Deceiving Two Masters: The Effects of Financial Incentives and Reputational Concerns on Reporting Bias

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Abstract. We study managers' decisions to bias financial reports if these reports are used by capital and labor markets to learn about firm value and managerial talent. If managers have private information on their financial and reputational incentives, we identify interactions in the capital and labor markets' use of reports: The reception of reports in one market motivates reporting bias, which reduces value relevance and price efficiency in the other market. This interaction changes established results and has implications for financial reporting standard setters: We characterize environments where capital market efficiency can be improved by eliminating information on managerial talent from financial reports – even if this information is relevant for investors. This is particularly the case if there is high uncertainty about managers' reputational concerns and if talent uncertainty represents a small part of the overall fundamental uncertainty.

Keywords: reporting bias, reputation, market efficiency, reporting users

I. Introduction

In past decades, several severe cases of earnings management have attracted public attention. They usually were followed by debates on dysfunctional effects of equity-based incentives: Rewarding managers for changes in stock price potentially motivates them to misrepresent the economic situation of the firm, for instance by using their discretion in biasing financial reports (e.g., Burns & Kedia, 2006; Crocker & Slemrod, 2007). The public debate focuses on financial incentives. Yet, there are other reasons for managers to misreport earnings. In a survey of 169 CFOs, Dichev *et al.* (2013) find that "80.4% believe that senior managers misrepresent earnings to avoid adverse career consequences". This should not be surprising as academic literature on incentive provision emphasizes the role of reputation and career considerations in managerial decision making. Even in the absence of explicit financial incentives, managers try and signal talent to create job opportunities and influence future compensation (e.g., Fama, 1980; Holmström, 1982).

Preparers of financial reports arguably encounter both types of incentives when making their reporting choices. We therefore consider the joint effect of financial incentives and reputational concerns on a manager's decision to bias statutory reports. Financial reports convey information on both firm profitability and the talent of the management in place. They serve the dual purpose of informing investors about firm value and providing information about the management, which can be used by future employers. Thus, managers are tempted to inflate financial reports (i) to mislead the capital market and increase their variable compensation and (ii) to build up reputation in the labor market.

A key assumption in our study is that capital and labor markets face uncertainty about managers financial and reputational incentives.[1] Financial incentives may be unknown because outsiders do not know the details of managers' compensation arrangements and private stock holdings (e.g., Fischer & Verrecchia, 2000). Benefits of managerial reputation are potentially realized in the distant future. Thus, asymmetric information with regard to reputational concerns may result from managers' unknown career plans and individual time preferences. If managers' reporting objectives are uncertain, their bias cannot be perfectly backed out from financial reports but is associated with noise.[2]

[1] Ferri *et al.* (2018) find that investors' earnings response depends on the availability of public information on managers' compensation arrangements. This indicates that uncertainty about managers' financial incentives is relevant in real reporting environments. Moreover, price reactions to voluntary departures indicate that markets are unable to anticipate managers' career-related decisions. A recent example is the 8.4% stock price drop of Netflix, Inc. following the announcement that its CFO David Wells has decided to step down, see Ramachandran & Trentmann (2018).

[2] Beyer *et al.* (2018) find strong evidence for the occurrence and impact of such reporting noise.

Given this assumption, we find that financial incentives and reputational concerns have interrelated effects. Capital and labor market efficiency are reduced if the financial report is simultaneously used in both markets to learn about the firm value and managerial talent. To provide intuition for this result, assume that the labor market uses the financial report to update beliefs about managerial talent. This creates incentives for the manager to overstate firm performance. Because financial investors are uncertain about the strength of the manager's reputational motives, they anticipate *that* the manager manipulates the report, however they do not know *how much* bias is added. Thus, information on firm value is diluted and investors curtail the usage of the report to update their beliefs. Following this logic, increasing usage of the financial report in the labor market reduces its usefulness in the capital market and vice versa.

We show that the interactions of financial and reputational incentives challenge previously established results. Existing literature concludes that higher uncertainty about fundamental information improves value relevance and price efficiency. It creates additional demand for information and increases the value of financial reports in reducing uncertainty (Holmström, 1982; Narayanan, 1985; Fischer & Verrecchia, 2000). In our setting, managerial talent represents fundamental information in the labor market *and* in the capital market as it affects firm value. One might therefore expect that higher talent uncertainty improves capital and labor market efficiency. Yet, we identify cases where capital market efficiency decreases in the uncertainty about talent: We show that higher talent uncertainty generally amplifies earnings response in the labor market. This increases incentives to bias the report. The additional reporting noise potentially overcompensates the increased demand for information in the capital market.

Our results have implications for the design of financial reporting standards. A prominent objective of standard setters is to provide information that affects investors' firm valuations. For instance, the IASB Conceptual Framework for Financial Reporting directs firms to report information which is relevant to investors and creditors independent of its relevance to other reporting users. This includes information on managerial contribution to firm value (IASB, 2018, OB4 and OB10). We find ambiguous effects of such regulation. Requiring firms to report on managerial talent increases the weight that labor markets assign to reports and aggravates reporting noise. This may reduce value relevance of financial reports in capital markets – even if talent information is relevant to investors. We find that reporting on managerial contribution to firm value may reduce capital market efficiency if (i) there is high uncertainty about managers' reputational concerns and (ii) talent uncertainty represents only a small part of the overall fundamental uncertainty.

On a general level, our results indicate risks in mandating additional information in financial reports, which are not only relevant for financial investors as primary users but also for other stakeholders such as business partners, competitors, rating agencies and the authorities. If such stakeholders increasingly use financial reports as an information source, managers face complex incentives to dissemble, which aggravate the investors' problem to understand and back out reporting bias. Initiatives to increase the informational content of financial reports might therefore backfire and undermine the credibility of reports. This could be one explanation for the mixed empirical evidence of value relevance studies: Although standard setters have extended and refined reporting requirements over the past decades, empirical studies hardly identify an increase of value relevance of accounting information (Francis & Schipper, 1999; Barth *et al.* , 2001; Gu, 2007). Our results show similarities to existing work on relevance-reliability trade offs: Requiring firms to report more extensive information on firm value may have undesirable consequences if the corresponding standards offer managers additional discretion to bias reports. In contrast to this literature, reporting bias in our setting does not result from increased leeway in accounting but from additional reporting users, which are interested in the supplemental information and add incentives to bias financial reports.

Our analysis contributes to three strands of literature. First, our results are related to the literature on *biased financial reporting*. Previous work uses signal-jamming models to study how managers' financial incentives and reputational concerns affect earnings management and market efficiency. The seminal literature assumes that managerial incentives are common knowledge. Stein (1989) studies investment decisions of managers who are interested in maximizing the short-term stock price. Managers choose suboptimal investment levels and inflate current earnings even though this behavior is rationally anticipated by the market. Similar results are obtained if managers have reputational concerns: Holmström (1982) shows that even in the absence of explicit financial incentives managers exert productive effort to manage the labor market's expectations of their unobservable talent. While this outcome might be desirable if firms are unable to provide contractual incentives, Narayanan (1985) illustrates detrimental consequences of reputational concerns. In all these models, earnings management is an equilibrium outcome, but managers fail to deceive the markets. Their decisions are correctly anticipated and do not affect the ability to learn about firm value and managerial talent.

Fischer & Verrecchia (2000) show that this result depends on the assumption that managers' reporting objectives are publicly known. If investors face uncertainty about a manager's equity-based incentives, reporting bias dilutes the informational content of the financial report and reduces the capital market's ability to make inferences on firm value.[3] In this case, higher uncertainty about the manager's incentives reduces capital market efficiency while higher uncertainty about firm fundamentals increases value relevance and price efficiency.[4] We use a similar model framework assuming that firm value partly reflects managerial talent and managers face both financial incentives and reputational concerns. While there is other work addressing the joint effects of financial incentives and reputational concerns (e.g., Prendergast & Stole, 1996; Milbourn *et al.* , 2001), we are the first to consider asymmetric information on both types of incentives. We identify an interaction in the capital and labor market use of financial reports that challenges well-known comparative statics results and allows for novel empirical predictions: Although higher fundamental uncertainty creates additional demand for information, it may reduce earnings response and price efficiency in the capital market.

Second, our study complements the existing literature on *interactions of financial incentives and reputational concerns*. The career concerns literature studies optimal financial incentives in the presence of reputational concerns.[5] In his seminal work, Fama (1980) emphasizes the role of labor markets in disciplining managerial behavior. He delineates a dynamic model framework, in which incentives are provided implicitly by the wage revision process in a competitive labor market. Fama (1980) argues that reputational concerns play a natural role in motivating managers and may be a substitute for explicit financial incentives. Subsequent studies substantiate these results (e.g., Holmström, 1982; Gibbons & Murphy, 1992).[6] For instance, Gibbons & Murphy (1992) show that in the presence of implicit incentives, firms optimize total incentives: If reputational concerns are strong, optimal contracts provide only weak financial incentives. In contrast to this strand of literature, we view financial incentives and reputational concerns from a market perspective rather than a firm perspective: We do not consider optimal contracts in the

[3] Related work uses the assumption of uncertain reporting objectives to study reversal effects of reporting bias (Sankar & Subramanyam, 2001), relevance-reliability trade-offs in accounting (Dye & Sridhar, 2004), the interplay of real and accounting earnings management (Ewert & Wagenhofer, 2005) and implications for firms' voluntary disclosure decisions (Einhorn & Ziv, 2012; Heinle & Verrecchia, 2016).

[4] Uncertainty about managers' reporting objectives does not necessarily result from unknown incentives. For example, Dye & Sridhar (2004) consider unknown costs of misreporting and find similar results.

[5] Career concerns models typically employ a specific set of assumptions: Managers have unobservable ability to increase firm value; all parties hold symmetric ex ante beliefs about managerial ability; future compensation reflects the labor market's beliefs about talent. Our model shares some of these features. However, we do not explicate the formation of compensation contracts and do not require symmetric ex ante information. We therefore refer more generally to reputational concerns instead of career concerns.

[6] Other literature deals with optimal job design (Kaarbøe & Olsen, 2006; Casas-Arce & Hejeebu, 2012), the reporting environment (Autrey *et al.* , 2007) and performance measure aggregation (Autrey *et al.* , 2010; Arya & Mittendorf, 2011).

presence of implicit incentives, but study the joint effect of given financial incentives and reputational concerns on market reactions and market efficiency.

Third, we contribute to the literature studying the *effects of managers' reputational motives on capital market efficiency*. Nagar (1999) addresses firms' decisions on voluntary disclosure if managers maximize the market assessment of their talent. If there is uncertainty about the publicly available information and the corresponding market valuation, (risk-averse) managers might strategically withhold private information. In line with our results, reputational concerns have detrimental effects on price efficiency. Beyer & Dye (2012) consider managers' decisions on disclosing (unfavorable) financial forecasts when their information endowment is unknown. They find that even strategic managers might disclose unfavorable information in early periods to increase the credibility of future non-disclosure decisions. In contrast to our study, they do not address managers' reputation to increase firm value, but their reputation to be forthcoming, i.e., to disclose all available information. While we study a mandatory reporting setting, both Nagar (1999) and Beyer & Dye (2012) consider decisions on (verifiable) voluntary disclosure.

The rest of this paper is organized as follows: In Section II, we explain our model and characterize the reporting equilibrium. The benchmark analysis is presented in Section III. Section IV provides our main results with regard to market efficiency and reporting bias. In Section V, we discuss implications for reporting standard design. Section VI considers two model extensions to illustrate the effects of correlated fundamentals and multiple reporting users. In Section VII, we summarize the results and conclude.

II. Model setup

The manager of a publicly traded firm privately observes information about the firm value and releases a (potentially biased) financial report. This report is used by the capital and labor markets to update their beliefs about the firm fundamentals.[7] Before receiving information, the manager shares the market participants' ex ante beliefs about the structure and distribution of firm value. We assume that firm value is the sum of two normally distributed components:

$$\tilde{v} = \tilde{\eta} + \tilde{\theta}. \tag{1}$$

[7]Real reporting environments are characterized by multiple stakeholders interested in various aspects of firm value and thus providing incentives to manipulate the information content. In Section VI, we show that our main results carry over to a setting with more than two reporting users.

The component $\tilde{\eta} \sim N(0, \sigma_\eta^2)$ represents all aspects of firm value which are not related to the manager in place. It comprises the value created by all tangible and intangible assets independent of managerial influence. We refer to this component as the *asset value* of the firm. The component $\tilde{\theta} \sim N(0, \sigma_\theta^2)$ is the managerial contribution to firm value and epitomizes the *talent* of the manager in place.[8] In our main analysis, we assume that the asset value and managerial talent are stochastically independent, i.e., $Cov[\tilde{\eta}, \tilde{\theta}] = 0$.[9] Thus, the firm value $\tilde{v}$ is normally distributed with mean 0 and variance $\sigma_v^2 = \sigma_\eta^2 + \sigma_\theta^2$.

The manager receives a private signal revealing both the asset value η and talent component θ of firm value.[10] For instance, this signal might represent internal information provided by the firm's accounting system which are not publicly observable.[11] Subsequently, the manager must issue a public financial report on firm value. We assume that she can engage in (accounting) earnings management, that is she can overstate or understate firm value in her report r by adding a positive or negative bias $b = r - v$. Misreporting is accompanied by convex private costs:[12]

$$c(r) = \frac{1}{2} \cdot (r - v)^2 = \frac{1}{2} \cdot b^2. \tag{2}$$

Such costs result from the time-consuming process of finding and using leeway in financial reporting standards as well as conflicts with auditors and potential legal liabilities if earnings management is detected.

The capital and labor markets cannot observe any other information about the firm value or its components, but form their beliefs based on the financial report. While there

[8] Expected asset value and talent do not affect our results qualitatively and are normalized to zero.

[9] This assumption excludes potential interactive effects of the asset value and managerial talent – a typical simplification in the literature (e.g., Holmström, 1982; Gibbons & Murphy, 1992; Nagar, 1999). However, we acknowledge that complementarities in firms' production functions are likely to exist: More profitable firms hire talented managers and, in turn, these managers increase the profitability of the available resources (see Murphy & Zábojník, 2004; Gabaix & Landier, 2008; Terviö, 2008). In Section VI, we allow for positive correlation of $\tilde{\eta}$ and $\tilde{\theta}$ to study the additional effects of such complementarities.

[10] The results of our main analysis do not depend on whether the manager receives disaggregate information on both components or only on aggregate firm value. It seems realistic to assume that an experienced manager holds private information on her talent. Thus, an additional signal of aggregate firm value allows her to make inferences on the realized asset value.

[11] We assume that the accounting signal perfectly reveals firm value. Allowing for noisy accounting measurement does not affect our results qualitatively.

[12] Many earnings management studies advance the view that misreporting may be accompanied by considerable costs for managers (e.g., Fischer & Verrecchia, 2000; Dye & Sridhar, 2004). This assumption is reasonable in our setting of mandatory disclosure where the content of financial reports is regulated by standard setters and firms are subject to legal enforcement. We therefore do not consider a cheap talk setting (see Crawford & Sobel, 1982; Stocken, 2000; Bertomeu & Marinovic, 2016). For an overview of disclosure models with both costless and costly signaling see Stocken (2013).

may be alternative ways for managers to signal talent, financial reports are particularly useful for this purpose. They reflect the manager's performance in a real business environment. Furthermore, audited financial reports are arguably more credible than most other information channels. We view capital and labor markets as symmetric and risk-neutral institutions, which efficiently process the available information. They differ only in the fundamental value evaluated. The capital market price P reflects all available information on firm value $\tilde{v} = \tilde{\eta} + \tilde{\theta}$.[13] The talent assessment T in the labor market represents public information on the manager's talent $\tilde{\theta}$ as one component of firm value.[14]

$$P = E[\tilde{v}|r] \quad \text{and} \quad T = E[\tilde{\theta}|r]. \tag{3}$$

We assume that the manager's utility U depends on both the market price P as well as the assessment T of her talent. The marginal increase of her utility in the market outcomes is given by the incentive weights x_P and x_T respectively:

$$U = x_P \cdot P + x_T \cdot T - c(r). \tag{4}$$

We do not endogenize incentives but view x_P and x_T as summation of the manager's given explicit and implicit interest in the market outcomes.[15] She privately knows the weights x_P and x_T while the capital and labor markets are uncertain about their realizations.[16]

The incentive weight x_P represents the manager's aggregate financial incentives in the firm's market price. This includes incentives to increase the market price like equity-

[13]There is empirical evidence that capital market prices incorporate managerial contributions to firm value. For instance, Johnson *et al.* (1985) and Jenter *et al.* (2016) document abnormal stock price reactions in cases of sudden executive deaths. Nam *et al.* (2018) show that information on managerial decisions at previous employers affects the current employer's stock price.

[14]This assumption is typical for career concern models. In contrast, Murphy & Zábojník (2004), Murphy & Zábojník (2007) and Eisfeldt & Kuhnen (2013) suggest that there are firm-specific and general talent components where only the latter are transferable between firms. Our results hold qualitatively if we assume that talent θ is the weighted sum of firm-specific and general talent.

[15]For an analysis of optimal incentives when managers provide productive effort and manipulate earnings see Goldman & Slezak (2006), Dutta & Fan (2014) and Peng & Röell (2014).

[16]We follow existing work and use a static reduced-form model to study the effects of misreporting (e.g., Fischer & Verrecchia, 2000; Dye & Sridhar, 2004; Heinle & Verrecchia, 2016). The incentive weights x_P and x_T render the net incentives to bias reports considering all future consequences of misreporting. We do not explicitly model bias reversals under clean surplus accounting nor do we delineate a (dynamic) contracting framework that implies the utility (4). In this regard, we deviate from career concerns models and borrow from disclosure models, which do not provide microstructure of reporting incentives (e.g., Nagar, 1999). The assumption that managers maximize the market price of their talent is not farfetched and could result from the fact that expected talent determines future wages (Holmström, 1982). Then, the incentive weight x_T could reflect the manager's negotiation power (Meyer & Vickers, 1997) or be a "proxy for the length of the agent's career horizon" (Autrey *et al.* , 2010).

based compensation, but also implicit incentives to decrease the price, for instance in the case of share repurchases. The incentive weight x_T reflects the manager's reputational incentives: By signaling talent to the labor market, the manager gains reputation. Such reputation is typically related to job opportunities and higher future compensation levels (e.g., Holmström, 1982). Managers differ in their exposure x_T to the talent assessment. For instance, prior studies argue that particularly young managers benefit from high talent assessment and show strong reputational concerns (e.g., Prendergast & Stole, 1996). Following this argument, x_T may reflect the manager's age. Moreover, note that x_T represents the evaluation of *future* wages. There may be considerable differences in the individual discounting of future compensation (see Holmström & Costa, 1986; Reichelstein, 1997). This could be a result of the individuals' time preferences or career planning. Managers might face high private costs of changing affiliations or are reluctant to change jobs because of attractive internal career opportunities and retention incentives. For this type of manager, talent assessment is less relevant. Negative values of x_T are characteristic of managers who fear the additional responsibility and higher expectations associated with positive talent assessments.[17]

We assume that the capital and labor markets have common beliefs about the distribution of incentives, $\tilde{x}_P \sim N(\mu_P, \sigma_P^2)$ and $\tilde{x}_T \sim N(\mu_T, \sigma_T^2)$ with $\mu_P, \mu_T \geq 0$.[18] It is reasonable to assume that the manager's incentives are not observable by the markets. This is obvious in the case of financial incentives if compensation contracts, bonus arrangements or the manager's private stock holdings are not fully disclosed. While managerial age as one determinant of reputational concerns is observable, there are other determinants, which can hardly be assessed by the market. For example, firms use incentives to retain managers: In many cases, managers suffer considerable losses in deferred compensation, pension claims or other perks like specific loan conditions if they retire. Such contractual clauses are not necessarily public and affect the power of managers' reputational concerns. Moreover, potential benefits of reputation are realized somewhere in the future. Their impact on managers' decisions depends on career plans and individual preferences (for instance, career horizons and time preferences), which are unobservable for firm outsiders.

[17] Note that our results do not hinge on the fact that x_T may be negative. Our results hold even if the probability of negative x_T is arbitrarily small.

[18] We study a manager's reputation to increase firm value if there is uncertainty about her talent. Instead, we could assume that the manager has private information on her costs of misreporting (see Dye & Sridhar, 2004) and cares for her reputation to report truthfully. Both types of reputation imply similar results.

We analyze perfect Bayesian equilibria of this reporting game characterized by

(i) the manager's reporting strategy $r(\eta, \theta, x_P, x_T)$, which maximizes her utility (4) for given asset value and talent realizations η and θ as well as incentive weights x_P and x_T and conjectures $\hat{P}(r)$ and $\hat{T}(r)$ about the markets' reactions to her report,

(ii) the capital and labor market prices $P(r)$ and $T(r)$ as functions of the financial report r according to (3) for given conjecture $\hat{r}(\eta, \theta, x_P, x_T)$ about the manager's strategy,

(iii) the condition that all conjectures are self-fulfilling, i.e., $\hat{r}(\cdot) = r(\cdot)$, $\hat{P}(\cdot) = P(\cdot)$ and $\hat{T}(\cdot) = T(\cdot)$.

As typical in the accounting literature, we restrict our analysis to linear equilibria, i.e., the manager's reporting strategy $r(\cdot)$ as well as the capital and labor market outcomes $P(\cdot)$ and $T(\cdot)$ are linear functions of the available information.[19,20] In line with previous work, we use two measures of market efficiency to evaluate reporting equilibria (e.g., Fischer & Verrecchia, 2000; Ewert & Wagenhofer, 2005; Heinle & Verrecchia, 2016). First, we study the earnings response coefficients (ERCs)

$$\beta_P \equiv dP/dr \quad \text{and} \quad \beta_T \equiv dT/dr \tag{5}$$

in the capital and labor markets. These measures reflect the sensitivity of the market outcomes to the firm's accounting information. They have been used in the theoretical literature as proxies of *value relevance*. Second, we analyze the relative reduction of uncertainty about fundamentals in the markets[21]

$$\Pi_P \equiv \frac{Var[\tilde{v}] - Var[\tilde{v}|P]}{Var[\tilde{v}]} \quad \text{and} \quad \Pi_T \equiv \frac{Var[\tilde{\theta}] - Var[\tilde{\theta}|T]}{Var[\tilde{\theta}]}. \tag{6}$$

The terms Π_P and Π_T measure the extent to which all public and private information about fundamentals is incorporated into market prices. We follow the literature in interpreting theses measures as proxies for *price efficiency* in the capital and labor markets.[22]

[19]The restriction to linear strategies allows us to focus on a single equilibrium. Einhorn & Ziv (2012) show that this restriction is useful to rule out unreasonable out-of-equilibrium beliefs.

[20]See Guttman *et al.* (2006) for a more general equilibrium analysis in a model with only financial incentives. The study characterizes equilibria with partial pooling. Even if there is no uncertainty about managers' reporting objectives, investors are no longer able to back out reporting bias.

[21]Market efficiency has been extensively studied in capital market settings, but is typically not considered in labor market models. Studies of reputational concerns typically assume that there is no uncertainty about the value of reputation for managers. In consequence, reporting bias is anticipated and can be backed out from the report. In our setting of uncertain reputational incentives, labor market efficiency is a valid question because bias is accompanied by reporting noise.

[22]Other measures of market efficiency comprise entropy measures (Huang, 2016; Jiang & Yang, 2017)

Proposition 1 proves the existence and uniqueness of a linear equilibrium.[23]

Proposition 1 *If the manager is motivated by financial incentives and reputational concerns, there exists a unique linear equilibrium with the following properties:*[24]

$$r = v + b = v + \beta_P \cdot x_P + \beta_T \cdot x_T, \tag{7}$$

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} \quad \text{and} \quad \beta_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{8}$$

The equilibrium strategies have a very intuitive interpretation. The manager chooses the bias level considering both her financial *and* reputational motives. The equilibrium bias level b trades off the marginal benefits and costs of dissembling. The former depend on the markets' responsiveness to the financial report: If it is easier to influence the markets, (i.e., for higher levels of β_P and β_T), the manager chooses a higher bias level. The capital and labor markets' equilibrium ERCs reflect the reported information on firm value and talent respectively, $\beta_P = Cov[\tilde{v}, \tilde{r}] \cdot Var[\tilde{r}]^{-1}$ and $\beta_T = Cov[\tilde{\theta}, \tilde{r}] \cdot Var[\tilde{r}]^{-1}$.

The equilibrium results are useful to determine the measures of market efficiency. It turns out that value relevance and price efficiency are identical measures: The degree to which rational markets rely on the financial report corresponds to its usefulness in reducing uncertainty about fundamentals.[25] Based on this observation, we focus on the analysis of the market ERCs knowing that they represent both value relevance and price efficiency.

Corollary 1 *In equilibrium, the measures of price efficiency and value relevance coincide, i.e.,* $\Pi_P = \beta_P$ *and* $\Pi_T = \beta_T$.

or the (negative) expected squared difference between reported and true value (Fischer & Stocken, 2004). In our model setting, all three alternative definitions coincide.

[23]Proposition 1 characterizes the equilibrium ERCs implicitly. We refrain from stating the explicit solutions as they do not provide additional insights.

[24]All proofs are provided in the appendix.

[25]The congruence of value relevance and price efficiency does not necessarily hold in a multi-stage reporting environment as considered by Caskey *et al.* (2010).

III. Benchmark analysis

Previous literature focuses on settings, in which managers' reports are either motivated exclusively by financial incentives ($x_T = 0$, i.e., $\mu_T = \sigma_T^2 = 0$) or by reputational motives ($x_P = 0$, i.e., $\mu_P = \sigma_P^2 = 0$). Lemma 1 summarizes comparative static results in these special cases of our model.[26]

Lemma 1 *Results with either financial incentives or reputational concerns*

a) *Consider the case that the manager only pursues financial objectives ($x_T = 0$). Higher uncertainty about the firm value (i.e., asset value $\tilde{\eta}$ or talent $\tilde{\theta}$) improves earnings response β_P^B in the capital market.*

b) *If the manager is motivated by reputational objectives only ($x_P = 0$), higher uncertainty about her talent $\tilde{\theta}$ improves earnings response in the labor market. In contrast, higher uncertainty about the asset value $\tilde{\eta}$ reduces the labor market response β_T^B.*

If the manager is not motivated by reputational concerns but seeks to maximize the firm's market price, higher uncertainty about asset value or managerial talent generally improves capital market efficiency. As there is more demand for information, financial reports become more valuable and are used increasingly by investors, i.e., the ERC in the capital market increases ($d\beta_P^B/d\sigma_k^2 > 0$ for $k \in \{\eta, \theta\}$).[27] These effects occur whenever investors use (biased) financial reports to learn about firm value (e.g., Holthausen & Verrecchia, 1988; Stein, 1989; Fischer & Verrecchia, 2000).[28]

In the absence of financial incentives, the manager's reputational concerns have similar effects. Higher uncertainty about her talent makes financial reports more useful for potential employers. Thus, the labor market ERC increases, $d\beta_T^B/d\sigma_\theta^2 > 0$. While talent θ is fundamental information for both markets, the asset value η represents noise for the labor market. It dilutes the talent information without having any explanatory value. In consequence, higher uncertainty about the asset value attenuates the labor market response, $d\beta_T^B/d\sigma_\eta^2 < 0$. These observations are in line with the results of the literature on reputational concerns (Narayanan, 1985; Holmström, 1982; Gibbons & Murphy, 1992).

[26] Let $\beta_P^B = \beta_P|_{x_T=0}$ and $\beta_T^B = \beta_T|_{x_P=0}$ denote the capital and labor market ERCs in the benchmark cases.

[27] Note that in equilibrium improved capital market efficiency is associated with higher expected reporting bias, i.e., $dE[\tilde{b}]/d\sigma_k^2 > 0$. This illustrates that measures of reporting bias are inappropriate to evaluate the level of information asymmetry between management and the capital market: Reporting bias is rationally anticipated by the markets, which discount reports for expected bias levels (e.g., Narayanan, 1985; Stein, 1989; Fischer & Verrecchia, 2000).

[28] Note that the uncertainty about the manager's incentives is irrelevant for these results. The logic applies even if her motives are publicly known.

The generalization of Lemma 1 seems obvious. If fundamental information is associated with higher uncertainty, there is a stronger response to the financial report in the respective market. Although this motivates additional reporting bias, market efficiency is effectively improved. Our main analysis shows that this logic no longer applies if the manager faces both types of incentives.

IV. Main results

Equilibrium analysis

Corollary 2 summarizes characteristics of the reporting equilibrium.

Corollary 2 *Characteristics of the equilibrium ERCs*

a) The capital market response to the financial report is always stronger than the labor market response, $\beta_T = \sigma_\theta^2 \cdot (\sigma_\eta^2 + \sigma_\theta^2)^{-1} \cdot \beta_P$.

b) The ERCs in the capital and labor market are positive and bounded from above, $0 < \beta_P < 1$ *and* $0 < \beta_T < \sigma_\theta^2 \cdot (\sigma_\eta^2 + \sigma_\theta^2)^{-1}$.

The capital market price is more sensitive to the manager's report than the talent assessment. This results from the nested structure of firm value and managerial talent. The financial report is a noisy signal of firm value, which is the sum of asset value and talent. In contrast to the capital market, the labor market is only interested in the talent component: Potential employers perceive the information on the firm's asset value as additional noise because this information is unrelated to managerial talent. Hence, financial reports show a higher correlation with the total firm value than with managerial talent as one of its components ($Cov[\tilde{\theta}, \tilde{r}] < Cov[\tilde{v}, \tilde{r}]$).

Note that in the presence of uncertain reporting objectives more reporting bias is associated with additional noise. If earnings response increases, the markets rationally anticipate *that* the manager adjusts her bias level. However, they do not know precisely *how much* bias is added due to the uncertainty about the manager's incentives $\tilde{x}_P$ and $\tilde{x}_T$. Formally, the uncertainty associated with the report increases in β_P and β_T:

$$Var[\tilde{r}] = Var[\tilde{v}] + Var[\tilde{b}] = \sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2. \quad (9)$$

This leads to our first main observation. With financial and reputational incentives, both market reactions motivate bias and induce reporting noise. Note that the noise induced by one of the markets represents an information externality for the other market: If the capital market's reaction dilutes the content of the report, the labor market learns less and reduces its response accordingly. Vice versa, the noise induced by the labor market represents an externality for the capital market and is considered by the firm's investors. As a consequence, the equilibrium capital and labor market ERCs are reduced compared to the benchmark cases with only one type of incentives.

Proposition 2 *The capital and labor market ERCs are lower than in a reporting environment with only financial or reputational concerns, i.e.,* $\beta_P < \beta_P^B$ *and* $\beta_T < \beta_T^B$.

Based on this result, we study comparative static results to gain further insights into the interaction of financial incentives and reputational concerns. Lemma 2 summarizes the effect of higher uncertainty about the manager's financial and reputational motives.

Lemma 2 *Both markets' equilibrium ERCs as well as the expected equilibrium bias are decreasing in uncertainty about the manager's financial and reputational motives,* $d\beta_m/d\sigma_n^2 < 0$ *and* $dE[\tilde{b}]/d\sigma_n^2 < 0$ *for* $m, n \in \{P, T\}$.

Higher uncertainty about the manager's financial incentives or her reputational concerns aggravates the noise in the report and attenuates the markets' equilibrium reactions. As a consequence, the manager faces lower-powered incentives to bias the report. This result is standard in the literature (e.g., Fischer & Verrecchia, 2000) and also holds in our model with financial and reputational incentives.[29]

Next, we study the effect of higher uncertainty about firm value on the equilibrium results. The results in this case are less obvious and require a detailed analysis. The equilibrium ERCs according to Proposition 1 formalize the interdependency between financial incentives and reputational concerns: The ERC β_P in the capital market is a function of the model parameters as well as the ERC β_T in the labor market and vice versa.

Corollary 3 *Increasing uncertainty* σ_η^2 *and* σ_θ^2 *about the value components has a direct as well as an indirect effect on each equilibrium ERC:*

$$\frac{d\beta_P}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_P}{\partial\sigma_k^2}}_{\equiv D_{P,k}} + \underbrace{\frac{d\beta_P}{d\beta_T}\cdot\frac{d\beta_T}{d\sigma_k^2}}_{\equiv I_{P,k}}, \qquad \frac{d\beta_T}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_T}{\partial\sigma_k^2}}_{\equiv D_{T,k}} + \underbrace{\frac{d\beta_T}{d\beta_P}\cdot\frac{d\beta_P}{d\sigma_k^2}}_{\equiv I_{T,k}} \qquad \text{for } k \in \{\eta, \theta\}. \tag{10}$$

$D_{m,k}$ *and* $I_{m,k}$ *measure the direct and indirect effects of increasing* σ_k^2 *on* β_m, $m \in \{P, T\}$.

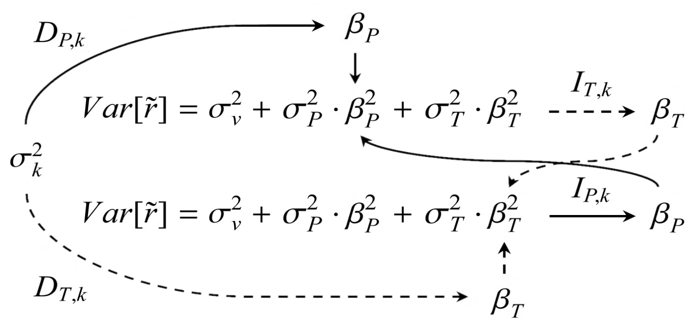

Figure 1 *Direct and indirect effects of higher uncertainty about firm value ($k \in \{\eta, \theta\}$)*

Figure 1 illustrates the direct and indirect effects identified in Corollary 3. If the uncertainty σ_k^2 about the asset value ($k = \eta$) or managerial talent ($k = \theta$) increases, this has direct impact on both equilibrium ERCs according to (8). The direct effects reflect the optimal earnings response in one market holding the other market's response fixed.

The indirect effects are a consequence of the manager's reaction to the direct effects. Higher uncertainty about the firm value implies an adjustment of the markets' ERCs β_P and β_T. As illustrated in (9), the adjustment of the capital market ERC β_P also affects the reporting noise and thus creates an externality on the usefulness of the report in the labor market. Vice versa, the direct effect on β_T alters the investors' ability to learn about firm value. These externalities create the indirect effects formally defined in Corollary 3.

Following the argument above, the indirect effect $I_{m,k}$ of higher uncertainty about the value component $k \in \{\eta, \theta\}$ on the ERC β_m aggregates two effects formally given by the derivatives $d\beta_m/d\beta_n$ and $d\beta_n/d\sigma_k^2$. First, the other market's ERC β_n influences the reporting noise and thereby the equilibrium level of β_m.[30] Second, the other market adjusts its reaction to higher uncertainty about the value component. If managers are motivated exclusively by financial incentives ($x_T = 0$), the ERC in the capital market fully reflects the direct effects, i.e., $I_{P,\eta} = I_{P,\theta} = 0$. Analogously, if managers are motivated by reputational concerns only ($x_P = 0$), the reaction of the labor market is independent of the capital market response, i.e., $I_{T,\eta} = I_{T,\theta} = 0$.

[29]Although not explicitly stated, this result also prevails in the benchmark cases of section III.

[30]This requires that the incentive weight related to the outcome of the other market is uncertain, $\sigma_n^2 > 0$. It is obvious from (8) that $d\beta_m/d\beta_n \leq 0$. Equality only holds for $\sigma_n^2 = 0$.

The effect of higher uncertainty about the asset value

This section provides a detailed analysis of the direct and indirect effects of increasing uncertainty about the asset value. Lemma 3 establishes the signs of these effects.

Lemma 3 *Direct and indirect effects of higher uncertainty about the asset value*

a) *Higher uncertainty about the asset value σ_η^2 has a positive direct effect on earnings response in the capital market ($D_{P,\eta} > 0$), but a negative direct effect on the labor market reaction ($D_{T,\eta} < 0$).*

b) *The indirect effects that are associated with an increase of the uncertainty about the firm's asset value σ_η^2 amplify the direct effects, i.e., $I_{P,\eta} > 0$ and $I_{T,\eta} < 0$.*

The asset value $\tilde{\eta}$ represents fundamental information for investors, but noise in the labor market. Thus, higher uncertainty about this component provokes a positive direct effect in the capital market: There is more to learn for investors who show greater responsiveness to the report, i.e., $D_{P,\eta} > 0$. At the same time, information about the manager's talent is diluted and the labor market's reaction to the report is attenuated, i.e., $D_{T,\eta} < 0$.

The indirect effects of σ_η^2 amplify the direct effects. Increases in σ_η^2 attenuate the labor market's earnings response and thus reduce the manager's incentives to dissemble. The noise in the financial report is reduced, which, in turn, enhances its usefulness for the financial investors, $I_{P,\eta} > 0$. Moreover, the positive direct effect in the capital market motivates additional bias. According to (9), this dilutes information about managerial talent and makes the report less useful for the labor market, $I_{T,\eta} < 0$. The total effects are unambiguous because direct and indirect effects are equally directed.

Proposition 3 *If the uncertainty σ_η^2 about the asset value increases, the capital market's earnings response β_P increases while the labor market's earnings response β_T decreases.*

Our results confirm the expectations raised in the benchmark analysis. The asset value η is relevant information in the capital market. Hence, higher uncertainty σ_η^2 makes the financial report more valuable for investors of the firm. The corresponding ERC increases, $d\beta_P/d\sigma_\eta^2 > 0$. At the same time, η is unrelated to the manager's influence on firm value and dilutes the talent information in the report. The labor market therefore reduces its ERC in response to higher uncertainty about the asset value, $d\beta_T/d\sigma_\eta^2 < 0$. As the direct and indirect effects have the same sign, there is no ambiguity in the market reactions.

Figure 2 illustrates our results. The three graphs depict the equilibrium ERCs for different degrees of uncertainty about the manager's reputational concerns, $\sigma_T^2 \in \{1.6, 16, 49\}$.

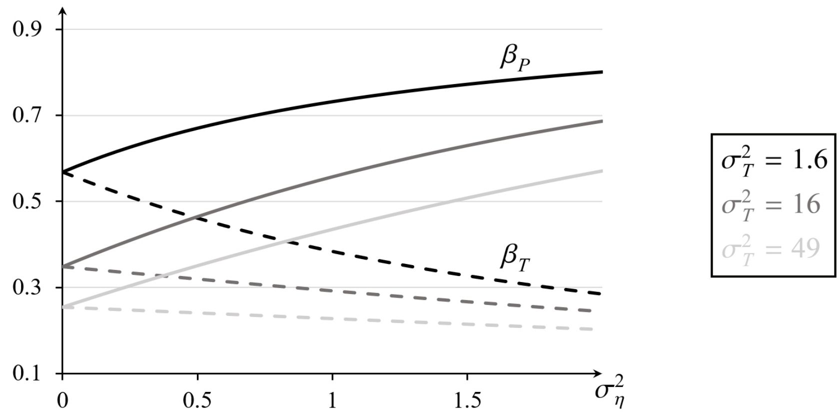

Figure 2 *Effects of higher uncertainty about the asset value on market efficiency* $(\mu_P^2 = \mu_T^2 = 40, \sigma_\theta^2 = 1.1, \sigma_P^2 = 1)$

As shown in Lemma 2, both earnings reactions are unambiguously decreasing in the variance σ_T^2: The markets learn less about firm fundamentals if there is more uncertainty about the manager's motives. As a consequence, the manager's incentives to dissemble are attenuated. Confirming Proposition 3, the capital market ERC β_P is increasing and the labor market ERC β_T is decreasing in higher uncertainty about the asset value.

The effect of higher uncertainty about talent value

In this section, we turn to the effects of higher uncertainty about the managerial talent. Lemma 4 characterizes the direct and indirect effects of talent uncertainty.

Lemma 4 *Direct and indirect effects of higher talent uncertainty*

a) Higher uncertainty σ_θ^2 about managerial talent implies a positive direct effect on both market reactions, i.e., $D_{P,\theta}, D_{T,\theta} > 0$.

b) The sign of the indirect effect of higher talent uncertainty σ_θ^2 on the capital market response is negative ($I_{P,\theta} < 0$). The indirect effect $I_{T,\theta}$ on the labor market response is ambiguous.

In contrast to the asset value, managerial talent θ represents fundamental information for capital *and* labor markets: The labor market is inherently interested in the manager's talent; financial investors learn about its contribution to firm value. Thus, increasing the uncertainty about talent makes the financial report more valuable for both reporting users. This is reflected in positive direct effects, $D_{P,\theta}, D_{T,\theta} > 0$.

Interestingly, the indirect effects of higher talent uncertainty can be opposed to the direct effects. The positive direct effects on both markets' ERCs provide additional incentives for the manager to bias the report and thus introduce additional noise as illustrated in equation (9). This creates a counterforce to the direct effects. The indirect effects subsume these countervailing effects: While the indirect effect on the capital market response is generally opposed to the direct effect ($I_{P,\theta} < 0$), the sign of the indirect effect $I_{T,\theta}$ on the labor market ERC is ambiguous. It can amplify or counteract the direct effect.

The reason for the asymmetry in the results is the nested structure of the fundamental information in the market objectives. Financial investors assign a market price based on both asset value and managerial talent; the labor market assesses only talent as a subset of these components. In line with Corollary 2 a), this implies that the equilibrium ERC in the labor market is always lower than the equilibrium ERC in the capital market. At the same time, β_T is more sensitive to changes in the variance σ_θ^2.[31] To formalize this argument consider the indirect effects according to Corollary 3. $I_{P,\theta}$ and $I_{T,\theta}$ reflect the total variations $d\beta_T/d\sigma_\theta^2$ and $d\beta_P/d\sigma_\theta^2$ of the equilibrium ERCs. It is easy to see that the marginal increase of the labor market ERC in talent uncertainty generally exceeds the increase of the capital market ERC, $d\beta_T/d\sigma_\theta^2 > d\beta_P/d\sigma_\theta^2$. While the former is always positive, the latter can take negative values. As a consequence, the capital market response is strictly attenuated while the indirect effect on the labor market response is ambiguous. Proposition 4 summarizes the total effects of higher talent uncertainty.

Proposition 4 *The labor market's earnings response β_T increases in the uncertainty about the manager's talent σ_θ^2. The effect of talent uncertainty on the capital market's earnings response β_P is ambiguous.*

Managerial talent θ represents fundamental information in both markets. Following the arguments of the benchmark analysis, higher talent uncertainty should therefore increase the demand for information and enhance the usefulness of the report for both reporting users. Proposition 4 only partly confirms this intuition. Indeed, the labor market's earnings response increases in talent uncertainty. However, higher uncertainty about the manager's contribution to firm value can reduce earnings response in the capital market. The reason for this observation is the interdependency between the markets' ERCs resulting from the manager's incentives to dissemble. Proposition 5 provides a detailed analysis of the ambiguous effects of talent uncertainty on the capital market ERC.

[31] This is apparent from the implicit characterization in (8).

Proposition 5 *The ambiguous effects of talent uncertainty on the capital market ERC*

a) *If the uncertainty about the manager's reputational concerns is sufficiently high compared to the uncertainty about her financial incentives ($\sigma_T^2 > 3 \cdot \sigma_P^2$), the capital market's earnings response is decreasing in intermediate values of talent uncertainty $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]$ and increasing elsewhere.*

b) *The range $[\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]$ is widened as the uncertainty about the manager's financial motives decreases or the uncertainty about her reputational concerns increases. It is bounded by the uncertainty about the asset value, $[\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2] \subset [0, 2 \cdot \sigma_\eta^2]$.*

Whether the capital market ERC is decreasing in the variance of talent depends on the relative uncertainty about the manager's financial and reputational motives. These results reflect our previous observations. As the uncertainty about financial incentives decreases, the externality of the financial investors' reaction on the labor market ERC β_T is attenuated. Thus, the labor market response provides high-powered incentives to bias the financial report. This again introduces noise into the report, especially if there is high uncertainty about the manager's reputational concerns. The report becomes less useful for investors. As a consequence, low values of σ_P^2 and high values of σ_T^2 characterize settings, in which the capital market ERC is decreasing in talent uncertainty.

Our results are illustrated in Figure 3, which depicts the equilibrium ERCs as functions of talent uncertainty σ_θ^2. The three differently shaded graphs visualize the effects of higher uncertainty about the manager's reputational concerns ($\sigma_T^2 \in \{1.6, 16, 49\}$). Confirming Lemma 2, increases in σ_T^2 reduce both ERCs. As shown before, the uncertainty about the manager's reputational concerns does not only affect the level of the ERCs, but also their slope. For low uncertainty about reputational motives ($\sigma_T^2 = 1.6$), the capital market earnings response β_P is generally increasing in talent uncertainty. For $\sigma_T^2 = 16$, the capital market ERC is decreasing within the range $\sigma_\theta^2 \in [0.03, 1.38]$. If the uncertainty about the managers reputational concerns increases to $\sigma_T^2 = 49$, this range is widened to $[0.01, 1.53]$. In line with Proposition 4, β_T is increasing in talent uncertainty.

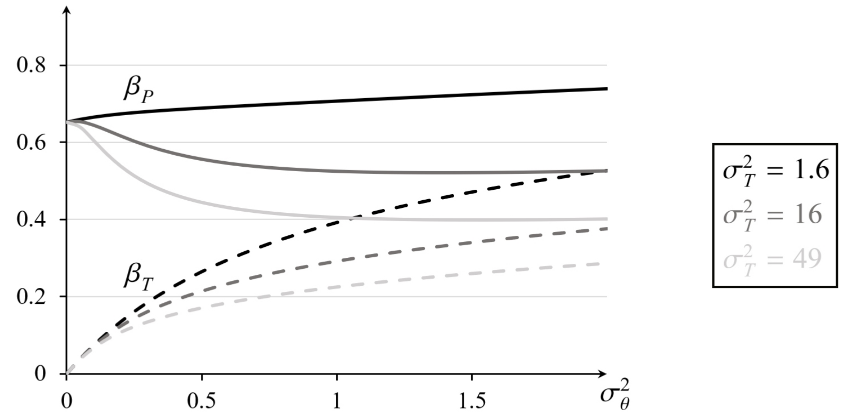

Figure 3 *Effects of higher talent uncertainty on market efficiency*
($\mu_P^2 = \mu_T^2 = 40$, $\sigma_\eta^2 = 0.8$, $\sigma_P^2 = 1$)

Expected reporting bias

We use our results to highlight implications for the expected bias level,

$$E[\tilde{b}] = E[b(\tilde{\eta}, \tilde{\theta}, \tilde{x}_P, \tilde{x}_T)] = \beta_P \cdot \mu_P + \beta_T \cdot \mu_T. \tag{11}$$

The derivative of the expected bias is thus given by

$$\frac{dE[\tilde{b}]}{d\sigma_k^2} = \mu_P \cdot \frac{d\beta_P}{d\sigma_k^2} + \mu_T \cdot \frac{d\beta_T}{d\sigma_k^2} \qquad \text{for } k \in \{\eta, \theta\}. \tag{12}$$

We can therefore use the comparative static results of the previous sections to analyze the effect of asset value and talent uncertainty on the expected bias level. We know from Proposition 3 that the capital market ERC is increasing and the labor market ERC is decreasing in the uncertainty about the asset value. Thus, it is unclear which of the two effects dominates. Corollary 4 clarifies how the statistical properties of the manager's reputational incentives affect the slope of the expected bias level.

Corollary 4 *The expected reporting bias is decreasing in the uncertainty about the firm's asset value if*
(i) the average benefits related to reputation are sufficiently high, i.e., $\mu_T > \underline{\mu}_T$,
(ii) markets have sufficient information about the reputational motives, i.e., $\sigma_T^2 < \overline{\sigma}_T^2$.

These results are intuitive. If the expected marginal benefits μ_T of increasing talent assessment are sufficiently high, it is likely that the manager chooses her report primarily to influence the labor market. The labor market's ERC is decreasing in the uncertainty about the asset value. Therefore, the expected bias is decreasing in σ_η^2 if μ_T is high.

To understand the second part of the proposition, consider the case that the uncertainty σ_T^2 about the manager's reputational concerns is high. Hence, any increase in the labor market's earnings response β_T is associated with significant incremental reporting noise. The labor market earnings response is therefore compressed: It takes low values and is hardly sensitive to changes in σ_η^2. As a consequence, the adjustment of the capital market ERC is leading the manager's bias choice. Higher uncertainty about the asset value implies higher expected reporting bias. Vice versa, the labor market's earnings response can only be dominant if there is low uncertainty about the manager's reputational motives.

The results of the previous section show that more uncertainty about talent σ_θ^2 generally implies higher responsiveness in the labor market, but may reduce earnings response in the capital market, i.e., $d\beta_P/d\sigma_\theta^2 < 0$ and $d\beta_T/d\sigma_\theta^2 > 0$. According to (12), this implies countervailing effects on the manager's bias choice: She increases the bias in response to the labor market reaction, but reduces it considering the attenuated reaction by financial investors. The total effect is ambiguous. Corollary 5 characterizes conditions for the expected reporting bias to decrease in talent uncertainty.

Corollary 5 *For $\sigma_T^2 > 3 \cdot \sigma_P^2$ and $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]$, the expected bias level is decreasing in the uncertainty about talent if and only if*

(i) the average benefits related to reputation are low on average, i.e., $\mu_T < \overline{\mu}_T$,

(ii) markets are sufficiently uncertain about the reputational motives, i.e., $\sigma_T^2 > \underline{\sigma}_T^2$.

According to Proposition 5, the capital market ERC decreases in talent uncertainty if the markets are sufficiently uncertain about the manager's reputational concerns ($\sigma_T^2 > 3 \cdot \sigma_P^2$). In this case, the expected bias level is decreasing in talent uncertainty $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]$ if (i) the average benefits of reputation are low or (ii) markets have little information on the manager's reputational concerns. Low values of μ_T ensure that the manager primarily reacts to the capital market ERC β_P, which is decreasing in σ_θ^2. Moreover, high uncertainty about reputational concerns σ_T^2 attenuates the labor market reaction. Thus, the manager's biasing decision is primarily led by the capital market response.

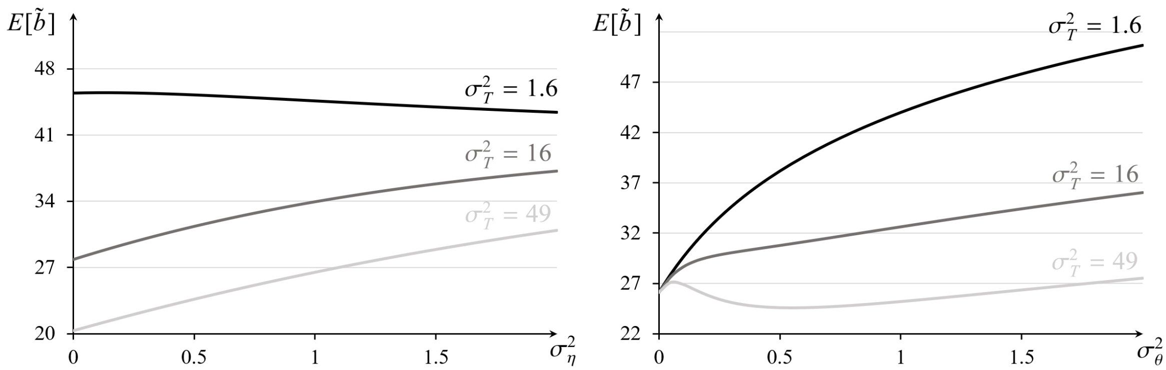

Figure 4 *Effects of higher uncertainty about firm value on the expected reporting bias* *($\mu_P^2 = \mu_T^2 = 40$, $\sigma_P^2 = 1$, $\sigma_\theta^2 = 1.1$, $\sigma_\eta^2 = 0.8$)*

Note that the effects of higher uncertainty about the asset value and managerial talent stand in stark contrast. Increasing variance σ_η^2 reduces the expected bias if the manager's bias choice is led by the labor market reaction (i.e., for high μ_T and low σ_T^2); increasing variance σ_θ^2 reduces the expected bias if the manager's decision is primarily motivated by the capital market (i.e., for low μ_T and high σ_T^2).

To illustrate the results, we use the numerical examples introduced in the previous sections. The left-hand and right-hand sides of Figure 4 depict the expected reporting bias as a function of σ_η^2 and σ_θ^2 respectively. $E[\tilde{b}]$ is decreasing in σ_η^2 for low uncertainty about the manager's reputational concerns ($\sigma_T^2 = 1.6$) and increasing for high uncertainty $\sigma_T^2 \in \{16, 49\}$. In contrast, low uncertainty about reputational concerns ($\sigma_T^2 \in \{1.6, 16\}$) ensures that the expected reporting bias is increasing in σ_θ^2. If the uncertainty about the reputational motives is sufficiently high ($\sigma_T^2 = 49$), the expected bias is decreasing within the range $\sigma_\theta^2 \in [0.06, 0.55]$. Note that the expected bias even falls below its level without *any* talent uncertainty. Talent uncertainty and the corresponding reputational incentives can reduce reporting bias compared to a situation with observable managerial talent.

V. Should firms report on managers' contributions to firm value? A standard setter's perspective

A prominent objective of financial reporting standards is the provision of decision-useful information for investors of the firm (Barth *et al.* , 2001).[32] For instance, the IASB Conceptual Framework for Financial Reporting states that reports should "provide financial information about the reporting entity that is useful to existing and potential investors, lenders and other creditors in making decisions" (IASB, 2018, OB10). A central criterion for information included in reports is relevance in the sense of IASB (2018, QC6): It should be capable of changing users' decisions to buy, sell or hold equity and debt instruments. These objectives are closely related to the concepts of *value relevance* and *price efficiency* as formally defined in our model. Information is useful if it has high impact on the capital market price and reduces the investors' uncertainty about the firm value.

Information on the abilities of the firm's management seem to be material in many cases (see Johnson *et al.* , 1985; Jenter *et al.* , 2016). Accordingly, the IASB classifies such information as relevant and mandates the disclosure of information "about how efficiently and effectively the reporting entity's management has discharged its responsibilities to use the entity's economic resources" (IASB, 2018, OB4). Moreover, the value-relevance criterion must be applied independent of the usefulness of the information for other stakeholders. The IASB acknowledges that there are other users of financial reports. However, reports are not primarily directed to these parties (IASB, 2018, OB10). This suggests that the reporting content should be tailored to the informational needs of investors and creditors and neglect the presence of other reporting users such as labor markets.

Such treatment disregards the interactions between reporting users identified in our study. Including information that is relevant for the managerial labor market motivates additional earnings management, which in turn dilutes information about the firm value. This can cause a reduction of value relevance and price efficiency in the capital market. To formalize our argument, consider a modified model setting, in which financial reporting standard setters require the management only to report on asset value η and to exclude any information about the talent component θ. While financial investors are still interested in the firm value $v = \eta + \theta$, the modified reporting objective alters the manager's costs of misreporting. In contrast to equation (2), the manager faces potential litigation costs if

[32] Aside from the provision of decision-useful information, financial reporting standard setters pursue other objectives such as stewardship (e.g., Holthausen & Watts, 2001). Due to the limited focus of our model, we can only address standard setters' intentions to provide value-relevant information.

her report does not correctly reflect the firm's asset value:[33]

$$c(r) = \frac{1}{2} \cdot (r - \eta)^2. \tag{13}$$

The modified reporting objective has considerable implications for the equilibrium results summarized by the following lemma.

Lemma 5 *If the manager is supposed to report exclusively on the firm's asset value, we have the following unique linear equilibrium:*[34]

$$r^{\dagger} = \eta + \beta_P^{\dagger} \cdot x_P, \quad \beta_P^{\dagger} = \frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_P^2 \cdot \beta_P^{\dagger 2}} \quad \textit{and} \quad \beta_T^{\dagger} = 0. \tag{14}$$

If managerial talent is not part of the reporting objective, the equilibrium financial report excludes any talent information. As a consequence, the report is irrelevant for the labor market and not used to update the a priori beliefs about talent, $\beta_T^{\dagger} = 0$. The interdependency between the capital market and labor market ERCs is dissolved.

A comparison of value relevance $\beta_P^{\dagger}$ and price efficiency $\Pi_P^{\dagger}$ in the capital market with the results of our main model highlights two differences. First, the financial report does not reflect managerial talent. Note that talent represents fundamental information for investors. In line with the IASB's argumentation, eliminating talent information therefore reduces the usefulness of the report in the capital market. However, there is a countervailing effect. In the absence of the labor market's earnings response, the manager's incentives to misreport are attenuated. Therefore, the noise associated with the manager's bias choice is reduced. The latter effect allows better inferences on the firm's asset value and improves the usefulness of the report for financial investors. Proposition 6 identifies conditions under which the elimination of talent information improves value relevance and price efficiency in the capital market.[35]

[33] In this case, it is important that the manager has disaggregate information about the asset value and her talent. This could be because she receives a report on firm value v by the firm's internal accounting system and has private information about her talent θ. We come to similar conclusions if the manager does not precisely know the value of her talent but observes a noisy signal of the talent realization.

[34] We use $(\cdot)^{\dagger}$ to denote the equilibrium coefficients under the modified reporting objective.

[35] In contrast to our main analysis, value relevance $\beta_P^{\dagger}$ and price efficiency $\Pi_P^{\dagger}$ are no longer identical if talent information is removed from reports. This is why Proposition 6 addresses both measures separately.

Proposition 6 *Eliminating the talent information from reporting objectives improves*

(i) value relevance (i.e., $\beta_P^\dagger > \beta_P$) if the uncertainty about the manager's reputational concerns is sufficiently high compared to her financial incentives ($\sigma_T^2 > 4 \cdot \sigma_P^2$) and if talent uncertainty takes intermediate values $\sigma_\theta^2 \in [\sigma_L^2, \sigma_H^2]$.

(ii) price efficiency (i.e., $\Pi_P^\dagger > \Pi_P$) if the uncertainty about the manager's reputational concerns σ_T^2 is sufficiently high and if talent uncertainty takes intermediate values $\sigma_\theta^2 \in [\sigma_l^2, \sigma_h^2] \subset [\sigma_L^2, \sigma_H^2]$.

The proposition highlights that it may be beneficial for value relevance and price efficiency to remove information about managerial talent from financial reports. This is the case if there is high uncertainty about the manager's reputational concerns. Then, the incentives provided by the labor market induce significant reporting noise. Regulations that restrict the reporting content or leave firms discretion about the reported information can help to alleviate this problem by making reports less useful for the labor market. This stands in contrast to the IASB's conceptual framework, which generally mandates to include (relevant) information on managerial contribution to firm value.

Moreover, the IASB conceptual reporting framework assesses the information needs of reporting users aside from investors and creditors as largely irrelevant for the design of financial reports. Our results indicate that the presence of other users, such as labor markets, can critically influence the adequate choice of reporting standards. This is even the case if standard setters focus exclusively on capital market efficiency. If users provide incentives for managers to dissemble, this may cause additional reporting noise. As a consequence, the usefulness of the report in the capital market may be reduced. Standard setters should carefully consider potential detrimental effects of mandating the disclosure of information which might be relevant for other reporting users.

VI. Extensions

Correlation of fundamentals

Empirical studies suggest a complementary relationship between the firm's asset value and managerial talent: Profitable firms with a large asset base are able to attract and retain talented managers. To capture such relationship, the analysis in this section allows for positive correlation $\rho \in [0, 1]$ of asset value $\tilde{\eta}$ and managerial talent $\tilde{\theta}$.[36] We find that

[36] If both components are perfectly correlated, learning about talent means learning about firm value.

there is still a unique linear equilibrium characterized by the following market ERCs:

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}, \;\; \beta_T = \frac{\sigma_\theta^2 + \rho \cdot \sigma_\eta \cdot \sigma_\theta}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{15}$$

Note that the correlation does structurally not affect the capital market ERC according to Proposition 1, but changes the form of the labor market ERC. To study the effect of increasing ρ on capital market efficiency, we distinguish direct and indirect effects:[37]

$$\frac{d\beta_P}{d\rho} = \underbrace{\frac{\partial \beta_P}{\partial \rho}}_{\equiv D_{P,\rho}} + \underbrace{\frac{d\beta_P}{d\beta_T} \cdot \frac{d\beta_T}{d\rho}}_{\equiv I_{P,\rho}}. \tag{16}$$

The direct effect $D_{P,\rho}$ represents the change of β_P implied by a marginal increase of ρ if the labor market does not adjust its earnings response β_T. We find that $D_{P,\rho}$ is strictly positive. The correlation ρ affects earnings response β_P only via the variance $\sigma_v^2 = \sigma_\eta^2 + \sigma_\theta^2 + 2 \cdot \rho \cdot \sigma_\eta \cdot \sigma_\theta$. A higher variance σ_v^2 raises financial investors' demand for information and implies higher earnings response, i.e., $d\beta_P/d\rho > 0$.

The indirect effect $I_{P,\rho}$ measures the adjustment of β_P that is mediated by the labor market earnings reaction $\beta_T(\rho)$. We find that this effect can be either positive or negative. Although the direct effect is strictly positive, the total effect of increasing correlation $d\beta_P/d\rho = D_{P,\rho} + I_{P,\rho}$ can be negative. Proposition 7 characterizes conditions which ensure that earnings response in the capital market is decreasing in correlation.

Proposition 7 *The effects of correlated fundamentals*

a) *If the uncertainty about the manager's reputational concerns is sufficiently high compared to the uncertainty about her financial incentives ($\sigma_T^2 > 12 \cdot \sigma_P^2$) and talent uncertainty is relatively small ($\sigma_\eta^2 > 5 \cdot \sigma_\theta^2$), the capital market's earnings response is decreasing within a non-empty interval of correlation levels $[\underline{\rho}, \overline{\rho}] \subset [0, 1]$.*

b) *As uncertainty σ_T^2 about reputational concerns increases, the interval $[\underline{\rho}, \overline{\rho}]$ approaches the full range of positive correlation, $\lim_{\sigma_T^2 \to \infty} \underline{\rho} = 0$ and $\lim_{\sigma_T^2 \to \infty} \overline{\rho} = 1$.*

To provide intuition for these results, it is useful to consider the equilibrium labor market response. According to equation (15), higher correlation ρ has two countervailing effects on the equilibrium level of β_T. First, it makes the report more informative for the labor market, which is apparent from the numerator $Cov[\tilde{\theta}, \tilde{r}] = \sigma_\theta^2 + \rho \cdot \sigma_\eta \cdot \sigma_\theta$. The financial report is a noisy signal about firm value and comprises both asset value and

[37]We focus on the analysis of capital market efficiency.

talent. If these components are correlated, the asset value is not perceived as pure noise but conveys information about managerial talent. Second, higher correlation increases the variance of the firm value σ_v^2 and therefore the uncertainty associated with the report, $Var[\tilde{r}] = \sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2$. The report becomes less useful for the labor market.

It depends on the reporting environment whether the first or the second effect dominates. If talent uncertainty is comparably high, increasing correlation does not have a significant effect on the labor market's ability to learn about talent. Correlation primarily increases the uncertainty associated with the report. In this case, the denominator increases at a faster rate than the numerator. If however talent uncertainty is sufficiently low, the labor market hardly uses the report. In this case, even a small increase in correlation improves the labor market's learning about talent significantly.

Proposition 7 characterizes the latter case: If the labor market ERC β_T increases in correlation ρ, this provides additional incentives to bias the financial report. As a consequence, the financial report is a noisier signal of firm value. This is particularly the case if there is high uncertainty about the manager's reputational concerns σ_T^2. For $\sigma_\eta^2 > 5 \cdot \sigma_\theta^2$ and $\sigma_T^2 > 12 \cdot \sigma_P^2$, this effect is strong enough to make the capital market reduce its weight on the financial report within a range of correlation levels $[\underline{\rho}, \overline{\rho}]$. This interval is widened and finally approaches the full range of positive correlation if the uncertainty about the manager's reputational concerns is sufficiently high.

Multiple users of financial reports

The previous analysis can be extended to more than two users of financial reports. In this section, we use a generalized model to study how the number of the reporting users and their objectives affect capital market efficiency. In contrast to our main analysis, assume that the manager issues her report to the capital market ($a = 0$) and n additional risk-neutral users ($a = 1, ..., n$). Addressee $a \in A \equiv \{0, ..., n\}$ is interested in a specific subset of assets of the firm, which contribute to firm value. For any subgroup of reporting users $M \in \mathfrak{P}(A)$, let $\tilde{v}_M$ denote the component of the firm value which constitutes fundamental information for all users $a \in M$ while it is irrelevant to any user $a \in A/M$.[38] This defines a disaggregation of firm value into disjoint components, $\tilde{v} \equiv \sum_{M \in \mathfrak{P}(A)} \tilde{v}_M$. As in our main analysis, we assume that each value component is normally distributed, $\tilde{v}_M \sim N(0, \sigma_M^2)$.

[38] $\mathfrak{P}(\cdot)$ denotes the power set of a given set, i.e., it is the set of all subsets.

Components are mutually independent.[39] We denote $\sigma_v^2 = \sum_{M \in \mathfrak{P}(A)} \sigma_M^2$.

Moreover, define $S_a \equiv \{M \in \mathfrak{P}(A) | \; a \in M\}$ the subgroups of reporting users which contain user $a \in A$ and $\tilde{v}_a \equiv \sum_{M \in S_a} \tilde{v}_M$ his aggregate objective. It is reasonable to assume that the capital market is interested in all aspects of firm value, i.e., $\tilde{v}_0 = \tilde{v}$. After observing the financial report, each user $a \in A$ defines a price P_a reflecting the publicly available information about his objective, $P_a = E[\tilde{v}_a | r]$. The manager chooses her reporting bias b anticipating all users' reactions. She is interested in the outcomes of all reporting users:

$$U = \sum_{a \in A} x_a \cdot P_a - \frac{1}{2} \cdot b^2. \tag{17}$$

The manager privately learns the realizations of the incentive weights x_a. All reporting users hold identical beliefs about their prior distribution: $(\tilde{x}_a)_{a \in A}$ follow a multivariate normal distribution and are mutually independent with $\tilde{x}_a \sim N(\mu_a, \sigma_a^2)$. We define efficiency measures analogously to our main analysis: The ERC β_a measures how closely the price P_a is linked to the financial report, $\beta_a \equiv dP_a/dr$.

Lemma 6 *There exists a unique linear equilibrium characterized by*

$$b = \sum_{a \in A} \beta_a \cdot x_a \;\; \text{and} \;\; \beta_a = \frac{\sum_{M \in S_a} \sigma_M^2}{\sigma_v^2 + \beta_a^2 \cdot \sum_{s \in A} \gamma^{(sa)2} \cdot \sigma_s^2} \tag{18}$$

where $\gamma^{(sa)} = Var[\tilde{v}_s]/Var[\tilde{v}_a]$ *measures the relative uncertainty associated with the objectives of the reporting users* s *and* a*.*

Note that the relative size of the equilibrium ERCs represents the relative uncertainty about the users' objectives, i.e., $\beta_s = \gamma^{(sa)} \cdot \beta_a$. To highlight implications for capital market efficiency, we focus on the financial investors' ERC β_0.

Corollary 6 *The capital market ERC* β_0 *is decreasing if*

a) a reporting user $a = n+1$ *is added who is interested in part of the firm value, i.e.,* $|S_{n+1}| > 0$*, and provides (uncertain) incentives to bias the report, i.e.,* $\sigma_{n+1}^2 > 0$.

b) user $a \in A/\{0\}$ *is interested in a different objective with higher relative uncertainty.*

[39] Our main analysis constitutes a special case of this general setup. The asset value represents fundamental information only for financial investors while managerial talent is fundamental in both markets, i.e., $\tilde{v} = \tilde{v}_{\{P\}} + \tilde{v}_{\{P,T\}}$ with independent components $\tilde{v}_{\{P\}} = \tilde{\eta}$ and $\tilde{v}_{\{P,T\}} = \tilde{\theta}$.

We can conclude that increasing the number of reporting users or the uncertainty about the users' objectives generally reduces capital market efficiency. As illustrated in our main analysis, the effect of higher uncertainty about firm value on the capital market ERCs depends on the origin of this uncertainty. For $M \in \mathfrak{P}(A)$, let

$$A_M \equiv \left\{ a \in M \,\middle|\, \gamma^{(a0)} < 2/3 \right\} \tag{19}$$

denote the set of reporting users who are interested in $\tilde{v}_M$ and whose objective is associated with relatively low uncertainty. More precisely, the definition requires that the uncertainty about the objective of a user is smaller than two thirds of the aggregate uncertainty about firm value. This helps us to characterize settings where higher uncertainty about firm value reduces capital market efficiency.

Proposition 8 *For $M \in \mathfrak{P}(A)$, the capital market ERC β_0 is decreasing in uncertainty about the value component $\tilde{v}_M$ if A_M is non-empty and the following condition holds:*

$$\sum_{a \in A_M} (-w_a) \cdot \sigma_a^2 > \sum_{a \in A/A_M} w_a \cdot \sigma_a^2 \quad \text{where } \; w_a \equiv \begin{cases} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} & \text{for } a \in M \\ 3 \cdot \gamma^{(a0)2} & \text{for } a \notin M \end{cases} . \tag{20}$$

Proposition 8 naturally generalizes the results of our main analysis. Capital market efficiency might decrease in the uncertainty about fundamental information $\tilde{v}_M$. This is the case if other reporting users exist who strive to learn about $\tilde{v}_M$ and whose objectives are associated with relatively low uncertainty, i.e., $\gamma^{(a0)} = Var[\tilde{v}_a]/\sigma_v^2 < 2/3$.[40] This condition ensures that, first, increasing the variance σ_M^2 does not only raise the information demand of financial investors but also of other users and, second, that σ_M^2 has a stronger effect on these users' ERCs than on the capital market ERC. Third, condition (20) requires that the aggregate uncertainty $(\sigma_a^2)_{a \in A_M}$ associated with the incentives provided by the competing reporting users must be sufficiently high. Under these three conditions the indirect effects of increasing the uncertainty σ_M^2 dominate the direct effect. Although financial investors have higher demand for information, the additional reporting bias induced by other reporting users significantly dilutes information on firm value. As a consequence, capital market efficiency is reduced.

[40]This observation is in line with the results of Proposition 5. The capital market ERC can only decrease in σ_θ^2 as far as $\sigma_\theta^2 < 2 \cdot \sigma_\eta^2$, which is equivalent to $\sigma_\theta^2/\sigma_v^2 < 2/3$.

VII. Conclusion

We study managers' reporting bias in the presence of financial incentives and reputational concerns. Our analysis identifies interactions of both types of incentives assuming that capital and labor markets are uncertain about managers' reporting objectives: The use of the financial report in one market motivates noisy bias and reduces the value of the report in the other market. As a consequence, the presence of both financial incentives and reputational concerns reduces financial and labor market efficiency compared to settings where managers encounter only one type of incentives. Furthermore, our results highlight the subtle role of fundamental uncertainty in real reporting environments with multiple reporting users. When financial reports are processed by a single user, increasing fundamental uncertainty creates additional demand for information and improves value relevance and price efficiency (e.g., Fischer & Verrecchia, 2000). Our results show that this conclusion may not be valid if multiple stakeholders have a joint interest in a subgroup of the firm's assets and use financial reports to learn about these assets. In this case, increasing fundamental uncertainty has countervailing effects. First, each reporting user assigns higher weight to the report, reacting to the additional demand for information. Second, the additional attention provides incentives to bias the report, which increases reporting noise. Considering managers' financial and reputational incentives, we find that higher uncertainty about managerial talent generally improves labor market efficiency, but may decrease value relevance and price efficiency in the capital market. This is particularly the case if markets are sufficiently uncertain about managers' reputational motives and if talent uncertainty is low compared to the overall fundamental uncertainty.

Our results have implications for standard setters' intentions to provide relevant information to investors and creditors. We characterize settings in which the value relevance of financial reports can be improved by eliminating talent information – even if this information is relevant to financial investors. What seems to be a contradiction can be explained by the reporting noise associated with managers' reputational concerns: Making reports less meaningful for labor markets mitigates incentives to dissemble and may therefore enhance investors' insights into firm fundamentals. A practical example is the standard setters' choice between different measurement concepts for assets. For instance, standard setters might require recording certain groups of assets at their value in use, which is typically calculated as net present value of future cash flows generated *in combination with the firm's given assets*.[41] Arguably, talented managers employ available assets in a

[41] IAS 36 requires firms to potentially report assets' value in use when conducting impairment tests.

more efficient way, which results in higher value in use. The value in use measurement is therefore informative about managerial talent. In contrast, fair value measurement does conceptually not convey information about the influence of the firm's management: Fair values represent (market) prices which do not reflect potential complementarities with the firm's other assets.

On a more general level, our results show that capital market efficiency is not necessarily improved if standard setters implement recognition and measurement rules that provide a more accurate depiction of firm value. In this regard, our results show similarities to existing work on relevance-reliability trade offs: A more precise depiction of firm value in financial reports may be undesirable if the corresponding standards offer managers additional discretion to bias reports. In line with this observation, we show that more precise measures of firm value may increase reporting bias. However, reporting bias in our setting does not result from increased leeway in accounting but from additional reporting users, which are interested in the supplemental information and add incentives to bias financial reports.

Following this logic, our analysis indicates risks of extending statutory reporting requirements. In an attempt to increase transparency and to provide a complete picture of firm assets, standard setters such as the IASB mandate the disclosure of information that affects investors' and creditors' decisions. However, if additional information is useful for various stakeholders, a more complete depiction of firm value may create complex reporting incentives, which aggravate the investors' problem to understand and back out reporting bias. This may be one reason for the mixed empirical evidence of value-relevance studies: Although reporting requirements have been extended and refined over the past decades, there is little evidence of improved value relevance of financial reports in capital markets (e.g., Francis & Schipper, 1999; Barth *et al.* , 2001; Gu, 2007). Existing literature discusses potential reasons such as the increasing relevance of intangible assets. This analysis shows that additional reporting noise might have contributed to this development: Financial reports have become a comprehensive instrument for managers to communicate with the firms' stakeholders. This creates implicit incentives to bias reports. Recent empirical findings confirm the practical importance of reporting noise (Beyer *et al.* , 2018; Ferri *et al.* , 2018). Our results could thus be an interesting starting point for empirical work to study interactions in the capital and labor markets' use of financial reports.

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Appendix

Proof of Proposition 1

We restrict our analysis to linear equilibria, i.e., the manager's biasing strategy as well as the market outcomes are linear functions of the available information:

$$b(v, x_P, x_T) = \lambda + \lambda_\eta \cdot \eta + \lambda_\theta \cdot \theta + \lambda_P \cdot x_P + \lambda_T \cdot x_T, \tag{21}$$

$$P(r) = \alpha_P + \beta_P \cdot r, \quad T(r) = \alpha_T + \beta_T \cdot r. \tag{22}$$

Given the linear strategies, the manager's objective (4) becomes

$$U = x_P \cdot (\hat{\alpha}_P + \hat{\beta}_P \cdot r) + x_T \cdot (\hat{\alpha}_T + \hat{\beta}_T \cdot r) - \frac{1}{2} \cdot (r - v)^2. \tag{23}$$

The optimal bias level is given by:

$$r = v + \hat{\beta}_P \cdot x_P + \hat{\beta}_T \cdot x_T. \tag{24}$$

A comparison with (21) shows

$$\lambda = 0, \quad \lambda_\eta = \lambda_\theta = 1, \quad \lambda_P = \hat{\beta}_P \text{ and } \lambda_T = \hat{\beta}_T. \tag{25}$$

Given linear beliefs about the manager's reporting strategy, the market outcomes (3) to the report are given by:

$$P = \frac{\hat{\lambda}_\eta \cdot \sigma_\eta^2 + \hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2} \cdot (r - (\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T)), \tag{26}$$

$$T = \frac{\hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2} \cdot (r - (\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T)). \tag{27}$$

Comparing the equilibrium market strategies with (22) yields:

$$\alpha_P = -(\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T) \cdot \beta_P, \quad \alpha_T = -(\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T) \cdot \beta_T, \tag{28}$$

$$\beta_P = \frac{\hat{\lambda}_\eta \cdot \sigma_\eta^2 + \hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2}, \quad \beta_T = \frac{\hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2}. \tag{29}$$

In equilibrium, the conjectures must be self-fulfilling. Substituting (25) into the above coefficients yields:

$$\alpha_P = -(\mu_P \cdot \beta_P + \mu_T \cdot \beta_T) \cdot \beta_P, \quad \alpha_T = -(\mu_P \cdot \beta_P + \mu_T \cdot \beta_T) \cdot \beta_T, \tag{30}$$

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} \text{ and } \beta_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{31}$$

The equilibrium conditions obviously imply

$$\beta_T = \frac{Cov[\tilde{\theta}, \tilde{r}]}{Cov[\tilde{v}, \tilde{r}]} \cdot \beta_P = \frac{\sigma_\theta^2}{\sigma_v^2} \cdot \beta_P. \tag{32}$$

Thus, there is a one-to-one mapping between the capital market equilibrium ERC β_P and all other equilibrium coefficients. To show existence and uniqueness of the equilibrium, it is sufficient to prove that there is a unique value of β_P solving

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{33}$$

Substitution of (32) and rearranging terms yields

$$\left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^3 + \sigma_v^2 \cdot (\beta_P - 1) = 0. \tag{34}$$

Note that the left-hand side of (34) is strictly increasing in β_P. It becomes strictly negative for $\beta_P = 0$ and strictly positive for $\beta_P = 1$. Continuity of the equilibrium condition guarantees that (34) has a unique solution $\beta_P \in (0, 1)$. □

Proof of Corollary 1

Consider the measures of price efficiency defined in (6). Assuming linear strategies according to (21) and (22), these measures have the following form.

$$\Pi_P = \frac{Cov[\tilde{v}, \tilde{P}]^2}{Var[\tilde{v}] \cdot Var[\tilde{P}]} = \frac{(\lambda_\eta \cdot \sigma_\eta^2 + \lambda_\theta \cdot \sigma_\theta^2)^2}{\sigma_v^2 \cdot (\lambda_\eta^2 \cdot \sigma_\eta^2 + \lambda_\theta^2 \cdot \sigma_\theta^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2)}, \tag{35}$$

$$\Pi_T = \frac{Cov[\tilde{\theta}, \tilde{T}]^2}{Var[\tilde{\theta}] \cdot Var[\tilde{T}]} = \frac{\lambda_\theta^2 \cdot \sigma_\theta^2}{\lambda_\eta^2 \cdot \sigma_\eta^2 + \lambda_\theta^2 \cdot \sigma_\theta^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2}. \tag{36}$$

Substituting the equilibrium strategies according to Proposition 1 yields

$$\Pi_P = \beta_P \text{ and } \Pi_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2} = \beta_T. \tag{37}$$

□

Proof of Lemma 1

The benchmark cases with either financial incentives or reputational concerns are special cases of the general model for $\mu_P = \sigma_P^2 = 0$ and $\mu_T = \sigma_T^2 = 0$. The proof of Lemma 1 follows from our general analysis. □

Proof of Corollary 2

The relationship between β_P and β_T in a) has already been established in (32). Furthermore, the proof of Proposition 1 shows that the equilibrium capital market ERC is bounded, $0 < \beta_P < 1$. Using the result in a), β_T is strictly positive and bounded by $\frac{\sigma_\theta^2}{\sigma_v^2}$. □

Proof of Proposition 2

The proof follows directly from Lemma 2. The equilibrium ERCs are independent of μ_P and μ_T but strictly decreasing in σ_P^2 and σ_T^2. As the benchmark ERCs β_P^B and β_T^B reflect the special cases for $\sigma_T^2 = 0$ and $\sigma_P^2 = 0$ respectively, the ERCs β_P and β_T in the general model must take lower values, i.e., $\beta_P^B > \beta_P$ and $\beta_T^B > \beta_T$. □

Proof of Lemma 2

We use the implicit function theorem to show comparative static results with regard to σ_k^2, $k \in \{P, T\}$. Using the result of Corollary 2 a), the equilibrium conditions for β_P and β_T according to Proposition 1 can be stated in the following form:

$$F_P(\sigma_k^2, \beta_P(\sigma_k^2)) \equiv \left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^3 + \sigma_v^2 \cdot (\beta_P - 1) = 0, \tag{38}$$

$$F_T(\sigma_k^2, \beta_T(\sigma_k^2)) \equiv \left(\frac{\sigma_v^4}{\sigma_\theta^4} \cdot \sigma_P^2 + \sigma_T^2\right) \cdot \beta_T^3 + \sigma_v^2 \cdot \beta_T - \sigma_\theta^2 = 0. \tag{39}$$

This reformulation of the equilibrium conditions dissolves the interdependency between the equilibrium ERCs: F_P characterizes β_P without referring to β_T; analogously, F_T defines β_T without referring to the capital market ERC. We obtain

$$\frac{d\beta_P}{d\sigma_P^2} = -\frac{\partial F_P/\partial\sigma_P^2}{\partial F_P/\partial\beta_P} = -\frac{\beta_P^3}{3\cdot\left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2 + \sigma_\nu^2} < 0, \tag{40}$$

$$\frac{d\beta_P}{d\sigma_T^2} = -\frac{\partial F_P/\partial\sigma_T^2}{\partial F_P/\partial\beta_P} = -\frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\frac{\beta_P^3}{3\cdot\left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2 + \sigma_\nu^2} < 0, \tag{41}$$

$$\frac{d\beta_T}{d\sigma_P^2} = -\frac{\partial F_T/\partial\sigma_P^2}{\partial F_T/\partial\beta_T} = -\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\frac{\beta_T^3}{3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2 + \sigma_T^2\right)\cdot\beta_T^2 + \sigma_\nu^2} < 0, \tag{42}$$

$$\frac{d\beta_T}{d\sigma_T^2} = -\frac{\partial F_T/\partial\sigma_T^2}{\partial F_T/\partial\beta_T} = -\frac{\beta_T^3}{3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2 + \sigma_T^2\right)\cdot\beta_T^2 + \sigma_\nu^2} < 0. \tag{43}$$

□

Proof of Corollary 3

Based on the implicit equilibrium conditions according to Proposition 1, we interpret the equilibrium ERC in one of the markets as a function of the model parameters and of the ERC in the other market, i.e., $\beta_P = \beta_P(\sigma_k^2, \beta_T(\sigma_k^2))$ and $\beta_T = \beta_T(\sigma_k^2, \beta_P(\sigma_k^2))$ with $k \in \{\eta, \theta\}$. Thus, varying the parameter value σ_k^2 has a direct effect on each of the equilibrium ERCs as well as an indirect effect:

$$\frac{d\beta_m}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_m}{\partial\sigma_k^2}}_{:=D_{m,k}} + \underbrace{\frac{d\beta_m}{d\beta_n}\cdot\frac{d\beta_n}{d\sigma_k^2}}_{:=I_{m,k}} \qquad \text{for } m, n \in \{P, T\}, m \neq n. \tag{44}$$

The direct effect reflects the change in the ERC if the other market does not adjust its earnings response. The indirect effect represents the change in the ERC as a result of the other market's adjustment. □

Proof of Lemma 3 and 4

Rearranging the equilibrium conditions (8) according to Proposition 1 yields:

$$G_P(\sigma_k^2, \beta_P(\sigma_k^2, \beta_T), \beta_T) \equiv \sigma_P^2 \cdot \beta_P^3 + (\sigma_\nu^2 + \sigma_T^2 \cdot \beta_T^2) \cdot \beta_P - \sigma_\nu^2 = 0, \tag{45}$$

$$G_T(\sigma_k^2, \beta_P, \beta_T(\sigma_k^2, \beta_P)) \equiv \sigma_T^2 \cdot \beta_T^3 + (\sigma_\nu^2 + \sigma_P^2 \cdot \beta_P^2) \cdot \beta_T - \sigma_\theta^2 = 0. \tag{46}$$

The direct effect of σ_k^2 on the capital market ERC β_P reflects the change in the capital market ERC holding the labor market response β_T constant ($k \in \{\eta, \theta\}$). To analyze the sign of $D_{P,k}$, we therefore neglect the adjustment of β_T in response to a change in σ_k^2:

$$D_{P,\eta} = \frac{\partial \beta_P}{\partial \sigma_\eta^2} = -\frac{\partial G_P / \partial \sigma_\eta^2}{\partial G_P / \partial \beta_P} = \frac{1 - \beta_P}{\sigma_\nu^2 + 3 \cdot \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} > 0, \tag{47}$$

$$D_{P,\theta} = \frac{\partial \beta_P}{\partial \sigma_\theta^2} = -\frac{\partial G_P / \partial \sigma_\theta^2}{\partial G_P / \partial \beta_P} = \frac{1 - \beta_P}{\sigma_\nu^2 + 3 \cdot \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} > 0. \tag{48}$$

According to Corollary 2, β_P is smaller than 1. As a consequence, the direct effects have positive sign. Analogously, we evaluate the direct effects of σ_k^2 on the labor market ERC assuming that β_P is constant:

$$D_{T,\eta} = \frac{\partial \beta_T}{\partial \sigma_\eta^2} = -\frac{\partial G_T / \partial \sigma_\eta^2}{\partial G_T / \partial \beta_T} = -\frac{\beta_T}{\sigma_\nu^2 + \sigma_P^2 \cdot \beta_P^2 + 3 \cdot \sigma_T^2 \cdot \beta_T^2} < 0, \tag{49}$$

$$D_{T,\theta} = \frac{\partial \beta_T}{\partial \sigma_\theta^2} = -\frac{\partial G_T / \partial \sigma_\theta^2}{\partial G_T / \partial \beta_T} = \frac{1 - \beta_T}{\sigma_\nu^2 + \sigma_P^2 \cdot \beta_P^2 + 3 \cdot \sigma_T^2 \cdot \beta_T^2} > 0. \tag{50}$$

The signs of the direct effects follow from Corollary 2. To identify the signs of the indirect effects, notice that

$$\frac{\partial \beta_P}{\partial \beta_T} = -\frac{\partial G_P / \partial \beta_T}{\partial G_P / \partial \beta_P} = -\frac{2 \cdot \sigma_T^2 \cdot \beta_P \cdot \beta_T}{\sigma_\nu^2 + 3 \cdot \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} < 0, \tag{51}$$

$$\frac{\partial \beta_T}{\partial \beta_P} = -\frac{\partial G_T / \partial \beta_P}{\partial G_T / \partial \beta_T} = -\frac{2 \cdot \sigma_P^2 \cdot \beta_P \cdot \beta_T}{\sigma_\nu^2 + \sigma_P^2 \cdot \beta_P^2 + 3 \cdot \sigma_T^2 \cdot \beta_T^2} < 0. \tag{52}$$

Moreover, we use the modified equilibrium conditions (38) and (39) to obtain the total effects of higher uncertainty on the equilibrium ERCs.

$$\frac{d\beta_P}{d\sigma_\eta^2} = -\frac{\partial F_P/\partial\sigma_\eta^2}{\partial F_P/\partial\beta_P} = \frac{2\cdot\sigma_\theta^4\cdot\sigma_T^2\cdot\beta_P^3+\sigma_\nu^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_\nu^2\right)\cdot\sigma_\nu^6} > 0, \tag{53}$$

$$\frac{d\beta_P}{d\sigma_\theta^2} = -\frac{\partial F_P/\partial\sigma_\theta^2}{\partial F_P/\partial\beta_P} = -\frac{2\cdot\sigma_\theta^2\cdot\sigma_\eta^2\cdot\sigma_T^2\cdot\beta_P^3-\sigma_\nu^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_\nu^2\right)\cdot\sigma_\nu^6}, \tag{54}$$

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{\partial F_T/\partial\sigma_\eta^2}{\partial F_T/\partial\beta_T} = -\frac{2\cdot\sigma_\nu^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^4\cdot\beta_T}{\left(3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_\nu^2\right)\cdot\sigma_\theta^4} < 0, \tag{55}$$

$$\frac{d\beta_T}{d\sigma_\theta^2} = -\frac{\partial F_T/\partial\sigma_\theta^2}{\partial F_T/\partial\beta_T} = \frac{2\cdot\sigma_\nu^2\cdot\sigma_\eta^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^6\cdot(1-\beta_T)}{\left(3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_\nu^2\right)\cdot\sigma_\theta^6} > 0. \tag{56}$$

This implies the following results:

$$I_{P,\eta} = \frac{\partial\beta_P}{\partial\beta_T}\cdot\frac{d\beta_T}{d\sigma_\eta^2} > 0, \quad I_{P,\theta} = \frac{\partial\beta_P}{\partial\beta_T}\cdot\frac{d\beta_T}{d\sigma_\theta^2} < 0 \;\text{ and }\; I_{T,\eta} = \frac{\partial\beta_T}{\partial\beta_P}\cdot\frac{d\beta_P}{d\sigma_\eta^2} < 0. \tag{57}$$

Furthermore, we can conclude that

$$sgn(I_{T,\theta}) = (-1)\cdot sgn(d\beta_P/d\sigma_\theta^2). \tag{58}$$

This sign depends on the model parameters as the numerical examples in section IV illustrate. Moreover, we use the characteristics of β_P and β_T established in Corollary 2 to show that $d\beta_T/d\sigma_\theta^2 > d\beta_P/d\sigma_\theta^2$. According to (54) and (56) we find

$$\begin{aligned}
\frac{d\beta_T}{d\sigma_\theta^2} &= \frac{2\cdot\sigma_\nu^2\cdot\sigma_\eta^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^6\cdot(1-\beta_T)}{\left(3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_\nu^2\right)\cdot\sigma_\theta^6} \\
&> \frac{\sigma_\theta^6\cdot(1-\beta_P)}{\left(3\cdot\left(\frac{\sigma_\nu^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_\nu^2\right)\cdot\sigma_\theta^6} \\
&= \frac{\sigma_\nu^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_\nu^2\right)\cdot\sigma_\nu^6} \\
&> -\frac{2\cdot\sigma_\theta^2\cdot\sigma_\eta^2\cdot\sigma_T^2\cdot\beta_P^3-\sigma_\nu^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_\nu^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_\nu^2\right)\cdot\sigma_\nu^6} = \frac{d\beta_P}{d\sigma_\theta^2}.
\end{aligned} \tag{59}$$

□

Proof of Proposition 3 and 4

The effect of higher uncertainty about asset value and managerial talent on β_P and β_T has already been established in the proof of Lemma 3 and 4. □

Proof of Proposition 5

Rearranging the equilibrium condition (38) yields:

$$\sigma_v^2 \cdot (1-\beta_P) = \left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^3. \tag{60}$$

When substituting this expression into (54), we have

$$\frac{d\beta_P}{d\sigma_\theta^2} \leq 0 \quad \Leftrightarrow \quad \underline{\sigma}_\theta^2 \leq \sigma_\theta^2 \leq \overline{\sigma}_\theta^2. \tag{61}$$

The threshold levels $\underline{\sigma}_\theta^2$ and $\overline{\sigma}_\theta^2$ are given by

$$\underline{\sigma}_\theta^2 \equiv \frac{\sigma_T^2 - \sigma_P^2 - \sqrt{(\sigma_T^2 - 3\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2+\sigma_T^2} \cdot \sigma_\eta^2, \quad \overline{\sigma}_\theta^2 \equiv \frac{\sigma_T^2 - \sigma_P^2 + \sqrt{(\sigma_T^2 - 3\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2+\sigma_T^2} \cdot \sigma_\eta^2. \tag{62}$$

The range $[\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]$ of opposed market reactions only exists if $\sigma_T^2 - 3\cdot\sigma_P^2 > 0$. It is easy to see that under this condition the lower bound $\underline{\sigma}_\theta^2$ is strictly positive. Moreover, increasing the uncertainty about the manager's reputational concerns widens this range while higher uncertainty about financial incentives narrows it:

$$\frac{d\underline{\sigma}_\theta^2}{d\sigma_P^2} = -\frac{2 - \frac{5\cdot\sigma_T^2 - 3\cdot\sigma_P^2}{2\cdot\sqrt{(\sigma_T^2-3\cdot\sigma_P^2)\cdot\sigma_T^2}}}{(\sigma_P^2+\sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_T^2 > 0, \quad \frac{d\underline{\sigma}_\theta^2}{d\sigma_T^2} = \frac{2 - \frac{5\cdot\sigma_T^2 - 3\cdot\sigma_P^2}{2\cdot\sqrt{(\sigma_T^2-3\cdot\sigma_P^2)\cdot\sigma_T^2}}}{(\sigma_P^2+\sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_P^2 < 0, \tag{63}$$

$$\frac{d\overline{\sigma}_\theta^2}{d\sigma_P^2} = -\frac{2 + \frac{5\cdot\sigma_T^2 - 3\cdot\sigma_P^2}{2\cdot\sqrt{(\sigma_T^2-3\cdot\sigma_P^2)\cdot\sigma_T^2}}}{(\sigma_P^2+\sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_T^2 < 0, \quad \frac{d\overline{\sigma}_\theta^2}{d\sigma_T^2} = \frac{2 + \frac{5\cdot\sigma_T^2 - 3\cdot\sigma_P^2}{2\cdot\sqrt{(\sigma_T^2-3\cdot\sigma_P^2)\cdot\sigma_T^2}}}{(\sigma_P^2+\sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_P^2 > 0. \tag{64}$$

The signs of these expressions follow from the fact that $\sigma_T^2 - 3 \cdot \sigma_P^2 > 0$ and thus

$$2 - \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}} < 0. \tag{65}$$

It is easy to see that

$$\lim_{\sigma_T^2 \to \infty} \underline{\sigma}_\theta^2 = 0 \quad \text{and} \quad \lim_{\sigma_T^2 \to \infty} \overline{\sigma}_\theta^2 = 2 \cdot \sigma_\eta^2. \tag{66}$$

□

Proof of Corollary 4

We have established in Proposition 3 that $d\beta_P / d\sigma_\eta^2 > 0$ and $d\beta_T / d\sigma_\eta^2 < 0$. Note that β_P and β_T do not depend on the average incentive weights μ_P and μ_T. It is therefore obvious that the derivative $dE[\tilde{b}]/d\sigma_\eta^2$ according to equation (12) is negative for sufficiently high values of μ_T that exceed a threshold value $\underline{\mu}_T$.

To show the second part of the proposition, we rearrange the equilibrium conditions (38) and (39) in the following way:

$$\beta_P^3 = \frac{\sigma_v^6 \cdot (1 - \beta_P)}{\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}, \quad \beta_T^3 = \frac{\sigma_\theta^4 \cdot (\sigma_\theta^2 - \sigma_v^2 \cdot \beta_T)}{\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}. \tag{67}$$

Substituting these identities into (53) and (55) yields:

$$\frac{d\beta_P}{d\sigma_\eta^2} = \frac{(\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2}{((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2) \cdot (\sigma_\eta^2 + \sigma_\theta^2)} \cdot \frac{(1 - \beta_P) \cdot \beta_P}{3 - 2 \cdot \beta_P}, \tag{68}$$

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{2 \cdot (\sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_P^2 - ((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_T}{((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2) \cdot (3 \cdot \sigma_\theta^2 - 2 \cdot (\sigma_\eta^2 + \sigma_\theta^2) \cdot \beta_T)} \cdot \beta_T. \tag{69}$$

Moreover, we use Corollary 2 a) to obtain the following equation:

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_v^4 \cdot \sigma_P^2 - (\sigma_v^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_v^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1 - \beta_P)} \cdot \frac{d\beta_P}{d\sigma_\eta^2}. \tag{70}$$

Thus, we have the following derivative of the expected bias with regard to σ_η^2:

$$\begin{aligned}\frac{dE[\tilde{b}]}{d\sigma_\eta^2} &= \frac{d\beta_P}{d\sigma_\eta^2} \cdot \mu_P + \frac{d\beta_T}{d\sigma_\eta^2} \cdot \mu_T \\ &= \left(1 - \frac{\mu_T}{\mu_P} \cdot \frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_\nu^4 \cdot \sigma_P^2 - (\sigma_\nu^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_\nu^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1 - \beta_P)}\right) \cdot \frac{d\beta_P}{d\sigma_\eta^2} \cdot \mu_P.\end{aligned} \tag{71}$$

Proposition 3 establishes $d\beta_P/d\sigma_\eta^2 > 0$. Therefore, higher uncertainty about the asset value reduces the expected reporting bias if and only if

$$\frac{\mu_T}{\mu_P} \cdot \frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_\nu^4 \cdot \sigma_P^2 - (\sigma_\nu^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_\nu^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1 - \beta_P)} > 1. \tag{72}$$

To simplify this condition, we must distinguish two cases.

Case a: $(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_\nu^2) \cdot \sigma_\nu^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_\nu^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2 > 0$
Solving condition (72) for β_P yields

$$\beta_P < 1 + \frac{\mu_T \cdot \sigma_\theta^2 \cdot (\sigma_\nu^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_\nu^2) \cdot \sigma_\nu^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_\nu^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2}, \tag{73}$$

which is generally true because $\beta_P < 1$ according to Corollary 2. Thus, in this case, the expected bias level is generally decreasing in the uncertainty about the asset value.

Case b: $(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_\nu^2) \cdot \sigma_\nu^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_\nu^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2 < 0$
The condition that characterizes *Case b* can be rearranged to

$$\sigma_T^2 > \frac{(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot (\sigma_\eta^2 + \sigma_\theta^2)) \cdot (\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2}{(\mu_P \cdot 3 \cdot (\sigma_\eta^2 + \sigma_\theta^2) + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4}. \tag{74}$$

Thus, *Case b* applies for sufficiently high values of σ_T^2. The condition (72) can now be rearranged as follows

$$\beta_P > 1 - \frac{\mu_T \cdot \sigma_\theta^2 \cdot (\sigma_\nu^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{\underbrace{(\mu_P \cdot \sigma_\nu^2 - \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\nu^4 \cdot \sigma_P^2 + (3 \cdot \mu_P \cdot \sigma_\nu^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2}_{\equiv H_\eta}}. \tag{75}$$

It is easy to establish that

$$\frac{dH_\eta}{d\sigma_T^2} = -\frac{2\cdot\mu_T\cdot(\mu_P\cdot\sigma_v^2+\mu_T\cdot\sigma_\theta^2)\cdot\sigma_\theta^6\cdot\sigma_v^4\cdot\sigma_P^2}{((\mu_P\cdot\sigma_v^2-\mu_T\cdot\sigma_\theta^2)\cdot\sigma_v^4\cdot\sigma_P^2+(3\cdot\mu_P\cdot\sigma_v^2+\mu_T\cdot\sigma_\theta^2)\cdot\sigma_\theta^4\cdot\sigma_T^2)^2} < 0. \tag{76}$$

Thus, the right-hand side of (75) is strictly increasing in σ_T^2. The left-hand side of (75) is strictly decreasing as shown in Lemma 2. As a consequence, condition (75) is fulfilled for a larger set of parameters if σ_T^2 decreases. Moreover, it is easy to see that $\lim_{\sigma_T^2\to\infty}\beta_P = 0$ while $\lim_{\sigma_T^2\to\infty}(1-H_\eta) > 0$. This proves the existence of $\overline{\sigma}_T^2 \geq 0$ such that the expected reporting bias is decreasing in σ_η^2 for $\sigma_T^2 < \overline{\sigma}_T^2$. □

Proof of Corollary 5

According to equation (12) the slope of the expected reporting bias in talent uncertainty depends on the derivatives of both markets' ERCs. A negative slope of $E[\tilde{b}]$ therefore requires that $d\beta_P/d\sigma_\theta^2$ or $d\beta_T/d\sigma_\theta^2$ have negative sign. According to Proposition 4 we have $d\beta_T/d\sigma_\theta^2 > 0$. Any decrease of the expected reporting bias in talent uncertainty therefore arises from a declining ERC in the capital market. We can therefore restrict our analysis to the case $d\beta_P/d\sigma_\theta^2 < 0$. According to Proposition 5, we have

$$\frac{d\beta_P}{d\sigma_\theta^2} < 0 \quad\Leftrightarrow\quad \left(\sigma_T^2 - 3\cdot\sigma_P^2 > 0 \quad\wedge\quad \sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \overline{\sigma}_\theta^2]\right). \tag{77}$$

If this condition holds, the derivative $dE[\tilde{b}]/d\sigma_\theta^2$ according to equation (12) is negative for sufficiently low values of μ_T that fall below a threshold value $\overline{\mu}_T$. This proves the first part of the proposition.

As shown in Proposition 5, the condition (77) holds for a wider range of parameters if σ_T^2 increases. Substituting (67) into (54) and (56) yields:

$$\frac{d\beta_P}{d\sigma_\theta^2} = \frac{\sigma_v^4\cdot\sigma_P^2-(2\cdot\sigma_\eta^2-\sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2}{(\sigma_v^4\cdot\sigma_P^2+\sigma_\theta^4\cdot\sigma_T^2)\cdot\sigma_v^2}\cdot\frac{(1-\beta_P)\cdot\beta_P}{3-2\cdot\beta_P}, \tag{78}$$

$$\frac{d\beta_T}{d\sigma_\theta^2}=\frac{(3\cdot\sigma_\eta^2+\sigma_\theta^2)\cdot\sigma_v^2\cdot\sigma_P^2+\sigma_\theta^4\cdot\sigma_T^2-((2\cdot\sigma_\eta^2+\sigma_\theta^2)\cdot\sigma_v^4\cdot\sigma_P^2+\sigma_\theta^6\cdot\sigma_T^2)\cdot\frac{\beta_T}{\sigma_\theta^2}}{(\sigma_v^4\cdot\sigma_P^2+\sigma_\theta^4\cdot\sigma_T^2)\cdot(3\cdot\sigma_\theta^2-2\cdot\sigma_v^2\cdot\beta_T)}\cdot\beta_T. \tag{79}$$

Thus, $d\beta_P/d\sigma_\theta^2 < 0$ requires that

$$\sigma_v^4\cdot\sigma_P^2-(2\cdot\sigma_\eta^2-\sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2 < 0. \tag{80}$$

Using Corollary 2, we can relate the derivatives $d\beta_P/d\sigma_\theta^2$ and $d\beta_T/d\sigma_\theta^2$:

$$\frac{d\beta_T}{d\sigma_\theta^2} = \frac{\sigma_\eta^2 \cdot \beta_P}{\sigma_v^4 \cdot (3 - 2 \cdot \beta_P)} - \frac{(2 \cdot \sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_v^2 \cdot \sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2} \cdot \sigma_T^2}{(2 \cdot \sigma_\eta^2 - \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_T^2 - \sigma_v^4 \cdot \sigma_P^2} \cdot \frac{d\beta_P}{d\sigma_\theta^2}. \tag{81}$$

Using this result, we obtain

$$\begin{aligned} \frac{dE[\tilde{b}]}{d\sigma_\theta^2} &= \mu_P \cdot \frac{d\beta_P}{d\sigma_\theta^2} + \mu_T \cdot \frac{d\beta_T}{d\sigma_\theta^2} \\ &= \frac{\mu_T \cdot \sigma_\eta^2 \cdot \beta_P}{\sigma_v^4 \cdot (3 - 2 \cdot \beta_P)} + \left(\mu_P - \mu_T \cdot \frac{(2 \cdot \sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_v^2 \cdot \sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2} \cdot \sigma_T^2}{(2 \cdot \sigma_\eta^2 - \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_T^2 - \sigma_v^4 \cdot \sigma_P^2} \right) \cdot \frac{d\beta_P}{d\sigma_\theta^2}. \end{aligned} \tag{82}$$

Substituting $d\beta_P/d\sigma_\theta^2$ yields

$$\begin{aligned} &\frac{dE[\tilde{b}]}{d\sigma_\theta^2} < 0 \\ \Leftrightarrow \quad & \beta_P < 1 - \frac{\mu_T \cdot \frac{\sigma_\eta^2}{\sigma_v^2} \cdot (\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{\underbrace{\mu_P \cdot ((2 \cdot \sigma_\eta^2 - \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_T^2 - \sigma_v^4 \cdot \sigma_P^2) - \mu_T \cdot ((2 \cdot \sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_v^2 \cdot \sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2} \cdot \sigma_T^2)}_{=H_\theta}}. \end{aligned} \tag{83}$$

It is easy to verify that $dH_\theta/d\sigma_T^2 < 0$. At the same time β_P is strictly decreasing in σ_T^2 (see Lemma 2). Thus, the expected reporting bias is decreasing for a larger set of parameters if σ_T^2 increases or μ_T decreases. □

Proof of Lemma 5

Following the procedure of Proposition 1 with the modified cost function (2), we establish the equilibrium conditions stated in the lemma. □

Proof of Proposition 6

A comparison of the capital market ERCs according to Proposition 1 and Lemma 5 shows that the ERC with modified reporting objective corresponds to the ERC in our main model when there is no uncertainty about managerial talent, i.e., $\beta_P^\dagger = \beta_P|_{\sigma_\theta^2=0}$. It is therefore sufficient to study under which conditions the capital market ERC β_P in our main model falls below its level without talent uncertainty, $\beta_P < \beta_P|_{\sigma_\theta^2=0}$.

For this purpose, it is useful to refer to the explicit solution of β_P. Applying Cardano's formula to the polynomial equation (38) yields the following unique real root:

$$\beta_P = \sqrt[3]{A} \cdot \left(\sqrt[3]{\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} + \sqrt[3]{\frac{1}{2} - \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} \right) \tag{84}$$

with $A = \frac{(\sigma_\eta^2 + \sigma_\theta^2)^3}{(\sigma_\eta^2+\sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}$. It is easy to see, that β_P is increasing in A. We therefore have

$$\beta_P < \beta_P|_{\sigma_\theta^2=0} \quad \Leftrightarrow \quad A < A|_{\sigma_\theta^2=0} \quad \Leftrightarrow \quad \sigma_L^2 \leq \sigma_\theta^2 \leq \sigma_H^2 \tag{85}$$

with $\sigma_L^2 \equiv \frac{\sigma_T^2 - 2\cdot\sigma_P^2 + \sqrt{(\sigma_T^2 - 4\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2} \cdot \frac{\sigma_\eta^2}{2}$ and $\sigma_H^2 \equiv \frac{\sigma_T^2 - 2\cdot\sigma_P^2 - \sqrt{(\sigma_T^2 - 4\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2} \cdot \frac{\sigma_\eta^2}{2}$. This proves the first part of the proposition. With the modified reporting objective, value relevance $\beta_P^\dagger$ and price efficiency $\Pi_P^\dagger$ are not identical:

$$\Pi_P^\dagger = \frac{Cov[\tilde{v}, \tilde{P}^\dagger]^2}{Var[\tilde{v}] \cdot Var[\tilde{P}^\dagger]} = \frac{\sigma_\eta^2}{\sigma_v^2} \cdot \beta_P^\dagger. \tag{86}$$

For the second part of the proposition, we must study the following condition:

$$\Pi_P < \Pi_P^\dagger \quad \Leftrightarrow \quad \beta_P < \frac{\sigma_\eta^2}{\sigma_v^2} \cdot \beta_P^\dagger. \tag{87}$$

As $\sigma_\eta^2/\sigma_v^2 \leq 1$, this condition cannot be satisfied for $\sigma_\theta^2 \leq \sigma_L^2$ or $\sigma_\theta^2 \geq \sigma_H^2$. Proposition 5 shows that β_P has a local minimum in $\overline{\sigma}_\theta^2 \in [\sigma_L^2, \sigma_H^2]$. The corresponding value of A is

$$A|_{\sigma_\theta^2 = \overline{\sigma}_\theta^2} = \frac{(\sigma_\eta^2 + \overline{\sigma}_\theta^2)^3}{2 \cdot \overline{\sigma}_\theta^2 \cdot \sigma_T^2 \cdot \sigma_\eta^2}. \tag{88}$$

We have already established that $\lim_{\sigma_T^2 \to \infty} \overline{\sigma}_\theta^2 = 2 \cdot \sigma_\eta^2$ and thus $\lim_{\sigma_T^2 \to \infty} A|_{\sigma_\theta^2 = \overline{\sigma}_\eta^2} = 0$. As a consequence, we have

$$\lim_{\sigma_T^2 \to \infty} \beta_P = \lim_{A \to 0} \beta_P = 0. \tag{89}$$

On the other hand,

$$\lim_{\sigma_T^2 \to \infty} \frac{\sigma_\eta^2}{\sigma_\eta^2 + \overline{\sigma}_\theta^2} \cdot \beta_P^\dagger = \frac{1}{3} \cdot \beta_P|_{\sigma_\theta^2 = 0} > 0. \tag{90}$$

To see this, note that $\beta_P^\dagger = \beta_P|_{\sigma_\theta^2=0}$ is independent of σ_T^2 and $A|_{\sigma_\theta^2=0} > 0$. As a consequence, condition (87) is satisfied for $\sigma_\theta^2 = \overline{\sigma}_\theta^2$ if σ_T^2 is large enough. Due to continuity, this is true within a neighborhood $[\sigma_l^2, \sigma_h^2] \subset [\sigma_L^2, \sigma_H^2]$ of $\overline{\sigma}_\theta^2$. □

Proof of Proposition 7

Following the procedure used in the proof of Proposition 1, we establish the equilibrium ERCs according to equation (15). Using these implicit characterizations, we use Cardano's formula to find the explicit solution of β_P:

$$\beta_P = \sqrt[3]{A} \cdot \left(\sqrt[3]{\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} + \sqrt[3]{\frac{1}{2} - \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} \right) \tag{91}$$

with $A = \frac{(\sigma_\eta^2+\sigma_\theta^2+2\cdot\rho\cdot\sigma_\eta\cdot\sigma_\theta)^3}{\sigma_P^2\cdot(\sigma_\eta^2+\sigma_\theta^2+2\cdot\rho\cdot\sigma_\eta\cdot\sigma_\theta)^2+(\sigma_\theta^2+\rho\cdot\sigma_\eta\cdot\sigma_\theta)^2\cdot\sigma_T^2}$. It is easy to see that β_P is strictly increasing in A. Moreover,

$$\frac{dA}{d\rho} \leq 0 \quad \Leftrightarrow \quad \rho \in [\underline{\rho}, \overline{\rho}] \tag{92}$$

with $\underline{\rho} = \underline{\alpha} \cdot \frac{\sigma_\eta}{\sigma_\theta} - (1 + \underline{\alpha}) \cdot \frac{\sigma_\theta}{\sigma_\eta}$, $\overline{\rho} = \overline{\alpha} \cdot \frac{\sigma_\eta}{\sigma_\theta} - (1 + \overline{\alpha}) \cdot \frac{\sigma_\theta}{\sigma_\eta}$,
$\underline{\alpha} = \frac{\sigma_T^2-4\cdot\sigma_P^2-\sqrt{(\sigma_T^2-12\cdot\sigma_P^2)\cdot\sigma_T^2}}{2\cdot(4\cdot\sigma_P^2+\sigma_T^2)}$, $\overline{\alpha} = \frac{\sigma_T^2-4\cdot\sigma_P^2+\sqrt{(\sigma_T^2-12\cdot\sigma_P^2)\cdot\sigma_T^2}}{2\cdot(4\cdot\sigma_P^2+\sigma_T^2)}$.

A prerequisite for the existence of the interval $[\underline{\rho}, \overline{\rho}]$ is that $\sigma_T^2 > 12 \cdot \sigma_P^2$. For $\sigma_\theta^2 < \sigma_\eta^2$, we have $d\underline{\rho}/d\underline{\alpha}$, $d\overline{\rho}/d\overline{\alpha} > 0$ and

$$\frac{d\underline{\alpha}}{d\sigma_T^2} = -\frac{(\sigma_T^2 - 12 \cdot \sigma_P^2) + 4 \cdot (\sigma_T^2 - \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2})}{(4 \cdot \sigma_P^2 + \sigma_T^2)^2 \cdot \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2}} \cdot \sigma_P^2 < 0, \tag{93}$$

$$\frac{d\overline{\alpha}}{d\sigma_T^2} = \frac{1}{2} \cdot \frac{8 + \frac{10\cdot\sigma_T^2-24\cdot\sigma_P^2}{\sqrt{(\sigma_T^2-12\cdot\sigma_P^2)\cdot\sigma_T^2}}}{(4 \cdot \sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_P^2 > 0. \tag{94}$$

As a consequence, $\underline{\rho}$ is decreasing and $\overline{\rho}$ is increasing in σ_T^2. Moreover:

$$\lim_{\sigma_T^2\to\infty} \underline{\rho} = -\frac{\sigma_\theta}{\sigma_\eta} < 0, \quad \lim_{\sigma_T^2\to\infty} \overline{\rho} = \frac{\sigma_\eta^2 - 2 \cdot \sigma_\theta^2}{\sigma_\eta \cdot \sigma_\theta}, \quad \lim_{\sigma_T^2\to 12\cdot\sigma_P^2} \underline{\rho} = \lim_{\sigma_T^2\to 12\cdot\sigma_P^2} \overline{\rho} = \frac{\sigma_\eta^2 - 5 \cdot \sigma_\theta^2}{4 \cdot \sigma_\eta \cdot \sigma_\theta}. \tag{95}$$

For $5 \cdot \sigma_\theta^2 < \sigma_\eta^2 < 25 \cdot \sigma_\theta^2$, we have $\lim_{\sigma_T^2 \to \infty} \overline{\rho} > 1$ and $0 < \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \underline{\rho} = \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \overline{\rho} < 1$, which completes the proof. □

Proof of Lemma 6

The proof is analogous to the proof of Proposition 1. □

Proof of Corollary 6

Rearranging equation (18) for the equilibrium ERC β_0 yields:

$$F_0 \equiv \left(\sum_{a \in A} \gamma^{(a0)2} \cdot \sigma_a^2 \right) \cdot \beta_0^3 + \sigma_v^2 \cdot (\beta_0 - 1) = 0 \tag{96}$$

Note that F_0 is increasing in β_0. Its slope depends on the sum $\sum_{s \in A} \gamma^{(s0)2} \cdot \sigma_s^2$. Raising the number of reporting users from $n+1$ to $n+2$ increases this sum by $\gamma^{(n+1,0)2} \cdot \sigma_{n+1}^2$. Similarly, $\sum_{s \in A} \gamma^{(s0)2} \cdot \sigma_s^2$ takes higher values if a reporting user $a \in A/\{0\}$ changes his objective such that the new objective is associated with higher (relative) uncertainty, $\gamma^{(a0)} = Var[\tilde{v}_a]/\sigma_v^2$. In both cases, equation (96) is satisfied by a lower level of β_0. □

Proof of Proposition 8

We use the implicit function theorem to show comparative static results of β_0 with regard to σ_M^2, $M \in \mathfrak{P}(A)$. Using the implicit characterization of β_0 according to (96), we can conclude that

$$\frac{d\beta_0}{d\sigma_M^2} = -\frac{\partial F_0 / \partial \sigma_M^2}{\partial F_0 / \partial \beta_0} = \frac{\sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2}{\left(\sum_{a \in A} \gamma^{(a0)2} \cdot \sigma_a^2 \right) \cdot \sigma_v^2} \cdot \frac{(1 - \beta_0) \cdot \beta_0}{3 - 2 \cdot \beta_0} . \tag{97}$$

Because $\beta_0 < 1$, we can conclude that

$$sgn\left(d\beta_0 / d\sigma_M^2\right) = sgn\left(\sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2 \right). \tag{98}$$

This sign can only be negative if $\gamma^{(a0)} < 2/3$ for at least one $a \in M$, i.e., $A_M \neq \emptyset$. Then, the expression on the right-hand side becomes negative if and only if

$$\sum_{a \in A_M} -(3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2 > \sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M/A_M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2. \quad (99)$$

□