CEO Overconfidence, Corporate Governance, and the Demand for Directors and Officers Insurance*

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Abstract

Previous work shows directors' and officers' (D&O) liability coverage provides insight into a firm's risk-taking and governance. We develop a theoretical model to show how CEO overconfidence impacts D&O insurance decisions. We find firms with overconfident CEOs have a lower demand for D&O insurance. Using an options-based measure for CEO overconfidence, we test this model and find that firms with overconfident CEOs have a lower demand for D&O insurance. This effect holds when controlling for litigation risk, CEO characteristics, firm characteristics, and corporate governance. This work gives insight on how CEO overconfidence impacts corporate risk through the D&O insurance decision.

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Chief executive officers who are overconfident – who persistently overestimate their own skills relative to others and, as a result, are too optimistic about the outcomes of their decisions – expose their firms to heightened risks (Malmendier and Tate, 2005a). Studies show how CEO overconfidence influences major corporate decisions, including investments, financing, mergers and acquisitions, and innovation.[1] In many ways, CEO overconfidence brings adverse consequences to the firm. The internal organizational structure of firms causes these individuals to be promoted from managers to CEOs (Goel and Thakor, 2008), yet evidence shows that too much or too little overconfidence can cause the CEO to face a higher probability of forced turnover (Campbell et al., 2011).

This paper examines how CEO overconfidence impacts the decision-making process for the purchase of Directors and Officers (D&O) liability insurance. D&O liability insurance is a branch of insurance that protects a company's directors and officers from personal loss that may stem from litigation. Their personal wealth is at risk when faced with a lawsuit in connection with their roles and responsibilities to their company, and their company correspondingly buys insurance on their behalf to safeguard their wealth. Directors and officers generally view such insurance as necessary for them to carry out their respective roles for their firms. Surveys have found that virtually all publicly traded corporations purchase D&O insurance for their directors and officers.

The corporate demand for D&O insurance offers some insight on firm risk and corporate governance. Higher coverage limits for D&O insurance are associated with firms that have higher litigation risk, more inside voting control, higher financial distress, lower announcement-period abnormal stock returns during mergers and acquisitions, and higher loan spreads.[2] D&O insurance has also been suggested to serve as a monitoring source for a firm's managers (O'Sullivan, 1997), helps mitigate bankruptcy risk (Kalchev, 2004), and indicates the quality of corporate governance within the

[1] See for example, Malmendier and Tate (2005a, 2005b, 2008), Goel and Thakor (2008), Campbell et al. (2011), Galasso and Simcoe (2011), Gervais et al. (2011), Malmendier at al. (2011), and Hirshleifer at al. (2012).
[2] See for example, Core (1997), O'Sullivan (2002), Fier et al. (2012), Lin et al. (2011), Lin et al. (2013), and Gillan and Panasian (2014).

firm (Core, 2000). Chalmers et al. (2002) and recent work by Boyer and Stern (2014) further suggest that D&O insurance can be used as a measure of governance risk for IPOs. Firms with higher D&O premiums pre-IPO have lower post-IPO returns than those with lower D&O premiums pre-IPO (Boyer and Stern, 2014). D&O insurance has valuable information for shareholders and investors regarding firm risk, as the amount of D&O insurance purchased relates to the firm's risk levels. Therefore, it is important to understand the factors that influence the demand for D&O insurance, including CEO characteristics, and how such factors can further impact firm risk.

Moreover, because D&O insurance protects directors and officers from personal loss associated with litigation for decisions they make on behalf of the corporation, D&O insurance could induce moral hazard. That is, D&O insurance could cause the directors and officers to make decisions that are not in the best interest of shareholders. Evidence shows that firms with higher risk do buy more coverage, lending support to this theory, and director characteristics could further impact the moral hazard dynamic, which we will consider.

In what follows, we investigate how CEO overconfidence impacts the demand for D&O insurance. We contribute to the literature by analyzing the intersection of two streams of research: the impact of CEO overconfidence on firm decisions and additional factors that influence D&O liability insurance coverage, which, as previous work shows, has implications for firm risk. Both research areas have produced valuable insights into corporate governance and risk tolerance, but relationships between the two areas remain unexplored. We consider a CEO who is overconfident in his/her own ability and thereby underestimates his/her potential loss from litigation associated with claims against him/her. We put forth a theoretical model of how overconfidence impacts demand for D&O insurance and find that an overconfident CEO will demand less D&O insurance than a rational (not overconfident) CEO. Furthermore, the more overconfident the CEO is, the less D&O insurance he or she will demand.

Using an options-based measure for CEO overconfidence, we then test these theoretical predictions with data from 2000-2006. Our empirical findings support the predictions from the model. Firms with overconfident CEOs are less likely to have D&O liability provisions; the more overconfident the CEO is, the less D&O insurance will be demanded. These results are robust to various specifications and controls for firm characteristics, CEO characteristics, and firm governance.

Our analysis also addresses the party dynamics involved in the decision-making process to purchase D&O insurance. As D&O insurance covers other top executives beyond the CEO, the decision to purchase D&O insurance is made jointly with the board of directors and not necessarily with just the CEO's input. We account for this issue in our analysis by developing an overconfidence measure for the firm's top executives using an options-based measure of overconfidence that is analogous to the CEO overconfidence measure. We find that overall top executive overconfidence does not impact the D&O insurance decision. Yet, when looking at CEO overconfidence, even after controlling for overall top executive overconfidence, the CEO overconfidence measure dominates and is statistically significant. An overconfident CEO will cause the firm to demand less D&O insurance, even when controlling for the overconfidence of other top executives at the firm.

We also expect a firm's corporate governance to influence the effects of CEO overconfidence upon D&O insurance decisions. Firms with stronger corporate governance should have better monitoring mechanisms. Although we control for corporate governance in our estimations, we also divide our sample into two subgroups: one with firms that have stronger corporate governance and one with firms that have weaker corporate governance. We find, as expected, strong corporate governance can mitigate the negative effect of CEO overconfidence on the demand for D&O insurance; the relationship between CEO overconfidence and D&O insurance demand is not significant for the subgroup of firms that have strong corporate governance. For firms with weak corporate governance, CEO overconfidence leads to

a lower demand for D&O insurance, and this effect is twice as large as when compared to the results obtained when looking at the entire sample of firms.

We also split our sample into rational (not overconfident) CEOs and overconfident CEOs. We find that, for the subgroup with rational CEOs, there is not a statistically significant relationship between their level of overconfidence and the demand for D&O insurance. The difference between the two subgroups is statistically significant; that is, there is a significant difference between the effect of rational CEOs and overconfident CEOs on the demand for D&O insurance.

Although our analysis controls for a variety of factors anticipated to influence the demand for D&O insurance, we address a potential endogeneity concern in our analysis, given that CEOs are often matched to companies based on CEO personalities and also on firm characteristics. For instance, boards might take CEO overconfidence into account when selecting a CEO. Similarly, firms in financial distress may match with overconfident CEOs and are less likely to have D&O insurance. To strengthen our conjecture that CEO overconfidence influences the demand for D&O insurance, we use propensity score matching techniques. In this analysis, "treated CEOs" (i.e., those who are overconfident) are matched with "control CEOs" (i.e., those who are rational) in an effort to isolate the causality from CEO overconfidence to the demand for D&O insurance. The propensity score matching results show that even when controlling for cross-sectional differences among firms and CEOs, including financial distress, CEO overconfidence negatively impacts the demand for D&O insurance. Furthermore, we look at how lagged overconfidence impacts the demand for D&O insurance and find a significant result. That is, we show that overconfidence is persistent over time using one, two, and three year lags. CEO overconfidence in the previous year leads to a lower demand for D&O insurance in the following year. If the presence of D&O insurance caused a CEO to be overconfident, we would not find this result with the lagged CEO overconfidence variables.

D&O insurance can provide insightful information for shareholders about a firm's risk, as coverage levels are associated with riskier firm behavior, such as higher loan spreads, lower post-IPO returns, higher litigation risk, and higher financial distress. Additionally, CEO overconfidence has been shown to impact firm decisions in ways that impact shareholder value, potentially in a negative direction. This paper further advances our understanding of the impact of CEO overconfidence on a firm's decisions, and we examine this phenomenon through the CEO's purchasing decision of D&O insurance. If CEOs are overconfident, previous research shows they are more likely to make decisions for the firm that might be harmful to shareholders and that might increase firm risk. As such, overconfident CEOs are more likely to make decisions that would boost the need for D&O insurance. Our findings show that overconfidence causes them to buy even less insurance. Traditionally, having D&O insurance has been shown to increase firm risk (moral hazard); if CEO overconfidence leads to lower levels of D&O insurance it may decrease the moral hazard effect. We use a Heckman treatment effects model to study this impact. That is, we look at the impact of both D&O insurance and CEO overconfidence on firm risk, controlling for the effect of CEO overconfidence on the D&O decision in the first stage of this analysis. We find that D&O insurance increases firm risk and that CEO overconfidence has a positive but not statistically significant effect on firm risk. Because CEO overconfidence leads to a lower demand for D&O insurance, it may reduce the moral hazard problem and mitigate the impact of CEO overconfidence on overall firm risk.

This work provides further evidence of factors that influence D&O insurance coverage and also provides valuable insight into how CEO characteristics impact corporate risk and shareholder value. Our results also give insight to insurers; CEO overconfidence should be taken into consideration when pricing D&O liability insurance contracts.

The remainder of the paper is organized as follows. Section I provides a short background on previous work related to D&O insurance and CEO overconfidence. Section II describes the model for

how CEO overconfidence impacts the demand for D&O insurance and the theoretical predictions that follow from this model. In Section III, we describe the data and methodology used to test the theoretical predictions from the previous section. In Section IV we describe and discuss our results. Finally, in Section V we conclude.

I. Background and Previous Literature

A. Director & Officer Insurance

In today's business environment, corporate directors and officers face significant exposure to lawsuits (Trautman & Altenbaumer-Price, 2012). Regardless of how careful, effective or well-intentioned their decisions may be, directors and officers find themselves to be litigation targets simply due to their titles and roles (Trautman & Altenbaumer-Price, 2012). Directors and officers encounter a broad spectrum of claims, ranging from common law breach of fiduciary duty claims to shareholder class actions for violations under federal and state securities laws (Trautman & Altenbaumer-Price, 2012). They face potentially massive legal defense and settlement costs to address any and all allegations, regardless of their merit. As the directors and officers are personally responsible for the actions of their corporation, their personal assets are at risk in the event a lawsuit is filed against the corporation and/or its management (Boyer, 2008).

Director and officer (D&O) insurance aims to shield directors, executives, and the companies they serve from liability that arises from decisions and actions made in the course of conducting business. This brand of insurance protects the insured from the costs inherent in defending lawsuits and from the baseline liability exposure. D&O insurance policies generally cover settlement amounts, legal fees and compensatory damages resulting from the conduct of directors and officers (Dobiac 2008). As Baker and Griffith (2007, pg. 488) explain, "[T]he D&O insurer serves as an intermediary between injured shareholders and the managers who harmed them." Essentially all public companies in the United States

purchase D&O insurance (Baker & Griffith, 2007). Coverage is not standard or "off the shelf," but rather highly tailored to meet the needs of the particular company.

Prior literature documents several factors surrounding the corporate demand for D&O insurance.[3] Many of these studies examine a company's decision to purchase D&O insurance coverage and the types of information that may be gleaned from D&O insurance purchases. With the data and time periods typically varying, these studies examine firms' motives for purchasing D&O insurance, including the notion that companies with higher litigation risk are more likely to select higher coverage limits (Core, 1997; O'Sullivan, 2002; Fier et al., 2012, Gillan and Panasian, 2014) and that D&O insurance helps mitigate bankruptcy risk (Kalchev, 2004). Companies with higher inside voting control are more likely to purchase D&O insurance coverage and with higher limits, and some of the main determinants surrounding the likelihood of D&O insurance purchases include litigation risk and financial distress (Core, 1997). D&O insurers also function as a monitoring source of the firm's managers for large companies (O'Sullivan, 1997). The quality of corporate governance will affect the premium charged (Core, 2000), and D&O premiums charged appear to be an indication of governance risk (Boyer and Stern, 2012). Additionally, higher D&O insurance coverage is associated with firms that have higher loan spreads (Lin et al., 2013) and lower abnormal-period returns during mergers and acquisitions (Lin et al., 2011). In the IPO market, D&O insurance premiums are higher and more coverage is purchased for firms that have lower post-IPO abnormal returns (Chalmers et al., 2002; Boyer and Stern, 2014). Some have argued that the level of coverage for D&O insurance is merely a pattern of habit (Boyer, 2005, 2008).

Prior work implies that D&O insurance decisions reveal beneficial information about the firm's corporate risk, litigation risk, governance structure, and potential managerial opportunism. Higher levels of D&O coverage are associated with greater corporate risk and litigation risk and weaker

[3] See for example Core (1997, 2000), O'Sullivan (1997), Chalmers et al. (2002), Kalchev (2004), Boyer (2005, 2008), Fier et al. (2012), Lin et al. (2011), Lin et al. (2013), Boyer and Stern (2012, 2013), and Gillan and Panasian (2014).

governance structure. As such, there is motivation for disclosing the details of D&O insurance for shareholders. It is also of interest to determine if CEO characteristics further influence the D&O insurance purchasing decision, and if so, what the resulting implications are to the firm's risk.

B. CEO Overconfidence

The work on CEO overconfidence focuses upon chief executive officers who are overconfident – who persistently overestimate their own skills relative to others and, as a result, are too optimistic about the outcomes of their decisions (Malmendier and Tate, 2005a). This line of research examines how the decisions of overconfident CEOs could potentially harm shareholder value in a number of different ways. Previous work has shown that CEO overconfidence can lead to overinvestment, a preferences for internal financing, the overpayment for target companies and the undertaking of value-destroying mergers (Malmendier and Tate, 2005a, 2005b, & 2008).

The hypothesis contends that overconfident CEOs overestimate the expected returns to a business decision or the probability of a project's success. They also tend to perceive their firms to be undervalued, and overestimate their ability to generate returns. These biased managerial beliefs lead to significant distortions in corporate investment policies. Overconfident CEOs view external funds as unduly costly, leading those CEOs to overinvest when internal funds are abundant and curtail investment when external financing is required (Malmendier and Tate, 2005b). Furthermore, in studying mergers and acquisitions, the odds of making an acquisition are 65% higher if the company's CEO is overconfident (Malmendier and Tate, 2008). The decisions made by a CEO will depend in part upon the CEO's prior life experiences. For instance, CEOs who grew up during the Great Depression will lean more toward internal financing, while those with military experience will pursue aggressive policies (Malmendier et al., 2011). These life experiences can mitigate or exacerbate the impact of overconfidence on firm decisions.

CEO overconfidence also carries implications for technology and innovation, which can yield positive consequences for firms in particular industries. For instance, overconfident CEOs are more likely to take their firms in a technological direction, and this push is more pronounced in more competitive industries (Galasso and Simcoe, 2011). Similarly, overconfident CEOs invest more in innovation, obtain more patents, and achiever greater innovative success for research and development endeavors; yet this success is only achieved in innovative industries (Hirshleifer et al., 2012).

With the documentation of CEO overconfidence and the corresponding potentially adverse consequences, one might question how such individuals become CEOs and how CEO overconfidence persists. Internal corporate governance tends to promote an overconfident manager to CEO relative to those who are less confident (Goel and Thakor, 2008). CEO confidence maximizes firm value up to a point, although excessive confidence is deemed harmful, and overconfidence does lead to underinvestment in information production which can be harmful to the firm and shareholders as well (Goel and Thakor, 2008). CEOs who are highly overconfident or not confident enough will face a higher probability of forced turnover, showing that boards of directors do account for CEO overconfidence in some way (Campbell et al., 2011).

In general, CEO overconfidence leads to reduced conservatism (Ahmend and Duellman, 2013), but from this recent stream of literature on CEO overconfidence, it seems a certain amount of CEO confidence is needed for the CEO to make decisions that maximize shareholder value. In fact, a certain amount of overconfidence is needed to induce managers to learn about investment opportunities relative to what their rational counterparts would do, which is helpful for shareholders; at the same time, excessive overconfidence causes managers to have too much risk exposure, which is detrimental (Gervais et al., 2011).

To our knowledge, the existing literature does not address how CEO overconfidence affects the demand for D&O insurance. This paper examines how CEO overconfidence can lead to decisions that

have a negative impact on firm risk and shareholder value. Like the realm of D&O insurance, CEO overconfidence carries significant implications for corporate governance and shareholder value. We explore the intersection of these two areas by modeling the relationship of CEO overconfidence on D&O insurance and testing the model empirically.

II. Model and Empirical Predictions

We develop a simple model to demonstrate the effect of overconfidence on the demand for D&O insurance. The goal of this paper is to show the distortionary power of overconfidence, and therefore we do not consider other informational asymmetries and/or agency problems. The CEO's inflated perception in his/her decision-making ability and consequently deflated perception of his/her potential litigation losses are the only friction in this model.

Following Campbell et al. (2011), suppose a firm has existing assets *A* and cash flow *C*. The risk-averse CEO chooses an investment level $I \in [0, \infty)$ and the level of D&O insurance to purchase. The firm's production function has decreasing returns to scale with a stochastic technology shock, $\bar{A}$, which is given by: $f(I, \bar{\text{A}}) = \bar{\text{A}} g(I)$. The function $g(I)$ has $g(0) = 0, g'(I) > 0, g''(I) < 0,$ and $\lim_{I \to 0} g'(I) = +\infty$ which guarantees a strictly positive level of investment is always optimal. The technology shock can be decomposed as $\bar{\text{A}} = \mu + \Delta_R + \varepsilon$ where ε is a random variable with $E[\varepsilon\,] = 0$ and a finite support. The mean of the technology shock is denoted $\mu > 0$. The support of ε is such that $\mu + \varepsilon > 0$ to eliminate negative production realizations.

An overconfident CEO overestimates the firm's investment projects by overestimating the mean of the technology shock by an amount, Δ_R. That is, if $\Delta_R = 0$ the CEO is rational (and hence not overconfident) and understands the true technology shock. This case represents the benchmark case. Different levels of overconfidence can be interpreted as a change in the mean of the random variable, $\bar{A}$. Following Campbell et al. (2011), we assume the technology shock is strongly unimodal for a given

level of overconfidence (i.e. its density function is log concave). Strong unimodal distributions include the normal, uniform, and exponential distributions.

The CEO is also subject to lawsuits regarding his decisions with probability *p* and the total loss for the lawsuit is given by $L \in \mathbb{R}_+$. This total cost can include legal fees, judgment, and/or settlement fees. Therefore, even if the lawsuit is filed, and ultimately the CEO is found not liable, legal fees (e.g., attorney fees) would still have been paid. In this sense, *p* is the probability of incurring any losses (fees), due to a lawsuit against the CEO. At time 1, the CEO decides how much D&O insurance to purchase, and at time 2 the loss is realized. For simplicity, assume insurers offer a co-insurance contract with co-insurance level $\alpha \in [0,1]$. Premiums are set equal to the expected indemnity with a proportional loading factor, $\lambda \geq 0$. That is, premiums are defined as $P(\alpha, \lambda, L) = \alpha(1 + \lambda)E[L]$ where *E[L] = pL*. Insurers properly assess the expected loss from lawsuits. An overconfident CEO underestimates the expected loss. This underestimation can occur in two ways. The overconfident CEO may assume the probability of being sued is lower overall. On the other hand the overconfident CEO might be aware that he will be sued, but because he is overconfident in his investment decisions, he believes any and all lawsuits will be found meritless. Therefore the loss value (severity) will be underestimated. An overconfident CEO will underestimate the expected loss by a proportion Δ_I. That is, the CEO assumes the expected loss to be $(1 - \Delta_I)E[L]$. The rational, not overconfident, CEO is represented by $\Delta_I = 0$.

We allow the degree of overconfidence to be different for both the investment return and the estimation of expected losses associated with D&O lawsuits. The two levels are interrelated. An overconfident CEO has a belief that his decision-making ability is superior; as such, he will assume higher returns on his investment decision. His overconfidence in his decision-making also causes him to believe the expected losses resulting from D&O lawsuits will be lower. The two aspects of overconfidence have an inverse relationship. That is, the more overconfident the CEO is that he or she makes good investments with higher returns, the more he or she will underestimate the expected loss

arising from lawsuits due to his/her decisions. That is, $\frac{\partial \Delta_I}{\partial \Delta_R} < 0$. We do not make any assumptions about the functional form of the relationship between these two degrees of overconfidence. We do not have a sense from previous literature on the properties of this relationship, and it is not the focus of the work here.

The maximization problem for the risk-averse CEO whose compensation scheme is proportional to the firm's ending period value can be given by:[4]

$$max_{I,\alpha}\, E[u(A + C + \bar{A}g(I) - I - P(\alpha, \lambda, L) - (1 - \Delta_I)(1 - \alpha)L)]$$
$$such\ that\ \ P(\alpha, \lambda, L) + I \leq C$$
$$P(\alpha, \lambda, L) \geq 0.$$

The CEO's utility function *u* is assumed to be strictly increasing and concave. Let (I^*, α^*) be the solution to the CEO's maximization problem given above when the CEO is not overconfident. When the CEO is overconfident, let (I_o^*, α_o^*) be the optimal solution to the maximization problem above. We solve the above maximization problem and compare its optimal solution to that to the first best solution, which would be chosen by a rational CEO. As stated in the next proposition we find that overconfident CEOs will overinvest and have a lower demand for D&O insurance.

PROPOSITION 1: *If the CEO is overconfident ($\Delta_R > 0$ and $\Delta_I > 0$), $I_o^* > I^*$ and $\alpha_o^* < \alpha^*$.*

Proof: See Appendix.

As expected, if the CEO is rational, he or she chooses the first best level of investment and D&O insurance. The overconfident CEO, however, will overinvest and underinsure. This combination only exacerbates the impact of overconfidence. An overconfident CEO will overinvest which can increase the potential for lawsuits if returns are lower than expected; as such an even greater amount of D&O insurance would be needed. Yet, an overconfident CEO will underinsure relative to a rational CEO.

[4] Following Campbell et al. (2011), we assume the CEO's compensation cannot be written contingent on risk aversion or overconfidence. The empirical work of Campbell et al. (2011) supports this assumption as they show that CEOs with relatively low or high optimism face greater rates of forced turnover, implying firms cannot or do not use compensation contracts that completely offset the effects of suboptimal overconfidence levels.

This result has important implications for shareholders, who are at risk for both the overinvestment and underinsurance. The impact of this overconfidence will depend on the sensitivity of the demand for D&O insurance to the degree of overconfidence, which we examine in the next proposition.

PROPOSITION 2*: If the CEO is overconfident ($\Delta_R > 0$ and $\Delta_I > 0$), the demand for D&O insurance is decreasing in the level of overconfidence. That is,* $\frac{\partial \alpha_o^*}{\partial \Delta_I} < 0$.

Proof: See Appendix.

As the CEO's level of overconfidence increases, the degree of underinsurance for D&O insurance will increase. That is, the more overconfident the CEO, the less D&O insurance will be demanded. From this model, we have two important empirically testable predictions which we will test in the next section.

PREDICTION 1: A firm with an overconfident CEO will have lower demand for D&O insurance relative to a firm with a CEO who is not overconfident.

PREDICTION 2: A firm with a more overconfident CEO will have a lower demand for D&O insurance relative to a firm with a CEO who is less overconfident.

In the following sections, we test these two predictions. Following the literature on overconfidence (Campbell et al, 2011), we construct an empirical measure for overconfidence using data on options held by the CEO. For each firm year we identify which firms have an overconfident CEO and which firms do not have an overconfident CEO using this measure. With this information we are able to analyze the relationship between overconfidence and the demand for D&O insurance (Prediction 1) and the sensitivity of this demand to the degree of overconfidence exhibited by the CEO (Prediction 2).

III. Data and Estimation Method

A. Data

We utilize several databases to obtain measures of CEO characteristics, corporate governance characteristics, litigation risk, D&O liability provisions, and firm characteristics. We use Execucomp to build our main data set. We then merge this data set with data from (1) Compustat, (2) CRSP, (3) RiskMetrics corporate governance database, and (4) Audit Analytics – Audit Fees. We start with 35,273 firm-year observations from Execucomp during 1992-2012. Since Execucomp only contains S&P 1500 firms, merging the data with Compustat reduces the number of observations to 18,879. Merging further with Audit Analytics –Audit Fees reduces the sample to 11,568. In addition, merging the data with RiskMetrics reduces the sample to 2,875 firm year observations from 2000-2006.

The unique characteristics of financial institutions and utilities, such as the presence of government regulation, may impact those firms' insurance and/or investment decisions. Therefore financial institutions (SIC 6000-6999) and utilities (SIC 4000-4999) are dropped from the sample. Fully merging the data sets and excluding financial institutions and utilities from the sample results in 1,050 firm-year observations from 2000-2006 in an unbalanced panel.[5]

A.1 Measuring CEO Overconfidence

CEO overconfidence cannot be directly observed, so measuring it to test empirically is somewhat challenging. Previous work has developed a series of measures based on actions taken (or not taken) by the CEO and/or how others view the CEO. Such measures include looking at the CEO's net stock purchases and stock option holding and exercising decisions (Malmendier and Tate, 2005b) or the CEO's portrayal in the media (Malmendier and Tate, 2008). Campbell et al. (2011) create a measure of overconfidence and/or optimism based on the CEO's stock option holding/exercising decisions, net stock purchases, and the firms' investment levels.

[5] Due to potential bias by small data values, we also ran all estimations with a merged dataset which excluded firms with end-of-the-year stock price less than $10, firms with less than $1 million in total assets, and CEOs with less than $100,000 in salary (cash plus bonus); the results were statistically the same.

In this paper, we measure CEO overconfidence (Δ) by considering the CEO's value of unexercised exercisable options. CEO compensation usually includes large values of company stock and options. At the same time, the CEO's human capital is invested in the company so that bad performance decreases his or her outside options as well. Rational CEOs should exercise their options early in order to properly diversify. Therefore, considering the value of the CEO's unexercised exercisable options is a way to capture CEO overconfidence (Malmendier and Tate, 2005b, 2008; Campbell et al., 2011; Malmendier et al., 2011; Hirshleifer et al., 2012). Following Campbell et al. (2011), for each year, we compute the percent of option moneyness (*moneyness%*) for each CEO, where option moneyness is defined as calculating the realizable value per option (Execucomp variable opt_unex_exer_est_val divided by opt_unex_exer_num) and dividing that number by the average exercise price. [6]

To test our first prediction, that firms with an overconfident CEO will have a lower demand for D&O insurance relative to firms without an overconfident CEO, we construct the variable *high_optimism_100* which is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money and 0 otherwise. This measure indicates the extent to which the CEO retains in-the-money options that are vested, which has been shown to be an indicator of CEO overconfidence (Malmendier and Tate, 2005b, 2008; Campbell et al., 2011). Our data (derived from Execucomp) does not have the CEO's exact portfolio holdings, which the dataset used by Malmendier and Tate (2008) has, but the measure we use is analogous to their measure. Malmendier and Tate (2008) define CEOs as overconfident if they hold stock options that are more than 67% in the money.[7] We follow Campbell et al. (2011) who argue that the 67% cutoff can be taken as given to indicate overconfident (optimistic) CEOs, and therefore the 100% cutoff would identify CEOs who are even more optimistic or overconfident.

[6] This measure is scaled the option moneyness variable by multiplying it by 100 in order to make it easier to interpret in various specifications.

[7] The cutoff of 67% was determined through calibration on a detailed dataset of executive stock option holding and exercise decisions. This method accounts for the fact that risk-averse executives will hold undiversified portfolios and should exercise options early if they are rational.

We also use the percent of option moneyness (*moneyness%*) as a continuous measure of CEO overconfidence to test our second prediction, that firms with more overconfident CEOs will demand less D&O insurance relative to firms with less overconfident CEOs. There is theoretical evidence from Goel and Thakor (2008) that "it may be empirically impractical to construct continuous measures of risk aversion and overconfidence". As Goel and Thakor (2008) explain, the relationship between CEO overconfidence and firm value is non-monotonic; therefore, even a binary overconfidence measure should reduce firm value. Applying this reasoning to our study suggests that the binary measure of overconfidence would give more reliable results than the continuous measure. As such, Campbell et al. (2011) do not use the continuous measure in their work, and instead use the continuous measure as a starting point to specify several cutoff values to create dummy variables for CEO overconfidence. The use of a continuous measure for CEO overconfidence is somewhat debated in the literature. We use the continuous measure here for completeness and to show our results hold even with using this measure of CEO overconfidence.

A.2 Measuring D&O Insurance

To consider the impact of CEO overconfidence on D&O insurance decisions, we derive a measure of D&O insurance. Currently, information on D&O insurance coverage is not publicly available in the United States. Firms incorporated in New York should report their D&O coverage limits and premiums paid, but sample size is severely limited through this method (~ 20 firms). Several consulting companies, such as Towers Perrin, have survey data on D&O insurance in the U.S., but such data are only available at the industry level. Since CEO information is firm specific, industry variables for D&O insurance are not applicable for this study. Previous work on D&O insurance has relied on these industry studies (Fier et al., 2012) or has used Canadian data (Boyer, 2008; Boyer and Stern, 2014; Lin et al., 2011; Lin et al., 2013).

We are aware of only two studies that use more detailed data from U.S firms. Kalchev (2004) uses proprietary data from two insurance brokerages on approximately 300 U.S. companies from 1997-2003 to examine the factors which influence the demand for D&O insurance. Chalmers et al. (2002) also uses proprietary data, which includes D&O premiums and coverage from 72 firms from 1992-1996, to investigate whether the amount of D&O coverage chosen at the time of an IPO can predict post-IPO stock performance. Our data cover over 500 firms from 2000-2006, and in this paper we consider how CEO overconfidence impacts the D&O insurance purchase decision, which in turn has been linked to firm performance in other work (Chalmers et al., 2002; Boyer and Stern, 2014).

To measure demand for D&O insurance, we use several proxies for D&O coverage that have been used in Bradley and Chen (2011) and Aguir et al. (2013). These measures include: (1) the existence of director liability limitation provisions in corporate charters or bylaws, (2) the indemnification of litigation expenses provided by corporate charters or bylaws for directors, and (3) the existence of indemnification contracts with individual directors. We use these measures to construct the L-dummy and the L-index, where the L-dummy is equal to 1 if the firm has any of the D&O provisions listed above, and the L-index is the sum of all the D&O provisions (variable ranges from 0 to 3). These liability protection provisions are available in RiskMetrics from 1990-2006.

The L-index does not identify the degree to which a firm maintains a high or low level of litigation risk, as the L-index solely indicates whether a firm employs certain liability protection instruments. We assess litigation risk in this study by using audit fee data. Audit pricing studies have shown that the amount of audit fees incurred by a firm is positively associated with that firm's level of litigation risk (Simunic, 1980). Given that audit fees function as a proxy for litigation risk, we incorporate audit fee data into our analysis to control for differences in litigation risk among firms (Chung et al., 2012).

A.3 Other Explanatory Variables

CEO Characteristics and Corporate Governance Variables

To control for CEO characteristics, we control for the CEO's age (variable name: ln(CEO_AGE)), compensation (variable name: ln(Total_Comp) which is equal to the natural logarithm of total compensation), tenure (variable name: ln(CEO_Tenure)), stock ownership excluding options (variable name: own%), and gender. A dummy variable for CEO gender is used that is equal to 1 if the CEO is a female (FEMALE). This variable is important since there are documented differences in risk taking behavior among men and women; for instance, men have been shown to take more risk and trade more often relative to women (i.e. Barber and Odean, 2001).

We also control for whether the CEO has a conflicting appointment through the variable INTERLOCK. This variable is a dummy variable equal to 1 if the CEO is involved in a relationship that requires disclosure in the "Compensation Committee Interlocks and Insider Participation" section of the proxy statement. Examples of such situations include, but are not limited to, the CEO serving on the board committee that makes his compensation decisions, or the CEO serving on the compensation committee of another company that has an executive officer serving on the board or compensation committee of the indicated CEO's company.

We use the Bebchuk, Cohen, and Ferrell (2009) entrenchment E-index as a way to control for corporate governance. While the Gompers, Ishii, and Metrick (2003) G-index is often used as a measure of corporate governance strength, with a higher G-index corresponding to weaker governance, we use the E-Index measure. The E-index does not include the D&O liability protection provisions (which the G-index does), so it will not bias the results. Additionally, the E-index is based on a subset of anti-takeover provisions used to construct the G-index and has a high correlation with the G-index, which implies robustness in obtaining similar results using either measure. Furthermore, Bebchuk et al. (2009)

argue that the six anti-takeover provisions that make up the E-index are the relevant provisions on which shareholders focus.

Firm Control Variables

These explanatory variables include measures for firm characteristics that also impact the demand for D&O insurance. We use the natural logarithm of firm assets to control for firm size. Leverage is the debt to assets ratio, ROA is the return on assets, and DEL_INC is a dummy variable which is equal to 1 if the firm is incorporated in Delaware (DEL_INC) and 0 if not. The Delaware dummy is an important variable since this state has different corporate governance laws that may affect the demand for D&O insurance. There is both theoretical and empirical evidence that audit fees reflect differences in liability regimes (e.g., Simunic and Stein, 1996; Seetharaman et al., 2002). Therefore we use the natural logarithm of audit fees (ln(Audit_Fees)) as a proxy for litigation risk.

Summary Statistics

The summary statistics for the variables discussed above are shown in Table 1. The mean of L-dummy is 0.487, which indicates that about half the firms in our sample have D&O indemnification provisions. The mean of the binary measure of CEO overconfidence (high_optimism_100) is 0.255, which indicates that about 25.5% of the CEOs in the sample are classified as overconfident. Meanwhile, the mean and median of the continuous measure of CEO overconfidence (moneyness%) are 92.459% and 38.111% respectively. Therefore, our sample is somewhat skewed toward CEOs who are not overconfident. The average CEO age (CEO_Age) is 55 years old, with an average CEO tenure (CEO_Tenure) of 10 years, which suggests that the sample consists of mostly older and more experienced CEOs. Similarly, looking at all top executives reported by Execucomp for each firm year, the average age of the top executives (Avg_Age) is 53 years old, with an average tenure (Avg_Tenure) of 9.5 years. The average CEO stock ownership excluding options (own%) is 4.186%, which means that

on average, CEOs do not own more than 5% of the company. The average stock ownership of the top executives (own_exec%) is 3.888%.

B. Estimation Method

To test how CEO overconfidence impacts the demand for D&O insurance, we estimate the following reduced form demand model:

$$\Phi^{-1}(\mathrm{L-dummy}_{it} = 1) = \beta\Delta_{it} + \delta CEO\ and\ Governance\ Control\ Vars. + \gamma Firm\ Control\ Vars. + \varepsilon_{it}$$

where the $\mathrm{L-dummy}_{it}$ is a measure of the total demand for D&O insurance as measured by the existence of D&O provisions in firm *i* at time *t*. CEO and Governance Control Vars. and Firm Control Vars. are control variables for CEO characteristics, corporate governance, and firm characteristics, respectively, and which we describe above.

To estimate the model with the L-index, we use Ordered-Probit regressions. Let y_{it}^* be the unobserved level of D&O coverage. Therefore we have:

$$y_{it}^* = \beta\Delta_{it} + \delta CEO\ and\ Governance\ Control\ Vars. + \gamma Firm\ Control\ Vars. + u_{it},$$

where there is a set of thresholds $\alpha_1 < \alpha_2 < \alpha_3$ that are additional unknown parameters of the model which satisfy

$$\begin{aligned} P(\mathrm{L-index}_{it} = 0) &= P(y_{it}^* \le \alpha_1) \\ P(\mathrm{L-index}_{it} = 1) &= P(\alpha_1 < y_{it}^* \le \alpha_2) \\ P(\mathrm{L-index}_{it} = 2) &= P(\alpha_2 < y_{it}^* \le \alpha_3) \\ P(\mathrm{L-index}_{it} = 3) &= P(y_{it}^* > \alpha_3). \end{aligned}$$

If CEOs are overconfident, we expect they will demand less D&O insurance. Therefore, controlling for other factors which impact the demand for D&O insurance, we expect to find that firms with overconfident CEOs will have less D&O insurance. That is, we expect to find that β is negative in both regressions.

We run both regressions shown above (that is, using the $\mathrm{L-dummy}_{it}$ or L-index as the dependent variable) for both our measures of CEO overconfidence. That is, we test the first prediction, that firms with overconfident CEOs will demand less D&O insurance, by using the high_optimism_100 dummy variable for CEO overconfidence and using separately either the $\mathrm{L-dummy}_{it}$ as a proxy for D&O insurance or the L-index as a proxy for D&O insurance. We then test the second prediction, that higher CEO overconfidence leads to lower demand for D&O insurance, by using the continuous measure for CEO overconfidence (*moneyness%*) and again using either the either the $\mathrm{L-dummy}_{it}$as a proxy for D&O insurance or the L-index as a proxy for D&O insurance.

IV. Results

A. CEO Overconfidence and D&O Insurance Demand

The effects of CEO overconfidence on the likelihood of a firm having D&O protection provisions are estimated in Table 2 using the binary measure of overconfidence (high_optimism_100). Specification (1) shows the Probit regression estimates for the L-dummy, while the results in specification (2) show the ordered Probit estimates for the L-index. The coefficient on the overconfidence proxy (high_optimism_100) is negative and significant in both specifications. The marginal effect for high_optimism_100 is -0.133 in specification (1). This finding suggests CEO overconfidence on average contributes to a 13.3% reduction in the probability of the firm having any D&O protection provisions. CEO age (ln(CEO_Age)) is also statistically significant and positive with a marginal effect of 0.336. This finding suggests that firms with older CEOs are more likely to have D&O provisions. The marginal effect of firm size (ln(Assets)) is statistically significant with a marginal effect of 0.086. This result means that larger firms are more likely to have D&O provisions.

In addition, the Delaware incorporation dummy (DEL_INC) is statistically significant and negative with a marginal effect of -0.148. This finding suggests that the probability of firms incorporated in Delaware having any D&O provisions is on average a 15% lower than for firms incorporated in other

states. This result shows that firms incorporated in Delaware are less likely to have D&O insurance, which is expected given Delaware's unique legal environment. The percent of share ownership by the CEO (own%) is statistically significant with a marginal effect of 0.006. This suggests that the demand for D&O insurance increases as CEO stock ownership increases.

The results of Ordered-Probit regressions for the L-index are estimated in specification (2) of Table 2. A higher value of the L-index indicates that a firm has more D&O provisions. The marginal effects are estimated for the probability that the L-index is 0, or the likelihood that the firm has no D&O provisions. The marginal effect of high_optimism_100 is 0.120, and it is statistically significant. This result suggests that CEO overconfidence on average contributes to a 12% increase in the probability of a firm not having any D&O provisions, which is consistent with results in specification (1). The coefficients of ln(CEO_Age), ln(Assets), and DEL_INC still have the same effects and are statistically significant as in specification (1). However, leverage is statistically significant and negative, while CEO stock ownership is not significant in this specification.

Overall, the results of Table 2 support the theoretical argument in Proposition 1, that overconfident CEOs are will underinsure relative to rational CEOs. Firms with CEOs who are overconfident are 13.3% less likely to have D&O provisions and 12% more likely to have no D&O provisions at all relative to firms with CEOs who are not overconfident. These results still hold even if we use the 67% option moneyness threshold, which is analogous to the *Holder67* measure from Malmendier and Tate (2005b).

We conduct the same analysis using the continuous measure of CEO overconfidence (moneyness%) in Table 3. The results of the Probit model for the L-dummy are presented in specification (1). The coefficient of moneyness% is negative and statistically significant, with a marginal effect of -0.0004. This finding shows that as the CEO's overconfidence increases due to a 1% increase in the option moneyness, the probability of the firm having D&O provisions decreases by 0.04%. The result implies

that D&O insurance demand is decreasing in the level of CEO overconfidence. Recall that the median value for option moneyness in our sample is 38.11%. The majority of the sample is not overconfident by this measure. Finding a statistically significant effect here, even if small, further confirms that CEO overconfidence impacts the D&O insurance decision. The coefficients of E-index, ln(CEO_Age), ln(Assets), DEL_INC, and own% are also statistically significant and have the same signs as in specification (1) of Table 2. Leverage is also statistically significant and positive, which suggests that firms with more debt financing are more likely to have D&O provisions.

The results of the ordered Probit model are presented in specification (2) of Table 3. The coefficient of moneyness% is positive and significant, with a marginal effect of 0.0004. This finding suggests that a 1% increase in the overconfidence of the CEO leads to a 0.04% increase in the probability of the firm not having any D&O provisions. This result is consistent with specification (1). The coefficients of ln(CEO_Age), ln(Assets), Leverage, and DEL_INC are also statistically significant and have the same signs as in specification (1) of Table 3. However, CEO stock ownership (own%) is not statistically significant in this specification.

Overall, the results of Table 3 support Proposition 2, which states that the demand for D&O insurance is decreasing in the level of CEO overconfidence. Using a continuous measure for CEO overconfidence, we find that the more overconfident the CEO is, the less likely the firm is to have D&O provisions. These results support the prediction that a firm with a more overconfident CEO will have a lower demand for D&O insurance relative to a firm with a CEO who is less overconfident (Prediction 2).[8]

We also accounted for industry fixed effects and our results did not change. Using poisson regressions and including industry dummies for SIC industry classifications, we estimate the impact of

[8] For both the dummy measure for CEO overconfidence and the continuous measure for overconfidence, we include the lag of own% as another explanatory variable. The CEO's ownership percentage in the previous year might influence the D&O decision today. Results are consistent. We also control for the interaction of CEO overconfidence with CEO ownership, as increased ownership could further impact overconfidence; results are consistent with what is reported here.

CEO overconfidence on the demand for D&O insurance using the L-index as the measure of D&O insurance. We consider both the dummy measure for overconfidence (high_optimism_100) and the continuous measure for overconfidence (moneyness%). Our results are consistent with what has been stated previously.

B. Corporate Governance and CEO Monitoring

Firms with stronger corporate governance should have better monitoring mechanisms compared to firms with weaker governance structures. Therefore, CEO overconfidence should not have a significant effect on the demand for D&O insurance in firms with strong governance structures.

We split the sample into firms with weak governance and firms with strong governance. We define firms with an E-index of less than or equal to 1 to be firms with strong governance.[9] Similarly, following Giroud and Mueller (2011) and Gu and Hackbarth (2013), we define firms with an E-index of greater than or equal to 4 to be those with weak governance.

The results of the models, which are split by the E-index thresholds of strong and weak governance, are presented in Table 4. Table 4 shows the results for the binary measure of overconfidence. The coefficient of high_optimism_100 in the specification with strong governance (E-index≤1) is not statistically significant. This result implies that effective corporate governance mechanisms can mitigate the effect of CEO overconfidence on the demand for D&O insurance. Conversely, the coefficient of high_optimism_100 in the specification with weak governance (E-index≥4) is negative and statistically significant, with a marginal effect of -0.255. This finding suggests that the probability of a firm having any D&O provisions is reduced by 25.5% if the firm has an overconfident CEO coupled with a weak corporate governance structure. This effect is almost double the magnitude of the effect in specification (1) of Table 2. The finding suggests that weak corporate governance exacerbates the effect of CEO overconfidence on the demand for D&O insurance. In addition, Leverage was statistically significant

[9] While Bebchuk et al. (2009) define "democracy" firms, or firms with strong governance as those with an E-index of 0, we use a higher threshold of 1 in order to have more statistical power.

with the same signs as in specification (2) of Table 2. Overall, the results in Table 4 show that effective corporate governance mechanisms can counteract the effect of CEO overconfidence on D&O insurance demand. Furthermore, the findings are consistent with the theoretical argument in Goel and Thakor (2008) where a board acting in the shareholders' best interests will fire a CEO who is perceived to be "overly overconfident".

C. Top Executive Overconfidence vs. CEO Overconfidence

Most D&O insurance contracts involve provisions for other top executives in addition to the CEO. It follows that the joint decision by the top executives may affect the demand for D&O insurance more so than the decision made by the CEO. In order to test the overall board or top executive demand for D&O insurance, we construct an aggregate measure of overconfidence for the top executives. While most companies report data for the top 5 executives, Execucomp collects data for up to 9 executives. Using this information, we construct the aggregate overconfidence measure for the top executives in the following way: (1) The high_optimism_100 measure is constructed for each executive, (2) The high_optimism_100 measures are aggregated among all executives for each firm-year, (3) The oc_top_exec_100 dummy is set equal to 1 if the majority of the top executives have high_optimism_100 equal to 1 (which in the aggregate is 5 since there are a maximum of 9 executives reported by Execucomp), and 0 otherwise. Looking at top executives serves as a proxy for controlling for board overconfidence given that many top executives are also board members.

The results of regressions with top executive overconfidence are given in Table 6. The coefficient of oc_top_exec_100 is not statistically significant in either specification (including CEO overconfidence or not). In contrast, the coefficient of high_optimism_100 is statistically significant with a marginal effect of -0.110. This finding implies that even when controlling for overconfidence for top executives at the firm, the effect of CEO overconfidence dominates. Firms with an overconfident CEO are 11% less likely to have D&O provisions. The coefficients of the average tenure of the top executives

(ln(Avg_Tenure)), the average age of top executives (ln(Avg_Age)), E-index, firm size (ln(Assets)), and ROA are statistically significant and positive with marginal effects of 0.064, 0.564, 0.033, 0.079, and 0.282 respectively. This result suggests that firms with older top executives members and top executives with more years of experience are more likely to purchase D&O insurance. Similarly, the demand for D&O insurance is positively affected by firms that have weak corporate governance, firms that are larger, firms that have more leverage, and firms that are more profitable.

D. Rational vs. Overconfident CEOs

We have shown that overconfident CEOs negatively affect the demand for D&O insurance. Therefore, in order for our results to be consistent we expect that rational CEOs would have a statistically different effect on the demand for D&O insurance. Following Campbell et al. (2011), we construct the dummy variable low_optimism_30 which is equal to 1 if CEOs hold options that are less than 30% in the money. This allows us to compare the coefficient of low_optimism_30 to high_optimism_100 across equations. In other words, we can compare the effect of rational CEOs to the effect of overconfident CEOs on the demand for D&O insurance.

We present the results of specifications with low_optimism_30 in Table 6. The coefficients of low_optimism_30 are positive and not significant in both specifications. This result suggests that rational CEOs do not affect the demand for D&O insurance. Furthermore, the low_optimism_30 coefficients are compared to high_optimism_100 coefficients in corresponding specifications from Table 2. Statistical tests of the difference between the coefficients yield χ^2 values of 5.83 and 6.53 respectively. This finding shows that there is a statistically significant difference between the effect of rational CEOs and the effect of overconfident CEOs on the demand for D&O insurance. These results provide additional support for Proposition 1.

E. Reverse Causality between D&O Insurance Demand and CEO Overconfidence

One can argue that CEOs become overconfident by having D&O insurance. This argument implies that CEO overconfidence changes over time and raises a potential reverse causality concern. In order to investigate if there is a reverse causality problem, we estimate Probit regressions for D&O provisions which have lagged CEO overconfidence as independent variables. If the lagged variables are significant it would show that overconfidence is driving D&O insurance demand as we expect. For robustness, regressions with one period, two period, and three period lags in CEO overconfidence are estimated.

The results of lagged CEO overconfidence regressions are given in Table 7. The marginal effects of high_optimism_100$_{t-1}$, high_optimism_100$_{t-2}$, and high_optimism_100$_{t-3}$ are -0.124, -0.131, and -0.082 respectively. This shows that past CEO overconfidence negatively affects current D&O insurance demand. In addition, the results show that there is persistence in overconfidence over time. Overall, these results rule out the possibility of reverse causality between CEO overconfidence and D&O insurance demand.

F. Endogeneity of CEO Overconfidence

CEOs are matched with companies based on CEO characteristics such as age, and company characteristics such as size. This process creates an endogenous matching problem which is present in any employer-employee matched data set (Graham et al., 2012). In addition, boards may take CEO overconfidence into account when selecting a CEO (Banerjee et al., 2013). It can also be argued that there is a selection bias regarding CEO selection, firm risk, and D&O insurance. That is, riskier firms may match with overconfident CEOs. At the same time, because the firms are risky, they might not be able to obtain D&O coverage or have enough funding to buy it. Therefore, the finding that firms with overconfident CEOs have less D&O coverage is a selection issue.

Following Vitanova (2014), we use propensity score matching to mitigate endogeneity concerns. Propensity score matching is a quasi-experimental technique which allows us to separate firms into two groups: (1) a control group with rational CEOs, and (2) a treatment group with overconfident CEOs.

The main feature of propensity score matching allows us to compare firms with rational CEOs to firms with overconfident CEOs based on firm-level and CEO-level characteristics. This method matches firms based on the probability of rational CEOs becoming overconfident given all observable firm and CEO covariates. In other words, we are able to replicate the impossible test of "treating" firms with overconfident CEOs and comparing the outcome of the firm (level of D&O coverage) to what it would be if the same firm did not have an overconfident CEO. We can then estimate the treatment effect of the control group and treatment group on the demand for D&O insurance (the treatment is high_optimism_100). The difference between the average treatment effect (ATT) of the treatment and control groups allows us to estimate the selection-free effect of CEO overconfidence on the demand for D&O insurance. Propensity score matching also relies on selection on observables (or ignorability of treatment). The assignment to the treatment (the CEO being overconfident) is random if we observe characteristics of treated and non-treated firms.

To use selection on observables, we use the condition on audit fees (ln(Audit_Fees)), committee interlocks (INTERLOCK), total compensation (ln(Total_Comp)), CEO tenure (ln(CEO_Tenure)), CEO age (ln(CEO_Age)), if the CEO is a female (FEMALE), corporate governance strength (E-index), firm size (ln(Assets)), leverage (Leverage), return on assets (ROA), if the firm was incorporated in Delaware (DEL_INC), as well as CEO stock ownership (own%) and distance-to-default (ln(Z)) variables. We use the Altman Z-Score as a measure of distance-to-default which captures a firm's financial distress.[10]

To ensure that the results are not sensitive to the choice of matching estimators, we use (1) Nearest Neighbor matching, (2) Radius matching, (3) Kernel matching. The results of various matching estimators are presented in Table 8. The ATT for the L-dummy is statistically significant and negative, ranging from -0.129 to -0.157 across the various specifications. The ATT for the L-index is also statistically significant and negative, ranging from -0.205 to -0.242 across the various specifications.

[10] We construct the variable ln(Z) which is the natural logarithm of Z-Score. As the original coefficients which were used to calculated Z-Score are from the 1960's, we use the Hillegeist et al. (2004) updated coefficients.

The average selection bias across all specifications ranges from 2.3% to 3.3%, which means that the results are reliable[11]. The results are also consistent with the Probit and ordered Probit regressions in Table 2. Overall, these findings suggest even when controlling for cross-sectional differences among firms and CEOs, CEO overconfidence still negatively affects the demand for D&O insurance. Additionally, the results provide further support for Proposition 1, that firms with an overconfident CEO will demand less D&O insurance.

G. CEO Overconfidence, D&O Insurance Demand and Firm Risk

CEO overconfidence has been shown to lead to increased risk-taking, thereby increasing firm risk. The D&O literature suggests that firms with D&O coverage will take more risk than without coverage because of the insurance – the moral hazard problem of D&O insurance. If CEO overconfidence causes the firm to have less D&O insurance, then the moral hazard problem may be reduced and the firm's risk taking might not be any higher. In this way, CEO overconfidence may not increase the riskiness of the firm.

We use the Heckman treatment effects model in order to estimate the effect of D&O insurance on firm risk while simultaneously correcting for selection bias due to the choice of D&O provisions. We use 12-month stock return volatility (σ_{it}) as a measure of the total risk of the firm. In the first stage the selection of D&O provisions is modeled with the Probit specification. The second stage models the effect of D&O insurance on total risk.

Let the L-dummy be denoted by DO_{it}. The model can be written as follows:

$$\sigma_{it} = \gamma Firm\ Control\ Vars. + \beta\Delta_{it} + \delta \mathrm{DO}_{it} + \varepsilon_{it},$$

$$DO_{it}^{*} = \beta\Delta_{it} + \delta CEO\ and\ Governance\ Control\ Vars. + \gamma Firm\ Control\ Vars. + u_{it},$$

where

$$\mathrm{DO}_{it} = \begin{cases} 1, \text{if } DO_{it}^{*} > 0, & \text{meaining the firm has D\&}O\ provisions \\ 0, & \text{otherwise} \end{cases},$$

[11] The rule of thumb is that a selection bias that is below 5% is reasonable.

and where ε_{it} and u_{it} have a bivariate normal distribution with zero mean and covariance matrix,

$$\Sigma = \begin{pmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{pmatrix}.$$

The parameters are estimated using the maximum likelihood estimator (MLE) based on Madalla (1983).

The results of the Heckman treatment effects model are given in Table 9. The first stage results are statistically the same as specification (1) in Table 2. The variables of interest in the second stage risk equation are statistically significant. The Wald χ^2 for the test of the null hypothesis that the correlation of the error terms, ρ, across equations is zero is 14.4, which is statistically significant at the 1% level. This means that we can reject the null hypothesis that the two error terms are uncorrelated, which suggests that the treatment effects model is appropriate.

In the second stage, the coefficient of high_optimism_100 is positive and not significant, which implies that CEO overconfidence has no effect on total risk. The coefficient of L-dummy is significant and positive, which suggests that firms with D&O provisions have a higher total risk. This is consistent with the literature which shows that firms with more D&O coverage will take more risk because of moral hazard. CEO overconfidence lowers D&O demand, as seen in the stage 1 model results, thereby reducing the moral hazard problem associated with D&O insurance, and causing the CEO to be less risky. This result can offset the impact of CEO overconfidence on firm risk which has already been documented.

V. Conclusion

In this paper, we examine how CEO overconfidence impacts the demand for D&O insurance. We develop a theoretical model and test the model's predictions to show that overconfident CEOs demand less D&O insurance and the more overconfident the CEO is, the less D&O insurance is demanded. This result holds controlling for CEO characteristics, firm characteristics, and corporate governance for the firm, and overall overconfidence for the top executives at the firm. We find that there is a statistically significant difference between overconfident CEOs and rational CEOs and that overconfidence is

persistent. Lagged overconfidence has a statistically significant negative impact on the demand for D&O insurance, and this finding helps address reverse causality concerns. Propensity score matching confirms that CEO overconfidence has a negative impact on the demand for D&O insurance, even when controlling for cross-sectional differences among firms and CEOs including financial distress.

If boards of directors act in the best interest of their shareholders, they should try to purchase more D&O insurance when the CEO is overconfident, knowing he or she might make riskier decisions, which could increase the chance of litigation for the firm. This dynamic shows the moral hazard problem in D&O insurance which has been supported somewhat in the literature as firms with higher litigation risk tend to purchase more D&O liability insurance (Gillan and Panasian, 2014). In this paper, we find overconfident CEOs demand less D&O insurance, which can potentially offset the moral hazard problem. In fact, using a Heckman treatments effects model, we find that this result holds. More D&O insurance does increase firm risk, but the impact of CEO overconfidence on firm risk is not statistically significant when controlling for that fact that overconfidence causes the firm to purchase less D&O insurance.

Our findings have several implications. If insurers can properly assess CEO overconfidence, then they can price D&O policies accordingly, with the caveat that they must control for adverse selection, since firms with higher litigation risk are more likely to demand D&O contracts. We have also shown that firms with weaker governance are more likely to purchase D&O insurance, which highlights the importance of considering CEO overconfidence in models that estimate D&O insurance demand. Models that do not incorporate CEO overconfidence may be mis-specified.

If firms have overconfident CEOs, which results in less D&O insurance purchased, there can be resulting implications for shareholders as well. Firms with overconfident CEOs will demand less D&O insurance, potentially decreasing the moral hazard problem that has been associated with D&O

insurance. This paper thereby offers important insight on how CEO overconfidence can impact corporate governance, firm risk, and shareholder value through the purchase of D&O insurance.

Appendix

Proof of Proposition 1:

The risk averse CEO's maximization problem is given by:

$$\max_{I,\alpha} E[u(A + C + \bar{A}g(I) - I - P(\alpha, \lambda, L) - (1 - \Delta_I)(1 - \alpha)L)]$$

$$such\ that\ \ \alpha(1 + \lambda)E[L] + I \leq C$$

$$I \geq 0\ and\ P(\alpha, \lambda, I) \geq 0.$$

The assumption on g(·) ensures I>0. For simplicity, we ignore the nonnegativity constraint* $P(\alpha, \lambda, I) \geq 0$, *and will show that the optimal solution to the unconstrained problem satisfies it. Let δ be the Lagrange multiplier on the constraint,* $\alpha(1 + \lambda)E[L] + I \leq C$. *The following conditions determine the optimal level of investment and insurance:*

$$E[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(\bar{A}g'(I^*) - 1)] - \delta = 0 \quad (A.1)$$

$$E[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + (1 - \Delta_I)L)] - \delta P'(\alpha^*, \lambda, L) = 0 \quad (A.2)$$

$$\delta[\ \alpha^*(1 + \lambda)E[L] + I^* - C] = 0 \quad and\ \delta \geq 0. \quad (A.3)$$

Suppose $\Delta_R = \Delta_I = 0$.

Looking at (A.1), if I=0 then (1) becomes:*

$$E[u'(A + C + \bar{A}g(0) - I - P(\alpha^*, \lambda, L) - (1 - \alpha^*)L)(\bar{A}g'(0) - 1)] - \delta.$$

Note that $(\bar{A}g'(0) - 1) > 0$ *since* $\lim_{I \to 0} g'(I) = +\infty$. *This makes the above equation infinitely positive even if* $\delta > 0$. *Therefore, I*>0.*

Looking at (A.2),it becomes

$$E[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + L)] - \delta P'(\alpha^*, \lambda, L).$$

Suppose $\delta > 0$. *This implies* $\delta = \frac{E[u'(A+C+\bar{A}g(I^*)-I-P(\alpha^*,\lambda,L)-(1-\alpha^*)L)(-P'(\alpha^*,\lambda,L)+L)]}{P'(\alpha^*,\lambda,L).}$. *The denominator is always positive. The above holds if the numerator is always positive. For this the loading times the expected loss priced by the insurer would have to be less than the loss incurred on average which will not hold. Therefore* $\delta = 0$.

Considering $\delta = 0$ *and allowing u'()=*$u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)$, *equation (A.2) can be rewritten as*

$$E[u'(\quad)(-P'(\alpha^*, \lambda, L) + L)]$$
$$= E[u'(\quad)(-(1 + \lambda)E[L] + L)]$$
$$= -(1 + \lambda)E[L]E[u'(\,)] + E[u'(\,)]E[L] + cov(u'(\,), L)$$
$$= -\lambda E[L]E[u'(\,)] + cov(u'(\,), L)$$

The covariance term is positive. As L increases, the premium will increase which will cause the term inside u'( ) to decrease. Since u''<0, then $cov(u'(\,), L) > 0$.

The entire equation above will satisfy (A.2) if it equals zero. Therefore, if $\lambda = \frac{cov(u'(),L)}{E[L]E[u'()]}$ *then the FOC holds. If* $\lambda < \frac{cov(u'(),L)}{E[L]E[u'()]}$ *then (A.2) is less than optimal amount of insurance is purchased. If* $\lambda > \frac{cov(u'(),L)}{E[L]E[u'()]}$ *then more insurance than optimal is purchased.*

Looking at (A.3), this equation holds if either $\delta = 0$ *or* $P(\alpha^*, \lambda, L)$*=C- I*. Since* $\delta = 0$ *then (A.3) will hold.*

Before comparing to an overconfident CEO, we check to see if there is a global maximum. Looking at the second order conditions – taking derivative of (A.1) and (A.2) wrt to their respective variables we have

$$E\left[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)\left(\bar{A}g''(I^*)\right) + (\bar{A}g'(I^*) - 1)^2 u''(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)\right] \text{ (A.4)}$$

$$E[u''(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + (1 - \Delta_I)L)^2] \text{ (A.5)}$$

Equation (A.4) is less than zero since u'>0, g''<0, and u''<0. Equation (A.5) is less than zero since u''<0. Therefore the objective function is concave in both I and α*. The FOC (A.1)-(A.3) are both necessary and sufficient.*

To look at how an overconfident CEO behaves, we evaluate the FOC for an overconfident CEO at the optimal solution for a rational (not overconfident) CEO. Suppose $\Delta_R = \Delta_I > 0$ *and so the CEO is overconfident. Let* I_o^* *and* α_o^* *be the optimal values for an overconfident CEO. Consider the following:*

$$\frac{\partial Eu}{\partial I_o}|_{I_o = I^*} = E[u'(A + C + \bar{A}_o g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(\bar{A}_o g'(I^*) - 1)]$$

Since u'>0, there is an unique $\bar{A}_o$, $\bar{A}^*{}_o$ *such that*

$$\bar{A}^*{}_o g'(I^*) - 1 > \bar{A}^* g'(I^*) - 1 > 0.$$

We assume that when the CEO is overconfident, his overconfidence is great enough that the support for $\bar{A}_o$ *does not overlap with the support for* $\bar{A}$*, and as such* $\bar{A}_o$ *dominates* $\bar{A}$ *in the sense of monotone likelihood ratio property. Further details to support this work on how the technology shock changes with overconfidence when the shock is unimodal can be found in Campbell et al. (2011).*

This implies

$$\frac{\partial Eu}{\partial I_o}|_{I_o = I^*} > E[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(\bar{A}g'(I^*) - 1)] = \frac{\partial Eu}{\partial I}|_{I = I^*} = 0$$

and so $\frac{\partial Eu}{\partial I_o}|_{I_o = I^*} > 0$*. Therefore* $I_o^* > I^*$*. An overconfident CEO invests more than a rational CEO.*

Considering the FOC wrt α *we have:*

$$\frac{\partial EU}{\partial \alpha_o}|_{\alpha_o = \alpha^*} = E[u'(A + C + \bar{A}_o g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + (1 - \Delta_I)L)]$$

Let $u'() = u'(A + C + \bar{A}_o g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)$ *then the above becomes:*

$$\frac{\partial EU}{\partial \alpha_o}|_{\alpha_o = \alpha^*} = E[u'(A + C + \bar{A}_o g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + (1 - \Delta_I)L)]$$

$$< E[u'(A + C + \bar{A}_o g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \Delta_I)(1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + L)]$$

$$< E[u'(A + C + \bar{A}g(I^*) - I - P(\alpha^*, \lambda, L) - (1 - \alpha^*)L)(-P'(\alpha^*, \lambda, L) + L)]$$

$$= \frac{\partial EU}{\partial \alpha}|_{\alpha = \alpha^*} = 0$$

The second inequality holds since u' is decreasing. Therefore $\frac{\partial EU}{\partial \alpha_o}|_{\alpha_o=\alpha^*} < 0$ *and* $\alpha_o < \alpha^*$. *The overconfident CEO buys less insurance than if he was rational.*

Proof of Proposition 2:

Taking the derivative of equation (A.2) from the original maximization problem in Proposition 1 (with an overconfident CEO) wrt Δ_I *we find the following:*

$$\frac{\partial \alpha_o^*}{\partial \Delta_I} = E[u'(A + C + \bar{A}_o g(I^*{}_o) - I_o^* - P(\alpha_o^*, \lambda, L) - (1-\Delta_I)(1-\alpha_o^*)L)(-L)]$$
$$+ E[(-P'(\alpha^*, \lambda, L) + (1-\Delta_I)L)u''(A + C + \bar{A}_o g(I^*{}_o) - I_o^* - P(\alpha_o^*, \lambda, L)$$
$$- (1-\Delta_I)(1-\alpha_o^*)L)(1-\alpha_o^*)L]$$

Let u'=$u'(A + C + \bar{A}_o g(I^*{}_o) - I_o^* - P(\alpha_o^*, \lambda, L) - (1-\Delta_I)(1-\alpha_o^*)L)$
and u'' =$u''(A + C + \bar{A}_o g(I^*{}_o) - I_o^* - P(\alpha_o^*, \lambda, L) - (1-\Delta_I)(1-\alpha_o^*)L)$.
The equation can be reduced to

$$\frac{\partial \alpha_o^*}{\partial \Delta_I} = -E[u'L] + E[u''(1-\alpha_o^*)L(-(1+\lambda)E[L] - (1-\Delta_I)L)]$$
$$= -E[u'L] - (1+\lambda)(1-\alpha_o^*)E[L]E[u''L] - (1-\Delta_I)(1-\alpha_o^*)E[u''L^2]$$

Re-arranging we find his term is less than zero iff

$$\Delta_I > \frac{E[u''L^2] - \frac{1}{(1-\alpha_o^*)}E[u'L] - (1+\lambda)E[L]E[u''L]}{E[u''L^2]}$$

The denominator is less than zero since u''<0. The numerator is positive if

$$-(1+\lambda)E[L]E[u''L] > E[u''L^2] - \frac{1}{(1-\alpha_o^*)}E[u'L]$$

Or

$$-(1+\lambda) < \frac{E[u''L^2]}{E[L]E[u''L]} - \frac{E[u'L]}{(1-\alpha_o^*)E[L]E[u''L]}$$

The left hand side of the above equation is always negative. On the right hand side, th first term is positive and the second term is negative making the entire right hand side positive. Therefore this statement always holds. Therefore the numerator in the following

$$\Delta_I > \frac{E[u''L^2] - \frac{1}{(1-\alpha_o^*)}E[u'L] - (1+\lambda)E[L]E[u''L]}{E[u''L^2]}$$

is always positive. As such the right hand side of the above equation is negative. By assumption $\Delta_I > 0$ *and therefore this condition holds. Therefore,* $\frac{\partial \alpha_o^*}{\partial \Delta_I} < 0$. *As the level of overconfidence increases, the optimal demand for insurance will decrease.*

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Table 1: Summary Statistics		
Variable	Mean	Median
L-dummy	0.487	0.000
L-index	0.810	0.000
high_optimism_100	0.255	0.000
oc_top_exec_100	0.062	0.000
moneyness%	92.459	38.111
ln(Audit_Fees)	14.116	14.084
INTERLOCK	0.046	0.000
Total_Comp ('000)	4517.112	2392.449
Avg_Comp ('000)	2158.185	1304.239
CEO_Age	55.390	55
Avg_Age	53.351	53
CEO_Tenure	10.616	9
Avg_Tenure	13.826	9.500
FEMALE	0.021	0.000
E-index	2.186	2.000
ln(Assets)	7.115	6.990
Leverage	0.532	0.513
ROA	0.029	0.052
DEL_INC	0.603	1
own%	4.186	1.000
own_exec%	3.888	0.500

L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. The L-index is the sum of all the D&O provisions (it ranges from 0 to 3). high_optimism_100 is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al. (2011). moneyness% is the continuous measure of CEO overconfidence based on the percentage of in the money unexercised exercisable options from Campbell et al. (2011). oc_top_exec_100 is a proxy for overconfidence among all the top executives, it is a dummy variable equal to 1 if high_optimism equals 1 for at least 5 of the top executives as reported in Execucomp, and 0 otherwise. ln(Audit_Fees) is the natural logarithm of audit fees, which is a proxy for litigation risk. INTERLOCK is a dummy variable equal to 1 if the CEO is involved in a relationship that requires disclosure in the "Compensation Committee Interlocks and Insider Participation" section of the proxy statement, and 0 otherwise. Total_Comp is the total incentive compensation (given by TDC1 in Execucomp). CEO_AGE is the age of the CEO. Avg_Age is the average age of the top executives. CEO_Tenure is the number of years the CEO worked at the company. Avg_Tenure is the average tenure of the top executives. FEMALE is a dummy variable equal to 1 if the CEO is a female, and 0 otherwise. E-Index is the entrenchment index from Bebchuk et al. (2009). ln(Assets) is the natural logarithm of firm assets. Leverage is the debt to assets ratio. ROA is the return on assets. DEL_INC is a dummy variable equal to 1 if the firm was incorporated in Delaware and 0 otherwise. own% is the percentage of company shares owned by the CEO excluding options.

Table 2: CEO Overconfidence and D&O Provisions (Dummy Measure)				
	Probit		Ordered Probit	
	L-dummy		L-index	
	(1)		(2)	
	Coefficient	dy/dx	Coefficient	dy/dx
high_optimism_100	-0.410***	-0.133***	-0.363***	0.120***
	(0.006)	(0.006)	(0.006)	(0.006)
ln(Audit_Fees)	-0.0325	-0.011	-0.0200	0.007
	(0.562)	(0.562)	(0.674)	(0.675)
INTERLOCK	0.147	0.048	0.250	-0.083
	(0.691)	(0.691)	(0.444)	(0.443)
ln(Total_Comp)	-0.00430	-0.001	-0.0327	0.011
	(0.869)	(0.869)	(0.276)	(0.284)
ln(CEO_Tenure)	-0.0663	-0.021	-0.0528	0.017
	(0.520)	(0.520)	(0.574)	(0.574)
ln(CEO_Age)	1.037***	0.336***	0.863*	-0.285*
	(0.009)	(0.008)	(0.063)	(0.058)
FEMALE	-0.0136	-0.004	0.161	-0.053
	(0.965)	(0.965)	(0.579)	(0.574)
E-index	0.0580	0.019	0.0558	-0.018
	(0.205)	(0.195)	(0.158)	(0.150)
ln(Assets)	0.265***	0.086***	0.260***	-0.086***
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.340	0.110	0.371*	-0.122*
	(0.113)	(0.115)	(0.098)	(0.096)
ROA	0.741	0.240	0.656	-0.217
	(0.162)	(0.156)	(0.176)	(0.171)
DEL_INC	-0.458***	-0.148***	-0.335***	0.111***
	(0.000)	(0.000)	(0.002)	(0.001)
own%	0.0183*	0.006*	0.00718	-0.002
	(0.082)	(0.079)	(0.312)	(0.308)
Thresholds				
α_1			5.206***	
			(0.007)	
α_2			5.707***	
			(0.003)	
α_3			6.785***	
			(0.000)	
N	1050		1050	
pseudo R-sq	0.095		0.058	

The dependent variable is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. high_optimism_100 is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al.(2011). E-Index is the entrenchment index from Bebchuk et al. (2009). *p*-values based on robust standard errors are reported in parentheses. The standard errors are clustered by 2-digit SIC industry codes. dy/dx denote average marginal effects with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 3: CEO Overconfidence and D&O Provisions (Continuous Measure)				
	Probit		Ordered Probit	
	L-dummy		L-index	
	(1)		(2)	
	Coefficient	dy/dx	Coefficient	dy/dx
moneyness%	-0.00126***	-0.0004***	-0.00113***	0.0004***
	(0.006)	(0.003)	(0.010)	(0.009)
ln(Audit_Fees)	-0.0343	-0.011	-0.0216	0.007
	(0.543)	(0.543)	(0.651)	(0.652)
INTERLOCK	0.140	0.045	0.230	-0.076
	(0.691)	(0.691)	(0.458)	(0.457)
ln(Total_Comp)	-0.00117	-0.000	-0.0302	0.010
	(0.966)	(0.966)	(0.321)	(0.327)
ln(CEO_Tenure)	-0.0677	-0.022	-0.0531	0.018
	(0.509)	(0.510)	(0.573)	(0.573)
ln(CEO_Age)	1.046***	0.340***	0.875*	-0.290*
	(0.009)	(0.007)	(0.060)	(0.054)
FEMALE	0.0139	0.005	0.183	-0.060
	(0.964)	(0.964)	(0.528)	(0.521)
E-index	0.0648	0.021	0.0634	-0.021*
	(0.151)	(0.141)	(0.106)	(0.098)
ln(Assets)	0.264***	0.086***	0.259***	-0.086***
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.360*	0.117*	0.385*	-0.127*
	(0.097)	(0.098)	(0.088)	(0.085)
ROA	0.729	0.237	0.648	-0.214
	(0.165)	(0.159)	(0.174)	(0.169)
DEL_INC	-0.468***	-0.152***	-0.344***	0.114***
	(0.000)	(0.000)	(0.002)	(0.001)
own%	0.0179*	0.006*	0.00685	-0.002
	(0.085)	(0.082)	(0.330)	(0.326)
Thresholds				
α_1			5.263***	
			(0.006)	
α_2			5.762***	
			(0.003)	
α_3			6.839***	
			(0.000)	
N	1050		1050	
pseudo R-sq	0.092		0.056	

The dependent variable is the L-index which is the sum of all the D&O provisions (it ranges from 0 to 3). moneyness% is the continuous measure of CEO overconfidence based on the percentage of in the money unexercised exercisable options from Campbell et al. (2011). dy/dx denote average marginal effects for P(L-index=0) with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 4: CEO Overconfidence and D&O Provisions by Corporate Governance Strength (Dummy Measure)

	L-dummy			
	E-index<=1		E-index>=4	
	Coefficient	dy/dx	Coefficient	dy/dx
high_optimism_100	0.0635	0.021	-0.737**	-0.255**
	(0.808)	(0.808)	(0.019)	(0.016)
ln(Audit_Fees)	-0.0174	-0.006	-0.137	-0.047
	(0.890)	(0.890)	(0.379)	(0.373)
INTERLOCK	-0.361	-0.117	-0.165	-0.057
	(0.481)	(0.480)	(0.847)	(0.846)
ln(Total_Comp)	-0.0352	-0.011	0.107	0.037
	(0.389)	(0.393)	(0.584)	(0.583)
ln(CEO_Tenure)	-0.0814	-0.026	-0.134	-0.046
	(0.733)	(0.732)	(0.636)	(0.633)
ln(CEO_Age)	0.968	0.315	1.869	0.646
	(0.256)	(0.244)	(0.199)	(0.188)
ln(Assets)	0.192	0.063*	0.167	0.058
	(0.106)	(0.097)	(0.366)	(0.360)
Leverage	0.543	0.177	1.163*	0.402*
	(0.153)	(0.170)	(0.095)	(0.092)
ROA	1.042	0.339	1.587	0.549
	(0.219)	(0.230)	(0.339)	(0.329)
DEL_INC	-0.103	-0.034	-0.411	-0.142
	(0.550)	(0.549)	(0.158)	(0.147)
own%	0.0174	0.006	0.111	0.038
	(0.372)	(0.375)	(0.110)	(0.102)
N	230		155	
pseudo R-sq	0.066		0.104	

The dependent variable in the Probit model is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. The dependent variable in the Ordered-Probit model is the L-index which is the sum of all the D&O provisions (it ranges from 0 to 3). high_optimism_100 is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al. (2011). E-Index is the entrenchment index from Bebchuk et al. (2009). *p*-values based on robust standard errors are reported in parentheses. The standard errors are clustered by 2-digit SIC industry codes. dy/dx denote average marginal effects with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 5: Top Executive Overconfidence and D&O Provisions

	L-dummy			
	(1)		(2)	
	Coefficient	dy/dx	Coefficient	dy/dx
high_optimism_100	-0.346**	-0.110**		
	(0.025)	(0.029)		
oc_top_exec_100	0.0207	0.007	-0.228	-0.073
	(0.914)	(0.914)	(0.217)	(0.221)
ln(Audit_Fees)	0.0610	0.019	0.0561	0.018
	(0.303)	(0.304)	(0.334)	(0.334)
ln(Avg_Comp)	-0.0948	-0.030	-0.0747	-0.024
	(0.236)	(0.234)	(0.267)	(0.266)
ln(Avg_Tenure)	0.201***	0.064***	0.173***	0.056***
	(0.001)	(0.001)	(0.005)	(0.004)
ln(Avg_Age)	1.776***	0.564***	1.985***	0.638***
	(0.000)	(0.000)	(0.000)	(0.000)
E-index	0.102***	0.033***	0.100***	0.032***
	(0.006)	(0.007)	(0.003)	(0.003)
ln(Assets)	0.248***	0.079***	0.227***	0.073***
	(0.001)	(0.001)	(0.001)	(0.000)
Leverage	0.363	0.115	0.462**	0.149**
	(0.140)	(0.146)	(0.033)	(0.038)
ROA	0.888**	0.282**	0.664**	0.213**
	(0.032)	(0.035)	(0.043)	(0.045)
DEL_INC	-0.355***	-0.113***	-0.374***	-0.120***
	(0.007)	(0.006)	(0.005)	(0.004)
own_exec%	0.00650	0.002	0.00841	0.003
	(0.457)	(0.457)	(0.211)	(0.209)
N	1489		1656	
pseudo R-sq	0.158		0.144	

The dependent variable is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. high_optimism_100 is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al. (2011). E-Index is the entrenchment index from Bebchuk et al. (2009). oc_top_exec_100 is a proxy for overconfidence among all the top executives, it is a dummy variable equal to 1 if high_optimism equals 1 for at least 5 of the top executives as reported in Execucomp, and 0 otherwise. ln(Avg_Comp) is the logarithm of the average total compensation of all the top executives reported in Execucomp for each firm-year. ln(Avg_Age) is the average age of all the top executives reported in Execucomp for each firm-year. *p*-values based on robust standard errors are reported in parentheses. ln(Avg_Tenure) is the natural logarithm of the average tenure of all the top executives. The standard errors are clustered by 2-digit SIC industry codes. dy/dx denote average marginal effects with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 6: Rational vs. Overconfident CEOs (Dummy Measure)

	Probit		Ordered Probit	
	L-dummy		L-index	
	(1)		(2)	
	Coefficient	dy/dx	Coefficient	dy/dx
low_optimism_30	0.0996	0.033	0.144	-0.048
	(0.281)	(0.279)	(0.142)	(0.141)
ln(Audit_Fees)	-0.0233	-0.008	-0.00995	0.003
	(0.691)	(0.691)	(0.841)	(0.841)
INTERLOCK	0.114	0.038	0.223	-0.074
	(0.745)	(0.744)	(0.478)	(0.476)
ln(Total_Comp)	-0.00698	-0.002	-0.0330	0.011
	(0.792)	(0.792)	(0.265)	(0.270)
ln(CEO_Tenure)	-0.0768	-0.025	-0.0578	0.019
	(0.458)	(0.459)	(0.538)	(0.538)
ln(CEO_Age)	1.012**	0.332**	0.837*	-0.279*
	(0.012)	(0.011)	(0.074)	(0.068)
FEMALE	0.0425	0.014	0.202	-0.067
	(0.888)	(0.888)	(0.477)	(0.469)
E-index	0.0714	0.023	0.0684*	-0.023*
	(0.118)	(0.108)	(0.082)	(0.075)
ln(Assets)	0.254***	0.083***	0.252***	-0.084***
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.367*	0.120*	0.376*	-0.125*
	(0.096)	(0.097)	(0.097)	(0.094)
ROA	0.555	0.182	0.560	-0.187
	(0.257)	(0.251)	(0.225)	(0.219)
DEL_INC	-0.470***	-0.154***	-0.345***	0.115***
	(0.000)	(0.000)	(0.002)	(0.001)
own%	0.0167	0.005	0.00587	-0.002
	(0.114)	(0.112)	(0.414)	(0.412)
Thresholds				
α_1			5.340***	
			(0.007)	
α2			5.837***	
			(0.003)	
α3			6.911***	
			(0.000)	
$H_0: \beta_{11}(\text{low\_optimism\_30}) - \beta_{21}(\text{high\_optimism\_100}) = 0$				
χ^2-test	5.83**		6.53**	
N	1050		1050	
pseudo R-sq	0.084		0.051	

The dependent variable is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. low_optimism_30 is the proxy for rational CEOs, it is a dummy variable equal to 1 if CEOs hold options that are less than 30% in the money from Campbell et al. (2011). E-Index is the entrenchment index from Bebchuk et al. (2009). The coefficients of low_optimism_30 (β_{11}) and high_optimism_100 (β_{12}) are compared across equations (see Table 2 for corresponding high_optimism_100 coefficients in specifications (1) and (2)). *p*-values based on robust standard errors are reported in parentheses. The standard errors are clustered by 2-digit SIC industry codes. dy/dx denote average marginal effects with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 7: Lagged CEO Overconfidence and D&O Provisions (Dummy Measure)

	L-dummy					
	(1)		(2)		(3)	
	Coefficient	dy/dx	Coefficient	dy/dx	Coefficient	dy/dx
high_optimism_100$_{t-1}$	-0.380***	-0.124***				
	(0.001)	(0.001)				
high_optimism_100$_{t-2}$			-0.395***	-0.131***		
			(0.003)	(0.002)		
high_optimism_100$_{t-3}$					-0.242**	-0.082**
					(0.016)	(0.017)
ln(Audit_Fees)	-0.0529	-0.017	-0.0549	-0.018	-0.0861	-0.029
	(0.321)	(0.325)	(0.349)	(0.351)	(0.151)	(0.156)
INTERLOCK	-0.0112	-0.004	0.0135	0.004	-0.0308	-0.010
	(0.975)	(0.975)	(0.969)	(0.969)	(0.928)	(0.928)
ln(Total_Comp)	-0.00856	-0.003	-0.00301	-0.001	-0.0186	-0.006
	(0.719)	(0.719)	(0.906)	(0.906)	(0.457)	(0.456)
ln(CEO_Tenure)	-0.0932	-0.030	-0.0909	-0.030	-0.0944	-0.032
	(0.367)	(0.367)	(0.384)	(0.383)	(0.359)	(0.357)
ln(CEO_Age)	0.981***	0.320***	1.014**	0.335**	1.081**	0.365**
	(0.008)	(0.007)	(0.014)	(0.012)	(0.012)	(0.010)
FEMALE	0.235	0.077	0.233	0.077	0.386	0.130
	(0.462)	(0.456)	(0.460)	(0.453)	(0.229)	(0.218)
E-index	0.0624	0.020	0.0561	0.019	0.0527	0.018
	(0.176)	(0.169)	(0.269)	(0.260)	(0.302)	(0.296)
ln(Assets)	0.274***	0.089***	0.280***	0.092***	0.300***	0.101***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.270	0.088	0.356	0.117	0.351*	0.118*
	(0.209)	(0.212)	(0.103)	(0.102)	(0.058)	(0.059)
ROA	0.695	0.227	0.579	0.191	0.535	0.180
	(0.164)	(0.156)	(0.308)	(0.301)	(0.347)	(0.340)
DEL_INC	-0.472***	-0.154***	-0.440***	-0.146***	-0.453***	-0.153***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
own%	0.0173*	0.006*	0.0176	0.006	0.0158	0.005
	(0.095)	(0.093)	(0.129)	(0.125)	(0.153)	(0.149)
N	1033		1003		948	
pseudo R-sq	0.091		0.095		0.089	

The dependent variable is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. high_optimism_100$_{t-1,}$ high_optimism_100$_{t-2,}$ and high_optimism_100$_{t-3}$ are one period, two period, and three period lag proxies for CEO overconfidence, they are dummy variables equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al. (2011). E-Index is the entrenchment index from Bebchuk et al. (2009). *p*-values based on robust standard errors are reported in parentheses. The standard errors are clustered by 2-digit SIC industry codes. dy/dx denote average marginal effects with *p*-values based on Delta-method standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 8: Propensity Score Matching

		ATT NN, N=2		ATT Radius, r=.05		ATT Kernel		
Treatment	Outcome	*Diff.*	mean bias	*Diff.*	mean bias	*Diff*.	mean bias	N
high_optimism_100	L-dummy	-0.157***	3.3%	-0.136***	2.3%	-0.130***	2.4%	986
high_optimism_100	L-index	-0.243***	3.3%	-0.207***	2.3%	-0.205***	2.4%	

The treatment is high_optimism_100, is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al. (2011). The outcome variables are: (1) L-dummy, which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise, and (2) L-index is the sum of all the D&O provisions (it ranges from 0 to 3). The main variable of interest is the average treatment effect on the treated (ATT) for *Diff.*, which is the difference between the treatment (firms with overconfident CEOs) and control groups (firms with rational CEOs). ATT NN, N = 2, denotes the average treatment effect on the treated via nearest neighbor matching with 2 neighbors. ATT Radius, denotes the average treatment effect on the treated via radius matching with a caliper of .05. ATT Kernel denotes the average treatment effect on the treated via kernel matching with the Epanechnikov kernel. Bias is the estimated average selection bias. Standard errors are calculated assuming independent observations, fixed weights, homoscedasticity of the outcome variable within the treated and within the control groups and that the variance of the outcome does not depend on the propensity score. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

Table 9: D&O Insurance and Total Risk - Heckman Treatment Effects Model			
1st stage Probit determinants of D&O Insurance		2nd stage Total Risk Equation	
L-dummy		σ	
(1)		(2)	
high_optimism_100	-0.425**	ln(Assets)	-0.0247***
	(0.024)		(0.001)
ln(Audit_Fees)	-0.188**	Leverage	0.0206
	(0.021)		(0.304)
INTERLOCK	0.342	ln(mb)	-0.0234**
	(0.359)		(0.043)
ln(Total_Comp)	0.114	high_optimism_100	0.0142
	(0.371)		(0.353)
ln(CEO_Tenure)	0.0247	L-dummy	0.137***
	(0.806)		(0.000)
ln(CEO_Age)	2.454***		
	(0.001)		
FEMALE	0.0559		
	(0.883)		
E-index	0.0650		
	(0.158)	N	420
ln(Assets)	0.261*	Wald χ^2 –test, H_0: ρ=0	14.4***
	(0.064)		
Leverage	0.261		
	(0.159)		
ROA	0.565		
	(0.254)		
DEL_INC	-0.0667		
	(0.620)		
own%	-0.0328***		
	(0.006)		
ln(Z)	0.103		
	(0.649)		

The dependent variable in the 1st stage is the L-dummy which is equal to 1 if the firm has any director liability indemnification provisions, and 0 otherwise. high_optimism_100 is the proxy for CEO overconfidence, it is a dummy variable equal to 1 if CEOs hold options that are more than 100% in the money from Campbell et al.(2011). The dependent variable in the 2nd stage is σ, which is 12-month return volatlity. ln(mb) is the natural logarithm of the market-to-book ratio. E-Index is the entrenchment index from Bebchuk et al. (2009). ln(Z) is the natural logarithm of the Altman Z measure of distance-to-default with Hillegeist et al. (2004) updated coefficients. *p*-values based on robust standard errors are reported in parentheses. The standard errors are clustered by 2-digit SIC industry codes. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.