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Review

Determinants of corporate hedging: A (statistical) meta-analysis

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1. Introduction

The turbulences on the financial markets during the last years have strikingly shown the importance of risk management for firms. Although literature acknowledges the relevance of hedging in corporate financial management, still much dispute about the determinants of hedging remains.

Over the last 25 years, scholars have developed several theoretical frameworks that explain corporate hedging behavior and describe circumstances under which hedging adds value to the firm. For example, Smith and Stulz (1985) show that corporate hedging is value enhancing if the firm is subject to high costs of financial distress, faces a convex tax schedule, or incurs agency costs due to risk averse managers and other claimholders. Bessembinder (1991) demonstrates that hedging lowers the underinvestment problem since it allows shareholders to receive a greater percentage of the benefits from new investments. As managers have an informational advantage over shareholders, DeMarzo and Duffie (1991) conclude that corporate hedging is beneficial to the firm and its shareholders. Froot, Scharfstein, and Stein (1993) develop a model under which hedging helps to coordinate corporate investment and financing policies and thus lowers the firm's dependence on costly external financing.

Numerous studies empirically test the different theories of corporate hedging via univariate or multivariate analyses. Still, academics do not have a common understanding of what really induces firms to hedge. In their leading textbook, Brealey, Myers, and Allen (2008) list the question, what risks firms should hedge, as one of the 10 most significant unsolved problems in finance. Aretz and Bartram (2010, p. 318), who conduct a narrative review on the rationales of corporate hedging, find "surprisingly mixed empirical support for rationales of hedging with derivatives at the firm level."

Comparable to Aretz and Bartram (2010), we systematically review the empirical evidence on the determinants of corporate hedging. As against their narrative approach, we apply statistical meta-analysis, which Glass (1976, p. 3) defines as "statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings." The key advantage of meta-analyses compared to narrative reviews is their accuracy and objectivity. Narrative reviews often deploy vote-counting methods and always require subjective judgments by the authors. In contrast, meta-analysis uses statistical methods to synthesize primary data to a summary effect size. We follow the Cochrane Handbook for Systematic Reviews of Interventions as a general framework for the conduction of our review (Higgins & Green, 2011).[1] We use the methodologies of Borenstein, Hedges, Higgins, and Rothstein (2011) and Cooper, Hedges, and Valentine (2009) for our statistical analysis.

[1] The Cochrane Collaboration, "whose primary aim is to help people make well-informed decisions about health care by preparing, maintaining and promoting the accessibility of systematic reviews of the evidence that underpins them" Green et al. (2011, 1.1.1, chap. 1), publishes the Cochrane Handbook for Systematic Reviews of Interventions.

Up to now, the main field of application for meta-analysis is medicine. But it is also a common review method in the fields of education, psychology, and criminology (Borenstein et al., 2011). Researchers in financial economics have so far rarely used meta-analysis, although there is much review literature in this field (see, e.g., Allen & Michaely, 2003, chap. 7; Eckbo, Masulis, & Norli, 2007, chap. 6; Graham, 2003). One of our aims is to present the methodology of meta-analysis and to illustrate its possible applications in corporate finance as we consider this approach an excellent means to further examine various issues in financial economics.

We outline the paper as follows: in Section 2 we introduce the theories of corporate hedging, present the research methodology in Section 3, and describe the study search process in Section 4. Section 5 contains the results of our analysis, followed by a discussion in Section 6. We conclude our paper in Section 7.

2. Theory

Capital structure theory states that (non-financial) corporations have no incentives to manage (financial) risks, since hedging fully has the characteristics of a financing decision and thus is irrelevant to firm value (Modigliani & Miller, 1958). In general, there are two major rationales for corporate hedging decisions – the maximization of the shareholder value and the maximization of managers' private utility (for an detailed overview see Sprcic, Tekavcic, & Sevic, 2008). Nevertheless, according to Aretz and Bartram (2010) and Guay and Kothari (2003) our study focuses on the maximization of the shareholder value hypothesis, because – to our knowledge – regarding the other hypothesis there are too few studies available, which are necessary for carrying out a valid meta-analysis appropriately. Yet, most of the scholars acknowledge that corporate hedging may create value for corporations and their shareholders (see, e.g., Mayers & Smith, 1982; Nance, Smith, & Smithson, 1993; Smith & Stulz, 1985). Due to market imperfections, such as taxes, financial distress costs, or agency costs, which Modigliani–Miller do not account for, shareholders cannot fully replicate the hedging transactions of firms (see, e.g., Aretz & Bartram, 2010; Smith & Stulz, 1985). We review the following four theories of corporate hedging: taxes, asymmetric information and agency conflicts, bankruptcy and financial distress costs, and underinvestment and coordination of investment and financing. Table 1 provides an overview and a short description of these theories.

2.1. Taxes

Corporate taxes can induce firms to hedge their earnings. A prerequisite to this is a convex tax function, which implicates that the tax rate increases disproportionate to earnings. An implication of this convexity is that, compared to volatile earnings, constant earnings lead to lower average tax liabilities, due to Jensen's inequality. Thus, by reducing the volatility of earnings, hedging can add value to the firm (Smith & Stulz, 1985).

Table 1
Overview of the reviewed theories of corporate hedging.

Theory	Description
Taxes	Hedging can lower the volatility of tax earnings. Due to Jensen's inequality, hedging can add value to firms facing convex tax functions (Smith & Stulz, 1985).
Asymmetric information and agency conflicts	Managers (and other claimholders of the firm) ask an extra compensation for their non-diversifiable risk position in the firm. By reducing risks, hedging can lower this extra compensation and thus add value to the firm (Smith & Stulz, 1985). Since a firm has an informational advantage on its dividend stream, the shareholders cannot fully replicate its hedging decisions. Thus, corporate hedging may be beneficial to the shareholders (DeMarzo & Duffie, 1991).
Bankruptcy and financial distress costs	By reducing the probability of bankruptcy, hedging can lower the costs of bankruptcy and financial distress and thus add value to the firm (Smith & Stulz, 1985).
Underinvestment and coordination of investment and financing	Managers of firms facing financial distress may have incentives not to invest in positive net present value projects (Myers, 1977). By reducing the probability of financial distress, hedging can add value to the firm (Bessembinder, 1991). The lack of internal funds can detain corporations to invest in positive net present value projects. By increasing the availability of internal funds, hedging can add value to the firm (Froot et al., 1993).

2.2. Asymmetric information and agency conflicts

Managers (but also other claimholders like employees, suppliers, and customers) often have a non-diversifiable risk position in the firm. This risk derives from financial (such as future salaries) or from non-financial interests (such as reputation or career opportunities) in the firm. As they are risk averse, managers demand an extra compensation for bearing that risk. By hedging, a corporation can reduce the risks imposed on managers (and other claimholders). Through a reduced extra compensation, hedging can add value to the firm (Smith & Stulz, 1985).

Managers pursue their own interests, unless their compensation contracts give them incentives to act in the interest of the shareholders. Thus, these contracts often contain elements that tie the compensation to the value of the firm (such as share programs or stock option programs) or its accounting earnings (such as bonus plans). If the managers' compensation is a convex function of firm value, which is mostly the case if managers own stock options, corporations generally should not hedge or should even reverse-hedge. Due to Jensen's inequality, broadly distributed earnings increase the managers' compensation. For example, according to common option pricing theory, a higher volatility of the underlying increases the value of an option (Black & Scholes, 1973). Conversely, in case the compensation is in concave relation to firm value or earnings (e.g., through a bonus plan) hedging creates value. When managers own a large stake of the firm's equity, their wealth is a linear function of firm value. As we describe in the previous column, this risk position induces corporations to hedge (Smith & Stulz, 1985).

DeMarzo and Duffie (1991) develop a model of corporate hedging based on informational asymmetries between the firm and its shareholders. They assume that shareholders are not able to replicate the firm's hedging policy, as managers have proprietary information on the firm's dividend stream and have barriers to disclose them. Since its informational advantage enables the firm to hedge more effectively than its shareholders, hedging is beneficial to shareholders and adds value to the firm.

2.3. Bankruptcy and financial distress costs

The risk of bankruptcy increases with the volatility of firm value. This risk causes direct and indirect costs to the corporation (Jensen & Meckling, 1976). Firms could lower these costs by reducing leverage, though this reduction would at the same time lead to a loss of the tax shield of debt. Theory suggests that a decrease of the volatility of firm value by hedging reduces the costs of bankruptcy and financial distress without sacrificing the tax advantages of debt financing (Smith & Stulz, 1985).

2.4. Underinvestment and coordination of investment and financing

When a corporation faces the risk of bankruptcy, agency conflicts between shareholders and debtholders can arise that give incentives to hedge. In times of financial distress, management may not invest in positive net present value projects as the benefits would fully or mainly accrue to debtholders and not to shareholders (Myers, 1977). This underinvestment problem leads to a deterioration of firm value. Hedging can solve this problem. It reduces the probability of financial distress and thus lowers the incentives of managers and shareholders to underinvest (Bessembinder, 1991).

Froot et al. (1993) formulate a related model that describes situations in which the lack of internal funds detains corporations from investing in positive net present value projects. By lowering the volatility of cash flows, hedging can increase the availability of internal funds for attractive investment opportunities and thus leads to a reduction of the dependence on costly external financing.

3. Methodology

We perform the systematic review via meta-analysis based on means. The objective of the meta-analysis is to synthesize available data on the determinants of corporate hedging behavior.

To make results comparable, we calculate a uniform effect size for the proxy variables in each reviewed study according to Borenstein et al. (2011). Thereby we compare the means of the proxy variables of corporations that hedge (Hedgers or H) to corporations that do not hedge (Non-Hedgers or NH). For each proxy variable we aggregate the effect sizes to a summary effect size, which measures the relation between the variables and the hedging behavior across studies.

For continuous data we base the comparison of Hedgers and Non-Hedgers on the standardized mean difference between the two groups. We estimate the standardized mean difference by Cohen's d, with

$$d = \frac{X_{\mathrm{H}} - X_{\mathrm{NH}}}{S_{\mathrm{within}}} \quad (1)$$

where X_{H} and X_{NH} are the sample means of the two groups, and S_{within} is their pooled standard deviation. If a study does not specify S_{within}, we estimate it by

$$S_{\mathrm{within}} = \sqrt{\frac{(n_{\mathrm{H}} - 1)S_{\mathrm{H}}^2 + (n_{\mathrm{NH}} - 1)S_{\mathrm{NH}}^2}{n_{\mathrm{H}} + n_{\mathrm{NH}} - 2}} \quad (2)$$

where n_{H} and n_{NH} are the sample sizes of the two groups, and S_{H} and S_{NH} are their standard deviations. We calculate the variance of d by

$$V_d = \frac{n_{\mathrm{H}} + n_{\mathrm{NH}}}{n_{\mathrm{H}} n_{\mathrm{NH}}} + \frac{d^2}{2(n_{\mathrm{H}} + n_{\mathrm{NH}})}. \tag{3}$$

As d has a tendency to overestimate the true standardized mean difference for small samples, we eliminate this bias by applying the correction factor J, with

$$J = 1 - \frac{3}{4df - 1} \tag{4}$$

where $df = n_{\mathrm{H}} + n_{\mathrm{NH}} - 2$.[2] This correction yields the unbiased effect size Hedges' g with

$$g = J \cdot d \tag{5}$$

and

$$V_g = J^2 \cdot V_d. \tag{6}$$

If the two groups are equal, Hedges' g is zero. A positive (negative) result shows that the mean of the proxy variable is greater (smaller) for the Hedgers.

If all the required data – X_{H}, X_{NH}, and S_{within} or S_{H} and S_{NH} – is not available, Borenstein (2009, chap. 12) offers ways to calculate Hedges' g based on a t-test for difference between the two groups. We use these alternative calculation formulas if the reviewed study contains either the t-value or the p-value of a t-test between the Hedgers and Non-Hedgers.

For binary data we use the odds ratio OR as effect size, with

$$OR = \frac{X_{\mathrm{H}}}{1 - X_{\mathrm{H}}} \cdot \frac{1 - X_{\mathrm{NH}}}{X_{\mathrm{NH}}}. \tag{7}$$

Not to lose symmetry in the analysis, we use the log odds ratio $\log OR$ to calculate the summary effect size and convert it back to the odds ratio afterwards. We define the log odds ratio as

$$\log OR = \ln(OR) \tag{8}$$

and calculate its variance $V_{\log OR}$ by

$$V_{\log OR} = \frac{1}{(X_{\mathrm{H}} - X_{\mathrm{H}}^2) n_{\mathrm{H}}} + \frac{1}{(X_{\mathrm{NH}} - X_{\mathrm{NH}}^2) n_{\mathrm{NH}}}. \tag{9}$$

An odds ratio of one means that the two groups are equal. A value larger (smaller) than 1.00 shows that the mean of the proxy variable is larger (smaller) for the Hedgers.

We can convert the log odds ratio into Hedges' g and vice versa if the studies contain both continuous and binary data. This conversion allows us to calculate a summary effect size even in case of heterogeneous variables (Borenstein et al., 2011).

The aggregation of effect sizes to a summary effect size requires them to be comparable across studies. According to Borenstein (2009) proxy variables must either be linear transformations of each other or the effect size is defined as a measure of overlap between distributions (see, Cohen, 1988; Grissom & Kim, 2005). As the first condition is not always fulfilled, we follow the second definition which specifically means that we interpret the effect sizes as a measure for the difference of means of the proxy variables between the groups of Hedgers and Non-Hedgers. We base the calculation of the summary effect size on the random-effects model – as opposed to the fixed-effects model – as we cannot assume one true effect size for the reviewed proxy variables in all studies (e.g., for institutional inhomogeneities, such as different tax rules). Nevertheless, regarding the population we considered the entire global financial market, because under the assumption of risk aversion as well as the assumption that managers all over the world make their hedging decisions in order to increase the shareholder value ("shareholder value/firm value maximization hypothesis") it is not necessary to distinguish between industries and countries. There is no valid reason against the validity of these assumptions. The effect regarding the hedging decisions should be the same and, due to the large amount of observations in the primary studies, possible different effect sizes – if there any differences at all – would be compensated.

The summary effect size M is the weighted mean of the respective effect sizes. Thus, M is Hedges' g for continuous data and the odds ratio OR for binary data. The weight W_i assigned to each study i is the sum of the inverse of the variance of its effect size V_i and the between-study variance of the effect sizes denoted by T^2. We calculate W_i by

$$W_i = \frac{1}{V_i + T^2}. \tag{10}$$

T^2 measures the variance of the effect size across the reviewed studies. It is calculated by the method of moments.

$$T^2 = \frac{Q - df}{C}, \tag{11}$$

where

$$Q = \sum_{i=1}^{k} \frac{Y_i^2}{V_i} - \frac{\left(\sum_{i=1}^{k} Y_i / V_i\right)^2}{\sum_{i=1}^{k} 1/V_i}, \tag{12}$$

$$df = k - 1, \tag{13}$$

where k is the number of reviewed studies, Y the calculated effect size of the respective studies (g in case of a continuous variable and $\log OR$ in case of a binary variable) and

$$C = \sum\nolimits_{i=1}^{k} \frac{1}{V_i} - \frac{\sum_{i=1}^{k} 1/V_i^2}{\sum_{i=1}^{k} 1/V_i}. \tag{14}$$

Hence, we compute the summary effect size M by

$$M = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i}. \tag{15}$$

The variance of M is

$$V_M = \frac{1}{\sum_{i=1}^{k} W_i}. \tag{16}$$

As it is generally assumed that the effect sizes are normally distributed we calculate a 95% confidence interval for the effect sizes of the respective studies and the summary effect sizes (Borenstein, 2009). Additionally, we report the p-value p for a test of difference between Hedgers and Non-Hedgers. The p-value p (for both binary and continuous variables) is calculated as follows

$$p = 2\left[1 - \Phi\left(\frac{M}{\sqrt{V_M}}\right)\right], \tag{17}$$

where $\Phi(\,)$ is the standard normal cumulative distribution.

For the sake of clarity we include numerical examples to calculate the effect size measures (Hedges' g and the odds ratio OR) and the summary effect size in the appendix (see Appendix C).

[2] *Note*: The variable df is not the same variable as used in Eqs. (11) and (13). According to common literature we did not change the nomination of the variable.

Table 2
Documentation of the search process. The table gives an overview of the different phases and steps of the data-search for the meta-analyses.

Search step	Description
Definition of (eligibility) criteria for included studies	
Definition of inclusion criteria	To be included, a study must contain a comparison of Hedgers and Non-Hedgers and must allow the calculation of an effect size (Hedges' g or odds ratio). We exclude studies that mainly examine corporations from the financial services industry.
Database search with a fixed search command	
Determination of databases	We determined ABI/INFORM Complete (via ProQuest) and Business Source Premier (via EBSCOhost) as relevant databases for our search.
Composition of a sample of relevant studies	By randomly searching databases and screening of footnotes of studies and textbooks, we composed a sample of 30 studies that empirically investigate the determinants of corporate hedging.
Creation of the search command	We created a search command, which contains nineteen search terms, after screening the titles, abstracts, and keywords of the sample studies for frequently-used terms.
Execution of the database search	The database search on September 7, 2011, yielded 1415 results—660 for ABI/INFORM Complete and 755 for Business Source Premier. We cut the list to 1128 results by deleting duplicates.
Sorting of search results	
Screening of study titles	Screening the study titles cut the list to 456 studies.
Screening of study abstracts	Screening the study abstracts cut the list to 236 studies.
Screening of study contents and data	After thoroughly screening the remaining studies with regard to content and data, we finally arrived at 37 studies for our analysis.

4. Data

4.1. Data-search

An important part of a systematic review via meta-analysis is the design of the search process. Since a meta-analysis systematically synthesizes the reviewed data to a common effect size, identifying all relevant studies on the reviewed topic is essential to avoid bias. Yet, the search process must be feasible without an unreasonable commitment of time. Therefore, we employ a search strategy that is both comprehensive, which means that we maximize the number of included studies, and precise, which means that we minimize the initial search results (see, Lefebvre, Manheimer, and Glanville, 2011, chap. 6). We carry out the search process by searching databases and sorting of results. The search process consists of the following three phases in logical order: definition of the (eligibility) criteria for the included studies, database search with a fixed search command, and sorting of search results. Altogether these phases include eight individual search steps, which we document in Table 2.

To be included, a study must contain a comparison of a group of Hedgers with a group of Non-Hedgers for at least one proxy variable. Specifically, this requirement means that the studies need sufficient data that enables the calculation of an effect size – Hedges' g for continuous data or the odds ratio for binary data – as we describe in Section 3. We define Hedgers as corporations that either use derivatives or employ other measures that may have the same hedging effect as derivatives (e.g., foreign currency debt, FX matching, or foreign bank accounts). Thus, Non-Hedgers must not hold derivatives or employ the abovementioned similar hedging measures. Additionally, we exclude studies that explicitly examine corporations from the financial services industry (e.g., banks, insurance companies, real estate investment trusts) since they have entirely different motives for holding derivatives than other corporations (see, e.g., Berkman & Bradbury, 1996; Gay & Nam, 1998; Heaney & Winata, 2005). But we did not exclude studies that include financial firms if the sample was taken from one or more broad stock market indices.

We used the databases ABI/INFORM Complete (via ProQuest) and Business Source Premier (via EBSCOhost) for the search. To design the search command, we composed a sample of 30 studies that empirically investigate the determinants of corporate hedging behavior by comparing a sample of Hedgers with a sample of Non-Hedgers. But the availability of all relevant data, which we need to calculate either Hedges' g or the odds ratio, was not necessarily a requirement. Our goal was to create a search command that would yield all the 30 studies, but also keeps the result list to a minimum. We identified the sample studies randomly by searching databases and screening of footnotes of studies and textbooks. After screening the sample studies for terms that they often use in either title, abstract, or keywords, we created a search command (by using Boolean operators) containing nineteen search terms (for the exact search terms see Appendix B). The database search, which we conducted on September 7, 2011, yielded 1415 results – 660 for ABI/INFORM Complete and 755 for Business Source Premier.[3] By identifying duplicates we cut the list to 1128 results.

We identified the relevant studies by screening the titles, keywords, abstracts, and full texts of the studies in the result list. After reading the titles, we eliminated 672 studies and another 220, after reading the abstracts. We thoroughly screened the remaining 236 studies with regard to content and data. Finally, due to missing data and content we arrived at 37 studies for our analysis.[4]

4.2. Operationalization

The four theories of the determinants of corporate hedging that we present in Section 2, describe conditions under which hedging adds value to the firm. Literature tests these theories by using proxy variables. Each variable indicates if one or more theories might explain corporate hedging behavior. We cluster the variables using variable definitions that are similar to Aretz and Bartram (2010). We only include variables in our review that we found in at least six studies. As a consequence we are not able to include all existing proxy variables. Including only few studies would result in an unreliable estimation of the between-study variance T^2. A wrong estimation of T^2 can have substantial influence on the effect size (see, Borenstein et al., 2011). Table 3 gives an overview of the fifteen proxy variables that meet this criterion. We review seven variables (which are in bold face in Table 3) in detail and illustrate the results by forest plots. Table 4 shows the results of the remaining eight proxy variables and Appendix A lists the included studies.

We test the tax hypothesis via the following two variables: tax-loss carryforwards (binary) and tax-loss carryforwards (continuous). The existence of tax-loss carryforwards makes the effective tax function (more) convex (Zimmerman, 1983). Hedging reduces

[3] We limited the search to "peer reviewed" studies, which cut the search results by roughly 5.7 times. We address the problem of publication bias in Section 6.
[4] Fifteen of the 30 sample studies are part of the final result list.

Table 3
Overview of the proxy variables. We review the variables displayed in bold face bold in more detail and display their outcomes by forest plots. Our variable definitions arise from an aggregation of the variables in the reviewed studies and are similar to those of Aretz and Bartram (2010). We list the reviewed studies for each variable in Figs. 1–7 and Table 4.

Variable	Hyp. sign/Hedges *g* (continuous) or odds ratio *OR* (binary)	Description
Taxes		
Tax-loss carryforwards (binary)[a]	+/>1	**Binary variable that takes a value of "1" if the firm has tax-loss carryforwards available and "0" if not**
Tax-loss carryforwards (continuous)[a]	+/>0	Tax-loss carryforwards ÷ (total assets or firm value or sales)
Asymmetric information and agency conflicts		
Institutional investors	−/<0	Percentage of shares held by institutional investors
Option ownership	?/?	Number, market value or percentage of options held by managers or directors
Share ownership	+/>0	Number or market value of shares held by managers or directors
Bankruptcy and financial distress costs		
Convertible debt[b]	+/>0	Book value of convertible debt ÷ (book value of total assets or market value of the firm)
Current ratio[c]	−/<0	(Current assets or cash and cash equivalents) ÷ current liabilities
Dividend yield	?/?	Dividend per share ÷ (market price of shares or earnings per share)
Interest coverage ratio	−/<0	Earnings before interest and taxes ÷ interest expenses
Leverage ratio	+/>0	**(Total debt or long-term debt or interest-bearing debt) ÷ (market value of the firm or book value of assets or market value of equity or book value of equity)**
Sales	−/<0	Total sales
Size	−/<0	**Market value of the firm (market value of equity plus book or market value of debt) or book value of total assets**
Underinvestment and coordination of investment and financing		
Earnings-price ratio	−/<0	Earnings per share ÷ share price
Market-to-book ratio	+/>0	**Market value of the firm ÷ book value of total assets, or market value of equity ÷ book value of equity**
Research and development	+/>0	**Research and development expenses ÷ (sales or a measure of firm size)**

[a] The two tax-loss carryforwards variables also serve as a proxy for the bankruptcy and financial distress costs theory with a hypothesized sign of "+".
[b] The convertible debt variable also serves as a proxy for the asymmetric information and agency conflicts theory with a hypothesized sign of "−".
[c] The current ratio also serves as a proxy for the underinvestment and coordination of investment and financing variable with a hypothesized sign of "−".

the volatility of income and increases the probability of positive income. Since firms can deduct past tax losses only in times of positive income, hedging increases the net present value of the tax-loss carryforwards. Therefore, firms that have tax-loss carryforwards should have higher incentives to hedge (Nance et al., 1993). However, Graham and Smith (1999) argue that the existence of tax-loss carryforwards does not necessarily lead to a convex tax function. I consider the ambiguity of the tax variables when interpreting the results. Since they arise from past losses, tax-loss carryforwards also point to financial distress. Thus, we also use tax-loss carryforwards to test the bankruptcy and financial distress costs hypothesis.

We use institutional investors, share ownership, and option ownership as variables to test the asymmetric information and agency conflicts hypothesis. The number of institutional investors proxies the informational asymmetries between managers and shareholders. Via the managerial share and option ownership we want to measure how managers' payoffs affect a firm's hedging behavior (see Section 2). Most authors hypothesize a negative relation between managerial option ownership and corporate hedging (see, e.g., Haushalter, 2000; Tufano, 1996). However, since option payoffs and firm value are often (almost) linearly related, Gay and Nam (1998) argue that managerial option ownership induces firms to hedge.

Leverage ratio, current ratio, interest coverage ratio, and sales indicate the probability of financial distress (Table 3 shows the hypothesized signs of the variables) and we thus use them to test the bankruptcy and financial distress costs theory. Since the current ratio points to availability of liquid funds to invest in positive net present value projects (Froot et al., 1993), we also use this variable to test the underinvestment and coordination of investment and financing hypothesis. As bankruptcy costs are not directly proportional to the market value of the firm (Warner, 1977), which we measure by the variable firm size, larger firms should have lower incentives to protect against bankruptcy. Whereas Géczy et al. (1997) argue that it puts financial constraints on the firm, convertible debt may at the same time lower a firm's agency conflicts. This prohibits us from drawing conclusions from the use of

Table 4
Overview of the summary effect sizes for variables not displayed by forest plots. All variables in this table consist of continuous data, thus Hedges' *g* is the summary effect size for all variables.

Variable	Hedges' *g*	Standard error	Lower limit	Upper limit	*p*-Value
Taxes					
Tax-loss carryforwards (continuous)	−0.0082	0.0480	−0.1023	0.0858	0.8640
Asymmetric information and agency conflicts					
Option ownership	0.0436	0.1666	−0.2830	0.3702	0.7937
Bankruptcy and financial distress costs					
Convertible debt	0.0512	0.0753	−0.0964	0.1989	0.4965
Current ratio	−0.2592	0.0440	−0.3454	−0.1730	0.0000
Dividend yield	0.1985	0.0445	0.1113	0.2856	0.0000
Interest coverage ratio	−0.0584	0.0642	−0.1842	0.0674	0.3629
Sales	0.6719	0.0988	0.4784	0.8655	0.0000
Underinvestment and coordination of investment and financing					
Earnings-price ratio	−0.0007	0.0622	−0.1227	0.1212	0.9906

Odds ratio (random effects) - Tax-loss carryforwards (binary)

Study name	Odds ratio	Lower limit	Upper limit	p-Value	Relative weight
Berkman and Bradbury (1996)	2.1450	0.9996	4.6028	0.0501	12.23
Berkman et al. (2002)	2.9841	0.7595	11.7252	0.1174	6.34
González et al. (2010)	2.1538	0.9187	5.0496	0.0776	11.09
Heaney and Winata (2005)	1.1840	0.7641	1.8345	0.4497	17.04
Hu and Wang (2005)	0.8504	0.4937	1.4647	0.5590	15.43
Jalilvand (1999)	1.5765	0.4200	5.9172	0.4999	6.65
Marsden and Prevost (2005)	0.6402	0.2725	1.5044	0.3063	11.06
Mian (1996)	0.6360	0.5241	0.7718	0.0000	20.16
	1.1517	0.7628	1.7391	0.5016	

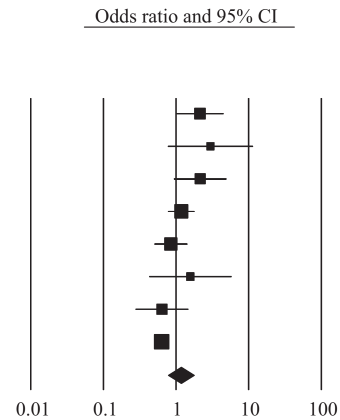

Fig. 1. Forest plot for the tax-loss carryforwards (binary) variable. The left side of the figure shows computed effect sizes (odds ratio) for the tax-loss carryforwards (binary) variable of each study, the lower and upper limits of the 95% confidence interval, the *p*-value for a test of the null and the relative weight (RW) of each study in percentage values (calculated by $RW = W_i / \sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval. *Note*: There is no 95% confidence interval for the study of Mian (1996), because it is too small or too tight in order to plot it (Marsden and Prevost, 2005).

convertible debt on corporate hedging behavior. On the one hand, a high dividend yield may indicate high liquidity (Nance et al., 1993), but on the other hand, high dividend payouts may constrain the firm financially (Aretz & Bartram, 2010). Thus, we cannot predict a relationship between the dividend yield variable and hedging.

As a high market-to-book ratio (or Tobin's *q*), high research and development expenses, and a low earnings-price ratio indicate growth opportunities, we use these variables to test the underinvestment and coordination of investment and financing theory.

5. Results

We show the results for seven proxy variables in detail by forest plots. Forest plots are a combination of a table and a figure and present data on the effect sizes of the individual studies and the summary effect size (we show the summary effect in the last row).

The table contains the computed effect size, its standard error, the lower and upper limits of the 95% confidence interval, the *p*-value for a test of the null (with a significance of 5%), and the relative study weight in percentage values. We do not report a standard error for the odds ratio, since we calculate the summary effect based on the log odds ratio (see Section 3).

The figure graphically displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the positions of the effect sizes of the individual studies. If the square lies right (left) of the middle line, which represents zero in case of continuous and one in case of binary variables, the respective proxy variable is greater (smaller) for the Hedgers. We do not directly interpret the differences between the values of the respective effect sizes, but only use them to measure if there is a significant difference between Hedgers and Non-Hedgers. In general, a higher absolute value of the effect size reflects a greater difference between the compared groups. The square areas are proportional to the weights of the studies, which are negatively correlated to the variance of the effect size of the respective study (see Eq. (10)). The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. If the confidence interval does not cross the middle line, the difference between Hedgers and Non-Hedgers is significant at the 5% level. We illustrate the results of the summary effect size by a diamond. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval. For reasons of symmetry, we display the results for the odds ratio on a log scale with the basis 10 (see Section 3).

Table 4 summarizes the results of the effect sizes for the eight remaining variables (we list the included studies for these variables in Appendix A).

5.1. Taxes

With an odds ratio of 1.157, the summary effect size of the tax-loss carryforwards (binary) variable (see Fig. 1) points to the predicted direction, but is not significant at the 5% level.[5] Especially, the lower and upper limits of 0.7628 and 1.7391 make clear that we may not interpret this summary effect as an indication in favor of the tax hypothesis. On a vote counting basis, five of eight reviewed studies point to the predicted direction (none of them is statistically significant) and three point to the opposite direction (one of them is statistically significant). Overall, the result does not give significant support for the tax hypothesis.

The sign of the summary effect of the tax-loss carryforwards (continuous) variable is in disagreement with the hypothesized direction. Though, with a value of −0.0082, the difference between the groups is negligible. Consequently, the tax-loss carryforwards (continuous) variable does not give support to the tax hypothesis, either.

Our findings are consistent with Aretz and Bartram (2010), who state that "in most cases, tax-loss carryforwards do not significantly associate with corporate hedging." From our results we clearly cannot confirm the tax hypothesis. Neither can we reject it, concerning the drawbacks of the tax-loss carryforwards variables that we describe in Section 4.2. Due to the lack of available data, we were not able to test the tax hypothesis by other variables that

[5] If we speak of (statistical) significance, we always mean significance at the 5% level, unless stated otherwise. Accordingly, confidence intervals are always for the 95% confidence level.

Hedges' g (random effects) - Institutional investors

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Adedeji and Baker (2002)	-0.0157	0.1740	-0.3567	0.3253	0.9281	12.43
Fok et al. (1997)	0.5175	0.1205	0.2813	0.7538	0.0000	15.23
Géczy et al. (1997)	0.4322	0.1080	0.2205	0.6439	0.0001	15.88
González et al. (2010)	0.0503	0.2047	-0.3509	0.4515	0.8059	10.94
Klimczak (2008)	0.1261	0.1762	-0.2193	0.4715	0.4744	12.31
Lin et al. (2010)	0.3636	0.0279	0.3089	0.4183	0.0000	18.97
Pincus and Rajgopal (2002)	1.0519	0.1395	0.7785	1.3253	0.0000	14.23
	0.3852	0.1031	0.1832	0.5872	0.0002	

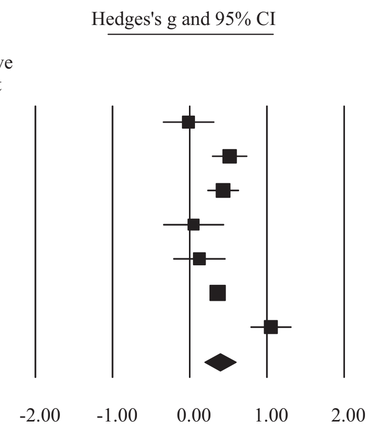

Fig. 2. Forest plot for the institutional investors variable. The left side of the figure shows computed effect sizes (Hedges' g) for the institutional investors variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the p-value for a test of the null and the relative weight (RW) of each study in percentage values (calculated by $RW = W_i/\sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval.

might be more suitable (e.g., marginal tax rate proxies, tax code progressivity dummies, or tax credits).

5.2. *Asymmetric information and agency conflicts*

The institutional investors variable (see Fig. 2) has a summary effect size of 0.3852 and lower and upper limits of 0.1832 and 0.5872. This outcome clearly shows that Hedgers have a greater percentage of institutional investors. Specifically, this value for Hedges' g means that the percentage of institutional investors is 0.39 standard deviations larger for Hedgers than for Non-Hedgers. Our result is contradictory to the predicted influence of institutional investors on corporate hedging behavior. Hence, our findings for the institutional investors variable conflict with the asymmetric information and agency conflicts hypothesis.

Also the share ownership variable (see Fig. 3) does not show the hypothesized sign. The summary effect size of −0.0755 means that companies with higher managerial share ownership are less likely to hedge, but with a p-value of 0.4504 this result is not statistically significant.

Hedgers tend to have slightly higher managerial option holdings, as indicated by the summary effect size of 0.0436 for the option ownership variable. Both the lack of significance and the distinct possibilities of interpreting the variable (see Section 4.2) prevent us from drawing any conclusions from option ownership on corporate hedging behavior. Further, the convertible debt variable also does not give support to the tested theory (see the

Hedges' g (random effects) - Share ownership

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Adedeji and Baker (2002)	0.6962	0.1789	0.3456	1.0468	0.0001	9.04
Berkman and Bradbury (1996)	-0.1795	0.1851	-0.5422	0.1833	0.3323	8.86
Berkman et al. (2002)	-0.4088	0.1952	-0.7914	-0.0262	0.0362	8.57
Brunzell et al. (2011)	-0.3443	0.1943	-0.7252	0.0365	0.0764	8.59
González et al. (2010)	0.5411	0.2084	0.1327	0.9495	0.0094	8.19
Lin et al. (2007)	-0.2716	0.0278	-0.3260	-0.2171	0.0000	12.59
Nguyen and Faff (2002)	-0.4537	0.1064	-0.6622	-0.2451	0.0000	11.12
Pincus and Rajgopal (2002)	0.0994	0.1309	-0.1572	0.3560	0.4475	10.44
Shu and Chen (2003)	0.1666	0.1019	-0.0332	0.3663	0.1022	11.23
Spanò (2007)	-0.4111	0.0970	-0.6012	-0.2209	0.0000	11.36
	-0.0755	0.1000	-0.2715	0.1205	0.4504	

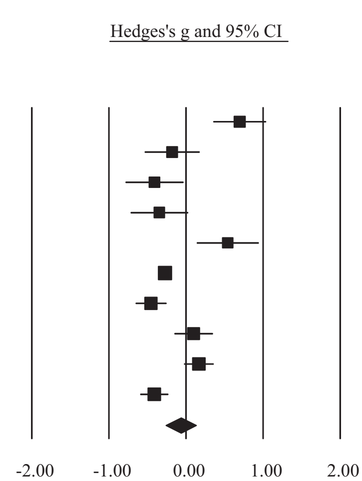

Fig. 3. Forest plot for the share ownership variable. The left side of the figure shows computed effect sizes (Hedges' g) for the share ownership variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the p-value for a test of the null and the relative weight (RW) of each study in percentage values (calculated by $RW = W_i/\sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval.

Hedges' g (random effects) - Leverage ratio

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Aabo et al. (2010)	-0.0524	0.1385	-0.3238	0.2189	0.7048	3.18
Adedeji and Baker (2002)	0.7385	0.1795	0.3868	1.0903	0.0000	2.54
Bartram et al. (2009)	0.3424	0.0241	0.2953	0.3896	0.0000	4.96
Berkman and Bradbury (1996)	0.5554	0.1883	0.1864	0.9244	0.0032	2.42
Berkman et al. (2002)	0.3102	0.1943	-0.0706	0.6911	0.1104	2.34
Brunzell et al. (2011)	0.0875	0.1931	-0.2909	0.4659	0.6504	2.36
Capstaff and Marshall (2005)	0.5099	0.1396	0.2364	0.7835	0.0003	3.16
Dadalt et al. (2002)	0.2766	0.0740	0.1316	0.4215	0.0002	4.33
Fehle (1999)	0.1818	0.0235	0.1358	0.2278	0.0000	4.97
Fok et al. (1997)	0.0491	0.1060	-0.1587	0.2569	0.6434	3.76
Gay et al. (2011)	0.0006	0.0186	-0.0358	0.0370	0.9756	5.00
Gay and Nam (1998)	0.3054	0.0967	0.1158	0.4950	0.0016	3.93
Géczy et al. (1997)	-0.1497	0.1056	-0.3567	0.0573	0.1563	3.77
Géczy et al. (2006)	-0.2084	0.4258	-1.0430	0.6261	0.6245	0.77
Goldberg et al. (1998)	-0.1198	0.0996	-0.3150	0.0755	0.2292	3.87
González et al. (2010)	0.5456	0.2084	0.1371	0.9541	0.0089	2.17
Heaney and Winata (2005)	0.5621	0.1107	0.3451	0.7790	0.0000	3.67
Hentschel and Kothari (2001)	0.0231	0.0768	-0.1275	0.1737	0.7639	4.28
Hu and Wang (2005)	0.1685	0.1121	-0.0512	0.3881	0.1327	3.65
Jalilvand (1999)	0.5569	0.3255	-0.0811	1.1948	0.0871	1.19
Kim et al. (2006)	-0.3203	0.0982	-0.5128	-0.1279	0.0011	3.90
Klimczak (2008)	-0.1431	0.1763	-0.4885	0.2024	0.4171	2.59
Lin et al. (2010)	-0.0255	0.0277	-0.0797	0.0288	0.3576	4.93
Mian (1996)	0.0415	0.0417	-0.0403	0.1233	0.3200	4.79
Nance et al. (1993)	-0.0582	0.1574	-0.3668	0.2503	0.7114	2.87
Nguyen and Faff (2006)	0.7159	0.1190	0.4827	0.9491	0.0000	3.52
Pincus and Rajgopal (2002)	0.3781	0.1320	0.1194	0.6368	0.0042	3.29
Shu and Chen (2003)	-0.1841	0.1020	-0.3839	0.0158	0.0710	3.83
Spanò (2007)	0.1628	0.0962	-0.0257	0.3514	0.0905	3.94
	0.1622	0.0406	0.0825	0.2418	0.0001	

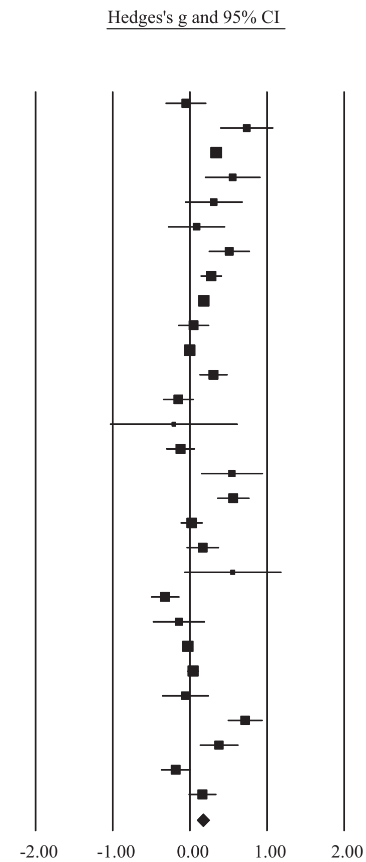

Fig. 4. Forest plot for the leverage ratio variable. The left side of the figure shows computed effect sizes (Hedges' *g*) for the leverage ratio variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the *p*-value for a test of the null and the relative weight (*RW*) of each study in percentage values (calculated by $RW = W_i / \sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval (Aabo et al., 2010; Hentschel and Kothari, 2001).

following subsection on the bankruptcy and financial distress costs hypothesis for a more detailed discussion of this variable).

Overall, we find no empirical evidence for the asymmetric information and agency conflicts theory. This finding is consistent with Aretz and Bartram (2010, p. 347), who conclude that “hypotheses related to agency conflicts between shareholders and managers are often only weakly confirmed.” Also for all individual proxy variables our results comply with Aretz and Bartram (2010).

5.3. Bankruptcy and financial distress costs

The results for the leverage ratio variable (see Fig. 4) are consistent with the bankruptcy and financial distress costs hypothesis. The summary effect of 0.1622 and its confidence interval, which ranges from 0.0825 to 0.2418, clearly show that firms with higher leverage are more likely to hedge. This result is remarkable, since on a vote counting basis the picture is not so clear. Nine of the 29 reviewed studies have a negative sign. Overall, only eleven variables show positive results that are statistically significant.

The summary effect of the size variable (see Fig. 5), which is 0.5276 and has a lower and upper limit of 0.3795 and 0.6757, is in disagreement with the predicted relation between firm size and hedging. Bigger firms are clearly more likely to hedge. Yet, we do not take this result as a matter to reject the bankruptcy and financial distress costs hypothesis, as other factors might explain the positive relation between firm size and hedging. When establishing risk management mechanisms, large firms are better able to make the necessary initial investments, are more likely to possess the required human and technological resources, and can realize higher economies of scale (Dolde, 1993).

The distinctly positive summary effect of 0.6719 for the sales variable is in disagreement with theory, too. Since sales and firm size are positively related, this result most likely also stems from the firm size theory that we describe in the previous column. The summary result for the convertible debt variable is 0.0512, but has low significance concerning the lower and upper limits of −0.0964 and 0.1989. The current ratio variable clearly gives support to the bankruptcy and financial distress costs hypothesis. Its summary effect size is −0.2592 and the lower and upper limits are −0.3454 and −0.1730. Although our meta-analysis yields such a definite result, on a vote-counting basis this would not be so obvious. Only half of the individual studies have negative effect sizes that are

Hedges' g (random effects) - Size

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Aabo et al. (2010)	0.3290	0.1393	0.0559	0.6021	0.0182	3.36
Adedeji and Baker (2002)	0.5847	0.1774	0.2370	0.9325	0.0010	3.14
Bartram et al. (2009)	0.7083	0.0246	0.6601	0.7565	0.0000	3.78
Berkman and Bradbury (1996)	0.9798	0.1956	0.5964	1.3631	0.0000	3.02
Berkman et al. (2002)	0.8254	0.2013	0.4308	1.2199	0.0000	2.99
Capstaff and Marshall (2005)	1.0958	0.1473	0.8071	1.3846	0.0000	3.31
Dadalt et al. (2002)	0.2766	0.0740	0.1316	0.4215	0.0002	3.66
Davies et al. (2006)	0.4229	0.2405	-0.0486	0.8943	0.0788	2.74
Fehle (1999)	0.9241	0.0246	0.8759	0.9724	0.0000	3.78
Fok et al. (1997)	0.7476	0.1093	0.5334	0.9618	0.0000	3.51
Gay et al. (2011)	0.0277	0.0185	-0.0086	0.0641	0.1345	3.78
Gay and Nam 1998	-0.0527	0.0962	-0.2413	0.1360	0.5841	3.57
Géczy et al. (1997)	0.9291	0.1105	0.7125	1.1458	0.0000	3.51
Géczy et al. (2006)	0.2169	0.4258	-0.6177	1.0516	0.6105	1.72
Goldberg et al. (1998)	0.3000	0.1001	0.1039	0.4962	0.0027	3.56
González et al. (2010)	1.1702	0.2214	0.7362	1.6041	0.0000	2.86
Heaney and Winata (2005)	0.8361	0.1130	0.6146	1.0575	0.0000	3.50
Hentschel and Kothari (2001)	0.3386	0.0774	0.1870	0.4903	0.0000	3.65
Hu and Wang (2005)	-0.0196	0.1119	-0.2389	0.1997	0.8610	3.50
Huang et al. (2007)	0.3126	0.0586	0.1978	0.4274	0.0000	3.71
Jalilvand 1999	0.8883	0.3303	0.2410	1.5355	0.0072	2.20
Kim et al. (2006)	0.2962	0.0981	0.1039	0.4885	0.0025	3.56
Lin et al. (2010)	0.2852	0.0278	0.2307	0.3397	0.0000	3.77
Mian (1996)	0.0045	0.0417	-0.0773	0.0863	0.9144	3.75
Nance et al. (1993)	0.6548	0.1614	0.3385	0.9711	0.0000	3.23
Nguyen and Faff (2006)	0.5918	0.1183	0.3600	0.8237	0.0000	3.47
Nguyen et al. (2007)	0.7118	0.2175	0.2855	1.1381	0.0011	2.89
Pincus and Rajgopal (2002)	0.5508	0.1333	0.2896	0.8120	0.0000	3.39
Shu and Chen (2003)	0.4682	0.1031	0.2660	0.6703	0.0000	3.54
Spanò (2007)	0.7692	0.0994	0.5743	0.9641	0.0000	3.56
	0.5276	0.0756	0.3795	0.6757	0.0000	

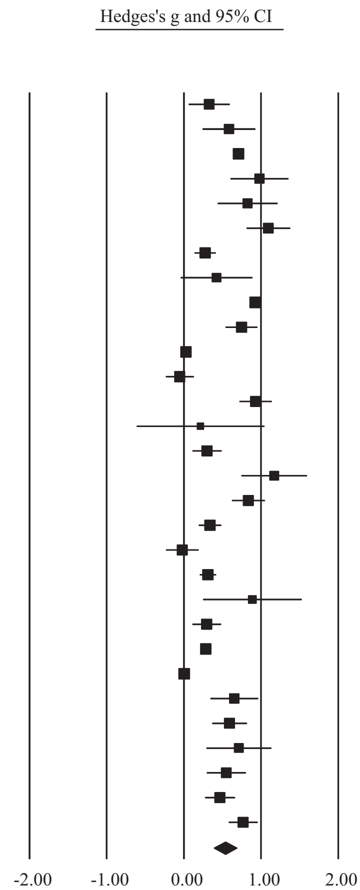

Fig. 5. Forest plot for the size variable. The left side of the figure shows computed effect sizes (Hedges' *g*) for the size variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the *p*-value for a test of the null and the relative weight (*RW*) of each study in percentage values (calculated by $RW = W_i/\sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval (Aabo et al., 2010; Hentschel and Kothari, 2001).

significant. We cannot observe a clear relationship between the interest coverage ratio variable, which yields a summary effect size of −0.0584 and a *p*-value of 0.3629, and corporate hedging.[6] With a summary effect of 0.1985 and lower and upper limits of 0.1113 and 0.2856, the results clearly show a positive relation between dividend yield and hedging. As hedging might theoretically be positively and negatively related to dividend yield, as we describe in Section 4.2, we cannot draw any conclusion on the tested hypothesis from this outcome. The two tax-loss carryforwards variables also do not give support to the theory (see Section 5.1).

Overall, we find at least some evidence for the bankruptcy and financial distress costs hypothesis. The results for the leverage ratio and the current ratio variable give empirical support to the assumption that the risk of bankruptcy and financial distress is positively related to corporate hedging. The outcome of the interest coverage ratio variable, although it has the predicted sign, challenges the hypothesis. We do not draw any conclusions on the theory from the contradiction of the results of the sales and the size variable with the predicted outcomes. Rather, the results reflect the inappropriateness of the variables to test the theory. In general our findings are in line with Aretz and Bartram (2010, p. 355), who state that "some evidence suggests that bankruptcy and financial distress costs are important determinants of corporate hedging, but the evidence is not entirely unambiguous." Even for most individual variables on the bankruptcy and financial distress costs hypothesis we come to the same results as Aretz and Bartram (2010).

5.4. Underinvestment and coordination of investment and financing

The summary effect of the market-to-book ratio variable (see Fig. 6) of −0.0109 (the confidence interval ranges from −0.0734 to 0.0516) shows no relation between a firm's market valuation and its hedging behavior. Although several studies report significant results – 10 studies report results that are significant, four of them have summary effects with a positive sign, six a negative – overall the summary effect is close to zero. Also the summary effect size of −0.0007 for the earnings-price ratio variable reveals no difference in valuation between Hedgers and Non-Hedgers.

The research and development variable (see Fig. 7) of Hedgers is 0.2498 standard deviations larger compared to Non-Hedgers.

[6] González et al. (2010) obviously give a wrong S_{within} for the interest coverage ratio variable. We deploy 28.9 instead of 2.89. We found the right S_{within} by a back-calculation from a *t*-statistic and a validation with the other given data.

Hedges' g (random effects) - Market-to-book ratio

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Allayannis and Weston (2001)	0.2293	0.0450	0.1411	0.3176	0.0000	6.41
Bartram et al. (2009)	-0.0240	0.0239	-0.0708	0.0228	0.3151	7.06
Brunzell et al. (2011)	-0.0258	0.1930	-0.4040	0.3524	0.8935	1.99
Capstaff and Marshall (2005)	0.0760	0.1374	-0.1933	0.3453	0.5803	3.11
Davies et al. (2006)	0.5302	0.2419	0.0561	1.0042	0.0284	1.41
Fehle (1999)	0.1200	0.0234	0.0740	0.1659	0.0000	7.07
Fok et al. (1997)	-0.0848	0.1060	-0.2926	0.1230	0.4239	4.06
Gay et al. (2011)	0.0009	0.0200	-0.0382	0.0400	0.9639	7.15
Gay and Nam (1998)	-0.0429	0.0962	-0.2315	0.1457	0.6559	4.40
Géczy et al. (1997)	0.3279	0.1057	0.1207	0.5352	0.0019	4.07
Géczy et al. (2006)	-0.1361	0.4255	-0.9702	0.6979	0.7491	0.52
González et al. (2010)	-0.2279	0.2053	-0.6304	0.1745	0.2670	1.82
Heaney and Winata (2005)	-0.3201	0.1094	-0.5345	-0.1057	0.0034	3.94
Hu and Wang (2005)	-0.0898	0.1120	-0.3092	0.1296	0.4225	3.86
Huang et al. (2007)	-0.2050	0.0584	-0.3194	-0.0906	0.0004	5.90
Khediri and Folus (2010)	-0.2363	0.1142	-0.4602	-0.0124	0.0386	3.78
Kim et al. (2006)	0.1421	0.0977	-0.0494	0.3336	0.1460	4.35
Klimczak (2008)	0.2813	0.1768	-0.0653	0.6278	0.1117	2.26
Mian (1996)	-0.1075	0.0417	-0.1893	-0.0257	0.0100	6.53
Nance et al. (1993)	-0.1181	0.1575	-0.4268	0.1907	0.4536	2.63
Nguyen and Faff (2002)	-0.2402	0.1057	-0.4473	-0.0331	0.0230	4.07
Nguyen et al. (2007)	-0.2833	0.2125	-0.6998	0.1332	0.1825	1.72
Pincus and Rajgopal (2002)	0.1858	0.1311	-0.0712	0.4428	0.1565	3.28
Shu and Chen (2003)	0.1783	0.1020	-0.0216	0.3781	0.0804	4.20
Spanò (2007)	-0.2064	0.0963	-0.3951	-0.0177	0.0321	4.40
	-0.0109	0.0319	-0.0734	0.0516	0.7332	

Hedges's g and 95% CI

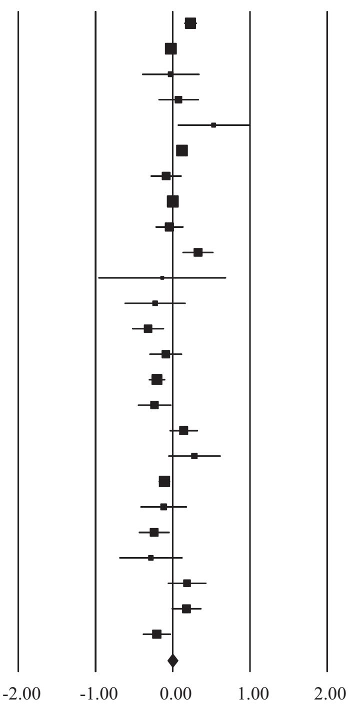

Fig. 6. Forest plot for the market-to-book ratio variable. The left side of the figure shows computed effect sizes (Hedges' g) for the market-to-book ratio variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the p-value for a test of the null and the relative weight (RW) of each study in percentage values (calculated by $RW = W_i / \sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval (Allayannis and Weston, 2001; Khediri and Folus, 2010).

Hedges' g (random effects) - Research and development

Study name	Hedges's g	Standard error	Lower limit	Upper limit	p-Value	Relative weight
Aabo et al. (2010)	0.1384	0.1386	-0.1332	0.4100	0.3180	8.28
Bartram et al. (2009)	-0.3247	0.0240	-0.3718	-0.2776	0.0000	8.87
Fok et al. (1997)	0.9067	0.1108	0.6896	1.1239	0.0000	8.49
Gay and Nam (1998)	0.1618	0.0964	-0.0271	0.3506	0.0932	8.59
Géczy et al. (1997)	0.9428	0.1282	0.6915	1.1942	0.0000	8.36
Goldberg et al. (1998)	0.5656	0.1015	0.3668	0.7645	0.0000	8.55
Heaney and Winata (2005)	-0.1038	0.1088	-0.3171	0.1095	0.3402	8.50
Hu and Wang (2005)	-0.1222	0.2513	-0.6147	0.3703	0.6268	7.15
Kim et al. (2006)	0.5483	0.0994	0.3536	0.7431	0.0000	8.57
Klimczak (2008)	-0.2277	0.1766	-0.5737	0.1184	0.1972	7.94
Nance et al. (1993)	0.3195	0.1584	0.0091	0.6299	0.0436	8.11
Spanò (2007)	0.1377	0.0961	-0.0507	0.3261	0.1521	8.59
	0.2498	0.1516	-0.0474	0.5470	0.0995	

Hedges's g and 95% CI

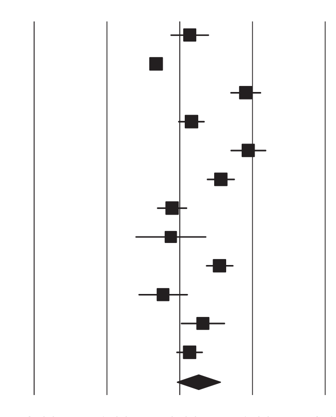

Fig. 7. Forest plot for the research and development variable. The left side of the figure shows computed effect sizes (Hedges' g) for the research and development variable of each study, its standard error, the lower and upper limits of the 95% confidence interval, the p-value for a test of the null and the relative weight (RW) of each study in percentage values (calculated by $RW = W_i / \sum_{i=1}^{k} W_i$). The last row shows the data for the summary effect size. The right side of the figure displays the computed effect sizes and their 95% confidence intervals for the individual studies and the summary effect. Squares show the position of the effect sizes of the individual studies. The square areas are proportional to the weights of the studies. The horizontal lines left and right of the squares display the 95% confidence interval of the effect sizes. The diamond in the last row illustrates the result of the summary effect size. The middle of the diamond represents the summary effect size and the width of the diamond its 95% confidence interval (Aabo et al., 2010).

Although eight of the twelve reviewed studies yield a positive effect size – with five results being statistically significant – the summary effect size is not statistically significant. Still, the *p*-value of 0.0995 indicates a positive relation between R&D activity and corporate hedging. As we describe in the results for the bankruptcy and financial distress costs hypothesis, we find a clearly negative relation between the current ratio and corporate hedging.

Overall, we find only limited evidence on the underinvestment and coordination of investment and financing hypothesis. Aretz and Bartram (2010, p. 340) conclude that "the empirical support for theories of motives for corporate hedging based on agency costs of debt are mixed at best." Analogous to our findings, they do not come to the predicted results for the market-to-book ratio, either. Our outcomes for the earnings-price ratio differ from those of Aretz and Bartram (2010, p. 334), who find "some support for the agency cost hypothesis in multivariate tests" for this variable.[7] Further, they state that "empirical results strongly support the hypothesized relation between R&D expenditures and corporate risk management" (2010, 334). We find rather weak evidence for this relation as the research and development variable has a *p*-value just below the 10% significance level. As we mention in the previous column, on a vote counting basis, our data also implies a strong positive relation between hedging and research and development expenses, but statistically combining the distinct results draws another picture.

6. Discussion

Although it is a mathematical correct method to synthesize data of the reviewed studies, meta-analysis may still yield incorrect results due to the publication bias problem. Publication bias means that studies with high statistical significance, large effect sizes, and large sample sizes are more likely to be published and are therefore more likely to be included in meta-analyses. However, the problem of publication bias does not solely occur with meta-analyses or systematic reviews. Also narrative reviews or even the individual research of studies may be equally biased (Borenstein et al., 2011; Sutton, 2009, chap. 23).

One way to address publication bias is to thoroughly search for gray literature. However, we have not been able to find a database for gray literature that would allow a systematic search with our defined search command. Thus, we only include published journal articles and test if publication bias is inherent in our meta-analyses.

We base the test for publication bias on a model formulated by Borenstein et al. (2011). Since larger studies more often yield significant results and require a greater dedication of time and resources, the model assumes that the risk for a study of not being published increases with a decline in study size or a rise in standard error. We examine if our results may be biased via funnel plots for three variables that yield significant results: leverage ratio, current ratio, and research and development. The funnel plots show the effect sizes of the individual studies on the *x*-axis and their standard errors on the *y*-axis (standard error is negatively related to study size), whereby the values of the *y*-axis are in reverse order. We mark the individual studies with a circle. The middle dashed line represents the summary effect size of the respective variable. The outside dashed lines span a funnel that defines the area where we expect point estimates of the effect sizes for the individual studies. The intersection points of the outside dashed lines and the *x*-axis are

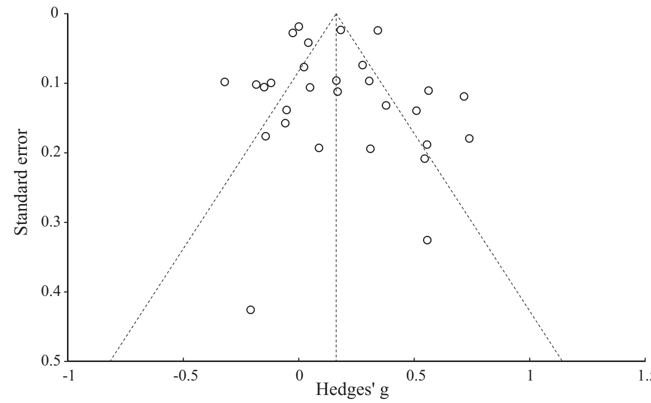

Fig. 8. Funnel plot for the leverage ratio variable. The middle dashed line represents the summary effect size. The outside dashed lines span a triangle that defines the area where we expect point estimates of the effect size for the individual studies.

defined by the lower and upper limits of the 95% confidence interval of the summary effect size in case of the maximum standard error on the *y*-axis (e.g., 0.5 in Fig. 8). With a decreasing standard error the confidence interval narrows and gets zero in case of a standard error of zero. Since smaller studies have greater sampling errors, the dispersion of their calculated effect sizes should be greater and thus the funnel broadens toward the bottom of the diagram.

Fig. 8 shows the funnel plot of the leverage ratio variable. Without publication bias, the studies should be symmetrically distributed around the middle dashed line. In case of publication bias, we should be able to observe a gap in the lower left corner of the plot, since the hypothesized relation between the variable and the effect size is positive and thus studies located in this area would yield insignificant results. In the middle of the funnel in Fig. 8 we observe a slight overbalance on the right side. But, overall we do not find evidence of publication bias for the leverage ratio variable concerning the circle on the lower left corner of the plot. We detect a small gap on the lower right corner in the funnel plot of the current ratio variable (Fig. 9). Since the hypothesized sign of the current ratio is negative, this gap might be a slight indication of publication bias – especially, because 10 out of the 20 reviewed studies show results that are statistically significant. Conversely, the research and development variable speaks against the existence of publication bias, since its funnel plot clearly shows a gap

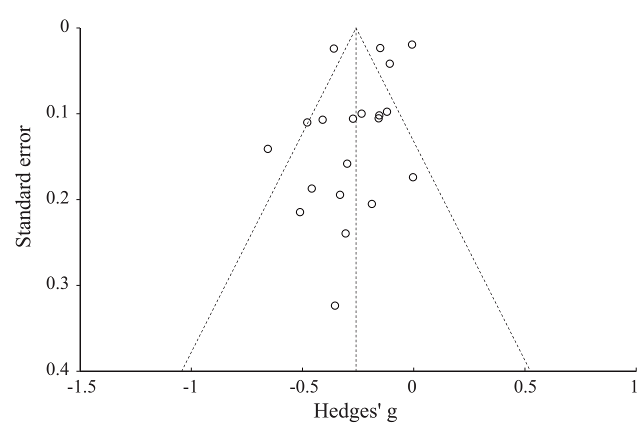

Fig. 9. Funnel plot for the current ratio variable. The middle dashed line represents the summary effect size. The outside dashed lines span a triangle that defines the area where we expect point estimates of the effect size for the individual studies.

[7] We do not include multivariate tests in our meta-analysis.

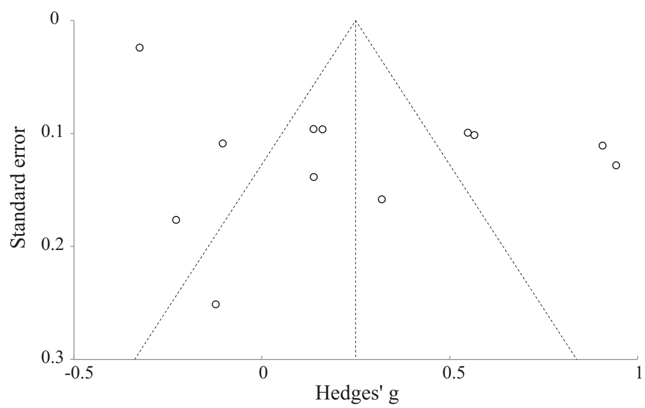

Fig. 10. Funnel plot for the research and development variable. The middle dashed line represents the summary effect size. The outside dashed lines span a triangle that defines the area where we expect point estimates of the effect size for the individual studies.

in the lower right corner (Fig. 10). In case of publication bias, the gap should be on the lower left corner, since research and development expenses and hedging should be positively related according to theory.

Although we cannot fully dismiss it, we do not find strong evidence for publication bias. Moreover, the reviewed studies contain numerous variables – 29 of the 37 reviewed studies contain at least 10 variables. Thus, we conclude that the significance of individual variables does not have a strong influence on the probability of publication. Overall, we do not consider publication bias to be a serious drawback for our analyses.

Another issue in our meta-analyses is that the reviewed studies are non-random samples of the universe of firms. Effect sizes of several individual studies are not statistically independent of each other. Therefore, regarding the population we considered the entire global financial market. For example, eighteen out of the 37 reviewed studies (mainly) use data of firms located in the United States. Some studies even collect data from almost the same sample. For example, the sample of Nance et al. (1993) consists of non-financial corporations of the combination of the Fortune 500 and the S&P 400 in 1986 and Géczy et al. (1997) review non-financial corporations of the Fortune 500 in 1990.[8]

Another constraint is that some studies (e.g., Dadalt, Gay, & Nam, 2002; Fehle, 1999) contain firm data of several years. Thus, the standard error of these studies is smaller and their weight in the meta-analysis is larger. We did not find a consistent method to adjust the study weights accordingly.

We consider it important to keep these issues in mind when interpreting the results of our analyses. But, as with publication bias, these drawbacks are not unique to meta-analysis, but are also inherent in narrative reviews or the individual research of studies.

7. Conclusions

We test four theories of corporate hedging via meta-analyses based on means for fifteen proxy variables. Three variables yield outcomes that are consistent with hedging theory. The leverage ratio and the current ratio variables show results that are significant at the 5% level and the result for the research and development variable is significant at the 10% level. Our findings largely confirm the theory that hedging is more valuable to firms that face a higher risk of bankruptcy and financial distress. We find limited evidence that the underinvestment problem and the potential lack of internal funds for profitable investment opportunities induce firms to hedge. Our results contradict that neither taxes or asymmetric information and agency conflicts have an influence on corporate hedging behavior. The validity of the conclusion for the tax hypothesis is limited, since we base our analysis only on tax-loss carryforwards variables, whose applicability in that matter is not without controversy.

Our results are mainly in accordance with Aretz and Bartram (2010), who conduct a narrative review on the rationales of corporate hedging. However, our outcomes differ for the research and development, the earnings-price ratio, and the dividend yield variables.

Nevertheless, a meta-analysis as well as a traditional literature review cannot address the fundamental problems in analyzing determinants of corporate hedging policy alluded to Aretz and Bartram (2010). The main problems – amongst other things – are “endogeneity and identification problems” and “empirical modelling of structural relations” in the reviewed primary studies. But it is beyond the scope to address these problems and probably, it is not possible to solve the mentioned problems by carrying out this methodology. Especially, due to missing data it is even not possible to solve the problems by using other appropriate methodologies. In detail, we would need to get access to the whole samples or data used in the primary studies, which is in our opinion not very realistic.

Nevertheless, in contrast to a traditional (narrative) literature review the added value of a meta-analysis is, that you receive (objectively comprehensible) uniform effect sizes, which can be reasonably interpreted. By carrying out a traditional literature review you “only” get a qualitative analysis of the related literature. Last but not least, according to Borenstein et al. (2011) we want to point out the alternative to a meta-analysis: every researcher would have to carry out this analysis himself. The consequence would be – amongst other things – an approach that is not standardized and therefore, different (subjective) results could occur.

To sum up, we think that carrying out this methodology as well as a traditional review brings about the above mentioned problems. But in contrast to a traditional literature review there is – as mentioned above – an added value.

We see the potential for further research on the determinants of corporate hedging via statistical systematic reviews. Meta-analysis based on correlations allows synthesizing the numerous regression analyses on corporate hedging behavior.

Whereas meta-analysis is a standard tool in the fields of medicine, psychology, and sociology, academics in financial economics rarely use it. One goal of this paper is to present the methods of meta-analysis. We see various application possibilities of this research method, especially in the field of corporate finance.

Acknowledgements

We would like to thank Söhnke M. Bartram, Gregor Dorfleitner, Georg Hoffmann, Dennis Kundisch, Manfred Steiner, Caren Sureth and Martin Wallmeier for their valuable comments and suggestions.

[8] Both Lin et al. (2007) and Lin et al. (2010), and Nguyen and Faff (2002) and Nguyen and Faff (2006) respectively use the same data sample (but they use partly different variables). If both studies of one of these pairs contain the same variable, we only include the more recent study.

Appendix A.

Overview of the reviewed studies for variables not displayed by forest plots

Variable	Reviewed studies
Taxes	
Tax-loss carryforwards (continuous)	Gay, Lin, and Smith (2011); Gay and Nam (1998); Géczy, Minton, and Schrand (1997); Huang, Ryan, and Wiggins (2007); Kim, Mathur, and Nam (2006); Shu and Chen (2003)
Asymmetric information and agency conflicts	
Option ownership	Brunzell, Hansson, and Liljeblom (2011); Gay and Nam (1998); Géczy et al. (1997); Heaney and Winata (2005); Nguyen and Faff (2002); Pincus and Rajgopal (2002)
Bankruptcy and financial distress costs	
Convertible debt	Berkman and Bradbury (1996); Fehle (1999); Fok, Carroll, and Chiou (1997); Gay and Nam (1998); Géczy et al. (1997); Jalilvand (1999); Nance et al. (1993)
Current ratio	Adedeji and Baker (2002); Bartram, Brown, and Fehle (2009); Berkman and Bradbury (1996); Berkman, Bradbury, Hancock, and Innes (2002); Capstaff and Marshall (2005); Davies, Eckberg, and Marshall (2006); Fehle (1999); Fok et al. (1997); Gay et al. (2011); Géczy et al. (1997); Goldberg, Godwin, Kim, and Tritschler (1998); González, Búa, López, and Santomil (2010); Heaney and Winata (2005); Jalilvand (1999); Kim et al. (2006); Mian (1996); Nance et al. (1993); Nguyen and Faff (2002); Nguyen, Faff, and Marshall (2007); Shu and Chen (2003); Spanò (2007)
Dividend yield	Adedeji and Baker (2002); Bartram et al. (2009); Berkman and Bradbury (1996); Berkman et al. (2002); Davies et al. (2006); Fehle (1999); Fok et al. (1997); Géczy et al. (1997), Géczy, Minton, and Schrand (2006); Heaney and Winata (2005); Jalilvand (1999); Lin, Pantzalis, and Park (2010); Mian (1996); Nance et al. (1993); Nguyen and Faff (2006); Pincus and Rajgopal (2002); Shu and Chen (2003); Spanò (2007)
Interest coverage ratio	Adedeji and Baker (2002); Bartram et al. (2009); Berkman and Bradbury (1996); Berkman et al. (2002); Capstaff and Marshall (2005); Davies et al. (2006); Fok et al. (1997); Gay and Nam (1998); Géczy et al. (1997), Géczy et al. (2006); González et al. (2010); Heaney and Winata (2005); Hu and Wang (2006); Jalilvand (1999); Klimczak (2008); Nance et al. (1993); Shu and Chen (2003)
Sales	Brunzell et al. (2011); Capstaff and Marshall (2005); Dadalt et al. (2002); Davies et al. (2006); Fok et al. (1997); Kim et al. (2006); Klimczak (2008); Nguyen et al. (2007); Shu and Chen (2003)
Underinvestment and coordination of investment and financing	
Earnings-price ratio	Adedeji and Baker (2002); Berkman and Bradbury (1996); Berkman et al. (2002); Gay and Nam (1998); Hu and Wang (2006); Jalilvand (1999)

Appendix B.

Overview of the search terms

Database	Search term
ABI/INFORM complete	(cabs(hedg*) or cabs(derivative*)) and (ab(use) or ab(using) or ab(usage) or ab(polic*) or cabs(activit*)) and (cabs(compan*) or cabs(corporat*) or cabs(firm*)) and (cabs(sample*) or cabs(evidence) or cabs(result*) or cabs(data) or cabs(investigat*) or cabs(test*) or cabs(empiric*) or cabs(survey*) or cabs(examine*))
Business source premier	"(hedg* OR derivative*) AND (AB use OR AB using OR AB usage OR AB polic* OR AB activit*) AND (compan* OR corporat* OR firm*) AND (sample* OR evidence OR result* OR data OR investigat* OR test* OR empiric* OR survey* OR examine*)"

Appendix C.

Numerical examples[9]

1. Calculation of Hedges' g using the continous variable "Institutional investors" and the data from the study of Géczy et al. (1997) – regarding the necessary statistics of the study see Fig. 2:

Calculation of Cohen's d:

$$d = \frac{X_H - X_{NH}}{S_{within}} = \frac{55.46 - 48.59}{15.8620} = 0.4331$$

with

$$S_{within} = \sqrt{\frac{(n_H - 1)S_H^2 + (n_{NH} - 1)S_{NH}^2}{n_H + n_{NH} - 2}} = \sqrt{\frac{(152-1)\cdot 14.70^2 + (205-1)\cdot 16.67^2}{152 + 205 - 2}} = 15.8620.$$

Variance of d:

$$Vd = \frac{n_H + n_{NH}}{n_H n_{NH}} + \frac{d^2}{2(n_H + n_{NH})} = \frac{152 + 205}{152 \cdot 205} + \frac{0.4331^2}{2\cdot(152+205)} = 0.0117.$$

Calculation of the correction factor J:

$$J = 1 - \frac{3}{4df - 1} = 1 - \frac{3}{4 \cdot 355 - 1} = 0.9979$$

with

$$df = n_H + n_{NH} - 2 = 152 + 205 - 2 = 355.$$

Calculation of Hedges' g:

$$g = J \cdot d = 0.9979 \cdot 0.4431 = 0.4322$$

and

Variance of g: $V_g = J^2 \cdot V_d = 0.9979^2 \cdot 0.0117 = 0.0117.$

Standard error: $\sqrt{V_g} = \sqrt{0.0117} = 0.1080.$

2. Calculation of the odds ratio OR using the binary variable "Tax-loss carryforwards" and the data from the study of Berkman and Bradbury (1996) – regarding the necessary statistics of the study see Fig. 1:

$$OR = \frac{X_H}{1-X_H} \cdot \frac{1-X_{NH}}{X_{NH}} = \frac{0.473}{1-0.473} \cdot \frac{1-0.295}{0.295} = 2.1450 \text{ and}$$

$$\log OR = \ln(OR) = \ln(2.1450) = 0.7631.$$

Variance $V_{\log OR}$:

$$V_{\log OR} = \frac{1}{(X_H - X_H^2)n_H} + \frac{1}{(X_{NH} - X_{NH}^2)n_{NH}} = \frac{1}{(0.473 - 0.473^2)\cdot 55} + \frac{1}{(0.295 - 0.295^2)\cdot 61} = 0.1516.$$

[9] *Note*: In all of the following numerical examples rounding errors can appear.

3. Calculation of the summary effect size M (Hedges' g) using the continous variable "Institutional investors" and the data from the study of Géczy et al. (1997). It is a continuation of the first example in Appendix C. Regarding the necessary data (effect size measures and the relative weights) of the other relevant studies see Fig. 2:

Calculation of the weight W of the study Géczy et al. (1997):

$$W_i = \frac{1}{V_i + T^2} = \frac{1}{0.0117 + 0.0552} = 14.9541$$

with

$$T^2 = \frac{Q - df}{C} = \frac{34.9204 - 6}{523.9099} = 0.0552.$$

Relevant variables for calculating the between-study variance T^2:

$$Q = \sum_{i=1}^{k} \frac{Y_i^2}{V_i} - \frac{\left(\sum_{i=1}^{k} Y_i/V_i\right)^2}{\sum_{i=1}^{k} 1/V_i}$$

$$= \left(\frac{0.4321^2}{0.0117} + \ldots\right) - \frac{((0.4321/0.0117) + \ldots)^2}{(1/0.0117) + \ldots} = 34.9204,$$

$$df = k - 1 = 7 - 1 = 6$$

and

$$C = \sum_{i=1}^{k} \frac{1}{V_i} - \frac{\sum_{i=1}^{k} 1/V_i^2}{\sum_{i=1}^{k} 1/V_i}$$

$$= \left(\frac{1}{0.0117} + \ldots\right) - \frac{1/0.0117^2 + \ldots}{1/0.0117 + \ldots} = 523.9099.$$

Calculation of the summary effect size M:

$$M = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i} = \frac{14.9541 \cdot 0.4322 + \cdots}{14.9541 + \cdots} = 0.3852.$$

Variance of M:

$$V_M = \frac{1}{\sum_{i=1}^{k} W_i} = \frac{1}{14.9541 + \cdots} = 0.0106.$$

Standard error: $\sqrt{V_M} = \sqrt{94.1440} = 0.1031.$

Note: "..." represents the necessary data of the other studies.

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