Does CDS trading affect risk-taking incentives in managerial compensation?

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ABSTRACT

We find that managers receive more risk-taking incentives in their compensation packages once their firms are referenced by credit default swap (CDS) trading, particularly in firms with bank debt, greater institutional holdings, and in financial distress. These findings suggest that boards offer pay packages that encourage greater managerial risk taking to take advantage of the reduced creditor monitoring after CDS trade initiation. Further, we find that the onset of CDS trading attenuates the effect of vega on leverage, consistent with the view that the threat of exacting creditors restrains managerial risk appetite.

JEL classification: G32; G34

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1. Introduction

Credit default swaps (CDSs) have been credited as one of the most influential and controversial innovations in global financial markets in recent decades.[1] The presence of CDSs not only facilitates risk sharing and alleviates credit supply frictions (Saretto and Tookes, 2013)[2] but it also separates creditors' control rights from their cash flow rights, giving rise to potential moral hazard problems (Hu and Black, 2008; Bolton and Oehmke, 2011). Therefore, CDSs significantly alter the creditor–debtor relation and influence corporate financial decisions. Indeed, a strand of literature has shown that the initiation of CDS trading is associated with higher leverage ratios and longer debt maturities (Saretto and Tookes, 2013), the increased likelihood of bankruptcy (Subrahmanyam et al., 2014), a decline in reporting conservatism (Martin and Roychowdhury, 2015), and more conservative liquidity policies (Subrahmanyam et al., 2016). Despite burgeoning research in this line of inquiry, little attention has been paid to the role of managerial incentives in a firm's transition associated with the onset of CDS trading. This scarcity is perhaps surprising, given that corporate decisions are made by managers who often have their own interests. To the best of our knowledge, our paper is the first attempt to shed light on this issue.

Managers are typically undiversified, holding significant stakes in their firms. Thus, they likely prefer to take on less risk than is desired by diversified shareholders, including the adoption of more conservative financial policies (Jensen and Meckling, 1976; Amihud and Lev,

[1] A CDS contract is between a protection buyer and a protection seller. The protection buyer pays a premium (commonly referred to as the CDS premium) to the protection seller. In exchange, the protection buyer receives a payment from the protection seller if a credit event (e.g., a credit rating downgrade, restructuring, or bankruptcy) occurs on a reference credit instrument within a predetermined time period. However, while a traditional insurance contract typically offers coverage only for damages incurred by the protection buyer, a CDS contract can be "naked" meaning it provides payment in case of a credit event, even if the protection buyer has no underlying credit exposure (Bolton and Oehmke, 2013).

[2] Originally, CDSs were engineered to help banks transfer credit risk exposure from their balance sheets to protection sellers (Augustin et al., 2016). In 1994, through the trading of the first CDS, JP Morgan, the protection buyer, off-loaded its credit risk exposure to Exxon by paying a fee to the European Bank for Reconstruction and Development, the protection seller (Tett, 2009). Since then, the CDS market has grown substantially, from a relatively small beginning of around $180 billion in notional amounts in 1997 to over $62 trillion at its peak in 2007. After the crisis, however, the market halved to slightly more than $32 trillion in 2011 (Jarrow, 2011; Bolton and Oehmke, 2013).

1981; Smith and Stulz, 1985; Holmström, 1999). While CDS contracts provide opportunities for credit risk transfer and change the relation between creditors and debtors, it remains unclear how they incentivize the reference firms' managers to overcome risk aversion and choose financial policies that increase firm risk, such as the higher leverage documented by Saretto and Tookes (2013). We fill this gap by investigating the compensation channel through which managers can be incentivized to increase the firm's risk-taking activities. The primary characteristic of compensation that we consider is the sensitivity of chief executive officer (CEO) wealth to stock return volatility, or vega.[3] The managerial compensation literature has shown that a higher vega makes risk more valuable to managers and leads to riskier financial policies (Guay, 1999; Knopf et al., 2002; Rajgopal and Shevlin, 2002; Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013). We therefore examine whether the board of directors adjusts the structure of CEO compensation, especially the convexity of the payoff structure (e.g., from options), to provide managers with more risk-taking incentives following the initiation of CDS trading.

Nevertheless, CDS-protected creditors are likely to be more intransigent in renegotiations (Bolton and Oehmke, 2011; Subrahmanyam et al., 2014), triggering bankruptcy that can impose significant personal costs on managers (Fama, 1980; Fama and Jensen, 1983; Gilson, 1989; Gilson and Vetsuypens, 1993; Eckbo et al., 2016). Therefore, for a given level of risk-taking incentives, risk-averse, rational managers may attempt to avoid renegotiations with exacting creditors by making more conservative financial decisions after the onset of CDS trading than before. We are particularly interested in firms' capital structures, because both vega and CDS trading have been documented to impact leverage (Coles et al., 2006; Saretto and Tookes, 2013; Li and Tang, 2016); in contrast, the predictions on the relation between CDS introduction and corporate investment decisions are ambiguous. To investigate how the threat of exacting creditors balances out risk-taking incentives in managerial compensation, we also examine the effect of CDS introduction on the relation between leverage and vega. Herein, investigating the

[3] We are interested in the impact of CDS trading on the reference firms' managerial compensation policies. Therefore, throughout the article, the term *vega* refers to the wealth sensitivity to stock return volatility of CEOs at CDS-referenced firms, or borrowing firms.

interactive effect of whether CDS trading attenuates the effect of vega on firm leverage helps to distinguish the impact of CDS introduction on managerial risk appetite (for a given level of risk-taking incentives) from that on the level of risk-taking incentives.

Managerial incentive contracts are an important internal governance device that influences the conflicts of interest between shareholders, managers, and creditors. On the one hand, it might be in the interest of diversified shareholders to link managerial compensation to firm risk and thereby mitigate their risk-related conflicts with managers. On the other hand, by encouraging excessive risk taking, the use of convex incentive schemes could exacerbate the conflicts of interest between creditors and shareholders. Creditors, especially banks, understand the effect of incentives on risk taking. They monitor borrowers' managerial compensation packages and take actions to deter managerial risk seeking. For example, prior literature has associated higher vega with larger bond credit spreads (Daniel et al., 2004), more short-term debt (Brockman et al., 2010), and a greater concentration of debt structure (Castro et al., 2016). These changes in response to higher vega reduce borrowers' incentives to offer pay packages that induce greater risk taking.

A CDS is essentially an insurance contract against losses incurred by creditors in the event that a debtor defaults on its debt obligations. The availability of CDS contracts limits the downside exposure of creditors, thereby enhancing their bargaining power in renegotiations (Bolton and Oehmke, 2011). Therefore, CDS-protected creditors may find it more efficient to rely on pre-specified credit events to trigger renegotiations or default payments and shift away from costly monitoring (Morrison, 2005; Parlour and Winton, 2013; Subrahmanyam et al., 2016). Thus, the reduced scrutiny from CDS-protected creditors may provide boards with the opportunity to increase risk-taking incentives in compensation to better align managerial incentives with shareholder interests.[4] We therefore expect the vega of a borrowing firm's CEO to increase following the onset of CDS trading.

[4] Alternatively, the optimal level of option grants could change due to an increase in a firm's bankruptcy risk following the onset of CDS trading. First, to compensate for the increase in bankruptcy risk, firms need to pay their

Our baseline empirical approach involves exploiting variation in the timing of CDS introduction and examining whether the CEO's vega changes around the event. It is based on prior studies, including those of Ashcraft and Santos (2009), Saretto and Tookes (2013), Subrahmanyam et al. (2014), and Subrahmanyam et al. (2016). The main finding from this analysis is that the inception of CDS trading on a firm leads to an increase in the vega of the firm's CEO, after controlling for standard determinants of managerial incentive compensation. Importantly, our baseline regressions include firm and CEO–firm fixed effects to absorb any time-invariant unobserved characteristics at the firm or CEO–firm levels that could affect compensation policies. The positive effect of CDS introduction on vega is also economically significant. For example, in a specification with CEO–firm fixed effects, we find that vega increases by 22.2% following the onset of CDS trading. This result is not driven by unobserved CEO characteristics associated with risk aversion or endogenous CEO–firm matching. Moreover, an examination of the timing of the CDS effect suggests that the reference firm adjusts the risk-taking incentives embedded in managerial compensation only *after* the initiation of CDS trading. Thus, the data reveal no contemporaneous or reverse patterns.

A potential concern with the interpretation of our baseline results is that the timing of CDS introduction is likely to be endogenous. Unobservable factors correlated with both managerial compensation and the selection of firms for CDS trading could bias the results. Moreover, CDS trading is more likely to be initiated when market participants anticipate greater risk taking by managers with convex incentive schemes. We use two identification strategies to address these concerns. First, we employ a difference-in-differences (DID) matching approach and examine the changes in the CEO's vega from the year before to the year after CDS introduction relative to

CEOs higher compensation, part of which is in options. Second, the cash equivalent of each dollar of stock options may decrease as risk increases, making it a less attractive method of paying the CEO. For both reasons, it is not clear how CDS trading affects the optimal level of option grants. Given that this optimal level is largely unobserved, it is hard to test explicitly whether these explanations influence our results. However, these explanations do not predict cross-sectional heterogeneity in the effect of CDS introduction on the level of risk-taking incentives, which is difficult to reconcile with the findings of our split sample analysis in Section 4.5.

the changes in a matched sample of non-CDS firms. We find a substantial increase in the vega of reference firms' CEOs near CDS introduction, compared with matched non-CDS firms.

Our second identification strategy employs the instrumental variable (IV) approach and two-stage least squares (2SLS) regression analysis. We use three instrumental variables, initially proposed by Saretto and Tookes (2013) and Subrahmanyam et al. (2014), as a source of exogenous variation in the likelihood of CDS trading: i) the foreign exchange hedging positions of lenders and bond underwriters, ii) the Tier 1 capital ratios of lenders and bond underwriters, and iii) Trade Reporting and Compliance Engine (TRACE) coverage. As noted by Subrahmanyam et al. (2014, 2016), these instruments are economically sound because they are associated with the overall hedging interest of lenders or credit suppliers. Indeed, we find that they are significant determinants of CDS trading. It also appears that they are uncorrelated with borrowers' managerial compensation policies, except through their impact on CDS market activities. Moreover, the overidentification tests fail to reject the hypothesis that the instrumental variables used are exogenous. The results confirm that introducing CDS trading on a firm has a positive causal effect on the vega of the firm's CEO.

We next explore the heterogeneity in the vega effect of CDS introduction. We expect that the increase in the CEO's vega following CDS introduction should be more prominent when the underlying borrowers have stronger motives to engage in risk shifting (i.e., shareholders have an incentive to expropriate creditor wealth by substituting with riskier investments). Such borrowers should be more likely to take advantage of reduced creditor monitoring and offer pay packages that encourage greater risk taking by managers in the post-CDS period. Consistent with this prediction, the results indicate that the increase in vega is concentrated among borrowers that are financially distressed and those with larger institutional holdings. Further, if creditors reduce scrutiny of their borrowers' managerial compensation policies after CDS trade initiation, then any effect that the reduced scrutiny has on vega should be more prominent for borrowers that were subject to stringent creditor monitoring in the pre-CDS period. Given the importance of banks in credit monitoring (Fama, 1985; Diamond, 1991; Park, 2000; Hadlock and James, 2002;

Lin et al., 2013), we hypothesize that the increase in vega after CDS introduction is more pronounced among borrowers with bank debt. Our findings support this hypothesis.

Having established a positive effect of CDS introduction on vega, we next explore whether the observed increase in vega affects the firms' leverage decisions. Saretto and Tookes (2013) show that CDS trade initiation leads to higher firm leverage. Given the important role of managerial incentives in determining firm leverage (Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013), we examine whether the higher leverage following CDS introduction can be partially attributed to the increase in managerial risk-taking incentives. The results suggest that the increase in leverage is concentrated among firms that increased vega after CDS trade initiation, consistent with convex payoffs encouraging risk taking.

To investigate whether CDS-induced exacting creditors reduce managerial risk appetite, we examine the impact of CDS trade initiation on the relation between managerial incentives and leverage decisions. Consistent with prior studies (Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013), we generally find that a higher vega leads to higher leverage. Importantly, we show that CDS introduction attenuates the positive relation between vega and firm leverage, suggesting that CDSs pose a potential threat to managers and thereby restrain their risk taking. Taken together, our findings appear to suggest that, when making leverage decisions, risk-averse managers balance the exacting creditor threat and convex incentive schemes. Their motive to avoid renegotiations with exacting creditors partially offsets the increased risk-taking incentives embedded in managerial compensation, resulting in a reduced sensitivity of leverage to vega following the onset of CDS trading.

The primary contribution of our study is in providing evidence that CDS trade initiation on a firm's debt influences the firm's managerial compensation policies because it alters contractual parties' payoffs and incentives. In particular, we find that managers receive more risk-taking incentives in their compensation packages once their firms are referenced by CDS trading. This finding adds to the strand of compensation literature that investigates the design or determinants

of managerial incentive contracts (Low, 2009; Hayes et al., 2012; Cohen et al., 2013; Gormley et al., 2013).

Our paper also sheds new light on the effects of credit derivatives on firms' financing decisions. Saretto and Tookes (2013) show that CDS trade initiation leads to greater firm leverage. Drawing upon prior literature that links managerial incentives to risk taking (Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013), we conjecture that the observed increase in vega have contributed to the higher leverage in the post-CDS period. We find evidence that the increase in leverage is concentrated among firms that increased vega after CDS trade initiation. Further, our study helps illuminate how managers balance the increased risk-taking incentives arising from the decreased creditor monitoring and their reduced risk appetite due to the exacting creditor threat when making leverage decisions. The results suggest that, although the initiation of CDS trading on a firm leads to an increase in the vega of the firm's CEO, it also lowers the sensitivity of leverage to vega.

The remainder of the paper is organized as follows. Section 2 presents the related literature and develops our hypothesis. Section 3 describes our sample, model specification, and summary statistics. Section 4 presents our main empirical results regarding the effect of CDS on the CEO's vega. Section 5 examines the impact of CDS on the relation between vega and firm leverage. Section 6 concludes the paper.

2. Related literature and hypothesis development

2.1. Managerial incentive compensation, creditor monitoring, and CDS trading

The undiversified wealth portfolios and firm-specific human capital of managers can make them risk averse, leading them to take on less risk than is desired by diversified shareholders (Jensen and Meckling, 1976; Amihud and Lev, 1981; Smith and Stulz, 1985; Holmstrom, 1999). In the presence of such risk-related conflicts, option-based incentives could reduce aversion to risky policies and better align the interests of managers with those of shareholders. Associated

with an increase in option holdings has been an increase in vega, which in turn results in riskier policy choices and higher firm risk (Guay, 1999; Knopf et al., 2002; Rajgopal and Shevlin, 2002; Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013).[5] Although linking managerial compensation to stock return volatility mitigates risk-related conflicts between shareholders and managers, it could encourage excessive risk taking and thus exacerbate shareholder–creditor conflicts. In their seminal studies, Fama and Miller (1972) and Jensen and Meckling (1976) posit that shareholders have incentives to expropriate bondholder wealth by shifting to riskier investments, a phenomenon commonly referred to as risk shifting or asset substitution. Increased alignment of managerial incentives with shareholder interests provides managers with a stronger motive for risk shifting (John and John, 1993; Guay, 1999).

A traditional creditor–debtor relation is typically characterized by lending institutions, especially banks, continuously monitoring borrowers to alleviate moral hazard and incentivize borrowers to make appropriate corporate decisions (Stiglitz and Weiss, 1983; Diamond, 1984; Fama, 1985; James, 1987; Diamond, 1991; Rajan, 1992; Billett et al., 1995; Lin et al., 2013; Acharya et al., 2014). In particular, creditors scrutinize their borrowers' managerial compensation packages and devote effort to deter potential risk-shifting behavior. For example, Daniel et al. (2004) show that higher levels of CEO vega are associated with higher bond credit spreads, suggesting that the bond markets understand and account for the effect of incentives on risk taking.[6] Billett et al. (2010) find that bondholders experience negative abnormal returns when firms announce new CEO option grants and that the returns are more negative with high

[5]Although the vast majority of empirical studies suggest a positive relationship between option-based compensation and a firm's risk-taking activities, the theoretical prediction of how options affect risk-taking incentives is ambiguous. On the one hand, options provide convex payoffs that create an incentive to take risk because managers share in the gains but not all of the losses (Jensen and Meckling, 1976; Smith and Stulz, 1985; Smith and Watts, 1992). On the other hand, by creating a leveraged position in the firm's equity, options can magnify a risk-averse manager's exposure to firm risk and thus weaken the manager's risk-taking incentives (Lambert et al. 1991; Carpenter, 2000; Ross, 2004).

[6] Relatedly, increasing evidence shows that credit rating agencies incorporate managerial compensation into their credit analysis of rated issuers because they are aware of the link between compensation arrangements and managerial risk appetite. In their 2008 Corporate Ratings Criteria report, Standard & Poor's identifies "management compensation poorly aligned with the interests of stakeholders" and "management incentives that compromised long-term stability for short-term gain" as indicators of poor governance that would impair creditworthiness. Similarly, a 2005 Moody's Special Comment argues that pay packages that induce greater risk taking by managers are perhaps consistent with shareholders' objectives but not necessarily with bondholders' objectives.

vega option grants. Further, Brockman et al. (2010) document a positive relation between CEO vega and short-term debt. This finding provides evidence for creditors' assessment of managerial incentives and risk-seeking behavior. Short-term debt can be a powerful tool for monitoring management (Rajan and Winton, 1995; Stulz, 2001). In turn, creditors adjust debt maturity to restrain managerial risk seeking in response to an increase in vega. In a similar vein, Castro et al. (2016) find that an increase in the CEO's vega leads to a greater concentration of the firm's debt structure.[7] Overall, in the context of the traditional creditor–debtor relation, creditors monitor their borrowers' managerial compensation policies and take actions that make excessive risk taking unattractive, which mitigates borrowers' incentives to offer convex incentive schemes.

The presence of CDSs significantly alters the creditor–debtor relation. Protection from a CDS contract limits the downside exposure of creditors and provides them with greater bargaining power in renegotiations (Bolton and Oehmke, 2011), which potentially diminishes creditors' reliance on continuous monitoring to protect the value of their claims. Thus, CDS-protected creditors may find it more efficient to rely on pre-specified credit events to trigger renegotiations or default payments and shift away from costly monitoring (Morrison, 2005; Parlour and Winton, 2013; Subrahmanyam et al., 2016).

In accordance with this argument, Martin and Roychowdhury (2015) find a decline in borrowers' accounting conservatism after CDS trade initiation, which they interpret as evidence of creditors' weakened incentives to monitor borrowers' financial statements upon acquiring CDS contracts. The authors further argue that CDS sellers might not be able to monitor borrowers on an ongoing basis due to i) the lack of private contractual agreements between CDS sellers and underlying borrowers, ii) their typically diversified portfolios of credit risk and the resulting low monitoring incentives, and iii) the availability of price protection (Martin and Roychowdhury, 2015). Ashcraft and Santos (2009) document that the introduction of CDS trading increases debt financing costs for risky and informationally opaque firms. They attribute

[7] More concentrated debt structures facilitate the monitoring activity that alleviates agency conflicts associated with asset substitution by mitigating free-rider problems and coordination problems among creditors (Diamond, 1984; Diamond, 1991; Park, 2000; Bris and Welch, 2005; Sufi, 2007).

the heightened debt financing costs to a potential reduction in creditor monitoring among this subset of firms in the post-CDS period. Along these lines, Wang and Xia (2014) find that banks known to transfer credit risk via collateralized loan obligations impose looser covenants on borrowers at origination and devote less effort to monitoring their borrowers' risk-taking activities after origination.

Taken together, the reduced scrutiny from CDS-protected creditors provides boards with the opportunity to increase CEOs' risk-taking incentives that likely compromise debtholder claims for shareholder interests. Although firms may not observe the timing of their creditors' investments in specific CDS contracts, they can observe CDS trade initiation on their own bonds and adjust the structure of managerial compensation accordingly. Therefore, we expect that introducing CDS trading on a firm leads to an increase in the vega of the firm's CEO.

Saretto and Tookes (2013) show that firm leverage increases after CDS trading. Subrahmanyam et al. (2014) find that firm bankruptcy risk is higher if the firm's debt is referenced by CDSs. Their findings raise the possibility that the board redesigns managerial incentives to induce riskier financial policy choices and higher firm risk in the wake of CDS introduction. To our knowledge, whether CDS-referenced firms exhibit any changes in their design of managerial incentives or whether creditors reduce the scrutiny of their borrowers' compensation practices upon CDS trade initiation is a largely unresolved empirical question, which our evidence addresses.

2.2. Heterogeneity in the effect of CDS introduction on vega

2.2.1. Borrowers' risk-shifting incentives

In addition to the above hypothesis, we conjecture that the vega effect of reduced creditor scrutiny upon CDS trade initiation should be amplified by borrowers' incentives to engage in risk shifting. We identify settings in which firms have greater risk-shifting incentives and are more likely to exploit the opportunity provided by reduced creditor scrutiny following CDS introduction. Prior literature suggests that institutional investors have the ability and incentive to

influence CEO compensation packages to provide more equity-based incentives (Gillan and Starks, 2000; Hartzell and Starks, 2003; Almazan et al., 2005; Fernandes et al., 2013). The direction of this influence is congruent with shareholder preferences. Thus, the boards of firms with larger institutional holdings are more likely to act in the interests of shareholders and design managerial compensation packages accordingly. Further, financially distressed firms can have greater risk-shifting incentives (Eisdorfer, 2008), which may manifest in increased convexity in CEO compensation. In sum, we expect any increase in the CEO's vega after the onset of CDS trading to be more prominent for financially distressed borrowers and those with greater institutional ownership.

2.2.2. Borrowers' dependency on bank loans

A strand of literature suggests that banks are more effective in monitoring debtors and deterring potential risk-shifting activities than public bondholders because of their concentrated holdings and superior access to private information (Fama, 1985; Diamond, 1991; Park, 2000; Hadlock and James, 2002; Lin et al., 2013). For borrowing firms characterized by greater bank loan dependency, stringent monitoring could provide CDS investments with greater scope to alter creditors' monitoring strategies. In other words, CDS trade initiation and its influence on creditors' monitoring incentives are less likely to matter if the lender–borrower relation is not characterized by bank scrutiny in the first place. Thus, given the important role of banks in monitoring, we hypothesize that any increase in the CEO's vega after CDS introduction should be more pronounced among firms with bank debt.

2.3. Managerial risk appetite and exacting creditors

Bolton and Oehmke (2011) provide a theoretical analysis of the empty creditor problem. The main insight from their model is that a creditor with CDS protection has a better outside option in renegotiation because, when renegotiation fails, the firm goes into default and the CDS pays out. This outside option increases the creditor's bargaining power in renegotiation and

reduces the incidence of strategic default by borrowers. However, if their CDS positions are sufficiently large, creditors may have little interest in sustaining the debtor and push the debtor into inefficient bankruptcy or liquidation. Consistent with the empty creditor hypothesis, Subrahmanyam et al. (2014) document that the probability of a rating downgrade or bankruptcy increases after creditors invest in CDS contracts. The authors show that this effect is partially due to creditor intransigence in the post-CDS period. Danis (2016) find that CDS-protected bondholders are less likely to participate in debt restructuring, which contributes to the heightened likelihood of bankruptcy.

Corporate bankruptcy can impose significant personal costs on the firm's CEO, ranging from forced turnover (Schwartz and Menon, 1985; Gilson, 1989; Hotchkiss, 1995; Nini et al., 2012) to losses of labor market reputation (Fama, 1980; Fama and Jensen, 1983; Gilson, 1989) and personal wealth (Gilson and Vetsuypens, 1993; Eckbo et al., 2016). Thus, the presence of empty creditors may decrease managerial risk appetite, partially offsetting the increased risk-taking incentives from compensation after CDS introduction, because managers anticipate tougher renegotiations and a higher probability of bankruptcy if their firms trigger pre-specified credit events. We test this conjecture by examining the effect of CDS trade initiation on the relation between the CEO's vega and firm leverage. We are particularly interested in firms' financing decisions because both an increase in vega and the onset of CDS trading have been associated with increases in leverage (Coles et al., 2006; Saretto and Tookes, 2013; Li and Tang, 2016); in contrast, the predictions on the relation between CDS introduction and corporate investment decisions are ambiguous. Unlike prior studies, we investigate the interactive effect of vega and CDS trading on firm leverage, which is less likely to be affected by omitted factors. Specifically, we expect the onset of CDS trading to restrain managerial risk appetite and thus attenuate the effect of the CEO's vega on firm leverage.

3. Data and empirical specification

3.1. Data

We are interested in the impact of CDS trading on the CEO's incentive contracts. Our starting point to construct the sample is the universe of nonfinancial firms over the period 2002–2010[8] in the ExecuComp database, which provides CEO compensation information.[9] We then expand this information to include CDS quote data from Bloomberg, also used by Saretto and Tookes (2013) and Das et al. (2014). As noted by Saretto and Tookes, the Bloomberg quote data capture firms with substantial CDS trading activities and allow for the sufficiently broad dissemination of contractual information to develop an impact. Given the over-the-counter nature of CDS contracts, we use the first CDS trading date in our sample as the CDS introduction date and explore changes in CEO vega following CDS trade initiation. Moreover, we obtain firm-level financial data from Compustat, stock price information from CRSP, and corporate governance variables from RiskMetrics. All accounting variables are winsorized at the first and 99th percentiles to mitigate the potential impact of outliers. The final sample, the intersection of these databases, consists of 7,153 firm–year observations and 892 firm–years in which CDS contracts are trading.[10]

3.2. Baseline empirical specification

We use panel regressions to examine the effect of CDS trading. The fully specified baseline empirical model is the following:

$$Ln(1+Vega)_{i,t} = \alpha + \beta \cdot CDS\ trading_{i,t-1} + \gamma \cdot Control_{i,t-1} + D_i + Industry \cdot year + \varepsilon_{i,t} \quad (1)$$

[8] The first year for which we have CDS quote data from Bloomberg is 2002. Therefore, our sample begins in 2002.
[9] Our dependent variable, the sensitivity of CEO wealth to stock return volatility (vega), is obtained directly from Coles et al. (2006), who construct the variable using ExecuComp data. Their data set is available at http://sites.temple.edu/lnaveen/data/.
[10] The number of firm–years in which CDS contracts are trading in our initial sample is 3,951. The attrition is due to the merging of numerous data sets, resulting in complete data on the rich set of controls.

The dependent variable is the sensitivity of CEO wealth to stock return volatility, or *vega*,[11] a common measure of managerial risk-taking incentives (Guay, 1999; Coles et al., 2006; Low, 2009; Brockman et al., 2010; Chava and Purnanandam, 2010; Hayes et al., 2012; Gormley et al., 2013; Bakke et al., 2016). Specifically, it is defined as the change in the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return (Coles et al., 2006). Following Ashcraft and Santos (2009), Saretto and Tookes (2013), Subrahmanyam et al. (2014), and Subrahmanyam et al. (2016), our main variable of interest, *CDS trading*, is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. *CDS trading* allows us to exploit the variation in the timing of CDS introduction to estimate the impact of the availability of CDS contracts on the CEO's vega.

Control stands for a set of determinants of the CEO's incentive contracts and potential confounders, following the previous literature on the design of CEO incentive compensation (Guay, 1999; Coles et al., 2006; Low, 2009; Hayes et al., 2012; Custódio et al., 2013; Fernandes et al., 2013; Bakke et al., 2016). First, we control for firm characteristics, including firm size, measured as the natural logarithm of sales (*Ln*(*Sales*)); profitability, measured as both the return on assets (*ROA*) and stock returns (*Stock return*); growth opportunities, measured as Tobin's q (*Tobin's q*); and firm risk, measured as stock return volatility (*Volatility*). Moreover, the CEO characteristics that we control for include CEO age (*Age*), CEO tenure (*Tenure*), an indicator of whether the CEO is female (*Female CEO*), and the level and structure of compensation packages (*Ln*(*Total pay*), *Equity mix*, and *Ln*(*1 + Delta*)). Finally, to account for the potential impact of corporate governance on the design of managerial compensation, we include the fraction of independent directors on the board (*Board independence*), the fraction of shares owned by institutional investors (*Institutional ownership*), and the entrenchment index (*E Index*) compiled by Bebchuk et al. (2009). Throughout our analysis, the explanatory variables are lagged by one

[11] We use the natural logarithm of one plus *vega* for regression purposes because the distribution of *vega* in the sample is right-skewed.

period to the dependent variable to alleviate potential endogeneity problems. Appendix A provides detailed variable definitions.

To further mitigate unobserved heterogeneity in our estimates of the effect of *CDS trading* on *vega*, we use a set of fixed effects. First, we include industry–year fixed effects, denoted *Industry · year*. This inclusion ensures that we are comparing CDS and non-CDS firms within the same industry at the same point in time, allowing us to difference away unobserved changes in industry conditions. In addition, we control for firm fixed effects, denoted D_i, to remove unobserved time-invariant differences between CDS and non-CDS firms. Under more stringent specifications, we replace firm fixed effects with CEO–firm fixed effects to absorb any unobserved CEO and firm heterogeneity that is fixed during the tenure of a given CEO. In other words, using the latter fixed effects, we can observe within-CEO–firm variation: the change in the vega of the same CEO working for the same firm for multiple years during which the firm initiates CDS trading. This setting thus increases the likelihood that any difference in the CEO's vega is due to the onset of CDS trading.

Although we control for a broad set of firm, CEO, and governance characteristics and use a variety of fixed effects, unobserved time-varying factors, such as a major shift in the firm's corporate strategy, could still be driving our results. To mitigate any remaining endogeneity concerns, we employ two approaches, including an IV approach and a DID matching analysis, which are discussed in more detail below.

3.3. Descriptive statistics

Insert Table 1 about here

Table 1 presents the descriptive statistics of the variables used in our baseline analysis. The dependent variable *Vega* has a mean value of 176,770, which is comparable to the reported mean of 149,453 in Table 1 of Hayes et al. (2012). In 9.3% of the firm–years, CDS contracts are trading. An average firm in our sample has a sales revenue of $5.761 billion, a return on assets of

13.9%, a Tobin's q of 1.9, a stock return of 11.0%, stock return volatility of 0.38, institutional ownership of 77.1%, a fraction of independent directors of 72.9%, and an E-index value of 2.8. In addition, 2.3% of the CEOs are female. The average CEO is 55 years old, has a tenure of seven years and a total compensation of $5.2 million, 60.6% of which is equity-based compensation. The summary statistics for our controls are consistent with those reported by Hayes et al. (2012), Custódio et al. (2013), Fernandes et al. (2013), Bakke et al. (2016), among others.

Insert Table 2 about here

Comparing the CDS and non-CDS samples in Table 2 provides useful insights. Compared to non-CDS firms, CDS firms offer much stronger risk-taking incentives in managerial compensation. On average, CEOs at CDS firms gain $396,975 when there is a 0.01 increase in the firm's stock return volatility, more than twice as much as the corresponding gain of $154,312 for CEOs at non-CDS firms. At the same time, CDS firms are larger and show lower performance in terms of Tobin's q, return on assets, and stock returns.

4. CDS trading and the sensitivity of CEO wealth to firm risk

4.1. Impact of CDS trading on vega

In Table 3, we establish the empirical relation between CDS trading and the CEO's vega as a first step toward understanding the mechanisms of the CDS effects. Columns (1) and (2) present the results of firm and CEO–firm fixed effects models, respectively. In both specifications, the coefficient estimates for *CDS trading* are positive and statistically significant at the 5% level, suggesting that CDS trade initiation has a positive effect on the CEO's vega. [12]

Insert Table 3 about here

[12] In untabulated results, we repeat the regressions in columns (1) and (2) of Table 3, replacing vega with the option pay ratio. We find a positive association between option pay ratios and the initiation of CDS trading.

The economic magnitudes are also substantial. For example, the coefficient of *CDS trading* in the CEO–firm fixed effect specification, in column (2) of Table 3, is 0.222, which implies that vega increases by 22.2% following the onset of CDS trading. This result is not driven by unobserved CEO characteristics associated with risk aversion, providing additional confidence for a causal interpretation of our findings. Absorbing unobserved CEO heterogeneity also addresses the concern that endogenous CEO–firm matching could bias our results.

A potential concern about the interpretation of our baseline results pertains to reverse causality: if, observing firms' managerial compensation decisions, creditors initiate hedging contracts and CDS markets emerge, then our results would be driven by reverse causation. To rule out this concern, we perform additional empirical analyses to examine the dynamics of the CDS effect. Specifically, we replace *CDS trading* with a set of four dummy variables indicating the year prior to CDS introduction ($CDS\ trading^{-1}$), the year of CDS introduction ($CDS\ trading^{0}$), the first year after CDS introduction ($CDS\ trading^{+1}$), and two or more years after CDS introduction ($CDS\ trading^{>=+2}$). If our results are affected by reverse causation, the likelihood of CDS trading might already be correlated with the CEO's vega before the inception of CDS trading. In that case, we should observe a positive and significant coefficient for $CDS\ trading^{-1}$.

The results in columns (3) and (4) of Table 3 alleviate concerns about reverse causation or pre-existing trends since, in both specifications, the coefficients of $CDS\ trading^{-1}$ are insignificant. Interestingly, we find that the coefficient of $CDS\ trading^{0}$ is also insignificant and the coefficients of both $CDS\ trading^{+1}$ and $CDS\ trading^{>=+2}$ are positive and statistically significant. These results indicate that it is only one year after the initiation of CDS trading that the positive effect on vega becomes large and significant. Overall, these findings suggest that the observed effect of *CDS trading* on *Vega* does not reflect reverse causation.

4.2. Robustness

We conduct a number of tests to ensure the robustness of our baseline results. First, we find similar results when we remove the 2007–2008 crisis period from our sample. Second, we

exclude firms that had never been referenced by CDS trading from the sample and find qualitatively the same results. Third, we test whether the results are robust to alternative clustering and industry classifications. The regressions in Table 3 include industry–year fixed effects based on the Fama–French 49 industry classifications, with standard errors clustered by firm. We confirm that our findings are robust to the two-digit Standard Industrial Classification (SIC) and the three-digit North American Industry Classification System (NAICS) industry classifications, the exclusion of industry–year fixed effects, clustering by industry and year, and double clustering by industry and year.

4.3. Difference-in-differences matching analysis

Our main variable of interest in the baseline specification, *CDS trading,* allows us to capture the change in *Vega* in all of the years following the onset of CDS trading. In this section, we employ an alternative DID approach to isolate firm–years near CDS introduction. Specifically, we compare the changes in *Vega* during the year of CDS introduction (from year t - 1 to year t) and in the year following CDS introduction (from year t - 1 to year t + 1) between CDS firms and their matched control firms. Thus, we require CDS firms and their potential control firms to have non-missing data on *Vega* from year t - 1 to year t + 1 to be included in this analysis. We then construct a control sample of non-CDS firms that are matched to CDS firms based on propensity scores one year prior to CDS introduction. The propensity scores are obtained by estimating a logit model of the likelihood of CDS trading,[13] where the independent variables include all the control variables in our baseline model, as well as industry and year effects. Each CDS firm is matched to a non-CDS firm with the closest propensity score.[14] Further, to ensure that CDS firms and their matched control firms are sufficiently indistinguishable, we require that the maximum difference between the propensity score of a

[13] The results are similar when we use a probit model.

[14] If a non-CDS firm in the control group is matched to more than one CDS firms, we retain only the pair with the smallest difference in propensity scores. As an alternative, we allow control firms matched to multiple CDS firms (i.e., matching with replacement) and find that the results are similar to those reported.

CDS firm and its matched control firm not exceed 0.05 in absolute value. Eventually, we identify matches for 74 firms with CDS introductions during the sample period.[15]

Insert Table 4 about here

After obtaining a closely matched sample of control firms, we use a DID approach to ensure that the difference in *Vega* between CDS and control firms is not driven by their cross-sectional heterogeneity or common time trends that affect both groups. A key identifying assumption behind the DID approach is that any trends in the CEO's vega during the pre-treatment era for both CDS and control firms are similar (i.e., the parallel trend assumption). Given the central importance of this assumption to the success of a DID estimator, we perform a diagnostic test in Panel A of Table 4 that examines the differences in observable characteristics between CDS firms and their matched controls in the pre-event year. The univariate comparisons indicate no statistically significant differences in observable characteristics between the two groups, suggesting that the parallel trend assumption is likely satisfied.

Panel B of Table 4 reports the results from the DID analysis using the matched sample. We first compute the difference in the vega values before and after CDS introduction (year t - 1 to year t + 1). The DID estimator is then the difference in the differences for CDS and control firms. The results show that, from year t - 1 to year t + 1, the increase in vega of CDS firms is statistically significant; however, we observe a statistically significant decrease in vega for non-CDS firms over the same period. As a result, the difference-in-differences is large and significant, which is reassuring.

The reduction in pay convexity at non-CDS firms can be linked to prior studies showing that firms dramatically decrease their usage of option-based compensation for the CEO after the

[15] The total number of firms in our sample with CDS introductions during the sample period is 116. This number is reduced due to either the lack of a close match (a propensity score difference larger than 0.05) or missing data on *Vega*.

adoption of FAS 123R in 2005 (Hayes et al., 2012; Bakke et al., 2016).[16] While this observation is as expected, it does raise a potential concern that our results may be influenced by the change in the accounting treatment of stock options under FAS 123R. To the extent that industry–year fixed effects capture trends in compensation practices over time, this concern is mitigated. Nevertheless, we conduct an additional robustness test and confirm that our findings remain when we end our sample period in 2004.

4.4. Instrumental variables approach

To address the concern of any remaining time-varying unobserved heterogeneity across firms or CEOs affecting our results, we use the instrumental variables approach to extract the exogenous component of *CDS trading* and use it to explain the CEO's vega. As sources of exogenous variation, we use three instrumental variables initially proposed by Saretto and Tookes (2013) and Subrahmanyam et al. (2014): first, *Lender FX Hedging* is the average notional amount of foreign exchange derivatives used for hedging purposes, relative to total assets, across the banks that have served as either lenders or bond underwriters for our sample firms over the previous five years.[17] Second, *Lender Tier 1 Capital* is the average Tier 1 capital ratios across the banks that have served as either lenders or bond underwriters for our sample firms over the previous five years.[18] Third, *TRACE Coverage* is the number of bond issues of a firm that have been covered by TRACE. As noted by Saretto and Tookes (2013) and Subrahmanyam et al. (2014, 2016), these instruments are economically sound because they are associated with the overall hedging interest of lenders or credit suppliers. For example, prior

[16] Prior to the implementation of FAS 123R, firms were allowed to expense stock options at their intrinsic value. Since nearly all firms granted stock options at-the-money, no expenses for option-based compensation were reported on the income statement. FAS 123R required firms to begin expensing stock-based compensation at its fair value, thereby eliminating accounting advantages associated with stock options. Consequently, firms significantly reduce their usage of option-based compensation after the adoption of FAS 123R.

[17] Following Saretto and Tookes (2013) and Subrahmanyam et al. (2014), to construct the variable, we first identify the lenders and bond underwriters for our sample firms based on data from DealScan and Bloomberg. We then supplement this information to include data on the foreign exchange derivative positions of these lenders and bond underwriters, obtained from the bank regulatory data set. In our sample, the mean (standard deviation) of *Lender FX Hedging* is 1.61% (1.34%), which is similar to the 1.85% (1.40%) reported by Saretto and Tookes.

[18] We use the Tier 1 capital ratio data from the Compustat bank files to construct this instrument.

literature suggests that lenders with larger hedging positions are more likely to trade the CDSs of their borrowers (Minton et al., 2009) and that banks with lower capital ratios have greater incentives to hedge the credit risk of their borrowers using CDSs (Subrahmanyam et al., 2014, 2016). Moreover, Subrahmanyam et al. (2014) indicate that the likelihood of CDS trading increases after the implementation of TRACE. Meanwhile, the instruments we use are expected to be uncorrelated with the CEO's vega, except through their impact on CDS trading. To verify this condition, we add the instruments to the ordinary least squares (OLS) regressions of vega both separately and together and find that they are not significant.

Insert Table 5 about here

Columns (1) and (3) of Table 5 present the results of the first-stage regression, where the dependent variable is *CDS trading*. Consistent with our predictions, we find that the coefficient estimates for the instruments are positive and frequently significant. We then conduct two additional tests to verify their validity. First, we test the joint significance of the three instruments and find that the values of the *F*-test are large and highly significant (*p*-value < 0.001). Second, the p-values for Hansen's (1982) J overidentification test are large (0.589 or higher), suggesting that the instruments are valid. Importantly, the second-stage regression results, reported in columns (2) and (4), show that *CDS trading* has a positive and significant impact on *Vega* after accounting for the potential endogeneity of managerial incentive contracts, confirming our prior results in Tables 3 and 4.

4.5. Heterogeneity in the effect of CDS introduction on vega

Our empirical analysis so far suggests a positive effect of CDS introduction on the CEO's vega. In this section, we explore whether this positive effect varies with borrowers' risk-shifting incentives and their dependency on bank loans to shed further light on the mechanisms through which CDS trading affects managerial incentive contracts.

First, we split the sample based on whether a firm's institutional ownership is above or below the sample median and estimate the vega regressions separately for firms with high and low institutional ownership. Table 6 presents the results. For brevity, we report only the coefficients of *CDS trading*, although the same set of control variables as in Table 3 is included. In addition, all specifications in columns (1) and (3) control for firm and industry–year fixed effects and those in columns (2) and (4) control for CEO–firm and industry–year fixed effects. The results reported in Panel A show that the coefficients of *CDS trading* are positive and statistically significant in the high institutional ownership subsample, but insignificant in the low institutional ownership subsample. These findings suggest that the boards of firms with larger institutional holdings tend to act in the interests of shareholders by offering managers greater risk-taking incentives following a decline in creditor monitoring.

Insert Table 6 about here

Second, we investigate whether the positive effect of *CDS trading* on vega is more pronounced in financially distressed firms. Eisdorfer (2008) indicates that financially distressed firms have stronger risk-shifting incentives. Thus, the managers of such firms might be motivated, via more convex incentive structures, to take greater risks after a decrease in creditor monitoring, particularly when their firms are closer to financial distress or are operating under stringent financial constraints. To test this, we estimate the vega regressions separately for distressed and non-distressed firms. We use *Altman Z-score*,[19] proposed by Altman (1968), and *KZ index*,[20] proposed by Kaplan and Zingales (1997), to measure the severity of financial distress facing a firm. The lower (higher) the *Z-score* (*KZ index*), the more financially distressed or constrained the firm. The results reported in Panels B and C of Table 6 show that, using both

[19] The Z-score is computed as: 1.2 × (working capital/total assets) + 1.4 × (retained earnings/total assets) + 3.3 × (earnings before interest and taxes/total assets) + 0.6 × (market value of equity/book value of liabilities) + 0.999 (net sales/total assets).

[20] The KZ index is computed as -1.002 × cash flow/K + 0.283 × Q + 3.139 × debt/total capital – 39.368 × dividends/K – 1.315 × cash holdings/K.

measures, the positive effect of *CDS trading* on vega is concentrated on financially distressed firms, consistent with the risk-shifting mechanism.

Third, we examine how firm dependency on bank debt affects the relation between *CDS trading* and *Vega*. Given the importance of banks in credit monitoring, any effect that the reduced monitoring following CDS introduction has on the CEO's vega should be more prominent for firms with bank debt. For firms without bank debt,[21] however, the effect of decreased monitoring is less pronounced. Consistent with our predictions, the results reported in Panel D shows that *CDS trading* has a positive and statistically significant effect on vega in firms with bank debt but not in those without bank debt.

5. Managerial risk appetite and exacting creditors

5.1. Do risk-taking incentives in managerial compensation matter?

Saretto and Tookes (2013) document that firms with CDS contracts traded on their debt maintain higher leverage ratios. Given the central role of managerial risk-taking incentives in determining corporate leverage (Coles et al., 2006; Chava and Purnanandam, 2010; Gormley et al., 2013), a question that naturally arises is whether the higher leverage can be partially attributed to the increase in the CEO's vega following the onset of CDS trading. To investigate this, we classify firms based on whether they actually increased *Vega* after CDS introduction, resulting in two indicator variables: *Vega_up* (*Vega_down*) equals one if a firm increases (decreases) *Vega* in the year following CDS trade initiation and zero otherwise. In Table 7, we first examine the effect of *CDS trading* on leverage and then replace *CDS trading* with two interaction terms, *CDS trading* × *Vega_up* and *CDS trading* × *Vega_down*. We consider both book leverage and market leverage measures of capital structure. Using both measures, we find that the increase in leverage is more pronounced for firms that increased *Vega* after CDS trade initiation relative to those that did not. This result indicates that the increased risk-taking

[21] In Table 6, we treat missing values of the bank loan variable as zeros. We confirm that the results are not materially affected if we alternatively remove observations with missing values.

incentives in managerial compensation after CDS introduction impact firms' capital structures and are, at least partially, responsible for the documented CDS effect on leverage.

Insert Table 7 about here

5.2. Exacting creditors and the relation between CEO vega and leverage

Next, we examine whether CDS trade initiation mitigates the impact of vega on firm leverage. CDS-protected creditors tend to be tougher in renegotiations, making distressed borrowers more vulnerable to bankruptcy (Bolton and Oehmke, 2011; Subrahmanyam et al., 2014). Given the significant personal costs associated with corporate bankruptcy, risk-averse, rational CEOs may attempt to avoid renegotiations with exacting creditors by making less aggressive capital structure decisions. Therefore, the decline in managerial risk appetite due to the exacting creditor threat could offset the observed increase in risk-taking incentives embedded in CEO compensation, resulting in a lower sensitivity of leverage to vega after the inception of CDS trading.

Insert Table 8 about here

We test this conjecture by including an interaction term between *CDS trading* and *Ln(1 + Vega)* in the leverage regressions. Table 8 presents the results. Using both book and market leverage, we find that the coefficients of *CDS trading* × *Ln(1 + Vega)* are negative and frequently significant. In terms of economic significance, the coefficient estimates in column (3) indicate that a 10% increase in vega is associated with an increase of eight percentage points in market leverage before the initiation of CDS trading, but an increase of only two percentage points after the initiation. The significant lower sensitivity of leverage to vega after CDS introduction suggests that the presence of CDS-induced exacting creditors reduces managerial risk appetite.

6. Conclusion

This paper investigates the impact of CDS trade initiation on reference firms' managerial compensation policies. We find evidence that the introduction of CDS trading on a firm's debt increases the vega of the firm's CEO. This finding prevails even after we control for the potential endogeneity of the timing of CDS introduction using DID matching and IV estimation. Moreover, the increase in vega is more pronounced for firms that have bank debt and greater risk-shifting incentives, suggesting boards offer pay packages that encourage greater managerial risk, taking advantage of the reduced creditor monitoring after CDS trade initiation.

Consistent with Saretto and Tookes (2013), we find a positive effect of CDS introduction on firm leverage. Importantly, this effect is concentrated among firms that increased vega following CDS trade initiation, suggesting that the increased risk-taking incentives are partially responsible for the higher leverage in the post-CDS period. Finally, we find that the onset of CDS trading attenuates the effect of vega on leverage, consistent with the view that CDS-induced exacting creditors pose a potential threat to managers and restrain their risk taking.

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Table 1
Descriptive statistics

This table presents the summary statistics for the variables used in our baseline analysis. *Vega* is defined as the change in the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. *Sales* is the sales revenue. *ROA* is earnings before interest and taxes divided by total assets. *Tobin's q* is the sum of total assets plus market value of equity minus book value of equity divided by total assets. *Stock return* is the annual returns over the past year. *Volatility* is the annualized standard deviation of monthly stock return over the past year. *Age* is the age of the CEO in years. *Tenure* is the number of years as CEO in the current position. *Female CEO* is a dummy variable equal to one if CEO is female, and zero otherwise. *Delta* is defined as the change in the value of the CEO's wealth due to a 1% increase in the firm's stock price. *Total pay* is the total CEO pay, which consists of salary, bonus, restricted stocks, options, long-term incentive plans, and other compensation. *Equity mix* is the CEO equity pay divided by total pay, where equity pay is the sum of restricted stocks and options. *Board independence* is the fraction of independent directors on the board. *Institutional ownership* is the number of shares owned by institutional investors divided by total number of shares outstanding. *E index* is the Bebchuk et al. (2009) entrenchment index.

	Obs.	Mean	Stdev	25%	50%	75%
Vega (thousand $)	7153	176.770	256.938	27.915	82.077	210.106
CDS trading	7153	0.093	0.290	0.000	0.000	0.000
Sales (million $)	7153	5761.025	12154.150	656.741	1642.468	4804.062
ROA	7153	0.139	0.084	0.091	0.133	0.184
Tobin's q	7153	1.903	1.035	1.216	1.564	2.229
Stock return	7153	0.110	0.432	-0.159	0.075	0.312
Volatility	7153	0.378	0.206	0.236	0.329	0.465
Age	7153	55.473	6.940	51.000	56.000	60.000
Tenure	7153	6.866	7.179	2.000	5.000	9.000
Female CEO	7153	0.023	0.149	0.000	0.000	0.000
Delta (thousand $)	7153	659.680	1247.467	97.661	252.630	642.995
Total pay (thousand $)	7153	5206.285	5646.759	1647.231	3303.067	6458.261
Equity mix	7153	0.606	0.263	0.465	0.676	0.812
Board independence	7153	0.729	0.150	0.636	0.750	0.857
Institutional ownership	7153	0.771	0.183	0.659	0.788	0.893
E index	7153	2.842	1.279	2.000	3.000	4.000

Table 2
Univariate analysis

This table compares the means and medians of firm, CEO and governance characteristics for firm-years with CDS contracts and those without. The total number of observations is 7153. All variables are defined in Appendix A. t-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences in the means (medians). ***, ** and * indicate significance at the 1%, 5%, and 10% level, respectively.

	CDS		Non-CDS		Differences			
	Mean	Median	Mean	Median	Mean		Median	
Vega (thousand $)	396.975	272.361	154.312	74.893	242.663	***	197.468	***
CDS trading	1.000	1.000	0.000	0.000	1.000	***	1.000	***
Sales (million $)	22189.140	12436.000	4085.564	1440.743	18103.576	***	10995.257	***
ROA	0.129	0.134	0.140	0.133	-0.011	***	0.001	*
Tobin's q	1.627	1.440	1.931	1.583	-0.305	***	-0.143	***
Stock return	0.098	0.075	0.111	0.075	-0.013		-0.001	
Volatility	0.325	0.274	0.384	0.335	-0.059	***	-0.061	***
Age	55.506	56.000	55.470	56.000	0.036		0.000	
Tenure	5.908	4.000	6.963	5.000	-1.055	***	-1.000	**
Female CEO	0.036	0.000	0.021	0.000	0.015	**	0.000	**
CEO delta (thousand $)	1005.704	526.772	624.390	234.272	381.314	***	292.500	***
Total pay (thousand $)	10416.680	8566.195	4674.891	3060.365	5741.789	***	5505.830	***
Equity mix	0.710	0.777	0.596	0.662	0.114	***	0.116	***
Board independence	0.772	0.800	0.725	0.750	0.047	***	0.050	***
Institutional ownership	0.747	0.763	0.773	0.791	-0.026	***	-0.028	***
E index	2.847	3.000	2.842	3.000	0.006		0.000	

Table 3

CDS trading and CEO's incentive contracts.

This table examines the impact of the onset of CDS trading on the CEO's vega. The dependent variable is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. Our main variable of interest *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. Control variables include the following. *Ln(Sales)* is the natural logarithm of sales. *ROA* is the earnings before interest and taxes divided by total assets. *Tobin's q* is the sum of total assets plus market value of equity minus book value of equity divided by total assets. *Stock return* is the annual returns over the past year. *Volatility* is the annualized standard deviation of monthly stock return over the past year. A*ge* is the age of CEO in years. *Tenure* is the number of years as CEO in the current position. *Female CEO* is a dummy variable equal to one if CEO is female, and zero otherwise. *Ln(1+Delta)* is the natural logarithm of one plus *Delta*, where *Delta* is the change (in thousands of dollars) in the value of the CEO's wealth due to a 1% increase in the firm's stock price. *Ln(Total pay)* is the natural logarithm of CEO total compensation. *Equity mix* is CEO equity pay divided by total pay. *Board independence* is the fraction of independent directors on the board. *Institutional ownership* is the number of shares owned by institutional investors divided by total number of shares outstanding. *E index* is the Bebchuk et al. (2009) entrenchment index. *CDS trading*$^{-1}$, *CDS trading*^{0}, *CDS trading*$^{+1}$, and *CDS trading*$^{>=+2}$ are indicator variables for the year prior to, the year of, the first year after, and two or more years after the CDS introduction, respectively. Industry-year fixed effects are constructed based on the Fama-French 49-indsutry classifications. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

	Dependent variable: *Ln(1+Vega)*			
	1	2	3	4
CDS trading	0.266**	0.222**	—	—
	(0.108)	(0.090)		
CDS trading^{-1}	—	—	0.198	0.161
			(0.145)	(0.150)
CDS trading^{0}	—	—	0.269	0.240
			(0.193)	(0.173)
CDS trading^{+1}	—	—	0.360**	0.358**
			(0.180)	(0.178)
CDS trading$^{>=+2}$	—	—	0.503***	0.448**
			(0.184)	(0.187)
Ln(Sales)	0.338	0.217	0.343	0.222
	(0.223)	(0.189)	(0.223)	(0.189)
ROA	0.106	0.245	0.100	0.235
	(0.408)	(0.347)	(0.407)	(0.348)
Tobin's q	-0.069*	-0.045	-0.067*	-0.044
	(0.037)	(0.035)	(0.037)	(0.035)
Stock return	0.006	0.014	0.006	0.014
	(0.038)	(0.035)	(0.038)	(0.035)
Volatility	-0.166	-0.118	-0.168	-0.121
	(0.104)	(0.089)	(0.104)	(0.089)
Age	-0.010*	-0.008	-0.010*	-0.008
	(0.006)	(0.005)	(0.006)	(0.005)
Tenure	-0.016**	-0.025***	-0.016**	-0.025***
	(0.007)	(0.006)	(0.007)	(0.006)
Female CEO	-0.263	0.147	-0.270	0.147
	(0.185)	(0.152)	(0.187)	(0.152)
Ln(1+Delta)	0.226***	0.143***	0.226***	0.143***
	(0.033)	(0.027)	(0.033)	(0.027)
Ln(Total pay)	0.130***	0.058	0.131***	0.059
	(0.043)	(0.041)	(0.043)	(0.041)
Equity mix	-0.005	0.033	-0.007	0.031
	(0.107)	(0.101)	(0.107)	(0.101)
Board independence	0.297	0.092	0.297	0.091
	(0.182)	(0.163)	(0.182)	(0.162)
Institutional ownership	-0.111	-0.083	-0.108	-0.081
	(0.217)	(0.177)	(0.217)	(0.177)
E index	0.019	-0.003	0.019	-0.003
	(0.027)	(0.028)	(0.027)	(0.028)
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	7153	7153	7153	7153
Adjusted R^2	0.126	0.091	0.126	0.091

Table 4

Changes in vega around CDS introduction

This table presents univariate analysis of changes in vega before and after CDS introduction (year *t-1* to year *t+1*) for CDS firms relative to their matched control firms. The matched sample of non-CDS firms is chosen based on propensity scores obtained from a logit model that estimates the likelihood of CDS trading, as described in Section 4.2. *Ln(Sales)* is the natural logarithm of sales. *ROA* is the earnings before interest and taxes divided by total assets. *Tobin's q* is the sum of total assets plus market value of equity minus book value of equity divided by total assets. *Stock return* is the annual returns over the past year. *Volatility* is the annualized standard deviation of monthly stock return over the past year. A*ge* is the age of CEO in years. *Tenure* is the number of years as CEO in the current position. *Female CEO* is a dummy variable equal to one if CEO is female, and zero otherwise. *Ln(1+Delta)* is the natural logarithm of one plus *Delta*, where *Delta* is the change (in thousands of dollars) in the value of the CEO's wealth due to a 1% increase in the firm's stock price. *Ln(Total pay)* is the natural logarithm of CEO total compensation. *Equity mix* is CEO equity pay divided by total pay. *Board independence* is the fraction of independent directors on the board. *Institutional ownership* is the number of shares owned by institutional investors divided by total number of shares outstanding. *E index* is the Bebchuk et al. (2009) entrenchment index. Δ *Ln(1+ Vega)* is the change in Δ *Ln(1+ Vega)*. We report the difference-in-differences estimates for the CDS firms relative to their matched control firms with the closest propensity score. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	CDS Firms	Control Firms	Differences	T-statistics
Panel A: Post-match differences				
Ln(Sales)	6.891	6.848	0.043	0.465
ROA	0.146	0.137	0.009	0.823
Tobin's q	1.751	1.683	0.068	0.593
Stock return	0.029	0.087	-0.058	-1.017
Volatility	0.338	0.369	-0.031	-0.995
Age	55.527	55.919	-0.392	-0.349
Tenure	7.149	6.905	0.243	0.189
Female CEO	0.027	0.014	0.014	0.580
Ln(1+Delta)	6.207	6.405	-0.198	-1.040
Ln(1+Total pay)	8.709	8.857	-0.149	-0.935
Equity mix	0.621	0.670	-0.050	-1.219
Board independence	0.718	0.713	0.005	0.190
Institutional ownership	0.748	0.713	0.035	1.212
E index	2.581	2.649	-0.068	-0.323
Panel B: DID estimators		CDS Firms	Control Firms	CDS-Control
Δ Ln(1+ Vega) from t-1 to t+1		0.234***	-0.466***	0.701***
(Standard error)		(0.078)	(0.123)	(0.145)

Table 5
Instrumental variables approach

Table 5 presents estimates of the instrumental variables method using two-stage least square (2SLS) panel regressions. The dependent variable is *CDS trading* and *Ln(1+Vega)* for the first and second stage regressions, respectively. *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. *Ln(1+Vega)* is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. The instrumental variables are as follows. *Lender FX Hedging* is constructed as the average notional amount of foreign exchange derivate contracts used for hedging purposes, relative to total assets, across all banks that have been identified as either leading lenders or bond underwriters for our sample firms over the previous five years. *Lender Tier 1 Capital* is defined as the average of Tier One capital across all banks that have served as either leading syndicate loan lenders or bond underwriters for our sample firms over the previous five years. *TRACE covergae* is defined as the total frequency of a particular firm's corresponding bond issuance deals that are reported by the TRACE in year *t*. All other variables are defined in Appendix A. Specifications (1) and (2) include industry and year effects and specifications (3) and (4) include firm and industry-year effects. Industry and industry-year effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent Variables:			
	CDS trading	*Ln(1+ Vega)*	*CDS trading*	*Ln(1+ Vega)*
	First stage	Second stage	First stage	Second stage
	(1)	(2)	(3)	(4)
Lender FX Hedging, z_1	0.730	—	0.515	—
	(0.754)		(0.757)	
Lender Tier 1 Capital, z_2	-2.557***	—	-1.577**	—
	(0.637)		(0.753)	
TRACE Coverage, z_3	0.054***	—	0.011**	—
	(0.010)		(0.005)	
CDS trading	—	0.968**	—	1.482*
		(0.478)		(0.813)
Ln(Sales)	0.193***	0.181	0.096*	0.074
	(0.030)	(0.141)	(0.051)	(0.393)
ROA	-0.374***	-0.342	-0.096	-0.404
	(0.145)	(0.573)	(0.153)	(0.760)
Tobin's q	-0.012	0.093**	-0.002	-0.050
	(0.012)	(0.043)	(0.017)	(0.061)
Stock return	-0.002	0.381***	0.019	-0.065
	(0.015)	(0.074)	(0.018)	(0.083)
Volatility	0.019	-0.366**	-0.001	-0.146
	(0.041)	(0.163)	(0.048)	(0.179)
Age	-0.003**	-0.013**	0.000	-0.010
	(0.001)	(0.006)	(0.002)	(0.009)
Tenure	0.001	-0.015**	-0.001	-0.007
	(0.002)	(0.007)	(0.002)	(0.010)
Female CEO	0.080	-0.478*	-0.002	-0.012
	(0.069)	(0.258)	(0.055)	(0.261)
Ln(1+Delta)	0.006	0.408***	0.004	0.247***
	(0.010)	(0.039)	(0.009)	(0.051)
Ln(Total pay)	0.011	0.450***	-0.015	0.161**
	(0.017)	(0.072)	(0.015)	(0.080)
Equity mix	-0.004	0.040	0.041	-0.083
	(0.047)	(0.185)	(0.033)	(0.183)
Board independence	0.069	0.485**	0.017	0.357
	(0.063)	(0.208)	(0.059)	(0.307)
Institutional ownership	-0.009	0.373*	-0.285***	0.574
	(0.058)	(0.225)	(0.084)	(0.654)
E index	-0.014	0.047	-0.016	-0.010
	(0.009)	(0.034)	(0.011)	(0.050)
Industry FE	Yes	Yes	No	No
Year FE	Yes	Yes	No	No
Firm FE	No	No	Yes	Yes
Industry-Year FE	No	No	Yes	Yes
N	2947	2947	2657	2657
F-statistics ($z1=z2=z3=0$)	17.090***	—	12.330***	—
Hansen's *J* test *p-value*	—	0.589	—	0.810

Table 6
Heterogeneity in the effect of CDS introduction on vega

This table presents the heterogeneity in the effect of CDS introduction on the CEO's vega. Each panel presents an excerpt of the results from subsample regressions of managerial risk-taking incentives on the introduction of CDS trading. The dependent variable is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. Our main variable of interest *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. We include the same set of control variables as in Table 3. The coefficient estimates for control variables are suppressed for brevity. In each panel, we partition the sample based on whether the split variable is above or below the sample median, except for panel D in which sample firms are split into two groups based on whether the firm has bank debt. *Institutional ownership* is the number of shares owned by institutional investors divided by total number of shares outstanding. *Altman Z-score* and *KZ index* are measures of financial distress based on Altman (1968) and Kaplan and Zingales (1997), respectively. *Bank loan dependency* indicates whether the firm has bank debt. Information on bank loan is from Capital IQ. Industry-year effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: *Ln(1+Vega)*			
Panel A: Partition based on institutional ownership				
	High institutional ownership		Low institutional ownership	
	1	2	3	4
CDS trading	0.448**	0.319*	0.262	0.172
	(0.214)	(0.164)	(0.166)	(0.125)
All Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	3577	3577	3576	3576
Adjusted R^2	0.155	0.154	0.136	0.101
Panel B: Partition based on Altman Z-score				
	High Z-score: Non-distressed		Low Z-score: Distressed	
	1	2	3	4
CDS trading	0.106	0.054	0.273*	0.426***
	(0.167)	(0.140)	(0.150)	(0.146)
All Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	3016	3016	3015	3015
Adjusted R^2	0.076	0.077	0.205	0.163
Panel C: Partition based on KZ index				
	High KZ index: Distressed		Low KZ index: Non-distressed	
	1	2	3	4
CDS trading	0.294**	0.241**	-0.089	-0.066
	(0.141)	(0.122)	(0.165)	(0.122)
All Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	3577	3577	3576	3576
Adjusted R^2	0.178	0.152	0.078	0.088
Panel D: Partition based on bank loan dependency				
	With bank debt		Without bank debt	
	1	2	3	4
CDS trading	0.220**	0.182*	0.499	0.091
	(0.094)	(0.106)	(0.316)	(0.188)
All Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	4790	4790	2363	2363
Adjusted R^2	0.153	0.115	0.140	0.135

Table 7

Managerial risk-taking incentives following CDS introduction and corporate leverage

This table provides the results of the effect of CDS introduction on corporate leverage for the firms that increased vega and those that did not increased vega following CDS introduction. The dependent variables are *book leverage* and *market leverage*. The former is defined as the sum of current liability and long-term debt scaled by total assets. The latter is defined as the sum of current liability and long-term debt scaled by firm value, where firm value is the book value of total assets, plus the market value of equity, minus the book value of common equity. *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. *Vega_up* (*Vega_down*) is a dummy variable equal to one if a firm increases (decreases) vega in the year following CDS introduction, and zero otherwise. All other variables are defined in Appendix A. Industry-year effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: *Book leverage*				Dependent variable: *Market leverage*			
	1	2	3	4	5	6	7	8
CDS trading	0.009	—	0.015*	—	0.012**	—	0.014**	—
	(0.008)		(0.008)		(0.006)		(0.007)	
CDS trading × Vega_up	—	0.013*	—	0.018**	—	0.012*	—	0.013**
		(0.007)		(0.009)		(0.007)		(0.006)
CDS trading × Vega_down	—	0.002	—	0.009	—	0.013	—	0.015
		(0.009)		(0.010)		(0.008)		(0.009)
Ln(Sales)	-0.004	-0.005	-0.006	-0.006	0.038**	0.038**	0.034**	0.034**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.016)	(0.016)	(0.016)	(0.016)
ROA	-0.048	-0.049	-0.047	-0.048	-0.100***	-0.100***	-0.090***	-0.090***
	(0.042)	(0.042)	(0.038)	(0.038)	(0.028)	(0.028)	(0.029)	(0.029)
Tobin's q	-0.005	-0.005	-0.002	-0.002	-0.008***	-0.008***	-0.006**	-0.006**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Stock return	-0.010***	-0.010***	-0.011***	-0.010***	-0.015***	-0.015***	-0.014***	-0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Volatility	0.024**	0.024**	0.013	0.013	0.022**	0.022**	0.010	0.010
	(0.011)	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)	(0.009)	(0.009)
Age	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tenure	0.001***	0.001***	0.001**	0.001**	0.001***	0.001***	0.001*	0.001*
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Female CEO	0.006	0.006	0.002	0.002	-0.002	-0.002	-0.000	0.000
	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)
Ln(1+Delta)	-0.005**	-0.005**	-0.007***	-0.006***	-0.006***	-0.006***	-0.005***	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln(Total pay)	-0.013***	-0.013***	-0.007*	-0.007*	-0.007***	-0.007***	-0.005*	-0.005*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
Equity mix	0.028***	0.028***	0.013	0.013	0.014**	0.014**	0.008	0.008
	(0.011)	(0.011)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)
Board independence	-0.042**	-0.042**	-0.026	-0.026	-0.029**	-0.029**	-0.018	-0.018
	(0.019)	(0.019)	(0.017)	(0.017)	(0.013)	(0.013)	(0.014)	(0.014)
Institutional ownership	0.019	0.019	0.021	0.020	0.021	0.021	0.025	0.025
	(0.019)	(0.019)	(0.020)	(0.020)	(0.015)	(0.015)	(0.016)	(0.016)
E index	0.001	0.001	0.001	0.001	-0.000	-0.000	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	Yes	No	No	Yes	Yes	No	No
CEO-Firm FE	No	No	Yes	Yes	No	No	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7153	7153	7153	7153	7153	7153	7153	7153
Adjusted R^2	0.107	0.107	0.115	0.116	0.230	0.230	0.232	0.232

Table 8

CDS trading and the relationship between the CEO's vega and leverage

This table examines whether CDS trading affects the relationship between vega and leverage. The dependent variables are *book leverage* and *market leverage*. The former is defined as the sum of current liability and long-term debt scaled by total assets. The latter is defined as the sum of current liability and long-term debt scaled by firm value, where firm value is the book value of total assets, plus the market value of equity, minus the book value of common equity. *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. *Ln(1+Vega)* is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. All other variables are defined in Appendix A. Industry-year effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: *Book leverage*		Dependent variable: *Market leverage*	
Variable	1	2	3	4
Ln(1+Vega)	-0.004	-0.008	0.008**	0.012*
	(0.008)	(0.008)	(0.004)	(0.008)
CDS trading × Ln(1+Vega)	-0.006**	-0.002	-0.006**	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)
CDS trading	0.039**	0.024	0.044***	0.031*
	(0.020)	(0.018)	(0.017)	(0.018)
Ln(Sales)	-0.007	-0.005	0.038**	0.034**
	(0.021)	(0.020)	(0.016)	(0.016)
ROA	-0.046	-0.047	-0.100***	-0.090***
	(0.046)	(0.038)	(0.028)	(0.029)
Tobin's q	-0.006	-0.003	-0.008***	-0.006**
	(0.004)	(0.004)	(0.003)	(0.003)
Stock return	-0.010***	-0.011***	-0.015***	-0.014***
	(0.004)	(0.003)	(0.003)	(0.003)
Volatility	0.028**	0.013	0.022**	0.010
	(0.011)	(0.011)	(0.009)	(0.009)
Age	-0.000	0.000	-0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
Tenure	0.001**	0.001**	0.001***	0.001*
	(0.001)	(0.000)	(0.000)	(0.000)
Female CEO	0.006	0.002	-0.002	0.000
	(0.014)	(0.015)	(0.013)	(0.013)
Ln(1+Delta)	-0.004*	-0.006**	-0.006***	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)
Ln(Total pay)	-0.015***	-0.007	-0.007***	-0.005*
	(0.005)	(0.004)	(0.003)	(0.003)
Equity mix	0.030***	0.012	0.014*	0.008
	(0.011)	(0.010)	(0.007)	(0.007)
Board independence	-0.039*	-0.026	-0.029**	-0.019
	(0.023)	(0.017)	(0.013)	(0.014)
Institutional ownership	0.016	0.021	0.021	0.025
	(0.020)	(0.020)	(0.015)	(0.016)
E index	-0.000	0.001	-0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Firm FE	Yes	No	Yes	No
CEO-Firm FE	No	Yes	No	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
N	7153	7153	7153	7153
Adjusted R^2	0.103	0.115	0.231	0.232

Appendix A. Variable definition

Variables	Description	Source
Main variables		
Ln (1+Vega)	Natural logarithm of one plus the CEO's vega, where vega is defined as the change in the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return.	Execucomp; Coles et al. (2006)
CDS trading	Dummy variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it.	Bloomberg
Firm characteristics		
Ln(Sales)	Natural logarithm of sales.	Compustat
ROA	Earnings before interest and taxes divided by total assets	Compustat
Tobin's q	Sum of total assets plus market value of equity minus book value of equity divided by total assets	Compustat
Stock return	Annual stock returns over the past year.	Compustat
Volatility	Annualized standard deviation of monthly stock return over the past year.	CRSP
Book leverage	Sum of debt in current liabilities plus long-term debts and divided by total assets.	Compustat
Market leverage	Sum of debt in current liabilities plus long-term debts and dividend by firm value, where firm value is defined as book value of total assets plus market value of equity minus book value of common equity.	Compustat
CEO characteristics		
Age	Age of CEO in years.	Execucomp
Tenure	Number of years as CEO in the current position.	Execucomp
Female CEO	Dummy variable that takes a value of one if CEO is female, and zero otherwise.	Execucomp
Ln (1+Delta)	Natural logarithm of one plus the CEO's delta, where delta is defined as the change in the value of the CEO's wealth due to a 1% increase in the firm's stock price.	Execucomp; Coles et al. (2006)
Ln (Total pay)	Natural logarithm of CEO total pay, where total pay consists of salary, bonus, restricted stocks, options, long-term incentive plans, and other compensation.	Execucomp
Equity mix	CEO equity pay divided by total pay, where equity pay is the sum of restricted stocks and options.	Execucomp

Corporate governance variables		
Board independence	Number of independent directors divided by board size.	RiskMetrics
Institutional ownership	Number of shares owned by institutional investors divided by total number of shares outstanding.	Thomson Reuters 13F Holdings
E index	Entrenchment index based on six antitakeover provisions: staggered boards, limits to shareholder bylaw amendments, poison pills, golden parachutes, and supermajority requirements for mergers and charter amendments. The index measures the number of antitakeover provisions in place.	RiskMetrics; Bebchuk et al. (2009)

Appendix B. Robustness Tests

This table presents the results of the robustness checks discussed in Section 4.2 of the paper. The dependent variable is the natural logarithm of one plus *Vega*, where *Vega* is the change (in thousands of dollars) the value of the CEO's wealth due to a 0.01 increase in the annualized standard deviation of the firm's stock return. For brevity, only the coefficient estimates on *CDS trading* are reported. *CDS trading* is an indicator variable that equals one for a CDS firm after the inception of the firm's CDS trading and zero prior to it. All regressions include the same set of controls as in Table 3. Industry-year effects based on the Fama-French 49-industry classification are included unless otherwise stated. Standard errors are clustered at the firm level unless otherwise stated. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

		Dependent variable: *Ln(1+Vega)*	
		Firm FE	CEO-firm FE
(1)	Exclude 2007 and 2008 crisis period from sample	0.257**	0.178*
		(0.113)	(0.095)
(2)	Exclude firms never been referenced by CDS trading from sample	0.419*	0.300
		(0.215)	(0.206)
(3)	Industry-year FE based on the 2-digit SIC industry classification	0.318**	0.210**
		(0.125)	(0.097)
(4)	Industry-year FE based on the 3-digit NAICS industry classification	0.303**	0.183*
		(0.128)	(0.098)
(5)	Replace industry-year with year FE	0.202**	0.157**
		(0.101)	(0.075)
(6)	Cluster by industry	0.266**	0.222***
		(0.118)	(0.079)
(8)	Cluster by industry and year	0.266**	0.222***
		(0.116)	(0.084)