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The role of information: When is Directors' and Officers' insurance value-added?

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ABSTRACT

The paper presents a model of shareholders' decisions to purchase Directors' and Officers' liability insurance (D&O insurance) for their directors. We consider the tradeoff between the governance enhancing effect and the moral hazard effect of D&O insurance and focus on the role of information in determining the optimal level of D&O insurance purchase. The model shows that when directors are well informed, the governance enhancing effect of D&O insurance dominates the moral hazard effect, and thus, D&O insurance adds value to the firm. When directors are under-informed, the best strategy for shareholders is not to provide D&O insurance for directors. The model further shows that the optimal level of D&O insurance, when it exists, increases in the quality of the information received by directors. These results imply cross-firm variations in D&O insurance purchase.

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1. Introduction

The view that D&O insurance compromises the effectiveness of boards of directors pervades the corporate governance literature and has fostered a belief that D&O insurance is associated with poor corporate governance. Studies show that firms with greater D&O purchase experience increased likelihood of litigation (Gillan and Panasian, 2015), more managerial opportunism (Chalmers et al., 2002; Lin et al., 2011), and extra risk-taking (Hwang and Kim, 2018; Boyer and Tennyson, 2015). Many researchers raise the concern that D&O insurance weakens the disciplinary effect of shareholder litigation and creates moral hazard issues (e.g., Barrese and Scordis, 2006; Baker and Griffith, 2007a; Bradley and Chen, 2011; Jia and Tang, 2017).

Despite the criticisms, D&O insurance has become increasingly common and an essential part of directors' compensation scheme,[1] which suggests that the merits of D&O insurance should not be overlooked. Relatively few researchers draw attention to the positive influence of D&O insurance on corporate governance, which we refer to as the "governance enhancing effect". D&O insurance can benefit corporate governance in multiple ways. First, D&O insurance helps a firm recruit and retain competent directors (Brook and Rao, 1994) and lower the cost of hiring.[2] Second, D&O insurers serve as monitors of the insured firm and discipline the firms on their governance practice (e.g., Holderness, 1990; O'Sullivan, 1997; Core, 2000).[3] Finally, the absence of D&O insurance can encourage conservative governance by directors, which is unlikely to be in the

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[1] As many as 95% of Fortune 500 companies maintain D&O insurance policies, according to "Directors and Officers Liability Insurance" (http://corporate.findlaw.com/corporate-governance/directors-and-officers-liability-insurance.html, accessed in October 2017)

[2] Without liability insurance, risk-averse directors may decline the position or ask for a large amount of compensation (i.e., risk premium) for taking the liability risk. Insurance companies are risk neutral and price the liability risk based on the expected loss. Therefore, the premium of D&O insurance should be lower than the risk premium that would be asked by a risk-averse director.

[3] D&O insurers are competent professionals in controlling for moral hazard issues arising in insurance. Insurers carefully scrutinize the firm's governance structure during the underwriting and pricing process. Evidence has accumulated that the D&O insurance premium rate reflects the quality of a firm's governance (O'Sullivan, 1997; Baker and Griffith, 2007b; Gillan and Panasian, 2015). Firms with poor governance and directors with a history of liability lawsuits will be charged a higher price and offered limited coverage. Sometimes the insurer may require the applying firm to improve its governance procedures as a condition to offer coverage. Moreover, insurance companies update their knowledge of the insured firms and apply experience rating in contract renewal. Firms and directors with a good record of governance and low litigation risk will be offered price discount in renewal, while firms and directors with a record of claims or lawsuits in the past period will be charged a higher rate or even be rejected in renewal. The underwriting and pric-

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best interests of shareholders (O'Sullivan, 1997). With D&O insurance, directors can become less risk-averse and less likely to forego risky but value-adding investment opportunities.

The presence of both positive and negative sides of D&O insurance suggests that the net effect of D&O insurance on corporate governance could be either direction. Little is known about when D&O insurance can be value-added to a firm, and how. In other words, the mechanism of D&O insurance affecting the effectiveness of board of directors remains unclear. Furthermore, the determinants of optimal D&O insurance demand are also largely unknown. The goal of this paper is to address these issues by modeling a mechanism through which D&O insurance affects directors' monitoring decisions.

To this end, we focus on the role of information in the relationship between D&O insurance and directors' monitoring. Information is the key factor linking the moral hazard effect and the governance enhancing effect of D&O insurance. On the one hand, the root cause of moral hazard in insurance is asymmetric information. On the other hand, the effectiveness of the directors' monitoring directly depends on the information quality received by directors (Duchin et al., 2010). Good information can not only lessen moral hazard of directors but also makes it easier for directors to fulfill their duties and reduce litigation risk. We, therefore, incorporate information quality as a key factor in the decision-making model of directors and shareholders.

We develop a model in which outside directors choose an optimal level of monitoring effort in the context of shareholders' and CEOs' decisions. D&O insurance is endogenized in the shareholders' decisions to maximize firm value. D&O coverage and the information quality received by directors are incorporated into the directors' monitoring cost function. Our main findings are as follows: first, when directors are well-informed, the governance enhancing effect of D&O insurance dominates the moral hazard effect, and consequently, the purchase of D&O insurance will improve outside directors' oversight. On the other hand, when directors are under-informed, the moral hazard effect of D&O insurance dominates, and the optimal choice for shareholders is not to provide D&O coverage for outside directors. Second, only when the information quality falls into a certain range, there exists an optimal level of D&O insurance purchase for directors. In other words, when directors receive very poor or considerably good information, D&O insurance may not improve corporate governance and firm value. Third, the optimal level of D&O insurance, when exists, increases in the information quality.

Our paper contributes to the corporate governance literature at least in three aspects. First, our model derives conditions for when D&O insurance adds value to a firm. Our paper is the first to point out that the effect of D&O insurance on corporate governance is determined by the tradeoff between the moral hazard effect and the governance enhancing effect of D&O insurance. We then show that the tradeoff is affected by the information quality received by directors. When well-informed, outside directors are more likely to effectively oversee the firm and rely less on D&O insurance to cover their liabilities for wrong decisions, where the governance enhancing effect of D&O insurance dominates the moral hazard effect. On the other hand, when directors are under-informed about the firm's activities, naturally directors would rely more on D&O insurance to protect them from litigation risk, where the moral hazard effect dominates the governance enhancing effect of D&O insurance. We show that D&O insurance improves corporate governance when directors are well-informed and impairs corporate governance when directors are under-informed. This result explains the ambiguous evidence of the relationship between D&O insurance and corporate governance.

The second contribution of this paper is to provide insight into an essential question in corporate governance—how to make boards effective. Although outside directors have been the great hope of corporate governance reformers, there is no reliable evidence that outside directors help firm performance (Brickley et al., 1994; Yermack, 1996; Black and Bhagat, 2002; Hermalin and Weisbach, 2003; Laux, 2010). A relatively recent study by Duchin et al. (2010) suggests that the effectiveness of outside directors depends on the cost of acquiring information. They find evidence that outside directors improve firm performance when the information cost is low and degrade firm performance when the information cost is high. Our model supports their view and extends their analysis to show that information quality is also essential in determining the optimal compensation scheme for outside directors. Our analysis shows that when information is fairly transparent to directors, a right level of D&O coverage accompanied by appropriate equity compensation will motivate outside directors to exercise a higher level of monitoring effort. On the other hand, when directors are not able to get sufficient information, the optimal strategy for shareholders is to award equities to outside directors with no D&O insurance protection. Our model also shows another extreme, in that when directors are near perfectly informed, D&O insurance will become redundant. These results explain the cross-firm variations in D&O insurance purchase and have important implications for the design of incentive compensation scheme for outside directors.

Our analysis also contributes to the literature on director compensation. Many studies (Perry, 2000; Yermack, 2004; Linck et al., 2009; Dah and Frye, 2017) document significant increases in director pay, especially equity-based compensations, after the Sarbanes-Oxley Act (SOX) of 2002. A theoretical work by MacMinn et al. (2012) demonstrate the benefits of use incentive compensation for directors. By providing directors with a financial stake in the firm performance through incentive-based compensation, firms can align the interests of directors with those of shareholders. Consistent with this view, Bhagat and Bolton (2013) report a positive relationship between director ownership and firm performance. Other studies, however, have shown that directors are overcompensated, and the excess director compensation leads to worse firm performance (Brick et al., 2006; Dah and Frye, 2017). How to design an effective compensation scheme to motivate directors? The results of our study add a piece to the solution: a right level of D&O insurance coverage, combined with equity compensation, will provide the right incentives for directors to monitor. Furthermore, the substitute effect of D&O insurance on equity compensation can mitigate the issue of overcompensation. In sum, D&O insurance, as a part of director remuneration, is a useful mechanism to motivate directors, which should not be neglected.

While the theoretical literature on D&O insurance is thin, our work is closer to Gutiérrez (2003) and MacMinn et al. (2012). Gutiérrez (2003) analyzes the rationale of widespread use of D&O insurance in the United States. He adapted a principal-agent framework similar to ours in which the directors' compensation and D&O coverage are chosen by the shareholders. He also uses the assumption of risk neutrality as we do. Gutierrez focuses on how D&O insurance alters shareholders' incentive to litigate. In his model, the key variable of interest is the shareholder's decision to litigate against directors. Gutierrez shows, that given the high damage award in U.S., the use of D&O insurance and limited liability provisions leads to a more efficient litigation strategy for shareholders.

Our model differs from Gutiérrez's in that we focus on how D&O insurance alters directors' incentive to monitor. We characterize the litigation risk by assuming that litigation against directors

ing process conducted by insurance companies forces the insured firms to improve their governance structure.

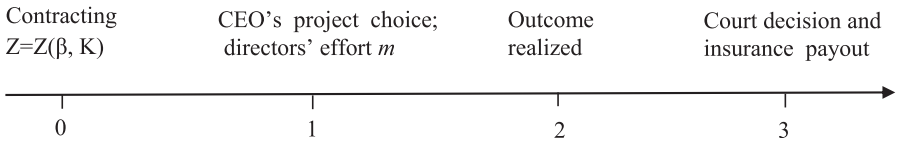

Fig. 1. Timeline of decision making.

occurs in a stochastic manner with a known probability. To focus on the determinants of directors' choices, we incorporate D&O insurance coverage and information quality into the directors' monitoring cost function. This approach allows us to characterize the governance enhancing effect of D&O insurance in the model. In contrast, the directors' monitoring cost is a fixed variable in Gutiérrez's model.

MacMinn et al. (2012) develop a model to demonstrate that directors' monitoring decisions are motivated by their pecuniary compensations. They argue that D&O insurance, only used as a hedging vehicle, does not alter the directors' decision to concur with or diverge from the CEO. The fact that the CEO controls the appointment of directors will also alter directors' incentive. Our model differs from their work in several ways. First, in MacMinn, Ren and Han's model, D&O insurance is not provided by shareholders but is selected by directors. In other words, personal access to D&O insurance is possible. In our model, D&O insurance is only provided by firms (shareholders). Second, no monitoring cost is assumed in MacMinn et al. (2012), while we emphasize on directors' monitoring cost and include D&O insurance and information quality in the cost function. Third, they do not conduct an equilibrium analysis as we do.

The remainder of the paper is organized as follows. Section 2 presents the model, and Section 3 extends the model. Section 4 discusses the policy implications of our findings. Section 5 concludes. All proofs are presented in the Appendix A.

2. The model

2.1. Model setup

We consider three types of agents—shareholders, CEO, and directors in a four-stage decision-making model. Following prior studies (e.g., Gutiérrez, 2003; Kumar and Sivaramkrishnan, 2008), we assume all agents are risk neutral, which provides great simplicity for model analysis.[4] The timeline of the decision-making is described in Fig. 1. At date 0, shareholders offer a reward contract $Z = Z(K, \beta)$ to a director, where K represents the amount of D&O insurance coverage, and $\beta \in (0, 1)$ represents the percentage of firm equity awarded to directors. This reward contract meets both the directors' individual rationality constraint and incentive compatibility constraint such that she decides to accept it. To focus on the decision of D&O insurance purchase, we assume the equity compensation is given. To further simplify the analysis, we leave out base salary for directors. The base salary for directors is largely determined by the job market and can be considered fixed. In the past, the trend has been toward greater focus on equity award,[5] which provides direct economic alignment to the shareholders who directors represent (e.g., Black and Bhagat, 2002; Ryan and Wiggins, 2004; Kumar and Sivaramkrishnan, 2008). We, therefore, emphasize on equity compensation rather than base salary. We further assume that the CEO is not involved in director selection to exclude the potential influence of CEOs on directors' monitoring incentive.[6]

At date 1, the CEO makes the project selection under the oversight of directors; the directors receive information and choose a level of effort to monitor and advise the CEO's project selection. We capture the level of directors' monitoring effort by a probability $m \in [0, 1]$. With probability m, the board gains control over project selection and chooses the project that shareholders prefer. With probability $(1 - m)$, the CEO retains decision rights to choose his preferred project. Assume there are two types of projects: high-risk and low-risk projects. A high-risk project fails with a probability of p_H, and a low-risk project fails with a probability of p_L $(p_L < p_H)$. The CEO will receive a private benefit $B > 0$ from a high-risk project and zero private benefit from a low-risk project.

Following Aghion and Bolton (1992), we assume shareholders rely on directors to oversee the CEO's decision-making. If directors' monitoring is effective, the board will make the CEO choose a low-risk project that shareholders prefer. On the other hand, when directors' monitoring is insufficient, the CEO will be able to choose a high-risk project from which she will receive a private benefit.

At date 2, the project outcome is realized and generates firm value R if the project succeeds; otherwise, the firm value is zero.

At date 3, if the project fails, directors may face lawsuits from shareholders. We assume that in case of litigation, directors will be successfully sued and pay a penalty D with a probability q. Note that directors will only be found culpable when the court finds that a high-risk project is selected, because a low-risk project is consistent to the shareholders' best interest. The award for damage D is fixed and known by both the shareholders and the directors. D&O insurers will pay up to K for the penalty. The rest $(D–K)$ will be paid out of the pocket of the alleged directors. Directors are protected by limited liability, which means they will never pay more than their initial wealth.

We make further assumptions to construct the model. First, we assume directors have a level of initial wealth. In the absence of insurance, in case directors are successfully sued and have to pay penalty D, they may go bankrupt, which imposes a deadweight cost to the directors. Directors can eliminate this deadweight cost by holding insurance. This provides an incentive for risk-neutral di-

[4] The incentive to buy insurance is often assumed to be risk aversion. This view holds when the market is perfectly competitive. Mayer and Smith (1982) and MacMinn (1987) show that in presence of bankruptcy cost and agency cost, how insurance can be used to lower such costs. In addition, insurance contracts can (1) provide real service efficiencies in claims administration, (2) monitor the compliance of contractual provisions, (3) bond the firm's real investment decisions, (4) lower the corporations' expected tax liability, and (5) reduce regulatory cost. These explain why risk-neutral agents have incentives to buy insurance.

[5] In a survey of 558 corporations in 2002 (Peck et al., 2002), 84% of the companies make some form of stock payment to outside directors. In manufacturing companies, this figure increases to 91%. In another survey of director compensation in 200 major US industrial and service firms in 2005, the compensation consultants Pearl Meyer & Partners report a 58% increase in the value of stock awards to directors between 2004 and 2005 (Kumar and Sivaramkrishnan, 2008).

[6] Although strategic interactions between directors and CEOs are not the focus of our paper, models exist that examine the role of CEO in affecting directors' monitoring incentives. For example, MacMinn et al. (2012) show that when the CEO controls the selection of board members, board members will concur with the CEO's decisions to maintain their seats on the board. A recent work by Chemmanur and Fedaseyeu (2017) models a situation where a CEO imposes costs of dissent on a director who votes to fire but fails to oust her. In that case, in lack of conformity within the board, each board member will vote to retain an incompetent CEO. An empirical study by Shivdasani and Yermack (1999) show that firms with higher CEO involvement in board selection will appoint less independent outside directors and more gray directors. The stock market reaction suggests that shareholders are not in favor of such involvement.

rectors to demand D&O insurance protection. Second, to focus on the directors' monitoring decisions, we simplify the CEO's role in our model.[7] Before shareholders contract with directors at date 0, we assume the CEO holds a reward contract with a proportion α of firm equity. This reward contract meets both the CEO's individual rationality constraint and incentive compatibility constraint. Last, we also assume a competitive insurance market, where the D&O insurance premium rate ρ is determined by the condition of zero profit. At date 0, shareholders determine the D&O insurance coverage K and pay premium G ($G=\rho K$).

2.2. Subgame perfect equilibrium

2.2.1. CEO's decision making

At date 1, the CEO chooses an investment project under the oversight of the board. Because of asymmetric information, the CEO's choice is unobservable but verifiable afterwards. The project risk and the outcomes are publicly observable but do not perfectly reveal the manager's private information.

The firm's expected value V_i as of date 1 is:

$$EV_i = (1-p_i)R \qquad i = H, L \tag{1}$$

where i represents either a high-risk project (H) or a low-risk project (L), and R is the firm value if the investment project succeed. If the project fails, firm value will be zero. From Eq. (1), we have

$$EV_L - EV_H = (p_H - p_L)R \tag{2}$$

If the CEO chooses a high-risk project, she will receive a private benefit B, and her expected utility realized at date 2 is

$$EU^H_{CEO} = \alpha EV_H + B = \alpha(1-p_H)R + B \tag{3a}$$

where α is the proportion of firm shares owned by the CEO. Similarly, if the CEO goes with the low-risk project, her expected utility is

$$EU^L_{CEO} = \alpha EV_L = \alpha(1-p_L)R \tag{3b}$$

Assume the private benefit B to the CEO is sufficient large and the condition $B > \alpha(p_H - p_L)R$ holds. Under this assumption, there is a conflict of interest between the CEO and the shareholders because the CEO prefers high-risk project. In the absence of directors' oversight, the CEO will choose the high-risk project over the low-risk project. The CEO's expected payoff is

$$EU_{CEO} = mEU^L_{CEO} + (1-m)EU^H_{CEO} \tag{4}$$

Eq. (4) shows that the CEO's expected payoff depends on the level of directors' monitoring effort m. If the level of monitoring effort m is higher (lower), the CEO is more likely to choose the low-risk (high-risk) project.

2.2.2. Director's decision making

The director supervises the running of the company on behalf of shareholders. The director chooses a level of monitoring effort at a cost and faces a litigation risk in case the project fails. Since the director is risk-neutral, we can normalize any fixed component of her compensation (e.g. initial wealth and base salary) to zero. Thus, a director's expected payoff function EU_D is

$$EU_D = \beta[mEV_L + (1-m)EV_H\} - TC(m,K) - (1-m)p_H qMax(D-K,0) \tag{5}$$

The expected payoff function EU_D consists of three parts, which shape the director's decision-making. The first term represents the director's equity compensation, which is a proportion β of the expected firm value. The second term is the director's monitoring cost. The third term represents the expected litigation cost faced by a director.[8]

The director's monitoring cost *TC(m, K)* is a function of the monitoring effort m and D&O insurance coverage K. To obtain a closed-form solution and subsequent tractable results, we assume *TC(m, K)* taking the following form:

$$TC(m,K) = \frac{1}{2}c(K)m^2, \tag{6}$$

where

$$c(K) = ce^{-\lambda K} \tag{7}$$

It should be noted that when we specify a functional form of directors' monitoring cost, the results derived from the model is insightful and not necessarily generalized.

The above monitoring cost function has the following features: first, *TC(m, K)* takes a general quadratic form, which is increasingly convex in m, i.e., $\frac{\partial TC(m,K)}{\partial m} = c(K)m > 0$ and $\frac{\partial^2 TC(m,K)}{\partial m^2} = c(K) > 0$. The term *c(K)* serves as a unit cost for each unit of monitoring output.[9]

Second, we incorporate information quality into the cost function.[10] Let $\lambda \in (\underline{\lambda}, \bar{\lambda})$ represent the quality of information received by the directors. Intuitively, the total monitoring cost of directors deceases in λ, i.e., $\frac{\partial TC}{\partial \lambda} = -Km^2\tau e^{-\lambda K} < 0$. Moreover, Eq. (6) implies that the marginal cost of monitoring effort also decreases in information quality, i.e., $\frac{\partial \frac{\partial TC(m,K)}{\partial m}}{\partial \lambda} = -Km\tau e^{-\lambda K} < 0$. With high-quality information, directors can better apply their skills, knowledge and experience to oversee the firm's activities. Recent literature (Adams and Ferreira, 2007; Adams et al., 2010; Harris and Raviv, 2008; Raheja, 2005) shows that the board needs to be well informed on material matters and given the appropriate information to function effectively.

Third, we further characterize the governance enhancing effect of D&O insurance into the monitoring cost function. Eq. (6) implies that both the total monitoring cost TC (m, K) and the marginal monitoring cost $\frac{\partial TC(m,K)}{\partial m}$ decrease in D&O coverage K.[11] As we explained earlier, D&O insurance can benefit corporate governance and reduce the monitoring cost of directors at least in three ways. First, higher D&O coverage helps the firm recruit and retain talented directors (Brook and Rao, 1994). Given the same level of monitoring effort, a more competent director will provide better monitoring service. Second, D&O insurance provides mechanisms to promote the internal monitoring by the insured firms/directors. For example, an insurance company may ask the insured firm to employ more rigorous governance policy as a condition for premium discount or policy renewal. Many studies (e.g. Holderness, 1990; Core, 2000; Baker and Griffith, 2007b; and Boyer and Stern, 2012) show that D&O insurers help outside directors assess corporate governance risks and facilitate internal monitoring. Lastly, with the protection of D&O insurance from the potential litigation, directors are more likely to provide independent judgment and avoid conservative management (e.g. Holderness, 1990; O'Sullivan, 1997).

[7] For simplicity and our research purpose, we assume the appointment of CEO and board members are exogenous to our model setup. Some recent papers, for example, Chemmanur and Fedaseyeu (2017), model the interactions between board members and CEO in appointment/replacement power.

[8] We assume that the penalty D is greater than the chosen D&O coverage K, i.e. $D>K$. This condition warrants a positive litigation cost for the director, i.e., $Max(D\text{-}K, 0) = D\text{-}K > 0$.

[9] To obtain tractable results, we employ the exponential form of $c(K) = \tau e^{-\lambda K}$ for its desirable properties in computation.

[10] We further discuss the determination of information quality λ in Part A Section III. We show that λ is influenced by both a CEO's choices and exogenous firm-specific factors, and as a result, λ is given before the decisions of directors.

[11] $\frac{\partial TC}{\partial K} = -\lambda m^2\tau e^{-\lambda K} < 0$, and $\frac{\partial \frac{\partial TC(m,K)}{\partial m}}{\partial K} = -\lambda m\tau e^{-\lambda K} < 0$.

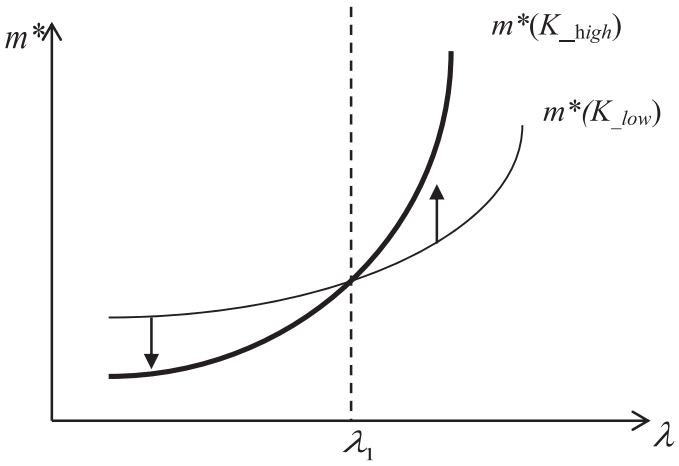

Fig. 2. Effect of D&O insurance on director's monitoring effort.

The moral hazard effect of D&O insurance is reflected in the third term in Eq. (5). The expected litigation cost, *i.e.*, $(1-\mathrm{m})p_H qMax(D-K,0)$, decreases in the monitoring effort m and D&O coverage K. Note that the optimal level of monitoring effort m depends on λ, which means the moral hazard effect of D&O insurance is also affected by information quality λ. When well informed, directors can monitor the management more effectively and thus rely less on D&O insurance to cover their liabilities for wrong decisions, naturally reducing the moral hazard effect of D&O insurance.

In sum, we consider both the positive governance enhancing effect and the negative moral hazard effect of D&O insurance in directors' monitoring decisions. We also incorporate information quality into the model, which allows us to investigate the role of information in determining the optimal level of D&O insurance coverage.

Lemma 1. (Conditions for Effective Director Compensation): Given the range of the degree of information quality $\lambda \in (\underline{\lambda}, \bar{\lambda})$, there exists a threshold $\lambda_1 = \frac{1}{(D-K)}$, such that

If $\lambda_1 < \lambda \le \bar{\lambda}$, *then* $\frac{dm^*(K)}{dK} > 0$; *if* $\underline{\lambda} \le \lambda < \lambda_1$, *then* $\frac{dm^*(K)}{dK} < 0$.

The result of Lemma 1 comes from the cost-benefit analysis of D&O insurance purchase. When the information quality is higher than the threshold, one additional unit of insurance coverage leads to greater governance enhancing effect than the moral hazard effect. Then it is optimal to increase monitoring effort. On the other hand, when the information quality is lower than the threshold, one unit increase of insurance coverage leads to more moral hazard effect than the governance enhancing effect, and results in a lower level of monitoring effort.

The effect of D&O insurance on board oversight is illustrated in Fig. 2. Each line represents the relationship between the optimal level of monitoring effort (m^*) and information quality (λ) at a given level of D&O coverage (K). The level of monitoring effort monotonically increases in the information quality. The bold line represents the relationship in context of a larger amount of K, while the thinner line is in context of a lower amount of K. As Fig. 2 shows, when information quality is greater than the threshold λ_1, the bold line is above the thinner line, which means that with a greater amount of D&O coverage directors will exert a higher level of monitoring effort. On the other hand, when λ is lower than λ_1, the thinner line is above the bold line, which indicates that a greater amount of D&O coverage leads to a lower level of monitoring effort. The figure illustrates how the impact of D&O insurance on directors' monitoring effort is affected by information quality.

Lemma 1 shows that the reward contract decided at date 0 will have an impact on directors' monitoring effort. In the next, we use Lemma 1 to analyze the equilibrium of the model.

2.2.3. Shareholders' decision making

The optimization problem for shareholders at date 0 is to choose D&O insurance coverage K to maximize expected firm value EV_s, which can be written as

$$EV_S = (1-\alpha-\beta)\{m^*(K)EV_L - [1-m^*(K)]EV_H\} - G + [1-m^*(K)]p_H qD \quad (8)$$

The first term in Eq. (8) represents the fraction of the expected value of the project that goes to shareholders. The second term is the cost of D&O insurance (insurance premium). The third term represents the expected damage award paid by directors if the shareholders sue the directors after the project fails. Differentiate Eq. (8) with respect to K and obtain the first order condition ($\mathrm{FOC_k}$) as follows.

$$\frac{dEV_S}{dK} = [(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\frac{dm^*(K)}{dK} - \rho = 0 \quad (9)$$

Lemma 1 shows that when the information quality falls in the range $\lambda_1 < \lambda \le \bar{\lambda}$, we have $\frac{dm^*(K)}{dK} > 0$, then there exists an interior solution K^* satisfying Eq. (9). The optimal D&O insurance coverage K^* can be solved from Eq. (9). Proposition 1 describes the condition for the existence of a unique solution of K and solves out the optimal monitoring effort for directors, i.e., $m^*(K^*)$.

Proposition 1. (Existence of Optimal D&O Insurance Coverage): There exists a unique Subgame Perfect Equilibrium (SPE), $\{K^*, m^*(K^*)\}$, where

(a) *the optimal D&O insurance coverage* $K^* > 0$ *exists when* $\lambda_1 < \lambda < \lambda_2$, *and*

$$\lambda_2 = \frac{2p_H q}{\beta(p_H - p_L)R + p_H q(D-K)}$$

(b) *the optimal monitoring effort* $m^*(K^*)$ *is*

$$m^*(K^*) = \tau^{-1}e^{\lambda K^*}[\beta(p_H - p_L) + p_H q(D-K^*)]$$

Proposition 1 has several important implications. First, we derive the conditions for when D&O insurance can contribute to firm value. When the information quality falls in the range of (λ_1, λ_2), D&O insurance is value-added to firm. Second, we obtain cross-sectional implications for a firm's choice of D&O insurance purchase. When λ falls out of the range of (λ_1, λ_2), our model suggests zero optimal D&O coverage. After SOX, many firms are mandated to hire more outside directors. To recruit directors, firms purchase a greater amount of D&O insurance, especially among smaller firms (Linck et al., 2009). Our result casts doubt on the effectiveness of D&O insurance if directors cannot receive sufficient information to monitor. Proposition 1 also implies that when the information quality is super good, D&O insurance will become redundant.

2.3. Equilibrium analysis

In this section, we conduct an equilibrium analysis for the model. We are particularly interested in the impact of information quality on the optimal D&O coverage as well as the relationship between D&O coverage and equity compensation.

Proposition 2. (Relation of Optimal D&O Insurance Coverage and Information Quality): Given that there exists an internal solution for D&O insurance coverage K*, the optimal D&O insurance coverage increases in information quality. i.e., $\frac{dK^*}{d\lambda} > 0$.

The intuition behind Proposition 2 is that when the information is fairly transparent to directors, the governance enhancing effect

of D&O insurance dominates. Under this condition, firms with better information quality should buy more D&O insurance coverage. Proposition 2 suggests cross-firm variation in D&O insurance purchase.

Proposition 3. (Relation of Optimal D&O Insurance and Equity Compensation): When there exists an interior solution for the optimal D&O insurance coverage K*, and directors' equity compensation β is larger than a threshold $\hat{\beta}$, i.e., $\beta > \hat{\beta}$, K* is a substitute for β.

Proposition 3 suggests a substitute, rather than a complementary, relationship between D&O insurance and equity compensation when the equity compensation is higher than a certain threshold. This result is intuitive because while equity compensation and D&O insurance are both a form of monetary compensation, the later one is a contingent benefit. In recent years, due to the increasing criticism on the directors' and officers' "fat cat pay", companies face a lot of pressure in offering generous compensation to directors. Our results show that D&O insurance can be used as a substitute for directors' incentive pay, which may help relieve such pressure for companies.

3. Model extensions

In this section, we extend the model to examine the influence of CEOs on information quality. We also discuss the exogenous impact of insurance cost, monitoring cost, and CEO equity compensation on D&O insurance demand.

3.1. CEO and information quality

A key variable of interest in our model is the information quality (λ). The information received by directors can be affected by shareholders, regulators, and CEOs (Hermalin and Weisbach, 2012). Some studies show that CEOs exert significant influence in disclosing information to directors (e.g. Adams and Ferreira, 2007; Adams et al., 2010; Harris and Raviv 2008; Hermalin and Weisbach, 2012). In our model set-up, the CEO's decision to share information with directors is exogenously determined depending on the relative personal payoff from the high-risk project compared to that from the low-risk project. Given that a CEO makes the project selection under the oversight of directors, if the personal payoff from the high-risk project is greater than that from the low-risk project, the CEO will minimize information sharing so that the high-risk project has a better chance of being passed by the board. On the other hand, if the CEO can benefit more from the low-risk project, she will maximize information sharing with directors to receive support from the board. In other words, the CEO's decision on information disclosure (λ) will be a corner solution, either the upper limit or the lower limit of λ, as demonstrated below.

The CEO's expected payoff, derived from Eqs. (3a), (3b), and (4), is

$$\begin{aligned} EU_{CEO} &= m^* EU^L_{CEO} + (1-m^*)EU^H_{CEO} \\ &= m^*\alpha EV_L + (1-m^*)(\alpha EV_H + B). \end{aligned} \tag{10}$$

The first derivative of CEO's expected payoff with respect to λ is

$$\frac{dEU_{CEO}}{d\lambda} = \frac{dm^*}{d\lambda}[\alpha(EV_L - EV_H) - B] \tag{11}$$

As Eq. (A1) in the Appendix A shows that $\frac{dm^*(K)}{d\lambda} > 0$, the sign of $\frac{dEU_{CEO}}{d\lambda}$ is determined by $\alpha(EV_L - EV_H) - B$. The first term, $\alpha(EV_L - EV_H)$, represents the value for CEO if she chooses the low-risk project over the high-risk project. This benefit depends on the shares of equity she owns in firm (α). B represents the private benefit from the high-risk project. When the CEO owns a significant amount of equity in the firm, i.e., $\alpha(EV_L - EV_H) > B$, the CEO's interest is more aligned with the interest of shareholders. In this case, the CEO will maximize information sharing with directors (and consequently a higher level of monitoring effort, m) so that the low-risk project can be selected. Otherwise, it's optimal for the CEO to minimize information disclosure to directors so that the high-risk project can be selected. Eq. (11) shows that a CEO's decision about information sharing depends on her equity compensation (α) as well as relative payoffs of the two projects (i.e., $a(EV_L - EV_H)$ and B). Because these factors are given for the model, a CEO's information disclosure strategy, characterized by λ, is also exogenously determined.

Moreover, in the real world, the information disclosure to directors is not only at the discretion of CEOs but also subject to many other factors, for example, corporate governance structures, corporate governance policies and codes, corporate culture, and complexity of the business a firm is engaged in. These factors, varying by firms, impose an upper limit and a lower limit for λ within a firm.

Taking the above together, the information regime for directors is firm specific and exogenous to the model. We demonstrate that the optimal demand for D&O insurance varies across firms depending on the nature of information disclosure within a firm.

3.2. The impact of D&O insurance price, monitoring cost, and CEO's equity compensation

Like many lines in property-liability insurance, the D&O insurance market follows underwriting cycles (Fier et al., 2015). The premium rate is significantly higher in hard markets and lower in soft markets. Our model shows that due to the substitute relationship between D&O insurance and equity compensation, the optimal D&O insurance coverage (K^*) decreases in premium rate (ρ). The following proposition describes such a relation.

Proposition 4. (Impact of D&O Insurance Price ρ on Optimal D&O Coverage): Given an equity compensation β, the optimal D&O insurance coverage decreases in D&O insurance premium rate ρ, i.e., $\frac{dK^*}{d\rho} < 0$.

The directors' monitoring cost function in Eq. (6) includes a factor (τ), which is positively related to monitoring cost. The factor c captures the differences in firm characteristics and governance practice across firms, which may influence directors' monitoring cost. For example, a firm employing more rigorous governance procedures should impose a lower monitoring cost (lower τ) for directors. A firm with a complicated ownership structure and a complex business nature is expected to have a greater c. The following proposition describes the relation between the monitoring cost τ and the optimal D&O insurance purchase.

Proposition 5. (Impact of Monitoring Cost Factor τ on Optimal D&O Coverage): Given an equity compensation β, the optimal D&O insurance coverage decreases in the monitoring cost component τ, i.e., $\frac{dK^*}{d\tau} < 0$.

Proposition 5 shows that optimal D&O insurance coverage decreases in the monitoring factor c. In addition to information quality, other factors may also influence the monitoring cost and thereby affect the optimal D&O insurance demand. In a firm where it's difficult or costly for directors to monitor the management effectively, a lower level, rather than a higher level, of D&O insurance protection is desired for shareholders. The intuition behind the result is that when directors' monitoring cost is high, the moral hazard of D&O insurance is likely to dominate the governance-enhancing effect.

Proposition 6. (Impact of CEO's Equity Compensation α on Optimal D&O Coverage): Given an equity compensation β, the optimal D&O insurance coverage decreases in CEO's equity compensation α, i.e., $\frac{dK^*}{d\alpha} < 0$.

Proposition 6 suggests a substitute relationship between CEO's incentive pay and D&O insurance for directors. Intuitively, when a CEO is provided a good incentive to act in the best interest of shareholders, there will be less demand for D&O insurance protection for directors. This result also implies that the optimal D&O insurance coverage varies across firms depending on the equity compensation to CEOs.

4. Policy implications

The findings of our study provide several important policy implications on D&O insurance and corporate governance regulation. First, there has been a voice for the abolition of D&O insurance, which claims that D&O insurance does not hold directors and officers fully accountable for the results of their actions. Our model shows that under certain conditions D&O insurance can improve corporate governance. We suggest that instead of prohibiting D&O insurance, efforts may focus on how to make D&O insurance effective and value added to a firm.

Second, our results shed light on the issue how to make D&O insurance and boards of directors effective. Our model suggests that when directors are fairly well informed, a right level of D&O coverage plus equity compensation will motivate directors to exert adequate care. Existing studies show that information disclosure to directors is essential for board effectiveness (e.g., Duchin et al., 2010). Our results support this view and add that greater information transparency will also make D&O insurance improve corporate governance.

Lastly, we call for special regulation of D&O insurance underwriting and pricing practice. D&O insurance, if well designed and well functioning, offers various mechanisms to monitor and deter the wrongdoing of insured firms. D&O insurers price the coverage according to risk and, thereby, force corporations, through insurance premiums, to internalize the cost of their actions. Insurers also provide loss-prevention service to the insured firm. For example, insurers will require the insured firms to adopt a governance practice designed to promote good governance and prevent wrongdoing. D&O insurance, to its best, can preserve the deterrence of shareholder litigation, control the moral hazard problem, and enhance corporate governance of the insured corporation. We suggest that regulators oversee the pricing and underwriting practice of D&O insurance providers to make sure that insurers are offered best incentives to serve as the monitors for the insured firms. For this purpose, a special guideline and/or rules may be created for the D&O insurance underwriting and pricing practice.

5. Concluding remarks

As the existing research debates the impact of D&O insurance on corporate governance, it remains unclear whether D&O insurance adds value to a firm. Our paper is the first to point out that the impact of D&O insurance on corporate governance depends on the tradeoff between the governance enhancing effect and the moral hazard effect of D&O insurance. We further demonstrate that such a tradeoff is affected by information quality. Our findings help answer the question when D&O insurance is value enhancing to a firm.

We develop a model that examines the role of information in shareholders' D&O insurance purchase decisions. The model derives conditions for when D&O insurance can enhance corporate governance. The tradeoff between the moral hazard effect and the governance enhancing effect of D&O insurance is affected by information quality. When directors are well informed, the governance enhancing effect of D&O insurance dominates the moral hazard effect, and so it is optimal to purchase D&O insurance for directors. On the other hand, when directors cannot acquire sufficient information about the firm's activities, the moral hazard effect of D&O insurance dominates, and the optimal strategy for shareholders is not to provide D&O insurance to directors. This result indicates that not all firms should buy D&O insurance for their directors. Only firms in which directors can acquire adequate information can benefit from D&O insurance purchase.

The model also predicts that the optimal level of D&O insurance purchase, if it exists, increases in the information quality. It suggests that the optimal D&O insurance coverage varies across firms depending on the information quality received by directors. This prediction implies the cross-firm variation in D&O insurance purchases.

Our study explores a channel through which D&O insurance may be used more effectively to improve the effectiveness of boards, which is a significant issue deserving further research. It would be interesting to extend our model to allow endogenous D&O insurance pricing by insurers so that the roles of D&O insurers can be further investigated.

Appendix A

Proof of Lemma 1. In order to get tractable results, we assume *TC(m, K)* in the following form:

$$TC(m,K) = \frac{1}{2}c(K)m^2, \tag{6'}$$

where

$$c(K) = ce^{-\lambda K} \tag{7'}$$

The above monitoring cost function has the following features:

$$\frac{\partial TC(m,K)}{\partial m} = c(K)m > 0,\ \frac{\partial^2 TC(m,K)}{\partial m^2} = c(K) > 0$$
$$\text{and } \frac{\partial \frac{\partial TC(m,K)}{\partial m}}{\partial K} = -\lambda m\tau e^{-\lambda K} < 0.$$

Differentiate Eq. (5) with respect to m, and we get the first-order condition

$$\frac{dEU_D}{dm} = \beta(EV_L - EV_H) - \tau e^{-\lambda K}m + p_H q(D-K) = 0 \tag{A1}$$

Note that since we assume the condition $D > K$ to warrants a positive litigation cost, *Max(D-K, 0)* = *D-K* > 0.

The second-order condition is satisfied because $\frac{d^2EU_D}{dm^2} = -\tau e^{-\lambda K} < 0$, which means there exists a unique optimal solution *m*(K)*. From the first-order condition, the optimal monitoring effort is derived as

$$m^*(K) = \tau^{-1}e^{\lambda K}\ [\beta(EV_L - EV_H) + p_H q(D-K)] \tag{A2}$$

Differentiate *m*(K)* with respect to K

$$\frac{dm^*(K)}{dK} = \tau^{-1}e^{\lambda K}\{\lambda[\beta(p_H - p_L)R + p_H q(D-K)] - p_H q\} \tag{A3}$$

From Eq. (A3), there exists a cut-off point $\lambda_1 = \frac{p_H q}{\beta(p_H - p_L)R + p_H q(D-K)}$ so that when $\underline{\lambda} \le \lambda < \lambda_1$, $\frac{dm^*(K)}{dK} < 0$; when $\lambda_1 < \lambda \le \bar{\lambda}$, $\frac{dm^*(K)}{dK} > 0$. ***Q.E.D.***

Proof of Proposition 1. ***Part (a)***

The objective function for shareholders is to maximize expected value EV_S. That is

$$K \in argMax\ EV_S = (1-\alpha-\beta)\{m^*(K)EV_L - [1-m^*(K)]EV_H\} - G + [1-m^*(K)]p_H qD$$

Differentiate EV_s with respect to K and obtain the first-order condition

$$\frac{dEV_S}{dK} = [(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\frac{dm^*(K)}{dK} - \rho \le 0 \quad (FOC_K)$$

Lemma 1 implies $\frac{dm^*(K)}{dK} > 0$ when $\lambda_1 < \lambda \le \bar{\lambda}$, (FOC_K) is binding and there exists of an interior solution K^*. On the other hand, when $\underline{\lambda} \le \lambda < \lambda_1$, $\frac{dm^*(K)}{dK} < 0$, $(FOC_K) < 0$, only the corner solution $K^* = 0$ exists.

To prove the uniqueness of the optimal solution, we need to check the second-order condition. Differentiate EV_s with respect to K twice, and we obtain

$$\begin{aligned}\frac{d^2EV_S}{dK^2} &= [(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\frac{d^2m^*(K)}{dK^2} \\ &= \tau^{-1}e^{\lambda K}\lambda[(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\{\lambda[\beta(EV_L - EV_H) \\ &\quad + p_H q(D-K)] - 2p_H q\} \quad (SOC_K)\end{aligned}$$

By binding (FOC_K), we can find that there exists a threshold $\lambda_2 = \frac{2p_H q}{\beta(p_H - p_L)R + p_H q(D-K)}$ and $\lambda_2 > \lambda_1$. As $\lambda_2 < \lambda < \bar{\lambda}$, $\frac{d^2EV_S}{dK^2} > 0$. In contrast, as $\lambda_1 < \lambda < \lambda_2$, $\frac{d^2EV_S}{dK^2} < 0$. The uniqueness of optimal$K^* > 0$ can be proved. ***Q.E.D.***

Part (b)

Substitute the optimal insurance coverage K^* into Eq. (A2), we have $m^*(K^*) = \tau^{-1}e^{\lambda K^*}[\beta(p_H - p_L)R + p_H q(D-K^*)]$ ***Q.E.D.***

Proof of Proposition 2. Binding (FOC_K) with respect to K gives

$$\frac{dEV_S(K^*)}{dK} = [(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\frac{dm^*(K^*)}{dK} - \rho = 0 \quad (A4)$$

Then use total differential

$$\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\lambda}d\lambda + \frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}dK = 0,$$

we have

$$\frac{dK^*}{d\lambda} = -\frac{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\lambda}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}} \quad (A5)$$

By (SOC_K), we know the nominator $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K} = \frac{d^2EV_S(K^*)}{dK^2} < 0$. For the denominator,

$$\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\lambda} = [(1-\alpha-\beta)(EV_L - EV_H) - p_H qD] \quad (A6)$$

Because $\frac{\partial(\frac{dm^*}{dK})}{\partial\lambda} > 0$, we can find $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\lambda} > 0$. Then $\frac{dK^*}{d\lambda} > 0$ is proved. ***Q.E.D.***

Proof of Proposition 3. Given a $K^* > 0$, totally differentiate Eq. (A4) with respect to β and K, $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\beta}d\beta + \frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}dK = 0$, we have $\frac{dK^*}{d\beta} = -\frac{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\beta}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}}$.

As $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K} = \frac{d^2EV_S(K^*)}{dK^2} < 0$ and

$$\begin{aligned}\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\beta} &= (EV_L - EV_H)\tau^{-1}e^{\lambda K}\{\lambda[(1-\alpha-2\beta)(EV_L - EV_H) \\ &\quad - p_H q(2D-K)] + p_H q\}\end{aligned}$$

We can find a cut-off point $\hat{\beta}$,

$$\hat{\beta} = \frac{1}{2}[(1-\alpha) + \frac{p_H q}{\lambda(EV_L - EV_H)} - \frac{p_H q(2D-K^*)}{(EV_L - EV_H)}$$

Such that $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\beta} > 0$, if $0 < \beta < \hat{\beta}$, and $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\beta} < 0$, if $0 < \beta < \hat{\beta}$.

Therefore, $\frac{dK^*}{\partial\beta} > 0$, if $0 < \beta < \hat{\beta}$, and $\frac{dK^*}{\partial\beta} < 0$, if $0 < \beta < \hat{\beta}$. ***Q.E.D.***

Proof of Proposition 4. Given a level of directors' equity compensation β and an optimal insurance coverage K^*(where $\lambda_1 < \lambda < \lambda_2$), totally differentiate Eq. (A4) with respect to ρ and K,

$$\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\rho}d\rho + \frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}dK = 0.$$

Then we have $\frac{dK^*}{d\rho} = -\frac{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\rho}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}}$.

As $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K} = \frac{d^2EV_S(K^*)}{dK^2} < 0$ and $\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\rho} = -1 < 0$, $\frac{dK^*}{\partial\rho} < 0$ is proved. ***Q.E.D.***

Proof of Proposition 5. Given a level of directors' equity compensation β and an optimal insurance coverage K^* (where $\lambda_1 < \lambda < \lambda_2$), totally differentiate Eq. (A4) with respect to τ and K, and we have

$$\begin{aligned}\frac{dK^*}{d\tau} &= -\frac{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\tau}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}} \\ &= \frac{\tau^{-2}e^{\lambda K^*}[(1-\alpha-\beta)(EV_L - EV_H) - p_H qD]\{\lambda[\beta(EV_L - EV_H) + p_H q(D-K^*)] - p_H q\}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}} < 0\end{aligned}$$

Q.E.D.

Proof of Proposition 6. Given directors' equity compensation β and an optimal insurance coverage K^* (where $\lambda_1 < \lambda < \lambda_2$), totally differentiate Eq. (9) with respect to α and K, and we have

$$\begin{aligned}\frac{dK^*}{d\alpha} &= -\frac{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial\alpha}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}} \\ &= \frac{(EV_L - EV_H)\tau^{-2}e^{\lambda K^*}\{\lambda[\beta(EV_L - EV_H) + p_H q(D-K^*)] - p_H q\}}{\frac{\partial(\frac{dEV_S(K^*)}{dK})}{\partial K}} < 0\end{aligned}$$

Q.E.D.

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