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Vivian W. Tai, Yi-Hsun Lai, Tung-Hsiao Yang

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The Role of the Board and the Audit Committee in Corporate Risk Management

Vivian W. Tai[1]
Department Banking and Finance
National Chi Nan University, Taiwan
Email: whtai@ncnu.edu.tw

Yi-Hsun Lai
Department of Finance
National Yunlin University of Science and Technology, Taiwan
Email: laiYiHsu@yuntech.edu.tw

Tung-Hsiao Yang
Department of Finance
National Chung Hsing University, Taiwan
Email: tyang1@nchu.edu.tw

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Abstract

This paper examines the impact of corporate governance on corporate risk-management activities in S&P 500 firms over the period 2004-2010 by measuring the characteristics of the board directors and audit committee. Our results show that the board of directors, especially the audit committee, plays an important role in the firm's hedging decisions, including whether to hedge and to what extent. Such evidence is even stronger in high-

[1] Corresponding author. Department of Banking and Finance, National Chi Nan University. No. 1, University Rd., Puli, Nantou County, Taiwan, R.O.C. E-mail: whtai@ncnu.edu.tw. Tel.: +886-49-2910960. Ext. 4636. Fax: +886-49-2914511.

leveraged firms with large risk-shifting incentives. These results are robust to the consideration of endogenous concerns, a board corporate governance index, and industrial effects. Our study contributes to the literature by showing the influential role of the audit committee on corporate risk management.

JEL: G30, G32, G34
Keywords: hedging; risk-shifting; derivatives; risk management; board; corporate governance

1. Introduction

Corporate scandals in the early 2000s, such as Enron, WorldCom, and Merck, have drawn unprecedented attention to the function of the board of directors. In particular, the Sarbanes-Oxley Act (SOX hereafter) in the U.S. requires that the audit committee be entirely composed of independent directors and contain at least one financially knowledgeable member to reinforce the auditing function. New rules set by the NYSE in 2004 define additional conditions concerning the independence of the board of directors and the composition of the audit, compensation, and governance committees. Specifically, Section 303.07 (D) of the NYSE Listed Company Manual requires the audit committee "to discuss policies with respect to risk assessment and risk management." Following such regulation reforms, this paper investigates the role of the board of directors, especially the characteristics of the audit committee, on corporate risk-management activities of U.S. firms.

We evaluate the impact of board structure, especially the characteristics of the audit committee, on corporate hedging decisions for three reasons. First, the changes in the rules of Section 303.07 (D) of the NYSE Listed Company Manual concerning the board or the audit committee might affect corporate hedging. Second, corporate hedging could reduce the executive compensation associated with bearing additional firm-specific risk and increase the board's ability to measure managerial performance (DeMarzo and Duffie, 1995). Third, it is well documented in the literature that risk management is beneficial to a firm's performance and value by eliminating operating risks and increasing access to external financing (Froot, Scharfstein and Stein, 1993; Carter, Rogers, and Simkins, 2006; Berrospide, Purnanandam, and Rajan, 2010; Allayannis, Lel and Miller, 2012; Chen and King, 2014). As very little research has directly looked into the impact of the audit committee on corporate risk-management activities, this study targets to fill this gap in the literature.

Stulz (1984), Smith and Stulz (1985), and Stulz (1996) argue that leverage motivates firms to hedge in order to reduce bankruptcy and financial distress costs. Recently, some studies observe a risk-shifting[2] phenomenon on corporate hedging, a firm with high leverage has a higher incentive to engage in hedging, however, the higher risk management incentives disappear for firms with extremely high leverage (Purnanandam, 2008; Lookman, 2009). Previous researchers suggest different types of restrictions in bond covenants, a short-term or convertible debt structure, or an optimal executive compensation structure as possible solutions to reduce the agency problem between shareholders and debt holders (Smith and Warner, 1979; Barnea, Haugen, and Senbet, 1980; Friend and Lang, 1988; Barclay and Smith, 1995; Frierman and Viswanath, 1993; Guedes and Opler, 1996; Chesney and Gibson-Asner, 2001; Lookman, 2009). However, by nature most board directors are block-shareholders, and they thus generally have a motivation to expropriate the wealth of debt holders by hedging less. Based on the regulation reforms geared at the role of independent directors and financially knowledgeable members, we also address whether board directors exhibit a more aggressive role in the corporate hedging activities of high-leveraged firms with more risk-shifting incentives.

We use non-financial S&P500 firms from 2004 to 2010 to test two important issues.[3] First, we analyze the linkage between board structure and corporate hedging activities and propose a new set of explanatory variables that have yet to be considered in the risk management literature. Second, we examine whether the board and audit

[2] The risk-shifting phenomenon could arise from the agency problem in debt financing in which equity holders have an incentive to expropriate the wealth of debt holders by transferring risks to them (Jensen and Meckling, 1976).

[3] We collect the sample beginning in 2004 for two reasons. First, disclosures of derivatives hedging are inconsistent in the 10-K reports of sample firms before 2004. Second, Section 303A of the NYSE Listed Company Manual of 2004 requires that members of the nominating, compensation, and audit committees achieve a majority of board independence. To focus on the primary issues affecting the impact of the board, we collect a sample from 2004 to eliminate these structural changes.

committee are able to mitigate the risk-shifting problem after the director requirements set by the SOX and the NYSE.

The empirical results support our arguments regarding the board directors' impact on a corporate hedging strategy. Firms with more directors, especially independent directors, and audit committee members, higher frequent meetings of audit committee, and higher proportion of financial experts in audit committee, present higher incentive to hedge and have higher hedge ratio. Further, consistent with Purnanandam (2008), we find that extremely high-leveraged firms scale back their hedging activity to increase firm risk and expropriate wealth from the debt holders, which reveal that risk-shifting phenomenon is also presented in S&P 500 firms. Finally, we find that board size, the number of audit committee members and audit committee meetings significantly mitigate the risk-shifting problem in high-leveraged firms' hedging activities. These results show that the monitoring effects of these board structure variables on corporate hedging are stronger in high-leveraged firms with risk-shifting incentive. Finally, we apply a comprehensive index of board characteristics to assess the robustness of our results. The empirical evidence is qualitatively unchanged in the robust tests.

The rest of the paper is organized as follows. We summarize the literature and hypotheses in Section 2. Section 3 introduces the design of the methodology to test for the risk-shifting phenomenon and the measure of corporate governance exercised by the board of directors. Section 4 tests the hypotheses and provides robustness checks. We conclude the empirical findings in Section 5.

2. Literature review and research hypotheses

2.1 Literature review

The board of directors plays an important role in corporate governance (Kose and Senbet, 1998). Cheng (2008) provides evidence that the accounting- and market-based

performances of firms with larger boards are significantly less volatile than firms with smaller boards. Pathan (2009) shows that board size is associated with reduced return volatility for financial institutions. Sakawa, and Watanabel (2018) find the advisory and monitoring roles of larger boards for the banking industry. Based on the prior literature, we expect that firms with a larger board size will be associated with a greater incentive to hedge and exhibit a greater extent of hedging.

The empirical findings regarding the effect of independent directors on a firm or shareholders are mixed.[4] Few papers have linked board composition to the firm's risk management activity. Borokhovich et al. (2004) is the first to analyze the relationship between outside directors and a firm's use of interest rate derivatives, finding that outside directors play active roles in monitoring the use of derivatives in the firm's hedging decisions. However, Dionne and Triki (2005) and Mardsen and Prevost (2005) report evidence suggesting that the presence of outside independent directors has no effect on a firm's risk management policy. The mixed empirical findings may be due to a failure to consider the financial status of companies (high-leveraged or not). Following the spirit of the new rules set by the SOX and the NYSE, we expect that independent directors will provide superior monitoring and advisory functions with respect to a firm's hedging policy.

The primary task of the audit committee is to oversee the firm's financial

[4] Weisbach (1988) suggests that CEO turnover is more sensitive to performance in firms with outsider-dominated boards than in firms with insider-dominated boards. Similarly, MacAvoy and Millstein (1999) find that board independence is positively correlated with accounting-based measures of firm performance. Beasley (1996) and Dechow and Sloan (1996) demonstrate that the presence of additional outside directors on the board decreases the likelihood of fraudulent information in the firm's financial statements; moreover, Klein (2002) finds that companies with independent boards are less likely to manage their earnings by reporting abnormal accruals. Wu, Chen, and Lee (2016) provides similar findings of the suppressing effect of independent directors on earnings management, and the existence of controlling shareholders enhances the suppressing effects. Conversely, the absence of a relationship between firm performance and the independence of its board members is confirmed by Fosberg (1989), Hermalin and Weisbach (1991), Klien (1998), and Bhagat and Black (2002). Other papers reporting evidence refuting the superior monitoring attributed to independent directors include Subrahmanyam et al. (1997) and Core et al. (1999) for CEO compensation and Agrawal and Chadha (2005) for earnings restatement.

performance and ensure the reliability of its financial reporting. A periodic review of the firm's risk assessment system and the managerial actions used to manage its risks is a critical step toward fulfilling this task. The new rules set by the SOX require the presence of at least one financially knowledgeable director on the audit committee and the independence of all its members, while the NYSE listed company manual requires that at least three members of the audit committee be independent and financially knowledgeable, with one of them having accounting knowledge. We expect that audit committee characteristics, such as the number of committee meetings, the size of the committee, the professional backgrounds of its members, and the number of independent directors, also play a role in monitoring corporate hedging activities, because the committee members are free of any influence from the firm's CEO and possess the financial background required to fully understand the firm's activities.

A large body of literature has investigated the extent to which audit committee independence and financial expertise are beneficial to shareholders (Fama and Jensen, 1983; Xie et al., 2003; Davidson et al., 2004; Agrawal and Chadha, 2005). Dionne and Trike (2005) are the first to establish a relationship between the independence and financial education background of the audit committee and a firm's corporate hedging, finding that financially educated directors seem to encourage corporate hedging of gold mining firms.

In addition to requiring the presence of independent and financially knowledgeable directors on the audit committee, the NYSE's listed company manual requires that the audit committee comprise at least three members. This rule is likely motivated by the desire to encourage firms to devote significant director resources to their audit committees. Indeed, audit committees with more members should be able to monitor the firm's management more efficiently. However, communications among members might become more difficult in large audit committees, which could

deteriorate the quality of monitoring. Therefore, to the extent that increases in both the audit committee's size and the meetings of audit committee do not hinder communication among members, we expect firms complying with this requirement to report a higher incentive to hedge and a larger hedge ratio. Further, Chen, Lai, and Chen (2015) find the difference association patterns between the multiple directorships and the performance of mergers & acquisitions in the pre-/post-SOX periods and highlight the importance of factoring in regulative environmental change. Thus, we expect to see the monitoring effectiveness of board and audit committee on corporate hedging after the mandatory changes by the NYSE.

Dionne and Trike (2005) also construct an index of board corporate governance based on the financial backgrounds of directors and test its effect on a firm's hedging policy. They note a significant and positive relationship between the score of the index and firm hedging behavior. To account for all board characteristics in the empirical tests, we construct a similar board corporate governance index for our sample.

2.2 Hypotheses' development

Based on the above literature, our first hypothesis is to test whether board characteristics, including board size, the number of audit committee members, the number of audit committee meetings, the percentage of financial experts on the audit committee, the number of independent directors, and a comprehensive index of board corporate governance, have a positive effect on corporate hedging. Extending the finding regarding the effect of the risk-shifting phenomenon on corporate hedging for high-leveraged firms (Purnanandam, 2008; Lookman, 2009), we focus on non-financial S&P 500 firms in our sample. In fact, this present paper is the first to analyze the risk-shifting behavior among S&P 500 firms. Although it is likely that large-cap S&P500 firms exhibit less information asymmetry relative to some small-cap firms, we expect that risk-shifting behavior should nonetheless exist in these firms due to the principle-

agent relationship. Therefore, our second hypothesis is that risk-shifting behavior is indeed present in S&P 500 firms.

In the existing literature, most solutions to reduce the agency problem between shareholders and bondholders are from the requests of debt holders. For example, Smith and Warner (1979) argue that different types of bond covenants, such as restrictions on investment or the disposition of assets, can reduce agency costs. Moreover, short-term bonds or convertible bonds also can reduce risk-shifting behavior (Barclay and Smith, 1995; Guedes and Opler, 1996; Chesney and Gibson-Asner, 2001). Lookman (2009) finds that hedging is positively associated with the proportion of bank debt amongst firms with large risk-shifting incentives, supporting that the monitoring function of bank debt can alleviate this problem. In addition to debtholders, Tai, Lai and Lin (2014) provide an evidence of the monitoring function from institutional investors for mitigating the risk-shifting problem of high leveraged firms. Moreover, from the angle of monitoring costs, local institutional investors play more important role in the monitoring function than foreign institutional investors.

In contrast to external corporate governance in the previous literature, there is no study that directly examines the impact of board structure on corporate risk-shifting behavior from the view of internal corporate governance. By nature, most board directors are block-shareholders, implying that they have a motivation to expropriate the wealth of debt holders by hedging less. Based on the regulation reform that focuses on the role of independent directors and financially knowledgeable members, we measure the risk-shifting incentive based on a firm's leverage and its hedging policy and examine how board characteristics, especially those of the audit committee, affect a high-leveraged firm's hedging activities. Therefore, our third hypothesis is that the role of board directors alleviates risk-shifting behavior.

3. Empirical models and sample selection

3.1 Empirical models

3.1.1 Board structure and hedging behavior

To examine the impact of the role of the board directors on corporate hedging activities, we estimate a series of Logit and Tobit models in the form of Eq. (1):

$$\begin{aligned} H_{it} = {} & \beta_0 + \beta_1 B_{it} + \beta_2 CEO\_Ownership_{it} \\ & + \beta_3 CEO\_Exercisable\_Option_{it} + \beta_4 CEO\_Unexercisable\_Option_{it} \\ & + \beta_5 Size_{it} + \beta_6 Quick_{it} + \beta_7 R\&D_{it} + \beta_8 \left(\frac{PPE}{TA}\right)_{it} + \beta_9 \left(\frac{NI}{Sales}\right)_{it} + \beta_{10} \left(\frac{DA}{TA}\right)_{it} \\ & + \beta_{11} Leverage_{it} + \sum Year_t + \sum Industry_k + \varepsilon_{it} \end{aligned} \quad (1)$$

We use two proxies for corporate hedging behavior, H_{it}, as the dependent variables. One is a dummy variable for hedging and the other is the hedge ratio. The *hedging dummy* is equal to one for firms using derivatives to hedge and zero otherwise. The *hedge ratio* is the sum of the nominal principal amount of derivatives held for hedging scaled by total assets.[5] The dummy variable tries to capture whether a firm hedges, but does not provide information regarding the extent of hedging.

We adopt the use of derivatives as a proxy for corporate risk management on the basis of earlier research findings that provide strong evidence in support of hedging effects of derivatives on various risks of a firm. Guay (1999) finds that firms using derivatives to hedge experience a decline in their earnings and stock price volatility after the initiation of derivatives contracts. Allayannis and Ofek (2001) find evidence that firms use currency derivatives for hedging significantly reduces the exchange rate exposure firms face. Further, Chang, Lin and Yu (2011), Chang, Lo, Lee and Yu (2013), and Yang, and Yu (2018) show that insurance companies may use various catastrophe

[5] The data format regarding the amount of derivative contracts prior to 2009 is not consistent across the sample firms. Therefore, only hedge ratio data of 2009 and 2010 are available for our tests.

equity put options to hedge losses with hurricane events. Additionally, Graham and Rogers (2002) and Chen and King (2014) find a significant impact of derivatives instruments on the firm's debt capacity and the cost of debt.

The primary independent variables of interest are denoted by B_{it}, which are board characteristics including board size, the number of audit committee members, the number of audit committee meetings, the percentage of financial experts on the audit committee, the number of independent directors, and our Board CG index. Following Gompers et al. (2003), we compile our Board CG index by using the sum of five dummies for the board characteristics in our independent variables. These dummies are unity if they are greater than their corresponding medians, and 0 otherwise.

To examine the risk-shifting phenomenon in corporate hedging and the impact of the role of the board directors on risk-shifting behavior, we estimate a series of Logit and Tobit models in the form of Eq. (2):

$$\begin{aligned} H_{it} = {} & \beta_0 + \beta_1 RSI_{it} + \beta_2 B_{it} + \beta_3 RSI_{it} \times B_{it} + \beta_4 CEO\_Ownership_{it} \\ & + \beta_5 CEO\_Exercisable\_Option_{it} + \beta_6 CEO\_Unexercisable\_Option_{it} \\ & + \beta_7 Size_{it} + \beta_8 Quick_{it} + \beta_9 R\&D_{it} + \beta_{10}\left(\frac{PPE}{TA}\right)_{it} + \beta_{11}\left(\frac{NI}{Sales}\right)_{it} + \beta_{12}\left(\frac{DA}{TA}\right)_{it} \\ & + \beta_{13} Leverage_{it} + \sum Year_t + \sum Industry_k + \varepsilon_{it} \end{aligned} \quad (2)$$

In addition to the variables of board structure, the second independent variable that we are interested in is risk-shifting incentive, which is denoted by RSI_{it}. Lookman (2009) measures the incentive for risk-shifting behavior using a dummy variable based on the percentile of the firm's leverage ratio in the sample. Following Purnanandam (2008) and Lookman (2009), we set our *RSI* dummy equal to one for firms in the top decile, and zero for the rest. If the relationship between hedging activities and the risk-shifting index is significant and negative, then it implies that high-leveraged firms hedge less than they should and shift the risk to debtholders, and hence risk-shifting behavior does

exist. In addition, the interaction term ($RSI_{it} \times Y_{it}$) examines the marginal effect of the board of directors on corporate hedging in high-leveraged firms compared to other firms.

We control other factors that could affect a firm's hedging behavior using the following variables. First, prior research finds that managerial risk aversion is an important determinant of risk management policy (Tufano, 1996; Pertersen and Thiagarajan, 2000). The greater the managers' human capital investment or equity investment is in the firm, the greater their incentives are to engage in risk management to reduce risk. However, if managers have large option components in their compensation structure, then the convex payoff structure provides an incentive to minimize risk management. We employ three variables to proxy for managerial risk aversion: the percentage of the firm's common shares held by the CEO (*CEO_Share_Ownership*) and the percentages of the CEO's exercisable and unexercisable option values in terms of total compensation (*CEO_Exercisable Option* and *CEO Unexercisable Option*). Next, firm size ($Size_{it}$), measured by the natural logarithm of net sales, may have a significant impact on a firm's hedging behavior, because it can serve as a proxy for bankruptcy costs or financial flexibility (Nance et al., 1993; Purnanandam, 2008; Lookman, 2009). We further measure the firm's liquidity using the quick ratio ($Quick_{it}$), which is the sum of cash and short-term investments scaled by net sales (Purnanandam, 2008). We employ the research and development ratio ($R\&D_{it}$), which is the ratio of research and development expenses to net sales, to proxy for growth opportunity (Froot et al., 1993). In addition, collateral assets are measured using the fixed asset ratio (*PPE/TA*), which is plant, property, and equipment scaled by total assets (Géczy et al., 1997). We measure profitability using the ratio of net income to net sales (*NI/Sales*) (Samant, 1996; Allayannis and Ofek, 2001). Finally, we consider the ratio of depreciation and amortization expenses to total

assets to capture the non-debt tax shield (*DA/TA*) and use the leverage level ($Leverage_{it}$) to capture the probability of financial distress (Smith and Stulz, 1985; and Balakrishnan and Fox, 1993).

3.2 Data and sample selection

The empirical tests are based on data on non-financial S&P 500 firms during the period 2004-2010. First, we collect all financial and accounting ratios from the Compustat database as the baseline sample. Second, to match the hedging data with the baseline sample, we follow Purnanandam (2008) to search SEC 10-K filings for key words, such as "risk management", "hedging", "derivative", "forwards", "swap", etc., and hand collect the hedging data. The hedge ratio is obtained by dividing the notional principal amount of all derivative contracts by total assets.[6] These derivative contracts include derivatives for hedging foreign currency, commodity prices, and interest rate exposure. Finally, we hand collect the data on the characteristics of the board members, the audit committee, and the number of their meetings from the SEC DEF 14A filings. In sum, we exclude firms where matched filings are unavailable, and the final sample has 2,364 firm-year observations, which represent 450 firms during the 7-year sample period.

To check the distribution of observations in different years and industries, we summarize the sample distribution in Table 1. In Panel A, we have approximately 80% of S&P 500 firms in our sample. The number of observations in each year is about 14% of the total sample. Based on the first 2-digit SIC code industry specifications, manufacturing is the largest industry in our sample. From the last two columns of Panel B, on average over 88% of firms in each industry adopt hedging activities, and most of them employ derivatives.

[Insert Table 1 about here.]

[6] The empirical results are qualitatively unchanged when we normalize the hedge ratio using net sales.

We summarize the sample statistics in Table 2. From the means and medians of total assets and sales, we suspect that both variables have skewed distributions. Therefore, we measure firm size by taking the logarithm of net sales to eliminate the impact of extreme values. In addition, the leverage ratios have a mean of 0.4321 and a median of 0.4266, denoting that its distribution might not be skewed. We follow Lookman (2009) to measure the incentive for risk-shifting behavior using *RSI*, and the dummy equals unity if the leverage ratio is in the top decile of leverage in each year for firms in our sample. The 90th percentile for leverage is 0.63 in our sample and is lightly lower than the 0.66 in Lookman (2009).[7]

From the summary statistics for the board and audit committee, we find that the average board size is 10.45 directors and 4.23 members on the audit committee. It is interesting to see that the average number of independent directors is 8.53, which is high compared to 10.54 directors for average board size.

[Insert Table 2 about here.]

Table 3 presents the correlation matrix among the variables we include in the regression analysis. We find that the correlation coefficient is 0.34 between board size and the number of audit committee members, is 0.84 between board size and the number of independent directors, and is 0.46 between the number of audit committee members and the number of independent directors. Therefore, we do not include these three variables in a single regression to avoid multicollinearity problems.

[Insert Table 3 about here.]

[7] We also use the 95th percentile ratio, 0.7, to create *RSI* and check the robustness. Our conclusions still hold.

4. Empirical results

4.1 Hedging and board characteristics

In this paper, we study the relationship between corporate hedging and the board characteristics. To do so, we first present the proportion of hedging and hedge ratios by various board characteristics in Table 4. In the full sample analysis of Panel A, we find that the mean proportion of hedging is significantly larger in above-median categories than below-median categories for each board characteristic at the 1% level. These findings demonstrate the positive impacts of the board of directors and audit committee on corporate hedging incentives.

Further, we group the top 10% leverage firms into the high-leveraged subsample in each year and the rest of the firms into the low-leveraged subsample, and investigate how hedging incentive of these two groups is affected by the board characteristics, respectively. We find that the mean proportion of hedging is significantly larger in above-median categories than below-median categories for each board characteristic at the 1% level in both high leveraged and low leveraged subsamples. The differences between above-median and below-median is larger in high leveraged firms than low leveraged firms for each board characteristic. Additionally, in the last column the differences between high-leveraged firms and low-leveraged firms in the above-median categories for each board characteristic are all negative and significant at the 1% level, but we cannot observe this pattern in the below-median categories. The differences are all negative in the below-median categories and significant at the 1% level for the number of audit committee meetings and percentage of financial experts in audit committee. In general, we expect that a firm with high leverage has a higher incentive to engage in hedging. Hence the negative differences in the below-median for each board characteristic show that the hedging incentives do not increase as the leverage increase, which shows the risk-shifting phenomenon exist in firms with weaker

monitoring of board and audit committee. The significant and positive differences in the above-median for each board characteristic show that high-leveraged firms have a higher hedging incentive as the leverage increase which shows the risk-shifting behavior disappear when the firm faces the stronger monitoring of board and audit committee.

Panel B of Table 4 presents the hedge ratios for the full sample and the subsamples based on various board characteristics. We find that the mean (median) of the hedge ratio is significantly larger in above-median categories than the below-median categories for board size, number of audit committee members and meetings and number of independent directors. The same pattern is also present in the low-leveraged sample, but only significant for number of audit committee members and meetings in the high-leveraged sample. These findings demonstrate the effect of the monitoring functions of the board of directors and audit committee on the extent of corporate hedging. Additionally, the differences between the high-leveraged and low-leveraged samples in the above-median categories for each board characteristic are all positive and significant at the 1%~10% level while the sample pattern can't be observed in the below-median categories. The insignificant differences between high and low leveraged subsample in the below-median board characteristics show that hedge ratios do not increase as the leverage increase, which shows the risk-shifting phenomenon may exist in firms with weaker monitoring of board and audit committee. On the other hands, the significant and positive differences in the above-median for each board characteristic indicate that strong monitoring by the board and audit committee may be able to mitigate risk-shifting behavior in firms with a high agency problem between debtholders and stockholders.

[Insert Table 4 about here.]

4.2 Regression analysis

To examine the relationship between board characteristics and hedging, we employ multivariate Logit and Tobit regression models using the dummy for derivatives hedging or the hedge ratio as the dependent variable and board characteristics as the main explanatory variables in Eq. (1). Panel A of Table 5 provides the results of five board characteristic Logit regressions on the dummy for derivatives hedging. Across all models, we find a significantly positive relationship between the probability of hedging and the five board characteristics. The larger the size of the board, the more audit committee members, independent directors, audit committee meetings in a year, and the higher the percentage of financial experts on the audit committee, the greater the incentive to hedge.

Panel B of Table 5 reports the results of the five board characteristic Tobit regressions on hedge ratios. We find that the coefficient of board size, the number of audit committee meetings, and the number of independent directors are significantly and positive associated with the hedge ratio, which demonstrates that monitoring by the board of directors affects the extent of hedging.

To check the consistency of these results, we wanna include all board characteristics in a single regression model. Because board size, the number of audit committee members, and the number of independent directors are highly correlated, we include these variables individually with other independent variables. From the results of models 6 to 8 in Panel A and Panel B, we find that the previous conclusion is qualitatively unchanged. Based on these results, the characteristics of the board are important factors affecting corporate hedging activities.

[Insert Table 5 about here.]

To examine the risk-shifting behavior and the effect of board characteristics on

risk-shifting behavior, we also employ multivariate Logit and Tobit regression models using the dummy for derivatives hedging or the hedge ratio as the dependent variable. At this time, we focus on risk-shifting index and the interaction terms with the risk-shifting index, *RSI*, and board characteristics as the main explanatory variables. Following the model setting in Eq. (2), we summarize the regression results in Table 6. As seen in models containing different independent variables in Panel A, the estimated coefficients of *RSI* are significantly negative suggesting that firms with strong risk-shifting incentives scale back their firm's hedging incentive to increase firm risk and expropriate wealth from the debtholders. Although we use S&P 500 firms, the result is consistent with the results in the literature regarding the negative relationship between a firm's high leveraged index and hedging decision. Firms have a greater incentive to hedge when exposed to greater risk. The relationship, however, is not monotonic after a certain level of debt financing.

Regarding the results of models 1 to 5 in Panel A, we find the estimated coefficients of the interaction terms of *RSI* and each board characteristic are all positive and significant at the 5%~1% level, suggesting that corporate governance by the board directors serves a substantial monitoring function to mitigate risk-shifting with respect to hedging policy. This evidence supports our hypothesis that board characteristics can enhance a firm's hedging incentives, especially for high-leveraged firms.

To check the consistency of these results, we include multiple board characteristics in a regression as the similar setting in models 6 to 8 in Table 5. From the results of models 6 to 8 in Panel A of Table 6, we find that the previous conclusion is qualitatively unchanged. Based on these results, the characteristics of the board are important factors affecting whether firms hedge in our low-leveraged and high-leveraged samples, and the effects of these board characteristics are stronger in high-leveraged firms.

We also examine the effect of these characteristics on the hedge ratio, which is the

proxy for the extent of a firm's hedging policy. The results for estimating the model specified in Eq. (2) are shown in Panel B. First, we find that most of the coefficients of *RSI* are still negative and significant at the 5%~1% significance level, suggesting that the risk-shifting phenomenon is shown in both the hedging decision and its extent. Second, the estimated coefficients of the interaction terms of *RSI* and each board characteristic in models 1, 2, and 3 are positive and significant at the 5% level, implying that the board size, number of audit committee members, and the number of audit committee meetings are able to mitigate the risk-shifting problem in the extent of a firm's hedging. Finally, when including multiple variables in a single regression, as we do in models 6 to 8 in Panel A, the significant and positive effects of board size, the number of audit committee members, and the number of audit committee meetings continue to hold for reducing risk-shifting behavior in the extent of hedging. Therefore, we find support for the hypotheses regarding the existence of risk-shifting behavior in S&P 500 firms and the effect of the board of directors on mitigating the risk-shifting behavior.

[Insert Table 6 about here.]

4.3 Robustness check

There are some potential concerns that could result in biased estimations or non-robust results. To check the robustness of our empirical results in different respects, we test for an alternative measure of corporate governance, endogeneity, and the presence of industry effects in leverage ratio.

4.3.1 Corporate governance index

Some of the characteristics of the board are highly correlated, such as board size, the number of audit committee members, and the number of independent directors. Due to these high correlations, we cannot simultaneously include all these characteristics in

a single regression. Following Gompers et al. (2003), we use a comprehensive measure of board corporate governance measured by the sum of five dummies generated from these board characteristics, which we name the *Board CG index*. Using the *Board CG index*, we reexamine the previous regression model of derivative hedging decisions in Table 5 and Table 6. Table 7 summarizes the empirical results.

In model 1 and model 3 of Table 7, the estimated coefficients of *Board CG index* are positive and significant at the level 1% in the hedging Logit regression and 10% in the hedge ratio Tobit regression respectively, which is supportive evidence for the monitoring function of the board on both the hedging decision and the extent of hedging. In model 2 and model 4 of Table 7, *RSI* shows a significantly negative impact on both the dummy of derivatives hedging decision and the hedge ratio, allowing us to observe risk-shifting behavior in S&P 500 firms' corporate hedging. Additionally, model 2 and model 4 presents the significantly positive estimated coefficient of the interaction terms of *RSI* and *Board CG index* at the 1% level in the hedging incentive Logit regression and hedge ratio Tobit regression, which provide evidence for the stronger monitoring function of the board on high-leveraged firms with risk-shifting incentives. These results are all qualitatively identical to those obtained previously. Therefore, our conclusion is also robust to the consideration of an alternative measure for corporate governance exercised by the board.

[Insert Table 7 about here.]

4.3.2. Endogeneity

There may be omitted variables that simultaneously affect hedging policy and leverage, and this could result in spurious results. To alleviate endogenous concerns, following Purnanandam (2008) and Lookman (2009), we utilize two-stage regression analysis and use a modified-Z score as the instrumental variable in the first-stage

regressions of *RSI*. Based on the predicted probability of *RSI*, we create a new RSI variable, *RSI_hat*, which is a dummy equal to unity if the predicted probability of RSI is in the top decile of the predicted probability in each year for firms in our sample. It serves as the risk-shifting incentive indicator, and we then perform the same regression as in Table 6, which is the second-stage regression. The two-stage regression model is as follows.

First-stage RSI Logit regression:

$$\begin{aligned} RSI_{it} = {} & \delta_0 + \delta_1 Modified\_Z_{it} + \delta_2 CEO\_Ownership_{it} \\ & + \delta_3 CEO\_Exercisable\_Option_{it} + \delta_4 CEO\_Unexercisable\_Option_{it} \\ & + \delta_5 Size_{it} + \delta_6 Quick_{it} + \delta_7 R\&D_{it} + \delta_8 \left(\frac{PPE}{TA}\right)_{it} + \delta_9 \left(\frac{NI}{Sales}\right)_{it} + \delta_{10} \left(\frac{DA}{TA}\right)_{it} \\ & + \sum Year_t + \sum Industry_k + \xi_{it} \end{aligned} \quad (3)$$

Second-stage Logit (Tobit) regression for hedging:

$$\begin{aligned} H_{it} = {} & \beta_0 + \beta_1 RSI\_hat_{it} + \beta_2 B_{it} + \beta_3 RSI\_hat_{it} \times B_{it} + \beta_4 CEO\_Ownership_{it} \\ & + \beta_5 CEO\_Exercisable\_Option_{it} + \beta_6 CEO\_Unexercisable\_Option_{it} \\ & + \beta_7 Size_{it} + \beta_8 Quick_{it} + \beta_9 R\&D_{it} + \beta_{10} \left(\frac{PPE}{TA}\right)_{it} + \beta_{11} \left(\frac{NI}{Sales}\right)_{it} + \beta_{12} \left(\frac{DA}{TA}\right)_{it} \\ & + \beta_{13} Leverage_{it} + \sum Year_t + \sum Industry_k + \varepsilon_{it} \end{aligned} \quad (4)$$

To save space we only report the results of the second-stage regression in Table 8. The empirical results are qualitatively identical to those in Table 6. In Panel A, the new RSI variable, *RSI_hat*, has a significantly negative impact on the hedging decision in all models. The coefficients of board characteristics are all positive and three of them, *Board Size*, Meeting number of audit committee, and Number of independent, are significant at the 1% level. These confirms the effectiveness of the board monitoring

on corporate hedging decisions. The coefficients of the board characteristics and their interaction terms with *RSI_hat* in models 1 to 5 are all significantly positive, meaning that monitoring by the board of directors has a stronger influence on hedging policy in high-leveraged firms that have a higher risk-shifting incentive. After combining all these characteristics in models 6 to 8, these variables still remain significant.

We also examine the effect of the board characteristics on hedge ratios by the two stage regressions. In Panel B, the coefficients of *RSI_hat* are significantly negative at the 5% or 1% level in five models among total models, which implies that, in contrast to hedging decision, the extent of hedging provides relatively weak evidence of risk shifting behavior. Regarding board characteristics, most coefficients are insignificant while the coefficients of the interaction terms of board size, number of audit committee, and number of audit committee meetings with risk *RSI* are positive and significant, which show that the monitoring of board characteristics on the extent of hedging mainly exhibits on high-leveraged firms with risk shifting incentives. These results are similar to that in Panel B of Table 6. Therefore, our results are robust to potential endogeneity.

[Insert Table 8 about here.]

4.3.3 Industry effect

We construct *RSI* on an annual basis, following the method in Lookman (2009). In his paper, however, Lookman only uses a sample of firms in the oil and gas exploration and production industry. Because we cover multiple industries in our sample, an industry effect might influence our empirical results. Therefore, we perform the regression analysis by using a re-create risk-shifting measure which equals to one for firms in the top decile on annual and industrial levels and zero for the rest. The empirical results are presented in Table 9. In models 1 to 5 in Panel A, the results of Logit regressions for the derivatives hedging dummy are qualitatively identical to those

obtained above. First, the presence of risk-shifting behavior is significant in all models. Second, the board characteristics, on an individual basis or when interacting with *RSI*, also have significant effects on the hedging dummy. Finally, models with different combinations of these characteristics support the previous conclusion regarding the effect of corporate governance by the board of directors. Therefore, our empirical results are robust to industry effects.

Panel B presents the results of Tobit regressions for the hedge ratio. We find that models 2, 3, 5 and 6 have significant and negative coefficients for *RSI*, but the other models do not reveal a significant effect of *RSI*. Although the evidence of risk-shifting behavior is not as strong as that in Panel A, the overall result is still partially supportive for the existence of risk-shifting behavior. Regarding the effect of board characteristics, except for the number of audit committee members and the percentage of financial experts on audit committee, the other three characteristics have a significant and positive impact on the hedge ratios in the low-leveraged firms. The number of audit committee members, however, exhibits a significantly stronger effect on hedging policy in high-leveraged firms that have a higher risk-shifting incentive.

[Insert Table 9 about here.]

5. Conclusion

In this paper we examine the impact of monitoring by the board and audit committee on corporate hedging based on a large sample of S&P 500 firms from 2004 to 2010. The empirical results allow us to draw the following conclusions. First, we find that the board of directors, especially the audit committee, plays an important role in monitoring a firm's hedging decisions. The characteristics of the board, including board size, the number of audit committee members, the number of audit committee

meetings, the percentage of financial experts on the audit committee, and the number of independent directors, have a significant and positive impact on a firm's decision of whether to hedge. Board size, the number of audit committee meetings, and the number of independent directors have a significant and positive impact on a firm's extent of hedging.

Second, when firms approach highly leveraged, these board characteristics have an additional effect on the hedging decision. Consistent with board directors being effective monitors, among firms with high risk-shifting incentives, we find that firms with good corporate governance by the board and audit committee have a higher incentive to hedge and hedge more as compared to firms with poor governance. This result indicates that good governance mechanism by the board can also play roles in mitigating the agency problem of risk-shifting between shareholders and debtholders whatever the board is mainly constituted by blockholders. Moreover, the result is robust to considering the endogeneity problem and industry effects.

Third and finally, we create a comprehensive measure of board corporate governance, *Board CG index*, and reconfirm the previous findings of the effect of corporate governance obtained with this overall measure. The results are consistent with the previous evidence of a significant impact of board corporate governance on the hedging decision and the risk-shifting behavior among high leveraged firms.

To the authors' knowledge, this is the first study in the literature to provide empirical evidence for the effect of board monitoring on a firm's hedging policy, especially the risk-shifting behavior of hedging. Our results support some of the newly enacted reforms that require a larger and independence audit committee on the board of directors in order to limit risk-shifting behavior of corporate hedging. Our findings provide important implications for corporate risk management, financial intermediation, and the SEC and stock exchange regulators.

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Table 1 Sample distribution

Panels A and B present the sample distribution by year and industry, respectively. Panel B also shows the proportion of hedging and derivatives hedging of our sample by industry. We adopt the first 2-digit of the SIC code to form nine main industry categories.

Panel A By year

YEAR	obs.	% of obs.
2004	316	13.37
2005	317	13.41
2006	326	13.79
2007	337	14.26
2008	341	14.42
2009	358	15.14
2010	369	15.61
Total	2364	100.00

Panel B By industry

First 2-digit SIC code	Industrial classification	Obs.	% of obs.	No. of firms	% of firms	% of derivative hedging	% of hedging
01-09	Agriculture, Forestry & Fishing	7	0.30	1	0.22	100.00	100.00
10-14	Mining and Minerals	136	5.75	28	6.22	96.32	96.32
15-17	Construction	13	0.55	3	0.67	100.00	100.00
20-39	Manufacturing	1260	53.30	231	51.33	91.67	92.22
40-49	Transportation, Communication & Utility	323	13.66	64	14.22	95.67	95.67
50-51	Wholesale Trade	58	2.45	10	2.22	65.52	70.69
52-59	Retail Trade	259	10.96	46	10.22	71.43	73.75
70-89	Services	299	12.65	65	14.44	78.60	78.60
91-99	Public Administration	9	0.38	2	0.44	100.00	100.00
	Total	2364	100.00	450	100.00	88.07	88.75

Table 2 Summary statistics

This table presents firm characteristics and board and audit committee characteristics for the sample of 2364 firm-years. *Total Assets* is the firm's book value in millions of dollars. *Sales* is the firm's net sales in millions of dollars. *EBIT* is earnings before interest and tax in millions of dollars. *Size* is the natural logarithm of the firm's net sales in millions of dollars. *Quick ratio* is constructed as the ratio of cash and short-term investments to current liabilities. *R&D ratio* is the percentage of research and development expenses scaled by net sales. *ppe/ta* stands for plant, property, and equipment scaled by total assets. *ni/sales* stands for the ratio of net income to net sales. *da/ta* is measured by depreciation and amortization scaled by total assets. *Leverage ratio* measures the ratio of total liabilities to total assets. *CEO Share Ownership* is the percentage of total shares owned by the CEO. *CEO Exercisable Option* is the percentage of estimated value of in-the-money unexercised exercisable options in a CEO's total compensation. *CEO Un-exercisable Option* is the percentage of estimated value of in-the-money unexercised un-exercisable options in a CEO's total compensation. *Board Size* is the number of directors on the board. *Number of auditing committee* is the number of auditing committee members. *Number of auditing committee meeting* is the number of auditing committee meetings in each year. *Percentage of financial experts in auditing committee* is the ratio of financial experts to total auditing committee members. *Number of independent directors* is the number of independent directors on the board. *Board CG Index* is the comprehensive measure of corporate governance which is the sum of five dummies for the corporate governance of the board. These five dummies are the number of the board of directors, the number of the auditing committee members, the number of auditing committee meetings, the percentage of financial experts in the auditing committee, and the number of independent directors compared with their medians in the sample.

Variable	Mean	Q1	Median	Q3	S.D.
Firm characteristics					
Total Assets	19,464	4,335	9,144	22,407	30,438
Sales	17,557	3,610	7,704	16,620	34,428
EBIT	2,178	463	948	2,108	4,246
Size	9.0128	8.1916	8.9495	9.7184	1.1737
Quick ratio	0.9733	0.1678	0.4070	0.9894	1.7050
R&D ratio	0.0473	0.0014	0.0139	0.0577	0.0798
ppe/ta	0.2859	0.1101	0.2134	0.4257	0.2161
ni/sales	0.0830	0.0407	0.0780	0.1301	0.1485
da/ta	0.0393	0.0258	0.0357	0.0470	0.0219
Leverage ratio	0.4321	0.3277	0.4266	0.5247	0.1608
CEO Share Ownership	0.0059	0.0000	0.0000	0.0000	0.0249
CEO Exercisable Option)	0.1502	0.0000	0.0000	0.0000	0.3573
CEO Unexercisable Option	0.5662	0.0000	0.1787	0.6059	2.3689
Board and audit committee characteristics					
Board Size	10.4463	9	10	12	2.0662
Number of audit committee	4.2293	3	4	5	1.0657
Meeting number of audit committee	9.0939	7	9	11	3.1487
Pct. of financial expert in AC	0.5495	0.2500	0.5000	0.8333	0.3115
Number of independent director	8.5288	7	9	10	1.9797
Board CG Index	3.4213	2	4	4	1.2601

Table 3 Correlation matrix

RSI equals 1 when the firm's leverage ratio is above the 90th percentile and 0 otherwise. All other variables are defined as in Table 2, ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively, using a t-test.

	variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1)	Total Assets	1.00																		
(2)	Sales	0.76 ***	1.00																	
(3)	EBIT	0.85 ***	0.81 ***	1.00																
(4)	size	0.66 ***	0.69 ***	0.60 ***	1.00															
(5)	Quick ratio	-0.12 ***	-0.13 ***	-0.05 **	-0.34 ***	1.00														
(6)	R&D ratio	-0.08 ***	-0.18 ***	-0.06 ***	-0.37 ***	0.50 ***	1.00													
(7)	ppe/ta	0.15 ***	0.13 ***	0.09 ***	0.18 ***	-0.27 ***	-0.37 ***	1.00												
(8)	ni/sales	0.04	-0.04 **	0.13 ***	-0.05 ***	0.13 ***	-0.14 ***	-0.01	1.00											
(9)	da/ta	0.05	0.02	0.02	0.02	-0.08 ***	-0.02	0.45 ***	-0.11 ***	1.00										
(10)	Leverage ratio	-0.06 ***	0.04 *	-0.10 ***	0.18 ***	-0.38 ***	-0.32 ***	0.05	-0.18 ***	-0.03	1.00									
(11)	CEO Share Ownership	-0.05 *	-0.04 *	-0.02	-0.05 **	0.07 ***	0.01	-0.06 *	-0.03	-0.01	0.01	1.00								
(12)	CEO Exercisable Option	0.00	-0.04	-0.01	-0.02	0.03	0.05 *	0.01	-0.16 ***	0.01	0.07 ***	0.11 ***	1.00							
(13)	CEO Unexercisable Option	-0.02	-0.03	-0.02	-0.03	0.05 **	-0.02	-0.02	0.09 ***	-0.03	-0.07 ***	0.00	-0.10 ***	1.00						
(14)	RSI	-0.06 ***	0.01	-0.06 ***	0.04	-0.10 ***	-0.13 ***	-0.05 ***	-0.06 ***	-0.04 *	0.63 ***	0.02	0.06	-0.04	1.00					
(15)	Board Size	0.36 ***	0.27 ***	0.27 ***	0.43 ***	-0.28 ***	-0.22 ***	0.18 ***	-0.06 **	0.04 **	0.11 ***	-0.07 ***	-0.01	-0.05 **	0.02	1.00				
(16)	Number of audit committee	0.13 ***	0.08 ***	0.09 ***	0.25 ***	-0.22 ***	-0.21 ***	0.21 ***	-0.04	0.03	0.14 ***	-0.11 ***	-0.03	-0.04 **	0.05 **	0.34 ***	1.00			
(17)	Meeting number of audit committee	0.09 ***	0.05 ***	0.05 ***	0.04 **	0.02	0.14 ***	-0.10 ***	-0.05 **	-0.03 *	0.00	0.03 *	0.04 **	0.04 **	0.03 *	0.00	-0.09 ***	1.00		
(18)	Pct. of financial expert in AC	0.03	0.00	0.03	-0.03	0.03	0.04	-0.14 ***	-0.02	-0.01	0.08 ***	0.02	0.03	0.00	0.06 ***	-0.03	-0.19 ***	0.07 ***	1.00	
(19)	Number of independent director	0.35 ***	0.25 ***	0.27 ***	0.43 ***	-0.28 ***	-0.20 ***	0.18 ***	-0.05 **	0.03	0.14 ***	-0.11 ***	-0.02	-0.04 *	0.06 **	0.84 ***	0.46 ***	0.02	-0.02	1.00
(20)	Board CG Index	0.29 ***	0.21 ***	0.22 ***	0.39 ***	-0.26 ***	-0.17 ***	0.19 ***	-0.07 ***	0.06 **	0.14 ***	-0.11 ***	-0.01	-0.04 *	0.04 *	0.68 ***	0.51 ***	0.25 ***	-0.05 **	0.75 ***

Table 4 Corporate hedging by board characteristics and leverage

Panel A Proportion to hedging

This table presents the proportion of hedging and hedge ratio by various board characteristics. Panel A shows the mean and median of the proportion of hedging for the full sample, high leveraged sample and low leveraged sample. Panel B show the hedge ratio for the full sample, high leveraged sample and low leveraged sample. The difference in means is tested by the t-test with unequal variances. The difference in medians is tested by the Wilcoxon signed-rank test. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively.

	Full Sample			Low Leveraged Sample			High Leveraged Sample			(High - Low) Differences
Variable	Mean	Median	N	Mean	Median	N	Mean	Median	N	in mean
Board Size										
below median	0.849	1.000	1420	0.849	1.000	1282	0.841	1.000	138	-0.009
above median	0.929	1.000	944	0.925	1.000	849	0.968	1.000	95	0.044 ***
Difference (above - below)	0.080 ***	0.000		0.075 ***	0.000		0.128 ***	0.000		
Number of audit committee member										
below median	0.854	1.000	1503	0.854	1.000	1368	0.852	1.000	135	-0.002
above median	0.928	1.000	861	0.925	1.000	763	0.949	1.000	98	0.024 ***
Difference (above - below)	0.074 ***	0.000		0.071 ***	0.000		0.097 ***	0.000		
Number of audit committee meetings										
below median	0.860	1.000	1398	0.862	1.000	1271	0.835	1.000	127	-0.028 ***
above median	0.911	1.000	966	0.905	1.000	860	0.962	1.000	106	0.058 ***
Difference (above - below)	0.051 ***	0.000		0.042 ***	0.000		0.128 ***	0.000		
Pct. of financial experts in audit committee										
below median	0.869	1.000	1252	0.873	1.000	1140	0.830	1.000	112	-0.042 ***
above median	0.894	1.000	1112	0.887	1.000	991	0.950	1.000	121	0.063 ***
Difference (above - below)	0.025 ***	0.000		0.014 ***	0.000		0.120 ***	0.000		
Number of independent directors										
below median	0.839	1.000	1439	0.839	1.000	1314	0.832	1.000	125	-0.007
above median	0.946	1.000	925	0.944	1.000	817	0.963	1.000	108	0.019 ***
Difference (above - below)	0.107 ***	0.000		0.104 ***	0.000		0.131 ***	0.000		

Table 4 Corporate hedging by board characteristics and leverage (continued)
Panel B Hedge ratio

Variable	Full Sample			Low Leveraged Sample			High Leveraged Sample			(High - Low) Differences in mean	(High - Low) Differences in median
	Mean	Median	N	Mean	Median	N	Mean	Median	N		
Board Size											
below median	0.085	0.052	208	0.080	0.049	183	0.121	0.076	25	0.041	0.026
above median	0.115	0.078	258	0.110	0.075	228	0.152	0.134	30	0.042 *	0.059 *
Difference (above - below)	0.030 ***	0.026 ***		0.030 **	0.026 ***		0.031	0.058			
Number of audit committee member											
below median	0.088	0.057	298	0.085	0.055	269	0.112	0.069	29	0.027	0.014
above median	0.126	0.092	168	0.119	0.085	142	0.166	0.160	26	0.047 *	0.075 **
Difference (above - below)	0.038 ***	0.035 ***		0.034 ***	0.030 ***		0.053	0.091 **			
Number of audit committee meetings											
below median	0.085	0.033	189	0.087	0.036	166	0.073	0.000	23	-0.014	-0.036 *
above median	0.113	0.080	277	0.103	0.070	245	0.185	0.173	32	0.081 ***	0.102 ***
Difference (above - below)	0.027 **	0.047 ***		0.016	0.034 ***		0.112 ***	0.173 ***			
Pct. of financial experts in audit committee											
below median	0.098	0.058	210	0.089	0.057	183	0.158	0.163	27	0.069 **	0.106
above median	0.104	0.070	256	0.103	0.066	228	0.118	0.094	28	0.015	0.029 *
Difference (above - below)	0.006	0.012		0.014	0.009		-0.040	-0.069			
Number of independent directors											
below median	0.083	0.049	226	0.079	0.048	200	0.118	0.068	26	0.040	0.020
above median	0.119	0.083	240	0.114	0.080	211	0.155	0.143	29	0.041 *	0.063 *
Difference (above - below)	0.036 ***	0.034 ***		0.035 ***	0.031 ***		0.037	0.074			

Table 5 The effect of board structure on corporate hedging

We measure the incentive for risk-shifting behavior by the dummy variable *RSI*, which is based on the 90th percentile of a firm's leverage ratio in each industry every year in the sample. It equals 1 when the firm's leverage ratio is above the 90th percentile and 0 otherwise. All other variables are defined as in Table 2. In Panel A, the dependent variable is *dummy for derivatives hedging*, and in Panel B the dependent variable is *hedge ratio*, which is the notional principal of derivative contracts divided by total assets. We winsorize the hedge ratio at the 1st and 99th percentiles. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

Panel A Logit regressions for derivatives hedging

Parameter	model (1)	model (2)	model (3)	model (4)	model (5)	model (6)	model (7)	model (8)
Board Size	0.181 ***					0.181 ***		
	(4.45)					(4.39)		
Number of AC		0.159 **					0.174 **	
		(2.04)					(2.19)	
Meeting number of AC			0.166 ***			0.162 ***	0.161 ***	0.160 ***
			(5.99)			(5.81)	(5.82)	(5.72)
Pct. of financial expert in AC				0.459 *		0.351	0.407	0.327
				(1.89)		(1.42)	(1.64)	(1.32)
Number of independent director					0.241 ***			0.237 ***
					(5.55)			(5.38)
CEO Share Ownership	-1.259	-0.919	-1.023	-1.223	-1.005	-0.765	-0.555	-0.731
	(-0.55)	(-0.41)	(-0.43)	(-0.54)	(-0.44)	(-0.32)	(-0.23)	(-0.31)
CEO Exercisable Option	0.032	0.031	-0.074	0.020	0.057	-0.056	-0.046	-0.034
	(0.15)	(0.15)	(-0.35)	(0.10)	(0.27)	(-0.26)	(-0.21)	(-0.16)
CEO Unexercisable Option	0.476 ***	0.463 ***	0.411 ***	0.450 ***	0.472 ***	0.433 ***	0.413 ***	0.423 ***
	(3.89)	(3.80)	(3.40)	(3.72)	(3.86)	(3.55)	(3.42)	(3.49)
Size	0.270 ***	0.364 ***	0.361 ***	0.390 ***	0.249 ***	0.250 ***	0.344 ***	0.228 ***
	(3.50)	(4.97)	(4.97)	(3.53)	(3.23)	(3.22)	(4.69)	(2.95)
Quick ratio	-0.121 ***	-0.140 ***	-0.120 ***	-0.143 ***	-0.114 ***	-0.100 **	-0.120 ***	-0.094 **
	(-3.01)	(-3.53)	(-3.03)	(-3.59)	(-0.87)	(-2.51)	(-3.03)	(-2.36)
R&D ratio	2.362 **	2.406 **	0.981	2.168 *	2.083 *	1.186	1.236	0.915
	(1.97)	(2.01)	(0.85)	(1.83)	(1.76)	(1.01)	(1.05)	(0.79)
PPE/TA	3.195 ***	3.229 ***	3.737 ***	3.520 ***	3.185 ***	3.635 ***	3.661 ***	3.633 ***
	(5.14)	(5.19)	(5.93)	(5.63)	(5.08)	(5.67)	(5.72)	(5.61)
NI/Sale	0.071	-0.018	-0.243	-0.110	0.067	-0.079	-0.174	-0.079
	(0.14)	(-0.04)	(-0.49)	(-0.22)	(0.14)	(-0.16)	(-0.35)	(-0.16)
DA/TA	-2.593	-1.911	-3.573	-2.385	-3.168	-4.364	-3.896	-4.974
	(-0.66)	(-0.47)	(-0.91)	(-0.58)	(-0.82)	(-1.13)	(-1.00)	(-1.29)
Leverage	1.699 ***	1.455 ***	1.435 ***	1.465 ***	1.510 ***	1.521 ***	1.262 ***	1.352 ***
	(3.60)	(3.07)	(3.10)	(3.11)	(3.28)	(3.29)	(2.73)	(2.98)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-691	-699	-682	-700	-686	-671	-678	-666
# of observations	2364	2364	2364	2364	2364	2364	2364	2364

Table 5 The effect of board structure on corporate hedging (continued)

Panel B Tobit regressions for the hedge ratio

Parameter	model (1)	model (2)	model (3)	model (4)	model (5)	model (6)	model (8)	model (8)
Board Size	0.008 ***					0.008 ***		
	(2.70)					(2.81)		
Number of AC		-0.003					-0.002	
		(-0.50)					(-0.29)	
Meeting number of AC			0.005 **			0.006 ***	0.005 **	0.006 **
			(2.46)			(2.59)	(2.43)	(2.56)
Pct. of financial expert in AC				-0.002		-0.002	-0.006	-0.002
				(-0.12)		(-0.14)	(-0.33)	(-0.10)
Number of independent director					0.007 **			0.007 **
					(2.07)			(2.17)
CEO Share Ownership	-0.067	-0.211	-0.171	-0.196	-0.102	-0.034	-0.178	-0.070
	(-0.17)	(-0.53)	(-0.43)	(-0.49)	(-0.26)	(-0.09)	(-0.45)	(-0.18)
CEO Exercisable Option	0.028 *	0.025	0.027 *	0.026 *	0.028 *	0.029 *	0.026 *	0.029 *
	(1.80)	(1.60)	(1.74)	(1.68)	(1.78)	(1.87)	(1.68)	(1.85)
CEO Unexercisable Option	0.015 *	0.014 *	0.015 *	0.015 *	0.014	0.015 *	0.014 *	0.014 *
	(1.81)	(1.68)	(1.73)	(1.72)	(1.64)	(1.83)	(1.71)	(1.65)
Size	0.018 ***	0.023 ***	0.022 ***	0.023 ***	0.018 ***	0.017 ***	0.022 ***	0.017 ***
	(3.40)	(4.60)	(4.37)	(4.57)	(3.44)	(3.16)	(4.37)	(3.19)
Quick ratio	-0.003	-0.004	-0.003	-0.004	-0.002	-0.002	-0.003	-0.002
	(-0.61)	(-0.92)	(-0.70)	(-0.86)	(-0.54)	(-0.43)	(-0.72)	(-0.35)
R&D ratio	0.058	0.049	0.010	0.054	0.050	0.012	0.007	0.004
	(0.56)	(0.48)	(0.10)	(0.52)	(0.49)	(0.12)	(0.07)	(0.04)
PPE/TA	0.030	0.041	0.033	0.037	0.031	0.025	0.034	0.027
	(0.67)	(0.91)	(0.75)	(0.82)	(0.71)	(0.57)	(0.76)	(0.61)
NI/Sale	0.132 ***	0.123 ***	0.130 ***	0.123 ***	0.133 ***	0.139 ***	0.129 ***	0.141 ***
	(2.80)	(2.59)	(2.76)	(2.60)	(2.82)	(2.96)	(2.73)	(2.98)
DA/TA	-0.268	-0.281	-0.230	-0.264	-0.261	-0.226	-0.229	-0.220
	(-0.97)	(-1.02)	(-0.84)	(-0.96)	(-0.95)	(-0.81)	(-0.83)	(-0.80)
Leverage	0.156 ***	0.164 ***	0.163 ***	0.163 ***	0.162 ***	0.156 ***	0.164 ***	0.162 ***
	(4.80)	(5.00)	(5.00)	(4.97)	(4.97)	(4.82)	(5.01)	(5.00)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	212	208	211	208	210	215	211	213
# of observations	457	457	457	457	457	457	457	457

Table 6 The effect of board structure on hedging risk-shifting

We measure the incentive for risk-shifting behavior by the dummy variable *RSI*, which is based on the 90th percentile of a firm's leverage ratio in each industry every year in the sample. It equals 1 when the firm's leverage ratio is above the 90th percentile and 0 otherwise. All other variables are defined as in Table 2. In Panel A, the dependent variable is *dummy for derivatives hedging*, and in Panel B the dependent variable is *hedge ratio*, which is the notional principal of derivative contracts divided by total assets. We winsorize the hedge ratio at the 1st and 99th percentiles. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

Panel A Logit regressions for derivatives hedging

Parameter	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
RSI	-5.928 ***	-3.510 ***	-2.573 ***	-1.249 **	-3.985 ***	-8.221 ***	-6.021 ***	-6.748 ***
	(-3.66)	(-3.05)	(-2.62)	(-2.45)	(-3.24)	(-3.95)	(-3.45)	(-3.76)
Board Size	0.139 ***					0.143 ***		
	(3.32)					(3.35)		
*RSI*Board Size*	0.601 ***					0.493 ***		
	(3.41)					(2.88)		
Number of AC		0.073					0.091	
		(0.89)					(1.08)	
*RSI*Number of AC*		0.771 ***					0.661 **	
		(2.75)					(2.18)	
Meeting number of AC			0.146 ***			0.141 ***	0.142 ***	0.140 ***
			(5.08)			(4.92)	(4.93)	(4.89)
*RSI*Meeting number of AC*			0.288 **			0.309 **	0.275 **	0.297 **
			(2.38)			(2.21)	(2.02)	(2.16)
Pct. of financial expert in AC				0.262		0.152	0.194	0.130
				(1.02)		(0.59)	(0.74)	(0.50)
*RSI*Pct. of financial expert in AC*				1.792 **		1.307	1.497	1.592
				(2.14)		(1.33)	(1.57)	(1.64)
Number of independent director					0.199 ***			0.197 ***
					(4.40)			(4.31)
*RSI*Number of independent director*					0.477 ***			0.403 **
					(2.98)			(2.53)
CEO Share Ownership	-1.104	-0.576	-1.178	-0.968	-1.047	-0.593	-0.462	-0.324
	(-0.48)	(-0.25)	(-0.50)	(-0.42)	(-0.46)	(-0.24)	(-0.19)	(-0.13)
CEO Exercisable Option	0.052	0.059	-0.045	0.026	0.070	-0.049	-0.019	-0.033
	(0.24)	(0.28)	(-0.21)	(0.13)	(0.33)	(-0.22)	(-0.09)	(-0.15)
CEO Unexercisable Option	0.460 ***	0.462 ***	0.404 ***	0.446 ***	0.463 ***	0.417 ***	0.406 ***	0.412 ***
	(3.75)	(3.78)	(3.34)	(3.69)	(3.77)	(3.41)	(3.35)	(3.39)
Size	0.257 ***	0.363 ***	0.357 ***	0.393 ***	0.233 ***	0.237 ***	0.338 ***	0.215 ***
	(3.31)	(4.94)	(4.89)	(5.68)	(3.01)	(3.02)	(4.56)	(2.75)
Quick ratio	-0.106 ***	-0.130 ***	-0.115 ***	-0.135 ***	-0.100 **	-0.081 **	-0.106 ***	-0.076 *
	(-2.65)	(-3.28)	(-2.89)	(-3.36)	(-2.52)	(-2.01)	(-2.68)	(-1.90)
R&D ratio	2.491 **	2.354 **	1.171	2.365 **	2.208 *	1.547	1.455	1.308
	(2.09)	(1.97)	(1.00)	(1.98)	(1.87)	(1.31)	(1.23)	(1.12)
PPE/TA	3.198 ***	3.300 ***	3.687 ***	3.499 ***	3.210 ***	3.499 ***	3.589 ***	3.518 ***
	(5.14)	(5.28)	(5.79)	(5.54)	(5.11)	(5.44)	(5.54)	(5.40)
NI/Sale	0.278	0.032	-0.100	-0.008	0.245	0.270	0.064	0.240
	(0.56)	(0.06)	(-0.20)	(-0.02)	(0.50)	(0.54)	(0.13)	(0.49)
DA/TA	-3.395	-2.318	-3.234	-2.089	-3.606	-4.533	-3.306	-4.932
	(-0.56)	(-0.57)	(-0.81)	(-0.50)	(-0.94)	(-1.17)	(-0.84)	(-1.30)
Leverage	2.523 ***	2.077 ***	1.868 ***	1.915 ***	2.310 ***	2.480 ***	2.010 ***	2.304 ***
	(4.18)	(3.43)	(3.15)	(3.19)	(3.84)	(3.97)	(3.33)	(3.69)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-683	-694	-678	-697	-680	-660	-671	-657
# of observations	2364	2364	2364	2364	2364	2364	2364	2364

Table 6 The effect of board structure on hedging risk-shifting (continued)

Panel B Tobit regressions for the hedge ratio

Parameter	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
RSI	-0.204 ***	-0.172 **	-0.162 ***	0.012	-0.086	-0.407 ***	-0.295 ***	-0.216 **
	(-2.58)	(-2.34)	(-2.60)	(0.30)	(-1.15)	(-3.45)	(-2.72)	(-2.02)
Board Size	0.005					0.005		
	(1.45)					(1.62)		
*RSI*Board Size*	0.017 **					0.020 ***		
	(2.38)					(2.75)		
Number of AC		-0.008					-0.007	
		(-1.27)					(-1.00)	
*RSI*Number of AC*		0.033 **					0.032 **	
		(2.12)					(2.05)	
Meeting number of AC			0.004			0.004	0.003	0.004
			(1.55)			(1.52)	(1.45)	(1.55)
*RSI*Meeting number of AC*			0.015 **			0.019 ***	0.016 **	0.017 ***
			(2.32)			(3.02)	(2.51)	(2.65)
Pct. of financial expert in AC				0.005		0.003	-0.002	0.004
				(0.24)		(0.16)	(-0.08)	(0.22)
*RSI*Pct. of financial expert in AC*				-0.062		-0.021	-0.042	-0.051
				(-1.13)		(-0.37)	(-0.74)	(-0.91)
Number of independent director					0.006			0.006 *
					(1.59)			(1.86)
*RSI*Number of independent director*					0.006			0.007
					(0.83)			(0.86)
CEO Share Ownership	-0.097	-0.064	-0.131	-0.145	-0.060	-0.071	-0.032	-0.023
	(-0.24)	(-0.16)	(-0.33)	(-0.37)	(-0.15)	(-0.18)	(-0.08)	(-0.06)
CEO Exercisable Option	0.029 *	0.029 *	0.029 *	0.029 *	0.029 *	0.032 **	0.032 **	0.033 **
	(1.90)	(1.83)	(1.90)	(1.88)	(1.85)	(2.12)	(2.06)	(2.10)
CEO Unexercisable Option	0.015 *	0.015 *	0.012	0.015 *	0.014 *	0.012	0.013	0.011
	(1.78)	(1.82)	(1.40)	(1.79)	(1.65)	(1.41)	(1.56)	(1.35)
Size	0.019 ***	0.024 ***	0.021 ***	0.022 ***	0.019 ***	0.017 ***	0.021 ***	0.016 ***
	(3.67)	(4.73)	(4.18)	(4.55)	(3.46)	(3.20)	(4.32)	(2.97)
Quick ratio	-0.002	-0.003	-0.002	-0.003	-0.001	0.000	-0.002	0.000
	(-0.38)	(-0.71)	(-0.45)	(-0.78)	(-0.33)	(0.01)	(-0.38)	(0.02)
R&D ratio	0.065	0.057	0.020	0.061	0.060	0.024	0.020	0.019
	(0.64)	(0.56)	(0.20)	(0.59)	(0.59)	(0.23)	(0.20)	(0.18)
PPE/TA	0.032	0.047	0.027	0.038	0.029	0.023	0.037	0.022
	(0.72)	(1.04)	(0.61)	(0.85)	(0.66)	(0.52)	(0.84)	(0.50)
NI/Sale	0.135 ***	0.128 ***	0.135 ***	0.122 **	0.138 ***	0.144 ***	0.133 ***	0.145 ***
	(2.88)	(2.72)	(2.88)	(2.56)	(2.92)	(3.11)	(2.85)	(3.08)
DA/TA	-0.320	-0.266	-0.215	-0.291	-0.259	-0.279	-0.215	-0.222
	(-1.17)	(-0.98)	(-0.80)	(-1.06)	(-0.95)	(-1.03)	(-0.80)	(-0.82)
Leverage	0.195 ***	0.213 ***	0.212 ***	0.194 ***	0.207 ***	0.213 ***	0.228 ***	0.223 ***
	(4.35)	(4.67)	(4.71)	(4.32)	(4.48)	(4.78)	(5.00)	(4.84)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	215	211	214	209	211	223	217	218
	457	457	457	457	457	457	457	457
Log Likelihood								
# of observations								

Table 7 The effect of the board CG index on corporate hedging

We measure the incentive for risk-shifting behavior by the dummy variable *RSI*, which is based on the 90th percentile of a firm's leverage ratio every year in the sample. It equals 1 when the firm's leverage ratio is above the 90th percentile and 0 otherwise. *Board CG Index* is the comprehensive measure of corporate governance measured by the sum of five dummies for the corporate governance of the board. These five dummies are the board size dummy, the dummy for the number of the audit committee members, the dummy for the number of audit committee meetings, the dummy for the percentage of financial experts in the audit committee, and the dummy for the number of independent directors compared with their medians in the sample. If the board size is larger than the median, then the board size dummy is 1, and 0 otherwise. If the number of audit committee is larger than the median, then the dummy for the number of audit committee is 1, and 0 otherwise. If the number of audit committee meetings is larger than the median, then the dummy for the number of audit committee meetings is 1, and 0 otherwise. If the percentage of financial experts in audit committee is larger than the median, then the dummy for the percentage of financial experts in audit committee is 1, and 0 otherwise. If the number of independent directors is larger than the median, then the dummy for the number of independent directors is 1, and 0 otherwise. In Logit regressions, the dependent variable is *dummy for derivatives hedging*, and in Tobit regressions the dependent variable is *hedge ratio*, which is the notional principal of derivative contracts divided by total assets. We winsorize the hedge ratio at the 1st and 99th percentiles. All other variables are defined as Table 2. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

	Dummy for derivative hedging		**Hedge ratio**	
	Logit Regression	Logit Regression	Tobit Regression	Tobit Regression
	model (1)	model (2)	model (3)	model (4)
Parameter	Estimate	Estimate	Estimate	Estimate
RSI		-2.738 ***		-0.186 ***
		(-3.80)		(-3.30)
Board CG Index	0.269 ***	0.199 ***	0.008 *	0.002
	(4.32)	(3.07)	(1.66)	(0.42)
*RSI*Board CG Index*		0.837 ***		0.043 ***
		(3.50)		(3.13)
CEO Share Ownership	-0.773	-0.607	-0.138	-0.102
	(-0.33)	(-0.26)	(-0.35)	(-0.26)
CEO Exercisable Option	0.026	0.078	0.027 *	0.031 **
	(0.12)	(0.37)	(1.75)	(1.97)
CEO Unexercisable Option	0.464 ***	0.460 ***	0.014 *	0.013
	(3.82)	(3.75)	(1.70)	(1.52)
Size	0.290 ***	0.275 ***	0.020 ***	0.021 ***
	(3.82)	(3.61)	(3.86)	(4.06)
Quick ratio	-0.128 ***	-0.120 ***	-0.003	-0.001
	(-3.23)	(-3.05)	(-0.64)	(-0.33)
R&D ratio	2.222 *	2.346 **	0.052	0.083
	(1.86)	(1.97)	(0.50)	(0.81)
PPE/TA	3.194 ***	3.215 ***	0.028	0.030
	(5.14)	(5.16)	(0.62)	(0.69)
NI/Sale	0.046	0.259	0.129 ***	0.139 ***
	(0.09)	(0.53)	(2.73)	(2.96)
DA/TA	-3.807	-4.258	-0.250	-0.198
	(-0.99)	(-1.10)	(-0.91)	(-0.74)
Leverage ratio	1.468 ***	2.218 ***	0.160 ***	0.229 ***
	(3.14)	(3.70)	(4.91)	(4.96)
Year dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Log Likelihood	-692	-684	209	215
# of observations	2364	2364	457	457

Table 8 The effect of board structure on the hedging risk-shifting by 2SLS

Panel A shows the second-stage estimating results of logit regressions for derivative hedging. Panel B shows the second-stage estimating results of Tobit regressions for the hedge ratio, which is the notional principal of derivative contracts divided by total assets. We winsorize the hedge ratio at the 1st and 99th percentiles. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

Panel A Logit regressions for derivatives hedging

Parameter	model (1)	model (2)	model (3)	model (4)	model (5)	model (6)	model (7)	model (8)
RSI_hat	-2.609 ***	-1.625 ***	-1.681 ***	-0.495 *	-1.861 ***	-4.902 ***	-3.388 ***	-4.029 ***
	(-3.35)	(-2.64)	(-3.04)	(-1.75)	(-2.92)	(-4.29)	(-3.53)	(-4.00)
Board Size	0.074 ***					0.077 ***		
	(3.34)					(3.45)		
*RSI_hat*Board Size*	0.258 ***					0.263 ***		
	(3.26)					(3.01)		
Number of audit committee		0.050					0.070	
		(1.13)					(1.53)	
*RSI_hat*Number of audit committee*		0.367 **					0.312 *	
		(2.53)					(1.92)	
Meeting number of audit committee			0.065 ***			0.063 ***	0.064 ***	0.064 ***
			(4.65)			(4.54)	(4.63)	(4.57)
*RSI_hat*Meeting number of audit committee*			0.206 ***			0.247 ***	0.208 ***	0.233 ***
			(2.97)			(3.06)	(2.69)	(2.94)
Pct. of financial expert in AC				0.133		0.091	0.110	0.081
				(0.98)		(0.66)	(0.79)	(0.59)
*RSI_hat*Pct. of financial expert in AC*				0.764 *		0.574	0.709	0.692
				(1.73)		(1.06)	(1.37)	(1.30)
Number of independent director					0.104 ***			0.108 ***
					(4.32)			(4.43)
*RSI_hat*Number of independent director*					0.220 ***			0.215 **
					(2.82)			(2.55)
CEO Share Ownership	-0.751	-0.137	-0.484	-0.527	-0.542	-0.238	0.162	-0.244
	(-0.57)	(-0.11)	(-0.37)	(-0.41)	(-0.43)	(-0.17)	(0.12)	(-0.18)
CEO Exercisable Option	0.009	0.017	-0.040	0.011	0.024	-0.049	-0.027	-0.028
	(0.08)	(0.15)	(-0.34)	(0.10)	(0.21)	(-0.42)	(-0.24)	(-0.24)
CEO Unexercisable Option	0.222 ***	0.227 ***	0.193 ***	0.218 ***	0.225 ***	0.194 ***	0.196 ***	0.196 ***
	(3.86)	(3.92)	(3.37)	(3.80)	(3.89)	(3.40)	(3.41)	(3.43)
Size	0.135 ***	0.189 ***	0.184 ***	0.202 ***	0.120 ***	0.117 ***	0.169 ***	0.103 **
	(3.26)	(4.81)	(4.71)	(5.21)	(2.91)	(2.78)	(4.27)	(2.45)
Quick ratio	-0.060 **	-0.074 ***	-0.067 ***	-0.077 ***	-0.057 **	-0.048 **	-0.062 ***	-0.045 *
	(-2.57)	(-3.20)	(-2.91)	(-3.37)	(-2.45)	(-2.03)	(-2.66)	(-1.91)
R&D ratio	1.289 **	1.213 *	0.644	1.176 *	1.166 *	0.821	0.774	0.679
	(2.03)	(1.93)	(1.04)	(1.88)	(1.85)	(1.30)	(1.23)	(1.08)
PPE/TA	1.664 ***	1.746 ***	1.883 ***	1.827 ***	1.656 ***	1.780 ***	1.837 ***	1.758 ***
	(5.18)	(5.44)	(5.76)	(5.67)	(5.12)	(5.36)	(5.54)	(5.23)
NI/Sale	0.103	-0.026	-0.051	-0.039	0.092	0.142	0.031	0.121
	(0.37)	(-0.09)	(-0.18)	(-0.14)	(0.34)	(0.50)	(0.11)	(0.42)
DA/TA	-1.808	-1.810	-2.054	-1.902	-1.786	-2.272	-2.074	-2.066
	(-0.91)	(-0.92)	(-1.02)	(-0.95)	(-0.90)	(-1.11)	(-1.02)	(-1.02)
Leverage	1.360 ***	1.096 ***	1.061 ***	1.020 ***	1.251 ***	1.395 ***	1.117 ***	1.272 ***
	(4.21)	(3.49)	(3.38)	(3.31)	(3.88)	(4.17)	(3.46)	(3.82)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-682	-693	-677	-696	-679	-659	-670	-656
# of observations	2358	2358	2358	2358	2358	2358	2358	2358

Table 8 The effect of board structure on the hedging risk-shifting by 2SLS (continued)

Panel B Tobit regressions for the hedge ratio

Parameter	model (1)	model (2)	model (3)	model (4)	model (5)	model (6)	model (7)	model (8)
RSI_hat	-0.175 **	-0.162 **	-0.178 ***	0.046	-0.058	-0.347 ***	-0.267 **	-0.167
	(-2.17)	(-2.10)	(-2.78)	(1.12)	(-0.76)	(-2.90)	(-2.40)	(-1.55)
Board Size	0.005					0.005 *		
	(1.54)					(1.69)		
*RSI_h*Board Size*	0.015 **					0.016 **		
	(2.04)					(2.16)		
Number of AC		-0.009					-0.008	
		(-1.43)					(-1.19)	
*RSI*Number of AC*		0.032 **					0.029 *	
		(2.01)					(1.76)	
Meeting number of AC			0.003			0.003	0.003	0.003
			(1.31)			(1.28)	(1.19)	(1.31)
*RSI*Meeting number of AC*			0.017 ***			0.022 ***	0.019 ***	0.020 ***
			(2.66)			(3.34)	(2.98)	(3.08)
Pct. of financial expert in AC				0.005		0.004	-0.001	0.006
				(0.28)		(0.24)	(-0.07)	(0.30)
*RSI_hat*Pct. of financial expert in AC*				-0.108 *		-0.077	-0.102 *	-0.112 *
				(-1.87)		(-1.31)	(-1.73)	(-1.93)
Number of independent director					0.005			0.006 *
					(1.55)			(1.82)
*RSI_hat*Number of independent director*					0.004			0.003
					(0.53)			(0.36)
CEO Share Ownership	-0.213	-0.312	-0.267	-0.249	-0.189	-0.237	-0.325	-0.198
	(-0.53)	(-0.78)	(-0.67)	(-0.62)	(-0.47)	(-0.60)	(-0.82)	(-0.50)
CEO Exercisable Option	0.034 **	0.032 **	0.034 **	0.035 **	0.034 **	0.037 **	0.036 **	0.037 **
	(2.19)	(2.03)	(2.16)	(2.20)	(2.14)	(2.42)	(2.27)	(2.41)
CEO Unexercisable Option	0.016 *	0.017 **	0.013	0.017 **	0.015 *	0.013	0.014 *	0.013
	(1.94)	(1.99)	(1.50)	(2.01)	(1.81)	(1.57)	(1.69)	(1.50)
Size	0.020 ***	0.024 ***	0.021 ***	0.024 ***	0.020 ***	0.017 ***	0.022 ***	0.017 ***
	(3.80)	(4.85)	(4.34)	(4.77)	(3.64)	(3.34)	(4.47)	(3.18)
Quick ratio	-0.002	-0.003	-0.002	-0.004	-0.002	-0.001	-0.002	-0.001
	(-0.51)	(-0.77)	(-0.54)	(-0.88)	(-0.49)	(-0.15)	(-0.460	(-0.17)
R&D ratio	0.064	0.049	0.020	0.059	0.057	0.027	0.016	0.020
	(0.63)	(0.47)	(0.20)	(0.57)	(0.56)	(0.27)	(0.16)	(0.20)
PPE/TA	0.028	0.043	0.022	0.035	0.026	0.019	0.033	0.019
	(0.63)	(0.95)	(0.49)	(0.77)	(0.58)	(0.45)	(0.75)	(0.43)
NI/Sale	0.127 ***	0.119 **	0.127 ***	0.110 **	0.129 ***	0.130 ***	0.118 **	0.129 ***
	(2.71)	(2.52)	(2.70)	(2.31)	(2.72)	(2.80)	(2.53)	(2.75)
DA/TA	-0.318	-0.264	-0.217	-0.306	-0.261	-0.294	-0.241	-0.249
	(-1.15)	(-0.97)	(-0.81)	(-1.11)	(-0.96)	(-1.08)	(-0.90)	(-0.92)
Leverage	0.182 ***	0.197 ***	0.200 ***	0.180 ***	0.191 ***	0.202 ***	0.213 ***	0.207 ***
	(4.12)	(4.36)	(4.50)	(4.05)	(4.18)	(4.60)	(4.74)	(4.57)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	211	208	212	208	208	221	217	217
# of observations	455	455	455	455	455	455	455	455

Table 9 Robustness: Risk-shifting index formed by sorting by year and industry

We measure the incentive for risk-shifting behavior by the dummy variable *RSI*, which is based on the 90th percentile of a firm's leverage ratio in each industry every year in the sample. It equals 1 when the firm's leverage ratio is above the 90th percentile and 0 otherwise. All other variables are defined as in Table 2. In Panel A the dependent variable is *dummy for hedging*, and in Panel B the dependent variable is *hedge ratio,* which is the notional principal of derivative contracts divided by total assets. We winsorize the hedge ratio at the 1st and 99th percentiles. ***, **, and * denote statistically significant at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

Panel A Logit regressions for derivatives hedging

Parameter	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
RSI	-5.396 **	-3.196 **	-2.334 **	-1.171 **	-2.932 **	-9.195 **	-6.056 **	-6.668 **
	(-3.12)	(-2.54)	(-2.24)	(-2.10)	(-2.31)	(-3.77)	(-3.07)	(-3.35)
Board Size	0.151 **					0.155 **		
	(3.65)					(3.67)		
*RSI*Board Size*	0.522 **					0.525 **		
	(2.81)					(2.82)		
Number of AC		0.099					0.114	
		(1.23)					(1.38)	
*RSI*Number of AC*		0.680 **					0.652 **	
		(2.20)					(1.99)	
Meeting number of AC			0.152 **			0.147 **	0.148 **	0.145 **
			(5.31)			(5.16)	(5.28)	(5.09)
*RSI*Meeting number of AC*			0.240 *			0.318 **	0.252 *	0.289 **
			(1.89)			(2.18)	(1.78)	(2.05)
Pct. of financial expert in AC				0.321		0.178	0.244	0.156
				(1.26)		(0.69)	(0.94)	(0.60)
*RSI*Pct. of financial expert in AC*				1.471		1.768 *	1.672	1.945 *
				(1.62)		(1.66)	(1.61)	(1.84)
Number of independent director					0.215 **			0.211 **
					(4.78)			(4.64)
*RSI*Number of independent director*					0.323 **			0.341 **
					(1.99)			(2.10)
CEO Share Ownership	-0.982	-0.545	-1.070	-0.982	-0.905	-0.377	-0.273	-0.254
	(-0.42)	(-0.24)	(-0.45)	(-0.43)	(-0.40)	(-0.15)	(-0.11)	(-0.10)
CEO Exercisable Option	0.039	0.061	-0.058	0.028	0.062	-0.064	-0.012	-0.037
	(0.18)	(0.29)	(-0.27)	(0.13)	(0.30)	(-0.29)	(-0.66)	(-0.17)
CEO Unexercisable Option	0.467 **	0.460 **	0.405 **	0.448 **	0.466 **	0.421 **	0.408 **	0.415 **
	(3.81)	(3.77)	(3.35)	(3.70)	(3.81)	(3.46)	(3.38)	(3.43)
Size	0.260 **	0.362 **	0.358 **	0.388 **	0.239 **	0.231 **	0.336 **	0.215 **
	(3.36)	(4.93)	(4.91)	(5.32)	(3.10)	(2.96)	(4.56)	(2.77)
Quick ratio	-0.103 **	-0.130 **	-0.113 **	-0.135 **	-0.101 **	-0.073 *	-0.103 **	-0.072 *
	(-2.58)	(-3.29)	(-2.84)	(-3.37)	(-2.54)	(-1.80)	(-2.58)	(-1.77)
R&D ratio	2.530 **	2.413 **	1.164	2.317 **	2.201 **	1.616	1.466	1.321
	(2.11)	(2.02)	(1.00)	(1.95)	(1.86)	(1.36)	(1.23)	(1.13)
ppe/ta	3.208 **	3.278 **	3.703 **	3.525 **	3.200 **	3.599 **	3.620 **	3.534 **
	(5.13)	(5.26)	(5.82)	(5.57)	(5.09)	(5.56)	(5.59)	(5.41)

ni/sale	0.222	0.045	-0.122	-0.027	0.177	0.237	0.041	0.213
	(0.44)	(0.09)	(-0.25)	(-0.05)	(0.36)	(0.48)	(0.08)	(0.43)
da/ta	-3.009	-2.048	-2.982	-1.952	-3.252	-4.665	-3.028	-3.923
	(-0.76)	(-0.50)	(-0.75)	(-0.47)	(-0.84)	(-1.21)	(-0.76)	(-1.02)
Leverage	2.495 * **	2.010 * **	1.907 * **	1.905 * **	2.171 * **	2.617 * **	2.013 * **	2.328 * **
	(4.31)	(3.48)	(3.37)	(3.32)	(3.78)	(4.36)	(3.48)	(3.91)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-685	-696	-679	-698	-683	-661	-672	-659
# of observations	2364	2364	2364	2364	2364	2364	2364	2364

Table 9 Robustness: Risk-shifting index formed by sorting by year and industry (continued)

Panel B Tobit regressions of the hedge ratio

Parameter	model (1)	model (2)	model (3)	model (4)	model (5)	model (6)	model (7)	model (8)
RSI	-0.134	-0.149 **	-0.109 *	0.031	-0.022	-0.250 **	-0.192 *	-0.071
	(-1.64)	(-1.97)	(1.67)	(0.72)	(-0.28)	(-1.96)	(-1.67)	(-0.61)
Board Size	0.006 *					0.006 **		
	(1.86)					(1.98)		
*RSI*Board Size*	0.010					0.012		
	(1.42)					(1.55)		
Number of AC		-0.009					-0.007	
		(-1.37)					(-1.15)	
*RSI*Number of AC*		0.028 *					0.025	
		(1.79)					(1.52)	
Meeting number of AC			0.004 *			0.004 *	0.004 *	0.004 *
			(1.80)			(1.78)	(1.71)	(1.80)
*RSI*Meeting number of AC*			0.009			0.013 **	0.010	0.011 *
			(1.38)			(1.99)	(1.57)	(1.70)
Pct. of financial expert in AC				0.003		0.002	-0.004	0.003
				(0.14)		(0.08)	(-0.21)	(0.17)
*RSI*Pct. of financial expert in AC*				-0.085		-0.046	-0.067	-0.083
				(-1.47)		(-0.76)	(-1.12)	(-1.40)
Number of independent director					0.006 *			0.007 **
					(1.82)			(2.00)
*RSI*Number of independent director*					-0.0003			-0.001
					(-0.04)			(-0.15)
CEO Share Ownership	-0.086	-0.099	-0.149	-0.164	-0.079	-0.052	-0.073	-0.039
	(-0.21)	(-0.25)	(-0.38)	(-0.41)	(-0.20)	(-0.13)	(-0.18)	(-0.10)
CEO Exercisable Option	0.035 *	0.033 *	0.034 **	0.035 **	0.034 **	0.038 **	0.036 **	0.038 **
	(2.22)	(2.09)	(2.17)	(2.21)	(2.19)	(2.41)	(2.28)	(2.42)
CEO Unexercisable Option	0.016 *	0.016 *	0.014	0.017 *	0.015 *	0.014 *	0.015 *	0.014
	(1.90)	(1.89)	(1.63)	(1.96)	(1.72)	(1.73)	(1.80)	(1.63)
	**	**	**	**	**	**	**	**
Size	0.020 *	0.025 *	0.022 *	0.024 *	0.020 *	0.018 *	0.023 *	0.018 *
	(3.78)	(4.98)	(4.48)	(4.83)	(3.64)	(3.39)	(4.65)	(3.26)
Quick ratio	-0.002	-0.003	-0.003	-0.004	-0.002	-0.001	-0.002	-0.001
	(-0.53)	(-0.79)	(-0.60)	(-0.87)	(-0.54)	(-0.22)	(-0.55)	(-0.29)
R&D ratio	0.068	0.051	0.021	0.059	0.058	0.029	0.015	0.018
	(0.67)	(0.50)	(0.20)	(0.58)	(0.56)	(0.29)	(0.15)	(0.17)
PPE/TA	0.028	0.043	0.025	0.034	0.026	0.022	0.036	0.022
	(0.63)	(0.97)	(0.56)	(0.76)	(0.59)	(0.49)	(0.81)	(0.49)
	**	**	**		**	**		**
NI/Sale	0.127 *	0.119 *	0.126 *	0.111 **	0.129 *	0.133 *	0.120 **	0.131 *
	(2.71)	(2.52)	(2.67)	(2.35)	(2.71)	(2.83)	(2.56)	(2.76)
DA/TA	-0.301	-0.263	-0.224	-0.295	-0.263	-0.269	-0.230	-0.244
	(-1.09)	(-0.97)	(-0.83)	(-1.07)	(-0.96)	(-0.98)	(-0.85)	(-0.89)

Leverage	0.187 **	0.202 **	0.200 **	0.185 **	0.191 **	0.201 **	0.211 **	0.201 **
	(4.27)	(4.52)	(4.53)	(4.20)	(4.22)	(4.58)	(4.69)	(4.40)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	213	210	212	210	211	219	215	216
# of observations	457	457	457	457	457	457	457	457