Shadow Risks and Disasters*

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Abstract

We explore the relationship between incentives and Shadow Risks—those risks that are not easily measured by common financial measures and yet can lead to major adverse events. Theoretically, increased risk-taking is non-monotonic in higher powered executive compensation. However, for those settings where risky failures are high-stakes—e.g., environmental disasters and accounting scandals—the relationship is positive. We test these predictions for environmental and financial accounting failures of large US firms and find that changing CEO equity compensation from 100% stocks to 100% options can increases the odds of law breaking by 40-60% and the magnitude of events by over 100%. The effectiveness of policies such as Sarbanes-Oxley and FAS123R in reducing Shadow Risk-taking are discussed.

Keywords: pay for performance, corporate governance, risk-taking, environmental law, accounting law, misconduct

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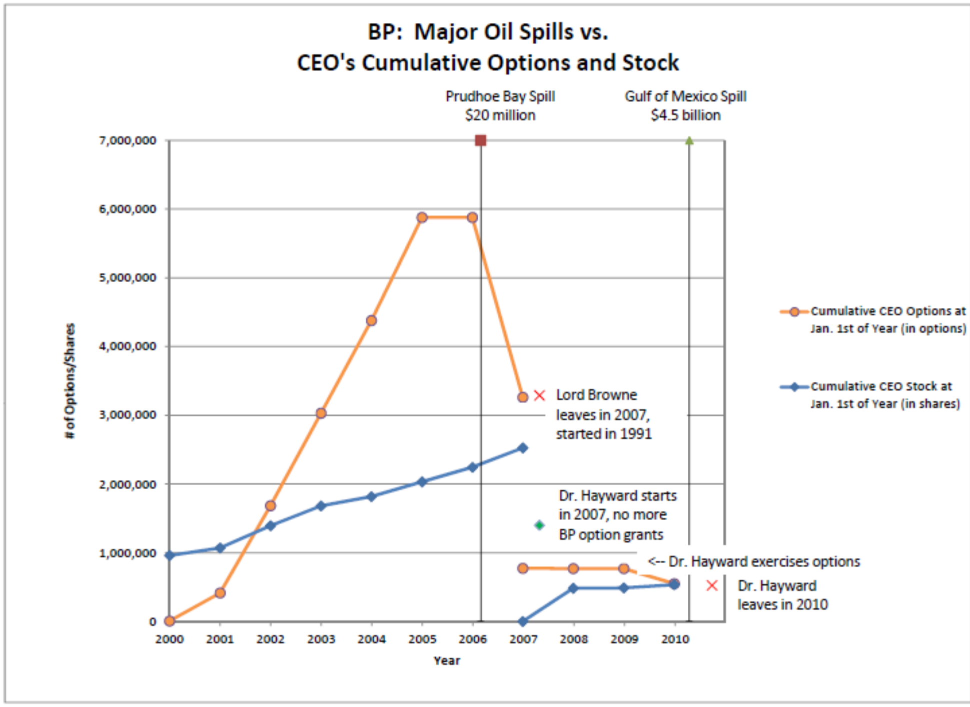
"An accident waiting to happen..."
Nancy Leveson, panel member investigating the BP Gulf Spill

Executive compensation has come under intense criticism in recent years. Some argue that typical levels of executive pay relative to their firm's other workers is excessive. However, more recently, criticism has suggested that pay has not only been gratuitous, but that it has also contributed to disasters such as the recent financial crisis and the BP Gulf of Mexico oil spill.

A dramatic example of such a potential relationship between executive compensation and such risks is provide by British Petroleum (BP). Figure 1 reports the cumulative award of options and stocks for BP CEOs Lord Browne and Tony Hayward, both of whom's career ended with a spectacular oil spill. In the case of the former, shares of stocks, and especially shares of options, reached a pinnacle just before the dramatic Prudhoe Bay oil spill. Following this disaster, Tony Hayward took over as CEO and began with a large number of options and stock. He would very soon oversee the massive Gulf of Mexico spill, though he did sell a sizable portion of his options just before the spill. Similar examples can be found for the recent financial crisis where high powered equity compensation was associated with financial disasters that ensued. An important question is if these kinds of examples are merely suggestive or if there is indeed something deeper at work.



In this paper, we explore the creation of Shadow Risks. That is, those risks that are difficult to capture via traditional financial measures and yet can result in a disaster or scandal. It is not obvious *a priori* how equity compensation might affect such Shadow Risk-taking. There has been much work exploring the relationship of equity compensation—both option and stock awards—and managerial risk-taking. Both the empirical and theoretical literature provide contradictory evidence on the relationships. Early theoretical work suggests that increased equity compensation in the form of options will increase managerial risk-taking. These arguments appear as early as Jensen and Meckling (1976) and Myers (1977). However, more recently some have argued that increased options can *reduce* risk-taking. For example, Lambert et al. (1991) argue that the leveraged feature of options can reduce managers' appetite for risk. Kadan and Swinkels (2008) show that when including managerial effort, risk-taking might be reduced as options are increased. In terms of empirical findings, most recently, Gormley et al. (2012) use a natural experiment to find that reduced exposure to options yields reduced risk-taking on several financial dimensions. Guay (1999) show that firms' stock return volatility is linked to increased options. Frydman and Jenter (2010) provide a survey of many more such papers that generally find increased options result in increased financial risk-taking. However, for risk-taking on the dimension of non-financial risk-taking—e.g., earnings manipulation—the empirical literature is divided on whether it is stocks or options (or neither) that increases such risk-taking (see Frydman and Jenter (2010) and cites therein).

The extant work on incentives and risk-taking often considers risk-taking on dimensions such as cash holdings, firm leverage, or diversifying acquisitions. However, how a manager is induced to increase Shadow Risk has two complications compared with these former types of risk-taking. First, it is likely more difficult to contract with a manager on her level of environmental risk-taking, for example, compared with other financial-based measures of risk. Second, when a Shadow Risk results in failure—some disaster or scandal ensues—it can be very costly to the CEO. In the extreme, such a CEO may have her labor market opportunity severely damaged, as well as face incarceration and large regulatory penalties. Thus, the manager potentially faces a large stick in the event of failure from sources outside the scope of the firm.

We formally consider how a CEO engages in Shadow Risks as a function of executive compensation. In particular, A CEO can choose a risky project that provides a greater upside compared with a safer project; however, the risky project also carries a worse downside, should the project fail. The executive's willingness to take on the riskier project is motivated by the *composition* of equity compensation: options and stocks differentially affect executive risk-taking. We argue that the underlying level of risk-taking decided by the firm determines the structure of executive compensation, which in turn affects the nature of projects chosen, which then results in a given magnitude and incidence rate of failure. The more extreme levels of risk-taking are considered Shadow Risks and, if failure results, become known as disasters or scandals. For example, in the case of BP, the immediate government fine for its Prudhoe

Bay spill was $20 million, and additional costs far exceeded this amount. The primary cause of the spill was deemed to be poorly maintained pipes. This allegedly arose from BP's dogmatic adherence to cost cutting, which was incentivized by the CEO's cost cutting incentives. Prosecutors estimated that such subpar maintenance saved the firm some $9.6 million.[1] Hence, the firm was enjoying a higher payoff until the firm's choice of high risk-taking (i.e., low maintenance levels) resulted in a failed risky project. However, this risk-taking was not readily quantified by non-insider investors.

We identify a simple ratio that we refer to as P that captures the nature of executive pay incentives. We find that the relationship between P and risk-taking—both in terms of magnitude and incident rate—is non-monotonic. In particular, for low-stakes settings, where project failures carry lesser consequences, there is a negative relationship between P and magnitude of failures. In contrast, for larger stakes failures that carry large consequences for the firm and the CEO (i.e., Shadow Risks), the relationship becomes positive. In particular, CEOs presiding over larger and more frequent disasters and scandals should also be the ones being offered a higher P compensation structure.

We test these predictions empirically for the setting of environmental failures for the largest US public firms. We find that changing equity pay consisting of 0% in options (i.e., which means 100% of equity pay in stock) to 100% in options results in a CEO's firm facing $42 - 65\%$ increased odds of an environmental incident. In addition, such change in compensation is linked to close to a 100% increase in the magnitude of environmental failures, as measured by total government fines. To our knowledge, this is the first paper to link equity compensation and environmental risk-taking. To test the ratio P in another setting, we explore the relationship of compensation structure and the likelihood of suspected accounting misconduct and negative earnings restatements; findings for this setting are similar to the environmental risk-taking setting.

[1] Associated Press reported via MSNBC News on 11/29/2007. Available at: http://www.msnbc.msn.com/id/22014134/ns/business-oil_and_energy/t/bp-pleads-guilty-alaska-oil-spill/

The balance of the paper is organized as follows. The next section provides our model and primary empirical predictions. Our following section provides our empirical analysis of equity compensation and environmental and accounting failures. Our final section concludes and provides some policy implications.

1 Shadow Risk-Taking

Our model is most similar in spirit to Edmans and Liu (2011) who assume that a firm must incentivize its manager via the two instruments of debt and stock. Instead, we consider the two instruments of stocks and options. In addition, whereas they explore the kinds of contracts expected to be found within firms as a function of the nature of the firm, we have a different task of linking the use of two compensation instruments to the outcomes of failures, both in terms of frequency and magnitude.

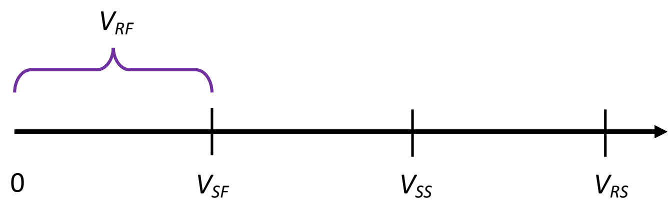
The CEO must choose between a risky project R and a safe project S. Let p be the probability project R (S) succeeds with the firm being worth V_{RS} (V_{SS}) and $1-p$ chance it fails, providing firm value of V_{RF} (V_{SF}). One might want to have different $p's$ for each project type. However, if doing so, we can simply redefine the firm value outcomes to make it equivalent to having the same p for both R and S. Thus, to simplify exposition, we assume that we have the same p for both project types. We also assume V_{RF} is a random variable that is only observable by the CEO and is drawn from some uniform distribution G distributed with support $[0, V_{SF}]$. Thus, if the most extreme risky project is chosen (i.e., $V_{RF}=0$), failure means the firm is completely destroyed and worth zero. Thus, when project R has a worse enough downside, it will be considered a Shadow Risk.

Sometimes it may be in the best interest of the firm for the executive to choose a risky project over a safe project. In particular, the principal of the firm wants the executive to choose R iff $pV_{SS}+(1-p)V_{SF} \leq pV_{RS}+(1-p)V_{RF}$, which is equivalent to

$$0 \leq p\left(V_{RS}-V_{SS}\right)+(1-p)\left(V_{RF}-V_{SF}\right). \qquad (1)$$

Where V_0 denotes initial firm value, we assume the ordering $0 \leq V_{RF} \leq V_{SF} < V_0 < V_{SS} < V_{RS}$. As expected, the value of the firm after a risky success is greatest, but its failure leaves the firm worth the least.

The following diagram summarizes these values, ending firm value V_{ij} is the realization for project type $i \in \{R\text{isky}, S\text{afe}\}$ and outcome $j \in \{S\text{uccess}, F\text{ailure}\}$



The CEO is paid in equity compensation consisting of some portion of options and some portion of stock. We normalize her salary to zero, since salary does not affect project choices. Payoffs for the CEO for each possible state of the world are as follows:

Payoff	V_{RS}	V_{SS}	V_{SF}	V_{RF}
Options	$\alpha\left(V_{RS} - V_0\right)$	$\alpha\left(V_{SS} - V_0\right)$	0	$-\frac{k}{V_{RF}}$
Stocks	βV_{RS}	βV_{SS}	βV_{SF}	$-\frac{k}{V_{RF}}$

.

Project success can be thought of as a state of the world that increases the value of the firm, whereas project failure reduces it. For the case of compensating a CEO in stock, she then simply receives fraction β of the firm, as long as there is not a risky failure. Thus, β could be thought of as her fraction of shares of the firm that she is awarded.

The fraction α measures the level of option payoff to the CEO. Typically option awards are issued at the money, which means for our setting that options only have value with a successful project outcome. Thus, the CEO receives share α of the firm's increase in value, but only in the event of project success, as failure reduces firm value.

Regardless of compensation structure, in the event of a risky failure, V_{RF} is realized and the executive faces a penalty of $\frac{-V_{RF}}{k}$.This can be thought of as lost future income or reputation for the executive, as well as regulator fines and possible incarceration. It is common in practice for a CEO to be made a scapegoat after a bad project failure, for which the consequence is graver than simply receiving no equity pay. As would be expected, this penalty is also increasing in the magnitude of failure.

An executive paid only in options chooses R when it has positive expected payoff to himself: $p\alpha\left(V_{RS}-V_{SS}\right)-(1-p)\frac{k}{V_{RF}}>0$. However, this will not be satisfied for some risky projects since we can have a realization as low as $V_{RF}=0$. An executive that is compensated only via stocks chooses R iff $p\beta\left(V_{SS}-V_{RS}\right)+(1-p)\left(\beta V_{SF}+\frac{k}{V_{RF}}\right)<0$. Again, since we may have $V_{RF}=0$, the CEO will at least sometimes choose the safe project when paid all in stock.

We also assume that $V_{RS}-V_{SS}\geq V_{SS}-V_{SF}$. This implies that succeeding at a risky project is at least as good as succeeding at a safe project, relative to the next best outcome. This assumption helps ensure the possibility of some risk-taking.

For the executive to choose the riskier project, it must be that the expected payoff from choosing R is greater than the safe one, which can be expressed as $p\left(\alpha+\beta\right)V_{SS}+\left(\ 1-p\right)\ \beta V_{SF}\leq p\left(\alpha+\beta\right)V_{RS}-(1-p)\frac{k}{V_{RF}}$ yielding

$$\left(\ 1-p\right)\ \left(\beta V_{SF}+\frac{k}{V_{RF}}\right)\leq p\left(\alpha+\beta\right)\left(V_{RS}-V_{SS}\right)\ . \tag{2}$$

The firm will choose some cutoff value V_{RF}^{*} such that the CEO chooses all risky projects R with $V_{RF}\geq V_{RF}^{*}$ and chooses S otherwise. This means that with a realization of V_{RF}^{*}, the principal is indifferent between the executive choosing R and S, which happens when $p\left(V_{RS}-V_{SS}\right)+(1-p)\left(V_{RF}^{*}-V_{SF}\right)=0$, which means the expected benefit of choosing the risky project equals the expected benefit of choosing the safe one. This implies that

$$V_{RF}^{*}=\frac{-p\left(V_{RS}-V_{SS}\right)}{(1-p)}+V_{SF}>0. \tag{3}$$

We assume that the primitives of the model take on values such that $V_{RF}^{*}=\frac{-p(V_{RS}-V_{SS})}{(1-p)}+V_{SF}>0$ so that we can rule out the case where the risky project is preferred for any possible realization of V_{RF}. We refer to V_{RF}^{*} as the *risk-taking* *standard* of the firm.

With these preliminaries, we can present the timeline of the game:

1. The firm offers the CEO an equity pay contract (i.e., stocks and options)

2. The CEO observes the return characteristics of each project and chooses one

3. A project succeeds (fails) at probability p $(1-p)$

4. Payoffs are realized

In the appendix, we analyze the firm's decision problem and the ultimate contract offered in terms of the share of options, which characterize in the following Lemma:

Lemma 1 *CEOs receive options share* $\alpha^* = \frac{V_{RF}^* \underline{\beta} + \frac{k}{V_{RF}^*}}{-V_{RF}^* + V_{SF}}$

Proof. See appendix ■

This α^* from Lemma 1 induces the CEO to implement the risky project R if and only if it has a higher expected net present value compared to if choosing the safe project S.

We next consider comparative statics to build some testable empirical predictions. As shown in the appendix, the relationship of the share of options α^* offered and a firm's risk standard V_{RF}^* is non-monotonic . However, for high-stakes kinds of environments (i.e., Shadow Risks), which is our empirical setting, we have some clear predictions. We state these findings in our next proposition.

Proposition 2 *Assuming risky projects are higher stakes (Shadow Risks), an* ***increase*** *in option share* α^****increases*** *the chance* $q\,(1-p)$ *of such an event and* ***decreases*** *the expected value of the firm upon a risky failure* $E[V_{RF}|V_{RF} > V_{RF}^*]$.

Proof. See appendix ■

Thus, as a greater share of options are offered to the CEO, we expect a greater chance of failure and such failure to even further reduce the value of the firm. To take our predictions to the data, we link the outcome variable α^* in our theory to a simple, observable variable. We call this new outcome variable the ratio P and define it thus

$$P \equiv \frac{E[V_{option}]}{E[V_{stock}] + E[V_{option}]},$$

which is the expected value of option awards divided by the expected value of option awards and stock awards. In other words, P is the fraction of the value of equity compensation the CEO receives in form options, which is readily identified in the data. Our final proposition provides our empirical predictions linked to P :

Proposition 3 *Assuming risky projects are higher stakes (Shadow Risks), an* ***increase in the ratio*** P *results in*

1. *an* ***increase*** *in the odds of such an event.*
2. *an* ***increase*** *in the expected magnitude of lost firm value upon a risky failure* $V_0 - E[V_{RF}|V_{RF} > V_{RF}^*]$

Proof. See appendix ■

After a discussion of risk-taking within organizations, we take these two predictions to the empirical setting of environmental risk-taking and disasters.

2 Empirical Analysis

2.1 Risk-Taking within Organizations

Firms are not simply silos of CEOs; CEOs work within and through organizations. Thus, we now consider an example that illustrates the process of a CEO translating their choosing of higher risk projects into organizational level risk-taking. Returning to our BP case, the former CEO Lord Browne chose to mandate aggressive short term earnings targets. In particular, he created an annual "contract" with some

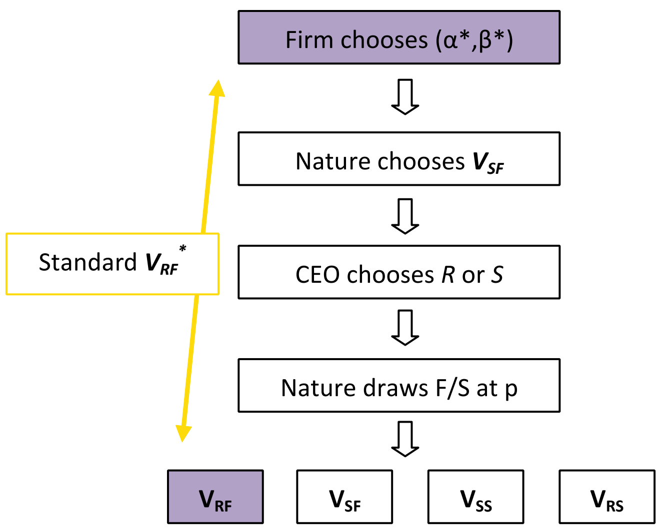
250 of BPs top managers that was based on their respective division's short-run annual profits.[2] As the Prudhoe Bay incident reveals, the primary means by which BP created short term increases in profits was to cut on maintenance and safety expenditures. Safety investments can both reduce the chance of an event, as well as its magnitude. Thus, the consequences of these firm-wide, incentivized choices were increased chance of environmental failures and increased expected magnitude of failure. The next BP CEO, Tony Hayward, was also committed to a policy of shaving costs: almost immediately upon becoming CEO, Howard emailed associates about the importance of continued cost cutting. Once a CEO decides to increase risk-taking—e.g., increased cost cutting—it may only be a matter of months until such risk-taking means an increased chance of an incident and an increase in likely magnitude of such incident. For example, if pipelines are inspected and maintained monthly, it could immediately be decided the next inspection will not occur for six months. In addition to oil companies, any firm can choose to be more lax about its environmental safety management protocol. Similarly, a CEO could put in place direct incentives with managers to encourage aggressive financial accounting practices, leading to an increased chance of accounting misconduct and the magnitude of that conduct. For the setting of financial accounting, the risk-taking standard could be translated to how aggressive a firm's overall accounting process is—the more aggressive the process, the more short-term profits may increase, but also the more there is a chance of running afoul of accounting law, as well as more severely so.

Whatever the case, we assume that we cannot consistently observe the micro, organizational level of risk-taking. Hence, we rely on our theory to link organizational risk-taking to CEO compensation and observed failures. In fact, it could be the case that traditional measures of financial risk-taking, such as volatility of earnings, record *lower levels of risk-taking* for some firms that are actually taking greater risks. For an extreme example, consider Bernard L. Madoff Investment Securities LLC. This firm was involved in major risk-taking by running an elaborate Ponzi scheme. However, if we wanted to measure such risk-taking via volatility of cash flow, we would find

[2]These institutional details can be found in the Fortune magazine article available here: http://features.blogs.fortune.cnn.com/2011/01/24/bp-an-accident-waiting-to-happen/

this firm was below average in terms of risk-taking; in fact, the firm's cash flows were remarkably stable. It was not until the Bernie Madoff scandal emerged that one could identify the extent of the organization's risk-taking.

In summary, the following chart shows the link of a firm's risk-taking standard V_{RF}^{*} that is induced by its choice of α^{*}, which translates into a certain compensation structure for the CEO. It is assumed that V_{RF}^{*} is generally unobservable to the econometrician, whereas the structure of executive compensation and failures are readily observable. For high-stakes risk-taking, the standard of risk is negatively correlated with both the relative level of options pay and relative magnitude and incidence rate of failure, based on our measure in equation (7). Hence, the underlying cause of risk-taking standard induces relative options pay to be *positively* correlated with incidence and magnitude of disasters, and this is something we can test empirically.



2.2 Data

Our environmental incident dataset, CEPD, was compiled by the IRRC. For the period 1996 through 2006, the IRRC aggregated breaches of environmental law for each physical location of a firm's operation up to the company level. In total, this included the (approximately) top 1,500 US public firms in the United States. MSCI acquired the CEPD dataset and has not increased the observations beyond 2006. Violations include the breaking of a myriad of environmental laws: Atomic Energy Act, Clean Air Act, Clean Water Act, Endangered Species Act, Federal Insecticide, Fungicide and Rodenticide Act, Mining Safety and Health Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, and the Toxic Substances Control Act. The CEPD dataset includes both the number of violations for each of these environmental acts, as well as the total government imposed fines. A particular incident may induce several violations of environmental law—both multiple violations of a particular act, as well as violations across acts.

We consider the magnitude of the total government fine (i.e., the total fines across all counts of environmental law breaking for an incident) as a proxy for the severity of the event. Government fines are typically only a fraction of the overall cost of an event. For a dramatic example, BP's Prudhoe Bay spill induced a $20 million government fine. However, BP also had to pay $25 million in civil costs, $60 million for instituting a new government mandated safety program and some $500 million of construction costs, bringing the final bill to at least $605 million.[3] Hence, for this particular case, the $20 million reported in our CEPD dataset represents roughly 3.3% of the total cost.

In total, the CEPD includes both large and small violations. Only the larger of these failures would be considered an environmental disaster. However, smaller violations can be thought of as increased chance of a larger disaster—a signal of increased risk-taking and possibly a looming Shadow Risk. The mean government fine for our data is approximately $223,000. Based on the Prudhoe example above, this would amount to $6.8 million in total average expenses.[4] The purpose of considering a continuum of event magnitudes, in addition to allowing for the possibility of smaller observed events being "the tip of the iceberg" for larger ones, is to admit enough observations for identification; if we limited ourselves to only the most ex-

[3]Figures are reported by the Associated Press in The Guardian 5/4/2011, available here: http://www.guardian.co.uk/environment/2011/may/04/bp-25m-north-slope-oil-spill

[4]Unfortunately, very few incidences have good data on all the of the expenses incurred for an incident, which is why we focus on the government fines.

treme of events there would be only a handful of observations over the past decades to consider.

We merge the CEPD dataset with COMPUSTAT and Execucomp data to identify firm financials and CEO compensation. Firm financial controls include firm leverage, as defined as total debt to total assets, firm market value, and Tobin's Q. For CEO compensation, we obtain the annual value of options and stock awards. These two values are then used to calculate the ratio P as identified from our theory in equation (7). Finally, we include total annual compensation as a control.

Although we control for firm invariant environmental factors through firm fixed effects, this does not control for any time varying environmental effects. To address this, we merge data from KLD analytics on the environmental performance ratings of firms. Chatterji et al. (2009) find that environmental performance ratings, as measured by KLD analytics, are important in explaining the next year of a firm's environmental failures, as measured by the CEPD database. Thus, we will be testing whether conditional on observable environmental performance, does compensation structure further explain environmental risk-taking and disasters. As suggested by our theory, we expect much of the managerial environmental risk-taking is latent and not observable until an incident occurs; hence, compensation patterns should provide further information on risk-taking in equilibrium.

Summary statistics for our primary variables are reported in Table 1. On average, firms experience an event (i.e., a breach of at least one environmental law in a given year) about 15% of the time, or about every 6 years. Firms are also large—averaging over $11 billion in market capitalization. The average CEO is receiving about $6 million per annum in total compensation and about 75% of equity compensation is in the form of options (i.e., ratio P), on average.

2.2.1 Results: Environmental Events

Our primary regression model for analyzing incidence rates is a panel logit model with firm fixed effects. Specifically, we use

$$\Pr\left(Event_{it}=1\right)=\frac{1}{1+e^{-Q_{it}}}, \tag{4}$$

where $Event_i$ equals 1 when firm i has broken the law in year t.

$$Q_{it}=\alpha_i+\beta\frac{O_{i,t-1}}{O_{i,t-1}+S_{i,t-1}}+\mathbf{X}_{it}\boldsymbol{\delta},$$

where α_i is a fixed effect for firm i and $\mathbf{X}_{it}$ is a matrix of control variables that include year fixed effects and financial and environmental performance controls outlined in the previous section. The regressor $\frac{O_{i,t-1}}{O_{i,t-1}+S_{i,t-1}}$ is the ratio P from our theory model and is calculated as the ratio of the total value of CEO option awards to the total value of CEO option and stock awards at time $t-1$ for firm i.[5] Hence, the coefficient estimate $\widehat{\beta}$ of β is our primary estimate of interest. Our model predicts that for larger stakes events, $\beta>0$. Although fixed effects estimation is possible in the panel logit setting, to do so, we must drop observations of firms that never have an event or firms that have an event ever year. Of the $1,459$ firms in our sample, 3.2% have an event every year and 74.5% never experience an event during our time series. By firm, the mean number of events across the entire 11 year time series is 1.3 events. Conditional on a firm having at least one event, the mean number of events is 3.5 across the 11 years.

In addition to this primary specification, we estimate a linear panel model with firm fixed effects. Although this model must assume the probability of an event is linear in its terms, it allows us to consider those firms that never or always have an event in our sample. We specify this model thus:

$$Event_{it}=\alpha_i+\beta\frac{O_{i,t-1}}{O_{i,t-1}+S_{i,t-1}}+\mathbf{X}_{it}\boldsymbol{\delta}+e_{it}. \tag{5}$$

For conciseness, we will most often refer to the ratio $\frac{O_{i,t-1}}{O_{i,t-1}+S_{i,t-1}}$ from our theory as P throughout the balance of the paper. In the next section, we consider the relationship

[5] Based on personal conversations with officials at the Environmental Protection Agency and a human resource consultant, it appears that with this $t-1$ specification, a CEO typical knows her compensation structure $6-24$ months before an event is recorded in our $CEPD$ data as an event.

between P and incident rates, our first prediction. In the following section, we then turn to our second prediction—the relationship of P and the magnitude of events.

2.2.2 Prediction 1: Increased P results in increased odds of an event

We report our baseline specification in Table 2. Column (1) reports results controlling for unobserved firm heterogeneity and total CEO compensation. The logit estimate of roughly .5 can be converted to an odds ratio format,[6] yielding $e^{.5} = 1.6487$. This means that if a CEO goes from receiving all equity compensation in stock (i.e., $P = 0$) to receiving all equity compensation in options (i.e., $P = 1$), her firm will have 64.87% increased odds of facing an environmental incident the next year. Adding all of the other controls does little to change the relative magnitude and significance of the coefficient of interest, as shown in columns $(2) - (4)$.

We next consider our linear panel model with firm fixed effects. Table 3 reports coefficient estimates for this specification. Note that the observations for column (1) are $5,108$ compared to $1,750$ for column (1)in Table 2; this is due to the inclusion now of all firms (i.e., adding those never and always facing an event). As seen in column (1), coefficient estimates suggest that the probably of an environmental incident increases by approximately 5%. Recall from Table 1 that the baseline chance of an event is 15%, which means that a CEO going from equity compensation structure $P = 0$ to $P = 1$, results in a 33% increased chance of an event. We can convert our linear model coefficient estimate to odds in order to compare these estimates to our results found in Table 2. In particular, a baseline probability of 15%, means that the odds of an event are$\frac{15\%}{85\%} = 0.17647$. Adding another 5% chance results in an event odds of $\frac{20\%}{80\%} = 0.25$. This means the impact of a CEO going to $P = 1$ from $P = 0$ results in an odds ratio of $\frac{0.25}{0.17647} = 1.4167$. In other words, our linear specification estimates a CEO going from equity compensation consisting of all stock to all options increases the odds of an event by 41.67%, versus our panel logit model which predicts increased odds of 64.87%. Both of these estimates are substantial in

[6] Recall that the odds of an event is calculated as $\frac{\Pr[Event=1]}{\Pr[Event=0]}$. The odds ratio is the ratio of two odds.

magnitude and both models report coefficient estimates that are significant at the 5% level for all specifications, with the exception of the specification reported in column (4) in Table 3, where the estimate is significant at the 5.6% level. The similarity in estimates persists despite the fact that the logit model uses approximately 34% of the observations that the linear model utilizes. If we drop firms that always or never experience an incidence in our sample and re-run the linear panel model, we find similar results and the same level of significance on all coefficients compared to the unconstrained panel model reported in Table 3. However, for this specification, the odds ratio becomes approximately 56%. We omit these results for brevity.

Thus far we have been using firm fixed effects to control for unobserved firm heterogeneity. Recent financial economic research suggests not doing so, can produce spurious results and incorrect inferences. Nonetheless, if fixed effects are not called for, we are using a less efficient estimator, possibly failing to identify other important effects. We run a Hausman test to determine if a linear random effects panel model would be appropriate given that a linear fixed effect panel model is correct. Since we are using clustered standard errors it is important to not use the conventional Hausman test, which assumes α_i and e_{it} are *i.i.d*—but this is violated if clustered standard errors are appropriate for within firm serial correlation. Instead we turn to the method of Wooldridge (2002) to accommodate our setting. Results from this test report a Sargan-Hansen statistic of 113.50, which yields a p-value = 0.0000. Hence, we can strongly reject the appropriateness of using a random effects model for our empirical setting.

One feature of theory that we have not taken advantage of is that high-stakes event settings should yield a positive relationship with P, whereas as small-stakes events should yield a negative relationship. Of course, our setting of environmental events could consist mostly of higher stakes events, which means all event rates would have a positive relationship to compensation structure P. To consider this prediction, we return to our logit fixed effects panel model and re-code events as either bottom-quartile or top-quartile magnitude events. Magnitude is again the total government fines imposed for an incident. Table 4 reports these results. Column (1) contains the same specification reported in column (4) of Table 2, which contains all controls.

Column (2) shows us that if we define an event as only those in the smallest quartile magnitude-wise, the effect is no different statistically from zero. However, the top quartile, in contrast, has a coefficient estimate on P that is 80% greater than if we include all events: .93 vs. .53. This estimate from column (3) suggests a CEO going from compensation $P = 0$ to $P = 1$ will oversee a firm with increased odds of 253% that the next year his firm will face a substantial environmental event. The top-quartile event has an average total government fine of $\$865,625$. This means total expenses would likely reach many of millions of dollars. In contrast, the bottom-quartile event has an average total fine of just \$466. If we instead partition the event space into above and below median magnitude events, neither partition is significant at conventional levels on its own: The above median event-sample estimate of the coefficient of P has a p-value of 18.1%, whereas the below median event sample estimate has a p-value of 32.8%.

We also conduct the same exercise with our linear fixed effect model so we can include all observations. Table 5 reports these results, which are similar to Table 4: the top-quartile events are significantly related to P and the bottom ones are not. For the linear model, while our magnitude on the top quartile is less than the magnitude on the overall sample, the significance level is greater. In sum, these findings suggest that in terms of incidence rate, CEO compensation structure, as measured by P, is positively related to high-stakes events and this is the primary source of identification when considering all possible events.

Robustness Tests We are not claiming that CEO compensation causes environmental risk-taking and disasters *per se*; instead, as argued in Section 2, we are proposing that CEO compensation is an important channel through which a firm ultimately influences firm-level environmental risk-taking. In particular, if higher levels of relative options pay, as measured by P, increase next year's odds of an event, it should not be the case that this year's odds of an event influences next year's compensation structure P. A simple test of this is to reverse the order of events: We re-run the specifications in Table 2 with the modification that we measure P the year *after* rather than the year *before* an event. As reported in Table 6, none of the specifications are significant. In fact, with all of our controls (i.e., column (4)), the estimated relationship actually becomes slightly negative.

Another natural question is to what extent is compensation structure P simply a proxy for other important compensation variables. First, it could be that the total option awards currently held by a CEO is what really matters in determining incident rates; last year's option award is simply a proxy for this larger value. Similarly, it could also be that the current total value of stock held by the CEO is what really determines incident rates and P somehow proxies for this. We explore these possibilities by rerunning the specification from Table 2 in column (4) (i.e., the specification with all of our controls), and add in controls for a CEOs value of total stock an option awards currently held through the previous year, each logged.[7] We report these results it Table 7. Column (1) replicates the results from column (4) in Table 2 for comparison purposes: our baseline regression with all controls. Column (2) then replaces our lagged ratio P with the lagged values for the log of total stocks and options owned by the CEO. Surprisingly, neither regressor can help predict the odds of an environmental event. Meanwhile, the coefficient P changes little in estimate or magnitude when adding these additional controls.

Another important measure of executive compensation is the CEO's Delta of their options portfolio. Some argue that Delta should increase risk-taking, whereas others argue that it should decrease risk-taking. This ambiguity arises both in the theory and empirical literature (see Coles et al. (2006) and cites therein). In this paper, Delta is the dollar change in CEO wealth as function of a 1% change in stock price. We calculate the CEO's Delta for each executive in our sample using the same method as in Guay (1999) and Core and Guay (2002). The results of adding this measure of Delta as a regressor are reported in column (3) . The coefficient on Delta is not statistically different from 0, though its estimate is positive. The coefficient on our ratio P is still significant, but now it falls to the 10% significance level. In

[7]Specifically, we calculate the log of the current total options and stock holdings as each $\ln(1 + Value)$, where Value is the value given by Execucomp for each of total holding values. Execucomp reports zero values.

addition, the magnitude drops slightly to .41 from .53.

A final common measure of the nature of equity compensation is Vega. This measures how much of an increase in wealth a CEO receives by a 1% increase in her company's stock volatility. We calculate this measure as in Guay (1999) and Core and Guay (2002). All things equal, this measure should be positively correlated with managerial risk-taking (see Coles et al. (2006)). However, it should positively correlated only with managerial risk-taking that increases her company's stock volatility. Column (4) reports that our coefficient on Vega is no different statistically from zero. This suggests Vega does not incentivize environmental risk-taking. Meanwhile, the coefficient on our compensation ratio P is similar to the case of adding Delta.

In total, it does not seem to be the case that our compensation ratio P is simply a noisy proxy for measuring other important executive compensation measures. In fact, for our setting of environmental risk-taking it seems to do a better job than conventional measures in predicting such risk-taking. However, it is important to stress environmental risk-taking—especially the kind that results in spectacular disasters—could be considered more of an off balance sheet risk. The conventional measures of managerial risk-taking—firm leverage, reduced cash surplus, R&D investment, reduced capital purchases, and more focused lines of business and acquisitions—are all forms of risk-taking easily observable by the financial market and thus embedded in a company's stock return and volatility. In contrast, managerial choices such as shirking on oil pipe inspections or choosing not to install automatic shutoff valves on oil platforms are much more difficult for the market to identify and price into a company's stock. Perhaps the ratio P can help on that dimension in predicting such risks. Now we turn to quantifying the risky failures.

2.2.3 Prediction 2: Increased P results in increased magnitudes of events

For testing our second prediction, we use a similar specification to our linear panel model in the previous section. However, we now change our dependant variable from an event indicator to the log of total government fines. In particular, we utilize the following model:

$$\ln(1 + fine)_{it} = \alpha_i + \beta \frac{O_{i,t-1}}{O_{i,t-1} + S_{i,t-1}} + \mathbf{X}_{it}\boldsymbol{\delta} + e_{it},$$

where $fine$ is the total government fine assessed for the incident and all of the other regressors are as they were in equation (5) . Of course, since Prediction 2 is a conditional theoretical prediction, we now only have observations for those firms that experience an environmental incident, and only for those years that such an event happens. Our coefficient of interest is again β.

Table 8 reports the results for similar specifications to Table 2. The first three specifications yield a significant coefficient on P at the 5% level. The final specification with all controls yields significance at the 10% level. Since these are semi-elasticities, the coefficient estimates suggest that, roughly speaking, a CEO going from $P = 0$ to $P = 1$, conditional on experiencing an event, will witness total event costs of 78% to 96% more than when $P = 0$.

Since we are using a linear panel FE model we again need to ask if it is the appropriate model vis-a-vis a random effects model. Conducting a Hausman test, as we did in section in our previous section, we find a Sargan-Hansen statistic of 39.948 p-value =0.0008,which causes us to strongly reject the null that the random effects model is appropriate given that the fixed effects model is appropriate.

Informed by our theory, we again consider the comparison of the large and small events. Unfortunately, we now have significantly reduced sample size compared to the previous section; thus, we now simply partition fines into below and above median fines. We use all of the controls used for the results in column (4) of Table 8 for Table 9. For comparison purposes, column (1) in Table 9 replicates the results in Column (4) of Table 8. We find that using the sample of large fines (i.e., above median) creates an estimate of the coefficient on P significant at the 5% level compared with a 10% significance level when using the sample of all fines. Further, the estimate using only larger fines is over 50% greater in magnitude compared with the full sample that includes small fines. Meanwhile, a sample of only small fines does not yield a significant estimate of the coefficient on P. If we instead partition fines, as in the previous section—by top and bottom quartiles—small events have a negative correlation with lagged P (i.e., coefficient of $-.64$) and large events have a positive coefficient on lagged P (i.e., coefficient of .25), which are both consistent with our theory. Nonetheless, these do not reach statistical significance.

We also re-run the specification from column (4) in Table 8 with the addition of the natural log of total company stock, options, Delta, and Vega. Again, none of these control variables are significant and they do not materially change the results. Similarly, the current magnitude of an event does not predict next year's compensation structure P. In sum, it seems the CEO compensation structure as measured by P does seems positively correlated with the magnitude of losses for higher stakes events, as predicted by the theory.

Despite all of the above findings, it is possible the ratio P only predicts the incident rate and magnitude of events for environmental risk-taking and not other settings. To further explore this possibility, we now analyze the ratio P in a different setting—financial accounting risk-taking—which also occurred over a different time period.

2.3 Results: Financial Accounting Risk-Taking

Financial accounting represent another setting where, similar to environmental failures, getting caught for breaking accounting law can be viewed as a failed risky-project. Firms can choose to be more aggressive in their accounting practices, amplifying their firm's risk-taking standard. However, this increased risk-taking may not be readily observable day-to-day. In this setting, an event is an earnings restatement that results in an SEC investigation. This means that we are really measuring the *likelihood* of breaking the law; to the extent being investigated by the SEC for suspicious financial accounting is correlated with greater risk-taking, we can conceptualize an SEC investigation as a signal of higher risk-taking.

The reason that we proceed with this section of analysis is several fold. First, some studies have shown that options pay is related to accounting misconduct (e.g., see Burns and Kedia (2006) and cites therein). Since we are using an uncommon measure of equity pay (i.e., P), we want to examine if its use replicates past results using other measures. Second, restatements with SEC investigations are rare events—these carry less than a 0.5% annual incident rate in our dataset. Thus, this provides a test for rarer events than the previous environmental setting. Finally, at the end of 2005, it became more costly to provide options due to FAS 123R.[8] Our accounting data cover the period 2000 through 2011; hence, we can consider any differential effects of options before and after this policy change, whereas this is not possible with our environmental data since the database was discontinued after 2006. We can also consider any time trend differences between another major policy change potentially affecting financial accounting conduct: Sarbanes Oxley. Instead of directly shifting the cost of providing options, as did FAS 123R, this policy essentially increased the penalty an executive faced if presiding over a financial accounting incident.

Our analysis proceeds just as before. However, our dependent variables are now different. Specifically, we obtain them from Audit Analytics, which reports accounting restatements and whether or not these result in an investigation by the SEC. Restatements can be due to simple, benign clerical errors or can be due to consequential issues such as earnings manipulation. The most suspicious of restatements are the ones presumably investigated by the SEC. Audit Analytics also reports the net change in earnings of a restatement.

For this section, we employ a random effects model instead of a fixed effects model. For our linear model, we again conduct a Hausman test. We find in this setting of financial accounting risk-taking, that if a fixed effects estimate model is appropriate, we cannot reject a random effects model as also appropriate (p value of 0.53). However, since this then means the Random Effects model is the more efficient estimator, we utilize it. For consistency, we also use a random effects model for the logit panel. In addition, if we used a fixed effect logit panel model, due to the rare event nature of this sample, we would only be following 50 firms—since the fixed effect model must drop all firms that never have an event.

Table 10 reports our logit panel specifications. Including all controls, as reported in column (3) , the coefficient of 1.49 implies a CEO going from receiving all equity compensation in stock to all in options (i.e., $P = 0$ to $P = 1$), will the next year

[8] See Hayes et al. (2012) for a summary of this rule as it pertains to options accounting.

oversee a firm with some 443% increased odds of a financial accounting investigation. This coefficient estimate on P is significant at the 5% level in column (3) and at the 1% level for the columns.

Table 11 reports the same specifications as in Table 10, but for a linear panel model. All specifications show the coefficient estimates on P to be significant at the 1% level, and close to an average value of .4%, which amounts to an 80% increase in the likelihood of a financial accounting event. Since incident rates are less than 1%, the increase in odds, as indicated by the odds ratio, is similar to an increase in probability. Converting the 80% increase in chance to an odds ratio yields 1.81, which implies an 81% increased odds of an event. Thus, in contrast to our environmental risk-taking setting, the linear estimator and logit estimator imply sharply different increases in odds. When estimating low probability events, the shape of the tail of the statistical distribution matters.

As mentioned, a nice feature of studying this accounting data, in addition to having a larger sample, is that our time series passes through two significant accounting policy changes. We had the passage of both the Sarbanes-Oxley Act (2002) and FAS 123R (2005). The former act essentially created a bigger stick for CEOs involved in accounting misconduct. In terms of our model, this means the penalty k becomes greater. In this case, the equilibrium risk-taking will still be the same, as it is not determined by k. Instead, the firm will need to increase the CEO's carrot by means of increased options to induce the CEO take on the same desired level of risk as before. Hence, our model predicts Sarbanes-Oxley will have no effect on risk-taking in equilibrium and thus will not be associated with the incidence of restatements investigated by the SEC.

The FAS 123R policy change essentially made it more expensive for a firm to award options. Although not explicitly considered in our model, if this somehow limited the level of options that could be provided compared with before such a rule change, we would witness relatively fewer options, and, consequently, a lower of level of risk-taking. This would result in fewer and lesser in magnitude Shadow Risks, on average.

We consider these two policy changes with a simple, non-parametric time specification. We add an indicator variable that takes on the value 1 for all years that the new policy is effective, which begins in 2002 and 2006 for the Sarbanes-Oxley Act and FAS 123R, respectively. To limit collinearity with our year fixed-effects, we create year fixed-effects from 2004 onward. We report these results in Table 12. Columns (1) and (3) do not include year fixed effects and columns (2) and (4) do. Columns (1) and (2) are created from our logit specification with all of our controls (i.e., the specification from column (3) found in both Table 10 and 11), whereas columns (3) and (4) are created from our linear model. Coefficient estimates on P are similar to before adding such policy controls and are significant at the 5% (1%) level for the logit (linear) panel. It appears Sarbanes-Oxley had no effect on apparent financial accounting misconduct—at least in terms of SEC investigations. This is consistent with our theory. Meanwhile, FAS 123R caused a significant drop in accounting incident rates across all specifications at the 1% level, except for the logit panel specification without year fixed-effects.

We now consider the magnitude of accounting restatements that are investigated by the SEC. Accounting restatements can result in a positive or negative change in earnings. To account for this, we regress separately negative and positive restatements. For negative restatements, we take the absolute value. We also take the natural log of each positive and negative earnings. Positive earnings restatements, as might be expected, have no relationship to compensation structure. This is tested by means of an OLS regression since there are too few observations for a linear panel regression. Thus, we focus on (weakly) negative earnings restatements. If we restrict ourselves to those restatements that also have an SEC investigation, we have a mere 47 observations with our specifications and not enough power to identify a relationship between CEO compensation and magnitude. Further, of these 47 observations, 22 have a net zero value in earnings restatement, leaving only 25 observations to identify the magnitude of any possible effect.

However, we can more loosely define our event as an earnings restatement (i.e., rather than one that also results in an SEC investigation). Doing so increases our observations to 495. In contrast to our environmental incident data, accounting restatements are quite rare even for firms that experience one. In fact, for our 12 year sample, for firms that face a restatement, 72.4% never experience an additional restatement. If we only consider negative earnings restatements, then 82.1% of firms only experience one such an event. Thus, when considering the conditional magnitude of an event, our sample is similar to a cross section. Consequently, we implement an OLS model to measure the relationship of firm compensation and earnings restatement magnitude. We also add industry controls at the NAICS code 2-digit level.

We do find a relationship between compensation structure P and the magnitude of negative earnings restatements. Table 13 reports these results. Since these are semi-elasticities, the magnitudes suggest that a CEO going from $P = 0$ to $P = 1$ will oversee a 56.5% to 71% increase in the magnitude of a negative earnings restatement, conditional on facing such a restatement. If we restrict our sample only those firms that experience a single event, and use all of the controls from column (4) in Table 13, our reduced sample of 182 observations yields a coefficient on P of .84 and is significant at the 10% level.

3 Conclusion

We explored the possible link between equity compensation and failed risky projects, where the largest of these failures (i.e., Shadow Risks) represent environmental disasters and accounting scandals. Our theoretical model showed that the relationship is non-monotonic. In particular, for those environments where the opportunities and failures are relatively low-stakes, there is a *negative* relationship between the share of equity compensation in options and risky-project incident rate and magnitude. Here, options encourage the CEO to take on "too much" risk since the failure of such projects carries little penalty for the CEO. Hence, as project attractiveness increases, the firm must decrease relative options compensation. However, for those large-stakes settings, where failure can be very costly to the CEO—i.e., disasters and scandals—the firm must aggressively incentivize the CEO to take on the firm's desired level of risk-taking. This is accomplished through relatively more options, as measured by the ratio P. More risk-taking then means more observed disasters and increased magnitude of these disasters, on average.

We tested these predictions in the setting of breaking environmental law and accounting law. We found that changing a CEO's compensation from 100% stock to 100% options (i.e., $P = 0$ to $P = 1$) resulted in $42 - 65\%$ increased odds of an environmental incident and close to a doubling of the magnitude of fines. Similarly, for the same change in equity compensation, we found over an 80% increased odds that the firm has an accounting restatement that is investigated by the SEC. Similarly, we found the magnitude of negative earnings restatements increase by 56% to 71%. As suggested by our theory, we found that it is primarily the largest events that are positively related to CEO compensation structure P. We also found the effect of P seems to be coming from not only a selection effect of particular CEOs, but also an incentive effect.

As far as policy, our theoretical model suggests increasing the regulatory stick against a CEO for failed risky project outcomes does not change the incident rate nor the magnitude of loss. Intuitively, making the stick larger does not change the optimal risk-taking level for the firm and thus the firm simply restructures compensation to induce the CEO to still incur the same level of risk-taking as when the stick was smaller. In contrast, making it more costly to provide a carrot (i.e., increasing the cost of providing options) can reduce a firm's optimal choice of risk-taking. We found evidence that a rule change of the former—Sarbanes-Oxley—did not reduce risk-taking (and thus risky project failures), whereas a rule change of the latter—FAS 123R—was effective in reducing risk-taking.

In sum, our findings suggest that the largest failures in firms may come from higher risk-taking by the CEO. However, this higher risk-taking is being incentivized by the firm's choice of equity compensation. Thus, it is not clear that liability over such events should rest primarily on the CEO. To the extent that the board of directors freely sets the CEO's compensation structure, which is generally assumed to be the case, they too can be complicit in the firm's disasters and scandals.

We note that we only studied the largest of US firms. It would be interesting to determine to what extent these forces operate in smaller firms. Unfortunately, many of these firms are private and thus compensation details are generally not available to the researcher. However, if one could obtain some private data, it would be illuminating.

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4 Appendix: Proofs

Lemma 1 *CEOs receive options share* $\alpha^* = \frac{V_{RF}^* \beta + \frac{k}{V_{RF}^*}}{-V_{RF}^* + V_{SF}}$

Proof: The firm's problem is written thus

$$\max_{\alpha,\beta} [qp\left(\left(1-\alpha-\beta\right)V_{RS} + p\alpha V_o + \left(1-p\right)E[V_{RF}|V_{RF} > V_{RF}^*]\right) + \left(1-q\right)\left(p\left(\left(1-\alpha-\beta\right)V_{SS} + p\alpha V_o\right) + \right.$$

$$\text{subject to } \frac{\beta + \frac{k}{V_{RF}^* V_{SF}}}{\alpha+\beta} = \frac{p}{(\ 1-p)}\frac{V_{RS}-V_{SS}}{V_{SF}}, \alpha^* + \beta^* \leq 1 \text{ and } \alpha^*, \beta^* \geq 0.$$

Here, we define $q \equiv \Pr(V_{RF} \geq V_{RF}^*)$ and assume that the firm does not pay the cost of penalizing the manager for a risky failure—we consider this penalty is created by the labor market and/or regulators. We assume as in Edmans and Liu (2011) that the firm induces the CEO to choose the first-best policy (i.e., choose R if and only if its expected value is greater than S). This adds the constraint $\frac{\beta + \frac{k}{V_{RF}^* V_{SF}}}{\alpha+\beta} = \frac{p}{(\ 1-p)}\frac{V_{RS}-V_{SS}}{V_{SF}}$. The conditions $\alpha^* + \beta^* \leq 1$ and $\alpha^*, \beta^* \geq 0$ assure only positive shares of the firm are given away, and no more than the entire firm is given away. With the above setup, the maximization problem is equivalent to minimizing the expected cost of executive compensation and such cost is linear in the parameters, we will have a so-called bang-bang solution. This is can be seen by taking the first order conditions and noting:

$$\frac{\partial}{\partial\alpha} < \frac{\partial}{\partial\beta} < 0,$$

which means that options are lower cost to the firm to provide than stock. Assume some $\underline{\beta} \geq 0$.[9] This means that the optimal payment α^* is then

$$\alpha^* = \frac{\underline{\beta} + \frac{k}{V_{RF}^* V_{SF}}}{\frac{p}{(\ 1-p)} \frac{V_{RS}-V_{SS}}{V_{SF}}} - \underline{\beta}.$$

Recalling that $V_{RF}^* = \frac{-p(V_{RS}-V_{SS})}{(1-p)} + V_{SF} > 0$, with further rearranging our expression becomes:

$$\alpha^* = \frac{V_{RF}^* \underline{\beta} + \frac{k}{V_{RF}^*}}{-V_{RF}^* + V_{SF}}. \tag{6}$$

QED

Proposition 2 *Assuming risky projects are higher stakes, an increase in option share* α^* *increases the chance* $q(1-p)$ *of such an event and decreases the expected value of the firm upon a risky failure* $E[V_{RF}|V_{RF} > V_{RF}^*]$.

Proof: We first show how α^* changes when V_{RF}^* changes. We will then link this to how changes in V_{RF}^* affect $E[V_{RF}|V_{RF} > V_{RF}^*]$ and $q(1-p)$. We first consider a change in variables other than V_{SF} (we consider this case separately sinceV_{RF}^* is a function of V_{SF}) that change V_{RF}^*. Taking the derivative of α^* with respect to the risk-standard yields

$$\frac{\partial \alpha^*}{\partial V_{RF}^*} = \frac{2kV_{RF}^* + V_{SF} \left(V_{RF}^*\right)^2 \underline{\beta} - kV_{SF}}{\left(V_{RF}^*\right)^2 \left(-V_{RF}^* + V_{SF}\right)^2} <> 0.$$

[9] This is intuitive: options are a "cheaper" form of compensation due to their not providing the manager any compensation for safe failures, whereas stocks do provide compensation in this state of the world. Thus, without some constraint, the optimal contract is that equity compensation consists of 100% options and no stock. Kadan and Swinkles (2008) similarly find that firms should provide 100% options and no stocks—unless the firm has a substantial threat of bankruptcy, which does not generally include our empirical setting. Nonetheless, in practice we often observe that equity compensation consists of stock, in addition to options, even for large, stable firms. This could be driven by industry norms or a budget constraint for offering options. It could also be driven by convexity of cost in providing stocks and options, rather than the linear cost assumed above. Abstracting away from the source, we assume that there is some minimum $\underline{\beta}$ such that firms need to provide some amount of stock to managers.

First note as $V_{RF}^{*}\rightarrow 0$, we have $\frac{2kV_{RF}^{*}+V_{SF}\left(V_{RF}^{*}\right)^{2}\underline{\beta}-kV_{SF}}{\left(V_{RF}^{*}\right)^{2}\left(-V_{RF}^{*}+V_{SF}\right)^{2}}\rightarrow-\infty$ and with $V_{RF}^{*}\rightarrow V_{SF}$, we have that $\frac{2kV_{RF}^{*}+V_{SF}\left(V_{RF}^{*}\right)^{2}\underline{\beta}-kV_{SF}}{\left(V_{RF}^{*}\right)^{2}\left(-V_{RF}^{*}+V_{SF}\right)^{2}}\rightarrow+\infty$. Thus, $\frac{\partial\alpha^{*}}{\partial V_{RF}^{*}}<0$ for low-risk standards (i.e., V_{RF}^{*} has a low value) and $\frac{\partial\alpha^{*}}{\partial V_{RF}^{*}}>0$ for high-risk standards (i.e., V_{RF}^{*} has a high value). As can also be shown also for low risk-standards, $\frac{\partial\alpha^{*}}{\partial V_{RF}^{*}}<0$ when V_{RF}^{*} changes as a result of V_{SF}. This can be seen by noting that

$$\frac{\partial\alpha^{*}}{\partial V_{SF}}=\frac{\underline{\beta}+\frac{-k}{\left(V_{RF}^{*}\right)^{2}}}{\frac{p}{(\ 1-p)}\left(V_{RS}-V_{SS}\right)}$$

This expression is negative when $\underline{\beta}+\frac{-k}{\left(V_{RF}^{*}\right)^{2}}<0$, which occurs with low enough risk standard V_{RF}^{*}. In sum, for low risk-taking standards, an reduction in risk standard V_{RF}^{*} results in an increase in α^{*}.

Now we consider how V_{RF}^{*} affects $E[V_{RF}|V_{RF}>V_{RF}^{*}]$ and $q\left(1-p\right)$. It is trivial that $E[V_{RF}|V_{RF}>V_{RF}^{*}]$ decreases as V_{RF}^{*} decreases: decreasing V_{RF}^{*} lowers the lower bound of support of V_{RF} while maintaining the same upper bound of support. It is not trivial, however, that $q\left(1-p\right)$ increases as V_{RF}^{*} decreases. In particular, the incident rate of risky failures is $q(1-p)$. An increase in p lowers the risk-standard V_{RF}^{*}, which means that q increases but it also means that $(1-p)$ decreases. To determine the net effect, we must then take the derivative of $q(1-p)$ with respect to p and recall q is a function of p, yielding

$$\frac{\partial}{\partial p}\left(q(1-p)\right)=\frac{\left(V_{RS}-V_{SS}\right)}{V_{SF}}>0.$$

We can now link these three comparative statics to conclude that an increase in option share α^{*}

1. increases the chance $q\left(1-p\right)$ of an event

2. decreases the expected value of the firm upon a risky failure $E[V_{RF}|V_{RF}>V_{RF}^{*}]$

QED

Proposition 3 *Assuming risky projects are higher stakes, an increase in the ratio R results in*

Proposition 4 *1. an **increase** in the odds of such an event.*

*2. an **increase** in the expected magnitude of lost firm value upon a risky failure* $V_0 - E[V_{RF}|V_{RF} > V_{RF}^*]$

Proof: We must show that an increase in R is equivalent to an increase in α^*. Once noting an increased chance of an event also means increased odds and noting that $V_0 - E[V_{RF}|V_{RF} > V_{RF}^*]$ is strictly decreasing in $E[V_{RF}|V_{RF} > V_{RF}^*]$, the proof is complete. The expected value of options pay can be written as

$$\begin{aligned} E[V_{option}] &= \alpha\left(qp\left(V_{RS} - V_0\right) + (1-q)\,p\left(V_{SS} - V_0\right)\right) \\ &= \alpha\left(qpV_{RS} + (1-q)\,pV_{SS} - pV_0\right) \end{aligned}$$

The expected value of payment in stock is

$$E[V_{stock}] = \beta\left(qpV_{RS} + (1-q)\left(pV_{SS} + (1-p)\,V_{SF}\right)\right).$$

Now consider the ratio P, which we define as

$$P \equiv \frac{E[V_{option}]}{E[V_{stock}] + E[V_{option}]} \tag{7}$$

Since $P < 1$ and increasing α increases the value of $E[V_{option}]$ while not affecting $E[V_{stock}]$, we have $\frac{\partial P}{\partial \alpha} > 0$. Thus, P increases if and only if α increases.

QED

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Event (1/0)	7705	15.04%	35.75%	0	1
Total Fines	1132	$ 223,674	$ 1,346,869	$ 1	$ 25,000,000
Ratio ***P*** of Equity Comp	5999	75.08%	35.42%	0%	100%
Total Compensation (mm)	7628	$ 6,257	$ 12,758	$ -	$ 600,347
Environmental Strengths	7705	0.17	0.47	0.00	4.00
Environmental Concerns	7705	0.32	0.80	0.00	6.00
Market Value	7704	$ 11,261	$ 31,666	$ 0	$ 507,217
Market to book Ratio	7696	2.51	1.62	1.00	28.88
Leverage	7465	0.21	0.18	0.00	4.91
Year	7705	n/a	n/a	1996	2006

ratio ***P*** is the ratio of CEO total options compensation divided by total options and stock compensation for a given year

Table 2: The Relationship of *P* and Environmental Events: Logit Panel Model

Dependent Variable: Environmental Incident (1,0)				
	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	0.5095**	0.4878**	0.5830***	0.5278**
	(2.29)	(2.07)	(2.61)	(2.24)
Total Compensation at t-1	0.0000	0.0000	0.0000	0.0000
	(0.26)	(0.30)	(0.09)	(0.36)
KLD Env Strengths at t-1		-0.0304	-0.0025	-0.0225
		(-0.17)	(-0.01)	(-0.12)
KLD Env Concerns at t-1		-0.1013	-0.0935	-0.0466
		(-0.73)	(-0.66)	(-0.32)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Env Controls	No	Yes	Yes	Yes
Financial Controls	No	No	Yes	Yes
Year Fixed Effects	No	No	No	Yes
N	1750	1750	1715	1715

t statistics reported in parentheses

Standard errors are calculated via bootstrap method (400 repetitions)

* p<0.10 **p<.05 ***p<.01

Table 3: The Relationship of *P* and Environmental Events: Linear Panel Model

Dependent Variable: Environmental Incident (1,0)				
	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	0.0509**	0.0488**	0.0577**	0.0496*
	(2.07)	(1.97)	(2.31)	(1.91)
Total Compensation at t-1	0.0000	0.0000	0.0000	0.0000
	(0.33)	(0.38)	(0.15)	(0.82)
KLD Env Strengths at t-1		-0.0042	-0.0028	-0.0058
		(-0.13)	(-0.09)	(-0.19)
KLD Env Concerns at t-1		-0.0215	-0.0207	-0.0130
		(-0.78)	(-0.75)	(-0.48)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Env Controls	No	Yes	Yes	Yes
Financial Controls	No	No	Yes	Yes
Year Fixed Effects	No	No	No	Yes
N	5108	5108	4938	4938

t statistics reported in parentheses

standard errors are clustered at the firm-level

* p<0.10 **p<.05 ***p<.01

Table 4: Relationship of *P* and High vs. Low Magnitude Events: Logit Panel Model

Dependent Variable: Environmental Incident (1,0)			
	(1)	(2)	(3)
Ratio ***P*** of Equity Comp at t-1	0.5278**	0.0103	0.9257**
	(2.40)	(0.03)	(2.18)
Total Compensation at t-1	0.0000	0.0000	-0.0000
	(0.35)	(0.27)	(-0.56)
KLD Env Strengths at t-1	-0.0225	-0.2237	-0.3571
	(-0.11)	(-0.94)	(-1.35)
KLD Env Concerns at t-1	-0.0466	-0.0173	-0.2651
	(-0.31)	(-0.08)	(-1.55)
Incident Magnitude	All	4th Q	1st Q
Firm Fixed Effects	Yes	Yes	Yes
Env Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Financial Controls	Yes	Yes	Yes
N	1715	895	749

t statistics reported in parentheses

Standard errors are calculated via bootstrap method (400 repetitions)

* p<0.10 **p<.05 ***p<.01

Table 5: Relationship of *P* and Large vs. Small Magnitude Events: Linear Panel Model

Dependent Variable: Environmental Incident (1,0)			
	(1)	(2)	(3)
Ratio ***P*** of Equity Comp at t-1	0.0496*	0.0028	0.0374**
	(1.91)	(0.16)	(2.19)
Total Compensation at t-1	0.0000	0.0000	-0.0000
	(0.82)	(0.51)	(-0.59)
KLD Env Strengths at t-1	-0.0058	-0.0129	-0.0230
	(-0.19)	(-0.77)	(-1.19)
KLD Env Concerns at t-1	-0.0130	-0.0015	-0.0248
	(-0.48)	(-0.11)	(-1.34)
Incident Magnitude	All	4th Q	1st Q
Firm Fixed Effects	Yes	Yes	Yes
Env Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Financial Controls	Yes	Yes	Yes
N	4938	4938	4938

t statistics reported in parentheses

standard errors are clustered at the firm-level

* p<0.10 **p<.05 ***p<.01

Table 6: Falsification Test of the Relationship of *P* and Incident Rates

Dependent Variable: Environmental Incident (1,0)	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t+1	0.2653	0.2654	0.2284	-0.1426
	(1.21)	(1.26)	(1.03)	(-0.63)
Total Compensation at t-1	-0.0000	-0.0000	-0.0000	-0.0000
	(-0.10)	(-0.16)	(-0.18)	(-0.20)
KLD Env Strengths at t-1		-0.1915	-0.1712	-0.1727
		(-1.26)	(-1.05)	(-0.96)
KLD Env Concerns at t-1		0.1801	0.2099	0.2493*
		(1.21)	(1.42)	(1.79)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Env Controls	No	Yes	Yes	Yes
Financial Controls	No	No	Yes	Yes
Year Fixed Effects	No	No	No	Yes
N	1666	1666	1642	1642

t statistics reported in parentheses

Standard errors are calculated via bootstrap method (400 repetitions)

* p<0.10 **p<.05 ***p<.01

Table 7: Additional Compensation Controls

Dependent Variable: Environmental Incident (1,0)	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	0.5278**	0.5087**	0.4139*	0.4386*
	(2.34)	(2.04)	(1.76)	(1.73)
Ln(Total Stock Value) at t-1		-0.0107		
		(-0.15)		
Ln(Total Option Value) at t-1		0.0025		
		(0.08)		
Total Delta at t-1			0.0002	
			(0.84)	
Total Vega at t-1				-0.0001
				(-0.18)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Env Controls	Yes	Yes	Yes	Yes
Financial Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
N	1715	1648	1653	1653

t statistics reported in parentheses

Standard errors are calculated via bootstrap method (400 repetitions)

* p<0.10 **p<.05 ***p<.01

Table 8: Relationship of *P* and Magnitude of Environmental Events

Dependent Variable: ln(1+total government fines)				
	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	0.9637**	0.9275**	0.9527**	0.7790*
	(2.26)	(2.12)	(2.15)	(1.79)
Total Compensation at t-1	-0.0000	-0.0000	-0.0000	-0.0000
	(-0.74)	(-0.55)	(-0.22)	(-0.17)
KLD Env Strengths at t-1		-0.1460	-0.1521	-0.1156
		(-0.47)	(-0.50)	(-0.38)
KLD Env Concerns at t-1		-0.2247	-0.2301	-0.1512
		(-0.92)	(-0.91)	(-0.61)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Env Controls	No	Yes	Yes	Yes
Financial Controls	No	No	Yes	Yes
Year Fixed Effects	No	No	No	Yes
N	820	820	813	813

t statistics reported in parentheses

standard errors are clustered at the firm-level

* p<0.10 **p<.05 ***p<.01

Table 9: Relationship of P and Magnitude of Events (Large vs. Small)

Dependent Variable: ln(1+total government fines)	(1)	(2)	(3)
Ratio ***P*** of Equity Comp at t-1	0.7790*	0.3243	1.2898**
	(1.79)	(0.62)	(2.07)
Total Compensation at t-1	-0.0000	-0.0000	-0.0000
	(-0.17)	(-0.48)	(-0.79)
KLD Env Strengths at t-1	-0.1156	-0.2886	-0.2623
	(-0.38)	(-1.03)	(-0.94)
KLD Env Concerns at t-1	-0.1512	0.0789	0.0204
	(-0.61)	(0.42)	(0.06)
Incident Magnitude	All	<Median	>Median
Firm Fixed Effects	Yes	Yes	Yes
Env Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Financial Controls	Yes	Yes	Yes
N	813	410	403

t statistics reported in parentheses

standard errors are clustered at the firm-level

* p<0.10 **p<.05 ***p<.01

Table 10: The Relationship of *P* and Financial Accounting Events: Logit Panel Model

Dependent Variable: Accounting Incident (1,0)			
	(1)	(2)	(3)
Ratio ***P*** of Equity Comp at t-1	2.1384***	2.4113***	1.4885**
	(3.29)	(3.42)	(2.07)
Total Compensation at t-1	0.0000	0.0000	0.0000
	(0.57)	(0.50)	(0.25)
Firm Random Effects	Yes	Yes	Yes
Financial Controls	No	Yes	Yes
Year Fixed Effects	No	No	Yes
N	13586	13098	13098

t statistics reported in parentheses

standard errors are bootstrap (400 repetitions)

accounting incident is a restatement that is investigated byt the SEC

* p<0.10 **p<.05 ***p<.01

Table 11: The Relationship of *P* and Financial Accounting Events: Linear Panel Model

Dependent Variable: Accounting Incident (1,0)	(1)	(2)	(3)
Ratio ***P*** of Equity Comp at t-1	0.0058***	0.0066***	0.0037***
	(4.76)	(4.77)	(2.95)
Total Compensation at t-1	0.0000	0.0000	0.0000
	(0.86)	(0.85)	(0.66)
Firm Random Effects	Yes	Yes	Yes
Financial Controls	No	Yes	Yes
Year Fixed Effects	No	No	Yes
N	13586	13098	13098

t statistics reported in parentheses

standard errors are clustered at the firm level

accounting incident is a restatement that is investigated byt the SEC

* p<0.10 **p<.05 ***p<.01

Table 12: The Effect of Policy Changes on Potential Accounting Misconduct

Dependent Variable: Accounting Incident (1,0)				
	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	1.4339**	1.4874**	0.0036***	0.0037***
	(1.97)	(2.24)	(2.80)	(2.96)
Post Sarbanes Oxley (1,0)	-0.2383	-0.2114	-0.0026	-0.0020
	(-0.60)	(-0.55)	(-0.86)	(-0.62)
Post FAS 123R (1,0)	-1.7309	-22.9125***	-0.0049***	-0.0063***
	(-0.70)	(-10.28)	(-3.97)	(-3.87)
Panel Regression Model	Logit	Logit	Linear	Linear
Firm Random Effects	Yes	Yes	Yes	Yes
Financial Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	No	Yes	No	Yes
N	13098	13098	13098	13098

t statistics reported in parentheses

Standard errors for logit are calculated via bootstrap method (400 repetitions)

Standard errors for linear are clustered at the firm level

accounting incident is a restatement that is investigated byt the SEC

* p<0.10 **p<.05 ***p<.01

Table 13: Relationship of *P* and Magnitude of Financial Accounting Events

Dependent Variable: ln(1+abs(negative earnings restatement))	(1)	(2)	(3)	(4)
Ratio ***P*** of Equity Comp at t-1	0.7114**	0.7080**	0.5645*	0.5920*
	(2.38)	(2.48)	(1.88)	(1.76)
Total Compensation at t-1	0.0001***	0.0000**	0.0000**	0.0000***
	(4.17)	(2.38)	(2.24)	(2.99)
Regression Model	OLS	OLS	OLS	OLS
Financial Controls	No	Yes	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes
Industry Controls	No	No	no	Yes
N	283	274	274	274

t statistics reported in parentheses

robust standard errors

* p<0.10 **p<.05 ***p<.01