Credit Default Swaps and CEO Compensation*

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ABSTRACT

What is the role of creditors in shaping the design of managerial compensation? This paper provides one of the first empirical studies from the lens of creditors by investigating how the trading of credit default swaps (CDS) shapes the design of the referenced firm's managerial compensation, especially the risk-taking incentives. We find that the CEO compensation vega significantly increases when a firm has CDS referring its debt, and this effect is stronger for firms with larger risk-shifting agency conflicts. The causal effects are verified by a set of endogeneity tests, including instrumental variable analysis. Additionally, we document the increase in CEO compensation vega caused by CDS trading results into more risk taking, which, however, does not lead to an improvement in firm performance and shareholder value.

Keywords: Credit Default Swaps, CEO Compensation, Vega, Debtholder-Shareholder Conflict, Managerial Risk Taking

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1. Introduction

The literature studies the design of managerial compensation contract primarily from the viewpoint of shareholders as a solution to the shareholder-management conflict (Jensen and Murphy, 1990; Murphy, 1999) or as a consequence of managerial rent extraction due to the lack of efficient shareholder control (Bebchuk and Fried, 2003). Yet, there are theoretical foundations supporting that creditors are also important for managerial compensation design. For example, managerial compensation contracts often use stocks and options to align the interests of managers and shareholders. Jensen and Meckling, 1976 argue that this type of compensation incentivizes greater risk taking among top managers due to the convex payoff structure. Creditors are aware of this excess risk-taking behavior and price debt issues accordingly (Ortiz-Molina, 2006; Brockman, Martin, and Unlu, 2010). Therefore, shareholders should take creditors' interests into account and adjust the risk-taking incentives in managerial compensation (John and John, 1993; Edmans and Liu, 2010; Bolton, Mehran, and Shapiro, 2015).

This paper provides one of the first empirical evidence on the role of creditors in shaping the managerial compensation design. Particularly, we investigate how the trading of credit default swaps (CDS) affects managerial risk-taking incentives in the referenced firms. The creation and exponential growth of CDS was one of the most significant changes in the creditor-debtor relationship in the past decades (Bolton and Oehmke, 2011).[1] CDS allow creditors to buy insurance against losses from the credit events of the referenced entities, and provide creditors a new way to lay off credit risk exposures without debtor approval (Bolton and Oehmke, 2013).

The effects of CDS trading on the risk-taking incentives of managerial compensation can be derived by comparing a market with or without CDS trading. Without CDS referring a firm's debt, creditors are averse to borrowers' risk taking because of the concave payoff

[1] The CDS market has grown, according to BIS statistics, from relatively small number of $180 billion in 1997 to around $10 trillion in notional amount in 2017, reaching a peak of more than $58 trillion in 2007.

structure of the debt contracts and the difficulty to lay off the credit risk. Borrowing firms can choose to reward managers with relatively low risk-taking incentives ex-ante (John and John, 1993), or grant creditors control rights through covenant constraints so that creditors can monitor ex-post to curb the risk taking behavior (Ferreira, Ferreira, and Mariano, 2018). In this case, borrowers face tight constraints from creditors in offering large risk-taking incentives in managerial compensation.

With a CDS market, the payoffs of debt become flatter and less concave for creditors with CDS protection (Chang, Chen, Wang, Zhang, and Zhang, 2017). Even if creditors do not purchase CDS, the CDS markets still provide them a valuable option to hedge against credit risks (Saretto and Tookes, 2013). Because of the significant reduction in market frictions of hedging risks, creditors become more tolerant to the risk-taking behavior of the referenced firms. In this case, CDS-referenced firms face less constraints from creditors in aligning the manager-shareholder interests with a convex compensation structure. Therefore, we expect that the risk-taking incentives in CEO compensation will increase when a firm has CDS referring its debt.

Nevertheless, CDS sellers may fully anticipate the risk tolerance of creditors and price them into the CDS premium. This cost may be ultimately born by shareholders, leaving CDS trading with less or no impact on the managerial compensation design. Moreover, CDS-protected creditors get tougher in debt renegotiation and may push the financially distressed firm into inefficient bankruptcy or liquidation (Hu and Black, 2008; Bolton and Oehmke, 2011). Subrahmanyam, Tang, and Wang (2014) document a significant increase in credit risk for the referenced firm after CDS inception. Firm bankruptcy imposes a significant loss on managers and workers (Gilson, 1989; Eckbo, Thorburn, and Wang, 2016; Graham, Kim, Li, and Qiu, 2016), which in turn leads to higher labor cost ex-ante (Chemmanur, Cheng, and Zhang, 2013; Graham et al., 2016). Hence, CDS referenced firms may lower managerial risk-taking incentives to reduce the bankruptcy risk and costs. The net impact of CDS on managerial compensation will reflect the tension among these competing effects, and thus is best determined empirically.

We test the net effects using comprehensive data on CDS transactions and CEO compensation packages during the period of $2002-2015$. Following the compensation literature, e.g., Guay (1999), Core and Guay (2002), Low (2009) and Hayes, Lemmon, and Qiu (2012), we measure the risk-taking incentives provided in the CEO compensation by *Vega*—the sensitivity of the CEO's wealth to a firm's stock return volatility. We follow Ashcraft and Santos (2009) by including two CDS variables in our baseline regressions: *CDS Traded*, an indicator equal to one if there exists a CDS market for a firm's debt in our sample period; and *CDS Trading*, an indicator equal to one if there is CDS trading for the referenced firm during that year, and zero otherwise. *CDS Traded* controls for the time-invariant unobservable differences between CDS and non-CDS firms. *CDS Trading* is our main variable of interest, which captures the effect of CDS trading on vega in the years following CDS introduction.

Our regression analysis shows that CEO compensation vega increases when a firm has CDS referring its debt. This effect is both statistically and economically significant: once a firm is CDS referenced, its *Vega* increases by $\$7,734$, a sizeable effect of about 35% of the mean vega. This net positive CDS effect is consistent with the view that CDS-protected creditors become more risk tolerant, and thus the referenced firms can offer higher managerial risk-taking incentives to align the shareholder-manager interests. Our finding is robust to tests that examine the effect of the liquidity of CDS markets on vega for CDS traded firms, and also robust after controlling for a wide range of firm characteristics, industry, year, industry-by-year and state-by-year fixed effects, as well as concurrent events, such as the emergence of financial securitization.

In the baseline analysis, we assume that the timing of the CDS introduction is exogenous. We use an instrumental variable approach to address concerns that the emergence of a CDS market and the referenced firm's managerial compensation might be simultaneously determined. Similar to Saretto and Tookes (2013), we construct an instrument for *CDS Trading* using the foreign exchange hedging positions of lenders and bond underwriters of the referenced firms. As shown by Minton, Stulz, and Williamson (2009), lenders with larger hedging positions are more likely to be the net buyers of credit derivatives. We focus on the lenders' foreign exchange hedging positions, since they are macro-level rather than firm-level hedge and the firms in our sample are U.S. firms, making foreign exchange hedging exogenous to the firm's managerial compensation decision, while related to the lender's general propensity to hedge. Our two-stage least square and propensity score matching analyses confirm the validity of the instrument, and further verify the causality of CDS trading on CEO compensation vega.

We further explore the channel through which CDS trading affects managerial compensation vega by examining how the sensitivity of compensation to CDS trading varies with firm characteristics. The increase in vega after CDS trading reflects that the effect of reduced creditors' concerns about managerial risk-shifting behavior dominates that of CDS induced bankruptcy risk. Thus, we expect to see a stronger positive CDS effect for firms with more severe risk-shifting agency problems or firms with a relatively low risk of default (i.e., investment grade rating). The risk-shifting behavior is more likely to occur in firms with more growth opportunities (Eisdorfer, 2008) and firms holding less tangible assets (Shleifer and Vishny, 1992; Kiyotaki and Moore, 1997; Almeida and Campello, 2007). A firm's bankruptcy risk is also lower if its rating belongs to investment grade. In line with these views, we find that the effect of CDS trading on vega is stronger among firms with more growth opportunities and less tangible assets, and firms holding an investment grade rating.

Finally, we test how the increase in CEO compensation vega caused by CDS trading affects a firm's risk-taking behavior and firm performance. We examine the relationship between the subsequent risk taking (firm performance) and CDS trading based on two subsamples: changes in CEO vega above and below sample median. Our empirical evidence suggests that CDS trading leads to larger risk-taking behavior only when CEO vega experiences above-median changes, but this increase does not translates into better firm performance.

Our study contributes to the following strands of related literature. First, we add a new dimension to the managerial compensation literature by highlighting the importance of creditors in the compensation design. Previous studies document that the managerial risk-taking incentives are adjusted when companies have more investment opportunities (Guay, 1999), or expose to sudden shocks, such as the risk environment (Gormley, Matsa, and Milbourn, 2013), regulatory changes (Low, 2009), and worker unemployment risk (Ellul, Wang, and Zhang, 2016). There are a few exceptions showing how creditor-side factors can also affect managerial compensation design. For example, Ortiz-Molina (2007) studies whether the CEO stock option-based compensation is related to the use of convertible and straight debt. Rhodes (2016) investigates how the implicit incentives provided by earning-based debt covenants affect the structure of CEO compensation. We take a new angle by examining the role of the CDS trading in designing the managerial risk-taking incentives, and establish a casual relationship using instrumental variable approach.

Second, our study contributes to literature on the real effects of CDS. Many recent papers focus on how CDS trading affects referenced firms' financial and investment decisions. Examples include leverage and debt maturities (Saretto and Tookes, 2013), liquidity management (Subrahmanyam, Tang, and Wang, 2017), credit risk (Subrahmanyam et al., 2014), accounting practices (Martin and Roychowdhury, 2015), managers' voluntary disclosure (Kim, Shroff, Vyas, and Wittenberg-Moerman, 2018), and corporate innovation (Chang et al., 2017). Our paper adds a new dimension by providing the first evidence of the CDS effect on CEO compensation structure.

Furthermore, Subrahmanyam et al. (2014) document that credit risk of firms, particularly those under distress, increases significantly after the inception of CDS trading. They provide an explanation based on the model of Bolton and Oehmke (2011), which posits that CDS-protected debtholders of the distressed firms are tougher in debt renegotiation, and may even push firms into inefficient bankruptcy. Our finding regarding the CDS induced risk-taking behavior of managers serves as another channel through which bankruptcy risk of the referenced firm increases after CDS trading.

The paper proceeds as follows. Section 2 presents the related literature and our testable hypotheses. Section 3 describes our sample and variables. Section 4 presents the empirical analysis. Specifically, Section 4.1 presents the baseline regression. Section 4.2 conducts several tests on endogeneity concerns. Section 4.3 sheds light on channels through which CDS affects vega. Section 4.4 conducts several sets of robustness tests. Section 4.5 discusses the real effects of CDS trading on a firm's risk taking and performance. Section 5 concludes.

2. Background and Hypotheses

Jensen and Meckling (1976) argue that the payoff structure of debt holders in a levered firm is concave while that of equity holders is convex, thus shareholders may take excess risk at the expense of creditors, i.e., the risk-shifting agency problem. The traditional compensation literature argues that managers should be granted with a convex payoff structure through stocks and options to better align the interests of managers and shareholders. The managers, on behalf of shareholders, thus will adopt risky corporate policies at the expense of creditors. This divergence of interests increases the agency cost of debt since rational lenders price debt issues conditional on managerial incentive structure. Indeed, Ortiz-Molina (2006) and Brockman et al. (2010) find that a firm's borrowing cost increases if managers are granted with larger risk-taking incentives through option-based compensation.

Creditors may want to lay off a firm's credit risk because of capital requirements, liquidity shocks, or other reasons. Without a CDS market, it is costly for creditors to sell corporate bonds or loans due to limited liquidity in the bond and loan markets. This market friction in laying off credit risk further amplifies creditors' concerns over the excessive risk taking of managers, and creditors may charge higher price for lending.[2] Therefore, to mitigate the concerns from creditors and reduce the cost of debt, shareholders can grant managers lower

[2] A growing literature, e.g., Faulkender and Petersen (2005), Leary (2009), Shivdasani and Wang (2011), Murfin (2012) and Cornaggia, Mao, and Tian (2015), has documented the importance of market frictions in capital markets for corporate financing and investment policies.

risk-taking incentives in compensation (Jensen and Meckling, 1976; John and John, 1993; Edmans and Liu, 2010; Bolton et al., 2015) or grant creditors more control rights to monitor the design of managerial compensation structure (Ferreira et al., 2018).[3]

In contrast, the CDS market reduces market frictions and transaction costs for creditors in building a hedging position against a firm's credit risk (Bolton and Oehmke, 2011). Chang et al. (2017) argue that creditors' payoffs become less concave with CDS protection, since CDS buyers will be compensated from sellers if the referenced firm defaults. Even if creditors do not purchase CDS, the existence of CDS markets provides them a valuable option to hedge against credit risk (Saretto and Tookes, 2013). The reduction in both the concavity of debt payoff structure and the market friction in hedging credit risk mitigates creditors' concerns over managerial risk-taking behavior. Consistent with this view, Saretto and Tookes (2013) and Shan, Tang, and Winton (2015) document that CDS trading firms are able to maintain higher leverage ratios and longer debt maturity, and their loans have laxer net worth requirements and are less likely to be secured. With the alleviation of creditors' risk concerns, managerial compensation can thus offer larger managerial risk-taking incentives to better align the interests of managers and shareholders. Therefore, this line of analysis predicts that the risk-taking incentive in managerial compensation is likely to increase when a firm has CDS referencing its debt.

Nonetheless, other theories also have implications for the relationship between CDS trading and managerial risk-taking incentives. For example, CDS sellers may demand a higher premium since they fully anticipate that CDS-protected creditors become more risk tolerant, which can in turn induce greater risk taking in the referenced firms. Rational creditors will correspondingly charge a higher price for lending, and shareholders will ultimately bear this cost. In this case, CDS trading may show a weaker or no effect on the managerial risk-taking incentives.

[3] Ferreira et al. (2018) find that after covenant violations, control rights are shifted to lenders and the managerial compensation is designed to include less risk-taking incentives through less stocks and options in compensation.

In addition, creditors with CDS protection can retain the control rights and exchange their cash flows to safe cash flows regardless of the firm's status. If the referenced firm is financially distressed, these creditors have incentives to push the firm into inefficient bankruptcy (Hu and Black, 2008; Bolton and Oehmke, 2011). Indeed, Subrahmanyam et al., 2014 document a significant increase in bankruptcy risk for a firm after CDS inception. The increase in the bankruptcy risk of CDS trading firms can impose significant costs to managers and employees, because their human capital and wealth are largely locked inside the firm.[4] The potential loss that the managers and employees face during bankruptcy will in turn result in higher ex-ante labor costs (Chemmanur et al., 2013; Graham et al., 2016). To lower the bankruptcy risk and costs, managerial compensation contract may need to lower risk-taking incentives to reduce the probability of bankruptcy. Thus, CDS trading can lead to a lower managerial risk-taking incentives along this line.

The net effect of CDS trading on managerial risk-taking incentives reflects the tension among the above competing forces, and thus the best answer can be reached through empirical analyses. Following the compensation literature, e.g., Guay (1999), Core and Guay (2002) and Hayes et al. (2012), the risk-taking incentives provided in the CEO compensation package are measured by vega, i.e., the sensitivity of the CEO's wealth to a firm's stock return volatility. Hence, our main hypothesis can be stated as follows:

HYPOTHESIS 1. *If the CDS effect of reducing creditors' risk concerns dominates that of induced bankruptcy risk, the CEO compensation vega will increase for a firm with CDS contracts referencing its debt.*

In addition to the above testable hypothesis, if CDS trading increases the referenced firms' CEO compensation vega because the effect of reducing creditors' risk concerns dominates

[4]Gilson (1989) find that 52% of sample firms experience management turnover when they are in default, bankrupt, or private debt restructure. Eckbo et al. (2016) examine CEO career and compensation changes for large firms filling for Chapter 11 and find that incumbent CEOs leaving the executive market suffer a loss of a present value about 7 millions. Graham et al. (2016) also document a significant reduction in employee earnings during corporate bankruptcy.

that of induced bankruptcy risk, we expect this effect to be more pronounced for firms with greater risk-shifting agency problems and lower bankruptcy risk.

We connect the risk-shifting agency problems and the bankruptcy risk with several firm characteristics. Eisdorfer (2008) argues that risk-shifting behavior is more likely to occur in firms with more growth opportunities. Studies focusing on the relationship between credit constraints and collateral, e.g., Shleifer and Vishny (1992), Kiyotaki and Moore (1997), and Almeida and Campello (2007), show that firms with less tangible assets face more severe risk-shifting problems. Furthermore, firms holding an investment grade credit rating indicate a relatively low risk of default. Consequently, the introduction of CDS allows such firms to offer a higher compensation vega to alleviate the creditors' severe risk concerns, while remaining far from bankruptcy.

Taking to the data, firms' growth opportunities are measured using the market-to-book ratio. Tangible assets (property, plant and equipment) are scaled by firms's total assets. If a firm's credit rating is BBB- or higher by Standard & Poor's, it is classified as investment grade. Therefore, our second hypothesis is derived as follows:

HYPOTHESIS 2. *If CDS trading increases the CEO compensation vega, this effect will be more pronounced for firms with larger risk-shifting agency problems or lower bankruptcy risk (e.g., higher market-to-book ratio, less tangible assets, and investment grade credit rating).*

3. Data and Variables

We obtain CDS transaction data from a popular CDS database Markit, which provides a pooled data of CDS trading starting in 2001 from a network of partner banks. This amalgamation of trading data gives us a comprehensive history of CDS transactions. Executive compensation data are obtained from the Compustat ExecuComp database. Firm characteristics and stock return information are from the Compustat and CRSP databases. We choose a matching sample period from 2002 to 2015.[5]

Following the compensation literature, e.g., Guay (1999), Core and Guay (2002), Coles, Daniel, and Naveen (2006) and Hayes et al. (2012), we measure *Vega* as the dollar change in the value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of stock returns. We focus on CEO compensation grants in the current fiscal year, since shocks to a firm can immediately result in adjustments to this aspect of compensation packages.[6] *Vega* captures the convexity of the relation between the CEO's wealth and the firm's stock performance, and provides a straightforward measure of the CEO's incentive to undertake financing and investment policies that increase firm risk (Smith and Stulz, 1985; Guay, 1999).

Our main variable of interest, *CDS Trading*, takes the value of one if a firm has CDS trading on its debt during that year, and zero otherwise. To address concerns that CDS and non-CDS firms might be different due to unobservable variables related to managerial compensation, we follow Ashcraft and Santos (2009) and include a dummy variable *CDS Traded*. This dummy denotes firms in our CDS sample with at least one CDS contract traded during the entire sample period.

In addition, following the compensation literature, e.g., Guay (1999), Hayes et al. (2012), Gormley et al. (2013) and Ellul et al. (2016), we control for a set of firm and CEO characteristics that are potentially related to the compensation vega: *LogSize*, the natural logarithm of book value of total assets; *Vol*, the annualized standard deviation of firm's daily stock returns; *Leverage*, the sum of long-term debt and debt in current liabilities scaled by book value of total assets; *MB*, market-to-book ratio calculated using the market value of assets scaled by book value of total assets, where market value of assets is equal to the book value of total assets minus common equity plus market value of equity; *ROA*, return-on-asset measured as income before extraordinary items scaled by book value of total assets; *Tangibility*,

[5]We use ticker to match the firms in Compustat database and those in Markit.

[6]See Low (2009), Hayes et al. (2012), Gormley et al. (2013), and De Angelis, Gustavo, and Michenaud (2017).

net property, plant and equipment scaled by book value of total assets; *Tenure*, the number of years that a manager has been CEO of the firm; *CashComp*, the sum of salary and bonus scaled by CEO's total compensation; and *Chair*, a dummy variable equal to one if the CEO of the firm is also the board chair, and zero otherwise.

Table 1 presents summary statistics of *Vega*, *CDS Trading*, and other firm and CEO characteristics during 2002-2015. Of our 19,571 firm-year observations, CDS trading sample counts for nearly 23%. The mean (median) of CEO compensation vega is $\$22,386$ ($\$5,596$), and the standard deviation is $\$34,367$.[7] These numbers are similar to those reported in Hayes, Lemmon, and Qiu (2012). Also included are statistics about other firm and CEO characteristics. The average firm in our sample has logarithm of book value of total assets (*LogSize*) of 7.730, annualized standard deviation of stock returns (*Vol*) of 0.395, book leverage ratio (*Leverage*) of 0.222, market-to-book ratio (*MB*) of 1.868, return on assets (*ROA*) of 0.034, and tangible-to-total assets ratio (*Tangibility*) of 0.241. CEO Tenure (*Tenure*) has a mean of 8.1 years, the cash proportion of CEO compensation (*CashComp*) counts for 38.8% on average, and 47.8% of CEOs are also board chairs (*Chair*).

Table 1 further lists the summary statistics for the sample with *CDS Trading* equal to one and zero in panel (b) and (c), respectively. A key finding is that the average *Vega* of the CDS trading sample is 44.3, while that of the non-CDS trading sample is 15.9. A simple clustered t-test shows that this difference $(44.3 - 15.9)$ is significant at the 1% level. This is consistent with the view that CDS trading reduces creditors' risk concerns, resulting to an increase in the risk-taking incentives in managerial compensation.

While CDS trading firms have significantly larger vega than non-CDS trading firms, we also observe notable differences in firm characteristics in the two samples. For example, CDS trading firms are larger in size, less volatile, and have higher market-to-book ratios and more tangible assets. CEOs of CDS trading firms have shorter tenure, a smaller proportion of cash compensation, and are more likely to be the board chair. This reinforces the importance

[7] Vega is winsorized at the 95% level. The results are virtually unchanged with vega winsorized at the 99% level.

of separating the effect on CEO compensation vega due to CDS trading from any effect of changes in other factors. In the next section, we will run a set of regression analyses to control for these variations in firm and CEO characteristics and pin down the CDS effects on vega.

4. Empirical Analysis

4.1. Baseline Regression

We employ the multivariate regression model to investigate the effect of CDS on the CEO compensation vega. The dependent variable is *Vega*, measuring the CEO's risk-taking incentives induced by the compensation. The independent variable of interest is *CDS Trading*. As mentioned earlier, we include *CDS Traded* to control for the time invariant differences between CDS and non-CDS firms, and time-varying firm and CEO characteristics related to the CEO compensation. Following Subrahmanyam et al. (2014), we also include year fixed effects and industry fixed effects.[8]

Table 2 reports the baseline panel regression results with the standard errors clustered at the firm level. We show that CDS trading is associated with a significant increase in CEO vega. For example, in column (1), the coefficient of *CDS Trading* is 8.374, with a t-statistic of 6.014. Column (2) presents the similar regression with *CDS Traded*. The coefficient of *CDS Traded* is statistically insignificant, indicating no clear evidence of an average difference in compensation vega across CDS and non-CDS firms after controlling for other characteristics. The coefficient of *CDS Trading* (7.734) is again significantly positive. This indicates that the effect of CDS trading is not driven by time invariant differences between firms with and without CDS. The magnitude is also economically significant: once CDS begins referring a firm's debt, the vega increases by $\$7,734$—a 0.01 increase in the standard deviation of stock returns leads to an increase in CEO compensation by $\$7,734$ after CDS trading—a

[8] Industry fixed effects are based on the two-digit SIC code.

sizable effect of about 35% ($= 7,734/22,386$) of the mean vega. This result is consistent with Hypothesis 1. The net positive CDS effect implies that the effect of reducing creditors' risk concerns dominates that of the induced bankruptcy risk, and thus the referenced firms can offer higher managerial risk-taking incentives to align the interests of managers and shareholders.

The effects of the control variables are consistent with previous compensation literature. For example, firms with larger size, less leverage and less tangible assets have higher compensation vega, and CEOs with proportionally more cash compensation have lower vega.

4.2. Tests on Endogeneity

The baseline result shows a positive relation between CDS trading and CEO compensation vega, but this relationship is still subject to potential endogeneity concerns. For example, CDS might be initiated if the firm's creditors worry that the risk-taking incentives induced by manager's compensation scheme are too great. Alternatively, a firm's goal of innovation might require the board to add stronger risk-taking incentives in managerial compensation and simultaneously induce creditors to hedge against credit risks using CDS contracts.

We will address these endogeneity concerns using four approaches. First, we address the selection bias issue by looking at CDS firms only and study how liquidity of CDS contracts affects vega. Second, we control for several alternative explanations driving the relationship between CDS trading and vega. Third and fourth, we apply an instrumental variable and propensity score matching analyses.

4.2.1. CDS Market Liquidity Proxies

Our first approach to address the endogeneity of a firm having CDS trading, we restrict the sample to CDS firms only (i.e., firms with *CDS Traded* $= 1$). Rather than focusing on the availability of CDS, we focus on how liquid the contracts are. We relate CEO compensation vega to two CDS liquidity proxies, *LogQuotes* and *LogDiffContracts*. *LogQuotes* is the logarithm of the total number of CDS quotes in a year. *LogDiffContracts* is the logarithm of the total number of different maturities of CDS contracts traded on a firm in a year. Saretto and Tookes (2013) argue that creditors find it easier to hedge using CDS if they are cheaper to trade and easier to locate. Therefore, we expect to see a stronger CDS effect on a firm's compensation vega if the CDS market referring its debt is more liquid.

Table 3 reports the regression results on the subsample of CDS firms. We have 5,545 firm-year observations, around 28.3% of the entire sample. Column (1) using *LogQuotes* as main variable of interest shows that CDS liquidity is positively related to vega, and the effect is significant at the 5% level. The result using *LogDiffContracts* in column (2) shows similar pattern. These results not only verify the positive effects of CDS liquidity on CEO compensation vega, but suggest that our main findings are not driven by selection bias.

4.2.2. Alternative Explanations

We conduct several tests to rule out some alternative explanations. First, we replace industry fixed effects and year fixed effects with industry-by-year fixed effects, which allow us to control for potential differential trends in CEO compensation and CDS trading across industries over time. For instance, when an industry faces more intense import penetration, firms in that industry would compensate managers with greater risk-taking incentives (Lie and Yang, 2018), and also experience survival difficulties (Bloom, Draca, and Van Reenen, 2016). This might motivate its creditors to trade CDS for hedging purpose. Thus, industry import penetration could drive an increase in both CEO compensation vega and the demand of CDS to hedge, thus we control for industry-by-year fixed effects.

Second, we include location state-by-year fixed effects. A firm's state is determined by the location of its headquarters. State-by-year fixed effects control for time-varying state-level factors, such as political economy and local business cycles. For example, an increase in the state-level unemployment benefits induces the board to add the risk-taking incentives in managerial compensation (Ellul et al., 2016), and, in the meanwhile, make firms adopt riskier financial policies (Agrawal and Matsa, 2013). Creditors might choose to trade CDS to hedge against this risk increase in the firm. In this case, the state-level changes in unemployment benefits might explain both CEO compensation vega and CDS trading, so we include the state-by-year fixed effects to control for this potential omitted variable.

Third, securitization can be another omitted concurrent event driving the increase in compensation vega. During the decade preceding the financial crisis of 2007-2009, one of the most significant changes in financial markets was the rapid growth of financial innovations, such as securitization and credit default swaps. Corporate loan securitization, like CDS markets, experienced substantial growth during the same period. It also allows creditors to transfer or hedge against the credit risk of the referenced firms more cheaply and conveniently. Thus, the popularity of corporate loan securitization might also increase the compensation vega. We control for this concurrent event using a dummy variable, *Securitization*, which equals to one if a firm's leader bank is active in the securitization in that year, and zero otherwise.[9]

The regression results controlling for the three alternative explanations are reported in Table 4. All of the three coefficients of *CDS Trading* are virtually unchanged comparing to that in the baseline regression in column (2) of Table 2. These results show that the positive effects of CDS trading on CEO compensation vega are not affected by the industry or state time-varying factors or the rise of securitization.

4.2.3. Instrumental Variable Analysis

We also examine how CDS trading affects vega using an instrumental variable that directly relates to CDS trading, but only affects vega through CDS trading. Following past CDS literature, e.g., Saretto and Tookes (2013) and Subrahmanyam et al. (2014), we use

[9] A bank is defined as securitization active if it belongs to the top 10 Collateralized Loan Obligations (CLO) originating banks listed in Nadauld and Weisbach (2012). They document that those top 10 banks have underwritten about 80% of all CLOs before the financial crisis.

bank foreign exchange hedging (*FX Hedging*) as an instrument for CDS trading. The idea is that banks using more foreign exchange derivatives have larger overall hedging interests and thus are more likely to trade the CDS of their borrowers (Minton et al., 2009). Since the analyses focus only on U.S. firms and foreign exchange hedging is a macro-level rather than firm-level hedge, the lender's decision to hedge foreign exchange is exogenous to a firm's managerial compensation decision. *FX Hedging* is constructed as the amount of foreign exchange derivatives used for hedging (not trading) purpose relative to the total assets of the banks that have served as either lenders or bond underwriters for the firm over the previous five years.

A concern about using bank foreign exchange hedging as an instrument is that some U.S. firms may have foreign operations. For those firms, their lenders' foreign exchange hedging positions might be correlated with the firms' managerial compensation scheme through other channels. Lenders' foreign exchange hedging positions and managerial compensation design might be simultaneously affected by the referenced firms' foreign exposure. To address this issue, we also consider a case which excludes our sample firms with foreign operations.

We identify lenders and bond underwriters for our sample firms based on Dealscan data (for lenders) and FISD data (for underwriters). We then obtain foreign exchange derivatives used for hedging purpose for these lenders and bond underwriters in Schedule HC-L of banks' FR Y-9C filings from the Bank Holding Company Database of the Federal Reserve Bank of Chicago.[10]

We use a two-stage least square (2SLS) model to verify the validity of our instrument, and then establish the causal relation. In the first stage, we run a probit model by regressing

[10] As Saretto and Tookes (2013), we rely on the holding bank data to calculate the bank's use of derivatives. We use dealscan-compustat link file provided by Chava and Roberts (2008) to match the companies to identify the lenders. In addition, we employ DealScan-Lender Link tables provided by Schwert (2016) and CRSP-FRB Link provided by Federal Reserve Bank of New York to help matching the lenders from DealScan to Holding Company Data. For unmatched lenders, we match them by names and then check its accuracy one-by-one. For the matching in FISD with Compustat and Bank Holding Company data, we match them by names and also double check its accuracy. Since the matching link of Chava and Roberts (2008) ends at 2012 August, the FX Hedging measure we constructed is from year 2002-2011. The mean and standard deviation of FX hedging are 1.5% and 1.7%, similar to those in Saretto and Tookes (2013).

CDS Trading on *FX Hedging* and all of the control variables used in the baseline regression, including time fixed effects and industry fixed effects. In the second stage, *Vega* is regressed on the fitted value of *CDS Trading* obtained from the first stage and the same set of controls. The 2SLS estimation results are presented in Table 5. In line with previous literature, Panel (a) of Table 5 presents the analysis using all available firms. Panel (b) excludes firms with foreign operations.[11]

In panel (a) of Table 5, the first stage regression in column (1) shows that bank foreign exchange hedging (*FX Hedging*) is significantly positively related to *CDS trading*, with a t-statistic of 4.06. Measuring the economic significance, a one-standard-deviation increase in bank foreign exchange hedging leads to an increase in the probability of CDS trading by 11% ($= 6.47 \times 0.017$). These results confirm there is no weak instrument problem. In the second stage regressions with or without *CDS Traded*, we find that Instrumented *CDS Trading* has positive and even larger estimates compared to the baseline regressions in Table 2. The t-statistics in both settings are about 8. In panel (b) of Table 5, bank foreign exchange hedging (*FX Hedging*) becomes weaker as an instrument when compared to results using the entire sample. Still, it is significant at the 5% level. The effects of Instrumented *CDS Trading* are virtually unchanged from those in panel (a). Overall, these results support a causal interpretation that CDS trading leads to a higher level of CEO vega.

4.2.4. Propensity Score Matching

As suggested by Roberts and Whited (2013), an alternative method of addressing the endogeneity issue is propensity score matching analysis. To construct the matched sample for CDS trading firms, we follow previous studies and model firm-level probability of CDS trading in a given year as a function of firm and lender characteristics. We first run a probit model to predict the probability of CDS trading for each firm. Specifically, we regress the binary variable *CDS Trading* on the firm characteristics used in the baseline regression, e.g.,

[11] We keep only firms with the Pretax Income Foreign (PIFO) reported as missing values.

LogSize, *Vol*, *Leverage*, *MB*, *ROA*, and *Tangibility*. This alleviates the concern that the determinants of managerial compensation may also affect the likelihood of CDS trading. These variables also help control for the effect of risk, overall information environment, and growth opportunities on the demand and supply of CDS contracts (Martin and Roychowdhury, 2015). We also include lender's foreign exchange hedging (*FX hedging*), firm's excess return over the previous year (*ExReturn*), and a set of accounting ratios (following Subrahmanyam et al., 2014).[12]

Column (1) of Table 6 reports the prediction results, showing that the independent variables can explain *CDS Trading* reasonably well, with a pseudo-R2 of 40.1%. Next, we construct a propensity-score-matched sample by matching each CDS trading firm with one or two firms that have the nearest predicted propensity scores. The nearest two matched sample diagnostics are given in the columns (2)-(4) of Table 6. The propensity scores of the treatment sample and matched sample both have mean values of 0.615. Comparing the 15 firm characteristics, we find that 11 of the mean differences between the treatment sample and matched sample are not significantly different at the 10% confidence level. These results indicate that the two samples are good matches.

The results of propensity score matching analysis are reported in Table 7. Column (1) shows the regression results with the sample of CDS trading firms and one nearest matched non-CDS trading firms. The coefficient of *CDS Trading* is 15.557 with a t-statistic of 2.11. Column (2) shows similar patterns with each CDS trading firm matching two nearest non-CDS trading firms. The effects of the control variables are also similar as those documented in the baseline regression. In addition, we restrict the matching of CDS and non-CDS trading firms with propensity score differences of less than 1% (following Subrahmanyam et al., 2014), and only less than ten observations are dropped, so the results (untabulated) look

[12]The set of accounting ratios we include are: *PPENT/Total Asset*, the ratio of property, plant, and equipment to total assets; *Sales/Total Asset*, the ratio of sales to total assets; *EBIT/Total Asset*, the ratio of earnings before interest and tax to total assets; *WCAP/Total Asset*, the ratio of working capital to total assets; *RE/Total Asset*, the ratio of retained earnings to total assets; *Cash/Total Asset*, the ratio of cash to total assets; and *CAPX/Total Asset*, the ratio of capital expenditure to total assets.

identical with or without this restriction. Overall, the propensity score matching analysis again confirms the causal effects of CDS trading on CEO compensation vega.

4.3. Cross-sectional Variations

Having established our main finding that CEO compensation vega increases when a firm has CDS contracts referring its debt, we link this effect to firm characteristics to further pin down the channel through which the effect operates. The net increase in vega reflects the CDS effects of reducing creditor's risk concerns dominates the potential increase in bankruptcy risk. We thus expect a more pronounced CDS effect for firms with more severe risk-shifting agency conflict or less bankruptcy risk. This is because, in these firms, CDS trading alleviates the severe risk concerns of creditors without inducing a direct threat of bankruptcy risk, and thus allows the firm to set greater risk-taking incentives to align the interests of managers and shareholders.

As in Hypothesis 2, we expect the positive effect of CDS trading on vega be more evident in firms with more growth opportunities, less tangible assets, and firms holding an investment grade credit rating. We include an additional interaction term of *CDS Trading* and the respective following variables in the baseline regression: *MB*, measuring the growth opportunity; *Tangibility*, measuring the amount of a firm's tangible assets; and *Investment Grade*, a dummy variable equal to one if a firm's credit rating is BBB- or higher by Standard & Poor's, and zero otherwise.

The regression results are reported in Table 8. Column (1) shows that the interaction term of *CDS Trading* and *MB* ratio has a positive coefficient of 7.805 and a t-statistic of 5.64, meaning that the CDS trading effect is stronger among firms with more growth opportunities. Considering the economic significance, a one-standard-deviation increase in *MB* leads to a stronger CDS effect on vega by \$9.647 ($= 7.805 \times 1.236$), about 43% of the mean vega. Column (2) presents a weaker effect of CDS trading on CEO vega among firms with more tangible assets. Column (3) shows a significant stronger CDS effect for firms whose credit rating belongs to investment grade. Overall, these cross-sectional variations confirm our Hypothesis 2, in which CDS trading alleviates creditors' risk concerns and allows better alignment of the manager-shareholder interests for firms with more severe risk-shifting agency problems and less bankruptcy risk.

4.4. Robustness

We conduct a variety of sensitivity tests to show the robustness of our findings. In the first set of robustness tests, we examine different sample selections. The results are reported in Table 9. Column (1) drops firms in the financial and utility industries, since these industries are highly regulated.[13] Column (2) excludes firm-year observations with CEO turnovers. New CEOs and their predecessors are likely to have different compensation contracts, so we could not totally attribute these changes to the effects of CDS trading. In column (3), we drop the period of recent financial crisis (2008-2009) to show the validity of our findings. The coefficients of *CDS Trading* in all three columns are positive and significant at the 1% level, and the magnitudes are similar to those documented in Table 2.

The second set of robustness tests use alternative measures of managerial risk-taking incentives; and results are in Table 10. Following Low (2009), we use the logarithmic transformation of CEO vega in Column (1). The coefficient of *CDS Trading* is 0.255, with a t-statistic of 2.542 (significant at the 5% level). Since the increase in delta of managerial compensation can reduce risk-taking incentive (Lambert, Larcker, and Verrecchia, 1991), we use the same CEO *Vega* scaled by CEO *Delta* as in Ellul et al. (2016).[14] The effect of CDS trading is again positive and significant at the 5% level. Last, we examine *Total Vega* in column (3).

Total Vega is the change in the dollar value of the CEO's total options granted in the current and previous years for a 0.01 change in the annualized standard deviation of stock

[13] Financial firms are those with one-digit SIC code of 6, and utility firms with two-digit SIC code of 49.

[14] *Delta* is measured as the dollar change in the CEO's wealth for a 1% increase in the firm's stock price. As vega in the paper, we compute the delta by using only CEO's equity and option grants in the current fiscal year.

returns. The coefficient of *CDS Trading* is 63.085, with a t-statistic of 4.348. The magnitude is also economically substantial: once CDS trading starts for a firm, the *Total Vega* of its CEO increases by \$37,192, a sizeable effect of about 30% of its mean value (= 37.192/123.24). *Total Vega* provides stronger evidence for the CDS effects by measuring the risk-taking incentives of managers based on their portfolios rather than options granted only in the current year.

4.5. Firm's Risk Taking and Performance

We have provided several forms of evidence that the effects of CDS trading on the CEO compensation vega. Two natural follow-up questions are whether firms that increase CEO vega after CDS trading also increase risk-taking behavior, and whether they further improve firm performance.

To address these questions, we examine the relationship between the subsequent risk taking (firm performance) and CDS trading based on two subsamples: one in which the changes in CEO vega are above sample median, and one in which they are below median. If the increase in vega induced by CDS trading leads to changes in risk-taking behavior and firm performance, we expect the effects to be more evident in the subsample in which the changes in vega are above median.

Table 11 reports the regression results of firm's risk taking and performance for different subsamples. Following Coles et al. (2006), we measure a firm's risk taking using its *R&D* and *CAPEX* (capital expenditure scaled by the total asset). We measure a firm's operating performance using *ROA* and its stock performance using *ExReturn* (stock return minus market return).

Panel (a) is based on the subsample with changes in vega above median. Columns (1) and (2) show that *CDS Trading* is significantly positively related to the future one-year *R&D* and *CAPEX*, verifying that the increase in CEO vega caused by CDS trading translates into greater risk-taking behavior. In columns (3) and (4), we find no significant effects of

CDS Trading on either *ROA* or *ExReturn*. Panel (b) conducts similar analysis based on the subsample with vega changes below median. We see that *CDS Trading* has no significant effect on the future one-year *R&D*, and has only weak effect (significant at the 10%) on the *CAPEX*. Again, there is no evidence for changes of firm performance with or without CDS trading. Overall, we find strong evidence of increased risk-taking behavior in the subsample with above median increases in CEO vega, and the additional risk taking induced by high vega does not translate into better firm performance.

5. Conclusion

This study provides the first empirical test, to the best of our knowledge, of whether CDS trading causally affects the design of the risk-taking incentives in managerial compensation. CDS trading mitigates creditors' concerns about firms' risk taking, and allows better alignment of interests between shareholders and managers with a more convex payoff structure. Our evidence shows an increase in CEO compensation vega when a firm has CDS referring its debt. Our results are robust when controlling for firm and CEO characteristics and a variety of fixed effects. We further establish the causal relationship using instrumental variable and propensity score matching analysis. In addition, we find that the increase in CEO vega leads to more risk taking, but does not enhance firm performance and shareholder value.

Table 1: Summary Statistics

(a) Full Sample

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) p25	(6) p50	(7) p75	(8) max
Vega	19,571	22.39	34.37	0	0	5.596	29.71	121.0
CDS Trading	19,571	0.229	0.420	0	0	0	0	1
CDS Traded	19,571	0.283	0.451	0	0	0	1	1
LogSize	19,571	7.730	1.754	-0.625	6.479	7.618	8.864	14.99
Vol	19,571	0.395	0.177	0.171	0.259	0.353	0.490	0.822
Leverage	19,571	0.222	0.206	0	0.054	0.196	0.332	3.676
MB	19,571	1.868	1.236	0.249	1.141	1.488	2.132	32.47
ROA	19,571	0.034	0.166	-14.76	0.012	0.044	0.082	0.783
Tangibility	19,571	0.241	0.232	0	0.059	0.161	0.357	0.983
Tenure	19,571	7.819	7.226	0.104	2.833	5.668	10.26	60.79
CashComp	19,571	0.363	0.323	-0.065	0.129	0.249	0.503	1
Chair	19,571	0.524	0.499	0	0	1	1	1
FX Hedging	10,926	0.017	0.018	0	0.006	0.012	0.023	0.192

(b) CDS Trading Firms

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) p25	(6) p50	(7) p75	(8) max
Vega	4,480	44.31	44.88	0	0	30.72	81.48	121.0
CDS Trading	4,480	1	0	1	1	1	1	1
CDS Traded	4,480	1	0	1	1	1	1	1
LogSize	4,480	9.343	1.333	4.633	8.382	9.197	10.16	14.67
Vol	4,480	0.332	0.161	0.171	0.214	0.284	0.397	0.822
Leverage	4,480	0.291	0.169	0	0.177	0.268	0.380	1.566
MB	4,480	1.667	0.765	0.533	1.157	1.433	1.921	8.409
ROA	4,480	0.044	0.075	-1.186	0.019	0.045	0.079	0.349
Tangibility	4,480	0.305	0.244	0	0.101	0.244	0.487	0.930
Tenure	4,480	6.725	6.073	0.104	2.668	5	8.695	44.03
CashComp	4,480	0.280	0.255	-0.065	0.119	0.194	0.352	1
Chair	4,480	0.679	0.467	0	0	1	1	1
FX Hedging	3,406	0.022	0.017	0	0.010	0.018	0.030	0.192

(c) Non-CDS Trading Firms

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) p25	(6) p50	(7) p75	(8) max
Vega	15,091	15.88	27.37	0	0	3.170	19.24	121.0
CDS Trading	15,091	0	0	0	0	0	0	0
CDS Traded	15,091	0.071	0.256	0	0	0	0	1
LogSize	15,091	7.251	1.569	-0.625	6.179	7.113	8.174	14.99
Vol	15,091	0.414	0.177	0.171	0.278	0.374	0.513	0.822
Leverage	15,091	0.201	0.211	0	0.022	0.164	0.312	3.676
MB	15,091	1.928	1.339	0.249	1.136	1.512	2.210	32.47
ROA	15,091	0.031	0.185	-14.76	0.011	0.043	0.083	0.783
Tangibility	15,091	0.222	0.225	0	0.052	0.143	0.318	0.983
Tenure	15,091	8.143	7.504	0.142	2.910	5.899	10.92	60.79
CashComp	15,091	0.388	0.336	0	0.135	0.270	0.568	1
Chair	15,091	0.478	0.500	0	0	0	1	1
FX Hedging	7,520	0.015	0.017	0	0.004	0.011	0.018	0.192

This table presents the summary statistics of all the firm-year variables used in the regression analysis. Vega is the CEO's dollar change in the value of the option portfolio for a 0.01 change in the annualized standard deviation of stock returns, calculated using the CEO's option grants in the current fiscal year. CDS Trading is an indicator equal to one if there is CDS trading for the referenced firm during that year, and zero otherwise. CDS Traded is an indicator equal to one if there exists a CDS market for firm's debt in our sample period. LogSize, the natural logarithm of book value of total assets; Vol, the annualized standard deviation of firm's daily stock returns; Leverage, the sum of long-term debt and debt in current liabilities scaled by book value of total assets; MB, market-to-book ratio calculated using the market value of assets scaled by book value of total assets, where market value of assets is equal to the book value of total assets minus common equity plus market value of equity; ROA, return-on-asset measured as income before extraordinary items scaled by book value of total assets; Tangibility, net property, plant and equipment scaled by book value of total assets; CEO Tenure, the number of years a manager has been CEO of the firm; CashComp, the sum of salary and bonus scaled by CEO's total compensation; and Chair, a dummy variable equal to one if the CEO of the firm is also the board chair, and zero otherwise. The sample spans from 2002 to 2015. Panel (a) reports the summary statistics of the whole sample, Panel (b) summarizes the sample with CDS Trading equal to one, and Panel C summarizes the sample with CDS Trading equal to zero.

Table 2: Effects of CDS Trading on CEO Compensation Vega

VARIABLES	(1) Vega	(2) Vega
CDS Trading	8.374***	7.734***
	(6.014)	(3.726)
CDS Traded		0.767
		(0.390)
LogSize	8.966***	8.936***
	(21.018)	(20.632)
Vol	-17.193***	-17.164***
	(-7.465)	(-7.444)
Leverage	-9.620***	-9.641***
	(-4.666)	(-4.676)
MB	4.774***	4.771***
	(10.876)	(10.873)
ROA	-1.095	-1.083
	(-0.670)	(-0.663)
Tangibility	-14.691***	-14.735***
	(-5.149)	(-5.160)
Tenure	-0.034	-0.033
	(-0.613)	(-0.603)
CashComp	-22.243***	-22.242***
	(-22.744)	(-22.728)
Chair	3.764***	3.762***
	(4.950)	(4.946)
Constant	-35.813***	-35.634***
	(-8.669)	(-8.600)
Observations	19,571	19,571
R-squared	0.391	0.391
Industry Fixed Effects	YES	YES
Year Fixed Effects	YES	YES

This table reports the effects of CDS trading on CEO compensation vega. The dependent variable is Vega, measuring the CEO's risk-taking incentives provided in the compensation package. The independent variables include CDS Trading (variable of interest) and a set of firm and CEO characteristics. CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 3: CDS Liquidity Proxies and CEO Compensation Vega

VARIABLES	(1) Vega	(2) Vega
LogQuotes	0.659**	
	(2.036)	
LogDiffContracts		0.565**
		(2.222)
LogSize	11.277***	11.179***
	(10.836)	(10.660)
Vol	-33.526***	-33.490***
	(-5.052)	(-5.052)
Leverage	-8.975	-9.097
	(-1.397)	(-1.422)
MB	10.545***	10.581***
	(7.794)	(7.825)
ROA	20.323**	20.280**
	(2.423)	(2.424)
Tangibility	-22.933***	-22.865***
	(-3.029)	(-3.018)
Tenure	0.362**	0.364**
	(2.330)	(2.346)
CashComp	-39.845***	-39.733***
	(-12.552)	(-12.530)
Chair	7.739***	7.695***
	(3.949)	(3.925)
Constant	-74.265***	-73.982***
	(-6.257)	(-6.246)
Observations	5,545	5,545
R-squared	0.370	0.370
Industry Fixed Effects	YES	YES
Year Fixed Effects	YES	YES

This table reports the CDS liquidity effects on the CEO compensation vega. The dependent variable is Vega, measuring the CEO's risk-taking incentives provided in the compensation package. The independent variables include CDS liquidity proxies, including LogQuotes and CDS Quotes (variables of interest), and a set of firm and CEO characteristics. LogQuotes is the log number of CDS quotes in a year. LogDiffContractss is the log number of different maturities of CDS contracts traded on a firm in a year. Vega, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 4: Controlling for Alternative Explanations

VARIABLES	(1) Vega	(2) Vega	(3) Vega
CDS Trading	7.853***	7.944***	7.728***
	(3.693)	(3.836)	(3.726)
CDS Traded	0.982	-0.135	0.697
	(0.488)	(-0.068)	(0.354)
Securitization			1.658**
			(2.441)
LogSize	8.837***	9.047***	8.864***
	(19.758)	(20.311)	(20.394)
Vol	-17.399***	-17.539***	-16.985***
	(-6.839)	(-7.045)	(-7.391)
Leverage	-10.733***	-9.115***	-9.933***
	(-4.952)	(-4.411)	(-4.812)
MB	4.780***	4.754***	4.787***
	(10.589)	(10.813)	(10.935)
ROA	-1.645	0.957	-1.082
	(-1.082)	(0.369)	(-0.667)
Tangibility	-14.084***	-12.279***	-14.829***
	(-4.723)	(-4.345)	(-5.194)
Tenure	-0.035	-0.016	-0.031
	(-0.628)	(-0.289)	(-0.560)
CashComp	-22.570***	-21.855***	-22.257***
	(-22.467)	(-21.908)	(-22.782)
Chair	3.965***	3.387***	3.732***
	(5.077)	(4.343)	(4.914)
Constant	-37.815***	-53.327***	-34.776***
	(-9.861)	(-4.994)	(-8.329)
Observations	19,571	19,061	19,571
R-squared	0.416	0.414	0.392
Industry-Year Fixed Effects	YES		
Industry Fixed Effects		YES	YES
Year Fixed Effects		YES	YES
State-Year Fixed Effects		YES	

This table reports the CDS effects on the CEO compensation vega after controlling for alternative explanations. The dependent variable is Vega, measuring the CEO's risk-taking incentives provided in the compensation package. The independent variables include CDS Trading (variable of interest) and a set of firm and CEO characteristics. Vega, CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry-by-Year fixed effects are included in column (1). Industry fixed effects and year fixed effects are included in columns (2) and (3). We also include state-by-year fixed effects in column (2), and a Securitization dummy variable in column (3). Securitization is equal to one if a firm's leader bank is active in the securitization process, and zero otherwise. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 5: Instrumental Variable Analysis of CDS Trading and Vega

(a) Whole Sample

VARIABLES	(1) CDS Trading 1st Stage	(2) Vega 2nd Stage	(3) Vega 2nd Stage
FX Hedging	6.470***		
	(4.063)		
Instrumented CDS Trading		41.219***	39.546***
		(8.302)	(7.710)
CDS Traded			1.658
			(1.148)
LogSize	0.658***	4.725***	4.705***
	(17.320)	(5.996)	(5.983)
Vol	-0.643***	-18.138***	-18.063***
	(-2.724)	(-5.821)	(-5.808)
Leverage	0.682***	-16.034***	-16.057***
	(3.373)	(-6.674)	(-6.704)
MB	-0.007	6.841***	6.837***
	(-0.181)	(10.480)	(10.464)
ROA	0.081	-0.706	-0.733
	(0.295)	(-0.225)	(-0.234)
Tangibility	0.320	-18.331***	-18.437***
	(1.222)	(-5.385)	(-5.410)
Tenure	-0.002	0.105	0.105
	(-0.297)	(1.543)	(1.553)
CashComp	-0.156*	-24.984***	-24.992***
	(-1.901)	(-19.667)	(-19.651)
Chair	0.142**	2.361***	2.373***
	(2.109)	(2.591)	(2.602)
Constant	-9.716***	-51.343***	-51.422***
	(-11.365)	(-4.640)	(-4.684)
Observations	10,805	10,805	10,805
R-squared		0.434	0.434
Industry Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES

(b) Firms with No Foreign Operations

VARIABLES	(1) CDS Trading 1st Stage	(2) Vega 2nd Stage	(3) Vega 2nd Stage
FXHedging	5.494**		
	(2.209)		
Instrumented CDS Trading		42.652***	40.642***
		(5.001)	(4.610)
CDS Traded			2.045
			(0.949)
LogSize	0.582***	4.092***	4.053***
	(11.006)	(3.428)	(3.413)
Vol	-0.104	-18.335***	-18.271***
	(-0.305)	(-4.106)	(-4.096)
Leverage	0.497**	-11.359***	-11.402***
	(1.997)	(-3.457)	(-3.464)
MB	0.059	3.572***	3.545***
	(1.161)	(4.369)	(4.358)
ROA	0.073	0.352	0.353
	(0.170)	(0.065)	(0.065)
Tangibility	0.542	-14.126***	-14.206***
	(1.520)	(-3.511)	(-3.525)
Tenure	0.010	0.005	0.007
	(1.418)	(0.057)	(0.074)
CashComp	-0.053	-25.222***	-25.278***
	(-0.482)	(-15.010)	(-14.987)
Chair	-0.067	3.986***	3.962***
	(-0.660)	(3.169)	(3.150)
Constant	-5.943***	-35.543***	-35.161***
	(-11.079)	(-4.193)	(-4.170)
Observations	4,523	4,523	4,523
R-squared		0.401	0.401
Industry Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES

This table reports the instrumental variable analysis of the effects of CDS trading on CEO compensation vega based on the whole sample or that with no foreign operations. The instrument for CDS Trading is FX Hedging, measured as the amount of foreign exchange derivatives used for hedging purpose relative to the total assets of the banks that have served as either lenders or bond underwriters for the firm over the previous five years. Column (1) is the first-stage probit model regression of CDS Trading on FX Hedging and other control variables. Column (2) and (3) report the OLS regression of Vega on the Instrumented CDS Trading (variable of interest) and other control variables. Vega, CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. Panel (a) reports the results using whole sample. Panel (b) reports the results using firms with no foreign operations. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 6: Probability of CDS Trading

VARIABLES	(1) CDS Trading	(2) Treatment Sample	(3) Matched Sample	(4) Mean Difference
FX Hedging	7.328***	0.022	0.022	0.000
	(4.184)			(0.270)
LogSize	0.772***	9.094	9.203	-0.109
	(17.458)			(-0.831)
Vol	-0.511*	0.344	0.352	-0.008
	(-1.894)			(-0.839)
Leverage	1.095***	0.278	0.305	-0.018
	(4.418)			(-0.999)
MB	-0.054	1.691	1.560	0.131***
	(-1.232)			(2.594)
ROA	-0.497*	0.049	0.041	0.008**
	(-1.798)			(2.246)
Tangibility	0.572	0.341	0.337	0.004
	(1.189)			(0.209)
ExReturn	0.028	0.069	0.096	-0.026
	(0.958)			(-0.669)
PPENT/Total Asset	-0.283	0.340	0.334	0.007
	(-0.525)			(0.313)
Sale/Total Asset	0.151**	1.026	0.956	0.070
	(2.050)			(1.088)
EBIT/Total Asset	0.068	0.101	0.092	0.009**
	(0.152)			(2.048)
WCAP/Total Asset	-0.238	0.117	0.111	0.007
	(-0.683)			(0.688)
RE/Total Asset	0.298**	0.247	0.182	0.065**
	(2.161)			(2.209)
Cash/Total Asset	0.169	0.072	0.072	-0.000
	(0.345)			(-0.076)
CAPX/Total Asset	0.720	0.052	0.048	0.004
	(0.714)			(1.304)
Constant	-9.132***			
	(-13.276)			
Observations	9,315	2,930	5,860	
Industry Fixed Effects	YES			
Year Fixed Effects	YES			

This table presents the estimates of the probability of CDS trading and the characteristics of the propensity score matched samples. Column (1) reports the probit model regression of CDS Trading on FX Hedging and a set of firm characteristics and accounting ratios. Column (2) and (3) reports the mean characteristics of the treatment sample and the propensity score matched sample based on the nearest two matches. Column (4) tests the differences between the treatment sample and matched sample. FX Hedging, CDS Trading, LogSize, Vol, Leverage, MB, ROA, and Tangibility are defined in Table 5 and Table 1. Excess Return is the firm's excess return over the previous year. PPENT/Total Asset is the ratio of property, plant, and equipment to total assets. Sales/Total Asset is the ratio of sales to total assets. EBIT/Total Asset is the ratio of earnings before interest and tax to total assets. WCAP/Total Asset is the ratio of working capital to total assets. RE/Total Asset is the ratio of retained earnings to total assets. Cash/Total Asset is the ratio of cash to total assets. CAPX/Total Asset is the ratio of capital expenditure to total assets. Industry fixed effects and year fixed effects are included in Column (1). The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 7: Effects of CDS Trading on Vega: Propensity Score Matching

VARIABLES	(1) Vega Nearest One Matching	(2) Vega Nearest Two Matching
CDSTrading	15.557**	13.474*
	(2.110)	(1.842)
CDSTraded	-13.709*	-13.010*
	(-1.837)	(-1.722)
LogSize	11.107***	12.782***
	(8.330)	(10.330)
Vol	-31.840***	-34.586***
	(-3.604)	(-3.819)
Leverage	-11.213*	-10.873**
	(-1.900)	(-2.476)
MB	14.073***	12.980***
	(10.449)	(9.750)
ROA	7.203	3.822
	(0.621)	(0.359)
Tangibility	-32.522***	-31.707***
	(-3.429)	(-3.252)
Tenure	0.448**	0.436**
	(2.097)	(2.182)
CashComp	-38.071***	-40.197***
	(-11.016)	(-10.335)
Chair	7.913***	6.583***
	(3.429)	(2.581)
Constant	-93.699***	-127.310***
	(-5.187)	(-7.325)
Observations	5,854	11,698
R-squared	0.408	0.395
Industry Fixed Effects	YES	YES
Year Fixed Effects	YES	YES

This table estimates the effects of CDS trading on vega including firms with CDS and non-CDS propensity score-matched firms. Propensity score-matched firms are selected based on propensity scores estimated from the probit model of CDS Trading in Table 6. Column (1) selects the propensity score-matched firms based on the nearest one match. Column (2) selects the nearest two propensity score-matched firms. Vega, CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 8: Cross-sectional Variation of the CDS Trading Effects

VARIABLES	(1) Vega	(2) Vega	(3) Vega
CDS Trading_MB	7.805***		
	(5.638)		
CDS Trading_Tangibility		-11.107**	
		(-2.112)	
CDS Trading_Investment Grade			12.097***
			(5.116)
Investment Grade			6.532***
			(4.408)
CDS Trading	-5.223*	11.050***	-1.665
	(-1.712)	(4.312)	(-0.774)
CDS Traded	0.697	0.733	0.164
	(0.352)	(0.373)	(0.083)
LogSize	8.865***	8.896***	7.974***
	(20.479)	(20.479)	(18.452)
Vol	-15.238***	-16.955***	-10.654***
	(-6.736)	(-7.316)	(-4.835)
Leverage	-9.484***	-9.746***	-6.881***
	(-4.642)	(-4.720)	(-3.378)
MB	4.200***	4.798***	4.560***
	(10.012)	(10.912)	(10.230)
ROA	-1.644	-1.081	-0.277
	(-1.134)	(-0.659)	(-0.158)
Tangibility	-14.683***	-12.469***	-13.257***
	(-5.280)	(-4.545)	(-4.727)
Tenure	-0.034	-0.032	-0.008
	(-0.614)	(-0.580)	(-0.147)
CashComp	-22.441***	-22.213***	-21.937***
	(-22.651)	(-22.636)	(-22.879)
Chairman	3.799***	3.750***	3.252***
	(5.023)	(4.942)	(4.327)
Constant	-34.873***	-36.403***	-33.399***
	(-8.444)	(-8.856)	(-8.230)
Observations	19,571	19,571	19,571
R-squared	0.397	0.392	0.404
Industry Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES

This table reports cross-sectional variation of the effects of CDS trading on CEO compensation vega. The variables of interest are the interaction terms of CDS Trading and three firm characteristics, respectively: MB, Tangibility and Investment Grade. Vega, CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Investment Grade is a dummy variable equal to one if a firm's credit rating is BBB- or higher by Standard & Poor's, and zero otherwise. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 9: CDS Trading and Vega: Alternative Samples

	(1)	(2)	(3)
VARIABLES	Vega	Vega	Vega
CDS Trading	8.188***	7.401***	8.271***
	(3.391)	(3.301)	(3.960)
CDS Traded	0.357	0.929	0.184
	(0.155)	(0.437)	(0.094)
LogSize	9.287***	9.360***	9.121***
	(18.453)	(19.235)	(20.620)
Vol	-16.243***	-17.601***	-15.824***
	(-6.435)	(-6.785)	(-6.129)
Leverage	-11.160***	-9.675***	-9.135***
	(-5.097)	(-4.364)	(-4.222)
MB	4.548***	4.894***	4.712***
	(10.337)	(11.296)	(10.364)
ROA	-1.676	-1.287	0.339
	(-1.184)	(-0.504)	(0.113)
Tangibility	-13.901***	-15.096***	-14.740***
	(-4.443)	(-4.942)	(-5.080)
Tenure	-0.016	0.011	-0.027
	(-0.253)	(0.186)	(-0.492)
CashComp	-22.931***	-22.405***	-23.269***
	(-20.769)	(-20.344)	(-23.086)
Chair	3.631***	3.937***	3.787***
	(4.238)	(4.671)	(4.850)
Constant	-35.626***	-57.671***	-50.463***
	(-7.435)	(-13.577)	(-12.851)
Observations	15,835	15,442	16,618
R-squared	0.407	0.404	0.392
Industry Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES

This table reports the robustness results using different samples. Vega, CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Column (1) drops firms in the financial and utility industries. Financial firms are those with one-digit SIC code of 6, and utility firms with two-digit SIC code of 49. Column (2) excludes the firm-year observations with CEO turnovers. Column (3) drops the period of recent financial crisis (2008-2009). Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 10: CDS Trading and Alternative Measures of Risk-Taking Incentives

VARIABLES	(1) Log(Vega+1)	(2) Vega_Delta	(3) Total Vega
CDS Trading	0.255**	0.043**	37.193***
	(2.542)	(1.969)	(3.960)
CDS Traded	0.029	-0.016	6.244
	(0.292)	(-0.731)	(0.664)
LogSize	0.297***	0.009	50.766***
	(14.803)	(1.615)	(23.916)
Vol	-0.863***	-0.325***	-86.109***
	(-6.714)	(-7.606)	(-7.900)
Leverage	-0.352***	-0.105***	-44.050***
	(-3.286)	(-3.133)	(-4.882)
MB	0.153***	0.011**	18.729***
	(8.384)	(2.496)	(10.330)
ROA	0.127	-0.092**	-11.029**
	(1.157)	(-2.196)	(-2.114)
Tangibility	-0.557***	-0.126***	-73.867***
	(-3.677)	(-2.942)	(-5.944)
Tenure	-0.007**	0.003**	1.286***
	(-2.192)	(2.345)	(4.218)
CashComp	-1.959***	0.469***	-47.328***
	(-39.824)	(12.850)	(-10.699)
Chair	0.163***	0.005	19.350***
	(3.929)	(0.426)	(5.304)
Constant	-0.089	0.683***	-328.659***
	(-0.426)	(12.221)	(-15.025)
Observations	19,571	16,692	19,571
R-squared	0.359	0.184	0.457
Industry Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES

This table reports the robustness results using different measures of managerial risk-taking incentives. Column (1) uses the logarithmic transformation of CEO Vega. Column (2) uses the CEO Vega scaled by CEO Delta. Delta is measured as the CEO's dollar change in wealth for a 1% increase in the firm's stock price using only CEO's stock and option grants in the current fiscal year. Column (3) uses the Total Vega. Total Vega is the change in the dollar value of the CEO's all current and prior year option grants for a 0.01 change in the annualized standard deviation of stock returns. CDS Trading, CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

Table 11: Managerial Risk Taking, Firm Performance, and CEO Vega

(a) Subsample with Changes in Vega above Median

	(1)	(2)	(3)	(4)
VARIABLES	R&D(t+1)	CAPEX(t+1)	ROA(t+1)	ExReturn(t+1)
CDS Trading	1.487**	0.210***	0.050	-0.504
	(2.145)	(2.918)	(0.148)	(-0.222)
CDS Traded	2.729	0.130*	0.304	3.850*
	(1.433)	(1.842)	(0.851)	(1.780)
LogSize	-1.983***	-0.432***	0.068	-1.477**
	(-2.781)	(-8.997)	(0.609)	(-2.572)
Vol	6.741	0.310	-9.813***	17.930**
	(1.287)	(1.541)	(-7.111)	(2.481)
Leverage	-8.322	-0.754***	0.687	8.123
	(-1.192)	(-2.859)	(0.746)	(1.531)
MB	0.854	0.317***	2.043***	-1.623**
	(1.315)	(4.093)	(13.574)	(-2.559)
ROA	-0.470*	-0.030***	0.418***	-0.341
	(-1.807)	(-2.999)	(12.600)	(-1.554)
Tangibility	-5.469	1.292***	3.115***	-2.388
	(-1.553)	(6.885)	(3.376)	(-0.396)
Tenure	-0.128	-0.012**	0.002	0.049
	(-1.336)	(-2.452)	(0.148)	(0.613)
CashComp	-1.650	0.035	0.311	5.897
	(-0.937)	(0.288)	(0.619)	(1.633)
Chair	0.699	0.129*	0.349	-0.116
	(1.350)	(1.756)	(1.582)	(-0.067)
Constant	29.011*	2.979***	-1.701	268.877
	(1.748)	(7.400)	(-1.155)	(1.581)
Observations	3,744	6,018	7,545	6,787
R-squared	0.052	0.273	0.319	0.052
Industry Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES

(b) Subsample with Changes in Vega below Median

VARIABLES	(1) R&D(t+1)	(2) CAPEX(t+1)	(3) ROA(t+1)	(4) ExReturn(t+1)
CDS Trading	0.976	0.253*	0.224	-1.652
	(1.332)	(1.720)	(0.496)	(-0.623)
CDS Traded	1.869*	0.337*	-0.728	4.137
	(1.952)	(1.667)	(-1.120)	(1.624)
LogSize	-1.628***	-0.612***	0.449	-1.479**
	(-5.817)	(-4.483)	(1.290)	(-2.191)
Vol	-2.620	0.382	-0.790	30.370***
	(-0.535)	(0.472)	(-0.092)	(3.900)
Leverage	-1.490	0.124	1.141	14.477***
	(-0.363)	(0.119)	(0.403)	(3.295)
MB	3.725***	0.763*	0.616	-2.166***
	(2.632)	(1.715)	(0.885)	(-4.107)
ROA	-0.654***	-0.080*	0.785**	-0.110
	(-3.638)	(-1.665)	(2.516)	(-1.182)
Tangibility	4.298	2.579***	1.019	-2.047
	(0.828)	(3.380)	(0.880)	(-0.365)
Tenure	-0.001	-0.024**	0.018	-0.066
	(-0.009)	(-2.203)	(0.753)	(-0.862)
CashComp	0.124	0.282	-0.434	-0.540
	(0.127)	(1.412)	(-0.506)	(-0.228)
Chair	0.921	0.222	-0.453**	-0.252
	(1.399)	(1.618)	(-1.971)	(-0.185)
Constant	-20.910*	3.704***	-3.188	-24.267**
	(-1.754)	(3.102)	(-0.352)	(-2.410)
Observations	3,381	5,567	7,196	6,430
R-squared	0.404	0.191	0.235	0.065
Industry Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES

This table reports OLS regression results of the effects of CDS trading on managerial risk taking and firm performance. Panel (a) presents the regression results on the subsample with changes in vega above median. Panel (b) presents the regression results on the subsample with changes in vega below median. Managerial risk taking is measured by firm's R&D and CAPEX next year, and firm's performance is measured by ROA and ExReturn next year. R&D is the research and development expense scaled by the total asset. CAPEX is the capital expenditure scaled by the total asset. ExReturn is the annual stock return minus market return. CDS Traded, LogSize, Vol, Leverage, MB, ROA, Tangibility, CEO Tenure, CashComp, and Chair are defined in Table 1. Industry fixed effects and year fixed effects are included in all specifications. The sample spans from 2002 to 2015. T-statistics are in parentheses and standard errors are clustered at the firm level. *, **, and *** denote statistical significance (two tailed) at the 10%, 5%, and 1% levels, respectively.

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