Why agents need discretion: The business judgment rule as optimal standard of care*

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Should managers be liable for ill-conceived business decisions? One answer is given by U.S. courts, which almost never hold managers liable for their mistakes. In this paper, we address the question in a theoretical model of delegated decision making. We find that courts should indeed be lenient as long as contracts are restricted to be linear. With more general compensation schemes, the answer depends on the precision of the court's signal. If courts make many mistakes in evaluating decisions, they should not impose liability for poor business judgment.

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1 Introduction

Agents are legally bound to act in the interest of their principals. If they fail to exercise due care, they must be liable for the losses – or so it seems. For corporate directors and officers ("managers" for short) the law turns out to be quite different. It is governed by the "business judgment rule." The leading corporate law court in the U.S. summarized the rule's effect as follows:

> "[I]n the absence of facts showing self-dealing or improper motive, a corporate officer or director is not legally responsible to the corporation for losses that may be suffered as a result of a decision that an officer made or that directors authorized in good faith. There is a theoretical exception to this general statement that holds that some decisions may be so 'egregious' that liability for losses they cause may follow even in the absence of proof of conflict of interest or improper motivation. The

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exception, however, has resulted in no awards of money judgments against corporate officers or directors in this jurisdiction" (Chancery Court of Delaware, 1996).

This is a staggering statement given the potentially enormous agency costs in public corporations. We therefore attempt to evaluate the business judgment rule in a theoretical model. Assuming a risk-averse agent, we use the basic set-up of Lambert (1986), augmented by a liability rule. In our model, liability is part and parcel of the manager's contract. The compensation terms and the standard of care are each set optimally. Our analysis thus incorporates a potential risk incentive from performance-based compensation, a concern that has figured prominently in recent criticism of the business judgment rule (Armour and Gordon, 2014; Wagner, 2014). We consider two dimensions of manager behavior: the effort in preparing a decision and the subsequent choice between a safe and a risky project. Courts receive a signal of the manager's conduct but the difficulties of adjudicating business decisions (and of predicting the court's judgment) create noise in the court's signal. In our basic setup, the noise affects only the court's assessment of whether the manager rightly chose the risky project. In line with the law in most jurisdictions, the manager has to fully compensate the corporation if he is found liable.

Our main results are the following: If the compensation scheme under the contract is linear, courts should always be lenient. By contrast, non-linear contracts can work against the risk-deterrent effect of liability. In this setting, courts should use precise signals. As the quality of the signal declines, liability causes increasing costs to the principal. If the signal is very noisy, the court should refrain from using it because liability exposes the agent to too much risk even if he is informed and makes careful decisions. This result conforms to the business judgment rule's prescription that liability should obtain only in evident cases of mismanagement (where courts can be very confident in finding liability) but not in others (where there are many errors in finding liability). We thus offer an economic justification for the surprising forbearance that U.S. law affords to corporate managers. In the broader context of contract theory, our result is an example of why an optimal incentive scheme might discard an informative signal in spite of the "informativeness principle" for risk-averse agents (Holmström, 1979). The reason is that we assume full liability with the agent's limited wealth as the only limitation.[1]

It appears that we were the first to formally analyze the business judgment rule and its leniency towards managers. The contribution closest to ours is Spamann (2015), who thoroughly studies the economics of the business judgment rule partly based on a formal model. Instead of assuming liability for all harm caused by the manager's decision (as is the law in most jurisdictions), Spamann allows full flexibility in tailoring the level of sanctions to uncertainty in the court's judgment. He argues that only litigation costs can justify why courts should abstain from using an informative, albeit noisy, signal regarding the behavior of managers. Hakenes and Schnabel (2014) study manager liability conditional on readily observable outcomes rather than

[1]See Chaigneau, Edmans and Gottlieb (2014) for an analysis of the informativeness principle with limited liability.

on a finding of fault after a court proceeding. Gutiérrez (2003) explains why shareholders may wish to protect managers by obtaining directors' & officers' (D&O) liability coverage or by eliminating liability in the articles of incorporation. While the question resembles ours, the thrust of Gutiérrez' argument is different: In her model, D&O insurance and liability limitations serve to determine the amount of ex post litigation.[2] Inefficiencies result only from shareholders spending too little or too much on suing managers. Liability does not distort the agent's incentives except when there is too little of it. By contrast, we directly address the chilling effect that liability could have on risk-taking.

Our paper is also related to the law and economics literature on uncertainty and errors in the determination of liability (see, e.g., Craswell and Calfee, 1986; Kaplow and Shavell, 1994). These contributions, however, do not consider delegated decision-making. Accordingly, they do not consider why uncertainty in this setting can make it preferable to avoid imposing liability altogether. The paper begins with explaining the business judgment rule and its justification by courts and legal commentators (Section 2). Section 3 presents our model, Section 4 contains our main results. In Section 5, we consider the possibility that managers can be held liable for a failure to take risk. Section 6 relaxes the assumption that the courts can perfectly observe the manager's effort in preparing a decision, and Section 7 concludes.

2 The business judgment rule

The classic statement of the business judgment rule is due to the Supreme Court of Delaware (1984):

> "[There is] a presumption that in making a business decision the directors of a corporation acted on an informed basis, in good faith and in the honest belief that the action taken was in the best interests of the company. [...] Absent an abuse of discretion, that judgment will be respected by the courts."

The passage sets out the legal structure of the business judgment rule in Delaware, the dominant corporate law jurisdiction in the U.S.: To a limited degree, the courts reserve judgment on the *process* of decision-making. To invoke the business judgment rule, managers must have considered "all material information reasonably available to them." Yet even at this stage of "process due care," there is a presumption that managers have lived up to their obligations and courts restrict themselves to a gross negligence standard (Supreme Court of Delaware, 1984 and 2000). Once the business judgment rule applies, the courts completely abstain from reviewing the *substance* of the decision (Supreme Court of Delaware, 1984 and 2000). The effort and choice dimensions in our model thus mirror the stages of "process due care" and "substantive due care" in the legal analysis of manager liability cases.

[2] See also Kraakman, Park and Shavell (1994) on whether enforcing manager liability is beneficial for shareholders.

As a result of the business judgment rule, personal liability for failure to exercise due care is only a remote threat for corporate managers:

Gagliardi v. Trifoods International. Plaintiff Gagliardi had founded Trifoods International, Inc., but had later been ousted as chairman of the board. He alleged that after his dismissal the board had embarked on a “grandiose scheme for TriFoods’ future growth” that within 18 months had destroyed the firm. He claimed, inter alia, that management had negligently chosen to manufacture its own products instead of buying them, to invest in a new and duplicative production facility, and to acquire a licence for the food product “Steak-umms” from Heinz at an excessive price. The court dismissed the case without trial because the board’s decisions fell “within ordinary business judgment” even if they could be considered “unwise, foolish, or even stupid in the circumstances” (Chancery Court of Delaware, 1996).

The Citigroup Case. Citigroup Inc. sustained very significant losses in 2007 and 2008 from its exposure to the U.S. subprime residential mortgage market. Shareholders sued directors and officers of Citigroup for failing to monitor risk in spite of a multitude of warning signs that market conditions were deteriorating. Yet the Delaware Chancery Court ruled out director liability at the outset. The court went so far as to deny a board duty to oversee business risk because this would “involve courts in conducting hindsight evaluations of decisions at the heart of the business judgment of directors” (Chancery Court of Delaware, 2009).

Judges and legal scholars offer various justifications for the surprising leniency of the business judgment rule: It is said, first, that business decisions are highly specific to the particular situation in which managers have to act. “The judges are not business experts” (Supreme Court of Michigan, 1919). The very same reason that prevents the corporate contract from being complete also impedes the courts in adjudicating claims of mismanagement (Fischel, 1985). Second, legal commentators point to the perils of judging in hindsight. The business judgment rule could serve to offset an inclination to give too much weight to bad outcomes in evaluating ex ante behavior (Chancery Court of Delaware, 2009; Eisenberg, 1993).

A third line of reasoning relates to the proper amount of risk-taking. If managers face a threat of personal liability, the argument goes, they will shy away from risky but value-enhancing projects. Instead of pursuing innovative opportunities they will stick to business as usual. Such fearful behavior runs against the interest of shareholders, particularly in a public corporation where shareholders are well diversified (American Law Institute, 1992, p. 135; Chancery Court of Delaware, 1996; Allen, Jacobs and Strine, 2002). Fourth, unfettered liability for negligence could reduce the supply of able directors and executives. Compensation would rise as a result or the quality of managers would decline (Allen, Jacobs and Strine, 2002; Black, Cheffins and Klausner, 2006b). A fifth and final argument is that there are other and less costly mechanisms to discipline managers. One element consists of price signals from the capital market that feed into stock-based compensation and the market for corporate control. Reputational concerns in the managerial labor market are believed to provide another powerful incentive (Easterbrook and Fischel, 1991, pp. 96-97; Black, Cheffins and Klausner, 2006b).

In the wake of corporate scandals and the great financial crisis, some commentators question the wisdom of the business judgment rule (Armour and Gordon 2013; Wagner 2014; Campbell, 2011; Nowicki, 2008; Fairfax, 2005). Critics of the business judgment rule argue that manager liability is needed to curb excessive risk taking induced by high-powered compensation. By incorporating performance-based compensation, our model directly addresses these concerns.

Jurisdictions outside the U.S. often recognize the business judgment rule only to a limited extent. German courts, for instance, seem far less deferential to the business judgment of corporate directors even under criminal law (as in the "Mannesmann" case, Bundesgerichtshof, 2005; Gevurtz, 2007). German lawyers sometimes argue that the business judgment rule only precludes strict liability for business failure but that managers remain accountable for any negligence (Ulmer, 2004). By contrast, our results counsel to restrict liability to cases where signal precision is high, that is where the court can be certain that the manager violated the duty of care. One way to translate this into law is that the applicable standard should be gross negligence or even knowing neglect of due care. This is especially relevant in jurisdictions where managers have enjoyed implicit protection because liability claims, traditionally, have been scarcely enforced. If policy reforms aim at facilitating enforcement, the standard of care becomes more important.

3 The model

Shareholders delegate decision-making to the managers of the corporation. In the following, we refer to shareholders as the principal and to managers as the agent. The agent has to decide between a safe option (continuation, business as usual) and a risky one (growth, reorganization). The safe project yields a certain cash flow x_0, while the risky project can either yield a high cash flow $x_H > x_0$ or a loss $x_L < x_0$. Ex ante, the probability that the risky project yields the cash flow x_H is equal to $p \in [0, 1]$. The agent can acquire additional information about the profitability of the risky project. We identify this information with probabilities: If the agent receives information $q \in [0, 1]$, he knows that the posterior probability of the high cash flow x_H is equal to q. From an uninformed perspective, information is distributed according to a distribution function F with $p = \int q dF$.

We assume that the principal is risk-neutral and the agent is risk-averse. The agent's (money) utility function is given by u, which is assumed to be twice differentiable with $u' > 0$ and $u'' \leq 0$. The agent can choose whether to acquire information or not. Acquiring information ($e = 1$) involves an effort cost of $\kappa \geq 0$ for the agent, while staying uninformed ($e = 0$) has no cost. Note that the agent has no inherent preference for either the risky or the safe project (other than from incentive compensation and the need to exercise effort). Money utility and effort cost are additively separable. Whether he learned and what he learned (e and q) is the agent's private knowledge.

The agent's initial wealth is set to 0 to save notation. The agent has limited assets: His wealth cannot sink below 0 in any contingency. We denote this lowest possible utility of the agent by $\underline{u} = u(0)$. Moreover, the agent only accepts the contract if his expected utility is not lower than his reservation utility $\bar{u}$, corresponding to wealth level $\bar{w} = u^{-1}(\bar{u})$.

First best

The model so far – without liability – is almost identical to the one in Lambert (1986), which the reader is referred to for a more detailed derivation of the first best solution. In the absence of any incentive problems, the principal can let the agent stay uninformed and pay him a wage $\bar{w}$ with $\bar{u} = u(\bar{w})$, or make the agent acquire information and pay him a fixed wage $\tilde{w}$ with $u(\tilde{w}) = \bar{u} + \kappa$. It is optimal to implement the risky project whenever the probability of success is greater than the cut-off

$$\bar{q}^{FB} = \frac{x_0 - x_L}{x_H - x_L}. \tag{1}$$

The principal's payoff if the agent stays uninformed is equal to

$$\max\{px_H + (1-p)x_L, x_0\} - \bar{w}. \tag{2}$$

To write down the principal's payoff if the agent obtains information, we introduce the following notation for the ex ante probabilities of realized profits

$$\rho_H(\bar{q}) = \int_{\bar{q}}^{1} q dF, \tag{3}$$

$$\rho_L(\bar{q}) = \int_{\bar{q}}^{1} (1-q) dF, \tag{4}$$

$$\rho_0(\bar{q}) = F(\bar{q}), \tag{5}$$

and for the expected surplus

$$S(\bar{q}) = \rho_H(\bar{q})x_H + \rho_L(\bar{q})x_L + \rho_0(\bar{q})x_0. \tag{6}$$

The first best involves information acquisition if

$$S(\bar{q}^{FB}) - \tilde{w} \geq \max\{px_H + (1-p)x_L, x_0\} - \bar{w}. \tag{7}$$

The incentive problem comes from the fact that the agent's effort and information are not observable to the principal. They are, however, to some extent verifiable by the court. In the following, we introduce some limitations on the contracts that can be written and the behavior of the court.

Contracts

Contracts specify transfers conditional on outcomes, $w(x_i)$ with $i \in \{L, 0, H\}$. We sometimes use the following short-cut notation: $w_i = w(x_i)$ and $u_i = u(w(x_i))$ for $i \in \{L, 0, H\}$. The class of contracts that we consider is hence restricted by the assumption that there is no communication once the agent has acquired information. There is no stage in the game at which the agent is informed and can choose from a menu of contracts. With this assumption we follow the literature on delegated expertise, which includes Lambert (1986) and Demski and Sappington (1987) for a risk-averse agent, as well as Biais and Casamatta (1999), Palomino and Prat (2003), Gromb and Martimort (2007) and Malcomson (2009),(2011) for a risk-neutral agent.[3] Another critical assumption is that the contract cannot condition on the outcome of the risky investment if the agent implements the safe project. In fact, it would often be exceedingly difficult to determine the forgone profits or losses if the manager decides not to pursue a risky investment. We make the same assumption for court-administered liability (see the next subsection).

Following other contributions (e.g. Kadan and Swinkels, 2008), we restrict the range of possible contracts further and focus on two subclasses: (Affine-)linear or sharing contracts of the form $w(x) = \beta + \alpha x$ and monotonic (nondecreasing) contracts. Linear contracts can only consist of a fixed salary and a variable salary that is proportional to the firm's revenue. Although not optimal in the context of our model, linear contracts can have other advantages (c.f. Murphy 2013). In fact, outside directors on corporate boards often receive only shares as variable compensation, which amounts to a linear contract. By contrast, the compensation of corporate executives usually contains convex elements from options or bonuses for performance above a certain threshold. Monotonic contracts permit such non-linear pay schemes. They only preclude a negative relationship between compensation and performance.[4]

Courts

The contract uses readily observable information on outcomes. By contrast, whether the agent has exercised due care is not obvious. For this reason, liability for a lack of due care is administered by a court. It is plausible that the court, in the course of its proceedings, gains access to evidence that the principal does not have, or that it brings together pieces of information of both parties.

In the main part of the paper, we assume that the agent can only be held to account if

[3] With similar consequences, Raith (2008) assumes that the agent possesses "specific knowledge" about his productivity that he cannot communicate to the principal.

[4] The monotonicity constraint is often imposed in models of moral hazard (Innes, 1990; Matthews, 2001), since rewarding an agent for reduced performance would create problems of ex post moral hazard. By imposing the monotonicity restriction, we show that our results do not turn on such an implausible compensation scheme. At the same time, the monotonicity assumption does not drive our results.

the risky project fails. There is no liability for taking the safe business-as-usual decision even if the risky project promises a superior expected profit. The reason for this assumption is the following: Courts calculate damages by comparing the actual outcome with a hypothetical outcome that would have obtained if the agent had exercised due care. With the risky project, the courts would have to estimate the expected cash flow over various states of the world as the hypothetical outcome. Courts are reluctant to engage in such guesswork, especially if the risky choice consists of a specific business strategy that only the firm's managers can devise. Even if the courts were willing to consider such claims, their estimate of the damages would be very hard to predict. As a result, litigation is significantly more attractive to the principal when the risky project has caused a major loss. Nonetheless, in Section 5 we also consider the case that both the risky and the safe choice can trigger liability.

During trial, the court receives signals regarding the agent's behavior. First, the court will seek to establish whether the agent was sufficiently informed about his decision, that is, whether he exercised process due care. The court receives a signal e^c about the agent's effort to become informed. Second, the court asks whether the agent took the correct decision from an ex ante point of view. It receives a signal q^c about the probability that the risky project yields a high cash flow. A liability rule compares these signals to standards of care $\bar{e}^c$ and $\bar{q}^c$. We assume that the court seeks to promote efficient contracting and applies standards that are optimal for the principal concerning the problem at hand, which may well differ from the first best values e^{FB} and q^{FB}. Indeed, corporate law's fiduciary duties are meant to fill gaps in the corporate contract in the way the parties themselves would have written the contract. One should remember, however, that the court only gets a chance to adjudicate the agent's decision if the agent makes the risky choice and causes the adverse outcome x_L. The agent can avoid any liability risk by pursuing the safe project, even if he remains uninformed.

Depending on how signals compare with the standards, courts rule that the agent is liable or not. If the agent is held liable, he has to pay damages to compensate the principal. Most jurisdictions impose full liability for all damages sustained by the principal. We assume that the wealth constraint always binds in this case. This seems resonable because usually the private wealth of managers will not suffice to cover corporate losses from mistaken business decisions.[5]

In the main part of the paper, we focus on liability for substantive due care. We therefore assume that the court's signal about effort is a perfect one, $e^c = e$. As a consequence, it is always optimal to impose process due care liability, with the standard set equal to the second best, $\bar{e}^c = e^{SB}$. If $e^c < \bar{e}^c$, the agent is liable; otherwise, the court could still find that the project was too risky ($q^c < \bar{q}^c$) and hold the agent liable.

We assume that $q^c = q + \epsilon$, where ϵ follows a symmetric distribution with mean zero.[6] This

[5]This assumption means that if D are the damages, then it must be that $w_L \leq D$, which can be shown to hold if, for example, $D = -x_L$ and $\bar{w} \leq x_0$.

[6]Note that we formally allow $q^c < 0$ and $q^c > 1$ and the same for the standard $\bar{q}^c$. The reason for this modeling choice is technical: It yields differentiability of λ with respect to $\bar{q}^c$ and q, for all values of $\bar{q}^c$ and q with

distribution is denoted by Φ. We assume that Φ is differentiable with density $\phi > 0$. For a given $\bar{q}^c$, we define

$$\lambda(q) = Prob[q^c < \bar{q}^c | q] = \Phi(\bar{q}^c - q) \tag{8}$$

as the probability of being found liable for a violation of substantive due care conditional on achieving the bad outcome from the risky project and on the true success probability being q. The function λ is continuous and decreasing in q, with $\lambda(\bar{q}^c) = \frac{1}{2}$ and $\lambda'(q) = -\phi(\bar{q}^c - q)$ for all q with $0 < \lambda(q) < 1$. There are two interpretations of the function λ: One is that in adjudicating substantive due care, the court errs in perceiving the true success probability q or in applying its standard of care $\bar{q}^c$. The second interpretation is that the agent himself is uncertain about the true success probability, the court's ability, or the standard of care.

A liability rule that is described by standards $\bar{e}^c = 1$ and $\bar{q}^c$ thus translates into the following probabilities of being liable for the agent: If $e = 0$, the agent is liable with probability 1. In case that $e = 1$, his probability of being liable is equal to $\lambda(q)$, where λ depends on the standard $\bar{q}^c$. We furthermore define a rule of no liability for substantive due care as $\lambda^{nl}(q)=0$ for all q and a rule of strict liability for substantive due care as $\lambda^{sl}(q) = 1$ for all q.

4 Analysis

The ex post stage: choosing projects

We will first look at the agent's choice between projects. With a contract w and a liability rule λ in place, an informed agent who knows the probability of the good state to be q chooses the risky project if and only if

$$qu_H + (1-q)((1-\lambda(q))u_L + \lambda(q)\underline{u}) \geq u_0. \tag{9}$$

We assume that if for some probabilities the agent is indifferent between the alternatives, he makes the efficient decision.

Lemma 1. *There exists a cut-off point $\bar{q}(w)$ such that the agent chooses the safe project for all $q < \bar{q}(w)$ and the risky project for $q > \bar{q}(w)$. At $\bar{q}(w)$, condition (9) holds with equality.*

Wherever the contract is clear from the context, we drop the reference to w and write only $\bar{q}$. For the special case of no liability for substantive due care we introduce the notation $\bar{q}^{nl}$, i.e.,

$$\bar{q}^{nl}u_H + (1-\bar{q}^{nl})u_L = u_0. \tag{10}$$

The analysis of the ex post stage provides a first intuition of how liability can deter efficient risk-taking. Assuming that the agent simply gets a fixed salary equal to his reservation wage

$0 < \lambda(q) < 1$.

$\bar{w}$, he is indifferent between the risky and the safe project and always chooses the one with the higher cash flow. The cut-off point is $\bar{q}^{nl} = \bar{q}^{FB}$. But once there is the slightest probability of liability, the safe project provides a safe harbor against liability and, therefore, strictly dominates the risky project no matter how valuable the latter. Hence, if a fixed wage is optimal, then also λ^{nl} (with $\bar{e}^c = e^{SB} = 0$) is optimal. This implies that with a fixed wage it is impossible to induce information acquisition because the agent can always avoid liability by choosing the safe project.

Of course, agents often get paid for performance. In the following, we study how incentive pay affects the agent's choice under the threat of liability. We start with the special case of linear compensation schemes.

Lemma 2. *For every linear contract $w(x) = \beta + \alpha x$ with $-\alpha x_L \leq \beta$, it holds that $\bar{q}(w) \geq \bar{q}^{FB}$. In addition, for any two contracts $w(x) = \beta + \alpha x$ and $\hat{w}(x) = \hat{\beta} + \alpha x$ with $0 \leq \beta - \hat{\beta} \leq \lambda(\bar{q}(w))(1 - \bar{q}(w))(\beta + \alpha x_L)$, it holds that $\bar{q}(w) \geq \bar{q}^{nl}(\hat{w})$.*

This lemma says that with a linear contract there is underinvestment in the risky project at least if the limited liability constraint does not bind. The intuition is simple: With a linear contract and no liability, a risk-neutral agent chooses the first best cut-off, while a risk-averse agent will at the first best cut-off still prefer the safe project. Liability makes the risky project even less attractive to the agent. Indeed, as the lemma also shows (think of the case $\beta = \hat{\beta}$), the agent will be more inclined to take risks if he is relieved of substantive due care liability.

While risk aversion thus limits the set of decision thresholds that a linear contract can implement, a more general contract can induce the agent to follow any threshold $\bar{q} \in [0, 1]$. In the following, we consider incentives to acquire information and solve the full optimization problem for both classes of contracts.

The ex ante stage: choosing effort

Every wage scheme w together with a liability rule induces an effort level $e(w) \in \{0, 1\}$ and a decision threshold $\bar{q}(w) \in [0, 1]$. We have already noted that $e^{SB} = 0$ is best implemented with a flat contract and no liability. Hence, the interesting case is that the optimal contract requires the agent to collect information ($e^{SB} = 1$). We write an informed agent's utility who faces contract w and decides according to threshold $\bar{q}$ as

$$U(w, \bar{q}) = \rho_H(\bar{q})u_H + \rho_L(\bar{q})u_L - \rho_\lambda(\bar{q})(u_L - \underline{u}) + \rho_0(\bar{q})u_0 - \kappa, \tag{11}$$

where

$$\rho_\lambda(\bar{q}) = \int_{\bar{q}}^{1} (1 - q)\lambda(q)dF. \tag{12}$$

In the following, we will derive the constraints that a contract w has to satisfy to induce $e = 1$ and decision threshold $\bar{q}$. First, $\bar{q}$ must be the cut-off above which the agent chooses the risky project:

$$\bar{q}u_H + (1-\bar{q})((1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}) = u_0. \tag{D}$$

The contract also has to make sure that the agent prefers acquiring information to just choosing the safe project:

$$U(w, \bar{q}) \geq u_0. \tag{SIC}$$

Similarly, the agent should prefer acquiring information to just choosing the risky project:

$$U(w, \bar{q}) \geq pu_H + (1-p)\underline{u}. \tag{RIC}$$

In addition to these two incentive compatibility constraints, we have the participation constraint

$$U(w, \bar{q}) \geq \bar{u}, \tag{PC}$$

and the limited liability constraint

$$w_L \geq 0. \tag{LL}$$

Finally, there is either the monotonicity constraint

$$w_H \geq w_0 \geq w_L, \tag{MON}$$

or the stronger linearity constraint

$$w_x = \beta + \alpha x. \tag{LIN}$$

The principal maximizes her payoff

$$\pi(w, \bar{q}) = S(\bar{q}) - \rho_H(\bar{q})w_H - (\rho_L(\bar{q}) - \rho_\lambda(\bar{q}))w_L - \rho_0 w_0 \tag{13}$$

subject to the constraints $(D), (SIC), (RIC), (PC), (LL)$ and (MON) or (LIN), respectively.

First, we deal with the case that the limited liability constraint is binding in the principal's optimization problem and with the case of strict liability, which has the same effect as imposing no liability and setting $w_L = 0$ in the contract.

Remark 1. *(i) If in the second-best the limited liability constraint* (LL) *is binding, then the standard of care does not matter. (ii) The strict liability rule* λ^{sl} *is dominated by the no liability rule* λ^{nl}.

Hence, the following we focus on the case that (LL) is not binding in the second-best and only compare liability rules with a standard of care to λ^{nl}.

Linear contracts

We start again with the analysis of linear contracts.

Proposition 1. *If contracts are linear, λ^{nl} is the optimal liability rule.*

If contracts are linear, there should be no liability for making wrong judgments, only for careless preparation of the decision. The intuition behind this result is the following. We have shown in Lemma 2 that with a linear contract, the agent chooses the risky project only if the probability of success of the risky project is relatively large, larger than the first best cut-off $\bar{q}^{FB}$. The problem thus is to encourage risk taking and – as we have also shown in Lemma 2 – under a linear contract this is best done by protecting the agent from liability. Proposition 1 suggests that the only useful role of substantive due care liability is to control a potential risk incentive from a convex wage scheme.

Non-decreasing contracts

If the principal can freely specify compensation for each contingency, she can offer extra rewards for pursuing the risky project. In fact, with liability the principal could even want to pay more for suffering losses from the risky project than for the safe project, in order to mitigate the risk-deterrent effect of liability. Consequently, the monotonicity constraint may be binding once it becomes optimal to impose substantive due care liability. Moreover, as we show in the following lemma, the incentive constraint regarding the safe project is always binding.

Lemma 3. *In the optimal contract, the incentive constraint (SIC) is always binding. Moreover, there is overinvestment in the risky project from the point of view of the principal.*

The binding incentive constraint (SIC) in Lemma 3 implies that the convexity of the wage scheme results from the difficulty to induce the agent to exert effort instead of just choosing the safe project. But the convex contract then leads to excessive risk taking, once the agent has acquired information. That there is overinvestment in the risky project means that given the optimal wages, the principal would prefer the agent to choose the safe project at the cut-off value $\bar{q}$. The intuition behind this result is that lowering the standard of care decreases the liability risk that the agent faces and makes him choose the risky project more often. If this were beneficial for the principal as well, imposing liability could not be optimal at all. Moreover, choosing the risky project is excessively rewarded under the contract because it is a way for the agent to demonstrate that he has expended effort to become informed.

That there is overinvestment in the risky project from the point of view of the principal also reveals that a linear contract is not optimal in our setting, since a linear contract would lead to underinvestment in the risky project from the principal's point of view (Lemma 2).

The next lemma addresses the potential benefit of liability for substantive due care within a convex contract:

Lemma 4. *Let λ denote the optimal liability rule with corresponding optimal contract w^{λ}. Let w^{nl} denote the contract that implements the same cut-off $\bar{q}(w^{\lambda})$ without imposing liability on the* *agent. Then the following comparisons must hold:*

$$w_H^{nl} \geq w_H^{\lambda} \text{ and } w_L^{\lambda} \geq w_L^{nl}. \tag{14}$$

Note that the optimal liability rule can also be "no liability" for substantive due care, in which case the condition of Lemma 4 holds trivially with equality. The main insight from Lemma 4 is how a liability rule other than "no liability" can, if at all, reduce the cost of inducing effort: To be optimal, substantive due care liability has to compress the optimal compensation scheme. Liability has the potential to flatten incentives for the risky choice because it increases the value of making an informed decision and in this regard substitutes for performance-based compensation. However, the downside of liability is that the agent has to be compensated for liability risk when he chooses the risky project. Lemma 4 shows that if, as a consequence, the wage distribution for the risky choice becomes steeper, imposing liability cannot be optimal.

To determine whether liability is optimal in light of Lemma 4, we consider how the standard of substantive due care should be set. This depends on the precision of the court's signal q^c. To measure the impact of precision, we assume that the signal $q^c = q + \epsilon$ follows a distribution that depends on a parameter Δ, where a larger Δ means greater precision. What is meant by precision is illustrated in Figure 1. There we show the function λ for a normal and a uniform error term, i.e. we consider the case that ϵ follows a normal distribution with mean 0 and variance $1/\Delta$ as well as the case that ϵ follows a uniform distribution with

$$\Phi(\epsilon) = \min\{1, \max\{0, (1 + \epsilon\Delta)/2\}\}. \tag{15}$$

For $\Delta \to \infty$ the case of a perfect signal, $q^c = q$, is approached, while for $\Delta \to 0$ the signal becomes perfectly uninformative, i.e., $\lambda(q) = 1/2$ independent of q. It can also be seen that the functions for different values of Δ cross only at a single point. Since we require these properties to hold in general, we make the following technical assumption about λ.

Assumption 1. *The function Φ is differentiable with respect to Δ. For all $\bar{q}^c$ and q, $\lambda(q)$ monotonically approaches 0.5 as Δ goes to 0. As $\Delta \to \infty$, $\lambda(q)$ monotonically converges to 1 for all $q < \bar{q}^c$, and to 0 for all $q > \bar{q}^c$. Moreover, we assume that for the inverse function $\lambda^{-1} : (0,1) \to \mathbb{R}$ it holds that the derivative of λ^{-1} is weakly increasing in Δ.*

The condition that $\frac{\partial}{\partial l}\lambda^{-1}(l)$ is weakly increasing in Δ can be illustrated using Figure 1: Imagine a horizontal line through any point below 0.5 on the vertical axis. The line is intersected by liability functions for different values of Δ, where functions that correspond to a larger Δ intersect the line more to the left. The assumption says that as one moves from left to right along this line, the liability functions that intersect the line become flatter. Similarly, if one draws a horizontal line through any point above 0.5 on the vertical axis, then if one moves from left to right along this line, the liability functions that intersect the line become steeper.

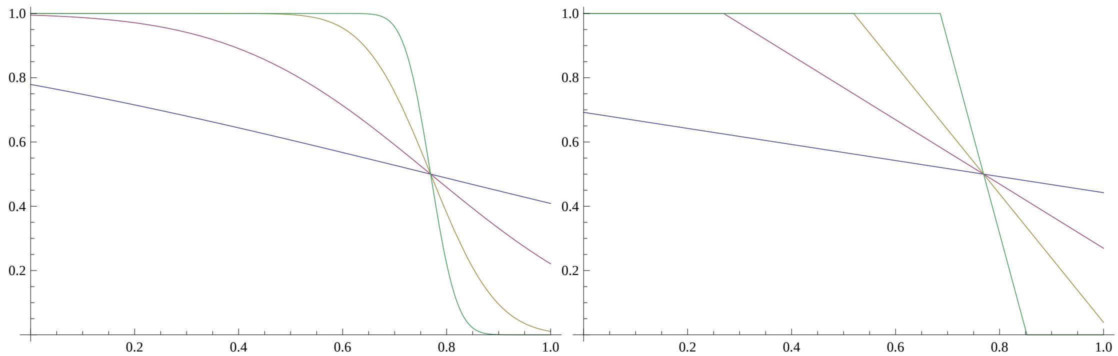

Figure 1: The left panel shows the function $\lambda(q)$ for the case of a normally distributed error term for different levels of precision Δ, with $q \in [0, 1]$ on the horizontal axis. The right panel shows $\lambda(q)$ for the case of a uniformly distributed error term, again for different levels of precision. A perfectly precise signal would be represented by a step function with a jump at $\bar{q}^c = 0.8$, an uniformative signal would be represented by a horizontal line at 0.5.

Remark 2. *Assuming normal or uniform error terms is stronger than Assumption 1, i.e, all properties in Assumption 1, hold for the normal and the uniform error terms.*

That this remark is true is quite intuitive from Figure 1. A formal proof is provided in the appendix. We can now state the main result of this section.

Proposition 2. *There exists a cut-off $\bar{\Delta}$ such that no liability for substantive due care is optimal if $\Delta < \bar{\Delta}$, while using some liability rule is optimal if $\Delta \geq \bar{\Delta}$.*

The intuition behind the proposition is the following: The trade-off between no liability and liability is between insurance for agents who learn a high probability of success and agents who learn a lower success probability. With precise signals, risk taking at success probabilities just below a desired cut-off $\bar{q}$ can be punished without punishing risk taking at larger success probabilities too much. Higher precision thus makes using the court's signal more valuable. By contrast, with a very imprecise signal, exposing the agent to liability risk for values close to the cut-off value $\bar{q}$ implies also exposing him to risk for larger success probabilities, which increases the cost of inducing effort.

Discussion

Proposition 2 enshrines the economic rationale of the business judgment rule. It militates against substantive due care liability if the courts commit too many mistakes in evaluating business decisions or, equivalently, if agents misjudge what courts require. Signal precision may also vary over cases. Where courts are more apt at evaluating business decisions, there can be cases where courts are sufficiently confident in their judgment to optimally impose liability. In this reading, Proposition 2 implies that liability should be confined to straightforward cases of evident mismanagement.

The business judgment rule thus can be a response to the difficulty and error-proneness of evaluating business decisions in the courtroom ("judges are not business experts"). The model also captures other considerations advanced by legal commentators: With a noisy signal, performance pay becomes comparatively more efficient in incentivizing the agent (the alternative-mechanisms argument). Remember, however, that liability can only be desirable if there is a non-linear compensation scheme and in this sense the two act as complementary mechanisms. Hence, our analysis shows that the alternative-mechanisms argument has to be carefully interpreted. Other typical considerations are confirmed in the model: If the courts raised the standard of care beyond the optimum, the principal would adjust the compensation scheme to counteract the risk-deterrent effect of liability. Hiring and incentivizing an agent would become more expensive (the higher-compensation argument). Without an adjustment, the agent would be less inclined to choose the risky project, even if it is worthwhile (the risk-deterrence argument).

We can also take up the concern about a potential hindsight bias. It is often said that even experts or professional judges overestimate the ex ante probability of an outcome that they observe ex post. Let $\bar{q}^c$ denote the optimal standard (without hindsight bias). Assume that there is a hindsight bias of the form that if the court observes signal q^c, it actually sees the signal $q^c - h$, for some $\bar{q}^c > h > 0$. With a bias, the probability of being liable from the agent's perspective is equal to $\lambda(q) = Prob[q^c - h \leq \bar{q}^c | q] = Prob[q^c \leq \bar{q}^c + h | q]$. The optimal standard is now $\bar{q}^c - h$ and thus decreasing in the size of the hindsight bias h. If courts cannot overcome the hindsight bias, the optimal standard should reflect the bias and be lower. However, the prevalence and extent of the bias are subject to debate.[7] Moreover, it is not clear how judges would apply a standard that aims at correcting their average hindsight bias.

In our model, the agent is exposed to risk from compensation and liability in order to induce him to become informed. The lower the agent's cost of effort κ, the less risk is needed. In the extreme case that $\kappa \to 0$, a wage of slightly more than $\bar{w}$ can almost achieve the first best. Introducing liability would only introduce unnecessary and costly risk.

Remark 3. If κ is sufficiently low, then λ^{nl} is the optimal liability rule.

This finding has immediate policy implications. Certain agents make far-reaching decisions without having to incur high personal cost in terms of time and labor. An example are outside directors on corporate boards. While their responsibility is to monitor the corporate officers and to ratify important decisions, they are allowed, as a general matter, to rely on information provided by the corporate officers, accountants etc. Their own effort usually remains limited to several board meetings per year.[8] Remark 3 counsels to eliminate substantive due care liability in this setting. In fact, the law appears to be especially lenient towards outside directors (Black,

[7] In a recent study, Rachlinski, Wistrich and Guthrie (2011) find that court rulings on the legality of searches in criminal proceedings do not vary between foresight and hindsight.

[8] In the taxonomy of Fama and Jensen (1983), outside directors exercise "decision control" while "decision management" is vested in the executive directors and officers. Because outside directors are not themselves involved in the day-to-day operation of the corporate business it would be particularly costly for them to obtain information on their own.

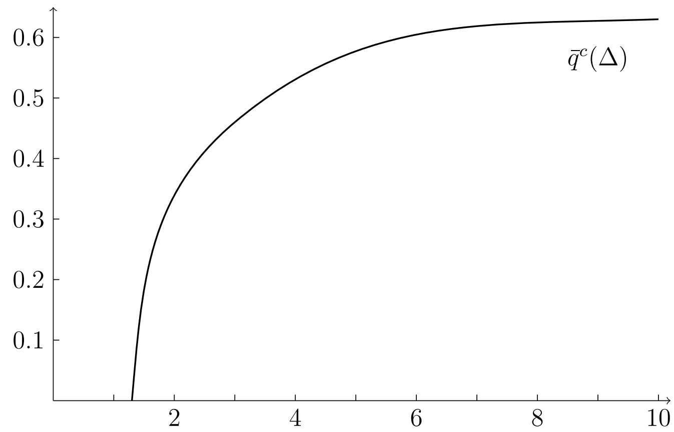

Figure 2: With precision (Δ) measured on the horizontal axis, this graph shows the optimal standard of care $\bar{q}^c$ in dependence on Δ for the following example: $u(w) = \sqrt{w}$, $\kappa = 1$, $\bar{u} = 20$, $x_L = 0$, $x_H = 1000$, $x_0 = 700$, and q and ϵ follow uniform distributions. The function is increasing and always below the first best cut-off $\bar{q}^{FB} = 0.7$.

Cheffins and Klausner, 2006a). To the extent that outside directors receive only a fixed wage or stock, our result for linear contracts leads to the same conclusion. In a similar vein, agents in charity and other pro bono activities should not be subject to liability if their decisions involve risky choices.

For agents with significant effort cost and a convex compensation scheme, the implications are less straightforward. Proposition 2 implies that beyond a certain level of noise in the court's signal, the agent should not face substantive due care liability. While we cannot show in general that the optimal standard is decreasing as the signal becomes noisier, Figure 2 shows a typical example, in which this is the case.

It is sometimes argued that a limit on damages borne by the agent can render liability less harmful and indeed desirable (Wagner, 2014). In fact, if one can set an appropriate cap for damages, in most cases even a noisier signal can be used. Turning this result into policy advice is difficult though. The court would have to adjust the damage cap to the difficulty of adjudicating the case (or, similarly, the severity of the agent's fault) and the agent's private wealth and risk aversion. While conceivable, this is not what courts usually do in private law litigation. In principle, one could also devise a D&O insurance with a variable deductible reflecting the noise in the court's signal. Yet D&O insurances in the U.S. typically do not contain deductibles for directors and officers (Baker and Griffith, 2010, p. 47; Trautman and Altenbaumer-Price, 2012, p. 346). The likely reason, again, is the difficulty of defining a cap as a function of the amount of noise in the court's signal combined with the rather limited benefit from using the noisy signal.[9]

[9] If the shareholders in our model were insured against the loss from a risky project, they would completely shield the manager from risk and let him choose the risky project in any case. This incentive would make D&O insurance premia prohibitively large unless the insurance companies monitor the compensation packages of managers. In fact, D&O insurance policies commonly do provide for deductibles in relation to the corporation

5 No safe haven

The basic model presumes that the agent is never liable for taking the safe path of "business as usual." This assumption is plausible when liability for the safe choice would require the court to compare the actual outcome to a hypothetical decision with a broad range of possible consequences. Sometimes, however, the implications of taking the risky decision can be observed quite well. For instance, in a takeover the safe choice on behalf of shareholders consists of selling the firm for cash (as happened in the famous Smith v. Van Gorkom case, Supreme Court of Delaware, 1985). But because the firm often continues to operate after the takeover, there is an indication of how the shareholders would have fared with keeping the firm. In such a setting, courts can use the observed outcome to calculate damages.

To study this possibility, we assume in this section that the outcome of the risky project is observable ex post. What if the principal can (and will) sue, not just in the case of a large loss, but whenever the performance could have been better? If the risky project would have yielded the larger profit and the agent is found liable for pursuing the safe project instead, damages amount to $d = x_H$; but as before, we assume that the limited liability constraint is binding. Again, the agent is always liable if he fails to become informed (and his project performs poorly). Therefore, for an uninformed agent the expected payoff from the safe choice is $(1-p)u_0 + p\underline{u}$.

If the agent has observed process due care, the court evaluates the substantive merit of his decision. In principle, the court could apply the same standard $\bar{q}^c$ to impose liability for taking the risky and the safe decision. When the agent pursues the safe project, he is held liable if $q^c > \bar{q}^c$; his expected payoff would be $u_0 - q(1-\lambda(q))(u_0 - \underline{u})$. However, using the same standard would prevent the court from adapting the standard to a noisy signal because relaxing it for the safe choice would imply a tightening for the risky choice (and conversely). Alternatively, two different standards can be used: The court can infer "too much risk-taking" from $q^c < \bar{q}^c$ and "too little risk-taking" from $q^c > \bar{q}_0^c$, with $\bar{q}_0^c > \bar{q}^c$. We take some function $l(q)$ to measure an informed agent's expected probability of being liable after choosing the safe project. The court can influence this function by setting a standard $\bar{q}_0^c$. The function that we have in mind is $l(q) = q\Phi(q - \bar{q}_0^c)$, but it can be any other function that decreases in the standard $\bar{q}_0^c$ and is differentiable for $0 < q < 1$. It should be noted that the agent's decision is still monotonic in q: if he prefers the risky project for $\bar{q}$, then he does so for all $q \geq \bar{q}$.

Proposition 3. *In the setting without a safe haven, there should never be liability for substantive due care following the safe decision. If* $(\bar{u} - \underline{u}) \geq \max\{\frac{1-p}{p}, \frac{p}{1-p}\}\kappa$, *then the first-best is implementable.*

An informed agent should never be held liable for taking the safe choice. The reason is that the cheapest way to restrain the agent's inclination towards the safe project is to reduce

itself (Baker and Griffith, 2010, p. 47) as well as for far-reaching limits of insurance coverage (E.g., Towers Watson (2013) report a median limitation of $100 million in their 2012 Directors and Officers Liability Survey).

compensation w_0 in that contingency. True, liability uses more information, namely the court's signal q^c and the hypothetical outcome of the risky project. But this time the information cannot be used to reduce risk: While liability for wrongfully taking the risky choice substitutes for variation in compensation between w_L and w_H, there is no such effect for the safe choice.

Without a safe haven, liability often becomes inefficient for the risky choice as well. Even the first best can be implemented in some cases now. Imposing a flat wage renders the manager indifferent over the projects, so that once fully informed, the manager takes the correct action on behalf of the principal. While in the basic model, a flat wage would induce the manager to choose the safe alternative and not exert effort to learn about the risky project, now not becoming informed can be punished after the safe choice as well. However, since information acquisition is not observable (but verifiable), the courts must always be involved at least with some probability, although the agent will never be found liable in equilibrium.

Inducing the agent to become informed requires no exposure to risk because we still assume that the court observes his effort perfectly. In the next section, we examine how much our results depend on this assumption.

6 Uncertainty in the effort dimension

So far, we have assumed that the court's signal e^c about the agent's effort to acquire information is perfectly precise. This allowed us to neglect the effort dimension throughout the analysis. A natural question to ask is what happens if we relax this assumption. Does the gist of our analysis hold up if courts commit mistakes in assessing the agent's procedural care? Judging the proper decision-making process can be difficult: Whether more information would have been needed raises similar questions as the validity of the decision. Also, courts may find it hard to distinguish genuine diligence in preparing the decision from a pretense of gathering relevant information that only serves to shield the agent against liability.

To model noise in the court's assessment of procedural care, we introduce a distribution function Ψ_e, $e \in \{0,1\}$, for the noisy signal e^c, and a standard $\bar{e}^c$ for process due care. The following two probabilities are important:

$$\Psi_0(\bar{e}^c) = Prob[e^c < \bar{e}^c | e = 0] \text{ and } \Psi_1(\bar{e}^c) = Prob[e^c < \bar{e}^c | e = 1]. \tag{16}$$

The court can influence these two probabilities by setting the standard.

Proposition 4. *If there exists a standard of care $\bar{e}^c = \tilde{e}$ such that $\Psi_1(\tilde{e}) = 0$ and at the same time*

$$\Psi_0(\tilde{e}) \geq \frac{p\kappa}{(\bar{u} - \underline{u}) \int_p^1 (q-p) dF}, \tag{17}$$

then with the standard for process due care set at $\bar{e}^c = \min\{e^{SB}, \tilde{e}\}$, λ^{nl} is optimal if contracts are linear or if contracts are monotonic and $\Delta \leq \bar{\Delta}$.

Proposition 4 essentially states that as long as the signal about effort is sufficiently precise, our earlier results remain unaffected; the process due care standard should be such that an informed agent is never held liable. The basic idea is that process due care only matters because it penalizes uninformed risk-taking and thereby relaxes the risky choice incentive constraint (RIC). With a precise signal, one can ensure that (RIC) does not bind and still relieve the agent of liability risk if he becomes informed. In this case, liability for process due care only confers benefits. With (RIC) out of the way, the analysis becomes the same as with a perfect signal on effort. Therefore, our earlier results (Proposition 1 and Proposition 2) are confirmed.

A standard $\tilde{e}$ as in the proposition only exists if the signal e^c is sufficiently precise. Note that the standard can only be set at $\bar{e}^c = 1$ if the signal is perfect. As the signal becomes less precise, the standard has to decrease, and condition (17) requires that $\Psi_0(\tilde{e})$ must remain sufficiently large. Condition (17) is easier to satisfy the lower p and κ and the larger $\bar{u} - \underline{u}$. A low p implies that the risky project is less attractive from an uninformed perspective and (RIC) is therefore less likely to bind. With a low κ, the contract can be relatively flat, which again makes (RIC) less likely to bind. Finally, a large $\bar{u} - \underline{u}$ implies that being held liable hurts the agent a lot; the probability $\Psi_0(\tilde{e})$ can then be lower.

It should also be noted that Proposition 4 provides only a sufficient condition. There are large parameter regions for which our results also continue to hold. In fact, liability for neither process nor substantive due care should be imposed in certain cases such as the one set out in the following corollary:

Corollary 1. *If $\bar{q}^{FB} \geq p$, then no liability at all (λ^{nl} and $\bar{e}^c = 0$) is optimal if contracts are linear or if $\Delta \leq \bar{\Delta}$.*

Hence, the result that no liablity for decisions is optimal with linear contracts and with noisy signals extends to the effort dimension for a realistic set of parameters. The condition $\bar{q}^{FB} \geq p$ means that without further information, it is efficient to take the safe decision. It hence captures the interpretation of the safe project as business as usual.

7 Conclusion

We have developed a theoretical argument for why courts in the U.S. routinely abstain from imposing liability for poor business judgment. Shareholders want managers to take risks, but also to be diligent and careful in pursuing risky projects. Following the legal analysis applied by the courts, we distinguish liability for lack of effort in preparing a risk-taking decision (process due care) and liability for the decision itself (substantive due care). Our key insight is the following: As long as the courts administer liability in the effort dimension reasonably well, they should be reluctant to second-guess managerial decisions. This prescription applies if compensation relates linearly to performance, if liability can also be imposed for failure to take risk or, most importantly, if courts (or managers) often err in evaluating business decisions.

Our model has direct policy implications. Outside directors on corporate boards often receive only a flat salary or shares in the corporation. The result for linear contracts suggests that they should not be subject to substantive due care liability. The same is evidently true for pro bono directors in charitable organizations. Thus, liability is not a substitute for lack of performance pay; in the sense that liability can only be beneficial if more complex compensation schemes are used, liability and performance pay are complements.

For corporate managers with a non-linear, convex compensation scheme, policy advice is less clear-cut: Courts should refrain from imposing liability if they commit too many mistakes in adjudicating the ex ante validity of business decisions, or if it is hard for managers to anticipate the court's ruling. The sweeping business judgment rule in the U.S. suggests that courts have little confidence in their ability to review and guide management decisions. This view is even more appealing if litigation costs are taken into account. However, one could also be more optimistic. Perhaps specialized courts can handle even difficult business cases in a sophisticated and predictable manner. With such expert courts, substantive due care liability could be efficient. Ultimately, the case for or against the business judgment rule must be made on empirical grounds.

We motivated our analysis with the example of corporate directors and officers. However, the model carries over to other settings in which an agent makes risky decisions on behalf of a principal. Asset managers are a case in point. To invest the capital of their clients, they continuously choose among projects with different risk-reward profiles. Our analysis suggests that exposing an asset manager to substantive due care liability can be costly for the client, especially if the asset manager has enough wealth to pay large damage awards. Isolating the agent from liability for his decisions – granting him discretion – can be efficient in this agency relation as well as in many others, such as for business consultants or attorneys. Discretion is, in this sense, a general feature of the law of agency.

In our model, the interests of the agent and the principal diverge with regard to the effort in decision-making, not to the decision itself. The problem only arises because incentivizing the agent can distort his decision: He can avoid having to exert effort (and liability for failure to take effort) by choosing the safe project. Liability in the decision dimension reduces the cost of inducing the agent to take profitable risks – if it is used at all. The analysis changes fundamentally if a conflict of interest arises with regard to the decision. For instance, the agent may obtain a private benefit from choosing the risky project. As the agent strictly prefers the risky choice even in the absence of any incentive contract, there can be a greater role for liability in the decision dimension. In legal terms, such a case may call up the agent's "duty of loyalty," to which the business judgment rule does not apply. We leave an inquiry of the duty of loyalty to future work.

Appendix

Proof of Lemma 1. First, take a $\bar{q}$ with $\bar{q}u_H + (1-\bar{q})\left((1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}\right) \leq u_0$. We show that for all $q < \bar{q}$, the agent prefers the safe project. Because $u_H \geq u_0$, it must be true that

$$(1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u} \leq u_0.$$

Because λ is a weakly decreasing function, for $q < \bar{q}$ it holds that

$$(1-\lambda(q))u_L + \lambda(q)\underline{u} \leq (1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}.$$

It then also follows that

$$qu_H + (1-q)\big((1-\lambda(q))u_L + \lambda(q)\underline{u}\big) \leq u_0.$$

Second, take a $\bar{q}$ with $\bar{q}u_H + (1-\bar{q})\left((1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}\right) \geq u_0$. We show that for all $q > \bar{q}$ the agent prefers the risky project. It holds that

$$(1-\lambda(q))u_L + \lambda(q)\underline{u} \geq (1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u},$$

such that if $(1-\lambda(q))u_L + \lambda(q)\underline{u} \leq u_0$ we again have that

$$qu_H + (1-q)\big((1-\lambda(q))u_L + \lambda(q)\underline{u}\big) \geq u_0,$$

because there is more weight on the larger of the two payoffs. If instead $(1-\lambda(q))u_L+\lambda(q)\underline{u} \geq u_0$, the inequality holds as well. Finally, since for $q = 1$ we have $u_H \geq u_0$ and for $q = 0$ we have $(1-\lambda(0))u_L+\lambda(0)\underline{u} \leq u_0$, there must exist a cutoff $\bar{q}$ with $\bar{q}u_H+(1-\bar{q})((1-\lambda(\bar{q}))u_L+\lambda(\bar{q})\underline{u}) = u_0$. □

Proof of Lemma 2. The first claim is a direct consequence of risk aversion. With a linear contract, the expected wage (without liability) from the risky project at $q < \bar{q}^{FB}$ is $\beta + \alpha(qx_H + (1-q)x_L) < \beta + \alpha x_0$. Hence, the agent chooses the safe project even if he is risk-neutral and $\lambda(q) = 0$. Liability and risk aversion will only distort the agent's choice towards the safe choice.

For the proof of the second claim, we define $l = \beta + \alpha x_L \geq 0$. We also set $x_0 = 0$ to make the proof more readable. We will show that for the probability $\bar{q}$ at which

$$u(\beta) = \bar{q}u(\beta + \alpha x_H) + (1-\bar{q})\big((1-\lambda(\bar{q}))u(\beta + \alpha x_L) + \lambda(\bar{q})\underline{u}\big), \tag{18}$$

the agent also prefers the risky to the safe project with no liability and the contract $\hat{w}$, i.e.,

$$u(\hat{\beta}) \leq \bar{q}u(\hat{\beta} + \alpha x_H) + (1-\bar{q})u(\hat{\beta} + \alpha x_L). \tag{19}$$

The intuition behind this result is that the agent would be willing to pay at least $(1-\bar{q})\lambda(\bar{q})l$ to be insured against the additional lottery to lose l with probability $\lambda(\bar{q})$ in the event of failure. Insurance against the additional risk of liability makes the lottery more attractive. The result can be proved by first noting that, due to concavity of u,

$$u(\hat{\beta}) \leq u(\beta) - (\beta - \hat{\beta})u'(\beta).$$

Using (18), we can conclude that

$$u(\hat{\beta}) \leq \bar{q}u(\beta + \alpha x_H) + (1-\bar{q})u(\beta + \alpha x_L - \lambda(\bar{q})l) - (\beta - \hat{\beta})u'(\beta).$$

With reasoning as before, we get

$$u(\hat{\beta}) \leq \bar{q}u(\hat{\beta} + \alpha x_H) + (1-\bar{q})u(\beta + \alpha x_L - \lambda(\bar{q})l) + (\beta - \hat{\beta})(\bar{q}u'(\hat{\beta} + \alpha x_H) - u'(\beta))$$

and from this

$$\begin{aligned} u(\hat{\beta}) \quad \leq \quad & \bar{q}u(\hat{\beta} + \alpha x_H) + (1-\bar{q})u(\hat{\beta} + \alpha x_L) - \lambda(\bar{q})(1-\bar{q})lu'(\hat{\beta} + \alpha x_L) \\ & + (\beta - \hat{\beta})\big(\bar{q}u'(\hat{\beta} + \alpha x_H) + (1-\bar{q})u'(\hat{\beta} + \alpha x_L) - u'(\beta)\big). \end{aligned}$$

Because $0 \leq \beta - \hat{\beta} \leq (1-\bar{q})\lambda(\bar{q})l$ the claim holds. □

Proof of Proposition 1. Again, we let $x_0 = 0$ for better readability. Take any liability rule with probability of being found liable λ and let $w(x) = \beta + \alpha x$ be the principal's optimal contract under this rule. The resulting threshold for risk-taking is denoted by $\bar{q}$. We define $l = \beta + \alpha x_L$ (≥ 0, because we are only concerned with the case that (LL) is not binding) and a contract $\hat{w} = \hat{\beta} + \hat{\alpha}x$ by

$$\hat{\alpha} = \alpha \text{ and } \hat{\beta} = \beta - l\rho_\lambda.$$

We will show in the following that the principal gets a higher payoff with $\hat{w}$ and λ^{nl} than with w and λ. Because

$$\beta - \hat{\beta} = l\int_{\bar{q}}^{1}(1-q)\lambda(q)dF \leq l(1-\bar{q})\lambda(\bar{q}),$$

we can apply Lemma 2, and get

$$\bar{q}^{FB} \leq \bar{q}^{nl}(\hat{w}) \leq \bar{q}. \tag{20}$$

Next, we will show that the agent is weakly better off with $\hat{w}$ and λ^{nl}. As the first step, we show that

$$U^{nl}(\hat{w}, \bar{q}) \geq U^{\lambda}(w, \bar{q}), \tag{21}$$

where U^{nl} denotes the agent's expected payoff with no liability and U^{λ} denotes the agent's expected payoff under liability rule λ. These payoffs are the expected utilities of two lotteries. We denote the distribution function of the lottery induced by $\hat{w}$ and no liability by G^{nl} and the

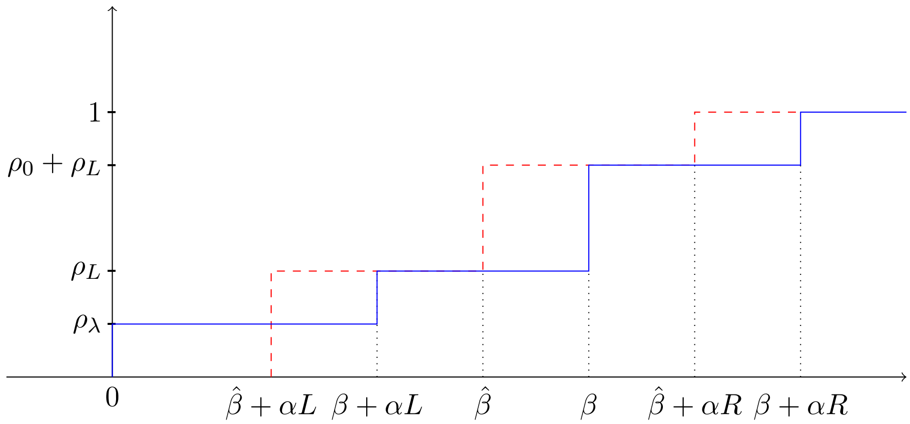

Figure 3: The (red) dashed line is the distribution function G^{nl} and the other line is the distribution function G^{λ}.

distribution function of the lottery induced by w and λ by G^{λ}. Figure 3 shows these distribution functions.

We use this figure to show that G^{nl} second order stochastically dominates G^{λ}. First note that the two lotteries have the same expected value. Second-order stochastic dominance follows because $0 \leq \hat{\beta} + \alpha x_L$ and the distribution functions cross only once. As the second step, we conclude that the agent's actual utility under no substantive due care liability must be even larger if he can choose the optimal $\bar{q}^{nl}(\hat{w})$ instead of $\bar{q}$:

$$U^{nl}(\hat{w}, \bar{q}^{nl}(\hat{w})) \geq U^{nl}(\hat{w}, \bar{q}) \geq U^{\lambda}(w, \bar{q}). \tag{22}$$

Knowing that the agent's utility is weakly greater under no liability immediately gives us the participation constraint (PC). Because $\hat{\beta} \leq \beta$, we also have the safe-choice incentive constraint (SIC). Similarly, the risky-choice incentive constraint (RIC) holds because $\hat{\beta} + \alpha x_H \leq \beta + \alpha x_H$. Finally, the principal's payoff under λ^{nl} is larger than the principal's payoff under the rule described by $\lambda:$

$$\pi^{nl}(\hat{w}, \bar{q}^{nl}) = (1-\alpha)S(\bar{q}^{nl}) - \hat{\beta} \geq (1-\alpha)S(\bar{q}) + \rho_\lambda l - \beta = \pi^{\lambda}(w, \bar{q}). \tag{23}$$

□

Proof of Lemma 3.

We consider the problem of implementing a given $\bar{q}$ at minimum cost. We find this lowest cost $C(\bar{q})$ by minimizing the expected wage payment subject to the constraints (D), (SIC), (RIC), (PC) and (MON). First, we hold λ fixed and minimize only with respect to the wages. The Lagrangian for this problem is

$$\begin{aligned}\min_{w_L,w_0,w_H} \quad & \rho_H w_H + (\rho_L - \rho_\lambda) w_L + \rho_0 w_0 \\ & -\mu_1(\bar{q} u_H + (1-\bar{q})((1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}) - u_0) \\ & -\mu_2(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \kappa - u_0) \\ & -\mu_3(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \kappa - p u_H - (1-p)\underline{u}) \\ & -\mu_4(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \kappa - \bar{u}) \\ & -\mu_5(u_0 - u_L)\end{aligned} \tag{24}$$

It holds that $\mu_i \geq 0$ for $i = 2, 3, 4, 5$, but we cannot yet infer the sign of μ_1. This optimization problem is well-behaved with concave constraint functions and a linear objective function. In any optimum, the following first order conditions with respect to w_0, w_H, and w_L have to hold:

$$\frac{1}{u'(w_0)} = -\frac{1}{\rho_0}\mu_1 + \frac{(\rho_0 - 1)}{\rho_0}\mu_2 + \mu_3 + \mu_4 + \frac{\mu_5}{\rho_0} \tag{25}$$

$$\frac{1}{u'(w_H)} = \frac{\bar{q}}{\rho_H}\mu_1 + \mu_2 + \frac{(\rho_H - p)}{\rho_H}\mu_3 + \mu_4 \tag{26}$$

$$\frac{1}{u'(w_L)} = \frac{(1-\bar{q})(1-\lambda(\bar{q}))}{(\rho_L - \rho_\lambda)}\mu_1 + \mu_2 + \mu_3 + \mu_4 - \frac{\mu_5}{\rho_L - \rho_\lambda} \tag{27}$$

with the usual complementary slackness conditions. Using these necessary conditions we can prove that in any optimum it holds that

$$\mu_4 + \mu_3 + \mu_2 \geq \frac{1}{u'(w_L)}. \tag{28}$$

This follows from (27) if $\mu_1 \leq 0$. If $\mu_1 > 0$ and $\mu_5 = 0$ it follows from the first condition (25), and if $\mu_1 > 0$ and $\mu_5 > 0$ (which implies $w_0 = w_L$), it follows from (25) and (27), which together yield

$$\frac{1}{u'(w_L)} = \frac{(1-\bar{q})(1-\lambda(\bar{q})) - 1}{(\rho_L - \rho_\lambda + \rho_0)}\mu_1 + \mu_2(1 - \frac{1}{(\rho_L - \rho_\lambda + \rho_0)}) + \mu_3 + \mu_4. \tag{29}$$

We can immediately determine the sign of μ_1 if (MON) is not binding ($\mu_5 = 0$). In this case it must be true that $\mu_1 < 0$, because else w_L would be larger than w_0. This in turn implies that $\mu_2 > 0$, because else w_0 would be larger than w_H. The optimal contract w is then defined as the solution to the equations $(D), (SIC), (PC)$ or $(D), (SIC), (RIC)$.

If (MON) is binding ($w_0 = w_L$), then the first order conditions are

$$\frac{1}{u'(w_H)} = \frac{\bar{q}}{\rho_H}\mu_1 + \mu_2 + \frac{(\rho_H - p)}{\rho_H}\mu_3 + \mu_4 \tag{30}$$

$$\frac{1}{u'(w_L)} = \frac{(1-\bar{q})(1-\lambda(\bar{q})) - 1}{\rho_L - \rho_\lambda + \rho_0}\mu_1 + \mu_2(1 - \frac{1}{(\rho_L - \rho_\lambda + \rho_0)}) + \mu_3 + \mu_4 \tag{31}$$

It can be seen that if $\mu_1 < 0$, it must hold that $\mu_2 > 0$ (because else w_H would be smaller than w_L). Therefore, in this case $\mu_1 < 0$ implies that (MON), (D), (SIC) are binding.

In the following, we solve the problem of choosing $\bar{q}^c$ optimally. The objective function and the constraints are differentiable in $\bar{q}^c$.[10] If an optimum $\bar{q}^c$ exists, then it must hold there that

$$-\frac{\partial \rho_\lambda}{\partial \bar{q}^c} w_L + (\mu_4 + \mu_3 + \mu_2)(u_L - \underline{u})\frac{\partial \rho_\lambda}{\partial \bar{q}^c} + \mu_1(1-\bar{q})\frac{\partial \lambda(\bar{q})}{\partial \bar{q}^c}(u_L - \underline{u}) = 0. \tag{32}$$

We know that $\frac{\partial \rho_\lambda}{\partial \bar{q}^c} \geq 0$ and $\frac{\partial \lambda(\bar{q})}{\partial \bar{q}^c} \geq 0$. Because

$$(\mu_4 + \mu_3 + \mu_2) \geq \frac{1}{u'(w_L)} \geq \frac{w_L}{u_L - \underline{u}}$$

the first two terms in (32) add up to something positive. We can therefore conclude that $\mu_1 < 0$ (which we knew for the case that (MON) is not binding, and now follows also for the case that (MON) is binding, which can only be true if there is an optimal standard of care). This also implies that (SIC) is always binding. To show that the condition $\mu_1 < 0$ means that given the optimal wages, the principal prefers the safe project at the cut-off $\bar{q}$, we take the derivative of the principal's payoff $\rho_H(\bar{q})x_H + \rho_L(\bar{q})x_L - C(\bar{q})$ with respect to $\bar{q}$ and get the first order condition:

$$\begin{aligned} & (-\bar{q}x_H - (1-\bar{q})x_L + \bar{q}w_H + (1-\bar{q})(1-\lambda(\bar{q}))w_L - w_0)f(\bar{q}) \\ = \; & -\mu_1(u_H - u_L + \lambda(\bar{q})(u_L - \underline{u}) - (1-\bar{q})\lambda'(\bar{q})(u_L - \underline{u})) \end{aligned}$$

Note that the left hand side shows the direct effect of a change in $\bar{q}$ on the principal's payoff function. Since the right-hand of this equation side is positive, the result follows. But because $\bar{q}w_H + (1-\bar{q})w_L - (1-\bar{q})\lambda(\bar{q})w_L > w_0$, we cannot determine the sign of $\bar{q} - \bar{q}^{FB}$. □

Proof of Lemma 4.

We can exploit that (SIC) and (D) are binding to compare the optimal contract w to the optimal contract w^{nl} for λ^{nl}. From (SIC) and (D) we can derive that

$$u_L^{nl} = u_0^{nl} - u_0 + (1-x)u_L + x\underline{u},$$

where

$$x = \frac{\int_{\bar{q}}(1-\bar{q})\lambda(\bar{q})q - (1-q)\lambda(q)\bar{q}dF}{\int_{\bar{q}}(q-\bar{q})dF}.$$

Assume first that $u_0^{nl} \leq u_0$, which implies $u_L^{nl} \leq (1-x)u_L + x\underline{u}$. Since it holds that $\frac{\rho_\lambda}{\rho_L} \leq \lambda(\bar{q}) \leq x$, this in turn implies that $u_L^{nl} \leq (1 - \frac{\rho_\lambda}{\rho_L})u_L + \frac{\rho_\lambda}{\rho_L}\underline{u}$, i.e $w_L^{nl} \leq (1 - \frac{\rho_\lambda}{\rho_L})w_L$. We also know that

[10] It is also straightforward to show that a regularity condition holds such that we indeed identify necessary conditions for an optimum.

$\bar{w} \leq w_0$, so that if it were true that $w_H^{nl} \leq w_H$ we would have

$$\rho_H w_H + \rho_L(1 - \frac{\rho_\lambda}{\rho_L})w_0 + \rho_0 w_0 \geq \rho_H w_H^{nl} + \rho_L w_L^{nl} + \rho_0 w_0^{nl},$$

which means that λ^{nl} is actually optimal. Hence, it must hold that $w_H^{nl} \geq w_H$ if the contract w is optimal.

Assume now $u_0^{nl} > u_0$. This can only be the case if for no liability (RIC) is binding. Hence we know that

$$pu_H^{nl} + (1-p)\underline{u} = u_0^{nl} > u_0 \geq pu_H + (1-p)\underline{u},$$

and therefore $u_H^{nl} > u_H$. (D) and (RIC) together yield

$$u_H^{nl} \int_0^{\bar{q}} (\bar{q} - q)dF + (\rho_L + \rho_0(1-\bar{q}))u_L^{nl} \quad = \quad \kappa + (1-p)\underline{u}$$

and

$$u_H \int_0^{\bar{q}} (\bar{q} - q)dF + (\rho_L + \rho_0(1-\bar{q}))u_L - (\rho_\lambda + \rho_0(1-\bar{q})\lambda(\bar{q}))(u_L - \underline{u}) \geq \kappa + (1-p)\underline{u}.$$

We can conclude that

$$(u_H - u_H^{nl}) \int_0^{\bar{q}} (\bar{q} - q)dF + (\rho_L + \rho_0(1-\bar{q}))(u_L - u_L^{nl}) - (\rho_\lambda + \rho_0(1-\bar{q})\lambda(\bar{q}))(u_L - \underline{u}) \geq 0,$$

hence $u_L \geq u_L^{nl}$.

□

Proof of Remark 2. We have to show that in these two cases $\frac{\partial}{\partial\Delta\partial\lambda}\lambda^{-1}(\lambda) \geq 0$. With $\phi = \Phi'$, the derivative of the function $\lambda^{-1}(\lambda) = \bar{q}^c - \Phi^{-1}(\lambda)$ is

$$\lambda^{-1\prime}(\lambda) = -\frac{1}{\phi(\Phi^{-1}(\lambda))}. \tag{33}$$

We have to show that this expression is increasing in Δ. To this end, we take the derivative with respect to Δ of the function $\phi(\Phi^{-1}(\lambda))$. If we can show that this is positive in the two cases, we are done. In general, this derivative is equal to

$$\frac{d\phi(\Phi^{-1}(\lambda))}{d\Delta} = \frac{\partial\phi}{\partial\Delta} - \left.\frac{\phi' \frac{\partial\Phi}{\partial\Delta}}{\phi}\right|_{\Phi^{-1}(\lambda)}. \tag{34}$$

For the linear error term with distribution $\Phi(\epsilon) = \frac{1+\epsilon\Delta}{2}$ on the interval $[-\frac{1}{\Delta}, \frac{1}{\Delta}]$ the second term is zero so that this derivative is

$$\frac{\partial\phi(\Phi^{-1}(\lambda))}{\partial\Delta} = \frac{1}{2} > 0. \tag{35}$$

For the normal error term with distribution $\Phi(\epsilon) = \sqrt{\frac{\Delta}{2\pi}} \int_{-\infty}^{\epsilon} e^{-\frac{1}{2}x^2\Delta} dx$ we can compute

$$\frac{\partial \phi(\epsilon)}{\partial \Delta} = (\frac{1}{\Delta} - \epsilon^2)\frac{1}{2}\phi(\epsilon),$$

$$\frac{\phi'(\epsilon)}{\phi(\epsilon)} = -\epsilon\Delta,$$

and, using integration by parts,

$$\frac{\partial \Phi(\epsilon)}{\partial \Delta} = \frac{1}{2\Delta}\epsilon\phi(\epsilon).$$

Putting everything together, we get

$$\frac{\partial \phi(\Phi^{-1}(\lambda)))}{\partial \Delta} = \frac{1}{2\Delta}\phi(\Phi^{-1}(\lambda)) > 0. \tag{36}$$

□

Proof of Proposition 2.

In a first step, we show that as the signal becomes more precise, eventually a positive standard must be better. We show that with a perfect signal, the same threshold as under no liability, $\bar{q}^{nl}$, can be implemented at lower cost than with the contract w^{nl}. To this end, we set the legal standard $\bar{q}^c = \bar{q}^{nl}$ and consider a contract with $w_0 = w_L = w_0^{nl}$ and w_H defined by

$$\rho_H(\bar{q}^{nl})(u_H - u_0^{nl}) = \kappa.$$

For the so defined contract it holds that $w_H^{nl} \geq w_H$ and $w_L \geq w_L^{nl}$. In the limit $\Delta \to \infty$, with a perfect signal, this contract implements $\bar{q}^{nl}$ because

$$\bar{q}^{nl}u_H + (1-\bar{q}^{nl})\underline{u} \leq u_0 \text{ and } \bar{q}^{nl}u_H + (1-\bar{q}^{nl})u_0 \geq u_0.$$

It exposes the agent to a lottery between w_0^{nl} (with probability $\rho_L + \rho_0$) and w_H (with probability ρ_H). The agent's expected utility of this lottery is equal to $U^{nl}(w^{nl}, \bar{q}^{nl})$. Because the lottery exposes the agent to less risk in the sense of second-order stochastic dominance, it must have a lower expected value than the lottery induced by the no liability contract, which means lower costs for the principal.

In a second step, we consider the limit $\Delta \to 0$ and show that a completely uninformative signal is worthless. For an uninformative signal it holds that $\lambda(q) = \frac{1}{2}$ for all q and $\bar{q}^c$. If w is the optimal wage, then we define a new contract $\tilde{w}$ by $\tilde{u}_H = u_H$, $\tilde{u}_0 = u_0$ and $\tilde{u}_L = \frac{1}{2}u_L + \frac{1}{2}\underline{u}$. This contract, with λ^{nl}, implements the same cut-off and the same agent's utility at a lower cost for the principal.

It remains to show that the principal's payoff, once it is equal to $\pi^{nl}(w^{nl}, \bar{q}^{nl})$ for some $\bar{\Delta}$, stays larger than $\pi^{nl}(w^{nl}, \bar{q}^{nl})$ for all $\Delta > \bar{\Delta}$. Let $\bar{q}$ be the optimal threshold for $\bar{\Delta}$, and $\bar{q}^c$ the optimal standard. First note that if the limited liability constraint (LL) is binding at this point, then the same payoff can be achieved for all $\Delta > \bar{\Delta}$ as well. We assume in the following that (LL) is not binding and show that as Δ increases, this particular $\bar{q}$ becomes easier to implement. To do this, we select standards $\bar{q}^c(\Delta)$ such that $\lambda(\bar{q})$ is the same for all $\Delta \geq \bar{\Delta}$. That is, we implicitly define a function $\bar{q}^c(\Delta)$ by

$$\Phi(\bar{q}^c(\Delta) - q, \Delta) = \Phi(\bar{q}^c - q, \bar{\Delta}), \tag{37}$$

where we have modified the earlier notation to make the dependence on precision explicit. We now look at the principal's cost of implementing $\bar{q}$ as the decision threshold, taking the standard $\bar{q}^c(\Delta)$ as given. This cost $C(\bar{q})$ is derived in the proof of Proposition 2. We take the derivative of the cost with respect to Δ, which varies ρ_λ. Note that by definition of the standard $\bar{q}^c(\Delta)$, $\lambda(\bar{q})$ does not vary with Δ.

$$\frac{\partial C(\bar{q})}{\partial \Delta} = -\frac{\partial \rho_\lambda}{\partial \Delta} w_L + (\mu_4 + \mu_3 + \mu_2)(u_L - \underline{u})\frac{\partial \rho_\lambda}{\partial \Delta}. \tag{38}$$

It follows from Assumption 1 that $\frac{\partial \rho_\lambda(\bar{q})}{\partial \Delta} \leq 0$. To see this, note that when we choose $\bar{q}^c(\Delta)$ such that $\lambda(q, \Delta)$ and $\lambda(q, \bar{\Delta})$ intersect at $q = \bar{q}$, then it must hold that

$$\frac{\partial}{\partial q}\lambda(\bar{q},\Delta) < \frac{\partial}{\partial q}\lambda(\bar{q},\bar{\Delta})$$

and consequently $\lambda(q, \Delta) \leq \lambda(q, \bar{\Delta})$ for all $q \geq \bar{q}$, which means that ρ_λ must be decreasing in Δ. Furthermore, as in the proof of Proposition 2, here it holds that

$$\mu_4 + \mu_3 + \mu_2 \geq \frac{1}{u'(w_L)}.$$

Because $w_L u'(w_L) \leq u_L - \underline{u}$, the derivative in (38) is negative. Hence, we have shown that cost decreases in precision if we take $\bar{q}^c(\Delta)$ as the standard for Δ. If we take the optimal standard, cost can only decrease further. Hence, the principal's payoff is increasing in the precision of the signal. □

Proof of Proposition 3. This time, we cannot a priori exclude the case that the monotonicity constraint is binding in the other direction ($w_0 = w_H$). However, as we will show in the following, if $w_0 = w_H$ is optimal with liability after the safe decision, then no liability must better. To this end, let λ be the probability of being liable after the risky choice and l the probability of being liable after the safe choice, defined by the optimal standards $\bar{q}^c$ and $\bar{q}_0^c$, and let w be the optimal wage. This contract induces a threshold $\bar{q}$, given by

$$\bar{q}u_H + (1 - \bar{q})((1 - \lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}) = u_0 - l(\bar{q})(u_0 - \underline{u})$$

Let $U^\lambda(w,\bar{q})$ denote the agent's payoff under the liability rule and contract w. The other constraints $(PC),(RIC),(SIC)$ are

$$\begin{aligned} U^\lambda(w,\bar{q}) &\geq \bar{u} \\ U^\lambda(w,\bar{q}) &\geq pu_H + (1-p)\underline{u} \\ U^\lambda(w,\bar{q}) &\geq (1-p)u_0 + p\underline{u} \end{aligned}$$

For the regime λ^{nl}, we set $\tilde{w}_H = \tilde{w}_L = \tilde{w}_0 = U^\lambda(w,\bar{q})$ such that the agent's payoff is the same, i.e. $\tilde{w}$ is defined to be the wage at which $U^{nl}(\tilde{w},\bar{q}) = U^\lambda(w,\bar{q})$. It then holds that $\tilde{w}_H \leq w_H$. The agent is indifferent between all decisions and will provide the efficient one. The constraints are now:

$$\begin{aligned} U^{nl}(\tilde{w},\bar{q}^{FB}) &\geq \bar{u} \\ U^{nl}(\tilde{w},\bar{q}^{FB}) &\geq p\tilde{u}_H + (1-p)\underline{u} \\ U^{nl}(\tilde{w},\bar{q}^{FB}) &\geq (1-p)\tilde{u}_0 + p\underline{u} \end{aligned}$$

In case that $u_0 = u_H$, the last inequality (i.e. the safe choice incentive constraint) follows from the original safe-choice incentive constraint. Since the agent is completely insured, the principal's payoff is higher. Note also that the first best can be reached with a wage of $\tilde{w}$ with $u(\tilde{w}) = \bar{u}+\kappa$, because then the incentive constraints become

$$\begin{aligned} \bar{u} &\geq \bar{u} \\ \bar{u} &\geq p(\bar{u}+\kappa) + (1-p)\underline{u} \\ \bar{u} &\geq (1-p)(\bar{u}+\kappa) + p\underline{u} \end{aligned}$$

and are satisfied due to our assumptions. In general, we can only show that there should be no liability after the safe alternative ($l=0$), but not that also λ^{nl} should be used. Compared to the main part of the paper, the problem of minimizing cost has changed in the following way:

$$\begin{aligned} \min_{w_L,w_0,w_H} \quad & \rho_H w_H + (\rho_L - \rho_\lambda)w_L + (\rho_0 - \rho_l)w_0 \\ & +\mu_1(\bar{q}u_H + (1-\bar{q})((1-\lambda(\bar{q}))u_L + \lambda(\bar{q})\underline{u}) - u_0 + l(\bar{q})(u_0 - \underline{u})) \\ & +\mu_2(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \rho_l(u_0 - \underline{u}) - \kappa - u_0(1-p) - \underline{u}p) \\ & +\mu_3(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \rho_l(u_0 - \underline{u}) - \kappa - pu_H - (1-p)\underline{u}) \\ & +\mu_4(\rho_H u_H + \rho_L u_L - \rho_\lambda(u_L - \underline{u}) + \rho_0 u_0 - \rho_l(u_0 - \underline{u}) - \kappa - \bar{u}) \\ & +\mu_5(u_0 - u_L) \end{aligned} \tag{39}$$

with

$$\rho_l(\bar{q}) = \int_0^{\bar{q}} l(q)dF. \tag{40}$$

The first order conditions are now

$$\frac{1}{u'(w_0)} = -\frac{1-l(\bar{q})}{\rho_0-\rho_l}\mu_1 - \frac{1-p}{\rho_0-\rho_l}\mu_2 + \mu_2 + \mu_3 + \mu_4 + \frac{\mu_5}{\rho_0-\rho_l} \tag{41}$$

$$\frac{1}{u'(w_H)} = \frac{\bar{q}}{\rho_H}\mu_1 + \mu_2 + \frac{(\rho_H - p)}{\rho_H}\mu_3 + \mu_4 \tag{42}$$

$$\frac{1}{u'(w_L)} = \frac{(1-\bar{q})(1-\lambda(\bar{q}))}{(\rho_L-\rho_\lambda)}\mu_1 + \mu_2 + \mu_3 + \mu_4 - \frac{\mu_5}{\rho_L-\rho_\lambda} \tag{43}$$

Only the first constraint has changed, and it follows immediately that

$$\mu_4 + \mu_3 + \mu_2 \geq \frac{1}{u'(w_0)}$$

if either $\mu_1 < 0$ (from (42)) or if $\mu_1 > 0$ and $\mu_5 = 0$ (from (41)). For the case that $\mu_1 > 0$ and (MON) is binding, the first and the third condition together yield

$$\frac{1}{u'(w_0)} = \frac{(1-\bar{q})(1-\lambda(\bar{q})) - 1 + l(\bar{q})}{\rho_0 - \rho_l + \rho_L - \rho_\lambda}\mu_1 - \frac{1-p}{\rho_0 - \rho_l + \rho_L - \rho_\lambda}\mu_2 + \mu_2 + \mu_3 + \mu_4.$$

As before, μ_1 is multiplied with a negative term. This follows directly if $l(\bar{q}) = \bar{q}\Phi(\bar{q} - \bar{q}_0^c)$, and more generally it follows from (D), which takes the form

$$\bar{q}(u_H - u_0) = ((1-\bar{q})\lambda(\bar{q}) - l(\bar{q}))(u_0 - \underline{u}),$$

and hence implies $(1-\bar{q})\lambda(\bar{q}) - l(\bar{q}) \geq 0$. We can then deduce as in the proof of Proposition 4 that $\mu_1 < 0$. Taking the derivative with respect to $\bar{q}_0^c$ yields

$$-\frac{\partial \rho_l}{\partial \bar{q}_0^c}w_0 + (\mu_4 + \mu_3 + \mu_2)(u_0 - \underline{u})\frac{\partial \rho_l}{\partial \bar{q}_0^c} - \mu_1 \frac{\partial l(\bar{q})}{\partial \bar{q}_0^c}(u_0 - \underline{u}) \leq 0.$$

Hence, the cost of implementing any $\bar{q}$ is decreasing in $\bar{q}_0^c$. □

Proof of Proposition 4. We will show that if the signal is as precise as stated and the standard is set at $\bar{e}^c = \tilde{e}$, then we can achieve the same outcome as with a perfect signal. First, we will show that given the assumption about $\Psi_0(\tilde{e})$, the constraint (SIC) always binds. If (SIC) did not exist, the best way to implement $\bar{q}$ and $e = 1$ would be setting $u_H = u_0 = u_L = \bar{u} + \kappa$ and λ^{nl}. The constraints $(D), (PC), (MON)$ would naturally be satisfied, and (RIC) would take the form

$$\bar{u} \geq \bar{u} + \kappa - \Psi_0(\tilde{e})(1-p)(\bar{u} + \kappa - \underline{u}). \tag{44}$$

To conclude from the assumption on $\Psi_0(\tilde{e})$ that this condition is satisfied, we have to show that

$$(\bar{u} + \kappa - \underline{u})(1-p)p \geq (\bar{u} - \underline{u})\int_p^1 (q-p)dF,$$

which holds because $(1-p)p \geq \int_p^1 (q-p)dF$ is equivalent to the obviously correct statement

$$\int_0^p qdF + \int_p^1 pdF \geq \int_0^1 qpdF.$$

The result that (SIC) binds holds true both for linear contracts and monotonic ones. It implies the result of Proposition 4, because in the proof only (SIC) and (D) were used to show how wages compare. Next, we will show that (RIC) is not binding with λ^{nl}. This follows immediately for $\bar{q} \geq p$ because in that case (RIC) follows directly from (SIC) :

$$u_0 = \bar{q}u_H + (1-\bar{q})u_L \geq pu_H + (1-p)u_L - (1-p)\Psi_0(\tilde{e})(u_L - \underline{u}). \tag{45}$$

Next we consider the case $\bar{q} < p$ and assume to the contrary that (RIC) is binding. Together with (D) it yields

$$(u_H - u_L)\int_0^{\bar{q}} (\bar{q} - q)dF + (u_L - \underline{u})\Psi_0(\tilde{e})(1-p) = \kappa, \tag{46}$$

while (SIC) and (D) together yield

$$(u_H - u_L)\int_{\bar{q}}^1 (q - \bar{q}) = \kappa, \tag{47}$$

and (PC) and (D) together yield

$$u_L - \underline{u} + (u_H - u_L)(\rho_H + \rho_0\bar{q}) \geq \kappa + \bar{u} - \underline{u}. \tag{48}$$

From (46) and (48) we take that

$$(u_H - u_L)\int_0^{\bar{q}} (\bar{q} - q)dF + \Psi_0(\tilde{e})(1-p)\big(\kappa + \bar{u} - \underline{u} - (\rho_H + \rho_0\bar{q})(u_H - u_L)\big) \leq \kappa, \tag{49}$$

which implies

$$\Psi_0(\tilde{e})(1-p)(\bar{u} - \underline{u}) \leq \kappa + (1-p)\big((\rho_H + \rho_0\bar{q})(u_H - u_L) - \kappa\big) - (u_H - u_L)\int_0^{\bar{q}} (\bar{q} - q)dF. \tag{50}$$

Exploiting (47) this can be rearranged to yield

$$\Psi_0(\tilde{e}) \leq \frac{(1-\bar{q})p\kappa}{(1-p)(\bar{u} - \underline{u})\int_{\bar{q}}^1 (q - \bar{q})dF} \tag{51}$$

Since the right-hand side is increasing in $\bar{q}$, this contradicts our assumption on $\Psi_0(\tilde{e})$. Hence, we can deduce also for $\bar{q} < p$ that (RIC) is not binding. The outcome of the optimal contract for λ^{nl} must hence be the same as with a perfect signal. This shows the result of Proposition 1, and it also implies that for monotonic contracts and all $\Delta \leq \bar{\Delta}$, the outcome of the optimal contract is still the same. $\square$

Proof of Corollary 1. For linear contracts we know that $\bar{q} \geq \bar{q}^{FB} \geq p$ always holds. It follows from (45) in the proof of Proposition 4 with $\Psi_0(\tilde{e}) = 0$ that for $\bar{q} \geq p$, (SIC) is stricter than (RIC). Hence, the outcome with $\bar{e}^c = 0$ is the same as with a perfect signal and a standard of $\bar{e}^c = 1$.

For the case of more general contracts, Lambert (1986) treats the case without liability in detail and shows that if $\bar{q}^{FB} > p$ holds, (RIC) is not binding, which gives us the result. $\square$

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