What do we really know about corporate hedging?

A multimethod meta-analytical study

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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.

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

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[1] 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 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%.

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:

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

Online 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

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

credits, tax-loss carryforwards (binary) and tax-loss carryforwards (continuous) have greater incentives to hedge (Nance et al., 1993).

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:

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 Online 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.

2.3 Asymmetric Information and Agency Conflicts of Equity[2]

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

[2] 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.

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:

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 Online 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).

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.

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:

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 Online 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.

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)[3]. 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 Online 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 $j = 1, \ldots, p$ from study $i = 1, \ldots, k$ are given by the inverse sum of the within-study variation v_{ij} (which captures the sampling error)

[3] 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.

and the between-study variation ${T_j}^2$ (which captures the variance of the effect size parameters across the population of studies):

$$w_{ij} = \frac{1}{v_{ij}+T_j^2} \quad (1)$$

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:

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

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[4] 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

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

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 containing the *k* study specific variance-covariance matrices $\boldsymbol{S_i} + \boldsymbol{T^2}$ 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

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

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.

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

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[5]: 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[6]. 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[7]. (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 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

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

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[8] major electronic databases of academic financial literature by adopting the search command from Arnold et al. (2014)[9]. 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[10] 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.

[8] 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.

[9] 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 Online Appendix B.

[10] 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.

At the end of the search process, we reached a sample of 167 relevant primary studies[11] meeting the inclusion criteria – with 54 of them providing all required data for univariate 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[12] 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[13]. Consequently, our final sample consists of 132 primary studies, which are listed in Online Appendix C. The basic statistics describing our sample are summarized in Online 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 1.

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

[12] 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.

[13] 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.

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 year observations[14]. 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[15]. 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.

5 Empirical Results

Empirical literature tests the hedging theories by the firm-specific proxy variables presented in Online 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

[14] 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.

[15] 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.

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 Online 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 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[16]. 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[17] 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 1. In the following, we present our result for each of the four hypotheses in detail. The corresponding random effects

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

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 Online Appendix E.

(INSERT TABLE 1)

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

(INSERT TABLE 2)

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 3.

(INSERT TABLE 3)

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 Online 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 4.

(INSERT TABLE 4)

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 5.

(INSERT TABLE 5)

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 Online 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 Online 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 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 (Online 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[18] to detect

[18] 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).

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 2 through 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 Online Appendix E, this is true for our empirical analysis as many proxy variables depend linearly on each other.

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.

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[19] 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

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

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 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).

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 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 (Online 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.

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.

Online Appendix. Supplementary data

Supplementary data associated with the article at hand can be found in the Online Appendix.

Table 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	*p*-value	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.

Table 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 Online 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.

Table 3: Statistical results for the bankruptcy and financial distress costs hypothesis (H2)

Proxy variable	Hyp. sign	No. of firms	Multivariate meta-analysis b	SE(b)	p-value	Univariate meta-analysis r	SE(z)	p-value	Eggers's regression test p-value	Vote counting $\alpha = 0.50$ -	$\alpha = 0.50$ +	$\alpha = 0.05$ -	$\alpha = 0.05$ 0	$\alpha = 0.05$ +
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 Online 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.

Table 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 Online 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.

Table 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 Online 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.

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