

# Managerial Reporting, Overoptimism, and Litigation Risk\*

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## Abstract

We examine how the threat of litigation affects an entrepreneur's reporting behavior when the entrepreneur (i) can misrepresent his privately observed information, (ii) pays legal damages out of his own pocket, and (iii) is optimistic about the firm's prospects relative to investors. We find higher expected legal penalties imposed on the culpable entrepreneur do not always cause the entrepreneur to be more cautious but instead can increase misreporting. We highlight how this relation depends crucially on the extent of entrepreneurial overoptimism, legal frictions, and the internal control environment.

**Keywords:** Mandatory Disclosure, Litigation, Overoptimism.

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## 1 Introduction

A fundamental feature of the financial reporting landscape is that investors want a firm's management to diligently and faithfully report on its firm's affairs. In the event of fraudulent material misstatement or omission of information, the federal securities laws provide investors with the right to take legal action. The efficacy of securities litigation at deterring fraudulent management and compensating aggrieved shareholders has been vigorously debated. Within this debate, a commonly held view is that securities actions can serve an important deterrence role only if legal damages are borne by the culpable managers and not by the corporation and its insurance firm (Alexander 1996; Coffee 2006; Langevoort 2007).

This paper examines this appealing argument by analyzing the relation between legal penalties imposed on a culpable entrepreneur and his financial reporting behavior. We study a model featuring an entrepreneur and a representative investor in a primary market setting. The entrepreneur is endowed with a project and issues a report to raise equity capital from the investor to finance it. If the entrepreneur reports fraudulently and the project is financed but fails, the investor can sue the entrepreneur for damages. We assume that any damages are paid by the culpable entrepreneur out of his own pocket and not by the corporation and its insurance firm. The investor incorporates the anticipation of legal damages when determining the cost of equity capital.

Our model views entrepreneurs as being more optimistic than investors about the chances that their business ideas will succeed. This premise is consistent with a large

body of evidence from surveys and empirical studies (e.g., Cooper, Woo, and Dunkelberg 1988; Pinfold 2001; Bankman 1994; Arabsheibani, et al. 2000; Malmendier and Tate 2005; Landier and Thesmar 2009).<sup>1</sup> In their survey, Cooper et al. (1988, 103) observe that “entrepreneurs’ perceptions of their own odds for success display a noteworthy degree of optimism.” Landier and Thesmar (2009) find empirical evidence that entrepreneurs tend to be upward biased regarding their assessment of their venture’s performance.

Our paper contributes to the theoretical literature examining the link between litigation and reporting behavior (e.g., Trueman 1997; Evans and Sridhar 2002; Spindler 2010; Caskey 2010). We show that even in an “ideal” deterrence environment in which the entrepreneur bears damages out of his own pocket, the deterrence role of legal penalties is more subtle than the conventional view suggests. We find an increase in expected legal penalties imposed on the entrepreneur for misreporting does not necessarily lead to more truthful reporting, but in fact can lead to more misreporting.<sup>2</sup> Further, assuming investors’ beliefs about the project’s prospects are correctly calibrated, this misreporting leads to overinvestment and a reduction in expected social welfare. To remedy this disconcerting relation and ensure that heightened le-

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<sup>1</sup>Van den Steen (2010) offers a survey of the rapidly growing literature that models players as having different prior beliefs. He notes that this assumption is not the same as endowing players with private information that cannot be communicated, an assumption often made in the extant disclosure literature.

<sup>2</sup>Trueman (1997) also considers damages that are imposed on the entrepreneur whereas Evans and Sridhar (2002), Spindler (2010), and Caskey (2010) consider damages that are paid by the firm and its insurer. While this literature comes to different conclusions regarding the deterrence effectiveness of litigation, none of these studies demonstrates a negative relation between litigation risk and financial misreporting.

gal penalties appropriately deter managerial misreporting, we suggest changes in the manner in which legal penalties are administered.

The anticipation of legal damages has two opposing effects on the entrepreneur's reporting behavior. On one hand, and consistent with standard arguments, potential legal penalties for fraudulent reporting directly reduce incentives for manipulation. We call this the *punishment effect*. On the other hand, the anticipation of legal damages raises the investor's expected payoff, which lowers the equity stake the investor demands if she finances the project. This reduction in the cost of capital, in turn, increases the entrepreneur's residual and makes implementing the project more attractive. Given that the project is only financed when a favorable report is released, legal damages increase the entrepreneur's incentive to manipulate unfavorable signals in an attempt to obtain financing. We label this the *compensation effect*.

Coupling the punishment and compensation effects, we emphasize three relations. First, we show that when the entrepreneur is more optimistic than investors, an increase in legal damages strengthens the compensation effect more than the punishment effect. If this is the case, an increase in legal damages does not mitigate but rather accentuates the entrepreneur's incentives to misreport. The broad intuition for this result is that an optimistic entrepreneur, believing the probability of failure is relatively small, is not particularly anxious about the threat of being punished but is strongly motivated by the prospect of receiving a large residual payoff if the project is financed and is successful.

Second, we establish that the effects of heightened legal damages on reporting behavior depends on the way those damages are shared between the investor and her attorney. When the legal environment is characterized by large frictions that allow the plaintiff's attorney to capture a substantial portion of the damages, the com-

compensation effect is weak. Importantly, in this case, any further increase in damages only weakly increases the compensation effect, but the increase in the penalty effect remains strong. Thus, the relation between legal penalties and misreporting is negative, as conventional wisdom suggests. In contrast, when legal frictions are small, the compensation effect is strong and the link between the expected damages and misreporting can be positive. This finding implies that penalties collected by the SEC more effectively discourage manipulation than damages awarded to investors under the securities laws because SEC penalties do not directly compensate investors. Accordingly, we support the argument in Alexander (1996) and the trend in recent legislation (e.g., Sarbanes Oxley Act of 2002 and Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010) to extend the authority of the SEC to impose fines and sanction fraudulent management.

Third, we explore how the effectiveness of the internal control environment, which was substantially altered following the implementation of the Sarbanes Oxley Act, affects the relation between legal damages and entrepreneurial misreporting. We show that raising the penalties for violation of the securities laws in a weak internal control environment, ironically, might weaken the quality of a firm's financial reporting. Thus, corporate governance systems and legal penalties are not necessarily substitutes for disciplining management behavior.

Our paper tackles issues that might guide policy-makers and regulators as they consider the effect of the litigation environment on firms' reporting behavior. Our paper highlights that the relation between potential legal damages and firm reporting behavior is subtle and depends crucially on the particular features of the institutional environment such as entrepreneurial optimism, legal frictions, and the strength of the internal control system. It has been well argued that director indemnification

for security law liabilities and payouts from the deep-pockets of auditors, insurance companies, and investment banks subvert the deterrence effect of the securities laws. However, even when a corporate executive is held responsible for paying damages, we continue to find that securities laws that compensate investors for their damages might not deter fraudulent misreporting. Accordingly, we support reforms to the anti-fraud mechanisms reforms that extend the authority of the SEC to collect fines from culpable managers.

The paper proceeds as follows: Section 2 provides a review of the legal environment; Section 3 outlines the model; Section 4 characterizes the unique equilibrium; Section 5 analyzes how the relation between legal damages and misreporting depends on entrepreneurial overoptimism, legal frictions, and the efficiency of the internal control environment; and, Section 6 concludes. All proofs are contained in the appendix.

## **2 Legal Environment**

A substantial number of federal securities class action filings allege accounting fraud. In its *2010 Securities litigation study*, PricewaterhouseCoopers reported that the rate of alleged accounting related securities fraud cases relative to the total number of securities fraud cases has been more than 50 percent for all but four of the last 15 years and that the median settlement value of accounting related U.S. federal securities class action lawsuits has varied between \$7 million in 2006 and \$13 million in 2010 (Lamont 2011). Thus, it is not surprising that the debate concerning the role of securities litigation at deterring fraudulent misreporting has been vigorous. The debate has focused on both primary market and secondary market actions.

In the primary market in which there is some privity between the shareholders

and the firm, most lawsuits against an issuer of securities are brought under Section 11 of the Securities Act of 1933; Lowry and Shu (2002) report that over five percent of firms with initial public offerings in the period 1988 to 1995 were sued and almost 80 percent of these firms were sued under Section 11. Section 11 creates a strict liability for the issuer if the registration statement contains a material misstatement or omission of which the purchaser of the securities was unaware. Damages are based on the difference between the offer price and either the sale price or the securities price at the time of the lawsuit depending on whether the securities had been sold. Further, all signatories of the registration statement are jointly and severally liable for the damages and the firm cannot provide indemnification for damages (see Spehr, De Simone, and Calica 2006). For instance, in the WorldCom case, Bernard Ebbers contributed \$40 million to the class action settlement, which represented almost all his personal wealth, and the directors were required to pay about 20 percent of their net worth to a settlement fund (Coffee 2006).

Claims under Section 11 are often accompanied by claims under Section 12 of the Securities Act of 1933. Section 11 and Section 12 differ in some significant respects, however. For instance, Section 11 imposes strict liability whereas Section 12 provides for a negligence-like claim for misstatements or omissions in a “prospectus or oral communication” in connection with the sale of a security; for further details, see Spehr, et al. (2006).<sup>3</sup>

In the secondary market in which a firm has neither bought nor sold its own shares, the key anti-fraud enforcement mechanism is the class action arising under Rule 10b-5

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<sup>3</sup>Only the decline in value below the initial offering price can be recovered under Section 11(e) and Section 12(b) of the Securities Act—the two primary market anti-fraud provisions (Coffee 2005, 2006).

of the Securities Exchange Act of 1934. Some of the most prominent legal scholars in the United States have impugned almost every aspect of “fraud on the market” class action arising under Rule 10b-5 claiming that it fails to deter fraud, fails to compensate investors, and inappropriately calculates damages (e.g., Alexander 1996; Arlen and Carney 1992; Coffee 2004, 2006; Langevoort 2007). This criticism seems to have eroded application of Rule 10b-5 and led to several legal reforms, including key provisions in the Private Securities Litigation Reform Act of 1995 and the SEC policy released in January 2006 for imposing financial penalties on culpable firm managers rather than innocent shareholders (Coffee 2005; Spindler 2010).<sup>4</sup>

While legal scholars have severely criticized the application of Rule 10b-5 in secondary market transactions, they have viewed the application of Sections 11 and 12 in primary market offerings more kindly. The remedies under the securities laws were developed by analogy to the common law torts of fraud and misrepresentation. Accordingly, when there are direct dealings between the plaintiff and defendant and the plaintiff relies on the misrepresentation or omission that directly benefits the defendant, damages under Sections 11 and 12, particularly when paid by the manipulative manager, are argued to be well suited to deter misreporting. Simply put, in these instances these scholars have argued that “securities litigation can work” (Coffee 2006, 1560). Similarly, Alexander (1996) cautions that any reform to correct defects in securities laws should be carefully designed to avoid changing the laws surrounding managerial liability arising from primary market offerings.

The premise that securities actions can serve an important deterrence role, but only a minor compensatory role, and hence there should be greater out-of-pocket

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<sup>4</sup>See the Securities and Exchange Commission statement concerning financial penalties released on January 4, 2006 at <http://www.sec.gov/news/press/2006-4.htm>.

liability for managers misreporting prima facie seems appealing (see Alexander 1996; Coffee 2006; Langevoort 2007). This premise motivates formally examining the effect of personal legal penalties on an entrepreneur's financial reporting behavior within a primary market setting.

### 3 Model

Consider a risk-neutral entrepreneur who does not have any private wealth and wishes to raise capital from investors to finance an investment project. The required amount of capital is denoted by  $I > 0$ . The project, if implemented, either succeeds or fails. In case of success, the project generates future cash flows of  $X_G$ , and in case of failure, the project generates future cash flows of  $X_B$ , with  $X_G > I > X_B > 0$ . Let  $\Delta = X_G - X_B$ . The entrepreneur's and the investor's prior subjective beliefs about the probability of project success are denoted by  $\alpha_E$  and  $\alpha_I$ , respectively. We consider environments where the entrepreneur may be overoptimistic relative to the investor about the project's prospects; that is,  $\alpha_I \leq \alpha_E < 1$ . The players' beliefs  $(\alpha_E, \alpha_I)$  are common knowledge.

Firms might seek both debt and equity financing.<sup>5</sup> However, to provide a meaningful role for shareholder litigation, we require that  $X_B$  exceeds the amount of the firm's debt financing. If this condition is not satisfied, then the providers of debt financing would receive  $X_B$  in case of failure and there would be no assets remaining in the firm that a plaintiff could claim. Accordingly, neither the shareholders nor

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<sup>5</sup>Landier and Thesmar (2009) offer a model containing investors and entrepreneurs with differences in opinion to explain a firm's capital structure and, in particular, a firm's reliance on short-term debt.

the debtholders would choose to sue the entrepreneur if the firm was to fail. The role of damages on the entrepreneur's reporting behavior, which is the focus of this study, then would be moot. Since the assumption that  $X_B$  exceeds the amount of the firm's debt financing implies that the providers of debt financing are not at risk, we normalize the firm's payoffs to be net of debt financing. This normalization allows us to focus on the providers of equity financing, which we label as the investor.<sup>6</sup>

The game has four stages. In stage one, the entrepreneur obtains a noisy signal  $S \in \{S_G, S_B\}$ . Signal  $S$  is informative about the project's prospects (the state  $X_\bullet$ ) and reflects either good news,  $S = S_G$ , or bad news,  $S = S_B$ . The precision or informativeness of the signal is determined by the parameter  $p \in (1/2, 1)$ . The precision  $p = \Pr(S_G|X_G) = \Pr(S_B|X_B)$  is exogenous and common knowledge. We assume that in the absence of further information, the project has a non-negative net present value from the investors' perspective:  $\alpha_I X_G + (1 - \alpha_I) X_B \geq I$ . To avoid the uninteresting case in which the reporting of additional information does not affect the investment decision, we assume that the precision  $p$  is sufficiently high such that the realization of a negative signal renders the project unattractive; that is,  $p$  is such that  $E[X|S_B; \alpha_I; p] < I$ .

In stage two, the entrepreneur releases a report  $R \in \{R_G, R_B\}$ . In the absence of manipulation, the entrepreneur reports  $R = R_i$  when  $S = S_i$ , where  $i \in \{G, B\}$ . However, the entrepreneur can exert effort  $m \in [0, 1]$  in an attempt to fraudulently manipulate the report and claim  $R_i$  even though  $R_i \neq S_i$ . The entrepreneur may

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<sup>6</sup>In Leland and Pyle (1977), a risk-averse entrepreneur can signal favorable private information by holding a greater equity stake in the firm (see also Baldenius and Meng, 2010). In our setting, the entrepreneur cannot increase the fraction of the firm's equity he retains because he does not have any private wealth.

choose to manipulate in both directions. Given effort  $m$ , manipulation is successful (i.e.,  $R_i \neq S_i$ ) with probability  $m$  and unsuccessful (i.e.,  $R_i = S_i$ ) with probability  $(1 - m)$ . The entrepreneur's non-pecuniary cost of manipulation is given by  $km^2/2$ , where  $k > 0$ .<sup>7</sup> This cost can be interpreted as the cost of manipulating the accounting system, including forging documents, deceiving the auditor, misleading the board of directors, and the like. As the parameter  $k$  increases, it becomes more costly for the entrepreneur to successfully manipulate his signal. To ensure that the equilibrium level of manipulation does not exceed one, we assume that  $k$  is above a certain threshold (see proof of Proposition 1 for details).

In stage three, the investor decides whether to finance the project given the entrepreneur's report  $R$ . When the investor finances the project, she provides the required capital  $I$  in return for an equity stake of  $\beta_i \in [0, 1]$  given the entrepreneur has claimed  $R_i$ , where  $i \in \{G, B\}$ . The investor's equity stake is determined assuming the investor is risk-neutral and participates in a competitive capital market, and therefore earns expected profits of zero. As in Evans and Sridhar (2002), we will refer to  $\beta_i$  as the entrepreneur's cost of capital.

In stage four, the project's outcome is realized. In case of project failure, the investor investigates whether the entrepreneur manipulated the report. If this is the case, the investor sues the entrepreneur and the expected legal damages imposed on the entrepreneur are  $D > 0$ . The investor and the plaintiff's attorney share in the

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<sup>7</sup>To illustrate, the entrepreneur might on the basis of contrived evidence understate the allowance for doubtful accounts to boost earnings. With probability  $m$ , the firm's external auditor accepts the allowance, and with probability  $(1 - m)$ , the auditor regards the evidence supporting the allowance as being inadequate and requires a restatement of the firm's results. Orchestrating this manipulation is costly to the entrepreneur. Demski, Frimor, and Sappington (2004) and Dutta and Gigler (2002) employ an equivalent representation of the entrepreneur's manipulative effort.

damages: the investor's share of the damages equals  $\gamma D$  and the attorney's contingency fee equals  $(1 - \gamma) D$ , where  $\gamma \in [0, 1]$ . If the entrepreneur did not manipulate the report, then we presume there is no basis for litigation against the entrepreneur; the Private Securities Litigation Reform Act of 1995 and the Securities Litigation Uniform Standards Act of 1998 have heightened the pleading standards for a securities action to be admitted to trial. Thus, in short, the entrepreneur faces litigation risk only in the case in which he manipulates the report and the project is financed but fails.<sup>8</sup>

In the last stage, the players' payoffs are determined. When the investor does not provide financing, the payoffs to both players are zero. In contrast, when the investor provides financing, investment occurs and the payoffs depend on the report and the outcome. Specifically, when the entrepreneur claims  $R_i$  and outcome  $X_j$  transpires, the entrepreneur's payoff  $U_E$  is given by

$$U_E = (1 - \beta_i) X_j - \Phi D \tag{1}$$

and the investor's payoff  $U_I$  is given by

$$U_I = \beta_i X_j + \Phi \gamma D, \tag{2}$$

where  $i, j \in \{G, B\}$ , and where the indicator variable  $\Phi = 1$  if  $R_i \neq S_i$  and  $j = B$ , and

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<sup>8</sup>Plaintiffs' attorneys have little incentive to pursue fraudulent managers in those circumstances in which the amount of the damages they receive is low. Damages are likely to be lower than current levels if culpable managers are held liable for paying the damage award rather than the firm, its insurer, or other deep-pockets, as is typically the case. Recognizing this damping of the incentives of plaintiffs' attorneys, Coffee (2006), Langevoort (2007), and others have suggested allowing the plaintiff's attorney to recover a great percentage or amount of the damages the defendant pays. We choose not to model the attorney's effort when litigating and assume the expected probability of a lawsuit and its success is independent of  $\gamma$ . However, we shall explore the consequence of varying  $\gamma$ .

$\Phi = 0$  otherwise. Expression (1) implies the entrepreneur only pays damages when he misrepresents his privately observed information and the project is unsuccessful. The investor shares the court awarded damages with her attorney and hence receives a net damage reimbursement of  $\gamma D$ .

The timing of events and the summary of notation is outlined in Figure 1.

[Figure 1]

At this point, we briefly pause to motivate several of our modeling choices. First, our focus is on personal instead of enterprise liability; that is, we assume that any legal damages are borne by the culpable entrepreneur and not by the corporation and its insurance firm. Our goal is to show that even in this ideal environment in which fraudulent entrepreneurs are directly penalized, heightened penalties do not necessarily deter manipulation but in fact can increase incentives for misreporting. Given the maximum amount of damages the entrepreneur is capable of paying is his share of the firm's net payoff, it follows that the upper limit for damages is  $D \leq (1 - \beta) X_B$ . This restriction on the maximum level of damages is not crucial for our main results. If we dropped this assumption (because, for example, the entrepreneur is endowed with private wealth), all the results would continue to hold as long as the damages are not so large that in equilibrium there is no manipulation.<sup>9</sup>

Second, the focus of our study is not on determining the expected legal damages that arise endogenously in equilibrium. For studies with such a focus see, for example, Evans and Sridhar (2002), Spindler (2010), and Caskey (2010). Instead, the goal

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<sup>9</sup>This relation is always satisfied in equilibrium when  $D \leq X_B I / (X_B (1 - \alpha_I) (1 + p\gamma) + \alpha_I X_G)$ . If we dropped this assumption, we would need to assume that inequality (9) in Proposition 1 is satisfied to ensure that  $m \leq 1$ .

of our work is to analyze the effects of changes in legal penalties on the entrepreneur's reporting behavior. Consequently, we take the expected legal damages,  $D$ , as given and explore how the entrepreneur's reporting behavior varies with the expected damages. As a side note, it is far from clear how damages are determined because most cases that survive pretrial dismissal are settled and only about three percent of investor losses are recovered on average (Coffee 2005, 542).

Third, a key feature of this model is that the entrepreneur and investors have heterogeneous prior beliefs about the probability that the project will be successful. While it has long been recognized that players might hold differing prior beliefs (e.g., Harsanyi, 1968), there has recently been renewed interest in the effects of heterogeneous priors on player behavior (e.g., Brunnermeier and Parker 2005; Van den Steen 2010). Heterogeneous priors have been used to explain several seemingly irrational behaviors, including overconfidence in choice of actions (Van den Steen 2004), the favorable price movement on the first day of trading following an initial public offering (Morris 1996), heightened sensitivity of corporate investment to firm cash flows (Malmendier and Tate 2005), and speculative bubbles in assets prices (Scheinkman and Xiong 2003).

To motivate why players might openly disagree about the likelihood of success of alternative actions, Van den Steen (2004) succinctly characterizes a "choice-driven overoptimism" mechanism. He supposes players randomly under or over estimate the probability of success of the various opportunities in their opportunity sets and that a player chooses to pursue the opportunity in the set that the player regards as having the greatest probability of success. As a consequence, a player—entrepreneur—is likely to be more optimistic than the other players—investors—about the opportunity the firm is seeking to pursue. He notes that this mechanism is similar to the winner's

curse notion in the auction literature in the sense that random variation coupled with a player's systematic choice induces a systematic bias.

Landier and Thesmar (2009) offer a detailed discussion about potential reasons for entrepreneurial exuberance. Expanding the argument in Van den Steen (2004), Landier and Thesmar (2009) note that individuals who forego other opportunities to start a new firm are often those who, on average, overestimate the chances of their own success. In contrast, pessimists do not start their own business. Indeed, they empirically find that entrepreneurs tend to be upward biased regarding the assessment of their idea's performance and that this bias is stronger for entrepreneurs with better outside options and for those pursuing their own ideas instead of taking over a business from someone else.

Appealing to the cognitive psychology literature, Malmendier and Tate (2005) suggest that management overconfidence (which they view as management overestimating the returns to their investment projects) is attributable to an illusion of controlling the outcome, strong commitment to desirable outcomes, and lack of suitable reference points making it difficult to evaluate their performance (e.g., March and Shapira 1987).

It is important to recognize that the assumption that players have different prior beliefs does not contradict the economic paradigm that players are rational. Rational players are required to use Bayes' rule to update their prior beliefs but are not required to have common prior beliefs. Indeed, Harsanyi (1968, 495-6) pointed out that "so long as each player chooses his subjective probabilities (probability estimates) independently of the other players, no conceivable estimation procedure can ensure consistency among the different players' subjective probabilities," and further, "by the very nature of subjective probabilities, even if two individuals have exactly the

same information and are at exactly the same high level of intelligence, they may very well assign different subjective probabilities to the very same events.”

Fourth, we model the entrepreneur as being able to report either  $R_B$  or  $R_G$  given his privately observed signal  $S_B$  or  $S_G$ . While we could model the entrepreneur’s privately observed signal as being continuously distributed and the entrepreneur choosing a report from the real line, this alternative set of assumptions together with the entrepreneur’s objective function being common knowledge would enable the investor to perfectly infer the entrepreneur’s private information; thus, the entrepreneur’s misreporting would not mislead the investor. To disable the investor from unraveling the entrepreneur’s disclosure, we could suppose that the investor is uncertain about the entrepreneur’s reporting incentives, as in Fischer and Verrecchia (2000). Modeling this investor uncertainty about the entrepreneur’s payoff would complicate our analysis without adding much additional insight. In contrast, modeling the reporting space and state space as being binary creates a parsimonious environment in which the entrepreneur can dissemble and investors cannot perfectly infer the entrepreneur’s private information.

## 4 Equilibrium Analysis

To characterize the equilibrium, assume for the moment that in equilibrium the entrepreneur always truthfully reports favorable signals and exerts effort  $m \leq 1$  manipulating negative signals. Then, if the entrepreneur issues a positive report,  $R = R_G$ , the investor believes that the project’s expected net present value is non-negative, even though she is aware that the report might be manipulated (recall that  $\alpha_I X_G + (1 - \alpha_I) X_B \geq I$ ). In this case, the investor finances the project and

the entrepreneur's expected payoff is positive. Alternatively, if the entrepreneur issues an unfavorable report,  $R_B$ , then the investor is unwilling to finance the project because she believes that the project has a negative expected payoff (recall that  $E[X|S_B; \alpha_I; p] < I$ ). In this case even if the investor offers financing, she cannot recover any damages in case of failure because the entrepreneur truthfully issued an unfavorable signal.

Given the investor's response to positive and negative reports, the entrepreneur will always report favorable news truthfully. However, if the entrepreneur observes a negative signal, he can pursue the investment opportunity only if he misreports and releases a favorable report. When the entrepreneur contemplates misreporting unfavorable information, he faces the following trade-off. On one hand, misreporting bad news is beneficial because it is the entrepreneur's only chance to obtain financing for the project and earn a positive expected payoff. On the other hand, manipulating information is costly to the entrepreneur because it involves a direct cost  $km^2/2$  and yields the possibility of a lawsuit if the project fails.<sup>10</sup> Faced with this calculus, after observing an unfavorable signal, the entrepreneur chooses a level of manipulation effort,  $m$ , that solves

$$\max_m [(1 - \beta_G(\hat{m})) (X_B + \Delta \Pr(X_G|S_B)) - D \Pr(X_B|S_B)] - km^2/2, \quad (3)$$

where  $\hat{m}$  is the investor's conjectured level of manipulation,  $\beta_G(\hat{m})$  is the equity share the investor demands upon observing a favorable report,

$$\Pr(X_G|S_B) = \frac{(1-p)\alpha_E}{(1-p)\alpha_E + p(1-\alpha_E)},$$

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<sup>10</sup>Teoh, Wong, and Rao (1998), Teoh, Welch, and Wong (1998a,b), among others, provide evidence that firms manipulate their financial report around the date of their initial public offerings.

and

$$\Pr(X_B|S_B) = \frac{p(1 - \alpha_E)}{(1 - p)\alpha_E + p(1 - \alpha_E)}.$$

The first-order condition for an optimal level of  $m$  is given by

$$(1 - \beta_G(\hat{m})) (X_B + \Delta \Pr(X_G|S_B)) - D \Pr(X_B|S_B) - km = 0. \quad (4)$$

We now step back and determine the stake in the firm the investor requires to contribute capital  $I$ . In a competitive market, the investor's expected return in case of a favorable report  $R_G$  equals the investment  $I$  in the firm; that is,

$$\beta_G(\hat{m}) (X_B + \Delta \Pr(X_G|R_G)) + \gamma D \Pr(X_B, S_B|R_G) = I, \quad (5)$$

where

$$\Pr(X_G|R_G) = \frac{(p + \hat{m}(1 - p)) \alpha_I}{(p + \hat{m}(1 - p)) \alpha_I + (1 - p + \hat{m}p)(1 - \alpha_I)}$$

and

$$\Pr(X_B, S_B|R_G) = \frac{\hat{m}p(1 - \alpha_I)}{\alpha_I p + (1 - \alpha_I)(1 - p) + \hat{m}(\alpha_I(1 - p) + (1 - \alpha_I)p)}.$$

Substituting  $\Pr(X_G|R_G)$  and  $\Pr(X_B, S_B|R_G)$  into (5) and solving for  $\beta_G(\hat{m})$  yields

$$\beta_G(\hat{m}) = \frac{I(p\alpha_I + (1 - p)(1 - \alpha_I(1 - \hat{m}))) + \hat{m}p(1 - \alpha_I)(I - \gamma D)}{X_B(1 - p + \hat{m}p)(1 - \alpha_I) + X_G(p + \hat{m}(1 - p))\alpha_I}. \quad (6)$$

Before characterizing the equilibrium choice of manipulative effort, it is helpful to explore how the firm's cost of capital  $\beta_G(\hat{m})$  varies with changes in the environmental parameters when the level of  $\hat{m}$  is kept constant. The following lemma, which highlights two relations we use extensively, establishes that the cost of capital decreases in the expected damage award  $D$  and the portion of the damage award the investor retains  $\gamma$ .

**Lemma 1**  $\partial\beta_G(\hat{m})/\partial D < 0$  and  $\partial\beta_G(\hat{m})/\partial\gamma < 0$ .

In equilibrium, the conjectured level of manipulation equals the entrepreneur's optimal choice of manipulation,  $m^* = \hat{m}$ . The equilibrium level of manipulation,  $m^*$ , is obtained by substituting  $\beta_G(m^*)$  given in (6) into (4), which yields the equilibrium condition

$$\begin{aligned} & m^*k((1-p)\alpha_E + (1-\alpha_E)p) \\ = & (1-\beta_G(m^*))((1-p)\alpha_EX_G + (1-\alpha_E)pX_B) - D(1-\alpha_E)p. \end{aligned} \quad (7)$$

To ensure a unique level of manipulation effort, we assume the investor demands a larger stake in the firm,  $\beta_G(m^*)$ , as the equilibrium level of manipulation increases. That is, the cost of capital is increasing in  $m^*$ . This is consistent with Coffee's (2006, 1565) warning: the "deeper problem in securities fraud is the impact of fraud on investor confidence and thus the cost of equity capital." The relation  $\partial\beta_G(m^*)/\partial m^* > 0$  is satisfied when the damages the investor obtains are not too large relative to the size of the investment in the firm; that is, if

$$D < \frac{\alpha_I\Delta(2p-1)I}{\gamma p(X_G\alpha_I p + X_B(1-\alpha_I)(1-p))}. \quad (8)$$

Conversely, if assumption (8) does not hold and  $\beta_G$  is fixed, the investor would be better off if the entrepreneur chooses a higher level of manipulation. Such an assumption seems unreasonable because investors can only recover about three percent of their losses on average (Coffee 2005, 542). Further note that assumption (8) ensures that the expected damages the investor obtains in case of a successful lawsuit does not exceed her initial capital investment,  $\gamma D < I$ .<sup>11</sup> The equilibrium can now

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<sup>11</sup>Recall the sufficient condition for the entrepreneur to be able to pay damages out of his share of the firm is given by  $D \leq X_B I / (X_B(1-\alpha_I)(1+p\gamma) + \alpha_I X_G)$ . It can be established that there exists a threshold  $\bar{X}_G$  such that for all  $X_G > \bar{X}_G$ , the condition  $D \leq X_B I / (X_B(1-\alpha_I)(1+p\gamma) + \alpha_I X_G)$  implies (8) is always satisfied.

be described as follows:

**Proposition 1** *In equilibrium, the entrepreneur reports truthfully when  $S = S_G$  and chooses a unique level of manipulation effort  $m^* \in (0, 1)$  when  $S = S_B$ . The investor provides capital  $I$  in exchange for the equity stake  $\beta_G(m^*) \in (0, 1)$  when  $R = R_G$  and does not finance the project when  $R = R_B$ .*

To tackle the welfare consequences of entrepreneurial manipulation, we need to specify the objective prior probability of project success. Given the large body of evidence from surveys and empirical studies indicating that entrepreneurs tend to overestimate the prospects of their business ideas (e.g., Cooper, Woo, and Dunkelberg 1988; Landier and Thesmar 2009), we view the entrepreneur as being overoptimistic and investors as being correctly calibrated. Accordingly, the objective probability of success of the project is regarded as being  $\alpha_I$ . When the entrepreneur always communicates truthfully, the investment decision is efficient: the project is not financed when the entrepreneur observes and reports unfavorable information and is financed otherwise. However, when the entrepreneur can manipulate, the misreporting of an unfavorable signal leads to overinvestment in the project. Therefore, from a social welfare perspective, manipulation is unambiguously undesirable. Changes in the firm's environment that reduce the extent of entrepreneurial manipulation enhance the efficiency of the investment decision and thereby increase expected social welfare.

## 5 Comparative Statics

Sections 11 and 12 of the Securities Act of 1933 prohibit firms from offering misleading reports when issuing shares. The threat of legal damages,  $D$ , has two opposing effects on the entrepreneur's reporting behavior. On the one hand, and consistent with

standard arguments, potential legal penalties associated with misreporting directly reduce incentives for manipulation. We call this the *punishment effect*. On the other hand, the presence of legal damages also makes manipulation more attractive for the entrepreneur. Given that the investor recovers a fraction of the damages,  $\gamma D$ , she is prepared to provide the required capital in exchange for a lower equity stake,  $\beta_G$ , if she expects positive damage payments. A lower cost of capital,  $\beta_G$ , in turn, increases the residual the entrepreneur obtains if the project is financed. The prospect of a higher residual makes implementing the project more attractive to the entrepreneur. Since the project is only financed when a favorable report is released, the presence of legal damages increases the entrepreneur's incentive to manipulate negative information in an attempt to obtain financing. We call this the *compensation effect*. Clearly, an increase in the expected damages will strengthen both the punishment effect as well as the compensation effect. The question, however, is which of the two effects will eventually dominate?

## 5.1 Role of Overoptimism

In this section, we first consider how heterogeneous beliefs affect the entrepreneur's trade-off between the benefits and costs of misreporting, when the expected damages are kept constant. We then study how heterogeneous beliefs affect the relation between a firm's reporting behavior and changes in legal damages.

The following proposition demonstrates that the entrepreneur's incentive to misrepresent negative signals increases in his exuberance about the firm's prospects.

**Proposition 2** *The equilibrium level of manipulation,  $m^*$ , is increasing in the entrepreneur's prior probability of success,  $\alpha_E$ .*

To develop intuition for this relation, note that upon observing bad news,  $S = S_G$ , the entrepreneur revises the probability of success to

$$\Pr(X_G|S_B) = (1 - p)\alpha_E / ((1 - p)\alpha_E + (1 - \alpha_E)p).$$

For high values of  $\alpha_E$ , the entrepreneur views the conditional probability of project failure and hence litigation as being relatively small. Accordingly, the exuberant entrepreneur is not that troubled by the threat of potential damages and the punishment effect is weak. Turning to the compensation effect, investor anticipation of damage payments reduces the cost of capital and increases the entrepreneur's residual if the project is financed. The prospect of a high residual is especially attractive to an entrepreneur who is confident that the project will be successful. Thus, for more exuberant entrepreneurs, the compensation effect, and hence the incentive to manipulate negative information, will be stronger. Combining these two effects explains why entrepreneurs that are more exuberant are more inclined to manipulate the report.

We next explore the question of how heterogeneous beliefs affect the relation between a firm's reporting behavior and changes in legal damages. When the entrepreneur is more optimistic than the investor about the project's probability of success,  $\alpha_E > \alpha_I$ , an increase in the potential damages can have a stronger impact on the compensation effect than on the punishment effect. In this circumstance, imposing tougher penalties on the entrepreneur leads to more and not less misreporting.

**Proposition 3** *Suppose  $\gamma > 0$ . There exists a threshold  $\alpha_E^T(k, \gamma) \in (\alpha_I, 1)$  such that:*

- i) for  $\alpha_E < \alpha_E^T(k, \gamma)$ , an increase in expected damages  $D$  leads to a lower level of manipulation,  $dm^*/dD < 0$ .*
- ii) for  $\alpha_E > \alpha_E^T(k, \gamma)$ , an increase in expected damages  $D$  leads to a higher level of manipulation,  $dm^*/dD > 0$ .*

To develop intuition for this result, consider the effects of a change in  $D$  on the entrepreneur's trade-off between the benefits and costs of misreporting. On one hand, as explained above, for high values of  $\alpha_E$ , the entrepreneur views the conditional probability of litigation as being relatively small—the punishment effect is weak. While an increase in expected damages always increases the punishment effect, this increase is weaker for more exuberant entrepreneurs. On the other hand, for exuberant entrepreneurs, the compensation effect is strong. More importantly, an increase in potential damages will further strengthen the compensation effect and this increase is stronger when the entrepreneur is more exuberant. As a result, for sufficiently high values of  $\alpha_E$ , the increase in the compensation effect dominates the increase in the punishment effect, leading to a positive relation between expected damages and misreporting.

While we emphasize circumstances in which the entrepreneur is more optimistic than the investor, it is worthwhile noting that when the players have homogeneous beliefs about the project's probability of success,  $\alpha_E = \alpha_I$ , an increase in expected damages always reduces the level of manipulation.

## 5.2 Role of Legal Frictions

We now turn to study how legal frictions affect incentives for misreporting and the relation between reporting and the size of legal damages. Frictions arise because attorneys retain a nontrivial share of any damage payments between the entrepreneur and the plaintiff. Attorney fees typically vary between fifteen and thirty percent (Grundfest 2007; Langevoort 2007).

Consider first the effect of changes in legal frictions,  $\gamma$ , on the entrepreneur's incentive to misreport when the expected damages  $D$  are held constant. A change

in the fraction of damages,  $\gamma$ , that the investor retains does not change the strength of the punishment effect. However, when the investor recovers a smaller portion of the damages, that is  $\gamma$  is smaller, the compensation effect declines. Coupling these effects, the entrepreneur's incentive to manipulate unfavorable information declines as litigation frictions increase. The next proposition summarizes this relation.

**Proposition 4** *For any level of expected damages  $D$ , reducing the portion of damages investors retain,  $\gamma$ , leads to a lower level of manipulation,  $m^*$ .*

Consider now the effect of legal frictions on the relation between a firm's reporting behavior and changes in legal damages. As just discussed, when legal frictions are small, that is  $\gamma$  is high, the compensation effect is strong. An increase in damages will further increase the compensation effect (and hence the entrepreneur's incentives to misreport) and this increase is stronger the smaller the litigation frictions. Further, note that the increase in the punishment effect associated with an increase in damages does not depend on  $\gamma$ . As a consequence, the relation between legal damages and the incidence of misreporting is more likely positive when frictions are small. Conversely, when litigation frictions are large such that investors can only recover a small fraction of the damages, then an increase in potential damages discourages misreporting. This result highlights that it is not only the presence of damages but, importantly, how the investor and the plaintiff's attorney share the damage award that affects the firm's reporting behavior. The next proposition summarizes these results.

**Proposition 5** *Suppose  $\alpha_E > \alpha_E^T(k, 1)$ . There exists a threshold  $\gamma^T \in (0, 1)$  such that:*

*i) for  $\gamma < \gamma^T$ , an increase in expected damages  $D$  leads to a lower level of manipulation, i.e.,  $dm^*/dD < 0$ .*

ii) for  $\gamma > \gamma^T$ , an increase in expected damages  $D$  leads to a higher level of manipulation, i.e.,  $dm^*/dD > 0$ .

### 5.3 Role of the SEC

The previous section suggests that legal penalties more effectively discipline an entrepreneur's reporting behavior when legal frictions are severe. Thus, the liability mechanism under the federal securities laws that compensates investors for damages might not be the most appropriate mechanism to deter manipulation. Consistent with this claim, some legal scholars have argued that a schedule of SEC administered fines is more effective in deterring fraudulent reporting than class actions (Alexander 1996). Indeed, in response to the wave of financial reporting fraud, the Sarbanes Oxley Act of 2002 was enacted, in part, to create more severe civil and criminal penalties for violation of the securities laws and to allow the SEC to collect penalties from firms that defraud shareholders (see Rezaee 2007). Likewise, the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 extended the authority of the SEC and provided it with additional enforcement tools, such as expanding its clawback powers to recover executive compensation from senior executives following restatements (see Lamont 2011).

In the context of our model, the effects of greater SEC involvement through its administration of a schedule of penalties follows from Propositions 4 and 5. An increase in the portion of damages the SEC collects in the form of penalties lowers the portion of damages investors recover. Thus, our analysis supports a move to a non-compensatory system of fines administered by the SEC.

**Corollary 1** *Penalties administered by the SEC are more effective in deterring misreporting than damages that play a compensatory role awarded under the federal se-*

*curities laws.*

## 5.4 Role of Internal Controls

The Sarbanes Oxley Act of 2002 was drafted to provide corporate governance guidelines, improve the quality of financial reporting, and raise the effectiveness of the audit function (Rezaee 2007). Perhaps one of the most important features of this Act is the requirement in Section 404 that firm management assess the effectiveness of the firm's internal control procedures for financial reporting and publicly report any material weaknesses.

Legal scholars have debated the interaction between internal control systems and the securities laws and the effect of this interaction on management misreporting (e.g., Arlen and Carney 1992; Coffee 2006). To reflect the role of internal control systems and examine its interaction with the securities laws, we assume the entrepreneur incurs a direct cost  $km^2/2$  when manipulating the report. This cost can be interpreted as the entrepreneur's cost of overriding the firm's internal control system and deceiving the board of directors or auditors. The higher the marginal cost,  $k$ , the more difficult it is to distort information, implying the internal control or governance system is of higher quality.

Intuitively, one might expect that legal penalties play a more important deterrence role when the internal control system is weak. However, as we show in the next proposition, this is not necessarily the case. Suppose the entrepreneur is more optimistic than the investor about the project's success, that is  $\alpha_E > \alpha_I$ , and the investor receives a relatively large share of the damage award, that is  $\gamma$  is high. Then, an increase in expected legal damages  $D$  is counterproductive and leads to even more misreporting exactly when the internal control system is not effective at preventing

the entrepreneur from manipulating information, that is  $k$  is small. Alternatively, if the internal control system is relatively effective, that is,  $k$  is large, then an increase in expected legal damages induces a further reduction in misreporting.

**Proposition 6** *Suppose that  $\alpha_E > \alpha_E^T(\bar{k}, \gamma)$ . There exists a threshold  $k^T \in (\bar{k}, \infty)$  such that:*

*i) for  $k < k^T$ , an increase in expected damages  $D$  induces a higher level of manipulation, i.e.,  $dm^*/dD > 0$ .*

*ii) for  $k > k^T$ , an increase in expected damages  $D$  induces a lower level of manipulation, i.e.,  $dm^*/dD < 0$ .*

To provide the intuition underlying Proposition 6, suppose the internal control system is ineffective. In this case, it is relatively easy for the entrepreneur to manipulate the report. Consequently, after observing a favorable report, the investor believes that the report is likely to have been manipulated. She therefore expects that the probability of a successful lawsuit is relatively high in the event of project failure—the compensation effect is strong. Importantly, an increase in the magnitude of damages further increases the compensation effect and this increase is stronger for less effective internal control systems. Further note that the increase in the punishment effect associated with an increase in damages does not depend on the effectiveness of the internal control environment. As a result, a heightened threat of legal penalties is more likely to increase manipulation when the internal control system is relatively weak.

## 5.5 Empirical Implication

We observe that increases in expected legal penalties can heighten or suppress entrepreneurs' incentives to misrepresent information that is mandatorially required. This relation has not been empirically tested. However, several related empirical studies document that stricter legal environments (or the perception thereof) are associated with less frequent voluntary disclosure (e.g., Johnson, et al. 2001; Baginski, et al. 2002; Rogers and Van Buskirk 2009)<sup>12</sup>. Our work highlights that an empirical examination of the association between changes in the legal environment and the quality of financial disclosure should partition the sample of firms based on management optimism, litigation frictions, and the quality of internal controls.<sup>13</sup> Failure to partition the sample along these dimensions mingles the effects of changes in the litigation regime on reporting behavior and thereby reduces the power of the empirical tests.

Using Propositions 3, 5, and 6, the next corollary summarizes conditions under which an increase in litigation risk is more likely associated with an increase in misreporting.

**Corollary 2** *An increase in expected penalties,  $D$ , is associated with an increase in manipulation if:*

- i) the entrepreneur is more exuberant about the firm's prospects, i.e.,  $\alpha_E$  is large,*
- ii) the investors are able to recover a large share of the damages, i.e.,  $\gamma$  is large,*
- iii) the firm's internal control system is weak, i.e.,  $k$  is small.*

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<sup>12</sup>Other studies that empirically analyze the relation between the legal environment and voluntary disclosure are Francis, et al. (1994), Skinner (1994, 1997), and Field, et al. (2005). For comprehensive surveys of the disclosure literature see Verrecchia (2001) and Beyer, et al. (2010).

<sup>13</sup>See Malmendier and Tate (2005) for an empirical measure of overconfidence.

## 6 Conclusion

The efficacy of securities litigation at deterring fraudulent financial reporting and compensating shareholders has long been the subject of debate. This debate seems to have precipitated several legal reforms, including provisions in the Private Securities Litigation Reform Act of 1995 and the Sarbanes-Oxley Act of 2002. While there is concern that the current securities laws fail as a deterrent because damages are typically paid by the corporation and its insurance firm, there is general agreement that personal liability imposed on the culpable managers is effective in deterring accounting fraud (e.g., Alexander 1996; Coffee 2006; Langevoort 2007).

By incorporating important descriptive features of the institutional environment—namely, entrepreneurial optimism, legal frictions, and the internal control system—into a model of managerial reporting, we offer a nuanced characterization of the effects of personal liability on the entrepreneur’s reporting behavior. We show that increased liability does not always reduce and, in fact, can exacerbate incentives for misreporting. Specifically, we establish that an increase in expected legal damages is associated with an increase in the frequency of misreporting when: the entrepreneur is exuberant relative to investors about the firm’s prospects; litigation frictions are relatively low; and, the internal control system is relatively weak.

In light of the subtle relation between legal penalties and managerial fraudulent reporting, we highlight issues policy-makers and regulators might consider as they further reform the litigation environment and implement key provisions of the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010. We also formalize some novel predictions about firm reporting behavior that await empirical testing.

## Appendix

This Appendix contains the proofs of the formal claims in the paper.

### Proof of Lemma 1:

Using (6), and keeping  $\hat{m}$  fixed, it follows that:

$$\frac{\partial \beta_G(\hat{m})}{\partial D} = \frac{-\hat{m}p(1 - \alpha_I)\gamma}{(X_B(1 - \alpha_I)(1 - (1 - \hat{m})p) + X_G\alpha_I(p + \hat{m}(1 - p)))} < 0,$$

and

$$\frac{\partial \beta_G(\hat{m})}{\partial \gamma} = \frac{-\hat{m}p(1 - \alpha_I)D}{(X_B(1 - \alpha_I)(1 - (1 - \hat{m})p) + X_G\alpha_I(p + \hat{m}(1 - p)))} < 0. \blacksquare$$

### Proof of Proposition 1:

In equilibrium, the conjectured level of manipulation equals the entrepreneur's optimal choice of manipulation,  $m^* = \hat{m}$ . The equilibrium level of manipulation,  $m^*$ , is obtained by substituting  $\beta_G(m^*)$  given in (6) into (4), which yields the equilibrium condition given in (7). The assumption  $\alpha_I X_G + (1 - \alpha_I)X_B - I \geq 0$  (which implies that  $X_B + \alpha_I \Delta - I \geq 0$ ) together with condition

$$\gamma D < \alpha_I \Delta (2p - 1) I / (p(\alpha_I p X_G + X_B(1 - \alpha_I)(1 - p)))$$

in (8) ensures  $\beta_G(\bullet) \in (0, 1)$ . This claim is established in the following three steps:

First, for  $m = 0$  and

$$D < (1 - \beta_G(0)) \frac{(X_G(1 - p)\alpha_E + X_B(1 - \alpha_E)p)}{(1 - \alpha_E)p}, \quad (9)$$

the left-hand side of (7) is less than the right-hand side. Inequality (9) is always satisfied due to the constraint  $D \leq (1 - \beta_G(m^*))X_B$ . To see this observe that  $((1 - p)\alpha_E + (1 - \alpha_E)p) / ((1 - \alpha_E)p) > 1$  and recall that  $d\beta_G(m^*)/dm > 0$  due to assumption (8).

Second, when  $m = 1$  and  $k > \bar{k}$ , where

$$\bar{k} \equiv \frac{\left(1 - \frac{I - \gamma D p (1 - \alpha_I)}{X_B + \Delta \alpha_I}\right) (X_G(1 - p)\alpha_E + X_B(1 - \alpha_E)p) - D(1 - \alpha_E)p}{(1 - p)\alpha_E + (1 - \alpha_E)p}, \quad (10)$$

the left-hand side of (7) is greater than the right-hand side.

Third, observe that the left-hand side of (7) is increasing in  $m$  whereas, given condition (8), the right-hand side is decreasing in  $m$ . It therefore follows from the intermediate value theorem that there exists a unique interior equilibrium. ■

### Proof of Proposition 2:

Let  $z \equiv (1 - p)\alpha_E + (1 - \alpha_E)p$ . Applying the implicit function theorem to the equilibrium condition

$$\begin{aligned} \psi &\equiv m^* k ((1 - p)\alpha_E + (1 - \alpha_E)p) \\ &\quad - (1 - \beta_G(m^*)) (X_G(1 - p)\alpha_E + X_B(1 - \alpha_E)p) + D(1 - \alpha_E)p = 0, \end{aligned} \quad (11)$$

(which follows from (7)) yields

$$\begin{aligned} \frac{dm^*}{d\alpha_E} &= - \frac{\partial \psi / \partial \alpha_E}{\partial \psi / \partial m^*} \\ &= \frac{m^* k (2p - 1) + (1 - \beta_G(m^*)) (\Delta(1 - p) - X_B(2p - 1)) + Dp}{kz + \frac{\partial \beta_G(m^*)}{\partial m} (\Delta(1 - p)\alpha_E + X_B z)}. \end{aligned} \quad (12)$$

Substituting

$$m^* k = \left( \frac{(1 - \beta_G(m^*)) (1 - p)\alpha_E \Delta - D \times (1 - \alpha_E)p}{((1 - p)\alpha_E + (1 - \alpha_E)p)} + (1 - \beta_G(m^*)) X_B \right)$$

from condition (7) into the numerator in (12) and rearranging yields:

$$\frac{dm^*}{d\alpha_E} = \frac{(1 - p)p ((1 - \beta_G(m^*)) \Delta + D)}{kz^2 + z \frac{\partial \beta_G(m^*)}{\partial m} (X_G(1 - p)\alpha_E + X_B(1 - \alpha_E)p)}, \quad (13)$$

which is positive because assumption (8) implies  $\partial \beta_G(m^*) / \partial m > 0$ . ■

**Proof of Proposition 3:**

Recall  $z \equiv (1 - p)\alpha_E + (1 - \alpha_E)p$ . Applying the implicit function theorem to the equilibrium condition (11) yields

$$\begin{aligned} \frac{dm^*}{dD} &= -\frac{\partial\psi/\partial D}{\partial\psi/\partial m^*} \\ &= \frac{-\frac{\partial\beta_G(m^*)}{\partial D} (\Delta(1-p)\alpha_E + zX_B) - (1-\alpha_E)p}{kz + \frac{\partial\beta_G(m^*)}{\partial m^*} (\Delta(1-p)\alpha_E + zX_B)} \end{aligned} \quad (14)$$

with

$$\frac{\partial\beta_G(m^*)}{\partial D} = \frac{-m^*p(1-\alpha_I)\gamma}{X_B((1-p) + m^*p)(1-\alpha_I) + X_G(p + m^*(1-p))\alpha_I} < 0.$$

As the denominator in (14) is always positive (because assumption (8) implies  $\partial\beta_G(m^*)/\partial m^* > 0$ ), it follows that

$$\frac{dm^*}{dD} \propto \Pi \equiv -\frac{\partial\beta_G(m^*)}{\partial D} (\Delta(1-p)\alpha_E + zX_B) - (1-\alpha_E)p, \quad (15)$$

where  $\propto$  indicates that the two expressions are proportional to each other, i.e., they have the same sign.

Using (15) yields

$$\frac{d\Pi}{d\alpha_E} = \frac{\partial\Pi}{\partial\alpha_E} + \frac{\partial\Pi}{\partial m^*} \frac{dm^*}{d\alpha_E} > 0,$$

where we use the fact that  $dm^*/d\alpha_E > 0$  (see (13)) and

$$\begin{aligned} \frac{\partial\Pi}{\partial\alpha_E} &= p \frac{m^*(1-\alpha_I)\gamma(1-p)X_G + (1-\alpha_I)X_B((1-p) + m^*p(1-\gamma)) + w}{X_B((1-p) + m^*p)(1-\alpha_I) + w} > 0, \\ \frac{d\Pi}{dm^*} &= -\frac{\partial^2\beta_G(m^*)}{\partial D\partial m^*} (\Delta(1-p)\alpha_E + X_B \times z) > 0, \end{aligned}$$

with  $w \equiv X_G\alpha_I(p + m^*(1-p))$  and

$$\frac{\partial^2\beta_G(m^*)}{\partial D\partial m^*} = -\frac{p(1-\alpha_I)\gamma(X_B\alpha_I(2p-1) + X_B(1-p) + \Delta\alpha_I p)}{(X_B(1-\alpha_I)(1-(1-m^*)p) + X_G\alpha_I(p + m^*(1-p)))^2} < 0. \quad (16)$$

Further, for  $\alpha_E = 1$ , observe that

$$\Pi = -\frac{\partial\beta_G(m^*)}{\partial D}(1-p)X_G > 0,$$

and for  $\alpha_E = \alpha_I$ , observe that  $\Pi < 0$ . It follows from the intermediate value theorem that there exists a threshold  $\alpha_E^T \in (\alpha_I, 1)$ , such that  $\Pi > 0$  if and only if  $\alpha_E > \alpha_E^T(k, \gamma)$ , where

$$\alpha_E^T(k, \gamma) \equiv \frac{A}{A + m^*(k, \gamma)\gamma(1 - \alpha_I)(1 - p)(X_B + \Delta)} \quad (17)$$

with

$$\begin{aligned} A \equiv & X_B(1 - \alpha_I)((1 - p) + m^*(k, \gamma)p(1 - \gamma)) \\ & + (X_B + \Delta)\alpha_I(p + m^*(k, \gamma)(1 - p)). \blacksquare \end{aligned}$$

### Proof of Proposition 5:

Recall  $z \equiv (1 - p)\alpha_E + (1 - \alpha_E)p$ . Using (15), it follows that

$$\frac{d\Pi}{d\gamma} = \frac{\partial\Pi}{\partial\gamma} + \frac{\partial\Pi}{\partial m^*} \frac{dm^*}{d\gamma} > 0,$$

where we use the fact that

$$\begin{aligned} \frac{\partial\Pi}{\partial\gamma} &= -\frac{\partial^2\beta_G(m^*)}{\partial D\partial\gamma}(\Delta(1 - p)\alpha_E + X_Bz) > 0, \\ \frac{d\Pi}{dm^*} &= -\frac{\partial^2\beta_G(m^*)}{\partial D\partial m^*}(\Delta(1 - p)\alpha_E + X_Bz) > 0, \\ \frac{\partial m^*}{\partial\gamma} &= -\frac{\partial\psi/\partial\gamma}{\partial\psi/\partial m^*} = -\frac{\frac{\partial\beta_G(m^*)}{\partial\gamma}(\Delta(1 - p)\alpha_E + X_Bz)}{kz + \frac{\partial\beta_G(m^*)}{\partial m}(\Delta(1 - p)\alpha_E + X_Bz)} > 0, \end{aligned}$$

with

$$\begin{aligned} \frac{\partial\beta_G(m^*)}{\partial\gamma} &= \frac{-m^*p(1 - \alpha_I)D}{X_B((1 - p) + m^*p)(1 - \alpha_I) + X_G(p + m^*(1 - p))\alpha_I} < 0, \\ \frac{\partial^2\beta_G(m^*)}{\partial D\partial\gamma} &= \frac{-m^*p(1 - \alpha_I)}{X_B((1 - p) + m^*p)(1 - \alpha_I) + X_G(p + m^*(1 - p))\alpha_I} < 0. \end{aligned}$$

Further, for  $\gamma = 0$ , observe that  $\Pi = -(1 - \alpha_E)p < 0$  and for  $\gamma = 1$ , note that  $\Pi > 0$  if  $\alpha_E > \alpha_E^T(k, 1)$ , where  $\alpha_E^T(k, 1)$  is defined in (17). Thus, if  $\alpha_E > \alpha_E^T(k, 1)$  is satisfied, it follows from the intermediate value theorem that there exists a threshold  $\gamma^T \in (0, 1)$  such that  $\Pi > 0$  if and only if  $\gamma > \gamma^T$ . ■

#### Proof of Proposition 4:

It follows directly from the proof of Proposition 5 that  $\frac{dm^*}{d\gamma} = -\frac{\partial\psi/\partial\gamma}{\partial\psi/\partial m^*} > 0$ . ■

#### Proof of Proposition 6:

Recall  $z \equiv (1 - p)\alpha_E + (1 - \alpha_E)p$ . Using (15) yields

$$\frac{d\Pi}{dk} = -\frac{\partial^2\beta_G(m^*)}{\partial D\partial m^*} \frac{dm^*}{dk} (\Delta(1 - p)\alpha_E + X_B \times z) < 0,$$

where we use the fact that  $\partial^2\beta_G(m^*)/\partial D\partial m^* < 0$  (see (16)) and

$$\begin{aligned} \frac{dm^*}{dk} &= -\frac{\partial\psi/\partial k}{\partial\psi/\partial m^*} \\ &= -\frac{m^* \times z}{k \times z + \frac{\partial\beta_G(m^*)}{\partial m^*} (\Delta(1 - p)\alpha_E + X_B \times z)} < 0, \end{aligned}$$

where  $\psi$  is defined in (11).

On one hand, when  $k = \bar{k}$ , defined in (10), then  $m^* = 1$ . For  $m^* = 1$  it follows that

$$\Pi = \frac{(\Delta(1 - p)\alpha_E + X_B \times z)}{(X_B + \Delta \times \alpha_I)} p(1 - \alpha_I)\gamma - (1 - \alpha_E)p,$$

which is positive if and only if  $\alpha_E > \alpha_E^T(\bar{k}, \gamma)$ , where  $\alpha_E^T(\bar{k}, \gamma) < 1$  is defined in (17).

On the other hand, when  $k \rightarrow \infty$ , then  $m = 0$ . For  $m = 0$ , it follows that

$$\Pi = -(1 - \alpha_E)p < 0.$$

Thus, if  $\alpha_E > \alpha_E^T(\bar{k}, \gamma)$  is satisfied, it follows from the intermediate value theorem that there exists a threshold  $k^T > \bar{k}$  such that  $dm^*/dD > 0$  if and only if  $k < k^T$ . ■

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**Figure 1: Time line of events**

