior and their strong heterogeneous results complicate this method of risk identification.

Another constraint, other than the discovery that this way of bottom-up risk identification is complicated by the number of studies and their heterogeneous results, is its' adaptability for different sectors. Most of the studies analyzing the reasons for corporate hedging focus on the industrial or financial sector. However, some new industries are underrepresented in these studies. As firms in emerging industries often show other additional risks compared to "traditional" industries (e.g., Harvey 1995), existing findings on hedging behavior may only be applicable to a limited extent. An example is the sports sector in general and the soccer[5] sector, which was established as an important industry in the 1980s, in particular (Sevil et al. 2014). First, the financial ratios of a soccer club can easily be compared to those of a traditional company (e.g., the turnovers of Real Madrid CF and the FC Bayern Munich AG in the fiscal year 2013/14 were 550 million € and 480 million €, respectively). Second, the financial success of a soccer club is predominantly driven by uncertain sporting success, as the club's success is the basis for the economic success of a soccer company (FCB 2014). This makes it necessary to identify and treat particular risks referring to the club's sporting success (Huth and Breuer 2011). Although risk management is in fact conducted in soccer clubs (e.g., Kupfer 2006, Beech and Chadwick 2013; Duff and Jones 2015, Szymanski 2015), corresponding financial research on hedging behavior in the general sports sector, and in soccer clubs in particular, is only available to a limited extent, consequently leading to a research gap.

What is "risk treatment" and how can risks be treated?

After the identification of risks as outlined above and the assessment of risk[6], which aims to monetarily evaluate risks and their correlations in order to identify those risks that should be addressed, the third phase of the continuous risk management process is the phase of "risk treatment". This phase aims to identify and conduct concrete responses to threats (Hillson 2002; Merna and Al-Thani 2010). According to Hallikas et al. (2004), or Dorfmann and Cather (2012), among others, measures in response to threats can be categorized as follows: (1) risk avoidance, or the elimination of a particular risk source such as a business entity, a project, or an investment; (2) risk reduction, or lowering the probability for a risk

[5] In several countries, e.g., the USA, "football" is termed as "soccer" in order to avoid mix-ups with "American football". Thus, in order to avoid misunderstandings, this thesis consistently uses the expression "soccer".
[6] For a description of appropriate measures in order to assess risks, please refer to McNeil et al. (2015).

respectively its expected financial impact; (3) risk transfer, or outsourcing the potential financial consequences of a risk by means of, for example, an insurance contract or alternating hedging instruments, such as derivatives which can be used in order to transfer credit risks, currency risks, interest rate risk, and commodity risks, among others; and (4) intentionally risk retention, as possible returns increase with increasing risk (Hull 2010).

The most discussed category for risk treatment in both economic research and recent public coverage is risk treatment by means of risk transfer, and specifically, by means of financial hedging instruments. Hedging instruments in terms of credit derivatives were one of the main triggers for the 2007-2009 financial crisis, and thus, for the subsequent economic crises (e.g., Acharya et al. 2009; Bartmann et al. 2009; Crotty 2009; Roe 2011). Although the functionality of many hedging instruments is well explained by financial research and consequently rather transparent (e.g., hedging by means of futures, forward contracts, or options), many structured hedging instruments are less transparent and thus subject to controversial discussion in financial research and public opinion. For example, credit default swaps (CDS) were voted Europe's "most dangerous financial product" in 2013 (DFP 2013). The idea of structured products like CDS or the similar Credit Linked Notes (CLN) is to allow the issuing bank to securitize its credit risk. According to Neil (1996), or Rathgeber and Wang (2011), the mechanism of a CLN contract is as follows: the buyer of the product receives payment for the notes only when the reference entity - another debtor of the CLN issuer, such as a company or a country - does not go into default. As a premium for taking the risk, the buyer receives an attractive coupon. In the instance of the reference entities' default, the buyer receives only the recovery rate of the CLN. CLN contracts are popular among retail investors, and as a CLN can also be interpreted as a "coupon paying security with an embedded credit derivative" (Schlösser 2011) among institutional investors who are not allowed to directly invest in credit derivatives due to, for example, regulatory restrictions or internal investment policies. Such institutional investors may aim to use CLN as a counterpart for their own risk exposure. The main research gap and point of criticism regarding structured financial products like CDS or CLN is their lack of transparency regarding their inherent risk structure and, consequently, regarding their fair and risk-adequate pricing (Stulz 2010; Rathgeber and Wang 2011). This may hamper their applicability as hedging instruments for both issuers as well as investors. First, for the issuer, CLN may no longer serve as an appropriate measure to hedge credit default risks, as the demand for CLN contracts may decrease with increasing lack of transparency. Second, retail or institutional investors may switch to hedging instruments that are more transparent and

fairly priced in case CLN market prices turn out to be “unfair” relative to the inherent risk structure. Further, financial research still lacks evidence on the influence of the 2007-2009 financial crisis, as it pertains to the applicability of hedging instruments.

Other than the financial sector, risk treatment is also important in the industrial sector. For instance, the management of commodity supply risks is of high priority, justified by the increasing supply risk of economically important industrial metals (European Commission 2010). In order to manage commodity supply risks, adequate indicators are required. Existing literature provides a variety of such indicators, such as the inventory level, the spot price, the Herfindahl-Hirschman Index, or production volume (Rosenau-Tornow et al. 2009; Graedel et al. 2012). Nevertheless, as commodity supply is a critical success factor for a company in the industrial sector, good indicators should provide managers with appropriate, easy, and continuously accessible information on supply risk (research paper 4). For instance, there is no indicator that is (1) available with a sufficiently high frequency (e.g., daily), (2) forward-looking to a certain extent, and at the same time (3) easily accessible to avoid delays due to data acquisition. Consequently, this results in a research gap.

In summation, there are several research gaps with respect to both the risk identification phase as well as the risk treatment phase, with both phases of high priority for a successful risk management, as outlined above. In terms of the identification of risk, section I shows that while several studies may exist on the determinants of corporate hedging, these studies provide heterogeneous results, thus hampering the usability of these results for holistic risk identification. In addition, there is a research gap regarding systematic risk identification within the sports sector. In terms of risk treatment, section I derives a research gap regarding the pricing of hedging instruments with respect to structured financial products in general, and particularly the influence of the 2007-2009 financial crisis on the pricing of hedging instruments. Regarding the industrial sector, literature lacks an appropriate indicator for the assessment of a commodity’s future supply risk. Consequently, derived from the research gaps outlined above, Figure I-2 summarizes the key components of this doctoral thesis.

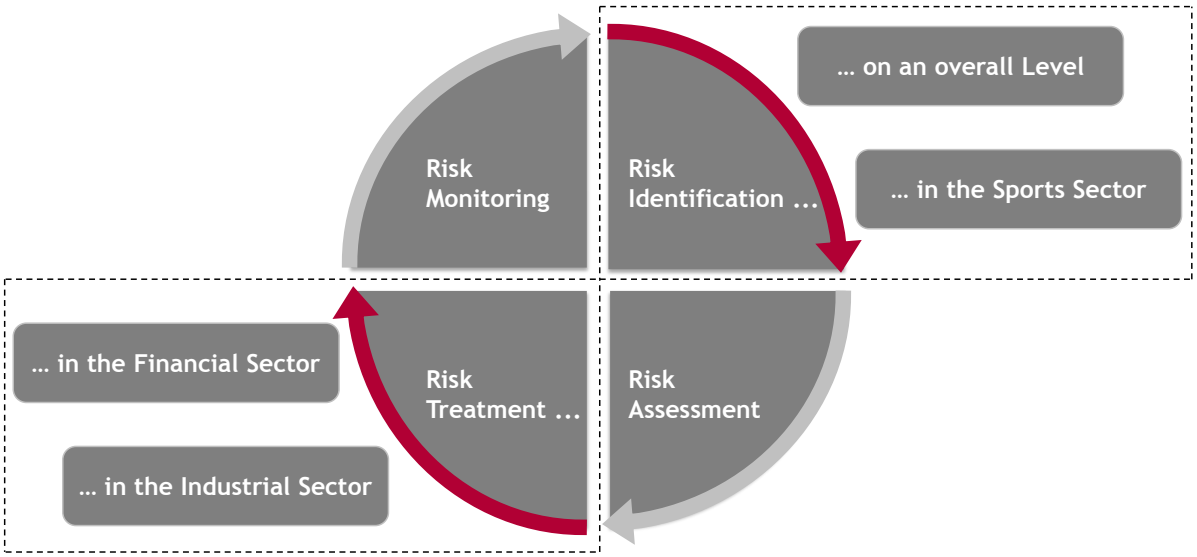

Figure I-2: Key components of the doctoral thesis

The following section I.1 substantiates the objectives and structure of this doctoral thesis. In the subsequent section I.2, the corresponding research papers are embedded in the research context and fundamental research questions are highlighted.

I.1 Objectives and Structure of this Doctoral Thesis

The main objective of this doctoral thesis is to contribute to the field of risk management with a particular focus on the identification and treatment of risks. Figure I-3 provides an overview of the objectives and structure pursued in this doctoral thesis.

I Introduction	
Objective I.1:	Outlining the objectives and the structure of the doctoral thesis.
Objective I.2:	Embedding the included research papers into the research context of the doctoral thesis and motivating the fundamental research questions.
II Risk Identification – Aggregated Empirical Evidence (Research Papers 1 and 2)	
Objective II.1:	Providing a comprehensive overview of existing empirical evidence in the field of corporate hedging research.
Objective II.2:	Applying a multivariate meta-analysis in corporate finance.
Objective II.3:	Providing guidance for the handling of different types of biases (publication bias, data mining bias) in corporate finance-related meta-analyses.
Objective II.4:	Identifying the key drivers for corporate hedging by aggregating empirical evidence on the four major corporate hedging hypotheses.

Objective II.5:	Identifying the key sportive-success-related risk drivers for a soccer club by analyzing the impact of soccer matches and competitions on stock markets (with respect to returns and volatility).
Objective II.6:	Challenging the presence of market efficiency in terms of soccer stocks.
Objective II.7:	Deriving implications for future research in the field of soccer and its influence on stock markets.
III	**Risk Treatment – Recent Empirical Evidence from the Financial and Industrial Sector (Research Papers 3 and 4)**
Objective III.1:	Challenging the adequacy of daily prices of CLN contracts with respect to the related credit risk for the German secondary market.
Objective III.2:	Analyzing the influence of the financial crisis on the pricing of credit derivatives.
Objective III.3:	Identifying the main drivers for mispricing on the German CLN secondary market.
Objective III.4:	Evaluating the presence of a product life cycle in the CLN secondary market in Germany.
Objective III.5:	Deriving key requirements for a feasible indicator of short-term commodity supply risks.
Objective III.6:	Evaluating the practicability of the convenience yield as indicator for short-term supply risk for five major industrial metals.
IV	**Summary and Future Research**
Objective IV.1:	Summarizing the key findings of the doctoral thesis.
Objective IV.2:	Highlighting starting points for future research.

Figure I-3: Objectives and structure of the doctoral thesis

I.2 Research Context and Research Questions

The research papers included in this doctoral thesis are embedded in the research context in the following section with respect to the above-stated objectives (cf. Fig. I-4). The respective research questions are motivated accordingly.

Figure I-4: Research papers embedded in the research context

The research papers in section II address different research gaps in terms of risk identification. In line with the identified research needs in this particular phase of the risk management process, the research papers in section II address both an overall level as well as the sports sector in particular. Specifically, research paper 1 focuses on why non-financial firms hedge their risks.[7] Therefore, the paper conducts, in all conscience, one of the first multivariate meta-analyses in corporate finance, thus providing a type of "meta-risk identification" applicable for non-financial companies in different sectors. Research paper 2 focuses on the sports sector and particularly on the soccer sector. Specifically, the paper contributes to the high impact of sporting performance risk on stock markets, by identifying the main risk drivers in terms of soccer matches and competitions on stock markets. To draw a comprehensive picture, the paper conducts a systematic literature review and aggregates existing findings by means of the vote counting method (Aretz and Bartram 2010).

The papers embedded in section III deal with the treatment of risks. Both research papers in this section provide original empirical evidence on risk treatment measures with respect to different sectors. In particular, research paper 3 focuses on the financial sector, analyzing the

[7] Research paper 1 solely investigates non-financial firms, as firms from the financial sector do not use derivatives exclusively for hedging purposes, but also for trading or speculative activities (e.g., Gay and Nam, 1998).

pricing on the German secondary market. Further, the paper examines how the pricing of structured financial products as an instrument for credit default risk treatment (as proposed by, e.g., Neal 1996) changed during and after the 2007-2009 financial crisis. Finally, research paper 4 focuses on the industrial sector, proposing the convenience yield, which is derived from the term structure of commodity futures as an indicator of future supply risk. Connecting both financial instruments, such as futures contracts, and commodity risk management, the paper examines whether the convenience yield can be used as an early warning regarding a commodity's future supply risks.

I.2.1 Section II: Risk Identification – Aggregated Empirical Evidence

Research Paper 1*: "What do we really know about corporate hedging? A multimethod meta-analytical study"*

Numerous studies in financial research have empirically investigated the theoretical explanations and sound theories for corporate hedging. Despite the large number of studies performed, or perhaps because of this number, the empirical evidence is mixed (Aretz and Bartram 2010; Bartram et al. 2009; Fauver and Naranjo 2010). This inconsistency in empirical findings can arise from the fact that results of a single empirical study are inherently restricted to a certain study design, observation period, country-specific attributes, and various variable selections and variable definitions. For instance, some studies particularly claim the reduction of bankruptcy financial distress costs (e.g., Judge 2004) as central for risk management, while some other studies note the reduction of agency cost of debt (e.g., Berrospide et al. 2008), and some papers find no evidence at all (e.g., Sprčić and Šević 2012). In order to obtain a clear picture from the existing literature, research paper 1 aims to provide new evidence on the determinants of corporate hedging by conducting three different approaches from the category of quantitative meta-reviews: (1) vote counting, (2) univariate meta-analysis, and (3) multivariate meta-analysis. Each of the analyses in research paper 1 tests the following hypotheses in order to identify determinants of hedging behavior and various sources of risk: corporate tax; bankruptcy and financial distress costs; asymmetric information and agency conflicts of equity; coordination of financing and investment policy and agency conflicts of debt. With this, the research paper addresses the following research questions:

- Which determinants influence corporate hedging behavior?
- How can the research method of multivariate meta-analyses be applied in the context of financial research?

Research Paper 2: *"How do soccer matches and competitions really influence stock markets? A review of recent empirical evidence."*

The era is long gone in which soccer was solely a type of sport. The meaning of soccer for the global economy has significantly broadened over the past decades. Soccer clubs' economic relevance has particularly increased in the past decade. To pick up the example from section I, the revenue of the FC Bayern Munich AG increased from 166.3 million € in the fiscal year 2003-2004 to 480 million € in 2013-2014, an increase of approximately 290% in ten years. This increase is strongly driven by the club's enormous sporting success during this decade, with six national championship titles, six wins in the domestic cup, and one win of the UEFA Champions League. Although Bayern Munich is an example of a club that is not market-listed, there are 22 soccer clubs listed across European stock markets. In literature, numerous studies have been conducted to explore the influence of soccer clubs', and even the national team's, sporting success on stock markets. Despite, or perhaps because of, a vast number of studies, empirical findings are still quite mixed. Analogous to research paper 1, the heterogeneous findings are predominantly reasoned in differing data samples, objects of study, and differing methodological approaches. In order to obtain a clearer and aggregated picture from the existing literature and thus on the influence of operational risks related to sporting success on stock markets, research paper 2 predominantly aims to provide a systematic review of the different studies by means of the vote counting method. Due to the heterogeneity of study designs and the lack of data sets provided in the different studies, the conduction of a meta-analysis in line with research paper 1 was not applicable. In particular, research paper 2 covers and analyzes 42 studies in detail. In addition, facilitated by soccer's characteristic that information about matches becomes available for all market participants simultaneously, and that soccer strongly influences investors' sentiments and thus their investment decisions (Lucey and Dowling 2005), soccer is an adequate subject to test the efficient market hypothesis and the behavioral alternative hypothesis, respectively. In accordance with this, soccer club matches as well as national teams in the course of soccer events are considered (e.g., the FIFA World Cup), as these events also affect a multitude of people and their sentiments. With this, the research paper addresses the following research questions:

- Referring to the current state of the art, are stock markets generally influenced by soccer, and what are the main sport-related drivers for this influence?
- Are stock markets in the context of soccer efficient, or driven by moods?

- Referring to the current state of the art, which methodological approaches and data sets have been examined in order to analyze the impact of soccer on stock markets?
- Concerning the impact of soccer on stock markets, are there any research gaps that can be identified and that lead to recommendations for further research?

I.2.2 Section III: Risk Treatment – Recent Empirical Evidence from the Financial and Industrial Sector

Research Paper 3: *"Market pricing of Credit Linked Notes - the influence of the financial crisis."*

The popularity of structured financial products like CLN has strongly increased in recent years. For instance, the gross sales of structured retail investment products in 2010 accounted for 174.2 billion € in Europe, 179.8 billion USD in the Asia-Pacific market, and 65.1 billion USD in North America (Jørgensen et al. 2011). Although the aforementioned figures show that CLN contracts are very popular for investors, as they provide the opportunity for a high coupon payment, they are subject to controversial discussions in financial research and the public opinion. As already outlined in section I, one major point of criticism regarding such structured products is their lack of transparency regarding whether the coupon payments for, and the prices of, these instruments are fair and adequate compared with the related risk. This lack of transparency can have a direct impact on the demand for such products, and thus on the applicability as instruments for the treatment of credit default risks. Consequently, and thus enhancing the study by Rathgeber and Wang (2011), which focused on the market pricing of CLN in the primary market, research paper 3 aims to test the presence of and reasons for CLN mispricing (i.e., the difference between a fair price and a quoted price) in the secondary market using a random effects panel regression model. In addition, research paper 3 analyzes how the mispricing of CLN changed during and after the 2007-2009 financial crisis. The financial crisis revealed the enormous complexity and inherent risks of structured financial products like CDS and CLN. Thus, investors' behavior may have changed from risk-loving and only bounded-rational to more reflective, leaving CLN issuers less space for overpricing, and thus for an overcompensation of credit default risks. Therefore, this may have induced a decline in demand for such products. By testing the change in mispricing during and after the financial crisis, research paper 3 simultaneously examines the validity of the product life cycle hypothesis for CLN. With this, the research paper addresses the following research questions:

- Are daily prices of CLN contracts fair and adequate compared with the related risk?
- If daily prices of CLN contracts are not fair, what are the reasons for the mispricing?
- How did the pricing of CLN contracts change during and after the 2007-2009 financial crisis?
- Is a product life cycle observable for CLN contracts?

Research Paper 4: *"Is the convenience yield a good indicator of a commodity's supply risk?"*

Due to the high relevance of industrial metals for the production of almost all industrial goods, such as cars and electronic devices, it is of high priority for companies from the industrial sector to treat potential supply risks adequately in regard to these commodities. Otherwise, disruptions in the production process are possible. In the occurrence of low stock levels, and particularly in just-in-time production strategies, a short delay in supply can cause production disruptions and financial losses for a single company, or, due to the increasing global cross-linking of supplier networks, even for the economic system as a whole (Hallikas et al. 2002; Harland et al. 2003). The threat of disruptions in the production process, combined with increasing production and consumption of industrial metals as well as the increasing financialization of commodity markets in recent years (European Commission 2010), makes manufacturers' assessment of the future availability of commodities increasingly important. As already outlined in section I, indicators for the future availability of a commodity should provide managers and policy makers with appropriate, easy, and continuously accessible information. As the literature lacks such an indicator, research paper 4 proposes the convenience yield, which is derived from the term structure of commodity futures as an early warning indicator of future supply risk. According to literature, the convenience yield can be interpreted as the benefit of having the commodity physically in stock (Copeland et al. 2004; Geman 2005). In order to check the applicability of this benefit as a short- to medium-term forward-looking indicator for future supply risk, research paper 4 examines the relationship between the convenience yield and the future inventory level respectively spot price by means of various regression models. Thereby, this research paper refers to convenience yields calculated from trading prices and inventory data of the London Metal Exchange (LME) for five major industrial metals (aluminum, copper, lead, nickel, and zinc) with different maturities (3, 15, and 27 months). With this, the research paper addresses the following research questions:

- What are the general indicators for a commodity's future supply risk, and what are the requirements for a feasible indicator of short-term supply risks in particular?
- Is the convenience yield (i.e., the benefit derived from having the commodity physically in stock) a good indicator of a commodity's future supply risk?

After this introduction, which aims at outlining the objectives and the structure of this doctoral thesis as well as at motivating the research context and formulating the fundamental research questions accordingly, the respective research papers are presented in sections II and III. Subsequently, the key findings are summarized and starting points for future research are highlighted in section IV.

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II Risk Identification – Aggregated Empirical Evidence

The research papers in section II focus on different aspects regarding the identification of risks. Risk identification is one of the major challenges within corporate risk management. Without the knowledge and awareness of different internal or external threats, risk management can only be performed in a reactive way - i.e., loss limitation - instead of in a proactive way (Hallikas et al. 2004). Comparable with similar learning spillover effects, one instrument of risk identification is learning from other companies, i.e., to examine why other companies do hedge. As the existing empirical findings regarding the reasons for corporate hedging are rather heterogeneous, a question arises as to which determinants really influence hedging behavior.

Consequently, the first research paper, *"What do we really know about corporate hedging? A multimethod meta-analytical study",* provides aggregated evidence on the determinants of non-financial firms' hedging behavior by conducting a multivariate meta-analysis. Thereby, the research paper uses a unique sample of 132 empirical studies, including more than 100,000 companies. By doing so, strong evidence for the bankruptcy and financial distress hypothesis. Also, the meta-analysis reveals weak support for the corporate tax hypothesis and the coordination of financing and investment policy and agency conflicts of debt hypothesis.

Due to the lack of theoretical and empirical contributions regarding risk management in soccer clubs, the second research paper, *"How do soccer matches and competitions really influence stock markets? A review of recent empirical evidence",* contributes to the closure of the research gap between the structured identification of risk and soccer teams' sporting success. The research paper provides a comprehensive review of recent empirical evidence from 42 studies and aggregates the existing knowledge to an overall level. By doing so, the paper shows that (1) soccer in general influences stock returns, and (2) losses and draws especially seem to influence investor sentiments, and even stock markets, in a negative way.

II.1 Research Paper 1: "What do we really know about corporate hedging? A multimethod meta-analytical study"

Authors: Jerome Geyer-Klingeberg[a], Markus Hang[b], Prof. Dr. Andreas Rathgeber[b], Prof. Dr. Stefan Stöckl[c], Matthias Walter[a]

[a] FIM Research Center, Department of Information Systems Engineering & Financial Management (Prof. Dr. Hans Ulrich Buhl), University of Augsburg, Germany
Jerome.Geyer-Klingeberg@fim-rc.de
Matthias.Walter@fim-rc.de

[b] Institute of Materials Resource Management
Faculty of Mathematics and Natural Sciences
University of Augsburg, Germany
Markus.Hang@mrm.uni-augsburg.de
Andreas.Rathgeber@mrm.uni-augsburg.de

[c] Department of Finance, Audit, Accounting and Control
ICN Business School Nancy-Metz (Grande école), France
Stefan.Stoeckl@icn-groupe.fr

Abstract:

We provide new evidence on the determinants of corporate hedging by conducting the very first multivariate meta-analysis in corporate finance. Hereby we use a unique sample of 132 empirical studies including more than 100,000 companies. Our results indicate a strong evidence for the bankruptcy and financial distress hypothesis. Moreover, we find weak support for the corporate tax and the coordination of financing and investment policy and agency conflicts of debt hypotheses. Regarding the asymmetric information and agency conflicts of equity hypothesis, we find no explanatory power.

JEL-classification: *G30, C32*

II.1.1 Introduction

The motivation for non-financial firms to engage in corporate hedging has been one of the most intensively discussed topics in financial research. Although the use of hedging instruments cannot be explained in a Modigliani and Miller (1958) world assuming a perfect capital market, more recent financial theory shows that hedging may increase firm value when frictions are present in the capital market (Bessembinder 1991; DeMarzo and Duffie 1991; Froot et al. 1993; Smith and Stulz 1985). In the meantime, many studies have empirically investigated the theoretical explanations for corporate hedging. However, despite or perhaps exactly because of the huge number of studies, the empirical evidence is quite mixed (Aretz and Bartram 2010; Bartram et al. 2009; Fauver and Naranjo 2010; Judge 2006). This discordance in empirical findings can arise from the fact that results of a single empirical study are inherently restricted to a certain study design, observation period, country-specific attributes, and various variable selections and definitions. For example, some empirical papers particularly claim some or one of the following aspects to be central for risk management: corporate tax avoidance (e.g., Berkman and Bradbury 1996), reduction of bankruptcy financial distress costs (e.g., Judge 2004), reduction of agency cost of equity (e.g., Fok et al. 1997), and reduction of agency cost of debt (e.g., Berrospide et al. 2008).

Contrarily, some papers find no evidence at all (e.g., Sprčić and Šević 2012). In order to obtain a clear picture from the existing literature, there are generally two opportunities imaginable:

1. Conduction of a large sample study. However, because different data sources (even in different legal regimes and languages) are needed, it is relatively difficult to successfully complete this task.
2. Conduction of a review. Here, secondary data from empirical studies on corporate hedging can be aggregated to condense the literature, which is otherwise hard to digest.

In the second case, there are two classes of meta-reviews: qualitative and quantitative reviews. As the qualitative procedure for synthesizing the studies depends on the reviewer and not on objective criteria, qualitative reviews are highly subjective. In contrast, quantitative reviews provide a more objective approach based on statistical measures. A simple form of a quantitative review is vote counting, which compares the number of statistically significant results for and against a certain hypothesis.

Aretz and Bartram (2010) conduct this procedure to present the state of the art in empirical research concerning explanations for corporate hedging in 31 primary studies. The major finding of their study is that they state "surprisingly mixed empirical support for rationales of hedging with derivatives at the firm level" (Aretz and Bartram 2010, p. 318). Some evidence exists for the coordinated financing and investment hypothesis. In addition, most proxy variables used to test whether corporate hedging can lower agency costs and whether corporate risk management alleviates agency conflicts between managers and shareholders lead to fairly mixed results. Regarding the bankruptcy and financial distress hypothesis, there is some support regarding the long-term debt. Furthermore, they find weak support for the tax hypothesis.

However, the main drawback of the vote counting method is the fact that each study receives an equally weighted vote, regardless of sample size and variance of the observed outcome. To circumvent this problem, Arnold et al. (2014) provide a univariate meta-analysis on that topic. They synthesize 15 proxy variables used to test the hedging hypotheses across 37 primary studies, and conduct separate univariate meta-analyses for each of their proxies. Their main result is that financial distress costs induce firms to hedge, which is in line with Aretz and Bartram (2010). In addition, they find weak evidence that the underinvestment problem and the dependence on costly external financing influence hedging behavior, which is mainly consistent with Aretz and Bartram (2010). Furthermore, taxes and agency conflicts of equity do not show explanatory power at all. This result deviates from Aretz and Bartram (2010). As a consequence of using univariate meta-analysis, they do not take into account interactions between the examined proxy variables. For example, in the case of existing corporate taxes, a combination of several influencing factors determines corporate hedging's firm value creation, such as volatility of pre-tax income, convexity of the tax function, and amount of tax payments. Riley (2009) shows that ignoring these dependencies in a meta-analysis can lead to a heavily biased estimation of the aggregated results. Furthermore, independent testing of correlated effects increases the chance of finding spuriously significant results (Bender et al. 2008).

In contrast, a multivariate meta-analysis offsets these shortcomings. It simultaneously integrates all outcomes from a sample of primary studies and accounts for their interactions in order to obtain a comprehensive view of the topic (Jackson et al. 2011; Mavridis and Salanti 2013; Nam et al. 2003).

Therefore, the aim of this paper is as follows: we provide new evidence on the determinants of corporate hedging by conducting the first multivariate meta-analysis in this research area. In our analysis we test the following specific hypotheses (and corresponding proxy variables): corporate tax (proxy: tax-loss carryforwards (binary)), bankruptcy and financial distress costs (proxies: dividend yield (continuous), interest coverage ratio, leverage ratio, liquidity, profitability, size, tangible assets), asymmetric information and agency conflicts of equity (proxies: institutional investors, option ownership (continuous), share ownership), and coordination of financing and investment policy and agency conflicts of debt (proxies: Capex, research and development, sales growth rate, Tobin's Q). Thereby, we significantly extend the sample of 37 studies analyzed by Arnold et al. (2014) to a total of 132 studies, including published as well as unpublished literature. In addition, we apply vote counting and the univariate meta-analysis as robustness tests. In this combination, we can take more proxy variables into account amongst many others, because these methods have fewer requirements, especially regarding necessary data. Last but not least, we emphasize different biases that can appear in quantitative reviews. In particular, we deal with the so-called publication and data mining biases. In case of the latter, we follow the concept of multiple testing, introduced by Harvey et al. (2014). For the conduction of a high-quality review, we follow the Cochrane Handbook for Systematic Reviews of Interventions as a general framework for our analyses (Higgins and Green 2011).

Our multivariate findings indicate strong evidence for the bankruptcy and financial distress hypothesis. In this respect, we find positive signs regarding the proxy variables dividend yield (continuous) and liquidity (each at a significance level of 5%) as well as size (at a significance level of 1%). In addition, we find some support for the corporate tax hypothesis, as well as weak support for the theory that the underinvestment and asset substitution problem, as well as the lack of internal funds for investing in profitable investments, induce firms to hedge. In this context, there is a positive sign for the proxy variable research and development at a significance level of 10%. Moreover, regarding the corporate tax hypothesis, there is a positive relationship between the use of hedging instruments and the tax-loss carryforwards (binary) at a significance level of 10%. However, we cannot provide consistent evidence for the hypothesis that hedging alleviates asymmetric information and agency conflicts between managers and shareholders. Hence, our results partly contradict the outcomes from previous vote counting and univariate reviews by Aretz and Bartram (2010) and Arnold et al. (2014).

The remainder of the paper is structured as follows. Section II.1-2 provides an overview of the four basic hypotheses of firm value creation by corporate hedging. Section II.1-3 serves as a short introduction to the methodology of (multivariate) meta-analysis. Section II.1-4 covers literature search and data preparation. Section II.1-5 reports empirical findings, which thereupon are discussed in Section II.1-6. Section II.1-7 concludes the paper.

II.1.2 Determinants of Corporate Hedging

According to Modigliani and Miller (1958), risk management and thus corporate hedging activities add no value to the firm as they can be fully replicated by shareholders' own transactions in the capital market. However, this proposition only holds under the assumption of a perfect capital market. By incorporating capital market imperfections, scholars have developed several hypotheses explaining why hedging at the firm level can add value to shareholders (e.g., Bessembinder 1991; DeMarzo and Duffie 1991; Froot et al. 1993; Smith and Stulz 1985).

These theoretical hypotheses can be classified into two major theories, depending on the general meaning of corporate hedging, which is either the maximization of shareholder value or the maximization of manager's private utility (Sprčić et al. 2008). In this study, we focus on the shareholder value maximization theory. The small number of empirical studies examining hypotheses related to the managerial utility maximization theory indicates that this is in line with the majority of previous literature (e.g., Aretz and Bartram 2010; Arnold et al. 2014; Guay and Kothari 2003). Within the shareholder value maximization theory, we review four hypotheses which explain how corporate hedging increases firm value by (1) reducing the corporate tax burden, (2) lowering bankruptcy and financial distress costs, (3) mitigating asymmetric information and agency conflicts of equity, as well as (4) improving the coordination of financing and investment policy and alleviating agency conflicts of debt. As these hypotheses are similar to those reviewed by Aretz and Bartram (2010) and Arnold et al. (2014), we can later compare results on a hypothesis-level.

Hereinafter, we give a short review of the four hypotheses mentioned above. Furthermore, we report the proxy variables[8] used to test whether firms with properties according to the hedging hypotheses are more likely to hedge. In addition, for each of the hypotheses we report the hypothetical sign for the different proxy variables as well as their definitions. The variable descriptions are therefore similar to those in Aretz and Bartram (2010), with differences remarked on accordingly. Further, to gather a comprehensive overview of the existing empirical body of knowledge regarding the four aforementioned corporate hedging

[8] See Section 4 for the selection criteria of the proxy variables.

hypotheses in reference to each of the corresponding proxy variables, we present a schedular overview of the primary studies providing (in)significant positive or negative statistical evidence, with respect to a probability level of 5%.

II.1.2.1 *Corporate Taxes*

Smith and Stulz (1985) show that if a firm faces a convex tax function (i.e., taxes increase overproportionally with taxable income) corporate hedging can increase post-tax firm value by reducing volatility of pre-tax income. This is due to Jensen's inequality as less volatile cash flows lead to a lower expected tax liability. Thus, we receive the following hypothesis H1:

- **Hypothesis H1: There is a relationship between corporate taxes and the firm's hedging decision.**

Appendix I provides an overview of the relevant proxy variables used to test the corporate tax hypothesis, the corresponding hypothesized signs, variable descriptions as well as the empirical findings of the primary studies examining the respective relations.

Accordingly, we estimate the relative convexity of the tax functions through two variables: tax-loss carryforwards and tax credits (Graham and Smith 1999; Zimmerman 1983). Both extend the convex portion of the tax function and thus we expect that firms with higher tax credits, tax-loss carryforwards (binary) and tax-loss carryforwards (continuous) have greater incentives to hedge (Nance et al. 1993).

II.1.2.2 *Bankruptcy and Financial Distress Costs*

Volatile future cash flows and a high leverage may induce situations in which a firm's liquidity is insufficient to fully meet its contractually fixed payment obligations. This increases the risk of bankruptcy and the firm encounters direct and indirect costs of financial distress (Jensen and Meckling 1976). Since corporate hedging lowers cash flow volatility and thus the probability of the company's default, it reduces expected costs of financial distress and thus adds value to the firm (Smith and Stulz 1985). Thus, we receive the following hypothesis H2:

- **Hypothesis H2: There is a relationship between bankruptcy and financial distress costs and the firm's hedging decision.**

We test the bankruptcy and financial distress hypothesis with thirteen different proxy variables, which are subsequently presented in Appendix J.

First, we use the firm's leverage ratio, debt maturity and interest coverage ratio, since they indicate probability of financial distress. As explained in the passage above, we assume a positive relation between the firm's leverage ratio and its hedging behavior. The same trend should appear for firms with more debt maturation in the short-term. The interest coverage ratio is expected to have a negative association with corporate hedging, since a higher interest coverage ratio implies that more pretax income is necessary to satisfy fixed payment obligations (Bartram et al. 2009).

Furthermore, we use availability of short-term funds represented by cash flow availability and liquidity as proxies for the bankruptcy and financial distress hypothesis. Liquid firms should have a lower risk of financial distress and thus both variables are assumed to be negatively correlated with the firm's hedging activity (Froot et al. 1993).

Convertible debt and preferred stocks constrain a firm financially (Géczy et al. 1997). However, at the same time, they lower agency conflicts of debt (Nance et al. 1993). Thus, we cannot predict a relationship between these two variables and the firm's hedging behavior. The influence of the dividend yield on corporate hedging is also conceivable in both directions. It can be argued that firms with higher dividend payouts are more liquid and thus have less incentive to hedge (Nance et al. 1993). In contrast, firms exhausting their liquidity by paying dividends may be more likely to engage in corporate hedging, as they have additional financial constraints from their shareholders (Haushalter 2000). We measure a firm's dividend policy with a binary and a continuous variable.

More profitable firms are expected to encounter fewer situations of financial distress and thus should have fewer incentives to hedge. Furthermore, as indirect costs of financial distress are disproportional to size (Myers 1977), we hypothesize that larger firms are less likely to protect against bankruptcy. Moreover, as tangible assets can be easily sold in the case of bankruptcy, firms with a higher level of tangible assets should have a lower probability of financial distress (Aretz and Bartram 2010). Finally, we use tax-loss carryforwards as a proxy for the bankruptcy and financial distress hypothesis. Since tax-loss carryforwards arise from past losses, this proxy variable indicates financial distress and we thusly assume a positive influence on a firm's hedging behavior.

II.1.2.3 *Asymmetric Information and Agency Conflicts of Equity*[9]

DeMarzo and Duffie's (1991) model states that information asymmetries can arise from a manager's proprietary information on the firm's dividend stream. Due to such preferred access to corporate information, shareholders cannot fully replicate the firm's hedging decision, thus allowing the firm to hedge more effectively than its shareholders. Since corporate hedging reduces the variability of the corporate cash flow and resulting "noise" in the firm's dividend stream, shareholders have fewer costs for monitoring the firm and to rebalance their portfolios (DeMarzo and Duffie 1991). Thus, we receive the following hypothesis H3:

- **Hypothesis H3: There is a relationship between asymmetric information and agency conflicts of debt and the firm's hedging decision.**

The proxy variables used to measure information asymmetry and agency conflicts of equity are presented in Appendix K.

We measure information asymmetry by the number of shares held by institutional investors and the number of analysts following the firm, because both groups have privileged access to information and both bring this information into the market (Graham and Rogers 2002). Accordingly, firm earnings can be predicted with greater accuracy and lower dispersion; therefore, firms should be less likely to hedge (DeMarzo and Duffie 1991; Dadalt et al. 2002). Furthermore, as costs of information verification are very high for firms with more intangible assets, we use this as further proxy variable indicating information asymmetries (Baker and Gompers 2003) and expect firms with more intangible assets to have greater incentives to hedge (Choi et al. 2013).

Moreover, in contrast to shareholders, managers cannot completely diversify their personal risk position (e.g., through future salaries, reputation or career opportunities). Whereas shareholders diversify their individual portfolio in the capital market, managers control their human capital only on a corporate level. This provides incentives for managers to hedge their individual human capital against risks that are diversifiable for shareholders (Amihud and Lev 1981). As corporate hedging decreases the variability of the firm value, it lowers the underlying risk imposed on the manager's human capital. Consequently, firm value increases as managers demand less extra compensation for their non-diversifiable risk exposures (DeMarzo and Duffie 1995; Smith and Stulz 1985).

[9] The agency conflicts of equity hypothesis can also be derived from the maximization of manager's private utility theory. However, we follow Aretz and Bartram (2010), Arnold et al. (2014) and Guay and Kothari (2003), and classify this hypothesis under the shareholder value maximization theory.

We measure a manager's personal risk position by the amount of CEO cash, which is the sum of CEO salary and bonus. We assume a negative relationship, since more CEO cash means that managers have more money available to invest in assets outside of the firm (Guay 1999).

Moreover, an incentive for hedging can be given by manager incentive structures, which are typically tied to the firm's market value. The positive effect of corporate hedging depends on the shape of the function between a manager's expected utility and firm value. If this function is convex, which is the case when managers own stock options, there is no incentive to hedge, as a more volatile firm value increases the option price value (Black and Scholes 1973). Consequently, we use the manager's option ownership (binary) and option ownership (continuous) as proxies with an unspecified predicted hypothesis sign. Most authors hypothesize a negative relation between managerial ownership and corporate hedging (see, e.g., Haushalter 2000; Tufano 1996). However, Gay and Nam (1998) argue that option ownership induces firms to hedge, as managerial stock option payoffs are often close to normal stock payoffs and thus (almost) linearly related to firm value. On the other hand, if the manager's utility function is concave, which is usually the case when compensation is based on the stock price, every stock price movement directly leads to changes in the manager's wage. A risk-averse manager has thus an incentive to hedge (Smith and Stulz 1985). Accordingly, we use the manager's share ownership as a proxy for the agency conflicts of the equity hypothesis, and therefore expect a positive hypothesis sign.

We also measure blockholder's ownership, as large shareholders are usually well diversified and thus less likely to hedge than poorly diversified managers (Haushalter 2000; Tufano 1996). However, the relationship may also be positive, as a greater percentage of large shareholders probably reduces agency conflicts and leads to fewer incentives to hedge (Marsden and Prevost 2005). Finally, according to May (1995), CEOs with a longer tenure are more risk averse and thus more likely to hedge, as they develop skills unique to the firm. In contrast, career concerns would suggest that younger managers have more incentive to hedge (Croci and Jankensgård 2014). Thus, the predicted sign of the proxy variable CEO tenure remains ambiguous.

II.1.2.4 *Coordination of Financing and Investment Policy and Agency Conflict of Debt*

High leverage and a low present value of the firm may give rise to the following agency conflicts of debt, as management has incentives under these conditions to transfer wealth from bondholders to shareholders. Thus, we receive the following hypothesis H4:

- **Hypothesis H4: There is a relationship between coordination of financing and investment policy and agency conflicts of debt and the firm's hedging decision.**

The proxy variables used to measure this hypothesis are presented in Appendix L.

First, managers may forego positive net present value projects if the expected project gains must be used mainly to satisfy fixed payment obligations to the bondholders (Myers 1977). Corporate hedging can relieve this problem, as a reduction of cash flow variability increases the probability that shareholders are residual owners after reimbursing bondholders. This reduces the incentive to underinvest in profitable projects (Bessembinder 1991; Myers and Majluf 1984). As a result of corporate hedging activities, positive net present value projects are more often accepted, thereby increasing firm value. Moreover, when external financing is more costly than internal financing (Myers and Majluf 1984), firms may forgo profitable investments due to a lack of internal funds. Froot et al. (1993) show that under this condition, corporate hedging may be used as an instrument to coordinate the availability of internal funds. This ensures that firms have sufficient capital available to invest in value-enhancing projects.

Secondly, managers acting in the best interest of shareholders may replace low-risk assets with high-risk investments (Smith and Warner 1979). This is due to the fact that shareholders' equity positions are a call option on the company's assets, and high variance projects enlarge the option value (Mason and Merton 1985). However, this exchange of assets raises additional risk for fixed payment receivers. Hence, bondholders anticipating the opportunistic behavior of management claim higher returns or protective bond covenants, due to this increasing risk and higher agency costs (Jensen and Meckling 1976). Corporate hedging adds value to the firm by lowering the project's risk and accordingly diminishing agency costs which arise from the managerial incentive of asset substitution (Campbell and Kracaw 1990).

Underinvestment and asset substitution problems are more likely to occur in firms with significant growth opportunities and high leverage. Thus, we use the firm's asset growth rate, capex, research and development expenses as well as sales growth rate as direct measures for the existence of available growth opportunities. The price-earnings-ratio and

Tobin's Q (market-to-book ratio) are indirect measures (Aretz and Bartram 2010). Moreover, firms with growth opportunities are expected to have market values far in excess of their book values and share prices higher than their earnings (Berkman and Bradbury 1996; Mian 1996). Finally, as convertible debt resolves debt-related agency problems (Nance et al. 1993), we expect firms with more convertible debt to hedge less.

II.1.3 Methodology

The objective of this meta-analysis is to comprehensively test the four above-mentioned hedging hypotheses on an aggregated empirical level across a broad set of primary studies. This allows drawing more powerful and generalized statements than any single empirical study could. In order to do so, we investigate the relationship between the proxies described in the previous section and the corporate hedging behavior, which is modeled by a dummy variable ("1" for the Hedgers and "0" for the Non-Hedgers)[10]. As an effect size for this relationship, we use the Pearson correlation coefficient. Due to the fact that the variance of the raw correlation strongly depends on the correlation coefficient itself, all computations are performed in the variance-stabilizing Fisher's *z*-scale and are later transferred back into the correlation metric for interpretation.

In order to aggregate these effect sizes across studies, we briefly present the core concepts of univariate meta-analysis according to Borenstein et al. (2009) and multivariate meta-analysis according to Becker (1992). The latter additionally accounts for the fact that when several proxy variables are extracted from the same study, dependencies must be taken into account. A more detailed insight into the methodology is presented in the numerical example in Appendix A. Besides the classical meta-analysis approach, we apply vote counting similarly to Aretz and Bartram (2010), which simply counts the number of statistically significant results for each proxy variable.

Univariate Meta-Analysis

Meta-analysis aims to derive the best estimate for the unknown population effect size by calculating a weighted mean correlation across all studies in the analysis. Hedges and Olkin (1985) show that the optimal weights w_{ij} for effect size $j = 1, \dots, p$ from study $i = 1, \dots, k$ are given by the inverse sum of the within-study variation v_{ij} (which captures the sampling error) and the between-study variation T_j^2 (which captures the variance of the effect size parameters across the population of studies):

$$w_{ij} = \frac{1}{v_{ij} + T_j^2} \tag{1}$$

[10] In contrast, other studies (e.g., Belghitar et al. 2013; Graham and Rogers 2002; Knopf et al. 2002) propose a continuous hedging variable to measure the extent of hedging (e.g., the gross notional derivative value or the fair value of derivative contracts). However, studies using a hedging dummy variable routinely report the descriptive statistics for Hedgers and Non-Hedgers or a mean difference test between both groups, consequently providing us with sufficient information to extract correlations. In contrast, studies examining a continuous hedging variable do not usually present this information. Moreover, the number of studies using a dummy instead of a continuous hedging variable is much higher, and therefore a meta-analysis based on these studies yields more meaningful results.

Accordingly, study weights are assigned with the goal of minimizing both sources of variance. As ${T_j}^2$ is unknown, we apply a method of moments estimator (DerSimonian and Laird 1986). Using these weights, the transformed mean correlation $\hat{z}_j$ is simply the weighted average of the transformed correlations z_{ij} observed from each study:

$$\hat{z}_j = \frac{\sum_{i=1}^{k} w_{ij} z_{ij}}{\sum_{i=1}^{k} w_{ij}} \tag{2}$$

Multivariate Meta-Analysis

Usually, primary studies on corporate hedging test their hypotheses through multivariate analyses. For example, in the case of corporate taxes, a combination of several influencing factors like volatility of pre-tax income, convexity of the tax function, and amount of tax payments determines the value contribution of corporate hedging. Consequently, a multivariate analysis in primary studies also requires a multivariate aggregation of these effect sizes on a meta-level. Thus, in addition to p correlations between the hedging variable and each proxy variable, correlations among the proxy variables themselves must also be considered. In the case that all proxy variables are available from the primary studies, we extract $p^* = p(p+1)/2$ correlations from each study of interest.

Instead of the inverse variance from equation (1), the weights for the observed study effect sizes from study *i* are accordingly given by the inverse of the variance-covariance matrix $\boldsymbol{S}_i$, where the diagonal elements capture the study specific effect size variation and the off-diagonal elements are the estimated[11] covariances between them. Again, we estimate the between-study variation for each effect size using a method of moments estimator for each set of transformed correlations (Raudenbush, 2009), which leads to the $p^* \times p^*$-matrix $\boldsymbol{T^2}$. The weights can be calculated by adding $\boldsymbol{T^2}$ to each study-specific covariance-matrix $\boldsymbol{S}_i$.

The multivariate weights are used in a GLS estimator for the *z*-transformed mean correlation vector $\hat{z}$, which is, according to Raudenbush et al. (1988), given by

$$\hat{z} = (\boldsymbol{X}'\boldsymbol{S}^{-1}\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{S}^{-1}z. \tag{3}$$

Here, $\hat{z}$ is a $p^* \times 1$ column vector, whose elements are the effect size parameters to be estimated. $\boldsymbol{X}$ is an indicator matrix with *k* stacked $p^* \times p^*$ identity matrices that show which correlations are given in each study. $\boldsymbol{S}$ is a block-diagonal variance-covariance matrix

[11] To estimate the covariances, we apply the large sample approximation according to Olkin and Siotani (1976).

containing the k study specific variance-covariance matrices $\boldsymbol{S_i + T^2}$ on its diagonal. z is a kp^* column vector storing the observed effect sizes p^* from all k studies.

Finally, we use the estimated mean correlations $\hat{z}$ for multiple regression model with the proxy variables as predictors and the hedging dummy as dependent variable. The standardized regression slopes in this linear model are given by

$$b = \boldsymbol{R}_{XX}^{-1}\boldsymbol{R}_{XY}, \tag{4}$$

with b as a $p \times 1$ vector of standardized regression coefficients, and $\boldsymbol{R}$ as the GLS estimator $\hat{z}$ from equation (3), transformed back into the correlation scale and organized as a matrix. $\boldsymbol{R}_{YX}$ (=$\boldsymbol{R}_{XY}$) is a $p \times 1$ matrix with the correlations between the hedging variable Y and each proxy variable X, where p is the number of proxies used as predictors. $\boldsymbol{R}_{XX}$ is a $p \times p$ matrix with the correlations between the proxy variables themselves.

II.1.4 Data

We employ multiple search techniques to identify prior empirical literature examining the determinants of corporate hedging. Our search process consists of the following six steps, outlined briefly[12]: definition of the inclusion criteria, search in electronic databases for published literature, search for gray literature, backward search, search in author's publication lists, and forward search.

Studies included in the meta-analysis met the following criteria: (1) As argued before, we require the hedging decision to be modeled as a dummy variable in the primary studies. (2) The correlation coefficient between the proxies and the hedging dummy should either be reported directly in the study, or there must otherwise be sufficient data from the descriptive statistics (e.g., t-statistic from a test with independent groups or the standardized mean difference between the Hedgers and Non-Hedgers group) to replicate the correlations[13]. If this is not given, the authors of the study must provide us with the required effect size data in order to be included in the analysis. (3) Additionally, for multivariate meta-analysis the correlations among the proxy variables should be stated in the primary study. However, this is not a necessary requirement to be included, as the relationship between the dummy and the proxies also carries information usable in a multivariate meta-analysis[14]. (4) The study's sample size must be extractable in order to calculate the effect size variation and the study weight. (5) Only studies investigating non-financial firms were included, as firms from the

[12] A summary of the literature search process can be found in Appendix B.
[13] The conversion of effect sizes is presented by Borenstein et al. (2009).
[14] Of course, if none of the studies provide correlations between the proxies, the multivariate analysis equals the univariate analysis.

financial sector do not use derivatives exclusively for hedging purposes, but also for trading or speculative activities (e.g., Allayannis and Weston 2001; Gay and Nam 1998; Heaney and Winata 2005). However, we do not exclude studies containing both financial and non-financial firms, if the sample was taken from a broad stock market index.

We searched for English and German studies in four[15] major electronic databases of academic financial literature by adopting the search command from Arnold et al. (2014)[16]. For each source of literature, the title, the abstract, and then the content were screened with regard to the inclusion criteria. In summary, we reached a total number of 2,790 studies, with 757 resulting from ABI/INFORM Complete, 1,300 from Business Source Premier, 593 from EconBiz and 140 from ScienceDirect. After sorting the results by the inclusion criteria, we cut the sample to 67 relevant studies.

Furthermore, we explicitly searched for gray literature to reduce the threat of publication bias. By screening the electronic working paper database SSRN (via ProQuest) and using the same search strategy as for published articles, we received another 18 relevant studies (from an initial sample of 808 studies). Additionally, we found 216 dissertations[17] in the Dissertations and Theses database (via ProQuest), which provided us with 6 relevant studies from 5 doctoral theses.

In the following step, we performed a backward search by screening the reference lists of the 91 studies identified as relevant to the sample from the search in the above-mentioned databases. Furthermore, we screened the publication lists of the authors appearing more than twice in our interim list from the database search. Finally, we conducted a forward search for all studies on the interim list via the "cited by"-option in Google Scholar. Another 76 relevant studies were identified in this step.

At the end of the search process, we reached a sample of 167 relevant primary studies[18] meeting the inclusion criteria – with 54 of them providing all required data for univariate

[15] We also screened the search results in JSTOR and the Wiley Online Library. However, the number of duplicates and irrelevant studies rapidly increased by adding more databases. Due to very low precision, we decided to stop the database search for published literature after sorting search results from the four databases named above, where we focused on peer-reviewed studies to yield an appropriate precision for the list of results.

[16] Arnold et al. (2014) derived a search command for electronic databases from a sample of thirty relevant primary studies. The search command consists of nineteen search terms linked by Boolean operators. See Appendix B.

[17] We also found 7 master theses with sufficient data. However, as the quality of student theses is hard to evaluate, and to reduce potential bias via the "garbage in, garbage out"-problem, we excluded them from our sample.

[18] The list of excluded studies from the initial sample of 167 relevant studies is available on request from the authors.

and multivariate meta-analysis, 69 studies reporting at least the data required for the univariate meta-analysis and 44 studies with none of the required data published. Thus, we finally sent a study-specific request mail[19] to the authors of all studies with missing data. In response, 12 authors provided us with additional data on their respective studies. All in all, our literature search produced a sample of 135 primary studies. However, we had to exclude 3 studies due to insufficient data or dependencies in the sample[20]. Consequently, our final sample consists of 132 primary studies, which are listed in Appendix C. The basic statistics describing our sample are summarized in Appendix H.

Whereas numerous effects have been studied multiple times, the inclusion of variables analyzed only in few studies would result in an unreliable estimation of the population effect size. Thus, we follow Fu et al. (2011), who recommend integrating only those proxy variables in the univariate meta-analysis that appear in at least six studies. As information about the dependencies between the proxy variables improves our population effect size estimate compared to the univariate meta-analysis, we consider all proxy variables for which each correlation with the other proxies is reported in at least one study. However, as several of these correlations are not given in any of the primary studies, we can calculate the multivariate results for only fourteen proxy variables. The variables covered by the multivariate analysis are shown in Table II.1-1.

In some studies, we had to do some adjustment in order to incorporate their findings in our meta-analysis. Some authors use the opposite assignment for the hedging dummy, i.e., "0" for the Hedgers group and "1" for the Non-Hedgers group. In these cases, we adjusted the sign of the correlations and the *t*-statistics. As sample size for the Hedgers and Non-Hedgers subgroup, we use the number of firms investigated in the primary study instead of the firm

[19] We sent a request mail to the authors of 113 studies with missing data and two weeks later a reminder mail to the authors and co-authors. From 10.62% of the contacted authors we received additional data. 22.12% rejected to provide us with the correlational data from their study, and from the remaining 67.26% we did not receive a response to our request.

[20] If studies use an identical sample of firms, we use each proxy variable from this sample only once. However, we do not control for overlapping samples, as the aim of meta-analysis is to aggregate propositions made in primary studies; despite their overlapping samples, each study reports an individual result. Beside the studies from Bartram (Bartram et al. 2009; Bartram et al. 2011; Bartram 2012) and Lin et al. (Lin et al. 2007; Lin et al. 2010), the studies from Nguyen and Faff (Nguyen and Faff 2002; Nguyen and Faff 2006; Nguyen and Faff 2007; Nguyen and Faff 2010) are also based on the same data sample. As the studies by Nguyen and Faff additionally investigate nearly the same variables, we had to exclude Nguyen and Faff (2006) and Nguyen and Faff (2010) from our sample as they do not contain additional variables. Furthermore, dependencies also arise when a study reports results for different groups dependent on each other (e.g., for disjoint observation periods, different hedging intensities, etc.). As some firms could be in several groups, as in the case of dependent results within one study, we include the subsample with the largest sample size.

year observations[21]. Seven studies do not contain any measures for the estimation of correlations. In these cases, we use statements from the article's text to extract the direction and magnitude of the proxy variable[22]. Moreover, some studies report the reciprocal value of the proxy variables in the same manner we defined (e.g., book-to-market value instead of market-to-book value). In this case, we use the reciprocal means and estimate the variance approximation of the reciprocal elements. Afterwards, we calculate the mean differences and convert the values to the Pearson correlation coefficient.

II.1.5 Empirical Results

Empirical literature tests the hedging theories by the firm-specific proxy variables presented in Appendix I through L of the paper with the corresponding definitions. We aggregate the effect size measures for these proxies across our sample of 132 primary studies using multivariate meta-analysis and carry out the univariate meta-analysis and vote counting as a robustness test. For each proxy variable we examine the underlying null hypothesis of no relationship with the hedging dummy variable. In the following, we first deal with heterogeneity in more detail, because this is important for the question of using a fixed or random effects model in our analysis. Afterwards, we present our main results for each of the four tested hypotheses including the respective results of the robustness checks. Last but not least, we deal with potential biases when applying meta-analyses.

One main aspect of meta-analysis is the detection and consideration of heterogeneity among study-specific effect size estimates. The corresponding heterogeneity statistics can be found in Appendix E. As Arnold et al. (2014, p. 4) have pointed out, "we cannot assume one true effect size for the reviewed proxy variables in all studies". Country-specific regulations or firm characteristics influence the true effect size, although the initial decision to hedge is the same. We consider these deviations by applying a random effects model, which is not comparable to a random effects model, as known in panel data analysis. In our case, the true effect size is random. To verify the assumption of random effects, we apply Cochran's *Q*-test resulting in a *Q*-statistic of 41056.49, which is under the null hypothesis approximately chi-square distributed with 1,522 degrees of freedom and thus highly significant at the 1% level. As the *Q*-statistic is a sum and as such strongly depends on the number of studies, we

[21] In case a study observes more than one year and does not provide the number of firms, we divide the total firm year observations by the years of observation. Moreover, some primary studies report the statistics for the proxy variables based on different samples. In this event we use the median sample size to create one single sample size for each study.

[22] If a significant relationship is stated in the text, we assigned a *p*-value of 0.05. If a weak relationship is reported, we assign a *p*-value of 0.10 and if the study concludes no relationship in the text, we assigned a *p*-value of 0.5 and a *t*-value of 0.

also look at the between-study variance T_j^2, which is in the same (squared) metric as the effect sizes. The largest variation of effect sizes is observable for tax credits with a between-study variance of 0.4572. The same holds for the univariate case[23]. As the results show, all proxy variables are significant at the 1% level and consequently vary strongly across primary studies in the univariate case, except for blockholders with a *p*-value of 0.078. Heterogeneity is also graphically confirmed by a forest plot[24] for each proxy variable, as the confidence intervals of the study-specific effect sizes mostly do not contain the true effect size from the fixed effects model.

A summary of the multivariate results is displayed in Table II.1-1. In the following, we present our result for each of the four hypotheses in detail. The corresponding random effects mean correlations matrix across the whole sample of studies calculated by equation (3), which then serves as input for the linear model, can be found in Appendix E.

[23] Heterogeneity of effect sizes cannot be integrated in the vote counting method.
[24] The forest plots are available on request from the authors.

Table II.1-1 Summary of multivariate results

Proxy variable	Number of different variable operationalizations in the primary studies for each proxy[a]	Hyp. sign	Multivariate results: Emp. sign	Multivariate results: *p*-value	Multivariate results: Adjusted *p*-value with *a(PF)*=0.05[bc]
CORPORATE TAXES (H1)					
Tax-loss carryforwards (binary)	1 definition in 18 studies	+	+	0.0956*	
BANKRUPTCY AND FINANCIAL DISTRESS COSTS (H2)					
Dividend yield (continuous)	7 definitions in 41 studies	?	+	0.0202**	0.0217
Interest coverage ratio	5 definitions in 30 studies	−	−	0.7530	0.0361
Leverage ratio	9 definitions in 108 studies	+	+	0.2607	0.0401
Liquidity	6 definitions in 72 studies	−	−	0.0108**	
Profitability	8 definitions in 68 studies	−	+	0.2135	0.0387
Size	7 definitions in 115 studies	−	+	0.0002***	
Tangible assets	3 definitions in 11 studies	−	+	0.2425	0.0302
ASYMMETRIC INFORMATION AND AGENCY CONFLICTS OF EQUITY (H3)					
Institutional investors	5 definitions in 22 studies	−	+	0.1203	0.0242
Option ownership (continuous)	7 definitions in 19 studies	?	−	0.5275	0.0087
Share ownership	6 definitions in 44 studies	+	−	0.2091	0.0352
COORDINATION OF FINANCING AND INVESTMENT POLICY AND AGENCY CONFLICTS OF DEBT (H4)					
Capex	5 definitions in 35 studies	+	−	0.3169	0.0420
Research and development	3 definitions in 37 studies	+	+	0.0541*	
Tobin's Q	3 definitions in 79 studies	+	+	0.1856	

This table sums up the proxy variables reviewed in the multivariate analysis in the paper at hand. The second column contains the number of different variable operationalizations that we aggregated in our proxy variable definitions. The following columns include their hypothetical sign for the impact on the corporate hedging decision as well as the empirically revealed results and the corresponding *p*-value. *, ** and *** indicate the rejection of the null hypotheses at the 10%, 5%, and 1% probability levels.

[a] If one study uses several variations for a specific proxy variable, we only considered the definition with the least deviation related to the other studies testing the same proxy variable. A spot check revealed that the underlying sample covers most variations in the proxy-specific definitions.

[b] To account for the different variable definitions and the possible data mining bias we adjusted the p-values similar to Harvey et al. (2014). Therefore, we used the Bonferroni correction respectively its exact version (the Sidak correction), both adjusting for the fact, that the probability of a type I error in a multiple test differs from that in a single test. However, in this connection we had to account for two facts (for details see for example Abdi, 2007).

First, there are *ns* number of studies applying the same variable definition. This effect leads to a change in the probability of the type I error in ns trials. Second, there are the number of variable definitions *nv* leading to an increase in the probability of a type I error. Altogether, this results in a probability *a(PF)* of making as least one type I error, which depends on the probability of making a type I error *a(PT)*, when only dealing with a specific test. Consequently, the adjusted probabilities can be expressed as follows:

$$a(PT) = 1 - \left(1 - a(PF)\right)^{\frac{ns}{nv}}$$

In case *ns*=*nv* there is no probability adjustment, because both effects equalize. However, we think that different studies applying the same definition leading to similar results due to similar samples, etc. Hence, the probability of making a type 1 error in the first study depends on the probability in the second study. We model this dependence structure by applying a binary variable (0=to reject the null hypothesis; 1=to accept the null hypothesis). Due to the fact, that we used a binary variable, the correlation coefficient can be easily calculated and emprises the complete dependence structure of the variables.

$$Korr = \frac{1 - a_{joint} - (1-a)^2}{(1-a) - (1-a)^2}$$

Inverting the equation the correlation structure can be fixed and the joint probability of making a type I error can be calculated as follows:

$$a_{joint} = 1 - Korr\left((1-a) - (1-a)^2\right) + -(1-a)^2$$

After taking the calculation of the probability for a quasi independent event $a_{sing} = 1 - \sqrt{1 - a_{joint}}$, the formula changes to

$$a(PT) = 1 - \left(1 - a_{sing}\right)^{\frac{ns}{nv}}$$

A look at the different studies showed a high dependency between the p-values of different studies having the same variable definition. Hence, we decided to use a high correlation *Korr*=0.8 in order to adjust for the correlation effect.

[c] Only those values were depicted, for which *a(PT)*<0.05.

For the corporate tax hypothesis (H1), we reveal some empirical evidence, seen below in Table II.1-2.

Table II.1-2 Statistical results for the corporate tax hypothesis (H1)

			Multivariate meta-analysis			Univariate meta-analysis				Vote counting				
										$\alpha = 0.50$		$\alpha = 0.05$		
Proxy variable	Hyp. sign	No. of firms	b	SE(b)	p-value	r	SE(z)	p-value	Eggers's regression test p-value	-	+	-	0	+
Tax credits	+	10,198	na	na	na	-0.7435†	0.2992	0.0014***	0.0000***	1	4*	1	2	3*
Tax-loss carryforwards (binary)	+	12,529	0.0711	0.0427	0.0956*	0.0828	0.0270	0.0021***	0.0520*	3	16*	1	15*	3
Tax-loss carryforwards (continuous)	+	9,050	na	na	na	0.0625	0.0423	0.1386	0.0381**	9	11*	4	11*	5

This table shows the results for the proxy variables related to the corporate tax hypothesis. Names of the proxy variables are listed in the first column, and the second column shows the specific hypothesized sign; the third column shows the number of firm observations summed up from the primary studies testing the respective proxy variable. Next, the results from multivariate meta-analysis are presented. Using the standardized regression slopes b from the multivariate linear model and their standard deviations SE(b) for each proxy variable, we calculate the z-statistic and the corresponding p-value to test the null hypotheses of $b_i = 0$. The table additionally provides the results from univariate meta-analysis. They contain the summary effect size r (back-transformed in the correlation metric for an easier interpretation) and the standard deviation SE(z) of the z-transformed values (as within the calculations in Appendix A). We calculate the z-statistic and the corresponding p-value to test the null hypotheses of $r = 0$. The Egger's regression test indicates the existence of publication bias for the respective proxy variable. Finally, the results from the vote counting procedure are displayed for $\alpha = 0.05$ and $\alpha = 0.50$. In the first case, "+" ("-") indicates the number of significantly positive (negative) results from the primary studies and "0" shows the number of insignificant results. The second case corresponds to a t-statistic of zero, which means that only the negative and positive directions of the relationships are counted as shown in column two and three. The asterisks (*) show the respective "winner category" for each proxy variable, i.e. the most reliable relationship due to the unique majority of entries, if the others have at least one entry fewer. In the case of equality between two or more winner categories, no statement can be made. *, ** and *** indicate the rejection of the null hypotheses at the 10%, 5%, and 1% probability levels.

† The underlying sample of this proxy variable is adapted by the trim-and-fill method in the univariate meta-analysis to account for the detected publication bias.

The only proxy variable considered in the multivariate meta-analysis for this hypothesis is tax-loss carryforwards (binary). Here we find a weakly significant relation with a standardized regression slope of 0.0711 and a corresponding *p*-value of 0.0956. Hence, if companies face higher tax-loss carryforwards (binary), they clearly tend to increase their hedging activities to take as much advantage as possible of higher profits in the current period, which is in line with the hypothesized positive direction.

As robustness check, we conducted a univariate meta-analysis as well as vote counting. Regarding tax-loss carryforwards (binary), the univariate meta-analysis leads to a correlation of 0.0828 and a *p*-value of 0.0021. Hence, we confirm an unreasonably high significance for the correlation with corporate hedging behavior in the (hypothesized) positive direction for this proxy variable. Additionally, vote counting shows a positive although insignificant relation for this proxy variable. Thus, we can clearly conclude that the intensity of corporate hedging increases with existence of tax-loss carryforwards (binary), as companies try to secure a compensation for them in the following years. Contrarily, we find for tax credits a highly significant correlation of -0.7435 in the univariate meta-analysis with a *p*-value of 0.0014. However, this contradicts our vote counting results and also the hypothesized positive direction. For tax-loss carryforwards (continuous) we again do not observe a significant relationship in the results from vote counting, which is in line with our findings from univariate meta-analysis.

Altogether, this means that the existence of tax-loss carryforwards is an indicator for the extent of corporate hedging, although the effect of the total amount of tax-loss carryforwards is uncertain.

In addition to the tax hypothesis, strong empirical evidence is also found for the bankruptcy and financial distress costs hypothesis (H2), as presented in Table II.1-3.

Table II.1-3 Statistical results for the bankruptcy and financial distress costs hypothesis (H2)

			Multivariate meta-analysis			Univariate meta-analysis				Vote counting				
										$\alpha = 0.50$		$\alpha = 0.05$		
Proxy variable	Hyp. sign	No. of firms	b	SE(b)	p-value	r	SE(z)	p-value	Eggers's regression test p-value	-	+	-	0	+
Cash flow availability	−	7,170	na	na	na	0.1307	0.0463	0.0045***	0.0352**	3	11*	0	9*	5
Convertible debt	?	10,223	na	na	na	0.0185	0.0208	0.3764	0.4061	6	8*	0	11*	3
Debt maturity	+	12,186	na	na	na	0.0974†	0.0346	0.0047***	0.0012***	0	6*	0	1	5*
Dividend yield (binary)	?	13,255	na	na	na	0.2422	0.0655	0.0002***	0.0740*	3	12*	1	4	10*
Dividend yield (continuous)	?	17,038	0.0741	0.0319	0.0202**	0.1125	0.0239	0.0000***	0.9816	7	33*	3	20*	18
Interest coverage ratio	−	16,187	-0.0127	0.0404	0.7530	-0.0145	0.0285	0.6110	0.1150	13	17*	4	23*	3
Leverage ratio	+	51,866	0.0302	0.0269	0.2607	0.0661	0.0165	0.0000***	0.4042	34	71*	13	58*	38
Liquidity	−	33,767	-0.0893	0.0350	0.0108**	-0.1100	0.0218	0.0000***	0.2666	54*	16	28	37*	7
Preferred stock	?	9,213	na	na	na	0.0712†	0.0534	0.1811	0.0000***	5	6*	2	8*	1
Profitability	−	33,308	0.0751	0.0604	0.2135	0.1108	0.0247	0.0000***	0.3895	21	46*	6	34*	28
Size	−	52,667	0.2148	0.0574	0.0002***	0.2647	0.0295	0.0000***	0.8943	20	94*	9	26	81*
Tangible assets	−	11,938	0.0715	0.0611	0.2425	0.1079	0.0495	0.0285**	0.0403**	4	7*	2	6*	3

This table shows the results for the proxy variables related to the corporate tax hypothesis. Names of the proxy variables are listed in the first column, and the second column shows the specific hypothesized sign; the third column shows the number of firm observations summed up from the primary studies testing the respective proxy variable. Next, the results from multivariate meta-analysis are presented. Using the standardized regression slopes b from the multivariate linear model and their standard deviations SE(b) for each proxy variable, we calculate the z-statistic and the corresponding p-value to test the null hypotheses of $b_i = 0$. The table additionally provides the results from univariate meta-analysis. They contain the summary effect size r (back-transformed in the correlation metric for an easier interpretation) and the standard deviation SE(z) of the z-transformed values (as within the calculations in Appendix A). We calculate the z-statistic and the corresponding p-value to test the null hypotheses of $r = 0$. The Egger's regression test indicates the existence of publication bias for the respective proxy variable. Finally, the results from the vote counting procedure are displayed for $\alpha = 0.05$ and $\alpha = 0.50$. In the first case, "+" ("-") indicates the number of significantly positive (negative) results from the primary studies and "0" shows the number of insignificant results. The second case corresponds to a t-statistic of zero, which means that only the negative and positive directions of the relationships are counted as shown in column two and three. The asterisks (*) show the respective "winner category" for each proxy variable, i.e. the most reliable relationship due to the unique majority of entries, if the others have at least one entry fewer. In the case of equality between two or more winner categories, no statement can be made. *, ** and *** indicate the rejection of the null hypotheses at the 10%, 5%, and 1% probability levels.

† The underlying sample of this proxy variable is adapted by the trim-and-fill method in the univariate meta-analysis to account for the detected publication bias.

Multivariate meta-analysis supports the findings with high significance and unique directions for the influences of dividend yield (continuous), liquidity, and size with *p*-values of 0.0202, 0.0108, and 0.0002, and the standardized regression slopes of 0.0741, -0.0893, and 0.2148, respectively. The last magnitude is clearly the dominating effect. We can only confirm with significance the hypothesized negative influence of liquidity on corporate hedging behavior, which means that increasing liquidity makes corporate hedging unnecessary. In contrast, a higher dividend yield and a higher firm size induce firms to hedge significantly. On the one hand, this enables firms to satisfy investors' expectations; on the other hand, higher company value requires a more conservative financing strategy with stable company results. Last but not least, the tax-loss carryforwards (binary) variable also serves as a proxy for the bankruptcy and financial distress hypothesis with a theoretical positive sign (see Appendix I). Regarding this variable we find weak evidence. For the other variables we find no evidence in our multivariate analysis.

The robustness checks confirm the significant results in the univariate analysis as well in the vote counting. However, leverage ratio, profitability ratio, tangible assets and tax-loss carryforwards (binary and continuous) show also (more or less) significant results in the univariate meta-analysis, only partly supporting the hypothesis that reduction of financial distress costs coincide with hedging activity. Whereas the variables for debt maturity confirm the tested hypothesis, the variable cash flow variability rejects the hypothesis. However, the variables are only inspected in the univariate analysis as well as in the vote counting based on only 10,000 companies and there are far fewer studies covering this topic.

All in all, our empirical findings indicate a strong evidence for the bankruptcy and financial distress hypothesis. In this regard, we find positive signs regarding the proxy variables dividend yield (continuous) and liquidity (each at a significance level of 5%) as well as size (at a significance level of 1%) and tax-loss carryforwards (binary) at a significance level of 10%.

Regarding the asymmetric information and agency conflicts of the equity hypothesis (H3), we do not find empirical evidence, as summed up in Table II.1-4.

Table II.1-4 Statistical results for the asymmetric information and agency conflicts of equity hypothesis (H3)

			Multivariate meta-analysis			Univariate meta-analysis				Vote counting				
										$\alpha = 0.50$		$\alpha = 0.05$		
Proxy variable	Hyp. sign	No. of firms	b	SE(b)	p-value	r	SE(z)	p-value	Eggers's regression test p-value	-	+	-	0	+
Blockholders' ownership	?	1,724	na	na	na	-0.0438	0.0330	0.1840	0.7162	9*	4	3	9*	1
CEO cash	−	2,800	na	na	na	0.0170	0.0653	0.7942	0.0504*	4	5*	4	1	5*
Institutional investors	−	18,040	0.0869	0.0559	0.1203	0.1352	0.0430	0.0016***	0.7883	6	16*	2	9	11*
Intangible assets	+	4,968	na	na	na	0.0844	0.0551	0.1252	0.2872	2	5*	0	6*	1
Number of analysts	−	7,396	na	na	na	0.1584	0.0701	0.0227**	0.7638	1	7*	0	4	4
Option ownership (binary)	?	1,208	na	na	na	-0.0398	0.0699	0.5688	0.5474	3*	2	1	5*	0
Option ownership (continuous)	?	13,026	-0.0279	0.0442	0.5275	0.0086	0.0331	0.7959	0.5585	8	10*	2	13*	4
Share ownership	+	13,643	-0.0421	0.0335	0.2091	-0.0876	0.0277	0.0015***	0.6446	28*	14	19	19	6
Tenure	−	2,591	na	na	na	0.0439	0.0728	0.5460	0.7986	4*	3	1	4*	2

This table shows the results for the proxy variables related to the corporate tax hypothesis. Names of the proxy variables are listed in the first column, and the second column shows the specific hypothesized sign; the third column shows the number of firm observations summed up from the primary studies testing the respective proxy variable. Next, the results from multivariate meta-analysis are presented. Using the standardized regression slopes b from the multivariate linear model and their standard deviations SE(b) for each proxy variable, we calculate the z-statistic and the corresponding p-value to test the null hypotheses of $b_i = 0$. The table additionally provides the results from univariate meta-analysis. They contain the summary effect size r (back-transformed in the correlation metric for an easier interpretation) and the standard deviation SE(z) of the z-transformed values (as within the calculations in Appendix A). We calculate the z-statistic and the corresponding p-value to test the null hypotheses of $r = 0$. The Egger's regression test indicates the existence of publication bias for the respective proxy variable. Finally, the results from the vote counting procedure are displayed for $\alpha = 0.05$ and $\alpha = 0.50$. In the first case, "+" ("-") indicates the number of significantly positive (negative) results from the primary studies and "0" shows the number of insignificant results. The second case corresponds to a t-statistic of zero, which means that only the negative and positive directions of the relationships are counted as shown in column two and three. The asterisks (*) show the respective "winner category" for each proxy variable, i.e. the most reliable relationship due to the unique majority of entries, if the others have at least one entry fewer. In the case of equality between two or more winner categories, no statement can be made. *, ** and *** indicate the rejection of the null hypotheses at the 10%, 5%, and 1% probability levels.

In multivariate meta-analysis three variables can be analyzed for hypothesis (*H3*): institutional investors, option ownership, and share ownership. None of the variables was significant at all. This is especially astonishing because these variables are taken from more than 10,000 companies, and the variables seem to operationalize the agency costs well. Furthermore, the variable "institutional investors" is intended to capture this agency conflict, as e.g. studies in corporate governance show.

In the robustness check for institutional investors and share ownership, univariate meta-analysis identifies a strong relationship with *p*-values, but each time in contrast to the hypothesized sign. However, vote counting does not consistently support a unique direction for these three proxy variables. Furthermore, we observe only a significant relationship between the number of analysts and corporate hedging behavior tested under this hypothesis. Again, the observed sign contradicts the predicted sign.

Overall, we are not able to determine any strong and consistent association between asymmetric information and agency conflicts of the equity with corporate hedging behavior.

Regarding the coordination of financing and investment policy and agency conflicts of debt hypothesis (H4), we find only weak empirical evidence, displayed in Table II.1-5.

Table II.1-5 Statistical results for the coordination of financing and investment policy and agency conflicts of debt hypothesis (H4)

			Multivariate meta-analysis			Univariate meta-analysis				Vote counting				
										$\alpha = 0.50$		$\alpha = 0.05$		
Proxy variable	Hyp. sign	No. of firms	b	SE(b)	p-value	r	SE(z)	p-value	Eggers's regression test p-value	-	+	-	0	+
Asset growth rate	+	3,909	na	na	na	-0.1838	0.0865	0.0315**	0.1019	8*	2	2	8*	0
Capex	+	25,482	-0.0263	0.0262	0.3169	-0.0009	0.0180	0.9593	0.1126	18*	15	7	21*	7
Price-earnings ratio	+	6,230	na	na	na	0.0058	0.0310	0.8506	0.4874	4	7*	0	10*	2
Research and development	+	28,770	0.0910	0.0472	0.0541*	0.0811†	0.0310	0.0087***	0.0002***	14	22*	6	18*	13
Sales growth rate	+	11,015	na	na	na	-0.0891	0.0389	0.0216**	0.2791	5*	2	4*	3	0
Tobin's Q	+	38,937	0.0433	0.0327	0.1856	0.0322	0.0202	0.1106	0.8578	37	42*	15	49*	15

This table shows the results for the proxy variables related to the corporate tax hypothesis. Names of the proxy variables are listed in the first column, and the second column shows the specific hypothesized sign; the third column shows the number of firm observations summed up from the primary studies testing the respective proxy variable. Next, the results from multivariate meta-analysis are presented. Using the standardized regression slopes b from the multivariate linear model and their standard deviations SE(b) for each proxy variable, we calculate the z-statistic and the corresponding p-value to test the null hypotheses of $b_i = 0$. The table additionally provides the results from univariate meta-analysis. They contain the summary effect size r (back-transformed in the correlation metric for an easier interpretation) and the standard deviation SE(z) of the z-transformed values (as within the calculations in Appendix A). We calculate the z-statistic and the corresponding p-value to test the null hypotheses of $r = 0$. The Egger's regression test indicates the existence of publication bias for the respective proxy variable. Finally, the results from the vote counting procedure are displayed for $\alpha = 0.05$ and $\alpha = 0.50$. In the first case, "+" ("-") indicates the number of significantly positive (negative) results from the primary studies and "0" shows the number of insignificant results. The second case corresponds to a t-statistic of zero, which means that only the negative and positive directions of the relationships are counted as shown in column two and three. The asterisks (*) show the respective "winner category" for each proxy variable, i.e. the most reliable relationship due to the unique majority of entries, if the others have at least one entry fewer. In the case of equality between two or more winner categories, no statement can be made. *, ** and *** indicate the rejection of the null hypotheses at the 10%, 5%, and 1% probability levels.

† The underlying sample of this proxy variable is adapted by the trim-and-fill method in the univariate meta-analysis to account for the detected publication bias.

Multivariate meta-analysis reveals a positive relation between research and development and corporate hedging, which confirms the hypothesized direction with *p*-values of 0.0514 and a regression coefficient of 0.092. This shows that avoidance of underinvestment allows the value of corporate hedging to increase. Furthermore, there is a negative relationship (at a significance level of 5%) between liquidity and corporate hedging. The liquidity variable also serves as a proxy for this hypothesis (see Appendix J).

However, neither capital expenditures for property plant and investment nor Tobin's Q show any significant results. The latter is especially astonishing, because the number of observations is relatively high in comparison to the other variables. However, besides the ability to capture underinvestment, Tobin's Q can also be interpreted as a risk factor in multifactor models or a measure for additional value in case of superior corporate governance. This might explain the non-significant results.

Univariate analysis confirms these results in the robustness check. Univariate meta-analysis also reveals highly significant evidence for the influence of research and development, liquidity and leverage on corporate hedging behavior in accordance with the hypothesized positive sign, but shows no significant results for the other two variables. Again, the proxy variables liquidity and leverage also serve as proxies for this hypothesis (see Appendix J). In contrast, vote counting does not show any tendency. Hence, we validate the assumption that hedging activities increase in line with growing engagement in research and development, to ensure the existence of the company. However, this might be also due to the bias of the method, which could lead to insignificant results. Looking at variables not inspected by the multivariate meta-analysis, univariate meta-analysis reveals a strongly positive relation between asset growth rate (sales growth rate, respectively) and corporate hedging, which contradicts the hypothesized direction, and which is not strongly supported by vote counting.

On the whole, all other results from vote counting as well as from univariate and multivariate meta-analysis do not point to further significant relationships under this hypothesis.

Looking at all hypotheses, multivariate meta-analysis only indicates strong evidence for the bankruptcy and financial distress hypothesis. We find weak or no support for the other hypotheses.

The robustness tests confirm the results of multivariate meta-analysis, whereby clear biases can be recognized. By comparing the explanatory power of the three different applied

approaches, vote counting predominantly shows inconsistent and insignificant results in our case, as the huge amount of insignificant results from primary studies are not differentiated. We can also conclude that univariate meta-analysis strongly tends to overestimate the single results, as no interactions between proxy variables are integrated in this approach. However, these interactions are apparent in the world of corporate hedging, which weakens the influences of the single proxy variables.

A further aspect is the existence of potential biases when applying meta-analyses. In the following we differ between two types of potential biases. The first bias occurs when researchers favor significant relationships, as significant results are more easily publishable. The second bias consists of the fact that significant results are in fact more likely to be published, according to Vevea and Woods (2005). The latter is also known as "publication bias", whereas the former is called "data mining bias" or a "fishing expedition".

In our case, we face both potential biases. However, the second bias is more pronounced in our situation due to the following: our factors are derived from theory and the authors test hypotheses based on economic principles, as opposed to, e.g. the papers inspected by Harvey et al. (2014), who analyzes papers that generate factors and therefor hypotheses. Nevertheless, there might be also a potential bias due to the different ways of operationalizing a variable of a hypothesis and/or due to a growing mean number of observed firms over time. The reason for this might be that the larger the sample size, the easier it is to reject the null hypothesis due to statistical facts. Besides the tax hypothesis and the respective proxy variable, the number of different operationalizations (in the primary studies) of proxy variables used to test the other three hypotheses suggests a potential bias (Table II.1-1). However, this is equally true for significant and non-significant results, and the significant results remain significant even after a multiple test. Additionally, there is no clear trend regarding the sample distribution over time (Appendix F). All in all, we suggest multiple testing, which is in line with Harvey et al. (2014).

The second, more severe publication bias leads to an overestimation of effect size. There is a battery of different tests estimating the size of the publication bias and the influence on effect size (see e.g., Thornton and Lee 2000). However, all tests show advantages and disadvantages. We excluded those tests where assumptions are not at all fulfilled, resulting in two different testing strategies. However, we implemented several approaches following the idea presented in Pigott (2012).

Therefore, in order to control for this problem and to prove the robustness of our results, we explicitly include gray literature in our sample, such as unpublished working papers, conference papers, and dissertations. In our sample, 31.82% of the analyzed primary studies are gray literature. This leads to the broader and more comprehensive sample seen in our study, and significantly enhances the power of our meta-analytical findings (Whiston and Li 2011). Moreover, for each of the 30 proxy variables we check the corresponding funnel plots[25] to detect a potential publication bias. To obtain an even more objective view, we apply Egger's regression test. Hence, we adjust proxy variables by the well-known trim-and-fill method to achieve more meaningful results, i.e. the variables: tax credits, debt maturity, preferred stock, and research and development which are all displayed with a 1% significance by Egger's regression test. The results improved by the trim-and-fill method are highlighted in the result tables II.1-2 through II.1-5. However, the changes in our results are only marginal, which is proof of the robustness of our results. As Kirkham et al. (2012) find out in their simulation study, the multivariate approach as applied in this paper is also a method to lower the effect of the publication bias on the summary effect sizes itself. Frosi et al. (2014) came to the same conclusion and state that this is especially true in the case of missing outcomes in the primary studies, which underlines the validity of our multivariate results and supports the approach for further applications. Both studies clearly point out the added value of the "borrowing of strength"-mechanism to the summary effect sizes in the multivariate meta-analysis which means that "one can learn about unreported outcomes through the reported results for other correlated outcomes" (Frosi et al. 2014, p. 2). Looking at our mean correlation matrix in Appendix E, this is true for our empirical analysis as many proxy variables depend linearly on each other.

II.1.6 Discussion

In the following, we first compare our main (multivariate) results, as well as the results of robustness checks (vote counting and univariate meta-analysis), with the three most cited primary studies on the determinants of corporate hedging by Geczy et al. (1997), Mian (1996) and Nance et al. (1993), which can generally be seen as representative of empirical literature in this field of research. After, we compare the results with the previous (univariate) reviews from Aretz and Bartram (2010) and Arnold et al. (2014). Second, we discuss the prime limitations of our work and potential for further research.

[25] The plots are available on request from the authors. For a detailed explanation of the interpretation of a funnel plot, see Arnold et al. (2014).

II.1.6.1 *Related Studies*

In general, Geczy et al. (1997), Mian (1996) and Nance et al. (1993) employ both univariate statistics and multivariate statistics (logit and/or probit models) in order to analyze differences between firms that use hedging and those that do not (see for details Geczy et al. (1997); Mian (1996); Nance et al. (1993)). Due to the fact that we only find multivariate results in these three primary studies, we first compare our main (multivariate) results with their results.

In accordance with our findings, all studies find weak support for the tax hypothesis in terms of the proxy variable tax loss-carryforwards.

Regarding bankruptcy and financial distress costs, they find mixed results. Concerning the proxy variables liquidity (negative relationship) and dividend yield (positive relationship), the same significant results similar to ours can be seen. In contrast to our work, they find weak support for the proxy variable size indicating a negative relationship. Moreover, the proxy variables interest coverage ratio, leverage ratio, and tangible assets are significant, which contrasts with our results. In addition, regarding the proxy variable profitability, they also find no significant relationship.

With respect to asymmetric information and agency conflicts of equity, they find mixed results. In total, as analogous to our results they find only weak and/or no support for this hypothesis. In detail, regarding the proxy variables institutional investors and share ownership, no clear relationship is discernible; in comparison, a low positive relationship can be observed for the variable option ownership. Interestingly, we find a positive relationship for institutional investors and a negative for the other variables, but all three relationships are not significant – at least at the 10% significance level.

Last but not least, they also find weak support for the research and development variable regarding coordination of financing and investment policy, and agency conflicts of debt. For Tobin's Q, their results are mixed. In contrast, we find a positive relationship for both variables.

To sum up, our results are more or less comparable to those of the three most cited primary studies. The main finding is strong evidence for the bankruptcy and financial distress hypothesis. Nevertheless, there are a few differences, which could be explained by different samples amongst many others, with regard to the relationship trend between the proxy variable and hedging behavior, as well as the respective significance level. But overall, there exist no fundamental differences.

Furthermore, regarding our robustness checks (vote counting and univariate meta-analysis), we can generally confirm the empirical results of the existing (quantitative) reviews from Aretz and Bartram (2010) and Arnold et al. (2014).

Concerning, in particular, Aretz and Batram (2010), our results coincide with their results, which are derived from univariate and multivariate vote counting. We both times find weak evidence for the influence of tax loss-carryforward variables. In reference to the financial distress hypothesis, the same is true for variables such as liquidity, size, and dividend yield. However, the vote counting method used by Aretz and Batram (2010) shows partly significant results for leverage, interest rate coverage, and tangible assets. However, these results could be explained by the differing analytical approach applied. In case of leverage and tangible assets, our univariate vote counting[26] shows the same tendencies as the vote counting of Aretz and Batram (2010). In case of the agency hypothesis, Aretz and Batram (2010) report results similar to those we derive in our multivariate setting, with a few exceptions. The exceptions concern option ownership and Tobin's Q, where some significant results are found. In the former case, we observe the same tendency in our univariate vote counting. However, for Tobin's Q our vote counting results differ from that of Aretz and Bartram (2010). The remaining deviation may arise from the larger sample, including gray literature. Looking at the variables, which could not be analyzed in a multivariate method, our results are largely similar to those of Aretz and Bartram (2010). These results are significant according to our vote counting. Dividend yield (binary) and tax credits remain especially significant in both analyses. Overall, the winning categories in our vote counting procedures often present no significant relationship. Compared to the vote counting results from Aretz and Bartram (2010), the integration of gray literature increases the number of insignificant findings from primary studies in our analysis. Hence, this limits the power of the vote counting procedures, as all of these study-specific insignificant results are simply sorted into a "no relationship" category.

Concerning Arnold et al. (2014), we can strongly confirm their findings. Particularly, the tax loss-carryforwards in our multivariate analysis have the same tendency as those in the univariate analysis of Arnold et al. (2014). However, as their analysis for the corporate tax hypothesis suffers from a lack of data, we can provide greater evidence to this point. The financial distress variables liquidity, dividend yield, and size are significant in our analysis as well as in the analysis of Arnold et al. (2014). Furthermore, additional financial distress

[26] This means an aggregation of univariate results from primary studies, which corresponds to our vote counting procedure.

variables, e.g. leverage ratio, contradict those of Arnold et al. (2014), in terms of respective significance level. Due to the fact that those variables are significant in our univariate analysis, these deviations are explainable by the methodology applied. Concerning the agency variables, our insignificant variables of share and option ownership coincide with those of Arnold et al. (2014). In contrast to our multivariate analysis, the institutional ownership variable is significant in ours and Arnold et al.'s (2014) univariate analysis. Furthermore, we observed the same results for the debt agency variables in our multivariate analysis as did Arnold et al. (2014). However, due to our larger sample we found (only partially) significant variables in our univariate analysis, which Arnold et al. (2014) declared to be non-significant. Concerning the variables not captured by our multivariate analysis, the results of our univariate analysis do not differ from the results in literature. To sum up, this speaks well both for the robustness of the findings of Arnold et al. (2014) and of the meta-analysis in general. Secondly, compared to the multivariate technique, we observe a systematic overestimation and an arguably high significance of aggregated proxy variables in our univariate meta-analysis, which was also apparent in the results of Arnold et al. (2014).

II.1.6.2 *Limitations and Further Research*

There are several issues to be critically considered when conducting a meta-analysis and interpreting its results. These aspects concern the underlying literature, the analyzed input data, and the pertinent mathematical framework.

First, the search for relevant literature brings the trade-off between search accuracy and comprehensiveness. Our search command developed by Arnold et al. (2014), aims to find all studies from an initial interim list of thirty primary studies, but not to find all existing relevant studies. In order to yield a higher recall of relevant primary studies, a broader search command could be considered. In addition, the search for literature could be expanded by inclusion of additional databases, although the number of duplicates would probably increase, thus lowering precision. In contrast to Arnold et al. (2014), we try in this study to overcome these circumstances by conducting a forward and backward search, as well as a search of the authors' publication lists. Another bias to meta-analysis with respect to the underlying sample is known as language bias (Rothstein and Hopewell, 2009). Studies written in languages other than English and German are not included in this study. For example, we found studies that are potentially relevant, but written in Portuguese or Chinese. Hence, there is a little bias concerning potential sources not published in these two languages.

Second, limiting factors incorporated only in few primary studies, are the "endogeneity and identification problems" as well as "empirical modeling of structural relations" as Aretz and Bartram (2010) state. This means that the causality of the variables is not unique. For example, many determinants of leverage also influence hedging strategies. Nevertheless, this problem is hard to address in meta-analysis, as only secondary data is available in most cases. A promising methodology to address the problem of endogeneity in a meta-analysis is the "meta-analytic structural equation modeling" (MA-SEM) approach presented by Cheung and Chan (2005). If a combined correlation matrix similar to the GLS estimator presented in Section II.1-3 were generated, this pooled correlation matrix could then be analyzed using structural equation models.

Third, we can confirm that the lack of reported data in primary studies as well as the lack of their uniformity is a huge problem for meta-analysis, as Walker et al. (2008) clearly point out. Many times, the data reported in primary studies is very sparse, which is the reason for the exclusion of nearly one fourth of the discovered primary studies from our analysis – even on request – most authors did not provide us with the relevant data. Often, the primary studies' samples are also not independent, as they are not randomly sampled, which is also stated by Arnold et al. (2014). After excluding results from primary studies based on the same sample, we still find some overlaps concerning observation time and country (Appendix C). However, each new data set provides us with new results, allowing us to reject the assumption of a biased sample, as the data is taken heterogeneously from all over the world and no regional bias is observable. Moreover, we limit the analysis to the four hypotheses of financial hedging mentioned above, in order to compare our results to findings of Aretz and Bartram (2010) and Arnold et al. (2014). Nevertheless, our analysis could be adopted to test the rationales for operational hedging (see, e.g., Allayannis et al. 2001 or Kim et al. 2006) or other theories of financial hedging.

Fourth, we identified a substantial variation in the proxy variables across the studies and adjust for it by applying a random effects model instead of a fixed effects model. However, we do not examine the factors driving this heterogeneity, which could be a subject of an exploratory meta-analysis (Anello and Fleiss 1995). For instance, Feld et al. (2013) applied the technique of meta-regression to explain heterogeneous results of marginal tax effect on corporate debt ratio. Regarding investigation of the heterogeneity of corporate hedging determinants, further research is necessary.

II.1.7 Conclusion

This paper provides new evidence on the determinants of corporate hedging, by taking a second look at the following specific hypotheses: corporate tax, bankruptcy and financial distress costs, asymmetric information and agency conflicts of equity, coordination of financing and investment policy, and agency conflicts of debt. In light of these hypotheses, our results indicate a strong evidence only for the bankruptcy and financial distress hypothesis. Regarding the other hypotheses, we find weak or no support. In general, the robustness checks (univariate meta-analysis and vote counting) confirm the results of multivariate meta-analysis. In this respect, we can conclude that univariate meta-analysis strongly tends to overestimate the single results, as no interactions between the proxy variables are integrated in this approach. However, these interactions are apparent in the world of corporate hedging, and thus weaken individual influences. Our vote counting results are mainly in accordance with previous findings by Aretz and Bartram (2010). Moreover, the same holds for our outcomes from the univariate meta-analysis, in comparison with the analysis of Arnold et al. (2014).

Finally, we see various subjects for further applications of multivariate meta-analysis in corporate finance. Multivariate meta-analysis can help to obtain a holistic view of the influential structure of determinants of, for instance, capital structure, dividend policy, or credit spreads. Last but not least, further research should especially be performed regarding the mentioned potential biases, e.g. publication bias and data mining bias or fishing expeditions.

II.1.8 References

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II.1.9 Appendix

Supplementary data associated with research paper 1 can be found in the appendix at hand.

II.1.9.1 ***Appendix A.*** *Numerical example for vote counting, univariate and multivariate meta-analysis*

This example illustrates the three methods of research synthesis applied in this paper. We show the vote counting procedure and the univariate meta-analysis based on the methodology presented by Borenstein et al. (2009) exclusively for the proxy variable "leverage ratio". For the case of the multivariate meta-analysis as presented by Becker (1992), we use the two proxy variables "leverage ratio" and "size"[27] to show how the dependencies between these proxies are modeled by the multivariate approach. To illustrate a random-effects model in a meaningful manner, we use three primary studies from the list in Appendix B with heterogeneous findings. Moreover, to demonstrate how to handle missing data, we ensured that one of the three studies in the multivariate case does not report all correlations of interest. Of course, altogether this selection is subjective. However, the aim of this example is to show the methodology of meta-analysis and not to interpret the results. So instead of this selection, you could choose some random values as well. The sample data is summarized in Table A.1. Missing correlations are marked as "na".

Table A.1 Data from primary studies

Name of study *i*	n_i	Leverage ratio/ Hedging dummy	Size/ Hedging dummy	Leverage ratio/ Size
Adedeji and Baker (2002)	140	na	na	0.3440
Ahmed et al. (2013)	288	0.001[28]	0.2970	0.2560
Choi et al. (2013a)	68	0.0260	0.3910	-0.0860

II.1.9.1.1. Vote counting

The vote counting procedure is performed on two different significance levels: $\alpha = 0.5$ and $\alpha = 0.05$. First, for $\alpha = 0.5$, we split the data in positive ("+") and negative ("-") relationships regarding the sign of the test statistic. Second, for $\alpha = 0.05$, we sort the effect sizes into one of the following three categories: "significantly positive" ("+"), "significantly

[27] We chose the two proxies with the highest number of total firm observations across all studies.
[28] This study reports the correlations between the proxies and the hedging dummy variable directly in the correlation matrix, but separately for interest rate, foreign currency and commodity price hedger. For this example, we focus on the correlation between the three proxies and the foreign exchange hedging dummy.

negative" ("-") and "no significant relationship" ("0"), considering the *p*-value additionally. The winning category must contain the absolute majority of effect sizes.

As the *t*-statistic is not always directly reported in the studies, we estimate it from the descriptive statistics as given in the primary studies. E.g., for the leverage ratio as reported by Adedeji and Baker (2002) we receive

$$t_{11} = \frac{\mu_H - \mu_{NH}}{S\sqrt{\frac{1}{n_H}+\frac{1}{n_{NH}}}} = \frac{0.442-0.292}{0.202\cdot\sqrt{\frac{1}{88}+\frac{1}{52}}} = 4.2454$$

The results for the vote counting procedure are summarized in Table A.2. An asterisk marks the final empirical result for the influence of leverage on the corporate hedging behavior. Accordingly, the numbers from vote counting in Table A.2 show no significant relationship between the proxy variable leverage ratio and corporate hedging behavior for $\alpha = 0.05$. Further statements about the magnitude or the absolute significance of the effect cannot be drawn from the vote counting results.

Table A.2 Results from vote counting (leverage ratio)

	Adedeji and Baker (2002)	Ahmed et al. (2013)	Choi et al. (2013a)	α = 0.5		α = 0.05		
Proxy variable	test statistic (*p*-value)	test statistic (*p*-value)	test statistic (*p*-value)	-	+	-	0	+
Leverage ratio	4.2454 (0.0000)	0.0169[29] (0.9865)	0.0610[30] (0.9515)	0	3*	0	2*	1

II.1.9.1.2. Univariate meta-analysis

We look at one proxy variable (leverage ratio), i.e., $j = 1$, from three primary studies ($k = 3$) with the indexes $i = 1,2,3$. As the correlation between "leverage ratio" and the "hedging dummy" is not directly observable from the Adedejji and Baker (2002) study, we apply the following transformation to derive the correlations from the descriptive statistics reported in the study. E.g., for Adedeji and Baker (2002), we use the *t*-statistic from the mean difference test as shown in Table A.2 and then we receive

$$r_{11} = \sqrt{\frac{t_{ij}^2}{t_{ij}^2+df_j}} = \sqrt{\frac{4.2454^2}{4.2454^2+(88+52-2)}} = 0.3399.$$

[29] In this case, as the *t*-statistic is not directly reported in the study, we receive it from the correlation coefficient between the leverage variable and the foreign exchange hedging dummy, which is reported in the primary study. The *t*-statistic is then calculated by the inverse of the first formula stated in section II.1.9.1.2.
[30] This value is directly reported in the primary study.

In the next step, we compute our effect sizes, which are Fisher's *z*-transformed correlations, and the effect size variation. E.g., for the Adedeji and Baker (2002) study, i.e. $i, j = 1$, we obtain

$$z_{11} = 0.5 \cdot \ln\left(\frac{1+r_{ij}}{1-r_{ij}}\right) = 0.5 \cdot ln\left(\frac{1+0.3399}{1-0.3399}\right) = 0.3540$$

and

$$v_{11} = \frac{1}{n_i - 3} = \frac{1}{140-3} = 0.0073.$$

As we cannot assume that all studies share one common population effect size, we test whether effect sizes are heterogeneous across studies by calculating the *Q*-statistic

$$Q_1 = \sum_{i=1}^{k} w_{ij} {z_{ij}}^2 - \frac{\left(\sum_{i=1}^{k} w_{ij} z_{ij}\right)^2}{\sum_{i=1}^{k} w_{ij}} = \sum_{i=1}^{3} w_{i1} {z_{i1}}^2 - \frac{\left(\sum_{i=1}^{3} w_{i1} z_{i1}\right)^2}{\sum_{i=1}^{3} w_{i1}} = (136.9863 \cdot 0.3540^2 + \cdots) - \frac{(136.9863 \cdot 0.3540 + \cdots)^2}{136.9863 + \cdots} = 11.9877,$$

with the following degrees of freedom

$$df_1 = k_1 - 1 = 3 - 1 = 2.$$

Obviously, we can reject the null hypothesis of homogenous effect sizes, and hence conclude that a random effects model is more appropriate than a fixed effects model. Thus, we estimate the between-study variation by the method of moments estimator

$${T_j}^2 = \begin{cases} \dfrac{Q_j - df_j}{C_j}, & Q_j > df_j \\ 0, & Q_j \leq df_j \end{cases}.$$

Therefore,

$$T_1^2 = \frac{Q_1 - df_1}{C_1} = \frac{11.9877-2}{273.1016} = 0.0366,$$

with

$$C_1 = \sum_{i=1}^{k} w_{ij} - \frac{\sum_{i=1}^{k} w_{ij}^2}{\sum_{i=1}^{k} w_{ij}} = \left(\frac{1}{0.0073} + \cdots\right) - \frac{\left(\frac{1}{0.0073^2} + \cdots\right)}{\left(\frac{1}{0.0073} + \cdots\right)} = 273.1016.$$

Accordingly, the random effects weight for the Adedeji and Baker (2002) study is given by equation (1):

$$w_{11} = \frac{1}{v_{ij} + {T_j}^2} = \frac{1}{0.0073 + 0.0366} = 22.7790.$$

Now, by means of equation (2), we can estimate the mean population effect size using the WLS estimator with random effects weights

$$\hat{z}_1 = \frac{\sum_{i=1}^{k} w_{ij} z_{ij}}{\sum_{i=1}^{k} w_{ij}} = \frac{(22.7790 \cdot 0.3540 + \cdots)}{(22.7790 + \cdots)} = 0.1283$$

and the variance

$$v(\hat{z}_1) = \frac{1}{\sum_{i=1}^{k} w_{ij}} = \frac{1}{(22.7790 + \cdots)} = 0.0149.$$

These results serve as input for a confidence interval for the normal distributed population effect size estimate, a *z*-test as well as the two-tailed *p*-value for a test of difference between Hedgers and Non-Hedgers. Finally, for interpretation, we convert the population effect size estimate back in the correlation metric with the inverse Fisher's *z*-transformation:

$$r_1 = \frac{\exp(2\hat{z}_1) - 1}{\exp(2\hat{z}_1) + 1} = \frac{\exp(2 \cdot 0.1283) - 1}{\exp(2 \cdot 0.1283) + 1} = 0.1276$$

Accordingly, by using random effects weights, we estimate an aggregated correlation of 0.1276 between leverage ratio and hedging behavior across the three sample studies.

II.1.9.1.3. Multivariate meta-analysis

Step 1: Deriving Mean Correlation Matrix via GLS

The first step is to arrange the data in such a way that information from each study is summarized in the indicator matrix $\boldsymbol{X}$ with an effect sizes vector z. Analogous to the univariate meta-analysis, for each study, we compute the Fisher's *z*-transformation of the correlation vector. However, now we look at the two proxy variables "leverage ratio" and "size". Thus, we extract $p^* = 2(2+1)/2 = 3$ correlations from each study, which are shown in Table A.1. Moreover, we build the indicator matrix with the number of rows equal to the number of correlations provided in the particular study. E.g., the data from the study by Adedeji and Baker (2002) is represented by

$$z_1 = \begin{bmatrix} 0.3540 \\ 0.2824 \\ 0.3586 \end{bmatrix} \text{ and } \boldsymbol{X}_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

After preparing this input for each study, we stack the three effect size vectors and the indicator matrices to z and $\boldsymbol{X}$:

$$z = \begin{bmatrix} 0.3540 \\ 0.2824 \\ 0.3586 \\ 0.0010 \\ 0.3062 \\ 0.2618 \\ 0.0260 \\ 0.4130 \\ -0.0862 \end{bmatrix} \text{ and } \boldsymbol{X} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Then, the sample size weighted mean correlations for each of the three effect sizes, i.e. for each column in Table A.1, are calculated. For the effect size "leverage ratio and hedging dummy" ($j = 1$), this leads to

$$r_1 = \frac{\sum_{i=1}^{k} n_i r_{ij}}{\sum_{i=1}^{k} n_i} = \frac{(140 \cdot 0.3399 + \cdots)}{(140 + \cdots)} = 0.1001.$$

The mean correlations for the other two effect sizes are 0.3037 for "size and hedging dummy" and 0.2340 for "leverage and size". In contrast to the univariate meta-analysis, we must consider the variation of each effect size as well as the covariances among the effect sizes. E.g., the within-study covariance between the effect size "leverage ratio and hedging dummy" z_{LH} and "leverage ratio and size" z_{LS} for the Adedeji and Baker (2002) study is

$$cov(z_{LH}, z_{LS}) = \frac{\begin{bmatrix} 0.5\ \rho_{1LH}\ \rho_{1LS}(\rho_{1LL}^2+\rho_{1LS}^2+\rho_{1HL}^2+\rho_{1HS}^2)+\rho_{1LL}\ \rho_{1HS}+\rho_{1LS}\rho_{1HL}- \\ (\rho_{1LH}\ \rho_{1LL}\ \rho_{1LS}+\rho_{1HL}\ \rho_{1HL}\ \rho_{1HS}+\rho_{1LL}\ \rho_{1LH}\ \rho_{1LS}+\rho_{1SL}\ \rho_{1SH}\ \rho_{1SL}) \end{bmatrix}}{n_1 A}$$

with

$$A = [(1 - \rho_{LH}^2)(1 - \rho_{LS}^2)].$$

By substituting the unknown population correlations by the sample size weighted mean correlations, we receive

$$cov(z_{LH}, z_{LS}) = \frac{\begin{bmatrix} 0.5 \cdot 0.1001 \cdot 0.2340 \cdot (1^2+0.2340^2+0.1001^2+0.3037^2)+1 \cdot 0.3037 \\ +0.2340 \cdot 0.1001-(0.1001 \cdot 1 \cdot 0.2340+0.1001 \cdot 0.1001 \cdot 0.3037 \\ +1 \cdot 0.1001 \cdot 0.2340+0.2340 \cdot 0.3037 \cdot 0.2340) \end{bmatrix}}{140 \cdot (1-0.1001^2)(1-0.2340^2)} = 0.0021.$$

The covariances for the other pairs of correlations are computed analogously. The diagonal elements are the effect size variances calculated in the previous section II.1.9.1.2. Consequently, we receive the following within-study variance-covariance matrix for Adedeji and Baker (2002):

$$\boldsymbol{S}_1 = \begin{bmatrix} 0.0073 & 0.0016 & 0.0021 \\ 0.0016 & 0.0073 & 0.0005 \\ 0.0021 & 0.0005 & 0.0073 \end{bmatrix}$$

After computing the variance-covariance matrices $\boldsymbol{S}_i$ for all studies $i = 1,2,3$, we stack them into the block-diagonal matrix $\boldsymbol{S}$. As we expect random effects, we test whether all studies appear to be drawn from a single population. The test of homogenous effect sizes[31]

$$Q = z'[\,\boldsymbol{P}^{-1} - \boldsymbol{P}^{-1}\boldsymbol{X}(\boldsymbol{X}'\boldsymbol{P}^{-1}\boldsymbol{X})\boldsymbol{X}'\boldsymbol{P}^{-1}]z$$

leads to a Q-statistic of 21.7001. This value is approximately chi-squared distributed with $(3-1)3 = 6$ degrees of freedom. Since the null hypothesis is rejected and thus a random effects model is appropriate, in the next step we estimate the between-study variance as follows:

$$T_{jj}^2 = \frac{\sum_{i=1}^{k} S_{ijj}^{-1}(z_{ij} - z_j)^2 - (k_j - 1)}{tr(\boldsymbol{M})},$$

with

$$tr(\boldsymbol{M}) = \sum_{i=1}^{k} S_{ijj}^{-1} - \frac{\sum_{i=1}^{k} S_{ijj}^{-2}}{\sum_{i=1}^{k} S_{ijj}^{-1}}$$

and

$$z_j = \frac{\sum_{i=1}^{k} S_{ijj}^{-1} z_{ij}}{\sum_{i=1}^{k} S_{ijj}^{-1}}$$

for each effect size $j = 1, \ldots, p^*$, where S_{ijj} are the corresponding diagonal elements of the estimated covariance matrices $\boldsymbol{S}_i$. Again, k_j is the number of studies measuring effect size j. As in the univariate methodology, the actual between-study variance τ_{jj}^2 cannot be zero; however, our estimates can be – thus negative estimates of T_{jj}^2 are set to zero. Consequently, we receive

$$\boldsymbol{T}^2 = \begin{bmatrix} 0.0366 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0.0256 \end{bmatrix}.$$

For the random-effects weights, we add the between-study variance to the diagonal of the block-wise covariance matrix ($\boldsymbol{S}_i + \boldsymbol{T}^2$). Then, z, $\boldsymbol{X}$ and $\boldsymbol{S}$ are used to estimate the random-effects mean effect size vector $\hat{z}$ via GLS as stated in equation (3):

[31] For reasons of clarity, we stop filling the matrices of the following formulas with exact values.

$$\hat{z} = (\boldsymbol{X}'\boldsymbol{S}^{-1}\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{S}^{-1}z = \begin{bmatrix}0.1294\\0.3137\\0.1986\end{bmatrix}$$

The covariance matrix of the GLS estimator is

$$\boldsymbol{Var}(\hat{z}) = (\boldsymbol{X}'\boldsymbol{S}^{-1}\boldsymbol{X})^{-1} = \begin{bmatrix}0.0149 & 0.0004 & 0.0007\\0.0004 & 0.0021 & 0.0001\\0.0007 & 0.0001 & 0.0112\end{bmatrix}.$$

Analogous to the univariate example, we retransform $\hat{z}$ in the correlation scale and arrange it in a matrix

$$\boldsymbol{R} = \begin{bmatrix}1 & 0.1287 & 0.3038\\0.1287 & 1 & 0.1960\\0.3038 & 0.1960 & 1\end{bmatrix}.$$

Thus, by applying a GLS estimator, we derive a mean correlation matrix across all three exemplary studies.

Step 2: Multiple Regression Model

This mean correlation matrix now serves as input for a linear model with "leverage ratio" and "size" as predictors for the hedging dummy variables. We partition $\boldsymbol{R}$ into

$$\boldsymbol{R}_{XY} = [0.1287 \quad 0.3038] \text{ and } \boldsymbol{R}_{XX} = \begin{bmatrix}1 & 0.1960\\0.1960 & 1\end{bmatrix}$$

and estimate the standardized regression slopes of the linear model according to equation (4)

$$b = \boldsymbol{R}_{XX}^{-1}\boldsymbol{R}_{XY} = \begin{bmatrix}0.0719\\0.2897\end{bmatrix}.$$

This leads to the regression slopes of the linear model predicting the aggregated hedging behavior by the aggregated proxy variables "leverage ratio" and "size", based on a sample of three primary studies. Finally, the variance of the slopes can be derived by

$$Var(b) = \boldsymbol{A}\boldsymbol{\Sigma}\boldsymbol{A}',$$

with the elements a_{ij} of $\boldsymbol{A}$ computed by

$$a_{ij} = \begin{cases} -\sum_{\boldsymbol{m=1}}^{\boldsymbol{p}}\left(\boldsymbol{\rho}^{ki}\boldsymbol{\rho}^{km} + \boldsymbol{\rho}^{lm}\boldsymbol{\rho}^{li}\right)\boldsymbol{\rho}_{m0} & if\ \boldsymbol{\rho}_j = \boldsymbol{\rho}_{kl} \in \boldsymbol{R}_{XX} \\ \boldsymbol{\rho}^{im} & if\ \boldsymbol{\rho}_j = \boldsymbol{\rho}_{0m} \in \boldsymbol{R}_{XY} \end{cases},$$

where $\boldsymbol{\rho}^{im}$ are the elements of $\boldsymbol{R}_{XX}^{-1}$ for $i = 1, \dots, p$ and $j = 1, \dots, p^*$. This leads to

$$\boldsymbol{Var}(b) = \begin{bmatrix}0.0160 & -0.0033\\-0.0033 & 0.0037\end{bmatrix}.$$

The standardized slopes and its variance serve as input to calculate confidence intervals of the standardized regression coefficient, a *z*-test and *p*-values.

In summary, this example illustrates the meta-analytical procedure for two proxies and three studies. Applying this approach on the whole sample of 132 studies leads to the results presented in section II.1.5.

II.1.9.2 ***Appendix B.*** *Overview of the literature search process in the electronic databases*

Search step	Detailed description
INCLUSION CRITERIA	
Appropriate data for effect-size calculation	The study contains sufficient information about the correlation between the hedging dummy and the examined proxy variables or/and the correlations among the proxy variables.
Only non-financial firms	The study investigates non-financial firms.
ELECTRONIC DATABASES	
Selected databases	ABI/INFORM Complete (via ProQuest), Business Source Premier (via EBSCOhost), EconBiz, ScienceDirect
Search period	January 01, 1990 – June 24, 2014
Search options	We search only peer-reviewed articles in ABI/INFORM Complete, Business Source Premier, EconBiz and ScienceDirect.
SEARCH COMMAND	
Search command for ABI/INFORM Complete, SSRN and Dissertations and Theses via ProQuest	(cabs(hedg*) or cabs(derivative*)) and (ab(use) or ab(using) or ab(usage) or ab(polic*) or ab(activit*)) and (cabs(compan*) or cabs(corporat*) or cabs(firm*)) and (cabs(sample*) or cabs(evidence) or cabs(result*) or cabs(data) or cabs(investigat*) or cabs(test*) or cabs(empiric*) or cabs(survey*) or cabs(examine*))
Search command for Business Source Premier via EBSCOhost	(hedg* OR derivative*) AND (AB use OR AB using OR AB usage OR AB polic* OR AB activit*) AND (compan* OR corporat* OR firm*) AND (sample* OR evidence OR result* OR data OR investigat* OR test* OR empiric* OR survey* OR examine*)
Search command for EconBiz[a]	(All Fields:hedg* OR derivative* AND All Fields:use OR using OR usage OR polic* OR activit* AND All Fields:compan* OR corporat* OR firm AND All Fields:sample OR evidence OR result* OR data OR investigat* OR test* OR empiric* OR survey* OR examine*)
Search command for ScienceDirect	tak(hedg* or derivative*) and (abs(use) or abs(using) or abs(usage) or abs(polic*) or abs(activit*)) and tak(compan* or corporat* or firm*) and tak(sample* or evidence or result* or data or investigat* or test* or empiric* or survey* or examine*)
SORTING OF RESULTS	
Steps for sorting of results	(1) Elimination by study title, (2) elimination by study's abstract, (3) elimination by screening content and (4) eliminating studies with no or negative response from the authors to our data request mail.

The table presents the details of our literature search in electronic databases.

[a] For this library, the search term was applied on all fields (title, abstract, keyword, and full text) as the library did not support our standard search command. The AND-operator was built by copying each part of the search command in an extra search field.

II.1.9.3 ***Appendix C.*** *Overview of the final primary study sample with the corresponding references*

Author(s) (Year)	Abbrev.	Published	Number of observed firms	Observation period	Observed countries
Aabo et al. (2010)	A10	P	213	2005, 2007	Denmark
Aabo et al. (2013)	Aa13	P	186	2008	Denmark
Adam (2002)	A02	P	111	1989-1999	US, Canada
Adedeji and Baker (2002)	AB02	P	140	1996	UK
Afza and Alam (2011a)	AA11a	P	105	2004-2008	Pakistan
Afza and Alam (2011b)	AA11b	P	86	2004-2007	Pakistan
Ahmad and Haris (2012)	AH12	P	110	2006-2009	Malaysia
Ahmed et al. (2013)	Ah13	G	288	2005-2012	UK
Alam et al. (2013)	Al13	P	1,612	2004-2010	Malaysia
Allayannis and Weston (1999)	AW99	G	916	1994-1995	US
Allayannis and Weston (2001)	AW01	P	120	1990-1995	US
Allayannis et al. (2012)	A12	P	272	1990-1999	Several countries
Alsubaie (2009)	A09	P	55	2001	US
Bartram (2012)	B12	G	6,896	2000-2001	Several countries
Bartram et al. (2009)	B09	P	7,319	2000-2001	Several countries
Bartram et al. (2011)	Ba11	P	6,860	2000-2001	Several countries
Bashir et al. (2013)	Ba13	P	107	2006-2010	Pakistan
Berkman and Bradbury (1996)	BB96	P	116	1994	New Zealand
Berkman et al. (2002)	B02	P	106	1995	Australia
Berrospide et al. (2008)	B08	G	167	1997-2005	Brazil
Brailsford et al. (2005)	B05	P	96	2000	Australia
Brown et al. (2006)	B06	P	44	1993-1998	US, Canada
Brunzell et al. (2011)	Br11	P	112	2006	Denmark, Finland, Iceland, Sweden
Búa et al. (2013)	Bú13	P	100	2004-2007	Spain
Buhr (2010)	B10	G	74	2007	New Zealand
Campello et al. (2011)	C11	P	1,185	1996-2002	US
Capstaff and Marshall (2005)	CM05	P	212	2000	UK, France
Chaudhry et al. (2014)	C14	P	75	2007-2011	Pakistan
Chen and Zhang (2012)	CZ12	G	119	2007-2010	China
Chernenko and Faulkender (2011)	CF11	P	1,854	1993-2003	US
Chiang and Lin (2007)	CL07	P	99	1998-2005	Taiwan
Chiorean et al. (2012)	C12	G	3,858	2000-2008	US
Choi et al. (2013a)	C13a	P	68	2001-2006	US
Choi et al. (2013b)	C13b	G	276	1996-2006	US
Chou and Lai (2013)	CL13	G	125	2005-2010	US
Clark and Judge (2008)	CJ08	P	192	1994	UK
Clark et al. (2006)	C06	G	227	2002	Hong Kong, China
Croci and Jankensgård (2014)	CJ14	G	40	2000-2008	US
Dadalt et al. (2002)	D02	P	752	1992-1996	US
Dadalt et al. (2012)	D12	P	1,327	2002-2004	US
Davies et al. (2006)	D06	P	81	2001	Norway
De Oliveira and Novaes (2007)	ON07	G	343	1999-2002	Brazil
Dionne and Triki (2013)	DT13	P	18	1991-1999	US, Canada
Dolde and Mishra (2007)	DM07	P	493	1996	US
Donohoe (2011)	D11	G	2,772	2000-2008	US
Elsawaf (2005a)	E05a	G	209	1996-1998	US
Elsawaf (2005b)	E05b	G	474	1993, 1995, 1998	US
Fauver and Naranjo (2010)	DN10	P	1,746	1991-2000	US
Fehle (1999)	F99	P	2,528	1993-1997	US
Fok et al. (1997)	F97	P	396	1990-1992	US
Gay and Nam (1998)	GN98	P	486	1995	US
Gay et al. (2011)	G11	P	1,341	1992-1996, 2002-2004	US
Gebhardt and Ruß (2002)	GR02	G	113	1996	Germany
Géczy et al. (1997)	G97	P	372	1990	US
Géczy et al. (2006)	G06	P	19	1993-1995	US
Glaum (2002)	G02	P	65	1998	Germany
Gleason et al. (2005)	G05	G	216	1998	US
Goldberg et al. (1998)	G98	P	410	1993	US
Gonzalez et al. (2007)	G07	G	49	2003	Spain
Gonzalez et al. (2010)	G10	P	96	2004	Spain
Goswami et al. (2004)	G04	P	314	1996	US
Graham and Rogers (2000)	GR00	G	404	1995	US
Hagelin (2003)	Ha03	P	101	1997-2001	Sweden
Hagelin et al. (2007)	Ha07	P	62	1998-1999, 2000-2001	Sweden
Heaney and Winata (2005)	HW05	P	374	1999	Australia
Hentschel and Kothari (2001)	HK01	P	325	1990-1993	US

Hu and Wang (2006)	HW06	P	369	2003	Hong Kong
Huang (2003)	Hu03	G	382	1992-1996	US
Huang and Li (2014)	HL14	G	90	2009-2010	Australia
Huang et al. (2007)	Hu07	P	599	1992-1996	US
Isin et al. (2014)	I14	G	32	2000-2012	Several countries
Jalilvand (1999)	J99	P	77	1992-1994	Canada
Jankensgård (2013)	J13	P	207	2009	Sweden
Jin and Jorion (2006)	JJ06	P	66	1998-2001	US
Jin and Jorion (2007)	JJ07	G	44	1991-2000	US, Canada
Judge (2004)	J04	G	356	1995	UK
Kang (2014)	K14	G	831	1997	US
Kapitsinas (2008)	K08	G	81	2004-2006	Greece
Khediri (2010)	K10	P	250	2000-2002	France
Khediri and Folus (2010)	KF10	P	320	2001	France
Kim et al. (2006)	K06	P	424	1998	US
Klimczak (2008)	Kl08	P	150	2001-2003	Poland
Krajcar et al. (2008)	Kr08	P	44	2006	Several countries
Lai et al. (2012)	La12	G	596	2005-2009	Taiwan
Lee (2001)	L01	G	151	1985-1997	US
Lel (2012)	Le12	P	253	1990-1999	Several countries
Lin (2003)	L03	G	1,198	1992-1996	US
Lin and Lin (2012)	LL12	P	39	2002-2004	US
Lin et al. (2007)	L07	P	1,046	1992-1996	US
Lin et al. (2008)	L08	P	494	1992-1996	US
Lin et al. (2009)	L09	P	450	1992-1996	US
Lin et al. (2010)	L10	P	1,045	1992-1996	US
Magee (2013)	Mag13	P	401	1996-2000	US
Mahayni (2001)	M01	G	138	1998	Germany
Marami and Dubois (2013)	MD13	G	967	1998-2005	US
Marsden and Prevost (2005)	MP05	P	185	1994, 1997	New Zealand
Marshall et al. (2013)	Mar13	P	801	2006	UK
Mefteh-Wali et al. (2012)	M12	P	130	1999-2000	France
Meredith (2002)	M02	G	61	1996-1998	US
Mian (1996)	M96	P	3,022	1992	US
Muff et al. (2008)	M08	G	277	2000-2001	UK
Muller and Verschoor (2005)	MV05	G	335	2003	Germany, Netherlands, Belgium
Nain (2004)	N04	G	1,630	1998-1999	US
Naito and Laux (2011)	NL11	P	434	2009	US
Nance et al. (1993)	N93	P	169	1986	US
Nguyen (2011)	N11	G	423	2000-2001	US
Nguyen and Faff (2002)	NF02	P	235	1999-2000	Australia
Nguyen and Faff (2007)	NF07	G	214	1999-2000	Australia
Nguyen et al. (2007)	N07	P	99	1996, 2000	France
Panaretou et al. (2013)	P13	P	169	2003-2008	UK
Pérez-González and Yun (2013)	PY13	P	203	1960-2007	US
Pincus and Rajgopal (2002)	R09	P	59	1993-1996	US
Ramlall (2009)	PR02	P	225	2005-2006	Mauritius
Reynolds et al. (2007)	Re07	G	99	1994-1999	New Zealand
Rossi (2007)	Ro07	P	212	1996-2004	Brazil
Rossi (2013)	R13	P	200	2007-2009	Brazil
Rossi and Laham (2008)	RL08	G	212	1996-2005	Brazil
Samitas et al. (2011)	S11	P	50	2007-2009	US
Sang et al. (2013)	Sa13	P	112	2000	UK
Schiozer and Saito (2009)	SS09	P	46	2001-2004	Argentina, Brazil, Chile, Mexico
Shu and Chen (2003)	SC03	P	391	1997-1999	Taiwan
Spanò (2007)	S07	P	222	1999-2000	UK
Sprčić (2013)	Sp13	G	49	2005	Croatia
Sprčić and Šević (2012)	SS12	P	89	2005	Croatia, Slovenia
Tufano (1996)	T96	P	17	1990-1993	US, Canada
Velasco (2014)	V14	P	74	2007-2011	Philippines
Wang and Fan (2011)	WF11	P	71	2003-2004	US
Wang et al. (2010)	W10	P	31	2002-2008	China
Wysocki (1998)	W98	G	403	1994	US
Yip and Nguyen (2012)	YN12	P	97	2006-2009	Australia
Yong et al. (2011)	Y11	P	235	1999-2000	Australia
Zhu (2012)	Z12	G	579	1994-2008	US

This table shows the study characteristics for the underlying sample of primary studies. Beside the study code, the corresponding abbreviation is noted, as well as if the study has been published or not. "P" stands for published literature. Gray literature, such as dissertations, working and conference paper are marked "G". The primary data examined by the studies is characterized by the observation period and the location of the investigated firms, shown in columns four and five.

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II.1.9.4 ***Appendix D.*** *Results of heterogeneity test and between-study variances from univariate meta-analysis*

Proxy Variable	Q	p-value	T^2
Asset growth rate	130.58	<0.0001***	0.0655
Blockholders	19.45	0.0783*	0.0050
Capex	183.31	<0.0001***	0.0067
Cash flow availability	147.10	<0.0001***	0.0243
CEO cash	90.14	<0.0001***	0.0355
Convertible debt	39.02	0.0002***	0.0033
Debt maturity	39.05	<0.0001***	0.0049
Dividend yield (binary)	493.23	<0.0001***	0.0598
Dividend yield (continuous)	311.99	<0.0001***	0.0175
Institutional investors	501.61	<0.0001***	0.0340
Intangible assets	44.73	<0.0001***	0.0140
Interest coverage ratio	241.36	<0.0001***	0.0175
Leverage ratio	1,229.53	<0.0001***	0.0227
Liquidity	900.52	<0.0001***	0.0268
Number of analysts	222.77	<0.0001***	0.0373
Option ownership (binary)	16.61	0.0053***	0.0186
Option ownership (continuous)	138.24	<0.0001***	0.0141
Preferred stock	198.9	<0.0001***	0.0280
Price-earnings ratio	35.68	0.0002***	0.0067
Profitability	1,111.74	<0.0001***	0.0342
Research and development	854.36	<0.0001***	0.0318
Sales growth rate	50.39	<0.0001***	0.0074
Share ownership	382.59	<0.0001***	0.0266
Size	4,741.20	<0.0001***	0.0921
Tangible assets	174.31	<0.0001***	0.0220
Tax credits	2,149.22	<0.0001***	0.4572
Tax-loss carryforwards (binary)	102.95	<0.0001***	0.0086
Tax-loss carryforwards (continuous)	260.50	<0.0001***	0.0298
Tenure	65.60	<0.0001***	0.0302
Tobin's Q	1,015.93	<0.0001***	0.0259

This table presents the results from Cochran's Q-test with the corresponding p-value, which identifies the intensity of heterogeneity among our study-specific effect sizes. *, ** and *** indicate rejection of the null hypotheses at the 10%, 5%, and 1% probability levels. T^2 stands for the magnitude of the effect size-specific between-study variance estimate, which is a measure of variation of the particular effect size around the mean of the true effect size across the examined primary studies.

II.1.9.5 ***Appendix E.*** *Mean correlation matrix*

	Hedging dummy	Dividend yield (continuous)	Institutional investors	Interest coverage ratio	Leverage ratio	Liquidity	Option ownership (continuous)	Profitability	Capex	Research and development	Share ownership	Size	Tangible assets	Tax-loss carryforwards (binary)	Tobin's Q
Hedging dummy	1														
Dividend yield (continuous)	0.1124***	1													
Institutional investors	0.1334***	-0.0216	1												
Interest coverage ratio	-0.0134	-0.0277	-0.0583*	1											
Leverage ratio	0.0666***	0.0175	-0.0249	-0.2469***	1										
Liquidity	0.0109	-0.0777***	0.2526***	0.0217	0.0481	1									
Option ownership (continuous)	0.1074***	0.1356**	0.0411	0.3264***	-0.1467***	0.1189**	1								
Profitability	-0.0014	0.0152	-0.1088***	-0.1096	0.0954**	-0.0471	-0.0431	1							
Capex	-0.1094***	-0.1002***	-0.0819***	0.1201*	-0.2081***	-0.0128	0.0743**	-0.0935*	1						
Research and development	0.0785**	-0.0257	0.118	-0.1112	-0.1090***	0.052	-0.0505	0.029	0.1989*	1					
Share ownership	-0.0876***	-0.1385***	-0.1705	0.0248	-0.0231	-0.024	0.0152	0.0029	0.0463*	0.0651***	1				
Size	0.2639***	0.1059*	0.0947***	0.0304	0.1172***	0.0587	0.1964***	-0.0206	-0.1234***	-0.0405	-0.0762*	1			
Tangible assets	0.1064**	-0.0281	-0.0144	0.0439	0.1633***	-0.1562***	-0.0154	0.1513	-0.0368	0.0496***	-0.0542	0.1015*	1		
Tax-loss carryforwards (binary)	0.0816***	-0.0456	0.0941	-0.0983	0.0973	0.0783	-0.1838	0.1916***	0.0261	0.1178**	-0.0671**	0.0236	0.0785	1	
Tobin's Q	0.0315	-0.0599	-0.0475***	0.1459*	-0.1015*	-0.0608	0.3076	-0.0022	0.1141***	0.0998**	0.0498	-0.0756***	-0.0647	0.0131	1

This table shows the mean correlation matrix ***R*** estimated via GLS with random effects weights across all 132 primary studies. *, ** and *** indicate a 10%, 5%, or 1% significance level, respectively.

II.1.9.6 ***Appendix F.*** *Sample distribution over time*

Publication year	Number of studies	Mean number of observed firms
1993	1	169
1996	3	1,052
1997	2	384
1998	3	433
1999	3	1,174
2000	1	404
2001	4	184
2002	9	182
2003	4	518
2004	3	767
2005	8	263
2006	7	176
2007	13	275
2008	8	202
2009	5	1,619
2010	8	472
2011	13	1,194
2012	13	1,105
2013	18	327
2014	6	190

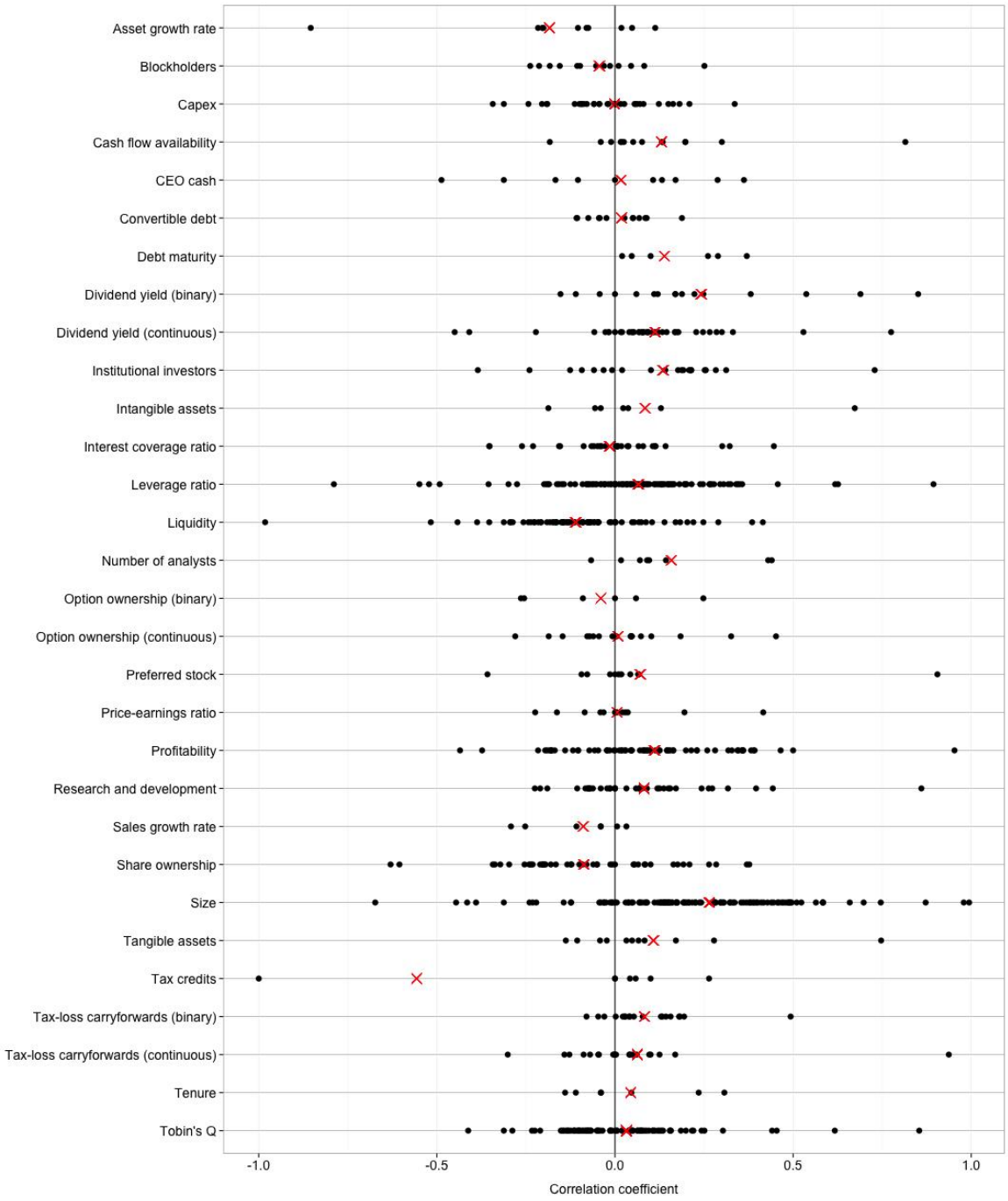
This table shows the temporal distribution of our analyzed sample. For each year we display the number of studies and the average number of firms in the respective sample.

II.1.9.7 ***Appendix G.*** *Sample description*

Criteria	Statistic
PUBLISHING TYPE	
Published studies	68.18%
Unpublished studies	31.82%
EXAMINED COUNTRIES	
North America	45.45%
Europe	25.76%
Asia and Pacific	9.85%
Australia	9.09%
South America	4.55%
Other countries	5.30%
OBSERVATION PERIOD	
Before 1995	22.66%
Between 1996 and 2000	33.99%
Between 2001 and 2005	25.62%
After 2005	17.73%
SAMPLE SIZE	
Minimum	17
Maximum	7319
Mean	555.96
Standard deviation	1155.29

This table gives an overview of the underlying 132 primary studies.

II.1.9.8 ***Appendix H.*** *Distribution of effect size estimates and univariate meta-analysis results*



This plot shows the effect size estimates observed from the primary studies for each proxy variable as black dots. The weighted mean correlations (i.e. the univariate meta-analytical results) are presented by the red crosses.

II.1.9.9 ***Appendix I.*** *Overview of the proxy variables for the corporate tax hypothesis reviewed in the meta-analyses (H1)*

Variable	Hyp. sign	Description	Classification of the findings by the reviewed studies
Tax credits	+	Absolute value of available (investment) tax credits	[+] B09, F97, N93
			[0^+] L07, SC03
			[0^-] na
			[−] SS12
Tax-loss carryforwards (binary)[a]	+	Dummy variable that takes a value of "1" if the firm has tax-loss carryforwards available and "0" otherwise	[+] BB96, C06, J04
			[0^+] AB02, AA11a, AA11b, B02, C12, CJ08, D11, G10, HW05, J99, MP05, PR02, Sa13
			[0^-] HW06, M08
			[−] M96
Tax-loss carryforwards (continuous)[a]	+	Tax-loss carryforwards (scaled)	[+] CL13, GN98, G05, N04, V14
			[0^+] F97, G97, Hu03, K06, Mar13, Sp13
			[0^-] Hu07, N93, Ro07, SS12, T96
			[−] D06, G11, L03, SC03

This table sums up the proxy variables reviewed in the paper at hand, including their hypothetical sign for the impact on the corporate hedging decision, as well as the corresponding definition. The hypothesized sign describes the theoretical relationship between the proxy and the incentive for corporate hedging. Our variable definitions arise from an aggregation of the variables in the reviewed studies and are similar to those of Aretz and Bartram (2010). The descriptions are generalizations of the study-specific variable definitions. All variables are analyzed by vote counting and univariate meta-analysis. The variables included in the multivariate meta-analysis are in bold face. The last column classifies the proxy-specific findings from the analyzed primary studies in significant positive [+], insignificant positive [0^+], insignificant negative [0^-] and significant negative [-] relations, by the study name abbreviation as presented in Appendix B, with respect to a probability level of 5%. The study abbreviations are explained in Appendix B.

[a] The two tax-loss carryforwards variables also serve as a proxies for the bankruptcy and financial distress hypothesis with a theoretical sign of "+".

II.1.9.10 ***Appendix J.*** *Overview of the proxy variables for the bankruptcy and financial distress hypothesis reviewed in the meta-analyses (H2)*

Variable	Hyp. sign	Description	Classification of the findings by the reviewed studies
Cash flow availability	−	Firm's operating cash flow (scaled)	[+] B08, CZ12, C13b, DN10, Re07 [0^+] A02, D11, Hu03, I14, L07, R09 [0^-] CM05, GR02, N11 [−] na
Convertible debt[a]	?	Book value of convertible debt (scaled)	[+] BB96, C12, Hu07 [0^+] F99, GN98, Hu03, J99, J04 [0^-] C06, F97, G97, Le12, N93, W98 [−] na
Debt maturity	+	(Logarithm of) Debt that matures in more than 1 year	[+] B09, CJ08, J99, M96, SC03 [0^+] C11 [0^-] na [−] na
Dividend yield (binary)	?	Dummy variable that takes a value of "1" if the firm pays dividend to its shareholders and "0" otherwise	[+] Ah13, B09, Ba13, C13a, GR00, Ha07, K08, Re07, RL08, V14 [0^+] CL13, J13 [0^-] CJ14, K10 [−] C12
Dividend yield (continuous)	?	Dividend per share (scaled)	[+] A09, BB96, C14, C13b, C06, E05a, E05b, F99, J04, Le12, L10, M96, M08, N93, NF02, Re07, S07, SS12 [0^+] AB02, AA11a, AA11b, D06, F97, Ha03, HW05, J99, M01, MP05, MV05, N04, PR02, SC03, W98 [0^-] B02, G97, G06, PY13 [−] Al13, L01, Y11
Interest coverage ratio	−	(Logarithm of) Earnings before interest and taxes ÷ interest expenses	[+] AB02, B12, Re07 [0^+] AA11a, AA11b, A09, B02, D06, GN98, G02, HW05, HW06, J99, Kl08, M02, Sp13, SS12 [0^-] BB96, CJ08, F97, G97, G10, N93, Sa13, SC03, W98 [−] CM05, C12, C06, J04
Leverage ratio[b]	+	Book value of long-term or total debt (scaled)	[+] AB02, Ah13, AW99, B12, BB96, B08, B05, C11, CM05, CF11, C13b, CL13, CJ08, C06, DN10, F99, G10, HW05, Hu03, J04, Kr08, La12, L03, L07, M01, MP05, Mar13, M12, MV05, N04, NF02, P13, PR02, Re07, Ro07, R13, V14 [0^+] AA11a, AA11b, A12, B02, Br11, CJ14, ON07, DT13, D11, E05b, F97, GR02, G06, GR00, HK01, HW06, J99, Kl08, LL12, L09, MD13, M02, M96, M08, N11, PY13, R09, Sa13, S07, Sp13, T96, YN12 [0^-] AH12, A09, Ba13, B10, D02, D06, E05a, G97, G05, G98, G07, G04, Ha03, K08, L10, N93, N07, SS09, SC03, SS12, W10 [−] Al13, C14, C12, D12, Ha07, I14, K10, K06, RL08, S11, WF11, W98, Y11
Liquidity[c]	−	Current assets or cash and cash equivalents (scaled)	[+] AA11b, B08, Bú13, C12, Ha07, WF11, Y11 [0^+] A02, A09, Ba13, L07, M02, M08, R09, R13, SS12, W10 [0^-] AA11a, AH12, B02, C14, CJ08, D06, DT13, GR02, G97, G10, GR00, Ha03, J99, K06, L01, M01, Mar13, MV05, N93, N11, NF02, Ro07, SC03, T96, YN12 [−] AB02, Al13, B12, BB96, CM05, CL13, C06, CJ14, F99, F97, G11, G98, G07, HW05, HL14, J04, La12, MP05, M96, N04, N07, PR02, Re07, RL08, Sa13, S07, V14
Preferred stock	?	Book value of preferred stock (scaled)	[+] V14 [0^+] C12, ON07, F99, F97, GN98

Profitability	−	(Logarithm of) Sales or return on assets or EBIT (scaled)	[0⁻] G97, J04, N93 [−] C06, W98 [+] A12, B12, B08, Br11, B10, CM05, C14, CZ12, CF11, C13b, CL13, D02, DM07, F97, G11, G05, J13, K10, Kl08, La12, MD13, N11, N07, Re07, RL08, S11, SC03, YN12 [0⁺] A02, AA11b, D06, DT13, D11, G10, GR00, Ha07, I14, K14, K08, Kr08, L07, L10, MV05, NF07, R09, Ro07 [0⁻] Ah13, Ba13, B06, Bú13, C12, C13a, CJ08, E05b, GR02, G07, M01, M02, M08, PY13, W10 [−] A10, E05a, DN10, SS09, Sp13
Size	−	(Logarithm of) Book value of total assets or market value of the firm	[+] A10, AB02, AH12, Ah13, AW99, A12, B12, Ba13, BB96, B02, B05, B10, C11, CM05, CZ12, CL07, C13b, CL13, C06, D02, ON07, DM07, E05a, DN10, F99, F97, G11, GR02, G97, G05, G98, G10, G04, GR00, Ha03, Ha07, HW05, HK01, Hu03, HL14, Hu07, J99, J13, JJ06, JJ07, J04, K14, K06, Kr08, La12, L01, Le12, L03, L07, L10, MD13, MP05, Mar13, M12, M02, M96, M08, MV05, N04, N93, NF02, N07, PY13, R09, PR02, Re07, Ro07, R13, RL08, Sa13, SC03, S07, SS12, V14, W98, YN12 [0⁺] Aa13, Aa13, AA11a, C13a, CJ08, D06, DT13, D11, E05b, G02, LL12, N11, P13, T96 [0⁻] AA11b, Al13, A09, C14, GN98, G06, HW06, I14, K08, Sp13 [−] Bú13, C12, CJ14, G07, K10, SS09, WF11, W10, Y11
Tangible assets	−	Tangible assets (scaled)	[+] HW05, MD13, Re07 [0⁺] AA11a, AA11b, C11, ON07 [0⁻] R09, SS09 [−] Al13, B12

This table sums up the proxy variables reviewed in the paper at hand, including their hypothetical sign for the impact on the corporate hedging decision, as well as the corresponding definition. The hypothesized sign describes the theoretical relationship between the proxy and the incentive for corporate hedging. Our variable definitions arise from an aggregation of the variables in the reviewed studies and are similar to those of Aretz and Bartram (2010). The descriptions are generalizations of the study-specific variable definitions. All variables are analyzed by vote counting and univariate meta-analysis. The variables included in the multivariate meta-analysis are in bold face. The last column classifies the proxy-specific findings from the analyzed primary studies in significant positive [+], insignificant positive [0⁺], insignificant negative [0⁻] and significant negative [-] relations, by the study name abbreviation as presented in Appendix B, with respect to a probability level of 5%. The study abbreviations are explained in Appendix B.

[a] The convertible debt variable serves as proxy for the asymmetric information and agency conflicts of equity hypothesis with a theoretical sign of "–" .

[b] The leverage variable also serves as a proxy for the coordination of financing and investment policy and agency conflicts of debt hypothesis with a theoretical sign of "+".

[c] The liquidity variable also serves as a proxy for the coordination of financing and investment policy and agency conflicts of debt hypothesis with a theoretical sign of "–".

II.1.9.11 ***Appendix K.*** *Overview of the proxy variables for the asymmetric information and agency conflicts of equity hypothesis reviewed in the meta-analyses (H3)*

Variable	Hyp. sign	Description	Classification of the findings by the reviewed studies
Blockholders' ownership	?	Number of outside investors holding a significant amount of shares (usually more than 5%)	[+] Ha07 [0^{+}] Br11, J13, NF02 [0^{-}] MP05, M02, M08, T96, WF11, W10 [−] D06, Kl08, Y11
CEO cash	−	CEO salary + CEO bonus (scaled)	[+] CL13, GR02, Hu07, Mar13, W98 [0^{+}], [0^{-}] na [−] C13b, CJ14, M08, WF11
Institutional investors	−	Percentage or number of shares held by institutional investors	[+] DN10, F97, G97, G10, GR00, Ha03, L09, L10, M01, N04, PR02 [0^{+}] D11, G02, Kl08, MP05, SS12 [0^{-}] AB02, ON07, DT13, G07 [−] B09, E05b
Intangible assets[a]	+	Intangible assets (scaled)	[+] C13a [0^{+}] Bú13, D11, DN10, G10 [0^{-}] G07, M01 [−] na
Number of analysts	−	(Logarithm of) Number of analysts following the firm	[+] D02, G11, G97, P13 [0^{+}] D11, L07, L09 [0^{-}], [−] na
Option ownership (binary)	?	Dummy variable that takes a value of "1" if managers or directors own options of the firm and "0" otherwise	[+] na [0^{+}] Ha07, Mar13 [0^{-}] Br11, CJ14 [−] Ha03
Option ownership (continuous)	?	(Logarithm of) Number, percentage or market value of options held by managers or directors	[+] B09, DT13, G97, GR00 [0^{+}] GN98, Hu07, M02, SS12, T96, Y11 [0^{-}] HW05, M08, NF02, PR02, Sa13, WF11 [−] N04
Share ownership	+	(Logarithm of) Number, percentage, or market value of shares held by managers or directors	[+] G10, GR00, Ha03, MP05, N04, Y11 [0^{+}] DT13, G97, Hu07, Le12, PR02, Sa13, SC03, T96 [0^{-}] AH12, BB96, Br11, CL13, G07, J99, J13, SS12 [−] AB02, AA11b, B02, ON07, DM07, DN10, F97, GN98, HW05, M01, Mar13, M02, M08, NF02, S07, V14, WF11, W98
Tenure	?	(Logarithm of) Number of years that the officer(s) hold in their current job	[+] WF11 [0^{+}] Hu07 [0^{-}] CJ14, K14, SS12 [−] Hu03

This table sums up the proxy variables reviewed in the paper at hand, including their hypothetical sign for the impact on the corporate hedging decision, as well as the corresponding definition. The hypothesized sign describes the theoretical relationship between the proxy and the incentive for corporate hedging. Our variable definitions arise from an aggregation of the variables in the reviewed studies and are similar to those of Aretz and Bartram (2010). The descriptions are generalizations of the study-specific variable definitions. All variables are analyzed by vote counting and univariate meta-analysis. The variables included in the multivariate meta-analysis are in bold face. The last column classifies the proxy-specific findings from the analyzed primary studies in significant positive [+], insignificant positive [0^{+}], insignificant negative [0^{-}] and significant negative [-] relations, by the study name abbreviation as presented in Appendix B, with respect to a probability level of 5%. The study abbreviations are explained in Appendix B.

[a] "Intangible assets" complements the proxy variables analyzed by Aretz and Bartram (2010).

II.1.9.12 ***Appendix L.*** *Overview of the proxy variables for the coordination of financing and investment policy and agency conflicts of debt hypothesis reviewed in the meta-analyses (H4)*

Variable	Hyp. sign	Description	Classification of the findings by the reviewed studies
Asset growth rate	+	Current year change in net tangible assets + depreciation (scaled)	[+] na [0+] NF07, R13 [0-] BB96, B02, B06, B10, D11, R09 [−] AA11b, V14
Capex	+	Capital expenditures (scaled)	[+] A02, B08, C11, CL13, G11, K10 [0^+] C12, C13a, D11, K08, L07, PY13, SS12 [0^-] Ah13, A12, CF11, GR00, Ha07, HW06, I14, J04, N11, R09, W10 [−] B12, Ba13, CJ14, G97, J13, SS09, Sp13
Price-earnings ratio	+	Earnings per share ÷ share price	[+] B02, Re07 [0^+] AB02, C12, GN98, MP05, YN12 [0^-] C06, HW06, J04, M01 [−] na
Research and development	+	Research and development expenses (scaled)	[+] C12, C13a, C13b, C06, DM07, F97, G97, G05, G98, K06, L01, N93 [0^+]A10, A12, Bú13, B10, CJ08, GN98, L07, S07, SS12 [0^-] D11, GR00, HW06, J04, K14, Kl08, L03, M08 [−] Ah13, AW99, B12, CF11, MD13, N04
Sales growth rate [a]	+	Current year or 4-year change in firm's sales	[+] na [0^+] D11, P13 [0^-] GR02 [−] Ba11, N11, Re07
Tobin's Q	+	(Logarithm of) Market value of firm ÷ book value of total assets	[+] AW01, B08, C12, DM07, E05b, G97, Ha03, Hu03, Re07, Ro07, RL08, S11, W98, Y11 [0^+] AA11a, AA11b, AH12, Ba13, B06, Bú13, C11, CM05, C14, D06, ON07, GN98, GR02, G02, G05, J99, J13, K08, K06, Kl08, La12, L07, L10, Mar13, PY13, PR02, SC03 [0^-] A09, Br11, CJ08, C06, D11, DN10, G06, G10, Ha07, HW06, JJ07, J04, L01, M01, MP05, M08, N11, NF02, N07, P13, S07, W10 [−] Ah13, A12, B12, CL13, CJ14, G07, HW05, Hu07, K14, KF10, M12, M96, MV05, N04, NL11

This table sums up the proxy variables reviewed in the paper at hand, including their hypothetical sign for the impact on the corporate hedging decision, as well as the corresponding definition. The hypothesized sign describes the theoretical relationship between the proxy and the incentive for corporate hedging. Our variable definitions arise from an aggregation of the variables in the reviewed studies and are similar to those of Aretz and Bartram (2010). The descriptions are generalizations of the study-specific variable definitions. All variables are analyzed by vote counting and univariate meta-analysis. The variables included in the multivariate meta-analysis are in bold face. The last column classifies the proxy-specific findings from the analyzed primary studies in significant positive [+], insignificant positive [0^+], insignificant negative [0^-] and significant negative [-] relations, by the study name abbreviation as presented in Appendix B, with respect to a probability level of 5%. The study abbreviations are explained in Appendix B.

[a] "Sales growth rate" complements the proxy variables analyzed by Aretz and Bartram (2010).

II.2 Research Paper 2: "How do soccer matches and competitions really influence stock markets? A review of recent empirical evidence"

Author: Matthias Walter

FIM Research Center, Department of Information Systems Engineering & Financial Management (Prof. Dr. Hans Ulrich Buhl), University of Augsburg, Germany
Matthias.Walter@fim-rc.de

Abstract:

The economic meaning of soccer has increased significantly in recent years; as a result, the number of empirical studies analyzing soccer's effects on stock markets has grown. These studies show that soccer's effect on stock markets can be explained from both rational and irrational perspectives. From a rational perspective, a soccer club's financial performance is a function of its sporting performance. From an irrational perspective, soccer "solely" affects investors' mood and consequently their investment behavior. Hence, soccer is a suitable subject to test the efficient market hypothesis and the behavioral alternative hypothesis, particularly because in the case of soccer, match information becomes available for all market participants simultaneously. Consequently, the paper provides a thorough review of the recent empirical evidence and aggregates existing knowledge to an overall level. In this regard, we show that soccer in general influences stock returns and that capital markets seem to be driven predominantly by moods.

JEL-classification: *G020, G140*

Keywords: *Behavioral Finance, Market Efficiency, Sentiment, Soccer, Stock Market*

II.2.1 Introduction

The 2014 Fédération Internationale de Football Association (FIFA) World Cup in Brazil once again proved that soccer affects peoples' sentiments worldwide, perhaps more so than any other sport. Consequently, the era in which soccer was solely a type of sport is long past. Further, soccer's meaning for the global economy has significantly increased over recent decades. For instance, the 2014 World Cup generated total revenue of US$4.8 billion (FIFA 2015), implying an expected increase of 30% compared with the total revenue of US$3.7 of the 2010 Football World Cup in South Africa (FIFA 2011). For soccer clubs, a significant increase in economic relevance is also observable. In 2010, the most valuable soccer club in the world was Manchester United FC, with a team value of US$1.84 billion, revenue of US$459 million, and an operating income of US$150 million (Forbes 2010). In contrast, Real Madrid CF, currently the most valuable soccer club, had a team value of US$3.44 billion in 2014, demonstrating an increase of nearly 100% compared with Manchester United FC in 2010. During the 2012–13 season, Real Madrid CF generated revenue of US$675 million and had an operating income of US$172 million (Ozanian 2014). Although Real Madrid CF is an example of a club that is not listed on a stock market, numerous soccer clubs are listed across European stock markets. For instance, the STOXX Europe Football index currently includes 22 European soccer clubs.

Because stock market reactions following the matches of these clubs or national teams can be observed regularly, one of the most "popular" debates in financial research can be considered with regard to soccer: Are financial markets efficient in the sense of, e.g., Fama et al. (1969), or are they driven by moods, thus supporting the behavioral alternative hypothesis that derives from Shiller et al. (1984)?

Because of its tremendous economic impact, soccer influences the future cash flows of either clubs or their sponsors respectively companies from interconnected sectors (e.g., sportswear sector). For instance, a win is associated with higher cash flow in the future, because with increasing sporting success, among other benefits, more merchandising items are sold and more fans attend matches. Thus, market reactions following matches, particularly for market-listed clubs, can be explained in a rational manner. However, psychological and financial research provides evidence that soccer strongly influences fans' sentiments (e.g., Hirt et al. 1992; Kerr et al. 2005) and that soccer fans can be found in all social classes (Edmans et al. 2007). Consequently, soccer could also influence stock market

participants and their investment decisions (Lucey and Dowling 2005), which in turn may lead to behavior-driven market reactions.

In the literature, numerous studies have been conducted to explore the influence of soccer matches and competitions on stock markets and consequently to help find an answer to the market efficiency debate. Despite, or perhaps because of, the large number of studies, the empirical evidence is mixed. The heterogeneous findings are reasoned predominantly by differences in data samples, study objects, and different methodological approaches. For example, some studies analyze the impact of club matches on stock markets and some consider the impact of national team matches. Further, some of the periods examined are hard to compare in the context of soccer's meaning to the economy.

Thus, the aim of our paper is three-fold. First, we want to provide a review of the different studies. In order to not only describe the results of these studies but also to deliver new evidence, we aggregate the findings by means of an approach similar to the vote counting method. By doing so, we aim to present generalized statements regarding the influence of soccer on stock markets in general and to provide the specific key drivers of this influence. To the best of our knowledge, there is no structured and comprehensive review available that synthesizes studies and provides a holistic overview of the different contributions respectively heterogeneous findings. Even the popular and comprehensive work of Dobson and Goddard (2011), *The Economics of Football*, does not analyze in detail soccer's impact on stock markets. In contrast, our paper covers 42 studies, identified through a structured literature search process. Second, although not all of the 42 studies explicitly analyze the presence of market efficiency, by providing such a comprehensive review, we want to offer a more general answer to the question of whether stock markets with regard to soccer are efficient or are driven by behavioral factors. Third, based on our findings, we want to provide opportunities for further research. Consequently, we formulated four concise research questions derived from the three aforementioned aims.

RQ1: Referring to the current state of the art, which methodological approaches and data sets have been examined in order to analyze the impact of soccer on stock markets?

RQ2: Referring to the current state of the art, are stock markets generally influenced by soccer, and what are the main sport-related drivers for this influence?

RQ3: Are stock markets in the context of soccer efficient, or driven by moods?

RQ4: Concerning the impact of soccer on stock markets, are there any research gaps that can be identified and that lead to recommendations for further research?

To answer these questions, we follow the commonly accepted process for literature reviews, based on, e.g., Cooper and Hedges (1994) and Webster and Watson (2002). Consequently, after formulating the research problem in this section, we provide a brief overview of the efficient market hypothesis and the behavioral alternative hypothesis in terms of soccer in section II.2.2. In section II.2.3, we elaborate on our evaluation of the literature in order to identify existing studies that examine soccer's influence on stock markets. In section II.2.4, we compile the key findings regarding the different methodologies and data samples (*RQ1*) and soccer's influence on stock markets (*RQ2*) from the different studies and try to provide an answer to whether stock markets in terms of soccer are efficient or not (*RQ3*). In section II.2.5, the current state of related research is analyzed with regard to opportunities for future studies (*RQ 4*). Finally, section II.2.6 summarizes the key findings.

II.2.2 Theoretical Foundations

Assessing the influence of soccer on stock markets helps to find an answer to one of the most controversial questions in financial research: Are financial markets efficient; namely, do investors behave in a fully rational manner and is all available information completely processed and reflected in market prices? Fama et al. (1969) test the incorporation of publicly available information in stock prices. When a stock price contains all relevant information relating to a specific underlying (e.g., company), it is assumed that the price is changed only by the publication of new information. Using the example of stock splits, Fama et al. (1969) show that the incorporation of new information in stock prices is completed almost as soon as they become public. Thus, in an efficient market, stock prices adjust rapidly to new information. This theory is also confirmed by, e.g., Stoll and Whiley (1990), thereby showing that the appearance of public information has a direct impact on listed companies' stock prices.

Nevertheless, in "traditional" industries it is often hard to identify the release of new public information and thus the corresponding market reaction because value-relevant public information is often released infrequently and in a confounding manner (e.g., during trading hours). In contrast, sporting events in general and soccer matches in particular elude these shortcomings, as they occur regularly (e.g., weekly), are easy to quantify (at the simplest level, win or lose), and mostly appear at times when stock markets are closed (late in the evening, at night, and at weekends); thus, the results become available for all market participants at the same time. However, sports in general and soccer in particular strongly affect people's, and thus also investors', sentiment. Consequently, two different

explanations for a stock market reaction following the release of new match-related information must be distinguished: the stock market reaction can be caused by *rational* economic considerations or it can be caused by *irrational* changes in investors' sentiment. Depending on which effect is observable, one can confirm the hypothesis of efficient markets or the behavioral alternative hypothesis derived from Shiller et al. (1984). With regard to the latter hypothesis, Shiller et al. (1984) propose that stock prices are heavily influenced by social dynamics and psychological effects, e.g., fashion or sentiments. Both lines of reasoning are now briefly considered.

Following, among others, Brown and Hartzell (2001), who examine the coherence of the publicly traded basketball club Boston Celtics of the National Basketball Association (NBA) and stock markets, the *rational* explanation is based on the belief that a club's share price is a function of the club's financial performance, which in turn is a function of sporting performance. This assumption is based mainly on the impact of successful sporting performances on cash flows, thus contributing to firm value. Although Brown and Hartzell (2001) analyze an NBA club, the cash flow impact of success in soccer is virtually the same.[32]

- Sporting success leads to better game attendance and thus to higher revenue (including regular ticket sales and luxury box leasing). Further, sporting success offers the opportunity to increase ticket prices.
- (Long-term) sporting success leads to an increase in advertising and licensing revenue (e.g., higher team-related merchandising sales).
- Depending on the country, (long-term) sporting success leads to higher revenue because of the sale of TV broadcasting rights.
- Sporting success may lead to more and higher value sponsoring deals.
- When a club qualifies to participate in an international tournament, additional revenue in the form of millions of dollars is generated. Winning such a tournament generates even further income.
- Aside from the direct cash flow impact, sporting success contributes to the value of a club's reputation and thus the value of the franchise.

In sum, good performances in soccer matches and competitions mean higher cash flow, which increases the fundamental value of the club. Thus, increases in stock market prices

[32] The relation between a club's financial performance and sporting performance is even more distinct for soccer because in the case of the NBA, sporting success is negatively correlated with the club's position in next season's draft order. Thus, in at least some respects, sporting success in basketball is even "penalized".

following wins and decreases following losses can be explained in terms of investors' rational behavior, thereby indicating market efficiency.

Hence, based on these theoretical considerations, we propose four major hypotheses regarding the *rational* influence of soccer matches on stock markets. Table II.2-1 presents an overview of the four major hypotheses and the predicted market reactions.

Table II.2-1 Hypotheses and predicted market reactions depending on match results

Hypothesis	Description	Match result	Predicted reaction[a]
H1: Wins positively affect stock market returns, and losses negatively affect stock market returns.	Wins lead to higher cash flow and thus to an increase in fundamental value and a positive influence on stock returns. The opposite applies for losses. For draws, the sportive and thus financial consequences are less negative compared with those of losses ("one point is more than no points"). Thus, the influence on stock returns from an ex ante position is unclear.	Win	+
		Loss	-
		Draw	?
H2: The results of important matches affect stock market returns more strongly than "normal" matches.	Important matches can be matches against direct rivals or local derbies; domestic cup matches; international competition matches (e.g., UEFA Champions League, the World Cup, or a continental championship); "post-March matches" (played at the end of the season, when "decisions are made"); an elimination match ("up or out"); and relegation and promotion matches (i.e., matches to determine whether a club stays in the league for the next season or advances to a higher league). Important matches can increase or decrease the probability of a successful season. In addition, important matches are often associated with higher success premiums (wins) or the prevention of higher cash flow in the future (losses); thus wins/losses may have a stronger positive/negative impact on firm value than "normal" matches, leading to higher positive/negative (abnormal) returns compared with wins in "normal" matches. For draws, the hypothesized market reaction remains unclear because draws in elimination matches still provide the opportunity to proceed to the next stage.	Important Win	++
		Important Loss	--
		Important Draw	?
H3: Stock market reactions are mainly driven by non-expected results.	The expected match outcome (quantified by, e.g., betting odds) is already priced prior to the match. Thus, market reactions to wins or losses should be stronger when a result is more unexpected because unexpected wins or losses increase the probability to reach/fail the objective for the season. However, when a result is strongly expected, a weak (insignificant) positive/negative market reaction can agree with the efficient market hypothesis because betting odds always imply a certain residual probability for an alternative result.	Expected Win/Loss/Draw	o/o/?
		Unexpected Win/Loss/Draw	+(+)/-(-)/?
H4: Overall, losses affect stock market returns more strongly than wins.	The monetary consequences of a loss can be worse than for a win. For example, a win in an elimination match "only" means reaching the next stage (unless it is the final game), thus providing the chance to generate higher cash flow. However, a loss in an elimination match immediately eliminates a club from a tournament, thus denying the opportunity for further cash flow. The same holds for a loss in the last match of the season, e.g., leading to non-qualification for an international tournament. In order to explain market efficiency from this hypothesis, it is necessary to examine the extent of the gap between the market reactions to wins and losses.	Win/Loss	|+| < |-|

[a] For each match result, the predicted market reaction is indicated. A "++" indicates high positive abnormal returns; "+" indicates positive (abnormal) returns; "-" indicates negative (abnormal) returns; and "--" indicates high negative (abnormal) returns. An "o" indicates weak (insignificant) market reactions and a "question mark" indicates an unclear direction. |+| and |-| indicate positive and negative (abnormal) returns respectively in absolute terms.

In contrast to rational explanations, market reactions following soccer matches can also be explained in terms of behavioral effects based on the *bounded-rational* or even *irrational* behavior of market participants. The behavioral alternative hypothesis tries to explain capital market anomalies (e.g., abnormal returns), combining cognitive psychological theories, e.g., sentiments and moods, with common financial theories (Baker and Nofsinger 2010). In order to examine the effect of investors' sentiment on capital market returns, Edmans et al. (2007) provide three characteristics of a "good" mood variable. First, the variable must show a substantial and clear impact on sentiments to guarantee that the effect really influences asset prices. Second, the mood variable must influence the mood of a large proportion of a specific population, otherwise only a few investors may be affected. Third, the effect of the mood variable must be correlated across most individuals within a population. For instance, Hirshleifer and Ahumway (2003) use sunshine duration as a mood variable, showing the highly significant effect of sunshine on stock returns, thereby enabling investors to gain substantial benefits from weather-based trading strategies. In addition, Kamstra et al. (2000) analyze the influence of changes in investors' sleeping patterns on stock indices' returns. Edmans et al. (2007) introduce soccer results (win/draw/loss) as a mood variable because sports in general and soccer in particular have a significant influence on sentiments. Indeed, especially in Europe, it is hard to identify any events other than soccer matches that influence sentiments in such a large proportion of a country's population.

With regard to the mood variable "soccer match result," it is doubtful whether fans treat wins and losses "equally." The literature provides several suggestions that losses may be more strongly valued by fans than wins (as already discussed from a rational perspective in *H4*). This phenomenon can be explained through prospect theory, which claims that gains and losses are measured against a specific reference point (Kahneman and Tversky 1979). For soccer, because of an "allegiance bias" (e.g., Markmann and Hirt 2002; Wann et al. 2001), this reference point is often an ex ante estimated win, thus leading to a greater stock price reaction following a loss. Consequently, confirmation of hypothesis *H4* does not necessarily confirm the existence of efficient markets.

An example of obvious irrational behavior is a stronger market reaction after (domestic) away wins than after (domestic) home wins because this reaction neither agrees with the aforementioned hypotheses nor is rational. The same holds for an increase in stock prices after a lost match. Further, a strong stock market reaction following national team matches is hard to explain from a rational viewpoint because national teams are not related to a single stock, thus indicating no direct cash flow impact (although one can argue that a national

team win has a positive influence on the cash flow of the national team's sponsor and that a win can stimulate consumer behavior, thus leading to higher sales within the national economy and consequently to higher cash flows among listed companies).

Numerous studies examining the influence of soccer matches on stock markets analyze the four aforementioned hypotheses. Although not all of these studies explicitly discuss the presence of market efficiency (e.g., some of the studies examine the influence of mood on financial decision-making), each study nonetheless delivers some evidence for market efficiency and the behavioral alternative hypothesis. Because such studies reach heterogeneous findings, this paper aims to provide a thorough overview of the research topic and tries to provide a more comprehensive answer to the question of whether or not stock markets with regard to soccer are efficient.

II.2.3 Identification and Description of Relevant Literature

II.2.3.1 *Identification*

In a similar fashion to other literature examinations (e.g., Müller 2014), the following review uses multidimensional classification to structure the literature. First, the literature is analyzed with regard to the different methodological approaches and data sets that have been used to examine soccer's impact on stock markets *(RQ1)*. Second, the results from the various studies are systematically analyzed *(RQ2, RQ3)* and the need for further research is derived *(RQ4)*. Thus, to provide a holistic and precise overview of the literature, it is necessary to identify all relevant articles from this field of research in a systematic manner. Consequently, we conducted a focused web search of the major online databases, Proquest, ScienceDirect, and EBSCOhost,[33] combing the search terms ("football" OR "soccer") and ("stock" OR "share"), and using title and abstract as search fields. These search terms are relatively broad and were chosen in order to avoid unintended exclusions because this field of research is rather a "niche". By using this broad search approach, we were also able to consider articles about the impact of (international) soccer events (e.g., the FIFA World Cup) on investment behavior. Our search achieved 610 results (after eliminating duplicates).

Because our search procedure still yielded numerous unrelated articles, e.g., articles dealing with American football and rugby, betting issues, and the influence of football events on a country's economy at a macroeconomic level, we screened the resulting hits for relevance. Thus, we screened the abstracts and the articles to see whether they focus on the impact of

[33] The following databases were used within EBSCOhost: Business Source Premier, EconLit, and eBook Collection.

soccer results or competitions on stock markets, including single stocks and stock indices. We also excluded studies that, for instance, analyse the impact of a clubs' match results on the industrial growth rate (e.g., Berument and Yucel 2005), the impact of economic success on the sporting performance (e.g., Baur and McKeating 2011; Ozawa et al. 2004), the stock market effects of the sale of live broadcasting rights (e.g., Gannon et al 2006) respectively the impact of soccer competitions on stock prices of jersey sponsors (e.g., Hanke and Kirchler 2013). After searching the above-mentioned databases, we obtained 25 relevant studies. By means of forward and backward reference searches, we obtained another 17 relevant studies, including six working papers. By including "grey literature", namely unpublished working papers, we tried to reduce the threat of publication bias in our systematic review. The major source of this threat is that studies containing insignificant results are published less frequently than studies reporting significant results. Further, it is important to note that the current study does not claim to be fully comprehensive. Although every effort has been made to include all relevant research, it is likely that studies exist of which the authors are not aware. Finally, to provide a holistic view, the timely scope of articles is unlimited but ends with September 2015. A descriptive overview of the 42 studies examined is presented in Table II.2-2.

Table II.2-2 Descriptive overview of the studies examined (in alphabetical order)

Reference (year)	Main analytical approach[a]	Sample examined		
		Object of study	Match/tournament sample size	Observation period
Ashton et al. (2003)	Event study (generalized method of moments)	National team on index	210 matches of the England national soccer team	1984–2002
Ashton et al. (2011)	• Descriptive statistics • Event study (nonparametric binomial test) • Regression model (OLS and GARCH)	National team on index	290 matches of the England national soccer team	1984–2009
Bell et al. (2012)	Regression analysis (OLS)	Club on single stock	5,187 matches of 19 quoted English soccer clubs	2000–2008
Benkraiem et al. (2009)	Event study (Wilcoxon signed-rank test)	Club on single stock	745 matches of 18 quoted European soccer clubs	2006–2007
Benkraiem et al. (2011)	Regression analysis (EGARCH)	Club on index	408 matches of eight quoted UK soccer clubs	2006–2007
Berlemann and Vöpel (2012)	Field experiment	National team on experimental stock market	All 64 matches of the 2010 World Cup	2010
Bernile and Lyandres (2009)	Regression analysis (OLS)	Club on single stock	595 matches of the UEFA Champions League/UEFA Euro League with at least one quoted European soccer club	2000–2006
Berument et al. (2006)	Regression analysis (GARCH-M)	Club on single stock	UEFA Champions League matches of three quoted Turkish soccer clubs (number not reported)	1987–2002
Berument et al. (2009)	Regression analysis (transfer function analysis)	Club on index	International matches of quoted Turkish soccer clubs (number not reported)	1987–2006
Berument et al. (2013)	Regression analysis (EGARCH)	Club on index	385 international matches of quoted Turkish soccer clubs	1990–2011
Berument and Ceylan (2012a)	Regression analysis (EGARCH)	Club on index	1,543 international matches of 13 soccer clubs from Chile, Spain, Turkey, and the UK	1977–2007
Berument and Ceylan (2012b)	Regression analysis (EGARCH)	Club on index	International matches of quoted Turkish soccer clubs	NA
Boido and Fasano (2007)	• Descriptive statistics	Club on single stock	157 matches of quoted Italian soccer clubs	2005–2006

	• Event study (Shapiro–Wilk normality test, Welch two sample t-test)			
Brahmana (2011)	• Probability distribution • Event study (correlation test, Holt–Winters method, Kruskal–Wallis test, Wilcoxon signed-ranked test)	Club on index	10 finals of the UEFA Champions League	1999–2009
Castellani et al. (2013)	Event study (OLS, SUR)	Club on single stock	2,157 matches of all quoted European soccer clubs	2007–2009
Demir and Danis (2011)	Regression analysis (OLS)	Club on single stock	Matches of quoted Turkish soccer clubs (number not reported)	2004–2009
Demir and Rigoni (2014)	Event study (OLS)	Club on single stock	Matches of quoted Italian soccer clubs (number not reported)	2004–2010
Dimic et al. (2015)	Event study (OLS)	Club on single stock	4,347 matches of 13 quoted European soccer clubs	2000-2013
Duque and Ferreira (2008)	Regression analysis (ARCH, GARCH)	Club on single stock	330 national championship matches of quoted Portuguese soccer clubs	1998–2002
Edmans et al. (2007)	Regression analysis (OLS, GARCH)	National team on index	1,162 tournament matches of 39 worldwide national teams	1973–2004
Floros (2014)	Regression analysis (TGARCH)	Club on single stock	179 matches of four soccer clubs from Italy, Portugal, and the Netherlands	2006–2011
Fung et al. (2015)	Regression analysis (OLS, GARCH, panel data analysis)	Club and national team on index	278 international matches of the Turkish national team and 3 quoted Turkish soccer clubs	1999-2011
Gerlach (2011)	Regression analysis (OLS)	National team on index	464 World Cup matches of 32 worldwide national teams	1974–2002
Jørgensen et al. (2012)	Regression analysis (news model of asset price determination)	Club on single stock	119 national matches of the quoted Danish soccer club Brøndby IF	2009–2011
Kaplanski and Levy (2010)	Event study (OLS, GARCH)	National team on index	304 trading days in the course of past World Cups relative to 14,375 trading days beyond World Cups	1950–2006
Klein et al. (2009a)	Replication study	National team on index	210 matches of the England national soccer team	1984–2002
Klein et al. (2009b)	Event study (constant mean model, two-state Markov-switching market model)	National team on index	1,017 European and World Cup matches (including qualification matches) of 14 European national soccer teams	1990–2006
Kolaric et al. (2015)	Event Study (GARCH)	National team on index	1,466 tournament matches of 41 worldwide national teams	1998-2012

Özdurak and Ulusoy (2013)	Regression analysis (GARCH)	Club on single stock	Matches of quoted Turkish soccer clubs (number not reported)	2011–2012
Palomino et al. (2009)	Own approach (based on event studies)	Club on single stock	916 matches of 16 quoted English soccer clubs	1999–2002
Renneboog and Vanbrabant (2002)	• Event study (Student's t-test) • Regression analysis (OLS)	Club on single stock	840 matches of 17 quoted UK soccer clubs	1995–1998
Samagaio et al. (2009)	Structural equation modeling	Club on single stock	235 matches of 16 quoted English soccer clubs	1995–2007
Saraç and Zeren (2013)	Regression analysis (OLS)	Club on single stock	882 matches of three quoted Turkish soccer clubs	2005–2012
Scholtens and Peenstra (2009)	Event study (Student's t-test, Corrado's rank test)	Club on single stock	1,274 matches of eight quoted European soccer clubs	2000–2004
Stadtmann (2004)	Regression analysis (news model of asset price determination)	Club on single stock	98 matches of one quoted German soccer club	2000–2002
Stadtmann (2006)	Regression analysis (reversed news model of asset price determination)	Club on single stock	175 matches of one quoted German soccer club	2000–2004
Stöckl and Schulz (2007)	"Sportive success and share price" model	Club on single stock	161 matches of one quoted German soccer club	2002–2006
Sun and Wu (2015)	Regression analysis (news model of asset price determination, reversed news model of asset price determination)	Club on single stock	215 matches of one quoted Italian soccer club	2001-2006
Tufan (2004)	• Descriptive statistics • Event study (Jargue–Bera test, Wilcoxon signed-rank test)	National team on index	All 64 matches of the 2002 World Cup	2002
Tufan and Hamarat (2014)	• Descriptive statistics • Event study (Kolmogorov–Smirnov test, Kruskal–Wallis test) • Regression analysis (logistic regression test)	Club on single stock	Matches of quoted Turkish soccer clubs (number not reported)	2005–2011
Vieira (2013)	Regression analysis (OLS)	National team on index	All 31 matches of the 2008 European Cup	2008
Zuber et al. (2005)	Regression analysis (OLS)	Club on single stock	1,072 matches of 10 quoted English soccer clubs	1997–2000

[a] OLS is ordinary least squares; GARCH is generalized autoregressive conditional heteroskedasticity; EGARCH is exponential GARCH; GARCH-M is GARCH-in-mean; TGARCH is threshold GARCH; ARCH is autoregressive conditional heteroskedasticity; and SUR is seemingly unrelated regressions.

II.2.3.2 *Description of Relevant Literature*

As Table II.2-2 shows, the selected 42 studies can be described in terms of their analytical approaches and the samples examined. Table II.2-3 presents aggregated "descriptive statistics" of the selected studies' analytical approaches and data samples.

Table II.2-3 Aggregated overview of analytical approaches and samples examined

Analytical approach	**Sample examined**		
	Object of study	Region examined	Period of study
Descriptive statistics:	**Club on single stock:**	Denmark:	Before 1980:
4	**24**	1	4
Event study:	Club on index:	Europe (> 1 country):	1981–85:
15	5	9	7
Regression analysis:	National team on index:	Germany:	1986–90:
25	13	3	11
of which			
ARCH/(T)GARCH/EGARCH(-M)	Other:	Portugal:	1991–95:
11	1	1	13
OLS regression:		Italy:	1996–00:
11		3	25
Other:		Turkey:	**2001–05:**
8		9	**31**
Other:		**The UK:**	2006–10:
7		**9**	27
		Worldwide (>1 country):	After 2010:
		7	9
			Not reported:
			1

Entries in alphabetical/chronological order; absolute values are in relation to the total number of studies; multiple mentions of "analytical approach", "object of study", and "period of study" are possible because the study covers multiple subcategories; and the most frequent entries in each category are in bold font.

In order to answer research question *RQ1*, the highlights of the different categories are presented hereafter.

II.2.3.2.1. Analytical approach

Considering the analytical approaches, 55% of the 42 analyzed studies use regression analysis methods. Here, in turn, 11 studies conduct standard OLS regressions with soccer-related variables (e.g., dummy variables for win/loss or the goal difference) as independent variables. However, several studies from our sample show that the volatility of the analyzed time series (e.g., stock returns) varies over time, thus implying heteroskedasticity and

violating one of the major assumptions of the standard OLS estimation. In addition, another 11 studies use autoregressive conditional heteroskedasticity (ARCH) family models, originally proposed by Engle (1982) and enhanced by Bollerslev (1986) and Nelson (1991). Only the studies of Ashton et al. (2011) and Edmans et al. (2007) use both standard OLS regression and an ARCH family model. Thus, *most studies that use regression analysis exclusively apply standard OLS regression, despite the fact that the examined time series may be heteroskedastic (Finding 1).*

Regarding the event study approach, which aims to examine the (abnormal) returns for a specific event (in our case soccer matches or competitions), we observe 15 studies (36%) in our sample. The most interesting finding regarding the event studies conducted in our sample is the heterogeneity of approaches used in order to test the statistical significance of (abnormal) returns. For example, Ashton et al. (2003) use generalized method of moments (GMM) estimation, whereas Renneboog and Vanbrabant (2002) and Scholtens and Peenstra (2009) conduct a Student's t-test. The latter authors also conduct Corrado's rank test to account for non-normality in data distribution. In addition, two approaches are conducted by Kaplanski and Levy (2010), who use the aforementioned standard OLS regression and a GARCH model, and by Klein et al. (2009b), who conduct a constant mean model as well as a two-state Markov-switching market model. *This heterogeneity of event study approaches makes it very difficult to compare the results of the different studies and thus to draw overall conclusions (Finding 2).*

Overall, we observe some patterns regarding the applied methodologies. In particular, we analyzed the three most frequently applied methodologies (event studies, OLS, and (E, G)ARCH regressions) with regard to the observed results. According to this, when conducting event studies, 44% of the results show at least the predicted sign. For OLS and (E, G)ARCH regression, we observed the predicted result in only 29% and 24% respectively.

II.2.3.2.2. Samples examined

The research regarding the impact of soccer matches on stock markets can be separated by using three categories and their corresponding core questions: (1) the object of study ("*What* was analyzed?"), (2) the examined region ("*Where* was it analyzed?"), and (3) the period of study ("*When* was it analyzed?").

Regarding the *"What,"* we observe that most studies in our sample (57%) analyze the impact of club matches on stock markets, with only five studies examining the impact of club matches on stock indices. Another 31% of the studies analyze the impact of national team matches on stock markets. Such studies include those on the impact of matches in the course of major international football competitions (continental tournaments and the FIFA World Cup). Because national teams by their nature cannot be market-listed, these studies solely examine the impact of soccer on stock indices. Only the study of Fung et al. (2015) examines both, national team and club matches simultaneously (with one-fifth of the sample comprising Turkish national team matches and four-fifth comprising international matches of Turkish soccer clubs). Although the total ratio between studies on single stocks and stock indices is balanced, *there is still an underrepresentation of studies analyzing the impact of (unlisted) club matches on indices, because the most successful soccer clubs from the last decade are mainly unlisted clubs with a widespread fan base and high economic relevance (Finding 3).* Apart from the studies on single stocks and indices, Berlemann and Vöpel (2012) examine the impact of World Cup games on trading behavior in an experimental stock market.

Regarding the *"Where,"* it is striking that 43% of the studies in our sample focus on either the UK or Turkey, countries in which soccer plays an important role in social life, thus influencing investors' sentiment. In order to account for behavioral investment patterns following soccer matches, a data sample is worthwhile that considers both, countries in which soccer plays a more respectively less important role. Otherwise, an "importance bias" can result (e.g., when only analyzing clubs from the UK and Turkey, it might be hard to distinguish between rational effects and behavioral-driven effects). Consequently, we observe eight Europe-wide studies and six worldwide studies.

All other countries examined in the remaining studies play only a subordinate role. Thus, to sum up, beside the predominant role of studies on the UK and Turkey, *other important soccer nations are underrepresented in the literature. This applies to Spain (no exclusive study available), Germany (only three exclusive studies available), and Italy (only three exclusive studies available), although these countries are ranked first, second, and fourth respectively in the 2015 UEFA coefficient ranking and are the latest three FIFA world champions (Finding 4).*

We further observe that the sample size is not directly correlated with the "clarity" of the results because studies with large and small match samples can either provide significant

and predicted or insignificant and surprising results. Nevertheless, seven of nine studies with a sample of more than 1,000 matches tend to confirm strongly the expected hypothesis (Bell et al. 2012; Berument and Ceylan 2012a; Castellani et al. 2013; Dimic et al. 2015; Scholtens and Peenstra 2009) or show obvious contradictory results (Klein et al. 2009b; Zuber et al. 2005).

Regarding the *"When"*, it is difficult to draw general conclusions. The first finding is that although the sample periods of the 42 studies overlap in most cases, we observe heterogeneous empirical findings. We further observe only six studies (Ashton et al. 2003; Ashton et al. 2011; Castellani et al. 2013; Fung et al. 2015; Gerlach 2011; Klein et al. 2009a) that examine the change in stock market reaction on soccer in sub-periods (e.g., through out-of-sample tests or panel regression) in order to account for soccer's growing economic importance and thus to check for the existence of different regimes. Because of overlapping samples, in Table II.2-3 we categorize the studies into five-year periods. There is a significant focus on the period between the mid-1990s and the mid-2000s, but only a few studies for the period after 2010. An explanation of this latter issue may be that studies analyzing the period after 2010 are not yet published and are still work in progress. Nevertheless, *the past decade is underrepresented in the literature, although the economic importance of soccer has grown in recent years (Finding 5).*

We further observe a possible pattern that shows that the number of studies providing predominantly surprising results has slightly increased in recent years.

Apart from the analytical approaches and examined samples, we controlled the relevant studies for the presence of a publication bias because it is easier to publish studies with significant results. Following Klein et al. (2009b), it seems natural that "through sheer coincidence significant (although useless) interrelations can sometimes be found". As a result, we observed some evidence for the presence of publication bias because the only study showing no correlation between soccer and stock markets (Tufan 2004) is unpublished. In addition, the unpublished study of Duque and Ferreira (2008) shows only a weak correlation. Overall, considering all the study characteristics presented in this section, *conspicuousness regarding the correlation of applied methodologies, examined samples, and the studies' results can be observed (Finding 6).*

II.2.4 Empirical Evidence regarding Soccer's Influence on Stock Markets

To answer research questions *RQ2* and *RQ3*, we identified the heterogeneous empirical evidence regarding the effect of soccer on stock markets as the core criteria of our analysis.

As aforementioned, we do not aim to describe only existing findings. Instead, our objective is to aggregate existing findings and thus provide new evidence for soccer's overall impact on stock markets. Thus, in a similar way to the vote counting method that simply "counts", which direction is confirmed the most often in primary studies (e.g., Aretz and Bartram 2010), we proceed as follows: (1) we distinguish between the four aforementioned hypotheses for the key drivers of soccer's impact on stock markets; (2) for each hypothesis, we identify the applicable studies; and (3) for each hypothesis, we count the number of studies that confirm/reject the hypothesis with at least a 10% significance level and provide mixed evidence depending on the subsample or applied methodology.

However, before distinguishing between the hypotheses, we must point out that 41 of the 42 studies provide statistical evidence for soccer having an impact on stock markets. Only Tufan (2004) concludes that soccer matches do not affect stock markets. Further, not all of the studies that indicate a correlation between soccer matches and stock markets provide statistically significant results. For example, Boido and Fasano (2007) show that stock markets are influenced by soccer matches but only to an insignificant extent. The same holds for Klein et al. (2009b), Vieira (2013), and Zuber et al. (2005). Subsequently, the overarching finding about soccer's general impact on stock markets is concretized.

II.2.4.1 *Evidence regarding the General Effect of Wins, Draws, and Losses*

Our first hypothesis (*H1*), which is somehow analyzed to some extent in 32 of the studies from our sample, is that *wins positively affect stock market returns, and losses negatively affect stock market returns*.[34] Table II.2-4 provides an overview of the evidence regarding the impact of wins.

Table II.2-4 Evidence regarding the general effect of wins

Object of study	Positive effect[a]	Mixed effect[a]	No effect[a]
National team on index	1	4	2
Club on single stock	11	4	6
Club on index	2	2	0
Total	**14 (44%)**[b]	**10 (31%)**[b]	**8 (25%)**[b]

[a] "Positive effect" indicates significant positive (abnormal) returns associated with a win; "Mixed effect" indicates that a study provides inconsistent results with evidence for both positive as well as negative (or no) market reactions following a win; and "No effect" indicates that no significant market reaction following wins had been observed.

[b] Absolute values and relative values are in relation to the total number of studies examining this relationship; general overall result or trend, based on the significance of the results with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

[34] In a similar way to most studies from our sample, we do not account for expectations or match importance effects in this particular first step of the analysis.

Evidence for positive market reactions after wins is provided by 44% of the studies. For national teams, only Ashton et al. (2003) provides (weak) significant evidence for the positive effect of wins on returns of the Financial Times Stock Exchange (FTSE) 100 Index. This finding is contradicted by the "corrected" version of this study provided by Klein et al. (2009a). Another 13 studies conclude that club wins positively affect stock markets. In particular, the studies of Boido and Fasano (2007), Castellani et al. (2013), Demir and Rigoni (2014), Dimic et al. (2015), Jørgensen et al. (2012), Palomino et al. (2009), Renneboog and Vanbrabant (2002), Saraç and Zeren (2013), Scholtens and Peenstra (2009), Stadtmann (2004), and Stadtmann (2006) provide significant evidence of positive (abnormal) returns for clubs' own stock following wins. Berument and Ceylan (2012a) and Berument et al. (2013) provide significant evidence of positive (abnormal) returns for indices following wins. This result is hard to argue from a rational viewpoint because it is doubtful that the Borsa Istanbul (BIST) 100 Index, which comprises many global companies, is rationally driven by a soccer club's win.

Of the appropriate studies, 31% provide mixed evidence regarding *H1*, depending on subsamples and applied methodologies. For club matches, according to Berument et al. (2006) and Berument et al. (2009), the win hypothesis holds exclusively for the matches of Beşiktaş and not for Fenerbahçe and Galatasaray. This may be explained by the "traditional" higher volatility of the sporting performance of Beşiktaş and the greater fanaticism of Beşiktaş' supporters (for the latter see, among many others, Berument et al. 2009). Özdurak and Ulusoy (2013) contradict this finding for a distinctly shorter observation period, and show only significant positive stock market returns following Fenerbahçe's wins. Bernile and Lyandres (2009) provide mixed evidence for stock market reaction after wins in UEFA club tournament matches because the mean abnormal returns on the days after the matches are not statistically significant; but when the authors apply standard OLS regression, they observe high significant positive abnormal returns following wins. The unpublished but methodologically sounder study of Duque and Ferreira (2008) confirms the win hypothesis only for matches of Sporting Lisbon and not for matches of FC Porto. Fung et al.'s (2015) methodological sound panel regressions show the predicted effect of wins only for the whole sample (comprising 45 national team matches and 233 international matches of Turkish clubs). When solely analyzing the club matches and the whole period (1999-2011), wins are surprisingly associated with negative returns (for Galatasaray even on a significant level). This surprising result may be reasoned in the data sample, as the negative impact of

wins disappears in case that Monday matches and sport-related firms are excluded from the sample.

For national teams, Vieira (2013), who solely analyses 31 matches from the 2008 European Championship, supports the win hypothesis only when accounting for general market trends. In particular, wins only have a significant positive influence on returns in bearish markets; otherwise, wins are followed by significant negative abnormal returns. In addition, Ashton et al. (2011) provide mixed evidence for national teams. Only when accounting for the full data period (2002–2009) and when using GARCH regression, significant positive returns are observed to follow wins (with the additional finding that the positive impact of wins has declined over time). In the Kolaric et al. (2015) study, wins are mostly associated with negative, but insignificant abnormal returns. Only in case of matches of Asian national teams, market reactions after wins are significant (and negative). Gerlach (2011) also provides inconsistent findings, which will be examined in Section II.2.4.2.

In contrast, 25% of the studies show no or negative market reactions after wins. What attracts attention is that most of these studies are published in prestigious journals and thus tend to be high quality. For national teams, the highly appreciated study of Edmans et al. (2007) presents only an insignificant (positive) relation between wins and returns. As aforementioned, the replication study of Klein et al. (2009a) does not provide evidence for positive market reactions following wins either, whereas Klein et al. (2009b) actually show contradictory results with significant negative abnormal returns following matches (although most of the other results are insignificant). For club matches, Benkraiem et al. (2009) provide evidence for significant positive returns prior to wins, but not following wins (a situation that is explained by investors' expectations); however, the study is limited because it comprises only a two-year period. In addition, the studies of Demir and Danis (2011), Floros (2014), Sund and Wu (2015), and Zuber et al. (2005) show no significant positive market reaction after wins.

Based on the results at this specific level of granularity, it is still hard to draw general conclusions regarding market efficiency following wins. For national teams, the only study that provides strong evidence for the "win effect" was corrected afterwards. For clubs, 14 studies provide mixed evidence. Conspicuously, two of the three studies examining the impact of wins on indices provide significant evidence for positive abnormal returns, although the impact of one club on an index is limited.

For lost matches, 67% of all appropriate studies confirm the hypothesis that losses have a significant negative effect on stock returns. Table II.2-5 provides an overview of the evidence regarding the impact of losses.

Table II.2-5 Evidence regarding the general effect of losses

Object of study	Negative effect[a]	Mixed effect[a]	No effect[a]
National team on index	4	3	1
Club on single stock	12	2	2
Club on index	2	1	0
Total	**18 (67%)**[b]	**6 (22%)**[b]	**3 (11%)**[b]

[a] "Negative effect" indicates significant negative (abnormal) returns associated with a loss; "Mixed effect" indicates that a study provides inconsistent results with evidence for both negative as well as positive (or no) market reactions following a loss; and "No effect" indicates that no significant market reaction following losses had been observed.

[b] Absolute values and relative values are in relation to the total number of studies examining this relationship; general overall result or trend, based on the significance of the results, with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

For national team matches, Edmans et al. (2007) shows next-day abnormal stock returns of -49.4 basis points after losses (which was, at that time, more than three times the market value of all clubs belonging to the English Premier League). This general market reaction is confirmed by the controversial study of Ashton et al. (2003) and by Gerlach (2011). The latter also shows that negative returns are not restricted to the playing country but further hold for the playing team's largest neighboring country (measured by its GDP). From another perspective, Vieira (2012) confirms the "win effect" but with a small amount of data. All these findings strongly support the behavioral alternative hypothesis because their magnitude is large (except for Vieira 2012) and the returns cannot be explained by changes in fundamental value.

Regarding the effect of club matches on single stocks, Renneboog and Vanbrabant's (2002) working paper confirms high significant negative abnormal returns following losses on the first and second days after matches. Palomino et al.'s (2009) comprehensive study provides evidence that "bad news", namely losses, is incorporated more slowly than wins because only 28% of three-day abnormal returns are incorporated on the first day following matches. These findings are partially contradicted by Benkraiem et al. (2009), who confirm significant negative abnormal returns only on the first day following losses and not on the second day. The authors further show a stronger effect following home losses rather than away losses, a finding that is also confirmed by Castellani et al. (2013) and Demir and Danis (2011). Bernile and Lyandres (2009) show that losses are followed by significant negative abnormal returns, but only on the day following the loss and not on the match day itself. Further studies proving the negative impact of losses are Boido and Fasano (2007), Demir and Rigoni (2014), Dimic et al. (2015), Saraç and Zeren (2013), Scholtens and Peenstra (2009), and Stadtmann (2004).

In addition, two studies provide evidence for the significant negative effect of lost club matches on stock indices. Berument and Ceylan (2012a) show that losses of FC Barcelona and Real Madrid CF have a negative impact on the Madrid Stock Exchange General Index, and losses of Arsenal FC, Chelsea FC, Liverpool FC, and Manchester United FC have a negative impact on the FTSE 100 Index. Similar evidence is provided by Berument et al. (2013) for the BIST 100 Index and the Turkish clubs Beşiktaş, Fenerbahçe, and Galatasaray.

Four studies provide inconsistent results regarding the effect of losses. Ashton et al. (2011) show a strong negative impact of English national team losses on the FTSE 100 Index when applying binomial statistics and examining the period 1984–2009. However, when the authors apply OLS/GARCH regressions, no significant influence of losses is observed. The replication study of Klein et al. (2009a) also provides evidence in both directions, depending on match type and sub-period. Kolaric et al. (2015) provide significant negative abnormal returns following losses in case of tournament (elimination) matches (especially European championship matches and World Cup matches). For clubs, Duque and Ferreira's (2008) working paper presents mixed results because (analogous to wins) losses have only a significant influence for Sporting Lisbon and not for FC Porto. Because the success of both clubs had been similar in the observation period, the most obvious explanation for this result is the significant difference between the supporters: Sporting Lisbon's supporters are more emotional than those of FC Porto. The finding regarding FC Porto is further confirmed by the TGARCH specification conducted by Floros (2014). This study rejects the "loss effect" for Benfica Lisbon and Ajax Amsterdam; indeed, significant negative returns after losses are observed only for Juventus Turin. Analogous to the win effect, Fung et al. (2015) show the predicted effect of losses only for the whole data sample. When solely analyzing the club matches and the whole period (1999-2011), losses are surprisingly associated with (insignificant) positive returns.

Only three studies provide no or exclusively contradictory results. Through a comprehensive data sample, Zuber et al. (2005) provide no evidence of any market reaction for the losses of nine out of 10 examined clubs. The same holds true for Sun and Wu (2015) examining Juventus Turin. Klein et al. (2009b) show a negative market reaction following losses for only one of the 14 examined countries (Belgium). All other results are insignificant and show even significant positive excess returns following losses for Denmark and England. This surprising result can be explained by the study's unique elaboration.

Overall, losses seem to be strongly associated with negative (abnormal) returns. Thus, at least in this particular regard, we can strongly confirm *H1*.

To date, the effect of draws is not well documented in the literature. Table II.2-6 provides an overview of the available evidence.

Table II.2-6 Evidence regarding the general effect of draws

Object of study	Positive effect[a]	Mixed effect[a]	Negative effect[a]	No effect[a]
Club on single stock	0	1	9	1
Club on index	0	0	1	0
Total	**0 (0%)**[b]	**1 (8%)**[b]	**10 (84%)**[b]	**1 (8%)**[b]

[a] "Positive effect" indicates significant positive (abnormal) returns associated with draws; "Mixed effect" indicates that a study provides inconsistent results with evidence for both positive and negative (or no) market reactions following draws; and "Negative effect" indicates significant negative (abnormal) returns following a draw. "No effect" indicates that no significant market reaction following draws had been observed.

[b] Absolute values and relative values are in relation to the total number of studies examining this relationship; general overall result or trend, based on the significance of the results, with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

Draws are only analyzed with regard to club matches. Overall, the respective studies come to almost the same conclusion that draws have a negative impact on stock markets.

In particular, Benkraiem et al. (2009) provide overall evidence for significant negative abnormal returns (only) on the day following a draw. When distinguishing between home and away draws, only away draws show significant (negative) results. Castellani et al. (2013) confirm this result. Similar results are provided by Demir and Danis (2011), although the detail of their study has contradictions. Demir and Danis (2011) also present overall evidence for negative abnormal returns following draws. Further, in contrast to Benkraiem et al. (2009), Demir and Danis's (2011) results show a higher significance for home draws (away draws are only significant for Galatasaray). This contradictory finding may be explained by the data samples: Benkraiem et al. (2009) analyze 18 clubs from across Europe for just 2006–2007, whereas Demir and Danis (2011) analyze three Turkish clubs, covering 2004–2009. Because the degree of soccer fanaticism is high in Turkey, fans visiting a match with "their" team may be more disappointed in the event of a draw. Further, the results of both sets of research show higher significance for domestic draws (i.e., league matches) than for European competition draws. Bernile and Lyandres (2011), Berument et al. (2013), Boido and Fasano (2007), Dimic et al. (2015), Renneboog and Vanbrabant (2002), Scholtens and Peenstra (2009), and Duque and Ferreira (2008) confirm the finding of negative market reactions following draws for different regions and periods. The last of these studies shows that for Sporting Lisbon draws have an even greater negative impact on returns than losses. For FC Porto, draws are the only "result" that leads to significant market

reactions. These findings might indicate that Portuguese markets at least anticipate losses more effectively than draws.

Only Floros's (2014) recent study provides at least partial evidence for significant positive returns after draws, particularly for Benfica Lisbon and Ajax Amsterdam (which are both exclusively examined in the study). The only club that shows significant negative returns after draws is Juventus Turin, a finding that accords with Boido and Fasano (2007).

The only study that does not confirm any significant market reactions to draws is the methodologically sound research by Palomino et al. (2009), although the sign is negative in all cases.

Overall, we observe a negative effect for lost matches and draws. Wins tend to be associated with positive (abnormal) returns, although the effect is less obvious. This finding is not yet sufficient to draw conclusions on market efficiency, because according to *H1*, positive and negative market reactions can be explained by rational behavior.

II.2.4.2 *Evidence regarding the "Importance Effect"*

Our second hypothesis (*H2*) that is recurrently analyzed in the studies is that *the results of important matches affect stock market returns more strongly than "normal" matches;* namely, market reactions in absolute terms are higher after important matches. Table II.2-7 provides an overview of the evidence regarding the "importance effect."

Table II.2-7 Evidence regarding the "importance effect"

Match type	**Yes**[a]	**Mixed**[a]	**No**[a]
Tournament match (national team)	0	6	1
International competition match (club)	2	6	4
Domestic cup match (club)	2	1	4
Relegation/promotion matches (club)	2	0	0
Late season match (club)	2	1	3
Matches against rivals/derbies (club)	1	1	1
Total	**8**[b]	**15**[b]	**13**[b]

[a] "Yes" indicates a significant market reaction associated with important matches; "Mixed effect" indicates that a study provides inconsistent results with evidence for both the confirmation and the rejection of *H2*, depending on the competition type; and "No" indicates that no significant market reaction following important matches had been observed.

[b] Only absolute values as relative values are not applicable because multiple entries from each study are possible; general overall result or trend, based on the significance of the results, with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

Regarding the "importance effect" in the context of *national team tournaments*, we assume that World Cup matches are more important than continental cup matches; continental cup matches are more important than qualifying matches; and qualifying matches are more

important than friendlies. Within a competition, elimination stage matches are more important than group stage matches because a loss is associated with immediate elimination. The most interesting finding is that the "importance effect" cannot be confirmed for national teams because all studies provide at least mixed results. Ashton et al. (2003) compare all examined matches (including friendlies) and more significant negative mean returns following losses in a tournament's final matches. However, for wins, the effect cannot be confirmed. The same holds for the corrected version of Ashton et al.'s (2003) study provided by Klein et al. (2009a), and for the studies of Edmans et al. (2007) and Vieira (2013). Ashton et al. (2011) also provide mixed evidence through a broad range of applied methodologies, thus indicating robust results. In this context, the mean returns (in absolute terms) following wins and losses are higher after qualifying matches; however, the significance levels of the regression results provide no evidence for any difference between more or less important matches (only the regression coefficients are higher for tournament matches). Gerlach (2011) shows that group-stage matches are associated with negative mean returns, regardless of whether they were won or lost. In elimination matches, wins are associated with positive mean returns and losses with less negative mean returns compared with group-stage matches. Kolaric et al. (2015) show that the importance effect exists for European and Asian national team matches, but not for matches of South American teams. Klein et al. (2009b) shows no corresponding evidence at all.

Regarding the "importance effect" in terms of *international club competition matches in relation to domestic matches*, Zuber et al. (2005) show that cup matches in general (which are not distinguished between international and domestic) are the only match type with a significant influence on returns. The same holds for the Sun and Wu (2015) study and Champions League matches of Juventus Turin. Scholtens and Peenstra (2009) provide mixed evidence because losses in European competition matches lead to higher (almost double) negative average abnormal returns than those in the domestic league, whereas for wins the opposite is true. Stadtmann (2004) provides equivalent findings for Germany (with losses also being almost twice as bad in international matches). In contrast, Stadtmann (2006), who examines a longer period, concludes that stock price reactions to European competition matches are not significantly different from reactions to domestic league matches, but they have a "lagged" effect that lasts more than one trading day. Castellani et al. (2013) show stronger reactions to losses for UEFA Champions League matches (compared to domestic league matches). The same does not hold for wins and UEFA Cup matches. In the UK, Renneboog and Vanbrabant's (2002) working paper shows that lost

international competition matches are associated with abnormal returns that are more negative compared to matches played in the English and Scottish leagues, and that once again the same does not hold for wins. For Turkish clubs, Demir and Danis (2011) show that after wins in European competitions, the abnormal returns are even negative (but insignificant) whilst after losses, they are more negative than for domestic matches. Saraç and Zeren (2013) confirm this and provide evidence for (mainly significant) negative returns following European competition matches. These findings might be explained by the moderate performance of Turkish clubs in international competitions over recent years and the correspondingly small number of European competition matches. In contrast, Demir and Rigoni (2014), Jørgensen at al. (2012), Özdurak and Ulusoy (2013), and Stöckl and Schulz (2007) show no significant difference between international and domestic matches for Italian, Danish, Turkish, and German clubs respectively.

Regarding *domestic cup matches*, Renneboog and Vanbrabant's (2002) working paper provides mixed evidence for the UK during 1995–1998 because wins in league and cup competitions show nearly the same abnormal returns. However, losses are associated with higher abnormal returns in cup competitions (even higher and more significant compared with international competition matches because of the high local value of the English cups). Palomino et al. (2009), who analyze the subsequent period from 1999 to 2002 by means of their own methodological approach, provide contradictory results. They do not show significant market reactions to English cup matches, indicating that the effect may have decreased. The same heterogeneous results are observed for German clubs. Stadtmann (2004) shows no difference between losses in the domestic cup and the German Bundesliga; however, by applying a larger data sample, Stadtmann (2006) provides evidence for higher stock price reactions following wins in the domestic cup competition rather than the Bundesliga (also depending on the applied model). Jørgensen at al. (2012) show no effect of Danish cup matches on Brøndby IF's stock price, but the sample comprises only seven such matches.

Regarding *promotion and relegation matches*, Renneboog and Vanbrabant's (2002) working paper confirms the "importance effect" because after wins and losses, both match types show high significant abnormal returns, which (in absolute terms) are at least twice as high as after normal league matches. Stöckl and Schulz (2007) provide similar evidence, showing that qualifying matches that are associated with high further cash flows cause stronger market reactions than "normal" matches.

Regarding the *progress of the season* in general (and the "post-March effect" in particular), the unpublished study of Duque and Ferreira (2008) provides overall evidence that wins (losses) at the end of the season that increase (decrease) the distance to the direct follower (the club ahead) in the league have a significant influence on stock returns. Bell et al. (2012) provide only modest evidence for the overall existence of the "post-March effect", whereas Castellani et al. (2013) show stronger market reactions at the end of the season. The studies by Demir and Rigoni (2014), Palomino et al. (2009), and Stöckl and Schulz (2007) show no significant reaction to late-season matches.

Regarding *matches against direct rivals and derby matches*, Özdurak and Ulusoy (2013) show through GARCH regression that such matches are the only ones with a significant effect on stock markets. Bell et al. (2012) further show that the influence of matches against rivals on returns increases with the number of goals ahead (otherwise, only modest evidence for this relationship is provided). In contrast, Saraç and Zeren (2013) show through their large data sample that derby matches do not have a significant influence.

In conclusion, the overall results regarding the "importance effect" show heterogeneous findings with a tendency to account solely for bad news in important matches and to ignore good news. This is surprising because important matches (at least in the case of club matches) are mostly associated with higher cash flow consequences and thus are hypothesized to have a stronger influence on stock returns from a rational viewpoint. Thus, we reject *H2* and support the behavioral alternative hypothesis instead.

II.2.4.3 *Evidence regarding the "Surprise Effect"*

Our third hypothesis (*H3*) examines the "surprise effect"; namely, the effect that *stock market reactions are mainly driven by non-expected results.* In other words, unexpected results are associated with higher (abnormal) returns (in absolute terms) than expected results. The predominant method to quantify expectations is the usage of betting odds, which seek to reflect a realistic estimation of probabilities for a win, draw, and loss. Table II.2-8 provides an overview of the evidence regarding the "surprise effect."

Table II.2-8 Evidence regarding the "surprise effect"

Object of study	Yes[a]	Mixed[a]	No[a]
National team on index	0	1	2
Club on single stock	5	8	1
Club on index	0	0	1
Total	**5 (31%)**[b]	**7 (44%)**[b]	**4 (25%)**[b]

[a] "Yes" indicates stronger market reactions after unexpected match results; "Mixed effect" indicates that a study provides inconsistent results with evidence for the confirmation and rejection of *H3*; and "No" indicates that no difference between expected and unexpected match results is observable**.**

[b] Absolute values and relative values are in relation to the total number of studies examining this relationship; general overall result or trend, based on the significance of the results, with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

In accordance with *H3*, five studies provide evidence that unexpected match results lead to stronger market reactions than expected ones, thus tending to support the efficient market hypothesis. Bell et al. (2012) show that point surprises (especially in home matches) have a strong impact on stock returns. The authors' large data sample, covering more than 5,000 matches and an observation period of eight years, might indicate the robustness of this finding. A similar conclusion (for European club competition matches but with a far smaller sample) is drawn by Bernile and Lyandres (2009), who show that markets have a significant positive reaction to wins in the context of expected losses and vice versa. The authors explain their finding by referring to investors' inability to form unbiased ex ante beliefs regarding the match outcome because they tend to be too optimistic. Thus, the authors conclude that primarily pre-match stock prices are inefficient, but that this does not necessarily apply to post-match prices. The small studies of Jørgensen at al. (2012), Özdurak and Ulusoy (2013), and Stadtmann (2006) confirm *H3* for Danish, Turkish, and German clubs respectively.

Kolaric et al. (2015) present mixed results because expected wins in tournament matches are accompanied with negative abnormal returns and unexpected wins in elimination matches with positive ones. In case of losses and draws, no surprise effect is observed. Demir and Danis (2011) present mixed results because they show that market reactions are mainly caused by unexpected outcomes; but they also provide evidence that market reactions to losses are significantly negative regardless of whether or not they are expected. The authors further show strong dependency on the investors' characteristic; namely, which club is examined. Demir and Rigoni (2014) show that surprising outcomes that are not related to the "own" club but the arch-rival influence stock markets. In particular, an arch-rival's unexpected loss counterbalances the negative reaction to an own loss (and increases the positive reaction to a win), whilst an arch-rival's unexpected win increases the impact of an

own loss. Dimic et al. (2015) show that positive abnormal returns after wins increase with increasing surprise. For losses, there is no surprise effect observable. Palomino et al. (2009) provide evidence for a kind of "inverse surprise effect", as investors react as stronger to wins, the more expected such wins are. Sun and Wu (2015) as well as Scholtens and Peenstra (2009) observe the "surprise effect" only for wins in European tournament matches (however, such matches cover only one-third and one-fifth of the entire sample, respectively). Further, for wins in the domestic league, Scholtens and Peenstra's (2009) study observes an "inverse surprise effect", because only expected wins lead to significant positive abnormal returns. For losses, highly significant abnormal returns are observed after expected and unexpected results. Although Stadtmann (2004) shows that unexpected wins have a positive impact (and unexpected losses vice versa), the "expectation effect" does not have superior information content compared with the match outcome (without accounting for expectations). Further, Castellani et al. (2013) show that the "surprise effect" exists only when accounting for the problem of event clustering through the SUR model.

Another four studies do not support the "surprise effect." For national teams, the well-elaborated studies of Edmans et al. (2007) and Klein et al. (2009b) do not show any relation between ex ante beliefs and stock market reactions. Zuber et al.'s (2005) study, which tends to reject any significant relation between soccer and stock markets, even provides (insignificant) evidence for negative market reaction to unexpected wins and positive market reaction to unexpected losses. In addition, the panel regressions of Fung et al. (2015) do not provide evidence for a "surprise effect" in case of 233 international matches of Turkish soccer clubs.

In conclusion, it is hard to identify patterns regarding the result of the "surprise effect" because sample size, observation period, and applied methodology seem to have no influence on the "direction" of the finding. Thus, because most studies provide at least mixed evidence, the overall finding regarding the "surprise effect" tends to reject hypothesis *H3*.

II.2.4.4 *Evidence regarding the "Bad News Effect"*

In the prior sections, we have already found evidence that investors tend to overvalue losses. Thus, we want to analyze this overall effect (*irrespective of match type and expectations*) through *H4*, which assumes a "bad (match-related) news effect"; namely, that *overall, losses affect stock market returns more strongly than wins*. In other words, we expect to observe

higher (abnormal) returns *in absolute terms* after losses than after wins. Table II.2-9 provides an overview of the evidence regarding the "bad news effect."

Table II.2-9 Evidence regarding the "bad news effect"

Object of study	Yes[a]	Mixed[a]	No[a]
National team on index	4	2	2
Club on single stock	6	3	3
Club on index	3	1	0
Total	13 (54%)[b]	6 (25%)[b]	5 (21%)[b]

[a] "Yes" indicates the overvaluation of losses; "Mixed effect" indicates that a study provides inconsistent results with evidence for both the confirmation and rejection of *H4*; and "No" indicates that losses do not affect stock markets more strongly than other match outcomes.

[b] Absolute values and relative values are in relation to the total number of studies examining this relationship; general overall result or trend, based on the significance of the results, with at least a 10% level. When the significance is not provided, the direction is derived from the verbal description in the study.

From the 24 studies, which draw conclusions on the difference between the "win effect" and the "loss effect," we again gather heterogeneous findings.

Regarding the eleven studies that show an overvaluation of losses, three analyze national team matches. Ashton et al.'s (2003) study shows that the number of returns that are smaller than the unconditional mean is much more significant after losses than after wins. Edmans et al.'s (2007) study draws a similar picture overall and shows that the mean returns (in absolute terms) after losses are higher than after wins. The same holds for the regression results, where both the significance levels and the β-values show a market reaction that is at least twice as strong after losses than after wins. Through a far smaller data sample but a comparably long observation period, Gerlach (2011) shows that the mean returns (in absolute terms) after losses are higher and more significant than after wins. Regarding these three studies, the direction and sheer magnitude of the "bad news effect" support *H4*.

Regarding club-related studies, Demir and Danis (2011) show that the daily returns on the first trading day after losses are (in absolute terms) several times as high as after wins. This is confirmed by the regression coefficients and the significance levels. The abnormal returns provided by Scholtens and Peenstra (2009) are four times as negative as they are positive after wins. Stadmann (2004) also shows that losses are at least twice as "bad" as wins for a small sample and the German stock market. The same holds for Dimic et al.'s (2015) working paper examining 13 European clubs. Castellani et al. (2013) and Renneboog and Vanbrabant's (2002) working paper present similar but weaker results. Further, the latter study shows that the significance of abnormal returns lasts longer after losses than after wins. Regarding the relationship of club matches and stock indices, Benkraiem et al. (2009) use a shorter but more recent sample and show that abnormal returns on the first and second

trading days following losses are, in absolute terms, six times as high as after wins. For home losses, the effect is even more intense. Berument et al. (2013) provide also a higher significance and regression coefficients that are at least twice as high following losses as wins. The explanation may be that this particular study only analyzes international tournament matches where a loss might have worse consequences than for a league match. Berument and Ceylan (2012a) present evidence that losses, as opposed to wins, lead to an increase in investors' risk appetite, thus proving that losses have a stronger impact.

Mixed evidence is provided by Palomino et al. (2009). On the trading day directly following a match, the average abnormal returns (in absolute terms) after wins are higher and more significant than after losses. The same applies for the cumulative abnormal returns for the two days after the match, but on the third day absolute cumulative abnormal returns following losses exceed those following wins. Floros's (2014) study confirms *H4* only for Ajax Amsterdam and not for Benfica Lisbon, FC Porto, and Juventus Turin. As aforementioned, Fung et al.'s (2015) panel regressions confirm the "bad news effect" only for the whole sample. When solely analyzing the club matches and the whole period (1999-2011), we observe an "inverse bad news effect".

For national teams, the replication study of Klein et al. (2009a) shows that the mean returns (in absolute terms) after losses are lower than after wins. Nevertheless, the number of returns after losses is lower than the unconditional mean and shows higher significance than the corresponding returns for wins. It is also difficult to draw an overall conclusion from Ashton et al.'s (2011) study because the magnitude of the effects changes in accordance with the data period. When examining the whole data period (1984–2009), losses seem to have a stronger impact on returns than wins (as observed in the mean returns and the OLS/GARCH regression results). However, especially when accounting for the data period 2002–2009, the effect seems to change and wins are penalized more than losses. Overall, the negative effect of losses has tended to decrease over time. Bernile and Lyandres (2011) also draw a mixed picture because abnormal returns (in absolute terms) on trading days following losses are a multiple of the returns for wins (with higher significance). Nevertheless, regression results provide only slight evidence for the "bad news effect"; and on match days, *H4* must be rejected because wins show stronger market reactions. A further interesting finding is that the abnormal returns after losses are negative (at an insignificant level), even when a club advances to the next tournament stage. The latter finding confirms the behavioral alternative hypothesis because from a firm value perspective, few reasons exist to penalize such a loss.

In contrast, five studies provide evidence for a "bad news effect," at least regarding bad news in terms of sporting performance. For national teams, Klein et al. (2009b) show that the numbers of excess returns greater and smaller than zero following losses are almost balanced, irrespective of the match type or the model applied (the same holds for wins). Further, the authors show that the average abnormal returns after wins tend to be higher than after losses (in absolute terms). Vieira (2013) shows for the small sample of the 2008 European Championship that there is not just a "bad news effect" but also, according to the correlation coefficients, a "wins are as bad as losses effect". For club matches, Duque and Ferreira's (2008) working paper shows that for Sporting Lisbon, wins have a stronger impact than losses (regarding regression coefficients as well as significance level). The same holds for Demir and Rigoni (2014). Boido and Fasano (2007) show for the Italian league that wins and losses are not significantly different. Thus, the latter two studies confirm the aforementioned results of Floros (2014) for Portuguese and Italian clubs respectively.

Overall, although the majority of studies provide at least mixed results, we confirm *H4* at an aggregated level. This is explained by the sheer magnitude of the "loss effect", which has already been discussed in prior sections, and in the prestigiousness of the studies examining the "bad news effect" (e.g., Edmans et al. 2007, Gerlach 2011, Scholtens and Peenstra 2009) that confirm *H4*. Nevertheless, as discussed in section II.2.2, *H4* can confirm both the efficient market hypothesis and the behavioral alternative hypothesis.

II.2.4.5 *Evidence regarding Volatility and Trading Volume*

Beside the studies examining soccer's influence on absolute returns, a number of studies also analyze soccer's influence on alternating stock-related variables. Five studies explicitly examine the *influence of soccer on the volatility of stock market returns.* The idea behind these studies is that short-term-oriented investors adjust their portfolios after matches because of changes in their risk attitude, thus causing an increase in price volatility.

In particular, Benkraiem et al. (2011) show for a short data period that price volatility is higher around match days, with wins and losses associated with an increase in volatility. The authors also find evidence that the effect of losses on price volatility is twice the effect of wins, which is in line with hypothesis *H4* and with prior non-soccer-related findings (e.g., Engle and Ng 1993, Nelson 1991). Additionally, Benkraiem et al. (2011) find that volatility is higher following losses at home than away. Although this circumstance can be "rationally" explained by the decreasing probability of forthcoming wins (a club seems unable to win despite the home advantage), this is also a signal for allegiance bias and thus

for investors' mood-driven behavior because it makes no difference whether a loss is at home or away in the context of sporting success. Surprisingly, away wins do not cause a similar market reaction. This emphasizes that markets may not be efficient because market reactions are unbalanced following comparable events. Berument et al. (2013) confirm these findings for a significantly longer observation period. The overvaluation of losses can, for instance, be explained by the significant decrease in risk tolerance after losses, a perspective that is confirmed by Berument and Ceylan (2012b), but only for losses and not for wins. Fung et al. (2015) show that international soccer matches increase stock market volatility after matches especially in case of smaller firms and firms with low(er) profit. Only Floros's (2014) study provides contradictory results because for three clubs in the sample, no effect of soccer matches on price volatility can be observed; and for Ajax Amsterdam, losses even have a decreasing effect on volatility. This result can be explained by the use of an asymmetric TGARCH model, which is exclusively applied in Floros's (2014) study.

Five studies argue *that soccer matches have a significant influence on trading volumes*, a proposal that is also based on the hypothesis that investors revise their portfolios instantaneously following matches. This can be explained in a rational way (the probabilities for further successes might have changed) and an irrational way (following Edmans et al. (2007), sad moods after losses can lead to an increase in trading volumes because investors try to negate negative moods by generating further profits). However, a decrease in trading volume can also be argued because investors may be "hungover" (Edmans et al. 2007) after a match, leading to a reduced order flow.

Three studies provide evidence for a significant increase in trading volume around match days. In line with the volatility-related findings and with *H4*, Benkraiem et al. (2009) present evidence that trading volumes increase, especially after losses, and that the effect after losses tends to last longer than after wins. The authors further show a significant difference between home and away matches, with the effect after away matches being more significant. They also provide evidence of a significant change in trading volume the day before home losses and argue that the primary cause of this change is different ex-ante beliefs. For Turkish clubs, Tufan and Hamarat (2014) present evidence that trading volume increases around match days in periods with match fixing accusations.[35] Palomino et al. (2009) also show significantly high trading volumes following soccer matches in the UK, with cup matches having a particularly strong influence.

[35] In 2011, several players from the clubs of Turkey's two highest soccer leagues, Süper Lig and First League, were accused of involvement in illegal match fixing.

In contrast, Edmans et al.'s (2007) well-elaborated study shows only insignificant changes in trading volumes after wins and losses. Zuber et al. (2005) confirm this finding through their comprehensive data sample. They show that the on-season and off-season trading volumes of soccer clubs are not statistically different although there are few matches in the off-season period and consequently less match-related information.

Overall, most studies show significant amplitudes in volatility and trading volumes. This result is rather surprising against the backdrop that soccer shares are often supposed to be "collectors' shares"; namely, shares that are held by fans regardless of the current sporting success of the club. This observation leads to the finding that *none of the studies in the sample analyzes the shareholder structure of clubs and distinguishes between, e.g., the investment behavior of fans and professional asset managers (Finding 7).*

In order to explain the market anomalies regarding volatility and trading volume, it can be helpful to account for the characteristics of "soccer stock markets". In particular, several studies (Edmans et al. 2007; Gerlach 2011; Vieira 2013) show that the impact of match results on returns is more significant in small stocks. Additionally, in line with the aforementioned idea of "collectors' shares", Zuber et al. (2005) conclude that soccer teams' stock market performance is different from "traditional" stocks because soccer stocks have four times as many trading days with zero returns; thus, soccer club investors are less active compared to "traditional" investors. Consequently, it is conceivable that investors trade their stocks after a match but include "non-match-related effects" that occur prior to a match in their investment decisions. This finding implies that the sheer "match-related effect" might be diluted in the literature because no study accounts for this particular market characteristic.

Overall, because these results provide some further insights into the characteristics of the stock market in terms of soccer, *a lack of studies that provide concrete investment strategies to exploit existing market anomalies can be observed (Finding 8).*

II.2.4.6 *Further Evidence regarding Soccer's Influence on Stock Markets*

Most of the studies in our sample analyze the influence of a specific club's or national team's match results on stock returns. Moreover, Stadtmann (2006) provides (subordinated) evidence that the results of a club's direct competitor have a direct influence on stock returns.

Three studies in our sample focus on tournaments as a whole and provide evidence that is not related to specific matches and their results. The comprehensive and methodologically

sound study of Kaplanski and Levy (2010) examines the influence of World Cup matches between 1950 and 2006 on the "neutral" U.S. market. The idea behind this approach is that non-U.S. investors conduct about one-third of the transactions on the U.S. market; thus, their sentiments are thought to influence stock returns in the U.S. Rather surprisingly, and not in line with our hypotheses, the study provides significant evidence that returns on U.S. markets are always lower during World Cups, regardless of the concrete match results. Also focusing on World Cup matches, Berlemann and Vöpel (2012) show that strong individual tournament incentives contribute to unstable markets. In the context of the UEFA Champions League, Brahmana (2011) finds that Asian stock markets show significant seasonality seven days before and after the final match because of investors' euphoria (which is a rather surprising finding).

II.2.4.7 *Overall Evidence on How Soccer Matches and Competitions Really Influence Stock Markets*

According to the aggregated empirical evidence, it is obvious that soccer matches and competitions have a significant impact on stock markets. In particular, and in line with the most prestigious study in our sample provided by Edmans et al. (2007), losses are associated with negative market reactions because only a small amount of contradictory evidence is available. The same holds for draws, which investors similarly penalize as losses (although this particular relation is not well documented in the literature). The empirical evidence regarding the remaining key drivers of soccer's influence on stock markets is less obvious and shows high heterogeneity. In line with some well-elaborated studies (e.g., Aston et al. 2011; Edmans et al. 2007; Klein et al. 2009b), wins that are hypothesized to have a positive impact on returns show predominantly no significant effect on stock markets. In addition, the "bad news effect" is confirmed by less than half of the studies examining this particular relation. Nevertheless, the most prestigious studies (e.g., Edmans et al. 2007; Gerlach 2011; Scholtens and Peenstra 2009) confirm the presence of a "bad news effect". Regarding the importance of matches, we hypothesized that matches with higher importance have a stronger impact because cash flow-related consequences are stronger. Surprisingly, the literature delivers heterogeneous results, making it almost impossible to draw an overall conclusion regarding the "importance effect". For example, Klein et al. (2009b) provide no evidence, whereas Bell et al.'s (2012) study, which examines the most comprehensive data sample, confirms the "importance effect" hypothesis. Only relegation/promotion matches provide an unambiguous picture and consistently show stronger impact than "normal" matches do. Finally, the same holds for the "surprise effect". We hypothesized that market

reactions to soccer match results are mostly driven by the unexpected part of the result information. Although some prestigious studies from our sample confirm the "surprise effect" (e.g., Bell et al. 2012; Scholtens and Peenstra 2009), most studies provide mixed evidence or reject the hypothesis, thereby proving that market reactions are also caused by expected outcomes (e.g., Edmans et al. 2007). To conclude, *there is a general trend regarding soccer's overall influence on stock markets. However, when the hypotheses become more specific, the heterogeneity of the findings increases (Finding 9).*

Research question *RQ3* considers whether stock markets in terms of soccer are efficient or not. As partially discussed in the prior sections, we observe rather mixed evidence to support either the efficient market hypothesis or the behavioral alternative hypothesis. The literature shows intense market reactions with a magnitude that cannot be explained by solely rational investment decisions (e.g., Edmans et al. 2007). The overall finding regarding draws emphasizes this observation because markets do not react much less weakly to draws than to losses, although the sporting and thus financial consequences are stronger regarding the latter. This may be reasoned in the fact that investors anticipate losses rather than draws. The finding that important matches are not necessarily followed by stronger market reactions further confirms the behavioral alternative hypothesis because it is hard to argue why a win at the start of the domestic league should have the same impact as a win in an "up or out" elimination match in an international competition. However, the two strongest pieces of evidence for the behavioral alternative hypothesis are: (1) the overall rejection of the "surprise effect", namely most studies do not confirm that market reactions to soccer matches are driven solely by unexpected match results (which from a rational perspective, at least for clubs, are the only results expected to cause market reactions), and (2) the strong influence of national team matches, which do not have any direct cash flow consequences. Overall, it is still hard to conclude whether or not stock markets in terms of soccer are efficient. Further, we have to consider soccer-specific market characteristics because many days show zero returns, implying that the sheer "match-related effect" in the literature might be diluted by other (good or bad) news. Thus, *although the empirical evidence fundamentally allows the conclusion that stock markets are driven by moods rather than by rational behavior and hence supports the behavioral alternative hypothesis, a final conclusion regarding market efficiency is as yet impossible to reach (Finding 10).*

II.2.5 Identified Opportunities for Future Research

Because the literature draws an ambiguous picture of soccer's impact on stock markets, there are still research gaps that should be addressed in future research. Table II.2-10 provides the list of findings from our review and corresponding research opportunities.

Table II.2-10 Findings and research opportunities

Findings	Research opportunity
F1: Most studies that use regression analysis exclusively apply standard OLS regression, despite the fact that the examined time series may be heteroskedastic.	RO1: Conduct a comprehensive study that covers a large data sample, accounts for market characteristics, and applies different methodologies.
F2: The heterogeneity of event study approaches makes it very difficult to compare the results of the different studies and thus to draw overall conclusions.	
F3: There is still an underrepresentation of studies analyzing the impact of (unlisted) club matches on indices because the most successful soccer clubs from the last decade are mainly unlisted clubs with a widespread fan base and high economic relevance.	RO2: Investigate the influence of the matches of Europe's most successful soccer teams from the last decade through a data sample covering recent years.
F4: Important soccer nations (e.g., Germany, Italy, and Spain) are underrepresented in the literature.	
F5: The past decade is underrepresented in the literature, although the economic importance of soccer has grown in recent years.	
F6: Conspicuousness regarding the correlation of applied methodologies, examined samples, and the studies' results can be observed.	RO1: *see above.*
F7: None of the studies in the sample analyzes the shareholder structure of clubs and distinguishes between, for example, the investment behavior of fans and professional asset managers.	RO3: Conduct a comprehensive study of investors' market reaction with regard to soccer matches, taking account of different investor types and providing concrete investment strategies.

F8: A lack of studies that provide concrete investment strategies to exploit existing market anomalies can be observed.	
F9: There is a general trend regarding soccer's overall influence on stock markets. However, when the hypotheses become more specific, the heterogeneity of the findings increases.	RO1: *see above.*
F10: A final conclusion regarding market efficiency is as yet impossible to reach.	RO4: Assess the fundamental value contribution of wins/losses and conduct a study that examines the rational and irrational parts of a stock market reaction.

Research Opportunity RO1: *Conduct a comprehensive study that covers a large data sample, accounts for market characteristics, and applies different methodologies.* Although the current study provides an overview of the empirical evidence on an aggregated level through an approach similar to vote counting method, Borenstein et al. (2009) indicate the major drawbacks of such method. Among other drawbacks, this approach do not account for studies' different sample sizes and do not indicate the clarity of the "victory" of a specific hypothesis. Further, they leave room for subjective interpretations. In order to provide an unbiased overall picture regarding soccer's influence on stock markets, we suggest a comprehensive empirical study. This suggested study should feature five major elements. (1) It should comprise all countries that are examined in the literature (analogous to the study of Fama and French 1996); thus, clubs and national teams should be examined. (2) The study should cover the maximum possible observation period (in order to identify and account for structural regimes because of soccer's increasing economic importance over time). (3) The study should account for all the aforementioned hypotheses; and (4) apply multiple methodological approaches (in order to ensure the results are as robust as possible). (5) Additionally, we suggest that the study accounts for the specific characteristics of soccer stock markets, e.g., the infrequent trading behavior that causes a high number of zero return days. We believe that providing such a comprehensive study offers the opportunity to check whether existing findings are robust and if they can be generalized to an overall level.

Research Opportunity RO2: *Investigate the influence of the matches of Europe's most successful soccer teams from the last decade through a data sample covering recent years.*

Regarding the clubs listed in the STOXX Europe Football index, most of the recent decade's top clubs (e.g., FC Barcelona, Real Madrid CF, and FC Bayern Munich) are missing because they are not market-listed. Nevertheless, analogous to Berument and Ceylan (2012a), it is reasonable to conduct studies on the impact of these clubs on stock indices because they have a widespread fan base. Further, although a club may not be listed, it is possible to observe trading volumes at a specific stock exchange that is located near the home base of such a club (e.g., trading volumes at the Munich Stock Exchange following a match of FC Bayern Munich). We also suggest analyzing the impact of Spanish and German national team matches on stock markets in more detail, because compared with their success in recent years and compared with the "soccer boom" in these countries, appropriate studies are underrepresented in the literature.

Research Opportunity RO3: *Conduct a comprehensive study of investors' market reaction with regard to soccer matches, taking account of different investor types and providing concrete investment strategies.* Because none of the studies in our sample distinguishes between different types of investor, we suggest conducting a study that accounts for this particular effect. We assume that fans, who hold shares primarily because they are fans, react differently to match results because institutional investors and professional asset managers, for example, try mainly to maximize returns. The insights regarding shareholder structure, in combination with the lessons learned regarding market anomalies, could be used to develop reasonable investment strategies.

Research Opportunity RO4: *Assess the fundamental value contribution of wins/losses and conduct a study that examines the rational and irrational parts of a stock market reaction.* As aforementioned, it is difficult to draw an overall conclusion about whether or not investors react rationally to soccer results. Thus, we suggest conducting a study based on a three-step approach. (1) Examine a match result's cash flow-related consequences (e.g., in case of international club competition matches, as premiums are available) and thus the realistic impact of a result on fundamental firm value (e.g., analogous to Hickman et al. 2008). (2) Account for expectations regarding a match result. (3) Analyze stock market reaction against the backdrop of realistic financial consequences. By adopting this approach, we are confident that it would be possible to provide more accurate evidence regarding the market efficiency debate.

II.2.6 Conclusions and Limitations

Against the backdrop of the high (and still increasing) economic relevance of soccer, it is unsurprising that the number of empirical studies regarding the impact of soccer matches and competitions on stock markets has increased in recent years. The main goals of most of these studies are to analyze how stock markets are influenced by soccer in general, establish which particular determinants are the key drivers of this influence, and, consequently (explicitly or implicitly), discover whether stock markets in terms of soccer are driven by rational investment decisions or by moods. The empirical evidence regarding these three central questions is mixed. Thus, the aim of this paper is three-fold. First, we want to provide a systematic and holistic review of all studies in this area of research in order to present aggregated evidence about soccer's impact on stock markets. Second, we aim to give a more general answer to the question of whether stock markets with regard to soccer are efficient or driven by behavioral factors. Third, we want to provide opportunities for future research.

Thus, we first conducted a systematic literature search covering multiple databases and using forward and backward reference searches. By doing so, we analyzed 42 relevant studies, including grey literature. Next, we systematically analyzed the methodological approaches and samples examined in order to find focus areas in the research and "plain spots". Our review's core criteria are the different results from the studies, which we discussed in detail. In this regard, we distinguished between specific hypotheses regarding soccer's influence on stock markets. Thus, we conducted a semi-quantitative approach similar to the vote counting method. Based on our analysis and the corresponding key findings, we concluded our work by suggesting further research opportunities.

The key result of our review is that soccer does influence stock markets, particularly soccer losses and draws (both to a high negative extent). Surprisingly, wins do not affect markets to the same magnitude. Another surprising result is that, at an aggregated level, important matches seem not to have a stronger influence than less important matches, although the cash flow-related consequences may be much more significant. The same holds for the "surprise effect" because investors also react strongly to expected results and not only to unexpected ones. Thus, based on the empirical evidence, we reject the efficient markets hypothesis and confirm the behavioral alternative hypothesis. Nevertheless, this overall impression might be biased by the specific characteristics of soccer stock markets, which show infrequent trading behavior, an issue that is so far neglected in most studies.

Although the market efficiency debate will never end because it is impossible to test fully for efficiency, we suggest conducting a study that is based on the realistic assessment of a soccer match's fundamental financial consequences. Further, we suggest conducting a comprehensive empirical study covering a large data sample, accounting for market characteristics, and applying multiple methodological approaches in order to provide robust empirical evidence at an aggregated level.

Although we used a semi-quantitative approach based on significance levels from primary studies, the major limitation of our review is that our approach still leaves room for subjective interpretations. Further, the literature was only analyzed with regard to the impact of soccer matches and competitions on clubs' share prices and indices; we excluded other factors such as, e.g., the impact of soccer on (jersey) sponsors' share prices.

Despite the limitations outlined above, our review delivers a holistic overview of the empirical evidence and thus contributes to the general understanding of how stock markets react to soccer.

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III Risk Treatment – Recent Empirical Evidence from the Financial and Industrial Sector

The research papers embedded in section III address the treatment of risks. As outlined in section I, risk treatment is one of the key challenges in risk management and provides broad potential for optimization. Section I-1 introduced four concrete forms of risk treatment – risk avoidance, reduction, transfer, and retention. Not all of these forms are applicable for each sector. For instance, within the financial sector risk transfer especially may be an adequate measure, as the transfer of credit risk liberates capital for further loan intermediation and can improve financial stability by spreading credit risks among a magnitude of investors (Duffie 2007). However, in the industrial sector, it may be more expedient to reduce or even avoid supply risks in order to avoid supply disruptions, and consequently, disruptions in the production process. Thus, several questions arise regarding risk identification that must be answered. First, regarding the financial sector and the transfer of credit default-related risks, suitable instruments have to be identified and examined as to whether their pricing is fair and risk-adequate. Second, regarding the industrial sector and the avoidance or reduction of (commodity) supply risks, suitable early warning indicators for a commodity's future supply risk have to be examined and proposed in literature.

Consequently, for the financial sector, research paper 3, *"Market pricing of Credit Linked Notes - the influence of the financial crisis",* focuses on Credit Linked Notes (CLN) as instrument in order to hedge credit default risks. In particular, the paper investigates whether CLN contracts are priced fairly and adequately in relation to the inherent risk structure. Ninety CLN contracts are examined, covering 13,555 daily quoted prices, and they provide strong evidence that CLN are not only overpriced, but in nearly 50% of cases are also underpriced in the secondary market. Further, evidence is provided to show that the 2007-2009 financial crisis increased market transparency for structured financial products and changed investors' behavior.

For the industrial sector, research paper 4, *"Is the convenience yield a good indicator of a commodity's supply risk?",* proposes the convenience yield derived from the term structure of commodity futures contracts as an indicator of a commodity's future supply risk. By using daily convenience yield data with different maturities and examining the period from 1999-2011, the research paper shows that – with some limitations – the convenience yield is in fact an applicable early warning indicator for future supply risks.

III.1 Research Paper 3: "Market pricing of Credit Linked Notes - the influence of the financial crisis"

Authors:	Matthias Walter[a], Prof. Dr. Björn Häckel[a], Prof. Dr. Andreas Rathgeber[b] [a] FIM Research Center, Department of Information Systems Engineering & Financial Management (Prof. Dr. Hans Ulrich Buhl), University of Augsburg, Germany Matthias.Walter@fim-rc.de Bjoern.Haeckel@fim-rc.de [b] Institute of Materials Resource Management Faculty of Mathematics and Natural Sciences University of Augsburg, Germany Andreas.Rathgeber@mrm.uni-augsburg.de

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Abstract:

In Germany, structured financial products already account for 6% to 8% of all assets invested, proving that the market for these products is still very attractive for retail investors. A question often discussed in this context is whether these products are priced fairly. One of the latest contributions in this field is the paper by Rathgeber and Wang (2011), who analyzed the pricing of Credit Linked Notes (CLN) in the primary market. In this paper, we significantly extend the work of Rathgeber and Wang (2011) and analyze the effect of the 2007 - 2009 financial crisis on the pricing of CLN and, specifically, on their pricing in the secondary market. Therefore, we analyzed the pricing of 90 CLN covering 13,555 daily quoted prices. In addition to the major finding that CLN in the secondary market are not only overpriced but also underpriced in many cases, we discovered that the overpricing of CLN significantly decreased after the financial crisis.

JEL-classification: *F64, M14, Q56*

Keywords: *Credit Linked Notes, Market Pricing, Fair Value, Financial Crisis, Product Life Cycle*

III.1.1 Introduction

In the last years, structured financial products have increased in popularity among retail investors. In Germany, they account for 6% to 8% of all invested assets. Even in the United States, structured financial products have an annual growth rate of approximately 30%, although the local market for these products is strongly regulated (Rieger 2012). To put these relative figures into absolute terms, the gross sales of structured retail investment products accounted for EUR 174.2 billion in Europe, USD 179.8 billion in the Asia-Pacific market and USD 65.1 billion in North America in 2010 (Jørgensen et al. 2011). One such structured product is the so-called Credit Linked Note (CLN), which allows the issuing bank to securitize its credit risk, particularly concentration risks. As explained in Rathgeber and Wang (2011), the mechanism of CLN is as follows: The buyer of the CLN receives payment for the notes only when the reference entity - another debtor of the CLN issuer - does not go into default. As a premium for taking over the risk, the buyer receives an attractive coupon. In case of the reference entities' default, the buyer receives only the recovery rate of the CLN. Although the figures mentioned above show that CLN contracts are very popular for retail investors as they provide the opportunity for a high coupon payment, they are subject of controversial discussions in financial research and the public. Therefore, not surprisingly, Credit Default Swaps (CDS), which are similar to CLN, were voted Europe's "most dangerous financial product" in 2013 (DFP 2013). One of the major points of criticism of such structured products is their non-transparency regarding the fact whether the coupon payments for and the prices of these instruments are fair and adequate compared with the related risk.

Several studies exist on the pricing of equity-linked notes, on certificates in general and the pricing of CLN in particular. In one of the latest studies on the pricing of CLN, Rathgeber and Wang (2011) found that CLN are generally overpriced to a large extent in the primary market, ie, on the date of their issue. This major finding was widely consistent with previous results in the literature. Since issuers of structured financial products are market makers, they participate in almost every transaction and, therefore, have the incentive to overprice. Further, overpricing tends to increase as products become more complex and as markets become less transparent.

As the study by Rathgeber and Wang (2011) primarily focused on the market pricing of CLN in the primary market, this study aims to apply a similar model to test mispricing of CLN in the secondary market. Consequently, "mispricing" (the difference between a fair

price and a quoted price), does not only imply overpricing but also underpricing of CLN, as particularly in the secondary market, quoted CLN prices can fall below the fair value. In our study, in particular, we analyze whether the financial crisis of 2007 - 2009 had an effect on the mispricing of CLN. The financial crisis revealed the enormous complexity and inherent risks of structured financial products. Thus, an investor's behavior may have changed from risk loving and only bounded-rational to more reflective (reasoned, among others, in a decrease of information asymmetry between the issuer and the investor), leaving CLN issuers less space for overpricing and inducing a decline in demand for such products. By testing the change in mispricing during the financial crisis, we simultaneously test the validity of the product life cycle hypothesis for CLN, i.e., whether mispricing – in the sense of overpricing (which is higher for CLN than for other standard certificates) – decreases during the products' lifetime. Therefore, in a first step, we calculate the daily fair prices of the CLN. In a second step, we compare them with the daily quoted prices and track the daily development of price differences.

The paper is structured as follows: First, we provide an overview of the existing literature regarding the pricing of structured financial products. We then derive our hypotheses and explain the details of the methodology. Next, we explain our valuation framework and describe the widespread data sample used for our analyses, which contains 90 CLN contracts from the German retail market with a total of 13,555 historical quoted prices on a daily basis (2008 - 2012), reflecting a significant extension of the data sample used in Rathgeber and Wang (2011). Based on our methodology and our data sample, we statistically test our hypotheses. In our test, we find statistically significant evidence that the mispricing of CLN changed during the financial crisis.

III.1.2 Literature

According to Fabiozzi et al. (2007), a CLN is a credit derivative that represents a bilateral contract under which the seller sells the credit risk of the reference entity and receives a certain premium from the protection buyer. Regarding the pricing of such credit derivatives, Rathgeber and Wang (2011) pointed out that various studies exist on the mispricing of equity-linked notes. For example, Chen et al. (1990) and Chen and Sears (1990) were the first to find evidence of overpricing of these products in the U.S. market. Whereas the former focused on overpricing in the primary market, the latter found the first evidence of decreasing overpricing with decreasing maturity in the secondary market and, thus, for the life cycle hypothesis. Later, these findings regarding the primary and the secondary markets

were transferred to non-U.S. markets by other studies, such as Wilkens et al. (2003) or Gruenbichler and Wohlwend (2005).

Baule (2011) provided further evidence for the existence of a product life cycle. He found that for discount certificates on the German DAX index, the investor's demand is driven by tax benefits. Because of the high demand for certificates with a maturity of just longer than one year, banks anticipate a significant number of net sales and thus are able to charge higher premiums than for shorter maturities. According to Henderson and Pearson (2011), some structured financial products are even sold with high average margins although they have expected negative returns. Stoimenov and Wilkens (2005) provided further evidence for the existence of life cycle effects, as banks are net sellers at the beginning of a product's lifetime and net buyers toward the end in order to increase the bank's margin.

Rathgeber and Wang (2011) provided the first comprehensive study on the mispricing of CLN. Thereby, they focused on the primary market, in other words, on the pricing of CLN on their date of issue. The paper provides evidence that CLN products are generally overpriced and further confirms the finding of, e.g., Benet et al. (2006) and Entrop et al. (2009) that the coupon rate and the complexity of a contract (measured by the number of reference entities, the number of payment days and the coupon structure) have a major influence on the mispricing.

To the best of our knowledge, no study is available that analyzed the pricing of CLN on the secondary market as proposed by Rathgeber and Wang (2011) at the end of their paper. By analyzing pricing in the CLN secondary market, we are able to test whether the results for the primary market are transferable to the secondary market. Further, we analyze whether significant differences exist regarding the causes of mispricing in the primary and secondary markets. Moreover, we are able to test the hypothesis of the product life cycle for CLN.

Of further interest is the question of whether the 2007 - 2009 financial crisis had an effect on the mispricing of CLN. This consideration is based on the thought that CLN investors often act in a risk-loving manner because they invest in a product that promises attractive coupon payments even though it may contain a complex and non-transparent risk structure, which investors do not know in detail due to, e.g., asymmetric information between the investor and the issuer. Thus, an investor's decisions are often based on biased or incomplete information. Hens and Rieger (2014) used the circumstance of incorrect beliefs (e.g., probability misestimations) or behavioral utility functions (e.g., prospect theory) to explain the utility gain of structured financial products and, thus, their popularity with retail

investors. Breuer et al. (2009) found evidence for such bounded rational behavior in the case of structured financial products with sports betting components, as their popularity can only be explained by the existence of inhomogeneous expectations and bounded rational, risk-loving investors. This bounded rational behavior may be intensified by very attractive coupons, which investors in structural financial products can receive. Wojtowicz (2014) showed that, for collateralized debt obligations (CDO) in general, even fair spreads are due to their conditions much larger than fair spreads on similarly rated corporate bonds. This is accompanied by a high sensitivity of these instruments in case of changes in the underlying's default probability. Bounded rational behavior may have ended during the financial crisis when investors became aware of the high risks of structured financial products. For example, tranches for high-yielded CDO were very appealing to investors before the financial crisis because they assumed that ratings represent the actual default risks. Then, this market collapsed during the financial crisis (Wojtowicz 2014). Thus, two effects of the financial crisis on the pricing of CLN are conceivable: On the one hand, investors may increasingly face up with the underlying risks of structured financial products (amplified by a stronger regulation) and, hence, consider them in the course of their investment decisions. On the other hand, the demand for such products may decrease. Based on theoretical considerations, both effects lead to a decrease in overpricing.

Hence, our research questions are concretized as follows. Are daily prices of CLN contracts fair and adequate compared with the related risk? If not, what are the reasons for the mispricing and did the financial crisis have an effect on mispricing? Does an observable product life cycle exist for CLN?

III.1.3 Hypotheses

According to Kelly and Ljungqvist (2012), asset prices are strongly driven by asymmetric information. Consequently, asymmetric information may lead to mispricing of financial assets. For instance, with focus on the primary market, Myers and Majluf (1984) showed that managers have strong incentives to issue overvalued equity in case of information asymmetry. Examining the interdependence of mispricing and asymmetric information more detailed, among many others, Glosten and Milgrom (1985) showed that market makers (in terms of security markets) use mispricing (in the sense of overpricing) to compensate the risk of trading with investors that have superior information. Another aspect contributing to information asymmetry is the complexity of a financial product. Particularly in the case of CLN contracts, it is very difficult for investors to estimate the default probabilities of the

underlying assets, which can be interpreted as some kind of information asymmetry, too (Rieger 2012). Additionally, the information asymmetry and the resulting mispricing are amplified by the circumstance that CLN are the only major credit derivate products available for retail investors. Thus, no adequate position exists in the retail market, making it difficult to replicate a CLN contract (particularly for multi-reference CLN) (Rathgeber and Wang 2011).

In addition to the aforementioned general reasons of information asymmetry, in the case of CLN, we particularly have to deal with information asymmetry in terms of bank lending. This is reasoned in the circumstance that a CLN contract is, at least from the issuer's perspective, a loan (provided to the reference entity). According to Sharpe (1990), "a bank learns more than others about its own customers", e.g., about the borrower's characteristics. Consequently, the CLN issuer has a significant information advantage regarding the default probabilities compared to the investor, thus providing the possibility to misprice the contract. Further, Wittenberg-Moeman (2008) provides evidence that loans issued by institutional investors, i.e., loans that are typically issued with long maturities, are associated with higher information costs, thus leading to an increase of information asymmetry.

However, although it may be undisputed that markets for structured financial products show high information asymmetry, there is evidence for a decline of information asymmetry concerning, e.g., a specific product (group), in the course of time. For instance, the recent contribution of McLean and Pontiff (2015) shows for the case of stock returns that investors learn about mispricing from academic publications, thus implying that (some) stock market anomalies become less anomalous (and instead more "normal") after being published. Thereby, the fact that the number of academic publications on the pricing of structured financial products increased in course of time is undisputed. For instance, when using the search database "ScienceDirect" and searching for journal articles using the search items ("structured product" AND "pricing"), we obtain an increase of more than 68% regarding the number of related articles between 2008 and 2012. Additionally, although more difficult to express in numbers, the public coverage regarding structured financial products like CLN increased in recent years, too. Therefore, coinciding with McLean and Pontiff (2015), we conclude that both, academic research and public coverage contributed to a decrease of information asymmetry. Thus, our major hypothesis is as follows:

- **Hypothesis H1: The mispricing of CLN in the German retail market decreases over time.**

Hypothesis H1 is strongly based on the fact that the pricing of CLN is influenced by the presence of asymmetric information within the CLN market and that this information asymmetry decreases generally over time. Now, we want to examine the influence of the financial crisis on the mispricing of CLN. Here too, we use information asymmetry as basic idea and obtain two major influences of the financial crisis: First, referring to the aforementioned development of academic research, we obtain a strong increase during respectively after the financial crisis. Using the same database and search items as above, we obtain 1,096 related articles for the 46-year covering period of 1960-2006 and 2,219 related articles for the 8-year covering period of 2007-2015. Obviously, information asymmetry regarding the general understanding for the pricing of structured financial products decreased, thus leaving issuers less space to misprice. The second major influence of the financial crisis on information asymmetry is related to regulation aspects, above all bank regulation and financial regulation. Since the financial crisis, financial markets in general and banks in particular are stronger supervised by federal authorities (e.g., the Federal Financial Supervisory Authority for the case of Germany). This stronger regulation of financial markets has had impact on the market for structured financial products, too. For instance, the European Market Infrastructure Regulation (EMIR), which was developed in late 2009 as consequence of the financial crisis and which came into force in August 2012, aims to increase the stability of the over-the-counter (OTC) derivatives market (which also includes the CDS as hedging for CLN) and, among others, also includes reporting obligations for OTC derivatives. Concluding, both, the increased number of academic contributions after the financial crisis as well as the stronger regulation of financial markets, led to (1) an increase in transparency of the CLN market and (2) to an increase of investor's awareness regarding the complexity of such products.

In addition to these two aspects related to a decrease of information asymmetry and thus to a decrease of mispricing, we assume a third aspect, how the financial crisis changed mispricing of CLN: During the financial crisis, the demand for structured financial products strongly decreased. For instance, the German securitization market broke down from 68.7 billion € in 2006 to 7.7 billion € in 2008, implying a decrease of approximately 90% (Schiller et al., 2009). Similar evidence is provided by Wojtowicz (2014), who showed that during the climax of the financial crisis of 2008, the CDO market collapsed. Even some highly rated CDO tranches lost up to 90% of their value and were classified as "junk". Based on logical considerations, two effects could be reasonable: On the one hand, one might assume that mainly expert traders remained in the market and (uninformed) retail

investors left the market due to the unknown risk exposure. Following, among many others, Glosten and Milgrom (1985), a shift towards a market "full of (informed) experts" would imply an increase in overpricing, as the CLN issuer tries to compensate the risk of insider trading. On the other hand, the strong decrease in demand might have forced the CLN issuer to price the contract more fairly in order to increase demand.

To conclude, although both, a decrease or even an increase in mispricing of CLN due to the financial crisis is conceivable, we expect at least some effect. Thus, our second major hypothesis is as follows:

- **Hypothesis H2: The mispricing of CLN in the German retail market changed after the financial crisis of 2007 - 2009.**

The hypotheses H1 and H2 are related to the temporal development of CLN mispricing on an aggregated market-level, regardless of a specific contract. To extent our analysis, we further want to examine the development of mispricing of a specific CLN contract, depending on its time to maturity. Thereby, the third hypothesis is based on two (closely related) research strands.

Firstly, taking up the already discussed strand of information asymmetry, we argue that the asymmetry of information between the CLN issuer and the CLN investor decreases with decreasing maturity. Sharpe (1990) and Berger et al. (2005) point out that the lender (and with that the CLN issuer) has a comparative advantage over public markets in gathering information. Consequently, the CLN issuer has an information advantage regarding the reference entities' default risks at the beginning of maturity. We hypothesize that this information advantage disappears with decreasing maturity, which is also in line with Longstaff et al. (2005), who provide evidence for a lower liquidity, i.e., higher information asymmetry, of long maturity bonds, and vice versa. Thus, due to the decreasing information advantage with decreasing maturity, we expect a decrease in mispricing. Indirectly associated with the idea of asymmetric information, Rathgeber and Wang (2011) showed that the complexity of the calculation of a CLN's fair value strictly increases with the number of payment days and with the maturity of a CLN. They outlined that several days may be required to determine the fair value for a (complex) CLN product with long maturity. Consequently, a longer maturity contributes to information asymmetry and with that to higher mispricing.

Secondly, we take up the idea of the product life cycle. Among others, Chen and Sears (1990), Baule (2011), Henderson and Pearson (2011) as well as Stoimenov and Wilkens (2005) provided evidence for such product life cycle, concluding that, due to multiple

reasons already pointed out in Section III.1.2, the mispricing decreases with decreasing time to maturity.

Considering both lines of reasoning regarding the time to maturity and its predicted effect on mispricing, our third hypothesis is as follows:

- **Hypothesis H3: Mispricings become more significant as the time to maturity increases.**

In addition to the three aforementioned main hypotheses that refer to the change in mispricing over time, we additionally seek to control for the remaining effects examined by Rathgeber and Wang (2011) and analyze whether the results from their paper are valid on both the product's day of issue and during its entire lifetime.

First, we adopt the notion that the number of reference entities has an effect on the mispricing of CLN contracts. Rathgeber and Wang (2011) found that the number of reference entities has a significant effect on mispricing. Among others, this finding owes to the fact that the calculation of the fair value for a multiple referenced CLN is very difficult. As Hernández et al. (2007) showed for equity-linked notes, this non-transparency regarding default probabilities (amplified by the aforementioned problem of asymmetric information) and complexity might lead to the fact that CLN issuers overprice multi-referenced CLN contracts even more than CLN contracts with only a small number of reference entities. This paper seeks to confirm the results of Rathgeber and Wang (2011) using a significantly larger data sample:

- **Hypothesis H4: Mispricings become more significant as the number of underlying reference entities increase.**

Analogous to Rathgeber and Wang (2011), our fifth hypothesis refers to the "first sight effect" of coupon payments, which are comparable to equity-linked bonds (Wallmeier and Diethelm 2009). The notion behind this security is that retail investors often act with bounded rationality: They only recognize a high coupon rate and, thus, the expectation of a high return instead of the hidden factors behind the high coupon rate (e.g., underlyings with extremely high risk). Thus, because the size of the coupon rate might influence the attractiveness of and, with that, the demand for CLN contracts, it also affects the significance of the overpricing:

- **Hypothesis H5: Mispricings become more significant with higher coupon rates.**

The CLN contracts in our data sample also cover different coupon structures (mixed and variable). As the complexity of a CLN contract increase, the more variable payments are, we

further included the coupon structure (hereafter, coupon type) as an additional control variable. The methodology used to test our hypothesis is presented hereafter.

III.1.4 Methodology

III.1.4.1 *Valuation of CLN*

Since a CLN can be interpreted as a bond with embedded Credit Default Swaps (CDS), the key for the valuation of a CLN is to duplicate the CLN cash flow with the help of CDS spreads. Hence, according to Rathgeber and Wang (2011), we use the CDS spreads to calculate implied probabilities of default *q*. Therefore, we impose the same central assumptions, namely: The recovery rate of a senior CDS REC_{CDS} is given and constant. Further, there are four payments dates of the CDS in one year, each at the end of the quarter, thus leading to premium payment days $T_m=\{t_{0.25},t_{0.5},t_{0.75},t_1,\ldots,t_m\}$ until maturity in *m*. In order to achieve probabilities for less than a year, we apply a natural cubic spline interpolation as smoothing method.

In order to estimate the fair value of a CLN, our first intermediate goal is to estimate the probabilities curve of the implied default probabilities. To do so, based on the aforementioned assumptions, we (1) calculate the expected cash flows $CF_{1,1}$ in the first payment year of an one-year CDS and (2) solve the resulting equation for the default probability *q*. Starting point of our calculation is the one-year CDS from the investor's, i.e., risk buyer's, point of view. As payments occur at four payment days, these payment days have to be discounted in order to achieve the present value. By doing so, we receive equation (1):

$$CF_{1,1}\cdot(1+r_{0.25})^{-0.25}+CF_{1,1}\cdot(1-q_{1|4})\cdot(1+r_{0.5})^{-0.5}+CF_{1,1}\cdot(1-q_{1|4})^2\cdot(1+r_{0.75})^{-0.75}+CF_{1,1}\cdot(1-q_{1|4})^3\cdot(1+r_1)^{-1}=0, \quad (1)$$

with $CF_{1,1}=-(1-REC_{CDS})\cdot q_{1|4}+0.25\cdot CDS_1\cdot(1-q_{1|4})$, as one-quarter of the annual CDS spread will be paid on each of the four annual payment days. Thereby, in line with Hull and White (2003), the CDS spread CDS_1 is set in a way that the swap is priced fairly.

Based on the a priori estimated yield curve of spot rates r_t and the CDS spread CDS_1, the quarterly probability of default $q_{1|4}=1-\sqrt[4]{1-q_1}$ for an one-year CDS can be solved by means of equation (1). As a result, we receive the cumulative probability of default for the end of the first year according to equation (2):

$$q_1=1-(1-q_{1|4})^4 \quad (2)$$

As CDS contracts with different maturities share the same underlying reference entity, they should also share the same cumulated probability of default during the same period. Therefore, we adopt the cumulated default probability q_{n-1} for the first year by calculating the quarterly probability of default $q_{n-1|4}$ for a CDS with maturity of n years. Next, in line with Rathgeber and Wang (2011), we calculate the quarterly probability of default for CDS with maturities of n years as long as CDS spreads CDS_n are available. Analogous to equation (1), we receive:

$$\sum_{t=1}^{4\cdot n-4} CF_{n,t} \cdot \prod_{k=1}^{t-1}\left(1-q_{\lceil k/4\rceil|4}\right)\cdot(1+r_{t/4})^{-t/4} + \sum_{t=4\cdot n-3}^{4\cdot n} CF_{n,t} \cdot \prod_{k=1}^{t-1}\left(1-q_{\lceil k/4\rceil|4}\right)\cdot(1+r_{t/4})^{-t/4} = 0 \qquad (3)$$

with $CF_{n,t} = -(1-REC_{CDS})\cdot q_{\lceil t/4\rceil|4} + 0.25\cdot CDS_n \cdot (1-q_{\lceil t/4\rceil|4})$ representing the cash flow of the CDS with a maturity of n years at the payment date t. Further, $\lceil\ \rceil$ represents the ceiling function by Gauss. Equation (3) is appropriate to estimate the implied default probabilities $q_{n/4}$, as the right hand sum has already been calculated by the past n-1 applications of equation (3). Thus, equation (3) has solely to be solved for $q_{n/4}$. The cumulative probability of default is defined recursively as:

$$q_n = \left(1-(1-q_{n|4})^4\right)\cdot(1-q_{n-1}) \qquad (4)$$

In our case, we receive a cumulative probability of default $q_1, q_2, \ldots, q_n$ for the end of each year. Furthermore, it can be stated that $q_0=0$, since, due to logical consideration, a default at the date of issue is assumed to be impossible. Finally, in a last step and in line with Rathgeber and Wang (2011), we estimate a continuous curve of cumulated default probabilities by means of 11 data points, which consist of 10 implied probabilities at 10 different times of maturity as well as the origin that we have already calculated. In line with Press et al. (2007), we used a natural cubic spline interpolation as smoothing method. This results in a continuous isotonic function of the cumulative probability of default named $Q(t)=s(q_1,q_2,\ldots q_n)$.

After calculating these probabilities of default, we are able to price the CLN as expected discounted cash flow under the martingale measure Q (see Jarrow and Turnbull 1995 respectively Jarrow et al. 1997). In doing so, the CLN is priced arbitrage free with respect to the CDS market (see in general Bielecki and Rutkowski 2002).[36]

[36] We are aware of the joint-hypothesis problem, implying that the CDS contracts may also be mispriced, thus leading to a biased result regarding the mispricing of CLN. Nevertheless, following Fama (1991) and most of the studies on capital market efficiency, we ignore this problem in our study.

Further, because our analyses also included CLN with multiple references, we considered the asset correlation of the underlying assets. By doing so, we were able to model multiple defaults of the reference entities. A detailed description of the calculation of the default probabilities with multiple reference entities, which extends the aforementioned valuation model by the possibility to handle joint defaults, is provided by Rathgeber and Wang (2011).

Our primarily goal is to price a CLN with an annual or semi-annual fixed coupon rate C_f maturing in T_m at a face value of N.[37] The price of issue is P_i. Let the date of issue be T_0 and the following payment dates be $T_1, T_2, \ldots, T_m$. On the basis of the default probabilities curve $Q(t)$ derived above, we can estimate the cumulated probability of default $Q(T_1\text{-}T_0)$, $Q(T_2\text{-}T_0), \ldots, Q(T_n\text{-}T_0)$ accordingly on each of these days.

If we impose a certain recovery rate REC_{CLN}, the value FV_i of the CLN can be expressed as:

$$FV_i = \sum_{t=1}^{m} \left(\left(C_f \cdot N \cdot (T_t - T_{t-1}) + 1^{\mu} \cdot N \right) \cdot (1 - Q(T_t - T_0)) + REC_{CLN} \cdot N \cdot (Q(T_t - T_0) - Q(T_{t-1} - T_0)) \right) \cdot (1 + r_{T_t - T_0})^{T_0 - T_t}, \quad (5)$$

whereby $\mu = \left\lfloor \frac{t}{m} \right\rfloor$ is the result of the floor function and $r_{Tt\text{-}T0}$ is the risk adjusted discount rate. The latter is the sum of the risk free rate and the credit spread of the issuer.

To calculate the overpricing, we evaluate the difference between the theoretical fair price FV_i and the price of issue in reality. A positive difference indicates overpricing and vice versa. Furthermore, we can assume the price of issue to be fair and estimate the implicit recovery rate, which fulfills this assumption.

$$\mathrm{REC}_{\mathrm{imp}} = \frac{P_i - \sum_{t=1}^{m} \left(C_f \cdot N \cdot (T_t - T_{t-1}) + 1^{\mu} \cdot N \right) \cdot (1 - Q(T_t - T_0)) \cdot (1 + r_{T_t - T_0})^{T_0 - T_t}}{\sum_{t=1}^{m} N \cdot (Q(T_t - T_0) - Q(T_{t-1} - T_0)) \cdot (1 + r_{T_t - T_0})^{T_0 - T_t}} \quad (6)$$

The relative price difference and the recovery rate REC_{imp} are two major indicators to determine if a CLN product is overpriced. Thus, they will serve as dependent variables in our subsequent test.

III.1.4.2 *Mispricing of CLN*

Our primarily aim is to analyze the mispricing of CLN not only in the primary market, but also in the secondary market. Thus, in contrast to Rathgeber and Wang (2011), we analyzed quoted prices of *different CLN* not only at one point in time (date of issue), but also *across the time axis*. Hence, as we obtained data for different clusters *i* (different CLN contracts) at

[37] For a detailed description of the calculation and the specifics of the fair value of CLN with floating coupon rates, please refer to Rathgeber and Wang (2011), as we proceed analogously.

different points in time *t*, we had two different analysis dimensions. As this circumstance implies the threat of aggregation biases (Keane and Runkle 1990), we tested our data sample for the existence of panel data. Thus, we were able to analyze the effects of structurally different CLN contracts on CLN mispricing.

To determine whether the data contained fixed or random effects, we tested the panel regressions against an unweighted ordinary least squares (OLS) estimation. For the random effects model, we conducted a Lagrange Multiplier test. The central idea of this test is to compare the residuals between the time series for one CLN with the residuals between the time series of different CLNs. For the fixed effects model, we conducted a simple F-test. Therefore, the F-statistic of both regressions are compared. Subsequently, we used the Hausman-Wu test to show that the random effects model dominates the fixed effects model for all cases analyzed in this paper (except for one robustness check). This test foots on the differences in regression coefficients using the random and fixed effects models respectively the standard errors of the coefficients. Because the Hausman-Wu test showed the existence of random effects within our data sample, we used a random effects panel regression model to test our hypotheses regarding the mispricing of CLN.

To test our hypothesis, in a first step, we operationalize the mispricing of CLN by means of the contracts' implicit recovery rate $REC_{imp,it}$ for CLN contract i at time t. Thereby, according to equation (6), the implicit recovery rate is calculated by means of the above-mentioned multi-borrower Jarrow and Turnbull model with a given CLN value (in this case the market price), resolved for the recovery rate. Furthermore, we assumed a recovery rate of 40% for the CDS, which served as the basis for the estimation of the default probabilities. This is because according to the Standard North American Corporate CDS Converter Specification (ISDA, 2009), the recovery rate of a (fair priced) senior CDS is 40%. As the recovery rate of a CLN (in course of the financial crisis) was only 8.8%[38], we can assume that the higher the implicit recovery rate is, the more overpriced the CLN contract is. To put it in other words, in case of an implicit recovery rate of 100%, the CLN contract equals a risk-free investment, which a CLN in fact never is. The corresponding panel regression for the base case is shown in equation (7):

$$REC_{imp,it} = \propto_0 + \tau \propto_1 + MAT_{it} \propto_2 + NoR_i \propto_3 + CR_i \propto_4 + + CT_i \propto_5 + v_i + e_{it} \qquad (7)$$

[38] Observing empirical recovery rates was possible for the first time during the financial crisis. According to Rathgeber and Wang (2011), four weeks after the bankruptcy of Lehman Brothers, retail investors found that the realized recovery rate for a Lehman-referenced CLN was 8.8%.

with i indexing the different analyzed panels, i.e., the different n CLN contracts. The parameter τ is a variable for the ongoing date in years since April 1, 2008, which is the earliest date with a quoted price in our data sample. CR_i is the coupon rate of the CLN and MAT_{it} is the time to maturity in t in relation to the CLNs' total time to maturity. CT_i is the coupon type of the CLN i (with CT_i=0 for fixed coupon payments and CT_i=1 for variable coupon payments) and NoR_i is the number of reference entities of the CLN i. v_i is the CLN random coefficient. Because we have a random effects model, the random coefficient v_i is a random variable with a fixed mean and a variance. Further, to test the influence of the financial crisis, we conducted two random effects panel regressions according to equation (7). The first additional panel regression covered all points of time t with quoted prices during the financial crisis and the second additional panel regression covered all points of time t with quoted prices after the financial crisis.

We further tested the residuals for autocorrelation within the random effects model. Therefore, we used a modified Durbin-Watson test according to Bhargava et al. (1982) in association with Baltagi et al. (2003). The test foots on the idea that in a panel only autocorrelation between the residuals of the time series (length T) of every single CLN are accounted for. This circumstance reduces the number of observation in the first place. However, the modified DW-statistics, as displayed in equation (8), is aggregated in the second step over all N CLN.

$$dw_{mod} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}(e_{it-}e_{it-1})^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}{e_{it}}^2} \tag{8}$$

Due to the special construction of the modified DW statistics, it cannot be analyzed with the critical values used in time series analysis. For the panel case, critical values are generated which account for this special setting and the random effects (see Bhargava 1982). To address the identified autocorrelation, we used a Prais-Winsten estimation for the panel data because this approach does not modify the length of the time series. After one iteration, the residual's autocorrelation was reduced to a sufficient extent. For the test of heteroscedasticity, we conducted a robust Lagrange Multiplier test according to Montes-Rojas and Escudero (2010). Following the idea of a Langrange Multiplier test, an auxiliary regression model has to be performed testing for a homoscedastic covariance matrix. Insofar, the test follows the well-known idea of the Breusch Pagan test. However, due to the fact that we observe differently distributed error terms for different CLN (random effects model), the homoscedastic covariance matrix (null hypothesis) is constructed in such a way

that differently distributed error terms for the different CLN contracts exist in the covariance matrix.

In another test for the influence of the financial crisis on the mispricing of CLN, we replaced the date parameter τ by a dummy variable for the points of time during the crisis respectively after the crisis.

To test the robustness of our results, we tested the panel regressions previously shown in equation (7) with alternating CDS recovery rates (8.8% and 60%) for the estimation of the default probabilities. Further, we tested our results in case of an estimated asset correlation equal to 0.

Additionally, we repeated the panel regression shown in equation (7) with the relative mispricing ΔCLN_{it} as dependent variable, Thereby, ΔCLN_{it} is calculated using equation (9):

$$\Delta CLN_{it} = \frac{P_t}{FV_t} - 1, \tag{9}$$

with the relative deviation $\frac{P_t}{FV_t} - 1$ of the market price P_t from the theoretical fair value FV_t of a CLN in *t*. The corresponding panel regression is shown in equation (10):

$$\Delta CLN_{it} = \beta_0 + \tau\beta_1 + MAT_{it}\beta_2 + NoR_i\beta_3 + CR_i\beta_4 + CT_i\beta_5 + v_i + e_{it} \tag{10}$$

For the calculation of the theoretical fair value FV_t, we used recovery rates of 40% respectively 8.8% for both the CLN contracts and the CDS, which served as the basis for the estimation of the default probabilities. Finally, we repeated the robustness check with a recovery rate of 40% and an estimated asset correlation equal to 0.

The next section presents the data sources for testing the panel regression models.

III.1.5 Data Sources

For our analysis, we identified six major German CLN issuers[39] (which are two issuers more than in the paper of Rathgeber and Wang 2011):

- Commerzbank AG (analogous to Rathgeber and Wang 2011);
- Deutsche Bank AG (additional issuer);
- DZ Bank AG (analogous to Rathgeber and Wang 2011);
- Landesbank Baden-Württemberg (analogous to Rathgeber and Wang 2011);
- Landesbank Berlin (additional issuer); and,

[39] Analogous to Rathgeber and Wang (2011), we used dummy variables to evaluate possible differences among the credit risk of the issuers.

- UniCredit Group (analogous to Rathgeber and Wang 2011).

The following data had to be obtained from each CLN contract to meet the requirements of our model:

- Payment dates including the final payment day;
- Coupon rate, coupon type and payment structure;
- Issue price and issuer;
- Underlying reference entities; and,
- Market prices of trading days with positive trading volume.

Except for the different product names given by the specific issuers, all of these CLN products are constructed similarly. They only differ from one another in the following aspects:

- Number of reference entities: single or multiple;
- Type of reference entities: corporate or national sovereign;
- Coupon type: fixed rate or variable rate (floating rate or a mix of fixed and variable);
- Payment structure: periodic or only at maturity; and,
- Issue price and final payment: at, under, or over par.

Altogether, we observed 90 CLN products issued from April 1, 2008 to February 27, 2012 covering 13,555 quoted market prices on a daily basis and correlated to a positive trading volume (we excluded some of the 136 CLN products from Rathgeber and Wang (2011) because data required for our model were not available). Prices for days, which had a trading volume equal to 0, were ex ante excluded and are not part of our 13,555 quoted prices-spanning data sample. The CLN data of the different CLN were obtained from the individual product descriptions, which were retrieved from the issuer's homepages. The daily market prices and the corresponding trading volumes were retrieved from the European Warrant Exchange Stuttgart (EUWAX).[40] Table III.1-1 shows the descriptive statistics on the 90 different CLN contracts used in our analysis. At the same time, the descriptive statistics show that the composition of the data sample used in the paper at hand is comparable to the one used by Rathgeber and Wang (2011).

[40] We gratefully acknowledge these data provided to us by the EUWAX.

Table III.1-1 Descriptive statistics of analyzed CLN

Issuer:	Frequency:	Date of Issue:	Frequency:	Maturity:	Frequency:	Number of Reference Entities:	Frequency:
Commerzbank AG	20%	2006	2%	< 1 year	0%	1	51%
Deutsche Bank AG	21%	2007	3%	1-3 years	3%	2-5	47%
DZ Bank AG	26%	2008	22%	> 3 years	97%	6-10	1%
Landesbank BW	22%	2009	31%			> 10	1%
Landesbank Berlin	1%	2010	22%				
UniCredit Group	10%	2011	19%				

Coupon Type:	Frequency:	Type of References:	Frequency:	Number of Payment Days:	Frequency:	Coupon Rate:	Frequency:
Floating	23%	Sovereign	16%	1-10	64%	< 3%	8%
Mixed	12%	Corporate	84%	> 10	36%	3% - 6%	78%
Fixed	64%					> 6%	14%

The descriptive statistics (Table III.1-2) of the implicit recovery rates of the CLN show that 4,021 of the quoted prices (which is 29.66% of the entire data sample) implied a recovery rate of 40% or higher. For comparison, the recovery rate of a (fair priced) senior CDS is 40%, the recovery rate of a Lehman-referenced CLN during the financial crisis was only 8.8%. The highest implicit recovery rate in the sample was 163.72%. Beside these rather high implicit recovery rates, we also observed 6,041 quoted prices (44.57%) implying negative recovery rates, with the lowest implicit recovery rate of -3,115.30%. In average, we observed an implicit recovery rate of -36.98%.

Furthermore, the descriptive statistics regarding the quoted prices of the CLN and the relative mispricing ΔCLN_t calculated using equation (4) and a recovery rate of 8.8% show that none of the quoted prices were priced with their fair values. In fact, 8,199 of the quoted prices (which is 60.5% of the entire data sample) showed a deviation between market price and fair value of more than 5%. Only 1,396 quoted prices showed a deviation less than 1% (which is 10.3% of the entire data sample). In total, 6,876 (50.73%) of the quoted prices were overpriced and 6,679 (49.27%) of the quoted prices where underpriced. The largest overpricing within the sample was 70.14% (observed for a CLN issued by Commerzbank) and the largest underpricing was 30.76% (observed for a CLN issued by Landesbank Baden-Württemberg). The average relative mispricing ΔCLN_t in absolute terms within the observation period was 9.38%, i.e., CLN were on average 9.38% overpriced. Separated by issuers, Commerzbank, DZ Bank AG and Landesbank Berlin showed the largest average mispricing at more than 10%.

In addition to the CLN data, input parameters are also needed to calculate values in accordance with our model. To discount the estimated cash flows for each date, we needed

the risk-free spot rate on a daily basis. The required parameters for the calculation of the spot rates and discount factors were estimated by the German Central Bank using the Svensson method (Svensson 1994).

The CDS spreads of the reference entities were retrieved through the Thomson Reuters Datastream, which uses historical data from Credit Market Analysis (CMA) as a source. We used daily quoted closing rates of senior CDS with maturities from one to ten years, which were available for most of our required reference entities since 2008.

To calculate the joint default probabilities for CLN with multiple underlying reference entities, we needed their asset correlation. Therefore, for each underlying corporation, we used its daily stock return within the observation period of April 1, 2008 to February 27, 2012 (or shorter if data were not available for the entire period). As a proxy for the correlations of national sovereigns, we took the major stock index of each underlying country and calculated the daily stock return. Following Rathgeber and Wang (2011), we applied Merton's model because the credit risk of a sovereign is closely related to its economic development, which is represented by the sovereign's stock index.

Table III.1-2 Descriptive statistics of quoted market prices, implicit recovery rate (calculated by means of a multi-borrower Jarrow and Turnbull model with the quoted market price as CLN value, resolved for the recovery rate), and the relative mispricing (calculated by means of equation (4)). The average relative mispricing in absolute values does only take into account the extent of the relative mispricing, not its sign.

	# of quoted prices	**Implicit Recovery Rate**					**Relative mispricing ΔCLN_t (Recovery Rate 8.8%)**							
		Average	Min	Max	< 0	> 0.4	> 5%	< 1%	Average	Average (absolute value)	Median	Min	Max	Standard deviation
Overall	13,555	-0.3698	-31.1530	1.6372	6,041	4,021	8,199	1,396	–0.0282	0.0938	0.0013	–0.3076	0.7014	0.1340
Issuer 1: Commerzbank AG	2,362	-0.1215	-10.6463	1.0853	987	761	1,721	122	0.0392	0.1138	0.0128	–0.2401	0.7014	0.1583
Issuer 2: Deutsche Bank AG	12	-0.4498	-1.8454	0.2670	7	0	5	0	–0.0656	0.0702	–0.0190	–0.2274	0.0277	0.0801
Issuer 3: DZ Bank AG	4,355	-0.2062	-16.1531	1.6372	1,892	1,449	2,976	330	0.0572	0.1232	0.0054	–0.2821	0.5863	0.1635
Issuer 4: Landesbank Baden-Württemberg	5,087	-0.3776	-31.1530	1.0350	2,269	1,266	2,512	762	0.0073	0.0624	0.0009	-0.3076	0.5406	0.0859
Issuer 5: Landesbank Berlin	540	-0.1040	-10.8750	1.3718	112	419	474	7	0.1108	0.1369	0.1373	–0.1462	0.4673	0.1160
Issuer 6: UniCredit Group	1,199	-1.5386	-26.4323	1.1863	774	126	510	171	–0.0467	0.0616	–0.0232	–0.2785	0.1034	0.0726

III.1.6 Tests and Results

III.1.6.1 *Mispricing in the German CLN secondary market – base case*

Table III.1-3 presents the test results for the entire observation period based on the panel regression model from equation (7).

Table III.1-3 Results for the panel regression for the entire observation period. Values are for regression coefficients α_0, α_1, α_2, α_3, α_4, α_5, Durbin-Watson test statistic (before Prais-Winsten estimation), Hausman-Wu test statistic, and explanatory power R^2 (values in brackets are t-values; ***significance at the 0.1% level; **significance at the 1% level; * significance at the 5% level).

	Entire observation period
$\boldsymbol{\alpha_0}$	-1.222***
	(-1093.200)
$\boldsymbol{\alpha_1}$ *(τ)*	-2.000***
	(-213.400)
$\boldsymbol{\alpha_2}$ *(MAT)*	13.993***
	(98.400)
$\boldsymbol{\alpha_3}$ *(NoR)*	4.130***
	(822.200)
$\boldsymbol{\alpha_4}$ *(CR)*	-191.968
	(-1.300)
$\boldsymbol{\alpha_5}$ *(CT)*	17.229***
	(211.800)
Durbin-Watson	0.215
Hausman-Wu	7.804
Adjusted R^2	0.229

The parameter values were negative for date and coupon rate. According to the regression model, this result indicates that the implicit recovery rate decreased with an increasing coupon rate (H5) and during the entire observation period (H1). For the maturity (H3), the number of reference entities (H4), and the control variable "coupon type" values were positive. Therefore, according to the regression model, this means the longer the maturity and the larger the number of reference entities had been respectively the more complex the coupon type was, the larger the implicit recovery rate was. In all cases except the coupon rate, we observed highly significant results. The explanatory power of the CLN contract panel regression was 0.229.

Further, the Hausman-Wu test statistic reported in Table III.1-3 distinctly shows that a random effects model is more appropriate than a fixed effects model. This is not astonishing due to several facts. First, we are inspecting time series of different CLNs, as different CLNs have different characteristics, which are not accounted for in the regression model according to equation (7), e.g., asymmetric information regarding default probabilities between the

issuer respectively investor and the reference entities (loan borrowers). Consequently, this leads to different mispricings of different CLN. At the same time, we expect to observe the same dependence structure on the independent variables, which are stationary in time but at different levels. Interestingly, these levels are not fixed, but random instead. The latter can be explained by the fact that these characteristics resulting in different levels are uncorrelated with the independent variables and not constant in time.

To account for dynamic effects, we also tried to estimate a panel regression with yearly effects. However, the CLN specific effects clearly dominated the model. In addition to that, due to the autocorrelation and the applied Prais-Winsten estimation, we estimate the equations in differences, which additionally reduced the potential influences of lagged variables.

III.1.6.2 *Mispricing during and after the financial crisis*

To test hypothesis H2 and, thus, CLN mispricing during and after the financial crisis, the first step conducted two further panel regressions: one with CLN data before May 8, 2009 and one after May 8, 2009. This date was selected because the European Central Bank performed the last reduction of the key interest rate with respect to the financial crisis on May 7, 2009. Table III.1-4 presents the results of this regression.

Table III.1-4: Results for the panel regressions regarding the implicit recovery rate during / after the financial crisis. Values are for the regression coefficients α_0, α_1, α_2, α_3, α_4, α_5, Durbin-Watson test statistic (before Prais-Winsten estimation), Hausman-Wu test statistic, and explanatory power R^2 (values in brackets are the t-values; ***significance at the 0.1% level; **significance at the 1% level; * significance at the 5% level).

	During Financial Crisis (April 1, 2008–May 7, 2009)	**After Financial Crisis (May 8, 2009–February 27, 2012)**
α_0	0.169***	-1.379***
	(53.215)	(-1022.400)
α_1 *(τ)*	0.030	-2.106***
	(0.068)	(-151.300)
α_2 *(MAT)*	6.896*	14.073***
	(1.679)	(101.000)
α_3 *(NoR)*	1.045***	4.610***
	(32.997)	(798.300)
α_4 *(CR)*	-222.543	-194.226
	(-0.112)	(-1.200)
α_5 *(CT)*	9.501***	17.691***
	(12.041)	(203.900)
Durbin-Watson	0.149	0.227
Hausman-Wu	0.321	5.044
Adjusted R^2	0.287	0.225

Highly significant results were obtained particularly after the financial crisis, at least at the 0.1% level in all cases except for the coupon rate. For the maturity, the number of reference entities and the control variable "coupon type," we observed positive values during and after the financial crisis, indicating an increasing implicit recovery rate with an increasing maturity, increasing number of reference entities and increasing complexity of the CLN. We observed negative values for the coupon rate during and after the financial crisis, indicating that both during and after the financial crisis, the implicit recovery rate decreased with increasing coupon rate. These findings are in line with the CLN panel regression previously shown in Table III.1-3. The parameter values had different signs during and after the financial crisis only for the date, indicating that the implicit recovery rate increased (statistically not significant) during the financial crisis but decreased (statistically significant) afterwards. The explanatory power during the financial crisis was 0.287 and thus higher than in the CLN contract panel regression previously shown in Table III.1-3. After the financial crisis, the explanatory power was 0.225 and with that almost on the level of the CLN contract panel regression from Table III.1-3.

In a second step, we tested, whether the mispricing of CLN is significantly different during and after the financial crisis by conducting a Chow test according to Chow (1960). The null hypothesis was that the mispricing of CLN during the financial crisis was equal to the mispricing of CLN after the financial crisis. The results of the Chow test at a 0.99 confidence level rejected the null hypothesis. Hence, the Chow test is an indicator that the mispricing of CLN did significantly change through the financial crisis.

Because only 35 of the 90 CLN in our data sample contain quoted prices during the financial crisis (2,545 out of 13,555 quoted prices), the Chow test may only be convincing to a limited extent. Thus, the third step conducted a further panel regression including a dummy variable for the financial crisis whereby the dummy is equal to one for dates after the financial crisis and zero otherwise. The date variable had to be excluded given high autocorrelation with the dummy variable. In this case, we (once again) obtained highly significant results for all variables except the coupon rate. The explanatory power was 0.224.

Table III.1-5 Results for the panel regression with a dummy for the period after the financial crisis. Values are for the regression coefficients α_0, α_1, α_2, α_3, α_4, α_5, Durbin-Watson test statistic (before Prais-Winsten estimation), Hausman-Wu test statistic, and explanatory power R^2 (values in brackets are the t-value; ***significance at the 0.1% level; **significance at the 1% level; * significance at the 5% level).

	Dummy Regression
$\boldsymbol{\alpha_0}$	-1.545***
	-1744.900
$\boldsymbol{\alpha_1}$ (post crisis dummy)	-0.343***
	(–639.200)
$\boldsymbol{\alpha_2}$ *(MAT)*	15.588***
	(119.700)
$\boldsymbol{\alpha_3}$ *(NoR)*	3.998***
	(806.200)
$\boldsymbol{\alpha_4}$ *(CR)*	-223.814
	(-1.200)
$\boldsymbol{\alpha_5}$ *(CT)*	17.130***
	(208.500)
Durbin-Watson	0.208
Hausman-Wu	3.198
Adjusted R^2	0.224

The financial crisis dummy parameter showed a highly significant negative sign, indicating that the implicit recovery rate decreased to a highly significant extent after the financial crisis. In line with the positive result of the Chow test, this result provides further evidence for the existence of two structural different regimes: one during the financial crisis and one after the financial crisis. The remaining parameters indicated the same sign as in the CLN panel regression previously shown in Table III.1-3, i.e., the implicit recovery rate and thus the mispricing of CLN decreased with an increasing coupon rate but increased with increasing maturity, an increasing number of reference entities, and an increasing CLN complexity.

III.1.6.3 *Robustness check*

To check the robustness of these results, we conducted six robustness checks. For three of the robustness checks, we applied the same procedure as previously described with alternative recovery rates of 8.8% and 60% for the CDS, which served as a basis for the estimation of the default probabilities (as mentioned above, in the base case, we assumed a CDS recovery rate of 40%). In another robustness check, we applied the same procedure as previously shown but assumed an asset correlation of zero (and a CDS recovery rate of 40% analogous to the base case). During the remaining three robustness checks, we repeated the aforementioned regression with the relative mispricing according to equation (4) as

dependent variable and different recovery rates respectively an asset correlation equal 0. Table III.1-6 shows the results for the robustness checks with alternating recovery rates and an asset correlation equal 0:

Table III.1-6 Results for the robustness checks with alternating CDS recovery rates for the estimation of the default probabilities and an asset correlation equal 0. Values are for the regression coefficients α_0, α_1, α_2, α_3, α_4, α_5, Durbin-Watson test statistic (before Prais-Winsten estimation), Hausman-Wu test statistic, and explanatory power R^2 (values in brackets are the t-value; ***significance at the 0.1% level; **significance at the 1% level; * significance at the 5% level).

	Recovery Rate 8.8%				**Recovery Rate 60%**				**Asset Correlation = 0**			
	Entire Period	During Crisis	After Crisis	Dummy Regression	Entire Period	During Crisis	After Crisis	Dummy Regression	Entire Period	During Crisis	After Crisis	Dummy Regression
α_0	-2.024***	0.071***	-2.247***	-2.563***	-0.722***	0.217***	-0.842***	-0.913***	-1.171***	0.222***	-1.332***	-1.509***
	(-1769.4)	(22.892)	(-1626.6)	(-2838.6)	(-686.724)	(66.216)	(-665.247)	(-1085.3)	(-1056.1)	(72.978)	(-994.916)	(-1715.3)
α_1 *(τ / post crisis dummy)*	-3.228***	0.276	-3.618***	-0.496***	-1.282***	-0.148	-1.165***	-0.263***	-2.115***	-0.350	-2.211***	-0.355***
	(-359.6)	(0.621)	(-268.900)	(-923.4)	(-122.472)	(-0.346)	(-76.694)	(-491.6)	(-222.3)	(-0.769)	(-157.152)	(-663.3)
α_2 *(MAT)*	23.443***	7.488*	24.151***	26.198***	7.946***	6.502*	7.605***	8.850***	13.764***	5.255	13.922***	15.486***
	(172.2)	(1.772)	(180.6)	(209.0)	(49.928)	(1.649)	(48.909)	(61.5)	(95.3)	(1.194)	(98.582)	(117.3)
α_3 *(NoR)*	5.128***	1.174***	5.696***	4.904***	3.735***	0.975***	4.184***	3.664***	4.343***	1.203***	4.805***	4.202***
	(1079.5)	(35.944)	(1040.0)	(1046.5)	(643.017)	(32.170)	(630.315)	(636.7)	(847.800)	(35.243)	(818.346)	(831.1)
α_4 *(CR)*	-255.385	-253.580	-249.029	-305.243	-163.120*	-203.115	-172.654*	-185.648	-195.127	-201.182	-196.940**	-229.260*
	(-1.3)	(-0.124)	(-1.4)	(-1.5)	(-1.721)	(-0.107)	(-1.933)	(-1.2)	(-1.3)	(-0.094)	(-2.488)	(-1.8)
α_5 *(CT)*	23.024***	11.368***	24.227***	22.972***	14.362***	8.388***	14.274***	14.219***	16.972***	9.001***	17.447***	16.869***
	(299.4)	(13.939)	(294.7)	(296.0)	(152.445)	(11.149)	(142.679)	(148.900)	(204.500)	(10.529)	(197.669)	(201.3)
Durbin-Watson	0.208	0.147	0.219	0.200	0.210	0.152	0.224	0.208	0.215	0.150	0.227	0.208
Hausman-Wu	24.988	1.493	15.096	9.172	2.003	0.135	1.516	1.773	8.350	0.177	5.602	3.767
Adj. R^2	0.216	0.291	0.211	0.208	0.230	0.282	0.230	0.229	0.229	0.251	0.226	0.222

Table III.1-6 shows that almost all of the results of the base case were robust against changes within the assumed recovery rate: regarding the CLN panel regression and the regression with the crisis dummy, all results from the base case were confirmed within these three robustness checks. The results of the base case were also confirmed during and after the financial crisis for an alternating CDS recovery rate of 8.8%. For a recovery rate of 60% as well as an asset correlation equal 0, all parameters were analogous to the base case except for the date variable during the crisis. In both cases, in contrast to the base case, the implicit recovery rate also decreased during the crisis and not only after the crisis. Furthermore, the robustness checks had no impact on the significance of the results from the base case.

Additionally, we repeated the aforementioned regression with the relative mispricing as dependent variable (equation (10)). Thereby, the relative mispricing was calculated according to equation (9). We further considered different recovery rates of 8.8% respectively 40% for the calculation of the CLN as well as CDS for the estimation of the default probability. In a separate robustness check, we further assumed an asset correlation equal 0. Table III.1-7 shows the results of these three robustness checks.

Table III.1-7 Results for the robustness checks with the relative mispricing as dependent variable, using different recovery rates as well as an asset correlation equal 0. Values are for the regression coefficients β_0, β_1, β_2, β_3, β_4, β_5, Durbin-Watson test statistic (before Prais-Winsten estimation), Hausman-Wu test statistic, and explanatory power R^2 (values in brackets are the t-value; ***significance at the 0.1% level; **significance at the 1% level; * significance at the 5% level).

	Relative Mispricing as dependent variable (Recovery Rate 8.8%)				**Relative Mispricing as dependent variable (Recovery Rate 40%)**				**Relative Mispricing as dependent Variable (Asset Correlation = 0)**			
	Entire Period	During Crisis	After Crisis	Dummy Regression	Entire Period	During Crisis	After Crisis	Dummy Regression	Entire Period	During Crisis	After Crisis	Dummy Regression
β_0	0.020***	–0.003	–0.020***	–0.056***	–0.089***	–0.069	–0.054***	–0.085***	–0.032***	–0.046***	–0.046***	–0.084***
	(12.423)	(–0.744)	(–46.478)	(–121.002)	(–122.607)	(–13.832)	(–90.531)	(–142.776)	(–14.648)	(–9.243)	(–84.260)	(–147.143)
β_1 *(τ / post crisis dummy)*	–0.441	–0.072	–0.411***	0.014***	–0.004	–0.277	–0.129***	–0.017***	–0.545	–0.392	–0.238***	–0.008***
	(–0.418)	(–0.171)	(–6.298)	(27.212)	(–0.171)	(–0.739)	(–3.128)	(–30.936)	(–0.690)	(–1.035)	(–5.173)	(–14.431)
β_2 *(MAT)*	–0.730	–0.374**	–0.356***	–0.118***	–0.107***	–0.077	–0.168***	–0.082***	–0.437	–0.233*	–0.248***	–0.113***
	(–1.149)	(–2.670)	(–6.198)	(–6.145)	(–5.674)	(–0.649)	(–5.127)	(–5.835)	(–1.088)	(–1.937)	(–6.624)	(–7.476)
β_3 *(NoR)*	0.460***	0.248***	0.747***	0.646***	0.358***	0.165***	0.468***	0.368***	0.375***	0.226***	0.607***	0.505***
	(4.329)	(11.251)	(12.577)	(20.193)	(25.539)	(8.999)	(14.967)	(23.933)	(5.653)	(12.049)	(16.576)	(28.600)
β_4 *(CR)*	19.311	12.065	35.122	21.161	9.422	–3.797	4.836	8.265	7.531	5.689	10.535	9.103
	(0.003)	(0.009)	(0.043)	(0.054)	(0.042)	(–0.003)	(0.012)	(0.038)	(0.002)	(0.005)	(0.021)	(0.038)
β_5 *(CT)*	3.433	1.712***	1.095	1.512**	1.516***	1.491***	1.487**	1.613***	2.545*	1.399***	1.551**	1.1635***
	(1.345)	(3.601)	(1.126)	(2.768)	(6.650)	(3.786)	(2.960)	(6.172)	(1.668)	(3.484)	(2.622)	(5.444)
Durbin-Watson	0.100	0.196	0.082	0.104	0.131	0.234	0.109	0.134	0.124	0.223	0.101	0.127
Hausman-Wu	5.916	0.840	4.735	2.548	2.761	2.166	6.246	1.534	3.405	1.562	6.727	1.677
Adj. R^2	0.230	0.320	0.094	0.125	0.154	0.273	0.108	0.154	0.230	0.291	0.123	0.171

Table III.1-7 shows that the robustness checks with the relative mispricing as dependent variable confirms the results of the aforementioned regressions in almost all cases. The two major differences are the reversed signs for the coupon rate and the maturity: in case of the coupon rate, we observe positive signs in each case except the relative mispricing during the crisis in case of a recovery rate of 40%, indicating an increasing mispricing with increasing coupon rate. In case of the maturity, we observed negative signs in each case, indicating an increasing mispricing with decreasing maturity. We furthermore observed smaller explanatory powers than in the base case, especially in case of a recovery rate of 40%.

III.1.7 Discussion of results

Overall, consolidating the base case and the robustness checks leads to the conclusion that all of our hypotheses except H5 (regarding the "first sight effect") are verified statistically.

Our first hypothesis H1 is based on the idea that CLN markets are characterized by strong information asymmetry, not least due to the fact that banks have a significant information advantage regarding borrower's, i.e. reference entity's, characteristics (Sharpe 1990). These information asymmetries and the resulting overpricing of CLN contracts on an overall market level ought to decrease in course of time due to an increasing "body of knowledge". We can confirm H1 during the entire observation period from 2008-2012, using the implicit recovery rate as proxy for the extent of mispricing. Accordingly, irrespective of the maturity of single CLN contracts, overpricing of CLN decreased in our data sample. Thus, this perception coincides with the recent evidence of McLean and Pontiff (2015), who postulate that academic research contributes to decrease market anomalies.

In a second step, hypothesis H2 examined the influence of the 2007-2009 financial crisis on the mispricing of CLN in more detail. In essence, we argued that due to a tremendous increase in the number of research papers dealing with the pricing of structured financial products after 2007 and due to a stronger regulation of the financial market, especially for credit derivatives, information asymmetry within the CLN market declined. We operationalized H2 by separately analyzing the implicit recovery rate respectively the mispricing during and after the financial crisis. In doing so, we observe a statistically significant decrease of mispricing after the financial crisis. In contrast, during the crisis, we observe a (statistically not significant) increase in mispricing. This finding is basically in line with, for example, Wojtowicz (2014), who stated that, as of today, bounded rational investors are increasingly aware of the underlying risks of structured financial products; thus, issuers are no longer able to overprice their products to the same extent as they did

before or during the crisis. Hence, although it may be also conceivable that mispricing increased due to the financial crisis because of a shift toward a market full of "informed experts", we obtain the result, which we ex ante considered to be logical. Moreover, our finding regarding the effect of the financial crisis is robust as both, a Chow test and a further regression with a dummy variable for the time after the financial crisis, confirm the result that mispricing decreased to a significant extent after the financial crisis, thus providing evidence for a structural break due to the crisis.

The third key hypothesis in our study, H3, examined the pricing of CLN not on an aggregated market level but on a contract level instead. In particular, we analyzed weather the mispricing is correlated to the time to maturity. We confirm H3 for the entire observation period from 2008 to 2012 as well as in case of the two identified regimes (during and after the crisis). In all cases, we observed an increasing overpricing with decreasing maturity. This result strengthens the assumption that information asymmetry between the issuer and the investor decreases with decreasing time to maturity, which is basically in line with Longstaff et al. (2005). Further, this result is in line with the findings of, e.g., Chen and Sears (1990), Stoimenov and Wilkens (2005), or Baule (2011), thus providing evidence for the existence of a product life cycle. Our results do not only confirm existing contributions in this field of research but rather put them on a broader basis as the data sample for this paper covers many more data points (13,555) and a longer period (e.g., Baule (2011) only analyzed the period from November 2006 to December 2007). As restriction, we have to point out that in case of the relative mispricing as dependent variable, we observed an "inverse product lifecycle" with an increasing mispricing with decreasing maturity.

Regarding the complexity of CLN products (which in turn also contributes to information asymmetry), we confirm hypothesis H4 that the overpricing increases with an increasing number of reference entities. The same result is observed for the control variable "coupon type", i.e., the complexity of the coupon structure. Thus, the two cases confirm the findings of Rathgeber and Wang (2011).

Surprisingly, Hypothesis H5 regarding the "first sight effect" has to be rejected in almost each of our tests (except the robustness checks with the relative mispricing as dependent variable). We hypothesized that the overpricing increases with higher coupons. In fact, our finding contrasts the findings of Rathgeber and Wang (2011) and of Wallmeier and Diethelm (2009). One reason for this contradictory and unpredicted result can be the

aforementioned higher awareness of investors for the high underlying risks of structured financial products after the financial crisis, which is amplified by the high number of academic and public coverage. Thus, a high coupon might no longer induce a "positive" first sight effect but rather put the investor on the alert for the inherent risk structure.

To summarize, our results provide evidence that the CLN market shows generally a decrease in overpricing in course of time. In particular, the overpricing of CLN during and after the financial crisis changed significantly, to the effect that the overpricing decreased to a more significant extent after the crisis, which is in line with our expectations based on existing literature. Another interesting contribution to the literature is the fact that Rathgeber and Wang (2011) only observed overpricing on the date of issue. We now identified that the majority of the 13,555 quoted prices was actually underpriced, instead of overpriced respectively showed (highly) negative implied recovery rates.

III.1.8 Conclusion and Outlook

The market for structured financial products grew in the past years. Hence, a significant number of studies analyzed the pricing of these products. This paper significantly extended the contribution of Rathgeber and Wang (2011): we analyzed whether CLN contracts are priced with their fair value not only on their date of issue but also during their life cycle. Thereby, our analysis was based on a widespread data sample covering 13,555 daily quoted prices of 90 CLN contracts from five major issuers in the German market, what is also a significant extension of Rathgeber and Wang (2011). Analogous to Rathgeber and Wang (2011), we applied a market-based valuation model for the calculation of the fair value of CLN. This approach is based on the reduced model by Jarrow and Turnbull (1995) respectively Jarrow et al. (1997), extended by the single factor Merton model to estimate the joint default probabilities by means of asset correlations. For the derivation of the default probabilities, we used the CDS spreads of the underlying entities.

One of the major findings of this paper is that CLN are not only overpriced in the secondary market but are often underpriced to a large extent. This result is rather surprising in view of the fact that Rathgeber and Wang (2011) only observed overpriced CLN products on their issue date. Further, we discovered that overpricing CLN significantly decreased after the 2007-2009 financial crisis due to a decrease in information asymmetry, although CLN markets are gradually recovering and demand for structured products is still high. This result is also robust for changes in recovery rates or correlation coefficients. The theory of the product life cycle, ie, decreasing overpricing with decreasing maturity, was confirmed as

well as well as the positive correlation between the complexity of the CLN product and the mispricing. The latter finding does not only confirm, but also strengthen the corresponding finding of Rathgeber and Wang (2011) because of the extended and widespread data sample used in this paper. Surprisingly, the common theory of the "first sight effect", i.e., an investors' focus on a high coupon rate in expectation of a high return instead of the hidden factors behind the high coupon rate, had to be rejected.

Based on the results of our paper, a few possibilities exist to extend our work. Although our data sample is quite large, with 13,555 quoted prices, it does not begin until April 2008. Thus, the data sample contains only data "during the financial crisis" and "after the financial crisis" but not "prior to the financial crisis". By extending the data sample with data prior to the financial crisis, we were also able to analyze CLN mispricing before the crisis. Moreover, the change in interest rates is modeled more specifically to more accurately calculate fair prices for CLN with floating coupon payments. Further, the valuation framework may be used for CLN products issued on CLN markets other than the German market to test whether the hypotheses are universally valid.

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III.2 Research Paper 4: "Is the convenience yield a good indicator of a commodity's supply risk?"

Authors:	Dr. Christian Stepanek[a], Matthias Walter[b], Prof. Dr. Andreas Rathgeber[c]
	[a] Dr. Christian Stepanek Christian.Stepanek@gmx.de
	[b] FIM Research Center, Department of Information Systems Engineering & Financial Management (Prof. Dr. Hans Ulrich Buhl), University of Augsburg, Germany Matthias.Walter@fim-rc.de
	[c] Institute of Materials Resource Management Faculty of Mathematics and Natural Sciences University of Augsburg, Germany Andreas.Rathgeber@mrm.uni-augsburg.de

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Abstract:

A strong increase in the demand for some commodities over the last decade will have a major impact on their future supply situation. Of increasing importance, therefore, is an assessment of a commodity's criticality, and especially its supply risk, by appropriate indicators. The literature has proposed numerous indicators of the supply risk. Here, we use the convenience yield of commodity futures as a supply risk indicator to address some of the major shortcomings of existing indicators, especially regarding their predictive power. This paper aims to test the applicability of the convenience yield as an indicator of a commodity's future supply risk. Therefore, we calculate historical convenience yields for 3-, 15-, and 27-month futures contracts for five major industrial metals (aluminum, copper, lead, nickel, and zinc) during the period 1999 to 2011. We compare the convenience yields at the beginning of the contract period to known indicators at maturity to find that the convenience yield has generally predictive power for the static stock lifetime (i.e., inventory volume/turnover) and future spot prices. Furthermore, we find that, with some restrictions, the convenience yield is an applicable indicator of a commodity's supply risk.

Keywords: Convenience Yield, Theory of Storage, Commodities, Supply risk indicators, Scarcity

IV Summary and Future Research

In this section, the key findings of this doctoral thesis are summarized (section IV.1), and potential starting points for future research are presented (section IV.2).

IV.1 Summary

The main objective of this doctoral thesis was to contribute to selected risk management topics with a particular focus on the risk management process phases of *risk identification* and *risk treatment*. Section II provided empirical evidence on an aggregate level by means of various meta-analyses, and examined selected topics with respect to the identification of risks. In particular, answers were provided to the questions "Why do firms hedge their risks?" and "How do soccer's success-related performance risks affect stock markets?" Section III concentrated on selected topics from risk treatment. In particular, section III distinguished between the financial and industrial sectors, and analyzed different ways to treat sector-specific risks. For the financial sector, CLN were analyzed as an instrument to hedge credit default risks, and an answer to the question "Are CLN priced fairly on the secondary market?" was provided. For the industrial sector, section III provides an answer to the question "Is the convenience yield a good indicator for a commodity's future supply risk?" In the following paragraphs, the key findings of the research papers included in this doctoral thesis are presented for sections II and III:

In section II, several aspects regarding the identification of risks were investigated:

- Research paper 1 focused on the analysis of corporate hedging determinants by aggregating the results of 132 empirical studies, including more than 100,000 companies, and provided a comprehensive literature review in this field of research (Objective II.1). Research paper 1 introduced the methodology of multivariate meta-analysis, which was predominantly conducted in medical and psychological research so far, to the field of financial research (Objective II.2). In addition, guidelines for the treatment of various types of biases were provided, such as publication and especially the data mining bias (Objective II.3). Finally, with respect to Objective II.4, the main purpose of this meta-analysis was to identify key drivers for non-financial firms' hedging behavior, and consequently, their potential risk sources. Thereby, the research paper focused on the following specific hedging hypotheses: corporate tax, bankruptcy and financial distress costs, asymmetric information and agency conflicts of equity, coordination of financing and investment policy, and agency conflicts of debt. In light of

these hypotheses, the results indicate a strong evidence only for the bankruptcy and financial distress hypothesis. For the remaining hypotheses, only weak or no support was found. In particular, at least on an overall and multivariate level, major risk sources that move firms to hedge seem to be the inability to satisfy investors' expectations, measured in a high dividend yield and the company's size, a firm's critical liquidity situation, and expenses for research and development (R&D) activities. The latter can be explained by the fact that the success of such activities has a major impact on a firm's future success, but simultaneously is anything but certain, leading to, for example, the underinvestment problem introduced in section I. The robustness check, by means of the univariate meta-analysis, confirmed the multivariate meta-analysis' results. From a methodological viewpoint, a core finding is that the univariate meta-analysis tends to strongly overestimate single results, as no interactions between the proxy variables are integrated in this approach. The robustness check, by means of the vote-counting method, led to predominantly inconsistent and insignificant results, as the high number of insignificant results from primary studies could not be differentiated, which is a major constraint of this approach. Regarding potential biases, research paper 1 showed that studies on corporate hedging face the presence of both a data mining bias as well as a publication bias, with the latter being more pronounced. Consequently, following the idea of Pigott (2012), this bias was addressed by various measures, such as the inclusion of grey literature, the conduction of funnel plots, and application of Egger's regression test. By doing so, the results of the original meta-analysis turned out to be robust.

- Research paper 2 put risk identification in the context of soccer matches, and examined how risks related to teams' sporting success influence financial performance with respect to stock returns, and especially volatility. Therefore, in line with the commonly accepted process for literature reviews suggested by, e.g., Cooper and Hedges (1994), the research paper provided a systematic and holistic review of 42 studies in this area of research. The paper also provided overall evidence for soccer's impact on stock markets on an aggregate level, and particularly distinguished between specific hypotheses regarding soccer's influence on stock markets by conducting the vote-counting method (Objective II.5). A key result of the vote-counting analysis is that the main risk factors regarding soccer clubs' sporting success are losses and draws (both to a high negative extent). Surprisingly, the same does not hold for wins - not in the sense of a threat, but of an opportunity - as wins do not affect stock markets in the same magnitude as negative outcomes do. Another unexpected result is that, on an aggregate level, important

matches seem to have *no* stronger influence than less important matches, although the related positive or negative financial consequences are expected to be much stronger. This is contrary to Birkhäuser et al. (2015), as they provide evidence for a positive relationship between investor cash flows and sporting success *only* in important matches. Sporting performance also demonstrates an observable influence regarding stock market volatility and trading volumes. In addition, as information about soccer matches becomes available for all market participants simultaneously, soccer is an adequate subject to test the efficient market hypothesis and the behavioral alternative hypothesis. Thus, research paper 2 aimed to challenge whether stock markets are efficient or driven by behavioral factors in regard to soccer (Objective II.6). Due to the strong reaction of investors to unexpected and expected results, which are already reflected in prices, research paper 2 rejects the hypothesis of efficient markets and supports the behavioral alternative hypothesis instead. Third, based on the systematic analysis of the existing literature, the paper pointed out opportunities for future research (Objective II.7; for further information, see section IV.2).

Section III focused on the treatment of risk in both the financial and industrial sectors. One exemplary instrument for risk treatment in each sector had been selected and carefully analyzed by means of empirical tests.

- Research paper 3 focused on the treatment of risks in the context of the financial sector. In particular, the paper took a closer look at CLN, which are used by financial institutions in order to hedge their credit default risks. CLN, which are closely related to credit default options, are blamed as one of the major triggers of the 2007-2009 financial crisis (Hull 2010), and are heavily discussed in financial research and in public debate due to the lack of transparency regarding their risk structure. This may hamper their applicability for financial institutions to hedge credit risks. In addition, the financial crisis itself may have had an influence on the pricing of CLN contracts. Consequently, both the mispricing of CLN in general (Objective III.1) and in particular, the influence of the financial crisis on mispricing (Objective III.2), were the focus of research paper 3. Determinants of mispricing were identified (Objective III.3) and the product life cycle hypothesis was examined for CLN contracts (Objective III.4). A data sample covering 13,555 daily quoted prices of 90 CLN contracts from five major issuers in the German market was analyzed. For the calculation of the fair value of CLN, a market-based valuation model based on the reduced model by Jarrow and Turnbull (1995), and Jarrow et al. (1997), was used, extended by the single factor Merton model to estimate the joint

default probabilities by means of asset correlations in the case of multi-referenced CLN. The major finding of this paper is that CLN in the secondary market are not only overpriced (50.73% of the quoted prices), but are often underpriced to a large extent (49.27% of the quoted prices). This result extends the findings of Rathgeber and Wang (2011), who demonstrated that CLN contracts in the primary market are exclusively overpriced. With respect to their applicability for risk management, CLN contracts draw an ambiguous picture: for institutional investors aiming to hedge their own risk exposure, an investment in an underpriced CLN contract features a suitable opportunity to benefit from such a hedging contract. Nevertheless, due to the high number of overpriced contracts, corporate hedging by means of CLN has to be treated with care. For the issuing bank, which tries to hedge its own credit default risk exposure, the previous findings of Rathgeber and Wang (2011) provide evidence that due to the significant overpricing in the primary market, hedging of credit default risks by means of CLN was an appropriate risk management instrument, at least in the period before the 2007-2009 financial crisis. Moreover, a further central finding of research paper 3 is that the aforementioned financial crisis significantly decreased the overpricing of CLN due to a decrease in information asymmetry, with the results being robust for changes in central input parameters. In addition, in the case of the German CLN market, overpricing seems to be predominantly driven by product complexity, measured in number of reference entities as well as in the coupon type. Finally, in line with existing studies - e.g., Stoimenov and Wilkens (2005) and Baule (2011) - the product life cycle hypothesis can be confirmed in the case of the German CLN secondary market.

- Research paper 4 focused on the treatment of risks in the context of the industrial sector. In particular, the paper derived requirements for a feasible short-term indicator of a commodity's future supply risk, as the assessment of commodity supply risks in terms of an early warning system is of high priority for producing firms in order to avoid disruptions in the production process, which may cause major financial losses (Objective III.5). Therefore, the research paper proposed the convenience yield of commodity futures contracts, which also depends on the future inventory level of a commodity (Weymar 1966), as an indicator for a commodity's future supply risk (Objective III.6). The predictive power of the convenience yield of commodity futures was tested by means of the static lifetime of inventory at the maturity of the contract, as well as the spot price at the contract's maturity, as proxy variables for a future supply situation. To test the relationships, trading data was used on 3, 15, and 27-month maturities of five

major industrial metals (aluminum, copper, lead, nickel, and zinc) for the period of 1999 until 2011. The paper provides empirical evidence that the convenience yield serves as an applicable early warning indicator for future supply risk, at least for aluminum, copper, nickel, and zinc. Nevertheless, the indicator works only as long as the inventory level is a good proxy for worldwide stocks; e.g., for lead, the indicator does not work, as the corresponding LME warehouse stocks are not a good proxy for the worldwide stocks, and the supply situation bears at least a small risk of disruption.

Taken together, it can be concluded that the corresponding research papers included in this doctoral thesis contribute to existing literature in the field of risk management with a particular focus on two particular phases of the continuous risk management process: risk identification and risk treatment. Despite the presented findings, further challenges remain and offer starting points for future research.

IV.2 Future Research

In the following, potential starting points for future research are highlighted for each research paper included in this doctoral thesis.

Section II: Regarding the identification of risks, there are several aspects for future research that are addressed in the following paragraphs:

Research paper 1 contributes to the identification of risk sources. The results of 132 studies analyzing the determinants of corporate hedging were synthesized by conducting a multivariate meta-analysis. In addition, to check the robustness of the multivariate results, a univariate meta-analysis and a vote count analysis were conducted, analogous to Aretz and Bartram (2010) and research paper 2, providing evidence that the univariate meta-analysis strongly tends to overestimate the results. However, the results have some limitations and may provide starting points for potential future research as well. The most important limitations and potentials for future research are outlined hereafter:

- First, the endogeneity and identification problems, as well as the empirical modeling of structural relations, are incorporated only in few primary studies, implying that the causality of the variables is not unique. For instance, many determinants of leverage also influence hedging strategies, which means that leverage is an endogenous variable with regard to corporate hedging. This problem is difficult to address in meta-analysis, as only secondary data is available in most cases. Future research should address the

problem of endogeneity by, e.g., the "meta-analytic structural equation modeling" (MA-SEM) approach presented by Cheung and Chan (2005).

- Second, in order to achieve comparability of research paper 1 to the findings of Aretz and Bartram (2010) and Arnold et al. (2014), the analysis is limited to the four major hypotheses of financial hedging mentioned by Aretz and Bartram (2010). Consequently, future research could adopt the methodology of multivariate meta-analysis in order to test the determinants of operational hedging (Allayannis et al.2001; Kim et al. 2006) or other theories of financial hedging, such as risk management as determined by behavioristic motives of managers (Pennings and Garcia 2004). To contribute to the effectiveness of risk management, related fields of financial research (such as determinants of the capital structure or credit spreads) or further sectors can be analyzed by means of multivariate meta-analysis.
- Third, as the proxy variables substantially vary across the studies, research paper 1 applies a random effects model instead of a fixed effects model. However, the factors driving this heterogeneity are not examined. Consequently, in future research, an exploratory meta-analysis, or a meta-regression in line with Feld et al. (2013) could be conducted (Anello and Fleiss 1995).
- Fourth, in line with Walker et al. (2008), research paper 1 shows that the lack of reported data in primary studies is a huge problem for meta-analysis. Due to the scarcity of data reported in primary studies, nearly one-fourth of the primary studies had to be excluded. Thus, less potential for future research, but rather an appeal to the financial research community, empirical studies using multivariate statistics should increase their transparency by reporting the examined data, such as the correlation matrix of the independent variables, as it is already common practice in medical and psychological research. A broader set of data included in a meta-analysis could improve the understanding of corporate hedging determinants and a variety of other research questions with mixed empirical evidence in the context of financial research in general, and risk management in particular.
- Fifth, although research paper 1 proposes "learning from other companies" as a concept for risk identification, literature lacks contributions that explicitly analyze learning spillover effects in terms of risk management. Consequently, in line with Leary and Roberts (2014), who provide evidence that the capital structure's choice of managers is influenced by those of their peers due to learning concerns, further research should examine how hedging decisions are influenced by peer companies.

Research paper 2 picked up research paper 1's finding from the literature search process that the literature on hedging in companies from the sports sector, and soccer clubs in particular, is still underrepresented in comparison to the economic meaning in this particular sector. Consequently, against the backdrop of the identification of financial risk with regard to the sportive success of a soccer club, the paper aggregates empirical findings of 42 primary studies by means of a systematic literature review, accompanied by the application of the vote count method. Caused by the nature of literature reviews, several opportunities for future research were systematically identified and outlined in detail (see section II.2). Moreover, the paper has some limitations that provide room for further research:

- First, research paper 2 conducted solely a vote-counting analysis. As outlined in detail in research paper 1, this semi-quantitative method based on significance levels from primary studies has some noteworthy weaknesses. The major weakness is that the method still leaves space for subjective interpretations of the author and is less objective than the two other approaches conducted in research paper 1. Consequently, further research should apply enhanced methods of meta-analysis in order to assess the impact of risks in terms of sporting performance on stock markets. However, the conduction of univariate as well as multivariate meta-analysis is disabled by the fact that the studies in this field of research provide data only to an insufficient extent. Consequently, in order to provide robust empirical evidence on an aggregate level, future research can conduct a comprehensive empirical study covering a huge data sample and applying multiple methodological approaches. In addition, future research can conduct a meta-regression analogous to Feld et al. (2013), and various sub-samples, as well as the influence of moderating variables – e.g., time periods, countries, tournaments, etc. – can be examined.
- Second, research paper 2 focused on the impact of soccer matches and competitions on clubs' share prices and indices. Other risk factors with relevance for the economic performance of a soccer club were neglected. Although sporting success may be the reason for each factor influencing the economic performance of a soccer club, as, for instance, the number of fans buying franchise articles and visiting matches depends on the club's success, there are still risk factors not directly correlated to sporting success, such as reputational risks, IT risks, management failures (Kupfer 2006; Beech and Chadwick 2013), or market risks (as in August 2015 the average beta of listed soccer

clubs was 0.65[41]). In addition, literature provides insufficient guidance for the treatment of these risks by means of concrete financial hedging instruments. Kupfer (2006) and Szymanski (2015) briefly describe the use of asset-backed securities in terms of soccer clubs without analyzing this topic in detail. The same holds true for Beech and Chadwick (2013), who provide a comprehensive overview of sports management in general, but neglect to provide concrete guidance with respect to risk management in soccer clubs. Future research should examine risks in terms of soccer clubs in more detail and propose concrete financial hedging instruments.

- Third, although there are some studies available on the influence of sporting success on associated companies like jersey sponsors, kit suppliers, or large-scale investors (Cornwell et al. 2001; Hanke and Kirchler 2013), this topic was neglected in research paper 2 because such studies are underrepresented in terms of soccer. In all conscience, one of few studies examining the impact of match results on jersey sponsors' stocks is the study of Hanke and Kirchler (2013). Future research should examine these interdependencies in more detail in order to gain an overall picture of soccer's influence on economics.
- Fourth, although soccer may be the sport with the strongest economic potential and influence, risk factors regarding the sporting performance are also relevant in other sports. To draw an overall conclusion on performance-related risk factors in the sports sector, various other types of sports - e.g., American football, baseball, basketball, or ice hockey - have to be examined in a similar way as soccer was examined in research paper 2.

Several unresolved issues exist regarding risk identification in general, and in the sports sector in particular. In order to link the basic ideas of research paper 1 and research paper 2, detailed analyses are necessary on the hedging behavior of sports clubs. By doing so, both the body of knowledge regarding the determinants of corporate hedging as well as the body of knowledge regarding risk factors in sports clubs will be extended.

Section III: Regarding the treatment of risks in the financial and industrial sector, several aspects for future research also exist, which are addressed in the following:

In research paper 3, the fair and risk-adequate pricing of CLN in the German secondary market was investigated, and this paper took a closer look at the 2007-2009 financial crisis'

[41] Mean value of the beta of 20 listed European soccer clubs; data retrieved from Reuters on August 22, 2015.

influence on CLN pricing. Thereby, the contributions of this article must be considered in the light of some limitations that provide room for future research.

- First, the widespread data sample of research paper 3 does not begin before April 2008. With that, the data sample contains only data "during the financial crisis" and "after the financial crisis". However, in order to gain a comprehensive impression on how the 2007-2009 financial crisis affected the pricing of CLN, the period prior to the financial crisis has also be to taken into account.[42] Consequently, future research should extent the findings of research paper 3 by means of a data sample also covering the period before July 2007 in order to analyze CLN mispricing before the crisis.
- Second, examining further markets other than the German secondary market can increase the explanatory power of research paper 3. For instance, as the popularity of structured financial products strongly increased in the United States over the past years (Rieger 2012), a closer look at the pricing of CLN (as a concrete kind of structured financial product) in the US market may provide additional evidence on pricing, and specifically the influence of the financial crisis. Thus, future research should apply the proposed valuation framework for CLN markets other than the German market to test whether the hypotheses are universally valid.
- Third, the accuracy of fair CLN price calculation can be enhanced by some changes to the valuation model. For instance, in the case of CLN with floating coupon payments, it is necessary to take into account the interest rate. However, due to the small number of CLN with floating coupon payments within the data sample, research paper 3 renounced applying a complex interest rate model for the calculation of fair values. Instead, analogous to Rathgeber and Wang (2011), forward rates, which are derived from spot rates on the date of issue, are applied to predict the coupon payments. Thus, future research can apply models that are more sophisticated in order to increase the accuracy of the calculation of fair prices.
- Fourth, research paper 3 also examined the influence of a product's complexity on the pricing of the CLN contract. Thereby, complexity was measured by proxy variables, such as the number of reference entities, the coupon type, and the time to maturity. In contrast to these specific, but possibly incomplete, complexity drivers, the comprehensive study of Célérier and Vallée (2014) examines the complexity by means

[42] Nevertheless, the financial crisis did not start from one day to the next and many investors first expected the crisis to end sooner. Consequently, as the data sample of research paper 3 also comprises the climax of the financial crisis with the collapse of Lehman Brothers in September 2008, the paper still allows for conclusions on the financial crisis' impact on the mispricing of CLN contracts.

of a detailed text analysis of the product descriptions retrieved from the product prospectuses of 55,000 structured products. Future research can adapt the detailed procedure of Célérier and Vallée (2014) for the CLN market in order to gain further insights on CLN pricing.

- Fifth, research paper 3 examined the mispricing of CLN contracts on the secondary market and, by doing so, also examined the influence of the financial crisis on pricing. Thus, some statements regarding the applicability of CLN as an instrument for risk treatment, as proposed by Neal (1996), can be derived. However, the body of knowledge in terms of CLN still lacks comprehensive studies examining the effectiveness of risk treatment by means of this particular instrument. Consequently, this gap should be addressed in future research.

In research paper 4, the convenience yield derived from the term structure of commodity futures was proposed as an early warning indicator for a commodity's future supply risk. By using statistical tests, the applicability of the convenience yield as a supply risk indicator was confirmed for at least four out of five examined industrial metals. However, the results of this article were accompanied by some limitations that provide room for future research.

- First, although the predictive power of the convenience yield for the static lifetime of a commodity as well as its' spot price is quite high, research paper 4 unveiled a high number of critical supply situations that were not predicted ex ante by a high convenience yield; however, the number of incorrectly predicted critical supply situations is rather low. These prediction errors depend on the specific commodity and its characteristics. For instance, for commodities with low inventory levels during the observation period yet a high convenience yield predicted a critical supply in the short run. For commodities with continuous excess demand and shrinking production capacity, the convenience yields with long maturities performed well. An implication of these results is that further research should focus on constructing an indicator based on convenience yields and, at the same time, address the limitations mentioned above. For instance, the convenience yield can be combined with other financial ratios, or "classic" supply risk indicators.
- Second, the applicability of the convenience yield as a supply risk indicator should also be tested for other commodities. This research opportunity also contributes to the aforementioned construction of an indicator based on the convenience yield: the more commodities are analyzed, the better a new indicator can address various commodity characteristics. For instance, with regard to the energy turnaround, the convenience yield

can also be tested for energy commodities, e.g., gas or electricity. In the case of crude oil, the relationship between the convenience yield and the future supply situation was already examined by Wimmer (2014). This bachelor thesis, which conducted simple regression tests, revealed that there seems to be no predictive power of the convenience yield in the case of crude oil, at least with respect to the future spot price.

To summarize, there is obviously room for further research regarding the treatment of risks in both the financial and industrial sectors. In particular, the thesis strongly recommends assessing the effectiveness of CLN as an instrument to treat credit default risks in the financial sector, and to construct a supply risk indicator that is applicable for various types of commodities and is based on the convenience yield.

Taken together, the research papers presented in this doctoral thesis contribute to the selected topics regarding the identification and treatment of risks. Even though this doctoral thesis can answer some particular questions regarding various aspects of risk management, the field will always remain a relevant and dynamic topic in research as well as in practice. Nevertheless, it is to be hoped that this doctoral thesis can contribute to some selected questions in risk management research.

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