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What Do We Really Know about Corporate Hedging? A Multimethod Meta-Analytical Study

by

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REVIEW

What do we really know about corporate hedging? A meta-analytical study

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Abstract This paper employs meta-analysis to aggregate and systematically analyze the mixed empirical evidence on the determinants of corporate hedging reported in 132 previously published studies covering data from more than 73,000 firms. Among the fourteen proxy variables analyzed by multivariate meta-analysis, three variables emerge as reliable explanatory factors for corporate hedging decisions supporting the bankruptcy and financial distress hypothesis: dividend yield (positive sign), liquidity (negative sign), and firm size (positive sign). Moreover, for tax-loss carry forwards (positive sign) and research and development (positive sign), our findings indicate a weak impact on corporate hedging behavior reflecting tax reasons, the coordination

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between financing and investment, and agency conflicts between shareholders and debtholders. Regarding the asymmetric information and agency conflicts of equity hypothesis, we find no explanatory power. The further analysis of heterogeneity via meta-regression reveals several factors that determine the mixed empirical evidence reported in previous studies. First, the results indicate that studies analyzing firms from North America report, on average, a lower impact of leverage on the corporate hedging decision. Moreover, studies examining more recent data samples tend to find a weaker relation between tangible assets and hedging, R&D and hedging, respectively. Overall, our results encourage scientific research to put more emphasis on finer-grained examinations of hedging variations and to discover rationales of corporate hedging extending classical financial theories.

keywords Corporate hedging · Corporate risk management · Derivatives · Meta-analysis

1 Introduction

The motivation for non-financial firms to engage in corporate hedging is one of the most intensively discussed topics in corporate finance research. Neoclassical finance theory claims that under the conditions of a perfect capital market, hedging on the firm level does not create additional value, since shareholders can perfectly hedge their position (Modigliani and Miller 1958). However, more recent financial theory suggests that when financial markets are not frictionless, there are several ways through which corporate hedging can increase firm value in the sense of the maximization of shareholder value (Bessembinder 1991; DeMarzo and Duffie 1991; Froot et al. 1993; Smith and Stulz 1985). In this manner, hundreds of primary studies have empirically investigated the theoretical explanations for corporate hedging. However, despite or perhaps exactly because of the vast amount of studies, the empirical literature presents rather mixed evidence for the drivers of corporate hedging (Aretz and Bartram 2010; Bartram et al. 2009; Fauver and Naranjo 2010; Judge 2007).

Two previous studies present quantitative summaries of the existing empirical findings for the hedging determinants (Aretz et al. 2007; Arnold et al. 2014). Aretz and Bartram (2010) conduct a broad literature review and apply vote counting to compare the number of statistically significant and insignificant results from the univariate/multivariate analysis sections reported in 31 primary studies. Their findings show weak evidence for the coordination of financing and investment policy hypothesis as well as the tax hypothesis. Although these results exhibit a detailed summary of the distribution and the extent of disagreement within the outcomes of prior research, vote counting approaches have been strongly criticized as ‘fatally flawed’ (Borenstein et al. 2009: 252; Stanley and Doucouliagos 2012: 2). This assessment arises from the fact that vote counts collapse the observed estimates into a few categories based on their statistical significance, do not present an economic magnitude for the aggregated effects, and ignore differences of sample sizes and precision of the findings reported in the primary studies (see, among others, Borenstein et al. 2009; Hedges and Olkin 1985; Stanley and Doucouliagos 2012).

To overcome the shortcomings of vote counting, Arnold et al. (2014) calculate weighted averages for a set of 15 different hedging determinants across a sample of 37 primary studies. Contradicting Aretz and Bartram (2010), their main result is that financial distress costs induce firms to hedge. In addition, they find weak evidence that the underinvestment problem and the dependence on costly external financing influence corporate hedging behavior. However, their univariate meta-analysis approach bears an essential caveat, since the computation of mean values across primary studies does not account for interactions between the examined proxy variables. 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). Beyond the threat of biased estimates caused by the assumption of uncorrelated proxy variables, none of the mentioned reviews explores the sources of heterogeneity among the primary studies' results. Hence, explanations for the mixed empirical evidence are still missing. Table 1 illustrates the contribution of this study to the existing literature and especially the two previous reviews on the determinants of corporate hedging.

First, the field of corporate hedging is characterized by its multivariate interrelations (Jackson et al. 2011; Mavridis and Salanti 2013; Nam et al. 2003). For example, in the case of existing corporate taxes, a combination of several influencing factors determines firm value creation through corporate hedging, such as volatility of pre-tax income, convexity of the tax function, and the amount of tax payments. For this reason, we employ the first multivariate meta-analysis in corporate finance research. This approach simultaneously integrates reported results for the fourteen most frequently analyzed hedging determinants based on manually collected data from a sample of 132 primary studies. The data availability from a sufficiently large number of studies allows to apply this multivariate approach, which requires reported estimates for the bivariate relations among all proxy variables. The number of articles included in this study is about three times larger than the samples analyzed by Aretz and Bartram (2010) or Arnold et al. (2014). In this way, we aim to comply with the requirement of any meta-analysis to examine the population of studies available in order to avoid systematic biases due to misspecification and publication selection while incorporating the multidimensional nature of empirical research findings (Stanley and Doucouliagos 2012). Moreover, this comprehensive data set increases the number of observations from different data sources and time periods, which reduces the impact of sampling errors within individual primary studies. In a second type of analysis, we employ meta-regression to explain the heterogeneity among the reported effect estimates by exploring the impact of regional differences, study quality, and observation period on the reported results. Finally, we consider the presence of a potential data mining bias, publication selection bias, and misspecification bias. These aspects have not been investigated in the other reviews on corporate hedging so far.

In summary, our multivariate estimates of the aggregated primary studies' results provide evidence for the bankruptcy and financial distress hypothesis. In this respect, we obtain statistically significant results (at least at a significance level of 5%) for the following proxy variables: dividend yield (positive sign), liquidity

Table 1 Summary of existing quantitative reviews

	This study	Aretz and Bartram (2010)	Arnold et al. (2014)
Data			
No. of studies	132	29	37
No. of observations	700[a]	200/267[b]	211
Literature search process is reported	Yes	No	Yes
Inclusion criteria are reported	Yes	No	Yes
Publication date of sample studies	1993–2015	1983–2009	1993–2011
Inclusion of unpublished studies	Yes	Yes	Yes
Methodology			
Aim of the review	Calculation of mean effect sizes considering the interdependencies among the proxy variables; Analysis of heterogeneity	Overview of reported sign and statistical significance	Calculation of mean effect sizes
Applied method	Multivariate meta-analysis following Becker (1992); meta-regression for analysis of heterogeneity following Stanley and Doucouliagos (2012)	Vote counting	Univariate meta-analysis following Hedges and Olkin (1985)
Effect sizes	Zero-order correlations between proxies and hedging variable	Dummy variables for significant results from univariate and multivariate analyses reported in primary studies	Standardized mean differences calculated from the univariate analyses reported in primary studies
Analyzing and explaining differences in study characteristics (heterogeneity)	Yes	Only separate results for FX and IR hedgers	No
Accounting for publication selection bias	Yes	No	Only graphical analysis
Accounting for data mining bias	Yes	No	No

This table provides an overview of the existing review articles in the corporate hedging literature and compares these reviews with the study at hand.

[a] This number includes only the observations for the correlations between the proxy variables and the binary hedging variable. For a better comparison of the studies, the correlations measuring the interrelations among the proxies are not considered

[b] The number on the left-hand side refers to the observations from univariate primary studies' results and the number of the right-hand side refers to multivariate results

(negative sign), and firm size (positive sign). In addition, we find weak explanatory power for the tax-loss carry forwards variable and the research and development (R&D) proxy (each at a significance level of 10%). This indicates weak support for the corporate tax hypothesis and agency costs of debt argument. Furthermore, we cannot find consistent evidence for the hypothesis that hedging alleviates asymmetric information and agency conflicts between managers and shareholders. Overall, these results differ from Aretz and Bartram (2010) and Arnold et al. (2014), since the former also find evidence for the asymmetric information hypothesis and both reviews identify some support for hedging to be driven by the motivation of firms to avoid agency conflicts of debt. The further analyses reveal that our main findings are robust against data mining bias and publication selection bias. Solely the results for interest coverage ratio, capital expenditure, and R&D seem to be slightly distorted towards reporting stronger and statistically significant results. Moreover, the impact of financial distress costs measured by the corporate leverage ratio are found to be less pronounced for US firms. Finally, the relation between tangible assets and corporate hedging, as well as R&D expenses and hedging decreases over time.

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 presents the search for literature, the data preparation, and descriptive statistics. Section 5 reports our empirical findings, which are discussed in the subsequent Sect. 6. Section 7 concludes.

2 Determinants of corporate hedging

By incorporating capital market imperfections, scholars have developed several hypotheses explaining why hedging at the firm level adds value to shareholders (e.g., Bessembinder 1991; DeMarzo and Duffie 1991; Froot et al. 1993; Smith and Stulz 1985). These theories especially gain in importance due to the increasing volatility in financial markets, in particular foreign exchange rates, interest rates, and commodity prices, which drive a firm’s market value to the extent to which it depends on the development of these risk factors (Rawls and Smithson 1990). Following previous literature (e.g., Aretz and Bartram 2010; Arnold et al. 2014; Guay and Kothari 2003; Kürsten 2006), the theoretical hypotheses can be subsumed under the maximization of shareholder value. Within the shareholder value maximization theory, we review four hypotheses that 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 most of the theoretical arguments are not directly observable, academics make use of proxy variables to test whether firms with properties according to the hedging hypotheses are more likely to hedge. Table 2 sums up our analyzed proxy variables for each of the hypotheses together with the hypothetical signs and variable

Table 2 Summary of proxy variables for the determinants of corporate hedging

Variable	Hyp. sign	Description
Corporate taxes (H1)		
Tax-loss carry forwards	+	Dummy variable that takes a value of '1' if the firm has tax-loss carry forwards available and '0' otherwise
Bankruptcy and financial distress costs (H2)		
Dividend yield	?	Dividend per share (scaled)
Interest coverage ratio	−	(Logarithm of) Earnings before interest and taxes ÷ interest expenses
Leverage ratio	+	Book value of long-term or total debt (scaled)
Liquidity	−	Current assets or cash and cash equivalents (scaled)
Profitability	−	(Logarithm of) Sales or return on assets or EBIT (scaled)
Firm size	+	(Logarithm of) Book value of total assets or market value of the firm
Tangible assets	−	Tangible assets (scaled)
Asymmetric information and agency conflicts of equity (H3)		
Institutional investors	−	Percentage or number of shares held by institutional investors
Option ownership	?	(Logarithm of) Number, percentage or market value of options held by managers or directors
Share ownership	+	(Logarithm of) Number, percentage, or market value of shares held by managers or directors
Coordination of financing and investment policy and agency conflicts of debt (H4)		
Capex	+	Capital expenditures (scaled)
R&D expenses	+	Research and development expenses (scaled)
Tobin's Q	+	(Logarithm of) Market value of firm ÷ book value of total assets

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 variable 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.

definitions. As these variables are the standard proxies examined in the majority of the hedging literature, we do not further discuss them. Excellent discussions of the proxy variables are provided, among others, by Bartram et al. (2009), Géczy et al. (1997), or Haushalter (2000).

2.1 Corporate taxes

Mayers and Smith (1982) as well as 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 the 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, which we test by tax-loss carry forwards as proxy variable:

H1: Firms use corporate hedging as an instrument to profit from tax advantages.

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 (Rawls and Smithson 1990). This increases the risk of bankruptcy and the firm might encounter direct and indirect costs of financial distress (Jensen and Meckling 1976). Since corporate hedging lowers cash flow volatility and therefore also the default probability, it reduces expected costs of financial distress and adds value to the firm (Brown and Toft 2002; Hahnenstein and Röder 2003; Smith and Stulz 1985; Stulz 1996). Thus, we receive the following hypothesis H2, which we test by dividend yield, interest coverage ratio, leverage ratio, liquidity, profitability, firm size, and tangible assets as proxy variables:

H2: Firms use corporate hedging as an instrument to reduce the risk of bankruptcy and financial distress costs.

2.3 Asymmetric information and agency conflicts of equity[1]

DeMarzo and Duffie (1991, 1995) show that information asymmetries can arise from a manager's proprietary information on the firm's dividend stream. Due to preferred managerial access to corporate information, shareholders cannot fully replicate the firm's hedging decision. Accordingly, under information asymmetry firms can hedge more effectively than its shareholders. Such informational asymmetries may result from high expenses for disseminating necessary information to the shareholders, whereby the costs increase with firm complexity (Dolde and Mishra 2007), or from protecting information transmission to competitors (Marshall and Weetman 2007). By reducing the variability of the corporate cash flow and thus lowering the noise in the firm's dividend stream, hedging can be used as an instrument to overcome informational asymmetries between shareholders and managers. Hence, we receive the following hypothesis H3, which we test by institutional investors, option ownership, and share ownership as proxy variables:

H3: Firms use corporate hedging to reduce information asymmetry and to mitigate agency conflicts of equity.

2.4 Coordination of financing and investment policy and agency conflicts of debt

High leverage and a low present value of the firm may give rise to the following agency conflicts of debt, because under these conditions managers may have

[1] 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.

incentives to transfer wealth from bondholders to shareholders. First, managers may forego positive net present value projects if the expected project gains are required 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 the bondholders. 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 instrument to coordinate the availability of internal funds. Secondly, managers acting in the best interest of shareholders may give rise to asset substitution by replacing low-risk assets with high-risk investments (Smith and Warner 1979). This is because shareholders' equity positions are a call option on the company's assets, and high variance projects enlarge option value (Mason and Merton 1985). However, for fixed payment receivers this exchange of assets raises additional risk. Hence, bondholders anticipating the opportunistic behavior of management claim higher returns or protective bond covenants, due to 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) additionally contribute that also credible commitments to hedge (for example, obligated hedging of interest rate risks via debt covenants) reduce agency costs of debt by lowering the incentive to asset substitution. Thus, we receive the following hypothesis H4, which we test by capital expenditures, R&D expenses, and Tobin's Q as proxy variables:

H4: Firms use corporate hedging as an instrument to coordinate investment and financing policies and to mitigate agency conflicts of debt.

3 Methodology of multivariate meta-analysis

The objective of this multivariate meta-analysis is to comprehensively test the hedging determinants on an aggregated empirical level across a broad set of primary studies. In detail, we investigate the relationship between fourteen proxy variables and the corporate hedging behavior, which is modeled as a dummy variable that is equal to one for hedgers and zero otherwise.[2] As effect size measure for this relationship we use the Pearson correlation coefficient between each proxy variable j ($j = 1, \ldots, p$) and the hedging variable reported in study i ($i = 1, \ldots, k$).

[2] 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 usually not 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 reliable results.

Due to the multidimensional behavior of the firm characteristics used as proxy variables for the hedging hypotheses, primary studies on corporate hedging usually test their hypotheses through multivariate analyses. These interrelations must be considered on a meta-level as well. Thus, in addition to p correlations between the hedging variable and each proxy variable, correlations among the proxy variables must also be incorporated in the aggregation. In the case that all proxy variables are investigated in each primary study, we extract $p^* = p(p-1)/2$ correlations from each study of interest. As the variance of the raw correlations 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.

Using this correlational data as input, meta-analysis aims to derive the best effect estimate for the unknown population correlation by calculating a weighted mean effect across all observations from the sample studies. For the estimation of the mean effect, we use a generalized least squares (GLS) estimator to derive the z-transformed mean correlation vector (Raudenbush 1988)

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

Here, $\hat{z}$ is a $p^* \times 1$ column vector containing 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. The weighting matrix $\boldsymbol{S}$ is a $kp^* \times kp^*$ 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 $kp^* \times 1$ column vector storing the observed effect sizes p^* from all k studies.

In the matrix $\boldsymbol{S}_i$, the diagonal elements capture the study-specific effect size variation and the off-diagonal elements are the estimated covariances[3] among the effect sizes. The effect-specific value T_j^2 define the $p^* \times p^*$-matrix $\boldsymbol{T}^2$. As T_j^2 is unknown, we apply a method of moments estimator (DerSimonian and Laird 1986). The weights are calculated by adding $\boldsymbol{T}^2$ to each study-specific covariance-matrix $\boldsymbol{S}_i$. This weighting scheme assigns higher weights to more precise studies. Furthermore, T_j^2 explicitly models the fact that the true population effect for a certain relation is not unique, but varies across primary studies (between-study variation). Hence, this parameter captures unobserved heterogeneity among the reported effect sizes. A model that includes an estimate for the between-study variance is commonly referred to as random effects model. In contrast, a fixed effects meta-analysis model would assume that all studies share a common population effect (Borenstein et al. 2009), which is indeed hard to justify as our sample includes studies from different countries and time periods.[4] Obviously, there might not be a single true effect underlying all studies in the sample. To verify the assumption of random effects, we conduct Cochran's Q-test.

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

[4] Note that the 'fixed' and 'random' effects estimators in meta-analysis do not correspond to the standard use of these terms in panel data econometrics.

Next, we use the estimated mean correlations $\hat{z}$ from Eq. (1) to estimate a 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 according to Becker (2009):

$$b = \boldsymbol{R}_{XX}^{-1}\boldsymbol{R}_{XY}, \tag{2}$$

with b as a $p \times 1$ vector of standardized regression coefficients, and $\boldsymbol{R}$ as the GLS estimator $\hat{z}$ from Eq. (1), which is 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 capturing the correlations among the proxy variables. Accordingly, b estimates the average impacts of the proxy variables on the corporate hedging decision, while accounting for dependencies among the proxies.

4 Data

We employ a comprehensive literature search to identify the full body of empirical studies examining the determinants of corporate hedging. Our search process consists of the following six steps[5]: definition of the inclusion criteria, search in electronic databases for published literature, search for gray literature, backward search, search in authors' publication lists, and forward search. To comply with the requirements of a high-quality review, we follow the Cochrane Handbook for Systematic Reviews of Interventions as a general framework for the literature search and the subsequent meta-analysis (Higgins and Green 2011).

4.1 Inclusion criteria

We consider only studies investigating non-financial firms because companies from the financial sector do not necessarily 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. Moreover, the hedging proxy must be modeled as a dummy variable in the primary studies. Additionally, we focus on studies meeting the following criteria, which are constitutive elements for the conduction of a multivariate meta-analysis: (1) the correlation coefficient between the proxies and the hedging dummy should either be directly reported in the study, or otherwise should be computable from the reported descriptive statistics[6] (e.g., t-statistic from a test of independent groups or standardized mean difference between hedgers and non-hedgers). If there is no sufficient data available, the authors must provide us the

[5] A summary of the literature search process can be found in Online Appendix A.

[6] The conversion of standardized mean differences into correlations is presented in Borenstein et al. (2009).

required effect size data to be included in the analysis.[7] (2) The study's sample size must be extractable to calculate the effect size variation and hence the study weights. (3) The correlations among the proxy variables have to be stated in the primary study. However, this is not a necessary requirement to be included, because the direct effects between the hedging dummy and the proxies also carry useful information for multivariate meta-analysis.[8]

4.2 Search strategy

We searched in four major electronic databases (ABI/INFORM Complete, Business Source Premier, EconBiz, ScienceDirect) by adopting the same search command used by Arnold et al. (2014).[9] For each study, the title, abstract, and the content were screened with regard to the inclusion criteria. In summary, we reached a total number of 2,790 studies identified by the search command. After sorting the results by the inclusion criteria, we cut the sample to 67 relevant studies.

In the next step, we explicitly searched for gray literature. 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 six relevant studies in the Dissertations and Theses database (ProQuest).

In the following step, we performed a backward search by screening the reference lists of the 91 studies identified as relevant after the search in the electronic 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 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 meeting the inclusion criteria—with 54 of them providing full correlation matrices for the hedging dummy and the other proxy variables, 69 studies reporting at least the direct effects between the proxy variables and the hedging dummy, and 44 studies with none of the required data published.[10] Finally, we sent a study-specific request mail to the authors of all studies with missing data.[11] In response, 12 authors provided us with additional data. As common in meta-analysis, we treat studies as independent, if the same authors use different data sets or different authors use the same data set (Hunter and Schmidt 2004; Stanley and Doucouliagos

[7] We sent an email request to all authors of studies with missing data.

[8] If none of the studies would provide correlations between the proxies, the multivariate analysis equals the univariate analysis.

[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 A.

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

[11] We sent a request email and two weeks later a reminder email to the authors of 113 studies with missing data. 10.62% of the contacted authors delivered additional data. 22.12% rejected to provide us with the correlational data from their study, and the remaining 67.26% did not reply to our request.

2012). In this regard, we had to exclude 3 studies due to insufficient data or dependencies in the sample.[12] Consequently, our final sample consists of 132 primary studies.[13] From this pool of studies, we manually collected 1,627 Pearson correlation coefficients covering the relation between the fourteen hedging determinants and the hedging dummy variable as well as the interactions among the hedging determinants.

4.3 Data preparation

A requirement for the feasibility of multivariate meta-analysis is the estimation of the complete correlation matrix between the proxy variables and the hedging dummy. Thus, we consider all proxies for which the correlation with other variables is reported in at least one study. As several of these correlations are not given in any of the primary studies, we focus on the fourteen most frequently examined hedging determinants (see Table 2).

As sample size for the hedgers and non-hedgers group we use the number of firms investigated in the primary study instead of the firm year observations.[14] In some studies, we had to apply the following adjustments. First, 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 this case, we changed the sign of the correlations. Second, some studies report the reciprocal value of the proxy variables (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 according to Borenstein et al. (2009).

4.4 Descriptive statistics

Figure 1 depicts the distribution of the primary studies' data samples across time and geographical regions (each observation refers to one study).

The sample distribution over time indicates that the observed empirical effects cover a long time horizon of more than 20 years, whereas the majority of observations falls into the period between 1990 and 2009. In total, about a third of the estimates is based on firm data from a single year, while the remaining part of studies examines more than one year. The regional distribution of the collected

[12] If studies use an identical sample of firms, we use each proxy variable from this sample only once. Beside the studies from Bartram (Bartram et al. 2009; Bartram et al. 2011; Bartram Bartram 2015) and Lin et al. (Lin et al. 2007, 2010), the studies from Nguyen and Faff (Nguyen and Faff 2002, 2006, 2007, 2010) are based on the same data sample. As the studies by Nguyen and Faff additionally investigate similar variables, we had to exclude Nguyen and Faff (2006) and Nguyen and Faff (2010) from our sample.

[13] The studies are listed in Online Appendix B together with the study characteristics. The corresponding references are listed in Online Appendix C.

[14] If 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.

estimates reveals a dominance of North American studies (45%) in the corporate hedging literature. Nevertheless, more than half of the observations is based on data from other geographical regions, especially from Europe (25%) and the Pacific (11%). Consequently, there is a certain proportion of studies investigating firms from the same country and identical or overlapping time periods (e.g., US studies commonly examine S&P 500 firms).[15] Therefore, effect sizes might be related across studies if different authors use similar data sets. This issue cannot be fully accounted by the multivariate meta-analysis approach. However, the wide distribution across time weakens the threat of non-independent study results. Moreover, we address the issue in our analysis of heterogeneity, where we explicitly account for these two levels of data dependencies (across countries and time) in our estimation method.

Table 3 reports further descriptive statistics regarding the publication quality and the number of firms investigated in the primary studies.

In total, the study sample comprises 73,387 firm observations with 52.50% hedging and 47.50% non-hedging firms. This sample includes 70.45% published articles and 29.55% unpublished working papers, doctoral dissertations and conference proceedings. The study quality measured by the journal ranking of the German Academic Association for Business Research (VHB) indicates that about a third of the observations is extracted from leading and important business research journals. As an alternative, the Scientific Journal Ranking (SJR) reveals a similar distribution when dividing the sample into journals having a SJR ranking above (below) 1. Therefore, it appears discussable why considering a large proportion of low-quality studies in our meta-analysis. We explicitly include these studies in the sample due to the following reasons. First, the inclusion of unpublished and low-quality studies leads to a broader and more comprehensive sample covering multiple countries and time periods. This approach significantly enhances the power of our meta-analytical findings (Whiston and Li 2011). As the exclusion of the studies dramatically reduces our sample, it would not be possible to conduct multivariate meta-analysis for all fourteen proxy variables. Second, we explicitly account for study quality in our analysis. Within the multivariate meta-analysis, the weighting approach (see matrix $\boldsymbol{S}_i$ in Eq. 1) is based on the within-study variation, i.e. observations from low-quality studies with small sample sizes and thus larger variation in their estimates receive a lower weight in the analysis. Third, excluding unpublished studies would reduce the observed time period, as new studies that might not have gone through the referee process would be excluded. Moreover, 'low-quality' studies often focus on firms from other countries than the US. Excluding these articles would lead to a strong country-level clustering in our observations because a larger fraction of findings would refer to US firms. Fourth, we conduct a robustness tests via meta-regression analysis, which explicitly models the impact of publication quality on the reported results.

[15] This is mostly driven by the better availability of corporate hedging data for large firms.

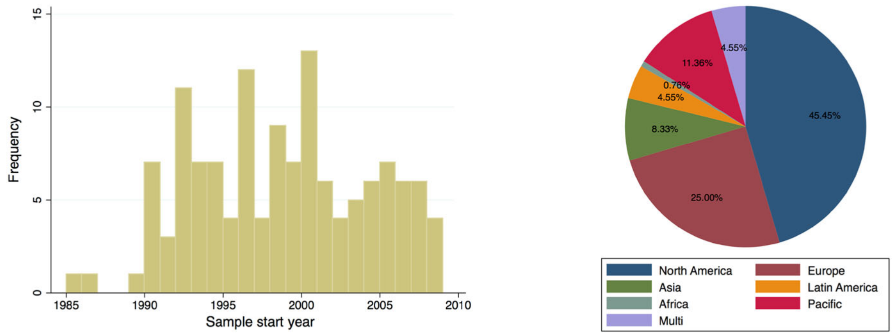

Fig. 1 Distribution of sample observations over time and over world regions. The plot in the left column shows the distribution of the sample start year of each study included in the sample. The pie graph in the right column depicts the distribution of the countries covered by the primary studies. 'Multi' refers to studies examining more than one country.

Table 3 Sample description

Criteria	Statistic
No. of firms investigated in the primary studies	
Minimum	17
Maximum	7,319
Mean	556
Standard deviation	1,155
Total number of firms	73,387
Proportion of hedging firms (non-hedging firms)	52.50% (47.50%)
Publication type and study quality	
Published studies (unpublished studies)	70.45% (29.55%)
VHB-JOURQUAL 3 ranking A+, A, or B (ranking C or not ranked)	31.82% (68.18%)
SJR ranking above 1.0 (SJR ranking equal to or below 1.0)	36.36% (63.64%)

This table presents descriptive statistics regarding the number of firms examined in the primary studies and the publication characteristics

5 Empirical results

We aggregate the reported effects for the hedging determinants across our sample of 132 primary studies using multivariate meta-analysis.[16] In the following section, we first address the issue of between-study variation 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 hedging hypotheses. For each proxy variable we examine the null hypothesis of no relationship with the

[16] Please refer to Online Appendix D for the results from vote counting following the approach by Aretz and Bartram (2010) and univariate analysis following Arnold et al. (2014).

hedging dummy variable. Further, we describe the findings from the analysis of heterogeneity. Therein, we test for the impact of study quality, time effects, and regional differences. Moreover, we explicitly analyze potential biases through data mining or publication selection at the end of this section.

5.1 Multivariate meta-analysis

For the correct specification of the multivariate model, one main aspect of meta-analysis is the detection and consideration of between-study variation. As the effect sizes are collected from studies examining data from different countries and time periods, it would be problematic to assume that there is one single underlying population effect across all studies in our sample (Borenstein et al. 2009; Card 2012; Lipsey and Wilson 2001). In the case of heterogeneity, the effect size variation is not only driven by sampling error but also by variation between studies. For example, country-specific regulation or firm characteristics influence the true effect size, although the initial decision to hedge is the same. The Cochran's Q-test is a commonly applied test for heterogeneity in meta-analysis that measures the excess variation beyond sampling error. The Q-test results in a test statistic of 41,056,[17] which obviously leads to a rejection of the null hypothesis of homogenous effect sizes at all common significance levels. We consider this aspect of heterogeneous effect sizes by applying random effects estimation, which explicitly accounts for the between-study variation.

The estimates of the linear model estimated by multivariate meta-analysis are displayed in Table 4.[18] Regarding the corporate tax hypothesis (H1), the results reveal weak empirical evidence. The aggregated effect for tax-loss carry forwards is 0.0711 and slightly significant at the 10% level (p-value is 0.0956). The positive sign of the estimate indicates that hedging companies can better time the use of tax-loss carry forwards, which results from the reduction in cash flow volatility hedging. This leads to an increase in the present value of tax preference items (Géczy et al. 1997).

The proxy variables used to test the bankruptcy and financial distress costs hypothesis (H2) show high significance levels for the influence of dividend yield ($b = 0.0741$, $p = 0.0202$), liquidity ($b = -0.0893$, $p = 0.0108$), and firm size ($b = 0.2148$, $p = 0.0002$). The estimate for firm size is the dominating effect in terms of statistical and economic significance. The positive sign of the size effect provides evidence that economies of scale are highly relevant for hedging firms. The finding that more liquid firms tend to hedge more is in line with theoretical predictions that financial liquidity enables greater flexibility in meeting financial requirements, which helps to mitigate financial distress costs. Consequentially, cash management can help to build a financial buffer acting as a substitute for hedging (Géczy et al. 1997). Moreover, the results show that corporate dividend policy

[17] The test statistic is approximately Chi-squared distributed with 1,522 degrees of freedom.

[18] The corresponding random effects mean correlation matrix calculated by Eq. (1) (which serves as input for the linear model) can be found in Online Appendix E.

influences corporate hedging behavior. The positive aggregated effect for dividend yield can be explained by the fact that higher dividend payments lower the availability of internal funds required for payments to fixed claimholders, which leads to raising expected costs of financial distress (Nance et al. 1993). In addition, Kalay (1982) argues that higher dividend payouts introduce underinvestment problems and associated costs occurring from agency conflicts between shareholders and bondholders. Therefore, firms offering higher dividend payments to their shareholders have more incentives to engage in hedging to avoid distress costs and underinvestment problems. The findings for liquidity and dividend yield also pronounce the important interactions between hedging and other corporate financial decision, namely cash management and dividend policy.

Regarding the coordination of financing and investment policy and agency conflicts of debt hypothesis (H4), the results show ambiguous empirical evidence. The estimated mean effects reveal a positive relation between R&D expenses and corporate hedging, which confirms the hypothesized direction ($b = 0.092,\ p = 0.0541$). As R&D expenses measure the availability of growth options in a firm's investment opportunity set, firms with greater R&D expenses can benefit more from the risk reduction of corporate hedging through lower risk of underinvestment problems and associated agency costs (Choi et al. 2013). In addition, neither capital expenditures for property, plant and investment, nor Tobin's Q show significant results at any conventional levels.

5.2 Further analyses

To verify the robustness of our multivariate results, we perform two groups of additional tests: (1) investigation of data mining bias, (2) analysis of publication bias and exploration of heterogeneity.

5.3 Data mining bias

First, we account for the fact that primary studies use different definitions for the examined proxy variables. Due to the large amount of emerging primary studies, this effect is even amplified. By using the testing methodology developed by Harvey et al. (2016), we consider the so-called data mining bias. In this manner, we account for the fact that various alternative variable definitions are used for the proxy variables. This large variety of definitions might by reasoned by an opportunistic behavior of researchers to favor certain findings. The corresponding results of the test are displayed in Table 5.

As an assumption for this test, we suppose that authors select the variable definitions of the proxies to reach significant results. This means, the larger the variety of different variable definitions for the same proxy variable, the higher the risk of biased primary studies' results driven by data-mining activities. To control for an overestimation of the multivariate effects arising from data-mining, we have to accommodate the test statistics of our results. Therefore, we calculate an adjusted 5% significance level for each proxy variable to get a more conservative limit. In the case of a high number of different variable definitions in relation to the number of

Table 4 Statistical results from multivariate meta-analysis

Proxy variable	Hyp. sign	No. of firms	b	SE(b)	p-value
Corporate taxes (H1)					
Tax-loss carry forwards	+	12,529	0.0711	0.0427	0.0956*
Bankruptcy and financial distress costs (H2)					
Dividend yield	?	17,038	0.0741	0.0319	0.0202**
Interest coverage ratio	−	16,187	−0.0127	0.0404	0.7530
Leverage ratio	+	51,866	0.0302	0.0269	0.2607
Liquidity	−	33,767	−0.0893	0.0350	0.0108**
Profitability	−	33,308	0.0751	0.0604	0.2135
Firm size	+	52,667	0.2148	0.0574	0.0002***
Tangible assets	−	11,938	0.0715	0.0611	0.2425
Asymmetric information and agency conflicts of equity (H3)					
Institutional investors	−	18,040	0.0869	0.0559	0.1203
Option ownership	?	13,026	−0.0279	0.0442	0.5275
Share ownership	+	13,643	−0.0421	0.0335	0.2091
Coordination of financing and investment policy and agency conflicts of debt (H4)					
Capex	+	25,482	−0.0263	0.0262	0.3169
R&D expenses	+	28,770	0.0910	0.0472	0.0541*
Tobin's Q	+	38,937	0.0433	0.0327	0.1856

This table shows the results for the proxy variables used to test the corporate hedging hypotheses in a multivariate meta-analysis. 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 $b_i = 0$.

*, ** and *** indicate the rejection of the null hypotheses at the 10, 5, and 1% probability levels.

effect size observations, the probability level is diminished in order to provide a more conservative significance level. For example, the significance level for dividend yield decreases from 5 to 2.17%. In some cases, the variable definitions are quite consistent across the sample of effect sizes, which leads to an increasing probability level (larger than 5%). For a conservative estimation, we leave these probability levels at 5% instead of increasing them as, for example, in the case of tax-loss carry forwards. As a result from this robustness test, it appears that our strongly significant findings are not affected by data mining bias as these estimates are still significant even when applying the more conservative, adjusted significance levels. For example, in the case of dividend yield, the 5% significance level is adjusted to 2.17%, due to 7 different variable definitions used in 41 studies. However, the estimated p-value for dividend yield ($p = 0.0202$) is still significant at the adjusted significance level. The same conclusions hold for liquidity and firm size.

Table 5 Results of the robustness test for data mining bias

Proxy variable	Number of different variable operationalizations in the primary studies[a]	Hyp. sign	Multivariate results		Multivariate results based on adjusted 5% significance levels	
			Emp. sign	p-value	Adjusted 5% significance levels $a(PF) = 0.05$[b]	p-value
Corporate taxes (H1)						
Tax-loss carry forwards	1 definition in 18 studies	+	+	0.0956*	0.0500	0.0956
Bankruptcy and financial distress costs (H2)						
Dividend yield	7 definitions in 41 studies	?	+	0.0202**	0.0217	0.0202**
Interest coverage ratio	5 definitions in 30 studies	–	–	0.7530	0.0361	0.7530
Leverage ratio	9 definitions in 108 studies	+	+	0.2607	0.0401	0.2607
Liquidity	6 definitions in 72 studies	–	–	0.0108**	0.0500	0.0108**
Profitability	8 definitions in 68 studies	–	+	0.2135	0.0387	0.2135
Firm size	7 definitions in 115 studies	+	+	0.0002***	0.0500	0.0002**
Tangible assets	3 definitions in 11 studies	–	+	0.2425	0.0302	0.2425
Asymmetric information and agency conflicts of equity (H3)						
Institutional investors	5 definitions in 22 studies	–	+	0.1203	0.0242	0.1203
Option ownership	7 definitions in 19 studies	?	–	0.5275	0.0087	0.5275
Share ownership	6 definitions in 44 studies	+	–	0.2091	0.0352	0.2091
Coordination of financing and investment policy and agency conflicts of debt (H4)						
Capex	5 definitions in 35 studies	+	–	0.3169	0.0420	0.3169
R&D expenses	3 definitions in 37 studies	+	+	0.0541*	0.0500	0.0541

Table 5 continued

Proxy variable	Number of different variable operationalizations in the primary studies[a]	Hyp. sign	Multivariate results		Multivariate results based on adjusted 5% significance levels	
			Emp. sign	p-value	Adjusted 5% significance levels $a(\mathrm{PF}) = 0.05$[b]	p-value
Tobin's Q	3 definitions in 79 studies	+	+	0.1856	0.0500	0.1856

This table shows the results of the data mining test. The second column contains the number of different variable operationalizations that we aggregated in our proxy variable definitions. The following column includes their hypothetical sign for the impact on the corporate hedging decision. Beside, the results (empirical signs and p-values) revealed from multivariate meta-analysis are presented, followed by the results using adjusted p-values to test the presence of data mining bias.

[a] If one study uses several variations for a specific proxy variable, we considered only 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 usage of different variable definitions and the possible data mining bias, we adjusted the p-values similar to Harvey et al. (2016). 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 the error probability in a single test. However, in this connection we had to account for two issues (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 $a(\mathrm{PF})$ of making as least one type I error, which depends on the probability of making a type I error $a(\mathrm{PT})$, when only dealing with a specific test. Consequently, the adjusted probabilities can be expressed as follows: $a(\mathrm{PT}) = 1 - (1 - a(\mathrm{PF}))^{\frac{\mathrm{ns}}{\mathrm{nv}}}$. In the case that $\mathrm{ns} = \mathrm{nv}$, there is no probability adjustment, because both effects equalize. In the other case ($\mathrm{ns} < \mathrm{nv}$), following Harvey et al. (2016), different studies applying different definitions lead to similar results. 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 = reject the null hypothesis; 1 = accept the null hypothesis). Due to the fact that we use a binary variable, the correlation coefficient can be easily calculated and comprises the complete dependence structure of the variables [in our case, a refers to $a(\mathrm{PF})$]

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

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

$$a_{\mathrm{joint}} = 1 - \mathrm{Korr}\Big((1-a) - (1-a)^2\Big) + -(1-a)^2.$$

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

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

A look at the different studies shows a high dependency between the p-values of different studies having the same variable definition. Hence, we decided to use a high correlation $\mathrm{Korr} = 0.8$ in order to adjust for the correlation effect. Only those values were depicted, for which $a(\mathrm{PT}) < 0.05$

*, ** and *** indicate the rejection of the null hypotheses at the 10, 5, and 1% probability levels.

5.4 Publication bias and analysis of heterogeneity

In this section, we test the heterogeneity of our dataset using a similar approach as presented by Carney et al. (2011). Consequently, we analyze and control for systematic differences in the reported effect sizes via multiple meta-regression analysis following recent publications in economics and finance (among others, Carney et al. 2011; Feld et al. 2013; Hang et al. 2017; Havranek and Irsova 2011). This step should serve as a verification that the aggregation of reported results in the multivariate meta-analysis is appropriate. Analogous to the work of Carney et al. (2011), this procedure especially allows us to examine the impact of overlapping firms and time periods in our sample.

As dependent variable in the meta-regression, we investigate the effect size estimates measuring the direct effect of the proxy variable on the hedging dummy variable. For each effect size, we consider the impact of study quality, observation period, regional effects, and publication bias as explanatory variables in a regression model. In this regard, the number of citations is calculated as the logarithm of [(Google Scholar citations)/(age of the study) + 1].[19] The number of citations is chosen as a criteria for study quality, as it considers study-specific quality characteristics and is available for all studies including unpublished papers. Second, to consider potential temporal variations due to regulatory changes or the development of financial markets, the mean observation year of each primary study sample is integrated in the analysis. Third, as a remarkable part of literature examines hedging data from US firms, we include a dummy variable that indicates whether a study uses data from North America (=1 for North America studies, zero otherwise).

Finally, we investigate the existence of a potential publication selection bias in the reported results. Publication selection arises when researchers favor results based on their statistical significance or because they are consistent with the majority of literature (Card and Krueger 1995). This biasing effect may distort statistical inferences and especially averaged effects from meta-analysis. As commonly included in meta-regression analysis research, our model consequently contains the standard deviation of the effect sizes (v) as explanatory variable (Doucouliagos and Laroche 2009; Stanley 2004). A significant regression coefficient for the effect size's standard error would imply that positive (negative) outcomes are more frequently reported than negative (positive) ones, due to a subjective selection of results (Stanley and Doucouliagos 2012). This test procedure follows the idea of the Egger's test (Egger et al. 1997). Overall, the general meta-regression model can be formularized as

$$z_{ij} = \beta_0 + \beta_1 v + \beta_2 \text{Citations} + \beta_3 \text{North America} + \beta_4 \text{ Mean year} + \varepsilon_{ij} \quad (3)$$

with the error term following a normal distribution with an expected value of zero and a variance set to the variance of the effect sizes according to

[19] The number of citations was collected on January 13, 2017.

$$\varepsilon_{ij} \sim N(0; v_{ij}^2). \quad (4)$$

The estimated regression coefficients $\beta_{1,\ldots,4}$ measure the explanatory power of the independent variables for the variation of the z-transformed correlation coefficients. Thus, they indicate whether a certain variable systematically influences the reported results. For example, a significant positive effect for β_3 could be interpreted as finding that studies with US data, on average, report larger effects for a certain hedging determinant than non-US studies.

Table 6 reports the results for the meta-regression model including the four explanatory variables.

The results in Table 6 show that the explanatory variables do not reveal a significant pattern across the various determinants of corporate hedging.[20] For the standard deviation as a test for publication bias, we observe significant values for interest coverage ratio with a coefficient of 1.8619, for capital expenditure with a coefficient of −1.1952, and for R&D with a coefficient of 1.7484, all significant at 5%. This finding allows us to conclude that the reported effect sizes tend to be biased in the way that authors favor to report positive effects for interest coverage ratio and R&D, and to report negative effects for Capex. Nevertheless, our main conclusions for tax-loss carry forwards, dividend yield, liquidity, and size are not distorted by selective reporting.

Moreover, we find no explanatory power for the number of study citations. This indicates that study quality captured by the number of citations has no systematic impact on the reported results. Furthermore, for the North America dummy, the results reveal a significant effect for leverage at the 5% level ($\beta_3^{\text{Leverage}} = -0.1375$). This means that the relation between capital structure and corporate hedging is diminished in North America studies compared to studies examined firm data from the rest of the world, where the effect tends to be more in line with the hypothesized positive sign. Additionally, we reveal significant temporal differences at the 5% level for tangible assets with a coefficient of −0.0679 and R&D with a coefficient of −0.0112. According to the empirical signs derived from multivariate analysis, the impact of tangible assets on the decision to hedge becomes less apparent over time. Furthermore, studies covering more recent data tend to report lower effect sizes for R&D expenses.

6 Discussion

In this section, we first compare our main results with the ten leading primary studies included in our sample.[21] These studies are Allayannis and Weston (2001), Campello et al. (2011), Choi et al. (2015), Donohoe (2015), Géczy et al. (1997), Jin and Jorion (2006), Nance et al. (1993), Pérez-González and Yun (2013), Pincus and

[20] In addition to a mixed effects multilevel model as displayed in Table 6, we also applied a simple ordinary least squares model as shown in Online Appendix F. Overall, both models show quite similar results.

[21] For the selection of studies we used the VHB-JOURQUAL3 and incorporate studies, which are classified as A +.

Table 6 Results of the robustness test for systematic differences in the heterogeneity of effect sizes

Hypothesis	Taxes (H1)	Bankruptcy and financial distress costs (H2)						
Dep. variable/ effect size	Tax-loss carry-forwards	Dividend yield	Interest coverage ratio	Leverage ratio	Liquidity	Profitability	Firm size	Tangible assets
Hyp. sign	+	?	–	+	–	–	+	–
This study	+*	+**	–	+	–**	+	+***	+
Intercept	0.0120 (0.08)	0.2117 (1.64)	–0.1355 (–0.91)	0.2319** (2.57)	–0.1147 (–0.78)	0.1593 (1.04)	0.3181* (1.86)	0.6392*** (2.60)
v	1.0863 (1.06)	–1.1137 (–1.37)	1.8619** (2.01)	–0.4779 (–0.92)	–0.5823 (–0.95)	0.3538 (0.49)	–0.1855 (–0.26)	2.4189 (1.64)
Citations	0.0056 (0.15)	0.0082 (0.22)	–0.0224 (–0.51)	–0.0052 (–0.19)	0.0194 (0.46)	0.0386 (0.91)	0.0074 (0.17)	–0.0300 (–0.57)
North America	–0.0505 (–0.71)	–0.0917 (–1.04)	0.0194 (0.24)	–0.1375** (–2.33)	0.0639 (0.42)	–0.1522 (–0.74)	–0.0886 (–0.43)	–0.0844 (–0.41)
Mean year	0.0002 (0.03)	0.0041 (0.44)	0.0014 (0.13)	–0.0096 (–1.57)	–0.0002 (–0.01)	–0.0010 (–0.12)	0.0008 (0.07)	–0.0679*** (–3.74)
Observations	18	41	30	108	72	68	115	11

Hypothesis	Asymmetric information and agency conflicts of equity (H3)			Coordination of financing and investment policy and agency conflicts of debt (H4)		
Dep. variable/ effect size	Institutional investors	Option ownership	Share ownership	Capex	R&D expenses	Tobin's Q
Hyp. sign	–	?	+	+	+	+
This study	+	–	–	–	+*	+
Intercept	0.3565* (1.94)	–0.0415 (–0.35)	–0.0907 (–0.79)	0.1022 (1.14)	–0.0517 (–0.54)	0.0288 (0.32)
v	–1.1190 (–1.19)	0.7877* (1.70)	0.9188 (1.36)	–1.1952** (–2.26)	1.7484** (1.97)	0.0077 (0.01)
Citations	–0.0543 (–1.22)	0.0427* (1.70)	0.0340 (0.90)	–0.0153 (–0.63)	0.0171 (0.70)	0.0101 (0.37)
North America	0.0369 (0.29)	–0.0313 (–0.38)	–0.0839 (–1.07)	0.0271 (0.53)	0.0775 (1.36)	0.0407 (0.74)
Mean year	–0.0167 (–1.09)	–0.0086 (–0.87)	–0.0118 (–1.39)	–0.0036 (–0.71)	–0.0112** (–2.02)	–0.0039 (–0.68)

Table 6 continued

Hypothesis	Asymmetric information and agency conflicts of equity (H3)			Coordination of financing and investment policy and agency conflicts of debt (H4)		
Dep. variable/ effect size	Institutional investors	Option ownership	Share ownership	Capex	R&D expenses	Tobin's Q
Observations	22	19	44	35	37	80

This table presents the results of the meta-regression analysis. This approach allows the inspection of systematic variation in the effect sizes. As dependent variable, we use the z-transformed effect sizes measuring the direct influences of each proxy variable on the hedging dummy variable. As independent variables, we use explanatory variables representing study quality, observation period, regional effects, and publication bias. In this regard, the number of citations is calculated as the logarithm of [(Google Scholar citations)/(age of the study) + 1]. The number of citations was collected on January 13, 2017. The number of citations is preferred, as it considers study-specific quality characteristics and it is available for each study, including unpublished works. As a remarkable part of literature examines hedging data from US firms, we include a dummy variable that indicates whether a study uses US data (=1 for US studies, 0 otherwise). To consider potential temporal variation due to regulatory changes or the development of financial markets, the mean observation year of a sample is integrated in the analysis. Finally, we investigate the existence of a potential publication selection bias in the reported results. As commonly included in meta-regression analysis research, our model contains the standard deviation of the effect size (v) as explanatory variable. The estimated regression model in general terms corresponds to

$$z_{ij} = \beta_0 + \beta_1 v_{ij} + \beta_2 \text{Citations}_i + \beta_3 \text{North America (binary)}_i + \beta_4 \text{ Mean year}_{ij} + \varepsilon_{ij}, \quad \varepsilon_{ij} \sim N(0; v_{ij}^2).$$

We estimate this model by a multilevel mixed-effects regression with country and time level effects. This estimation procedure controls for data dependencies between firm observations from the same country and the same decade. The table shows the regression coefficients, with the corresponding t-statistics reported in brackets below

*, ** and *** indicate the rejection of the null hypotheses at the 10, 5, and 1% probability levels

Rajgopal (2002), Tufano (1996), which can be seen as representatives of the empirical literature in this field of research. The studies cover firm data for the time period from 1993 to 2015. Furthermore, we compare the results with the existing (univariate) reviews by Aretz and Bartram (2010) and Arnold et al. (2014). The univariate results reported in these studies are contrasted with the findings of our multivariate meta-analysis as outlined in Table 7.

For the corporate tax hypothesis (H1), we are generally in line with existing literature. All studies in our comparison testing this variable do not find a strongly significant effect.

The bankruptcy and financial distress costs hypothesis (H2) represents the most frequently confirmed hedging hypothesis. For dividend yield, our finding of a positive effect is also confirmed by two of five primary studies as well as by Arnold et al. (2014). For leverage, five of ten primary studies and the two reviews state a significantly positive effect. In this case, our estimates contradict with the majority of studies. These deviations might be driven by a notable endogeneity between capital structure and the decision to hedge, as corporate hedging might also be seen as the starting point of the capital structure decision (Bartram et al. 2009; Lin and Smith 2007; Lin et al. 2008). For liquidity, we reveal a negative association with the decision to hedge, which is only in line with the findings reported in Pincus and Rajgopal (2002) and the two previous reviews. The other studies do not find a significant effect for this hedging determinant.

For the asymmetric information and agency conflicts of equity hypothesis (H3) the picture is the same as for the coordination of financing and investment policy and agency conflicts of debt hypothesis (H4). For both theories, existing studies partially proclaim strong evidence, which is not confirmed by our multivariate results. Deviations of our results exists in terms of institutional investors and R&D expenses. In both cases, four studies confirm a significantly positive association with the hedging dummy variable, which might be specifically driven by spurious effects in the correlational data, we collected as effect sizes.

A further aspect that becomes apparent from Table 7 is that the choice of the investigated hedging determinants differs across primary studies. This might drive the deviating results through misspecification bias. Kirkham et al. (2012) find out in their simulation study that the multivariate approach as applied in this paper is a method to lower the effect of the publication bias and misspecification bias on the aggregated effect sizes. Frosi et al. (2014) come to a similar 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 to be used in further applications. Both references 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: 2).

Table 7 Comparison of results

Proxy variable	Hyp. sign	This study	Allayannis and Weston (2001)	Campello et al. (2011)	Choi et al. (2015)	Donohoe (2015)	Géczy et al. (1997)	Jin and Jorion (2006)	Nance et al. (1993)	Pérez-González and Yun (2013)	Pincus and Rajgopal (2002)	Tufano (1996)	Aretz and Bartram (2010)	Arnold et al. (2014)
Corporate taxes (H1)														
Tax-loss carry forwards	+	**0**				0					0		0	0
Bankruptcy and financial distress costs (H2)														
Dividend yield	?	**+**			+		0		+	0	0		0	+
Interest coverage ratio	–	**0**					0		0				0	0
Leverage ratio	+	**0**		+	+	0	0		0	0	+	0	+	+
Liquidity	–	**–**					0		0		–	0	–	–
Profitability	–	**0**			+	0				0			0	+
Firm size	+	**+**		+	+	0	+	+	+	+	+	0	+	+
Tangible assets	–	**0**		0									–	
Asymmetric information and agency conflicts of equity (H3)														
Institutional investors	–	**0**				0	+				+		+	+
Option ownership	?	**0**					+				0	0	0	0
Share ownership	+	**0**					0				0	0	0	0

Table 7 continued

Proxy variable	Hyp. sign	This study	Allayannis and Weston (2001)	Campello et al. (2011)	Choi et al. (2015)	Donohoe (2015)	Géczy et al. (1997)	Jin and Jorion (2006)	Nance et al. (1993)	Pérez-González and Yun (2013)	Pincus and Rajgopal (2002)	Tufano (1996)	Aretz and Bartram (2010)	Arnold et al. (2014)
Coordination of financing and investment policy and agency conflicts of debt (H4)														
Capex	+	**0**		+		0	–			0			0	
R&D expenses	+	**0**			+	0	+		+				+	0
Tobin's Q	+	**0**	+	0		0	+			0	0		0	0

This table compares the results of this study with the most influential studies published in journals, which are classified as A+ in the VHB-JOURQUAL3. For these studies, we integrated the reported information as considered in the multivariate meta-analysis. Hence, we refer to reported information on mean difference tests or correlation matrices. Additionally, we also contrast our findings with the results from the two existing literature reviews by Aretz and Bartram (2010) and Arnold et al. (2014). Beside the hypothesized signs, significant results at the 5% level are displayed by '+' or '–' for positive and negative relations, zero otherwise.

7 Conclusion

This paper provides new evidence on the determinants of corporate hedging by taking a meta-level look at the following 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. The results of the multivariate meta-analysis indicate that hedging firms are larger companies with lower level of financial liquidity and higher dividend payouts than non-hedging firms. In comparison to existing reviews by Aretz and Bartram (2010) and Arnold et al. (2014), we can conclude that univariate meta-analysis tends to overestimate results, since this approach neglects the dependencies among the proxy variables and does not allow to investigate the heterogeneity among the effect estimates. For this reason, the results of our multivariate meta-analysis do not confirm their results, for example, regarding the impact of leverage ratio, institutional investors, and profitability on corporate hedging decisions. In addition to the multivariate meta-analysis, we also conduct a meta-regression analysis to explore the heterogeneity between the estimates reported in primary studies. Here, we find that studies analyzing firms from North America report, on average, a lower impact of leverage on the corporate hedging decision. Moreover, studies examining more recent data samples tend to find a weaker relation between tangible assets and hedging, R&D and hedging respectively.

Despite its power to model interrelations between multiple effect sizes, there are several issues to be critically considered when conducting a (multivariate) meta-analysis and interpreting its results. Limiting factors, which are incorporated only in few primary studies, comprise the ‘endogeneity and identification problems’ as well as ‘empirical modeling of structural relations’ as emphasized by Aretz and Bartram (2010). This means that the causality of the variables is not unique. For example, many determinants of leverage also influence hedging strategies and vice versa. A promising methodology to address the problem of endogeneity in a meta-analysis using secondary data is the meta-analytic structural equation modeling (MASEM) approach presented by Cheung and Chan (2005). If a combined correlation matrix (similar to the GLS estimator presented in this paper) can be generated, this pooled correlation matrix could then be used as input for a structural equation model. Furthermore, it should be considered that possible nonlinearities in the dependency structure are not captured by our multidimensional model. Incorporating such specific effects, however, requires a deep understanding of the dependencies as well as moving away from the modeling as it is performed in the majority of existing primary studies. These aspects open perspectives for future research.

Finally, our results suggest that classical financial theories do not seem to fully explain the first order concerns of corporate hedging in practice. For this reason, we encourage academics to widen their empirical work towards the analysis of more recent theoretical developments of classical financial theory as, for example, the influence of the time horizon on the hedging motivation of financially distressed firms (Kürsten and Linde 2011), hedging as a consequence of good corporate governance (Lel 2012), as well as behavioristic theories like, for example, the managerial overconfidence hypothesis (Adam et al. 2015).

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