

Information disclosure quality - correlation vs precision

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Abstract

We investigate how a multi-dimensional disclosure quality (i.e., correlation and precision) determines an optimal information disclosure strategy. We find that, for an infinitely-lived, unlevered firm with market perfection, a truth-telling disclosure is optimal at increasing the expected firm value. However, for a finitely-lived, levered firm in the presence of market imperfections (e.g., bankruptcy cost), the optimal disclosure quality depends negatively on the level of imperfections. Once we consider the agency problem, such dependence can become positive, thereby highlighting the importance of a proper managerial-incentive scheme to align the information-disclosure interests of managers and shareholders.

1. Introduction

This study is the first to propose an information disclosure principle aligned with bankruptcy cost and, furthermore, to investigate how conflicting concerns affect the disclosure strategy decisions of managers. The theoretical framework proposed in this paper can be modified or extended easily to consider other forms of market imperfection, such as the availability of tax shields, transaction costs, etc. These important problems have been overlooked because the standard disclosure-quality measure (i.e., the variance of announcement noise) commonly used in the literature was set to be univariate (see Diamond and Verrecchia 1991; Artiach and Clarkson 2011; Johnstone 2015a, 2015b). The concept of disclosure quality is too rich to be captured by a single dimension; if an essential dimension is omitted, the oversimplified disclosure-quality measure is not capable of identifying many interesting aspects of the disclosure.¹

This study completes the standard disclosure quality measure by introducing an extra dimension, which we call disclosure correlation. Standard disclosure quality literature is based on the intuitive principle that the lower the announcement noise variance, the better the disclosure quality. We show that this principle is of limited value if the correlation between payoff shock and announcement noise is non-zero.² As both payoff shock and announcement noise are unobservable to investors and under the control of the firm (i.e., able to be manipulated), the firm can explore ways of using this correlation to enhance (expected) firm

¹ In the language of information science, information quality denotes how information is perceived and used by its users (see Wang and Strong, 1996). Our setting deals with information asymmetry that exists between the firm and investors but not between investors, allowing us to use the terms “information quality” and “disclosure quality” interchangeably. See footnote 6 for more information on this issue.

² See Section 3 (especially, equations (1), (3) and (5)) for a formal definition of payoff shock, announcement noise variance and disclosure correlation.

value. The firm can make a disclosure on payoff in such a way that the disclosure is still information-revealing despite the fact that its announcement noise is not information-revealing. The trick is to correlate announcement noise with payoff shock. Smart investors, by using a simple regression technique with historical data, can gauge the correlation and use it to understand the quality of the disclosure and incorporate the information into their investment decisions which, in turn, will be reflected in the (higher) share price that the firm would like to see ultimately. This correlation opens up a new approach to understanding disclosure quality and information disclosure: in particular, one may consider not only announcement noise variance (precision) but also disclosure correlation when determining optimal disclosure policy.³

A parallel analogy can be drawn with respect to the capital asset pricing model (CAPM). The CAPM implies that it is the systematic risk inherent in an investment that determines the market risk premium, rather than the total risk. Hence, to the extent that the systematic risk of a disclosure is important for determining the information risk premium, the systematic risk depends on disclosure correlation, because it is, by construction, the product of disclosure correlation, standard deviation of announcement noise, and standard deviation of payoff shock.⁴ Therefore, the appearance of disclosure correlation in the information risk premium,

³ We apply the standard assumption that the firm's payoff shock and its corresponding announcement error are bivariate normal. Due to the fact that bivariate normal distribution is completely determined by the means, the variances, and the correlation, introducing the disclosure correlation will complete the standard disclosure quality measure.

⁴ The systematic market risk is the product of the correlation between market excess return and stock excess return, standard deviation of market excess return, and standard deviation of stock excess return. By analogy, we formulate the systematic risk of disclosure as above.

indicates that the innovation of introducing disclosure correlation to the disclosure quality measure is far more than a narrow extension. Instead, it has profound economic significance.

The idea of using information from correlation and precision underlies the following disclosure principle: for an infinitely-lived, unlevered firm with market perfection, a truth-telling disclosure is optimal in maximizing the expected firm value; however, for a finitely-lived, levered firm in the presence of market imperfections (e.g., bankruptcy cost), the optimal disclosure quality depends negatively on the level of imperfections. Once we consider the agency problem, such dependence can become positive, thereby highlighting the importance of a proper managerial-incentive scheme to align the information-disclosure interests of managers and shareholders.

This paper makes several contributions. First, it addresses the completeness of the disclosure measure and introduces the correlation dimension, generalizing results in the existing literature in the sense that their main findings can be derived from our model as a special case by setting the correlation to zero. Second, it extends the existing literature, e.g., Clinch (2013), with market imperfection considerations e.g., bankruptcy cost, making our application more general and closer to reality. Third, our comparative static analysis reveals the key determinants of an information disclosure strategy, and provides insights enabling firms to make suitable disclosure decisions. Fourth, this research discusses the impact of managerial incentives on management forecast decisions, i.e., how various levels of disclosure quality relate back to the managerial incentives driving them.

The paper is organized as follows. Section 2 depicts the disclosure procedure and clarifies several concerns regarding the basic setup of our model. Section 3 studies the optimal disclosure strategy for an infinitely-lived, unlevered firm with market perfection. Section 4 extends the focus onto a finitely-lived, levered firm with market imperfections. Section 5

discusses the impacts of managerial incentives on management forecast decisions. Section 6 concludes.

2. Disclosure procedure and cost of misrepresentation

We consider voluntary information disclosure as an infinitely repeated game between a single firm and many investors. The sequence of actions is as follows: The firm has the first-mover advantage to reveal information for its own benefit by choosing an optimal disclosure strategy (i.e., correlation and precision) to maximize the expected firm value at the beginning of the ‘game’. The firm then makes a payoff forecast announcement following the same strategy and decides the dividend for the next period. Meanwhile the investors observe the current dividend and the forecast. However the current payoff is unobservable to them, and they have to wait until the next period during which the actual dividend is made known to them, to be able to figure out the payoff as well as the announcement noise of this period ex post. Then the game repeats itself infinitely. Although the investors can choose to liquidate their positions by transferring their shares to the next generation of investors at the end of each period, the next generation is able to acquire all the historical information related to the firm, from which they can infer the information disclosure strategy of the firm and check its stability.

Before we proceed to discuss the model setup, we clarify a few general issues with the model setup: Why is the firm’s disclosure strategy supposed to be time-invariant? Is there any cost that comes with misrepresentation? Why is it a cost? And why is this cost appropriate?

First, a time-dependent disclosure will make investors lose interest in investing in the firm’s stock due to high research cost. Even if investors are still willing to invest, they might, due to the complexity of the forecast, extract information different from what the firm initially expects them to get. In other words, those investors who are accustomed to counting on the forecast find that they no longer make an informed decision based on the forecast. Once the firm’s forecast loses its signalling power, it takes time for the firm to restore its credibility over

information disclosure. Therefore, it is reasonable for the firm to initiate time-invariant disclosure strategies.

Second, the cost of misrepresentation may be explicit or implicit. For example, an explicit cost can be incurred whenever the firm makes some costly effort to be perceived as creditworthy and to conceal poor performance. An explicit cost can be represented as an explicit cost function, which modifies and becomes part of the firm's objective of disclosure optimization. However, the cost of misrepresentation within the scope of this research is an implicit one. It affects the development of the model and its occurrence will change the whole model structure. In particular, when realising ex post that a firm has given false or misleading information, investors may question its creditworthiness. As a result, they will put less weight on a forecast from a firm that has low credibility. Assuming a linear relationship between historical realised payoffs and the corresponding forecasts, then investors can exploit such a relationship and use the new firm announcement to extrapolate their own forecast, which, in turn, will eventually be reflected in the spot share price. We argue that when there is a firm misrepresentation problem, the share price is subject not only to the market risk but also to information risk, with the level of risk premiums being commensurate with the risks involved. Therefore, a less credible disclosure will widen the confidence interval of the investors' forecast, resulting in a higher risk premium and, thus, a higher cost of capital when valuing the share price. Therefore, for a given market risk, the cost of capital may be viewed as a proxy for the cost of misrepresentation.

Third, as long as the disclosure strategy initiated by the firm is time-invariant, misrepresentation brings more assurance to the firm regarding the share price at the beginning. This is because the information perceived by the investor will be quickly impounded into the share price, and the firm, as a first-mover, can guide the investors' perceptions in order to avoid large share price fluctuations. When market imperfection, e.g., bankruptcy cost, presents, such

“risk reduction” effects will effectively prevent the firm from going bankrupt (hence save bankruptcy costs) and, accordingly, increase the expected firm value. In this sense the cost of misrepresentation is appropriate (i.e., justifiable)

3. Information disclosure in perfectly competitive market

3.1. Model assumptions

We make the following assumptions: (A.1) the market is perfectly competitive, without any taxes, transaction costs, bankruptcy costs, contracting costs, or liquidity problems; (A.2) the firm is unlevered, lasts for an infinite period, and does not retain payoff but distributes essentially all its realized income and capital gains at the end of each period;⁵ (A.3) there are n identical, price-taking investors, each of whom holds a negative exponential utility with a risk aversion coefficient, a ; (A.4) the investors exist for only one single period, at the end of which they liquidate their positions by transferring their shares to the next generation of investors and consume the proceeds, which comprise the selling price and dividends; (A.5) information asymmetry exists between the firm and the investors, but not between the investors.⁶

Based on the above assumptions, we consider the following model setting:

$$x_t = x_{t-1} + \varepsilon_t, \quad t = 1, 2, \dots, \quad (1)$$

⁵ If the payoff for a certain period is negative, the firm raises additional capital through a rights issue. If we normalize the supply of the firm’s security to a constant one over time, then the rights issue results in negative dividend payments. Such a “closed-end” characteristic implies a zero plow-back ratio, and further suggests zero growth rates associated with payoff and dividends.

⁶ See Lambert *et al.*, (2012), and Tang (2014) on how information asymmetry between investors affects firm share price. With this assumption, we can use the terms “information quality” and “disclosure quality” interchangeably.

where x_t represents the payoff the firm receives at time t , and ε_t are independent and identically distributed (iid) payoff shocks, with normal distribution, $N(0, \sigma_\varepsilon^2)$. According to assumption (A.2), $\forall t = 1, 2, \dots$, $x_t = z_{t+1}$ and $\varepsilon_t = \varepsilon_{t+1}$ hold, and

$$z_{t+1} = z_t + \varepsilon_{t+1}, \quad t = 1, 2, \dots, \quad (2)$$

where z_t represents the dividend the firm distributed at time t , and ε_t are iid dividend shocks, with normal distribution, $N(0, \sigma_\varepsilon^2)$, and obviously $\sigma_\varepsilon^2 = \sigma_\varepsilon^2$. Eq. (1) implies that the payoff can be described as a random walk process, capturing the idea that changes in payoff are unpredictable. The firm's disclosure can be described as

$$y_t = z_{t+1} + e_t = x_t + e_t, \quad t = 0, 1, 2, \dots, \quad (3)$$

where y_t represents the firm's announcement made public at time t . Eq. (3) decomposes the announcement into two components: the actual dividend of the next period z_{t+1} (or, equivalently, the current payoff x_t) and the announcement noise e_t with normal distribution $N(0, \sigma_e^2)$. By substituting x_t from Eq. (1) into Eq. (3), we get

$$y_t = x_{t-1} + \varepsilon_t + e_t, \quad t = 0, 1, 2, \dots, \quad (4)$$

Eq. (4), which shows that the firm's disclosure can be further decomposed into three components: the historical payoff x_{t-1} , the payoff shock, ε_t and the announcement noise, e_t .

3.2. Disclosure and share price

To account for the possible relationship between the noise e_t and the payoff shock ε_t , we set the following Cholesky-decomposition form of e_t :

$$e_t = \frac{\sigma_e}{\sigma_\varepsilon} (\rho \varepsilon_t + \sqrt{1 - \rho^2} \xi_t), \quad (5)$$

where ξ_t is normally distributed with a mean of zero and variance, σ_ε^2 . ξ_t is independent of ε_t , and ξ_t is independent over time. This construction ensures that the correlation between e_t and

ε_t is ρ , and the standard deviation of e_t is σ_e . We define ρ as disclosure correlation to capture the (linear) relationship between the announcement noise and the payoff shock.⁷

Following Clinch (2013)'s approach, we obtain the share pricing directly Eq. (6),

$$P_t = \frac{1}{1+r} \left[\mathbb{E}_t(P_{t+1} + z_{t+1}) - \frac{\alpha}{n} \text{Var}_t(P_{t+1} + z_{t+1}) \right], \quad (6)$$

where r denotes the risk-free rate. The equation suggests that the current share price is the risk adjusted expectation of the future cash flow, where we interpret the second term of the right hand side of Eq. (4) loosely as the discount for the risk premium perceived by the investors, and view it as a measure of the cost of capital. This measure is inversely related to the share price, and affected by two terms: the market appetite for risk (α/n), which is represented as the investors' risk aversion α shared by all market participants n , and the market assessed risk, $\text{Var}_t(P_{t+1} + z_{t+1})$.

To forecast z_{t+1} , the investors form conditional expectations by making a projection of the observed actual dividend at time $t + 1$, z_{t+1} , on the firm's management forecast y_t :

$$z_{t+1} = \kappa + by_t + u_{t+1}, \quad (7)$$

where u_{t+1} is independent of y_t , and it is the investors' estimation error.

Clinch (2013) is a special case of the above model. He assumed that e_t and ε_t are independent, and allowed the firm to choose only σ_e^2 optimally, while we allow the firm to choose, not just σ_e^2 , but also ρ . The firm is fully aware of the following two facts: first, the investors will form their expectation of the future payoff based on the firm's management forecast; second, the share price P_t will be determined accordingly. In a perfect market, the firm value per share of an unlevered firm equals the share price. Then, maximizing the expected share price by choosing the optimal disclosure correlation (ρ) and precision (σ_e) at the

⁷ To understand the intuitive and economic meaning of the disclosure correlation, see the second and third paragraphs of the Introduction.

beginning, is the crux of the problem firm want to solve.

3.3. Optimal information disclosure strategy

In this subsection, we first derive the share price formation process (i.e., the pricing equation) for a given information disclosure strategy (ρ, σ_e) from the investors' perspective. Given the pricing equation, we then develop an optimal information disclosure strategy from the firm's perspective and summarize the result in Theorem 1.

Theorem 1. In the presence of information disclosure, the general pricing formula is

$$P_t = \frac{1}{r} \left[x_{t-1} + b_*(y_t - x_{t-1}) - \frac{\alpha}{n} s_*^2 \right], \quad (8)$$

where $b_* = (\sigma_\varepsilon^2 + \rho\sigma_\varepsilon\sigma_e)/(\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho\sigma_\varepsilon\sigma_e)$, and $s_*^2 = \frac{1}{r^2} \{ (1+r)^2 \sigma_\varepsilon^2 - [(1+r)^2 - 1] b_*(\sigma_\varepsilon^2 + \rho\sigma_\varepsilon\sigma_e) \}$. Under the assumptions (A.1) to (A.4), $(\rho^*, \sigma_e^*) \equiv \underset{(\rho, \sigma_e)}{\operatorname{argmax}} \mathbb{E}(P_t)$, and

$$(|\rho^*| - 1)\sigma_e^* = 0.$$

For proof, see Appendix A.

Theorem 1 suggests that in a perfect market, a truth-telling disclosure strategy (i.e., $\rho = \pm 1$ or $\sigma_e = 0$) is optimal. When $\rho = \pm 1$, the precision of the signal σ_e does not enter into the pricing formula. This result is in sharp contrast with the result of Clinch (2013) where the quality of the signal σ_e has an important role to play in determining the optimal information disclosure strategy. The implication of Theorem 1 is consistent with the empirical evidence on the relationship between management earnings forecasts and the cost of capital, which generally finds that disclosure precision does not affect the cost of capital (Kim and Shi, 2011; Baginski and Rakow, 2012; Larocque *et al.*, 2013).

Theorem 1 provides an ideal benchmark for evaluating the quality of a particular disclosure. In reality, other institutional and behavioral factors such as, agency costs, market liquidity, spillover effects, etc. (see, for examples, Diamond and Verrecchia, 1991; Lang and Lundholm, 1993; Boot and Thakor, 2001; Healy and Palepu, 2001; Hermalin and Weisbach,

2012), may move this optimal correlation away from a positive one. In view of this, Section 4 studies how the disclosure decision may be affected by market imperfections.

4. Information disclosure in presence of market imperfections

In this section, we investigate the situation where weakening disclosure quality can be optimal, depending on the level of market imperfection. That may shed light on understanding the puzzle that, in practice, the firm will be truth-telling if it is a ‘good news’ and will conceal the information or fool the market if it is a ‘bad news’, even if misrepresentation comes with the implicit cost discussed in Section 2. For illustration, we use bankruptcy cost as a form of market imperfection due to its great relevance and significance. We show that in the presence of bankruptcy cost, the firm’s optimal disclosure substantially changes (i.e., relevance), and the change is entirely opposite (i.e., significance).

We replace the first three assumptions about the market and the firm in Section 3 with the following three assumptions: B.1) the market is perfectly competitive, without any taxes, transaction costs, contracting costs and liquidity problems, but a bankruptcy cost applies; B.2) the firm is levered and finitely-lived until bankruptcy, and does not retain payoffs, but distributes all of their realized income and capital gains at the end of each period. We carry over assumptions (B.3) to (B.4) directly from (A.3) to (A.4).

4.1. “Risk reduction” effect

It is noteworthy that under assumptions (A.1) to (A.4), in a perfect market, the objectives of maximizing the expected firm value and maximizing the expected share price are consistent. However, with the set of relaxed assumptions (B.1) to (B.4) in place, these two objectives may diverge, because the firm value is now the sum of the market value of equity and debt, with the latter being exposed to bankruptcy cost. The well-known Modigliani-Miller proposition of hedging, suggests that leveraged firms benefit from reducing their risk in the presence of market imperfections, and that such benefits become zero when the market is perfect (see

Tufano, 1998; Graham and Rogers, 2002). In this case, reducing the variance of share price will effectively prevent the firm from going bankrupt, so as to save bankruptcy cost and add value to the firm accordingly. Corollary 1 implies that lowering disclosure quality can reduce the variance of share price. In a broad sense, we call it a “risk reduction” effect.

Corollary 1. $\forall \rho > 0, \partial \text{Var}(P_t) / \partial \rho > 0$; if $\rho = 0$ and σ_e is extreme large (very big noise), then $\text{Var}(P_t) = 0$.

For proof, see Appendix B.

The implication of Theorem 1 and Corollary 1 is clear: Although a perfect correlation between the payoff shock and the announcement noise maximizes the expected share price, it also increases share price risk. The firm now faces a trade-off and, therefore, chooses the optimal noisy disclosure strategies (ρ, σ_e) , to maximize the expected firm value.

Without loss of generality, we assume that the number of shares outstanding is 1, and we scale the firm’s current amount of exogenous liability outstanding L at any time to be \$100. Technically speaking, the firm goes bankrupt whenever the firm value falls below its liability L ⁸, therefore, the firm value per share V_t is equal to the sum of liability L and equity P_t if the firm is ongoing; otherwise it is equal to the sum of liability L net of the bankruptcy cost C , if the firm goes into bankruptcy; i.e., $V_t = L + \max(P_t, 0) - C \times 1_{\{P_t < 0\}}$, where C is proportional to L at a bankruptcy-cost-to-liability ratio c , i.e., $C = c \times L$. Bankruptcy offers the firm a chance to start afresh by forgiving any liability that simply cannot be paid. Then the firm’s optimal disclosure strategy is implied in Theorem 2.

Theorem 2. Under the assumptions (B.1) to (B.4), define $(\rho^*, \sigma_e^*) \equiv \underset{(\rho, \sigma_e)}{\text{argmax}} \mathbb{E}(V_t)$, st: $V_t =$

$L + \max(P_t, 0) - C \times 1_{\{P_t < 0\}}$, where P_t is given as Eq. (8), then $(\rho^*, \sigma_e^*) \in [-1, 1] \times [0, \infty)$ maximize

⁸ Or equivalently, whenever share price P_t turns into negative.

$$\mathbb{E}(V_t) = L + S - B \quad (9)$$

where

$$\begin{aligned} S &\equiv S_1 1_{\{\mathcal{V}(\rho, \sigma_e) > 0\}} + S_2 1_{\{\mathcal{V}(\rho, \sigma_e) < 0\}} + S_3 1_{\{\mathcal{V}(\rho, \sigma_e) = 0\}}; \\ B &\equiv B_1 1_{\{\mathcal{V}(\rho, \sigma_e) > 0\}} + B_2 1_{\{\mathcal{V}(\rho, \sigma_e) < 0\}} + B_3 1_{\{\mathcal{V}(\rho, \sigma_e) = 0\}}; \\ S_1 &\equiv \mathcal{M}(\rho, \sigma_e) [1 - \Phi(d(\rho, \sigma_e))] - \mathcal{V}(\rho, \sigma_e) \Psi(d(\rho, \sigma_e)); \\ S_2 &\equiv \mathcal{M}(\rho, \sigma_e) \Phi(d(\rho, \sigma_e)) + \mathcal{V}(\rho, \sigma_e) \times \Psi(d(\rho, \sigma_e)); \\ S_3 &\equiv \mathcal{M}(\rho, \sigma_e) 1_{\{\mathcal{M}(\rho, \sigma_e) > 0\}}; \\ B_1 &\equiv cL \times \Phi(d(\rho, \sigma_e)); \\ B_2 &\equiv cL \times (1 - \Phi(d(\rho, \sigma_e))); \\ B_3 &\equiv cL 1_{\{\mathcal{M}(\rho, \sigma_e) \leq 0\}}; \end{aligned}$$

and

$$\begin{aligned} \mathcal{M}(\rho, \sigma_e) &\equiv \frac{1}{r} \left(x_{t-1} - \frac{\alpha}{n} \frac{1}{r^2} \left[(1+r)^2 \sigma_\varepsilon^2 - [(1+r)^2 - 1] \frac{(\sigma_\varepsilon^2 + \rho \sigma_\varepsilon \sigma_e)^2}{\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho \sigma_\varepsilon \sigma_e} \right] \right), \\ \mathcal{V}(\rho, \sigma_e) &\equiv (\sigma_\varepsilon + \rho \sigma_e) / (r \sqrt{\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho \sigma_\varepsilon \sigma_e}), \\ d(\rho, \sigma_e) &\equiv -\mathcal{M}(\rho, \sigma_e) / \mathcal{V}(\rho, \sigma_e), \\ \Phi(d(\rho, \sigma_e)) &\equiv \mathbb{P}(W_t \leq d(\rho, \sigma_e)), \\ \Psi(d(\rho, \sigma_e)) &\equiv \mathbb{E}[W_t 1_{\{W_t \leq d(\rho, \sigma_e)\}}], W_t \sim N(0, 1). \end{aligned}$$

For proof, see Appendix C.

Theorem 2 implies that expected firm value can be decomposed into three items, and they are: liability L , equity value S , and bankruptcy cost B . Each of these three terms can be further decomposed into three sub-terms. For example, as far as S is concerned, the three sub-terms are S_1 , S_2 and S_3 . These refer to three different scenarios in which the systematic risk inherent in the announcement noise $\rho \sigma_\varepsilon \sigma_e$ insufficiently, excessively or exactly offsets the total risk of payoff shock σ_ε^2 . It is noteworthy to mention that Eq. (9) is homogenous in the sense that, if

we multiply x_{t-1} , L , σ_ε by a constant, the optimal ρ remains the same, and the optimal σ_e will be multiplied by the same constant. The financial intuition is that, if we change the numeraire of x_{t-1} , L , σ_ε from dollars into cents, it shouldn't affect the optimal results of (ρ, σ_e) , but σ_e is measured in cents as well. That implies the optimal (ρ, σ_e) is actually a function of earnings-to-debt ratio x_{t-1}/L and payoff-shock-variability-to-debt ratio σ_ε /L . Even though the actual payoff and the actual payoff-shock-variability changes over time, as long as their ratios to the actual liability remain stable, the market environment is recognised as not changing and, thus, the optimal (ρ, σ_e) is time-invariant.

4.2. Numerical example

As there is no closed form solution for the optimal strategy formulated in Theorem 2, we fix x_{t-1} at two benchmark levels (low and high) to conduct a comparative static analysis in order to investigate how changes of key parameters affect the optimal disclosure strategies.

To ensure that the sets of parameters match the key characteristics of real data, we do the following. Firstly, we choose the usual market practice: a 20% bankruptcy-cost-to-liability ratio c , a 4% risk-free rate, and a payoff shock σ_ε of a quarter of the payoff x_{t-1} as our benchmark settings, as well as a typical risk aversion coefficient of 3. Secondly, to ensure that the share-holdings are relatively well dispersed and the share price changes are solely determined by market behaviour and not manipulated by large institutional investors, we set the number of market participants at 80,000. Thirdly, to ease the interpretation, we choose \$0.40 as low, and \$10 as high, payoff benchmarks to represent the two regimes respectively, i.e., the significant bankruptcy cost regime and the insignificant bankruptcy cost regime. There is no clear pattern for identifying optimal strategies whenever the payoff lies between these two regimes,

Figure 1 shows $\mathbb{E}(V_t)$ in a three-dimensional surface chart where the optimum combinations of (ρ, σ_e) can be easily identified. In comparison with the result in Section 3

where, in a perfectly competitive market, an infinitely-lived, unlevered firm should always choose a fully revealing information disclosure strategy, Figure 1 indicates that, with bankruptcy cost, the optimal disclosure policy of a finitely-lived, levered firm may be either a fully revealing one or a purely noisy one. We discuss some detailed results as follows:

Result 1: As the bankruptcy cost becomes more significant, the optimal disclosure goes from a fully transparent one (corner solution with either $\rho^* = \pm 1$ or $\sigma_e^* = 0$) to a purely noisy one ($\rho = 0$ with high σ_e^* , $\rho < 0$ with low σ_e^*). See Panel F, Figure 2.

Result 2: (See Figure 3.) With an insignificant bankruptcy cost, the optimal disclosure strategy is not sensitive to the changes of parameters ($\sigma_\varepsilon, r, \alpha, n, L, c$); otherwise, the disclosure is sensitive to the changes in most of the parameters, except α (see Figure 2).

Result 3: For the significant bankruptcy cost regime, the optimized expected firm value has inverse relationships with $\sigma_\varepsilon, r, \alpha$ and c (see Panel A, B, C, F, Figure 2), and positive relationships with n and L . (see Panel D, E, Figure 2). For the insignificant bankruptcy cost regime, the optimized expected firm value has an inverse relationship with σ_ε (see Panel A, Figure 3), and positive relationships with α, n and L . (see Panel C, D, E, Figure 3).

Result 4: For the insignificant bankruptcy cost regime, a negative misrepresentation ($0 < \rho < 1$) will hammer the firm value more severely than a positive one ($-1 < \rho < 0$) (see Figure 1(B)). As bankruptcy-cost-to-liability ratio c goes to zero (see Panel F, Figure 3), the above result holds for the perfect market scenario.

So far we assume that managerial and shareholder interests are strictly aligned. In practice, such alignment is less than perfect. A discussion about the circumstances under which various disclosure quality pairs (ρ, σ_e) might arise, with each relating back to managerial incentives, will be provided in Section 5.

5. Agency problem and management forecast decisions

According to Theorem 2, the firm's optimization problem is to find a pair of (ρ, σ_e) that maximizes expected firm value $\mathbb{E}(V_t)$, implicitly assuming that the firm is risk neutral. However, a manager is usually risk averse, and her optimization is to look for a pair of (ρ, σ_e) that can maximize the expected utility she can get from her compensation package. For simplicity, we assume that, in the package, there are restricted firm stocks only⁹. Then the optimization problem to the manager can be formulated as $\max_{(\rho, \sigma_e)} \mathbb{E}(U(\max(P_t, 0)))$, where $U(x) = \frac{1-\gamma}{\gamma} \left(\frac{ax}{1-\gamma} + b \right)^\gamma$ is an Hyperbolic absolute risk aversion (HARA) utility function, with $a > 0$ and $\frac{ax}{1-\gamma} + b > 0$.¹⁰ The absolute risk aversion $A(x) = 1/\left(\frac{x}{1-\gamma} + \frac{b}{a}\right)$ is a linear function of wealth, x . We set $\gamma = 2$, which refers to the case where a quadratic utility function with an increasing absolute risk aversion is assumed.

We find that, if the interests of firm and manager are not strictly aligned, then the manager's disclosure decision may be opposed to that of the firm. See Figure 4.A, in a significant-bankruptcy-cost setup, the manager's optimal disclosure strategy is truth-telling ($\sigma_e \cong 0$ and $\rho \cong \pm 100\%$), which is in sharp contrast to the firm's misrepresentation strategy

⁹ Although the manager's compensation package includes base salary, bonuses, equity-based incentives (such as restricted stocks and employee options) and long term incentives, it is sufficient to study the case that manager's compensation includes restricted firm stock only. First, base salary and cash bonus can be understood as a certain amount of cash and, as such, can change the magnitude, but not the direction, of the optimal disclosure strategy. In addition, options can be replicated by borrowing money to buy the stocks and, hence, including options in the compensation package is not essentially different from including stocks only.

¹⁰ As the restricted stocks are subject to the no short-selling constraint, the expected utility optimization and security price optimization are not necessarily consistent. Thus, the former optimization is more appropriate in this setting. See, e.g. Colwell *et al.*, (2015).

with the same setup in Figure 1.A. With the same setting of insignificant-bankruptcy-cost, the manager's optimal disclosure strategy is fooling the market (high σ_e and $\rho \cong -100\%$), see Figure 4.B; however, the firm optimally takes a truth-telling strategy, see Figure 1.B.

The intuitive view is that, whenever bankruptcy cost is significant (i.e., the payoff level is low compared with the level of bankruptcy cost), the firm has a motivation to misrepresent information so as to reduce the share price risk and, consequently, avoid paying the bankruptcy cost. However, the manager, in the process of maximizing her personal utility, rarely considers the extreme case of going bankrupt, as long as the firm is nowhere near it. Furthermore, as the payoff is low, the share price is low, and the manager will not benefit from the capital gain of selling the firm stock she owns, or exercising employee stock options when they are deep out-of-the-money. Hence, the manager does not have a motivation to conceal the true information or to fool the market and she, rather, chooses a truth-telling strategy to avoid any misrepresentation cost.

Whenever the bankruptcy cost is insignificant (i.e., the payoff level is high compared with the level of bankruptcy cost), the firm does not have the motivation to reduce risk through misrepresentation, as bankruptcy cost is not a concern. However, the high share price before the announcement will make the manager benefit from selling her stock or exercising in-the-money employee stock options. Hence, the manager does have the motivation to provide a rosy picture for a coming low payoff shock, which can turn the in-the-money option into an out-of-the-money one. Furthermore, as the option price is an increasing function of stock volatility, the manager also chooses to release low quality information to increase the stock volatility and to boost the option price. It is noteworthy that, although the firm normally sticks to a time-invariant disclosure strategy, the manager may make decisions over time to manipulate the forecast strategically, so that she can benefit instantly from exercising the incentivizing options, which are deep in-the-money.

The above discussion highlights the importance of developing a proper managerial incentives scheme to align the interests of managers and shareholders regarding disclosure decision-making. Although it is well known that equity-based compensation can alleviate the agency problem, those incentivizing tools function mainly to boost share price rather than firm value. Hence, those incentives cannot stop managers from “strategically” releasing information for their own benefit and, thus, deviating substantially from the firm’s optimum disclosure strategy. Actually, as we discussed previously, managers are the main culprits responsible for such conflict of interests. To develop an optimal incentives scheme that encourages managers to disclose information in accordance with firms’ optimum is the direction of our future research.

6. Conclusion

This research proposes that the concept of information disclosure quality should be extended from the current one that is confined to precision (i.e., the variance of announcement noise), to include correlation (i.e., the correlation between announcement noise and payoff shock) in determining the expected firm value. In particular, we find that a truth-telling disclosure is optimal for an infinitely-lived, unlevered firm with market perfections. The main result of Clinch (2013), that a higher disclosure precision unambiguously increases the firm’s share price, can be derived in our model as a special case by setting a zero correlation. We then extend Clinch (2013)’s result by incorporating market imperfections and firm leverage, and find that an appropriate misrepresentation creates a “risk reduction” effect by sacrificing the expected share price. Then, according to the Modigliani-Miller proposition of hedging, the disclosure optimizing the expected firm value must be a noisy one.

Our comparative static analysis reveals the key determinants of an optimal disclosure strategy and, thus, provides the insights for firms to check the conditions they may face and make the most suitable disclosure decisions. The optimal disclosure strategy with significant

bankruptcy cost is sensitive to changes in most of the parameters. This implies that an optimal disclosure strategy might not be efficacious over a long period of time, and the firm may need to re-optimize the disclosure according to changes in the market environment.

Finally, we consider a plausible scenario where the interests of manager and shareholders are not strictly aligned. Under an increasing absolute risk aversion assumption, the manager's and the firm's optimal disclosure strategy may be opposed. This highlights the importance of putting a proper managerial incentives scheme in place, to minimise the agency problem.

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Appendix A

First, we prove that if $x_t = x_{t-1} + \varepsilon_t$, then $P_t = P_{t-1} + (1/r)\varepsilon_{t-1}$.

$$\begin{aligned}
P_0 &= PV(z_1) + PV(z_2) + PV(z_3) + \dots \\
&= (z_0 + \frac{z_0}{1+r} + \frac{z_0}{(1+r)^2} + \frac{z_0}{(1+r)^3} + \dots - z_0) \\
&\quad + (\mathbb{E}(m_1\varepsilon_1) + \frac{\mathbb{E}(m_1\varepsilon_1)}{1+r} + \frac{\mathbb{E}(m_1\varepsilon_1)}{(1+r)^2} + \dots \\
&\quad + \mathbb{E}(m_2\varepsilon_2) + \frac{\mathbb{E}(m_2\varepsilon_2)}{1+r} + \dots \\
&\quad + \mathbb{E}(m_3\varepsilon_3) + \dots \\
&\quad + \dots).
\end{aligned} \tag{A.1}$$

where m_i is the stochastic discount factor at time t_i . Notice that the terms in the first bracket after the second equality can be simplified as z_0/r . Substituting the above result into the first equation, we get $P_0 = \frac{z_0}{r} + \frac{(1+r)}{r} [\mathbb{E}(m_1\varepsilon_1) + \mathbb{E}(m_2\varepsilon_2) + \dots]$. Similarly, we may write the share price at time $t = 1$ as $P_1 = \frac{z_0}{r} + \frac{\varepsilon_1}{r} + \frac{(1+r)}{r} [\mathbb{E}(m_2\varepsilon_2|\mathcal{F}_1) + \mathbb{E}(m_3\varepsilon_3|\mathcal{F}_1) + \dots]$. By the Markov property of $m_i\varepsilon_i$, $\forall i \geq 2$, $\mathbb{E}(m_i\varepsilon_i|\mathcal{F}_1) = \mathbb{E}(m_{i-1}\varepsilon_{i-1}|\mathcal{F}_0)$, thus we have $P_t = P_{t-1} + (1/r)\varepsilon_{t-1}$.

Second, we prove the pricing formula: $P_t = \frac{1}{r} [x_{t-1} + b_*(y_t - x_{t-1}) - \frac{\alpha}{n} s_*^2]$, where $b_* = (\sigma_\varepsilon^2 + \rho\sigma_\varepsilon\sigma_e)/(\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho\sigma_\varepsilon\sigma_e)$, and $s_*^2 = \frac{1}{r^2} \{(1+r)^2\sigma_\varepsilon^2 - [(1+r)^2 - 1]b_*(\sigma_\varepsilon^2 + \rho\sigma_\varepsilon\sigma_e)\}$. We know the general pricing formula (see Clinch, 2013),

$$P_t = \frac{1}{1+r} \left[\mathbb{E}_t(P_{t+1}) + \mathbb{E}_t(z_{t+1}|y_t) - \frac{\alpha}{n} \text{Var}_t(P_{t+1} + z_{t+1}) \right]. \tag{A.2}$$

As $P_t = P_{t-1} + (1/r)\varepsilon_{t-1}$, the investors will have their expectation

$$\mathbb{E}_t(P_{t+1}) = P_t. \tag{A.3}$$

Because $\mathbb{E}_t(z_{t+1}|y_t) = a + b_*y_t$,

$$b_* = \frac{Cov(z_{t+1}, y_t)}{Var(y_t)} = \frac{Cov(z_t + \epsilon_{t+1}, z_t + \epsilon_{t+1} + e_t)}{Var(z_t + \epsilon_{t+1} + e_t)} = \frac{\sigma_\epsilon^2 + \rho\sigma_\epsilon\sigma_e}{\sigma_\epsilon^2 + \sigma_e^2 + 2\rho\sigma_\epsilon\sigma_e}. \quad (\text{A.4})$$

Suppose that the best fitting line across (z_t, z_t) does exist, then

$$\mathbb{E}_t(z_{t+1}|y_t) = a + b_*y_t = z_t + b_*(y_t - z_t). \quad (\text{A.5})$$

where $a = (1 - b_*)z_t$. Denote $Var_t(P_{t+1} + z_{t+1})$ as s_*^2 and substitute Eq. (A.3) and Eq. (A.5)

into Eq. (A.2), P_t can be simplified into $P_t = \frac{1}{r} \left[z_t + b_*(y_t - z_t) - \frac{\alpha}{n} s_*^2 \right]$. By the fact that $P_t =$

$P_{t-1} + (1/r)\epsilon_{t-1}$, we rewrite s_*^2 as $s_*^2 = Var(P_{t+1} + z_{t+1}) = \frac{1}{r^2} [(1+r)^2\sigma_\epsilon^2 - [(1+r)^2 - 1]b_*(\sigma_\epsilon^2 + \rho\sigma_\epsilon\sigma_e)]$.

Finally, substitute b_* and s_*^2 into $P_t = \frac{1}{r} \left[x_{t-1} + b_*(y_t - x_{t-1}) - \frac{\alpha}{n} s_*^2 \right]$, take unconditional expectation, then take derivative of $\mathbb{E}(P_t)$ w.r.t. ρ , we get the following:

$$\text{If } \rho = +1, \text{ then } \left. \frac{\partial \mathbb{E}(P_t)}{\partial \rho} \right|_{\rho=+1} = \frac{1}{r} \times \frac{2\alpha\sigma_\epsilon^2\sigma_e^2((1+r)^2-1)(\sigma_\epsilon+\sigma_e)(\sigma_e+\sigma_\epsilon)}{nr^2(\sigma_\epsilon^2+2\rho\sigma_\epsilon\sigma_e+\sigma_e^2)^2} > 0.$$

$$\text{If } \rho = 0, \text{ then } \left. \frac{\partial \mathbb{E}(P_t)}{\partial \rho} \right|_{\rho=0} = \frac{1}{r} \times \frac{2\alpha\sigma_\epsilon^3\sigma_e^3((1+r)^2-1)}{nr^2(\sigma_\epsilon^2+2\rho\sigma_\epsilon\sigma_e+\sigma_e^2)^2} > 0.$$

$$\text{If } \rho = -1, \text{ then } \left. \frac{\partial \mathbb{E}(P_t)}{\partial \rho} \right|_{\rho=-1} = \frac{1}{r} \times \frac{2\alpha\sigma_\epsilon^2\sigma_e^2((1+r)^2-1)(\sigma_\epsilon-\sigma_e)(\sigma_e-\sigma_\epsilon)}{nr^2(\sigma_\epsilon^2+2\rho\sigma_\epsilon\sigma_e+\sigma_e^2)^2} < 0.$$

and $\forall \sigma_e \geq 0$ and $\rho = \pm 1$, and $\mathbb{E}(P_t)$ achieves the optimal value. We then substitute $\sigma_e = 0$ into $\mathbb{E}(P_t)$, we have $\mathbb{E}(P_t) = [x_t - \alpha\sigma_\epsilon^2/nr^2]/r$, which is also the optimal $\mathbb{E}(P_t)$.

Appendix B

Proof of Corollary 1.

Taking the variance operator on P_t , we have $Var(P_t) = \frac{(\sigma_\epsilon^2 + \rho\sigma_\epsilon\sigma_e)^2}{r^2(\sigma_\epsilon^2 + \sigma_e^2 + 2\rho\sigma_\epsilon\sigma_e)}$. Taking derivative of $Var(P_t)$ w.r.t. ρ , we derive $\partial Var(P_t)/\partial \rho = \frac{(\sigma_\epsilon + \rho\sigma_e) \times (\sigma_e + \rho\sigma_\epsilon) \times 2\sigma_\epsilon^2\sigma_e^2}{r^2(\sigma_\epsilon^2 + \sigma_e^2 + 2\rho\sigma_\epsilon\sigma_e)^2}$. Then it is

obvious to have the results in Corollary 1.

Appendix C

Proof of Theorem 2.

By definition, we have $\mathbb{E}(V_t) = L + \mathbb{E}[P_t 1_{\{P_t > 0\}}] - C \times \mathbb{P}(P_t \leq 0)$, where $P_t = \mathcal{M}(\rho, \sigma_e) + \mathcal{V}(\rho, \sigma_e)W_t$, $W_t \sim N(0,1)$, $\mathcal{M}(\rho, \sigma_e) \equiv \frac{1}{r} \left(x_{t-1} - \frac{\alpha}{n} \frac{1}{r^2} \left[(1+r)^2 \sigma_\varepsilon^2 - [(1+r)^2 - 1] \frac{\sigma_\varepsilon^2 + \rho \sigma_\varepsilon \sigma_e}{\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho \sigma_\varepsilon \sigma_e} (\sigma_\varepsilon^2 + \rho \sigma_\varepsilon \sigma_e) \right] \right)$, and $\mathcal{V}(\rho, \sigma_e) = \frac{1}{r} \frac{\sigma_\varepsilon + \rho \sigma_e}{\sqrt{\sigma_\varepsilon^2 + \sigma_e^2 + 2\rho \sigma_\varepsilon \sigma_e}}$.

Suppose $\mathcal{V}(\rho, \sigma_e) > 0$, then $\mathbb{E}(V_t) = L + \mathcal{M}(\rho, \sigma_e)[1 - \Phi(d(\rho, \sigma_e))] - \mathcal{V}(\rho, \sigma_e)\mathbb{E}\mathbb{S}(W_t)\Phi(d(\rho, \sigma_e)) - C \times \Phi(d(\rho, \sigma_e))$,

where $\mathbb{E}\mathbb{S}(W_t) = \mathbb{E}(W_t | W_t < d(\rho, \sigma_e)) = -\frac{\exp[-d^2(\rho, \sigma_e)/2]}{\sqrt{2\pi}[1 - \Phi(-d(\rho, \sigma_e))]}$ and $\Phi(d(\rho, \sigma_e)) = \mathbb{P}(W_t \leq d(\rho, \sigma_e))$, are the expected shortfall (See Yamai and Yoshiba, 2002, P.61), and the cumulative probability of W_t at $d(\rho, \sigma_e)$, and $d(\rho, \sigma_e) = -\mathcal{M}(\rho, \sigma_e)/\mathcal{V}(\rho, \sigma_e)$ is the threshold of W_t at which the firm goes bankrupt. More precisely, it refers to the condition where $W_t \leq -\mathcal{M}(\rho, \sigma_e)/\mathcal{V}(\rho, \sigma_e)$.

Suppose $\mathcal{V}(\rho, \sigma_e) < 0$, then $\mathbb{E}(V_t) = L + \mathcal{M}(\rho, \sigma_e)\Phi(d(\rho, \sigma_e)) + \mathcal{V}(\rho, \sigma_e) \times \mathbb{E}\mathbb{S}(W_t) \times \Phi(d(\rho, \sigma_e)) - C \times (1 - \Phi(d(\rho, \sigma_e)))$.

Suppose, $\mathcal{V}(\rho, \sigma_e) = 0$, then $\sigma_\varepsilon + \rho \sigma_e = 0$, if $\mathcal{M}(\rho, \sigma_e) > 0$, then $\mathbb{E}(V_t) = L + \mathcal{M}(\rho, \sigma_e)$, else, $\mathbb{E}(V_t) = L - C$.

Summarizing the above analyses together, we have

$$\begin{aligned} \mathbb{E}(V_t) = & \left(L + \mathcal{M}(\rho, \sigma_e)[1 - \Phi(d(\rho, \sigma_e))] - \mathcal{V}(\rho, \sigma_e)\mathbb{E}\mathbb{S}(W_t)\Phi(d(\rho, \sigma_e)) - C \times \right. \\ & \left. \Phi(d(\rho, \sigma_e)) \right) 1_{\{\mathcal{V}(\rho, \sigma_e) > 0\}} + \left(L + \mathcal{M}(\rho, \sigma_e)\Phi(d(\rho, \sigma_e)) + \mathcal{V}(\rho, \sigma_e) \times \mathbb{E}\mathbb{S}(X) \times \right. \\ & \left. \Phi(d(\rho, \sigma_e)) - C \times (1 - \Phi(d(\rho, \sigma_e))) \right) 1_{\{\mathcal{V}(\rho, \sigma_e) < 0\}} + (L + \\ & \mathcal{M}(\rho, \sigma_e)) 1_{\{\mathcal{V}(\rho, \sigma_e) = 0\}} 1_{\{\mathcal{M}(\rho, \sigma_e) > 0\}} + (L - C) 1_{\{\mathcal{V}(\rho, \sigma_e) = 0\}} 1_{\{\mathcal{M}(\rho, \sigma_e) \leq 0\}}. \end{aligned}$$

Figure 1. Surface of expected firm value with respect to (*w.r.t.*) information disclosure quality (ρ, σ_ε)

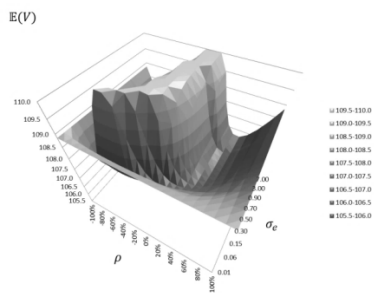


Figure 1.A

Significant bankruptcy cost regime

($x_{t-1} = \$0.4, \sigma_\varepsilon = \$0.1, r = 4\%, \alpha = 3,$
 $n = 80,000, L = \$100, c = 20\%$)

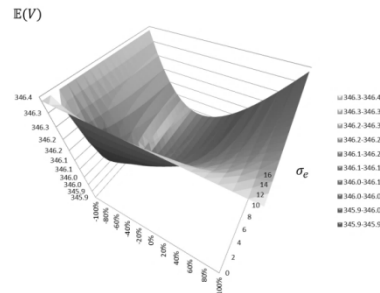


Figure 1.B

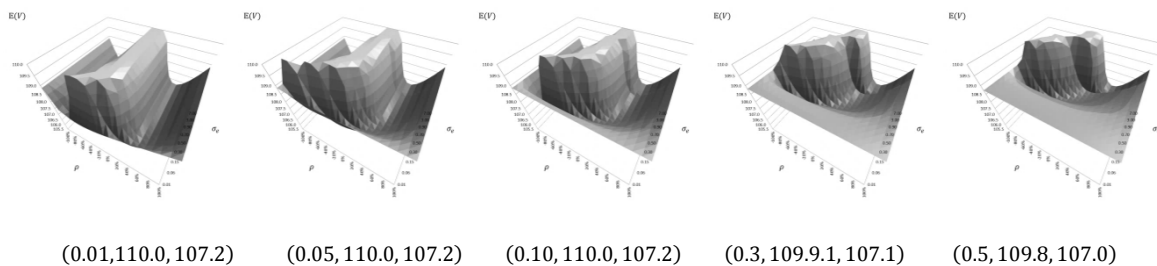
Insignificant bankruptcy cost regime

($x_{t-1} = \$10, \sigma_\varepsilon = \$2.5, r = 4\%, \alpha = 3,$
 $n = 80,000, L = \$100, c = 20\%$)

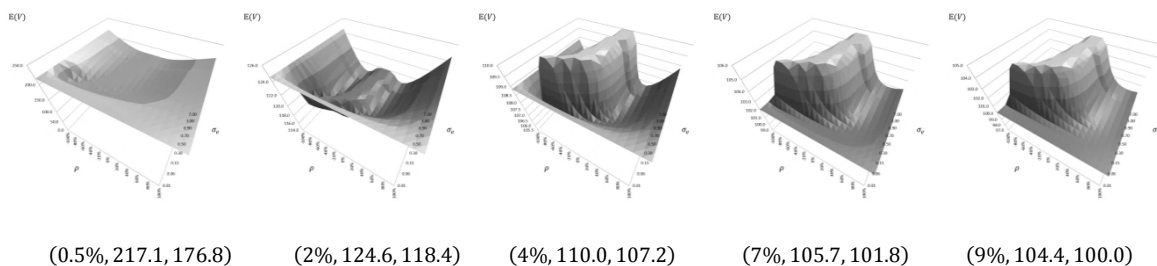
Figure 2. Comparative statics of disclosure strategy for significant bankruptcy cost regime

Panels A to F show the results of static comparative analysis of how disclosure performance [the surface of the expected firm value *w.r.t.* the information disclosure quality (ρ, σ_ε)] changes *w.r.t.* parameter changes. The significant bankruptcy cost scenario in Figure 1 (A) is used as the benchmark. The first elements of the triplets represent the value of the changing parameter; the second one is the maximum of the expected firm value; the third one is the minimum of the expected firm value.

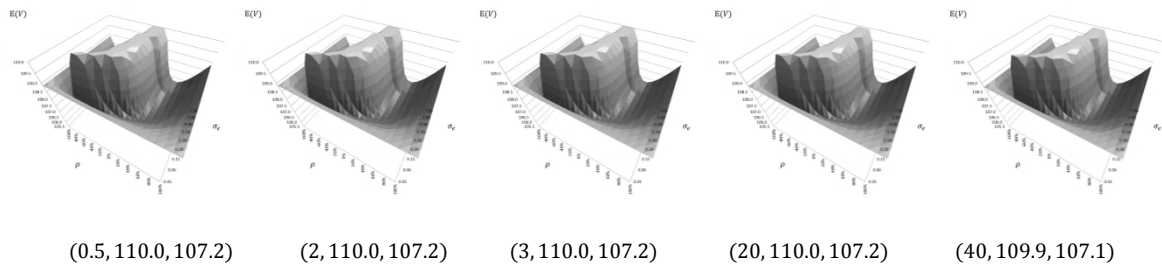
Panel A: Disclosure-strategy sensitivity *w.r.t.* standard deviation of payoff shock (σ_ε).



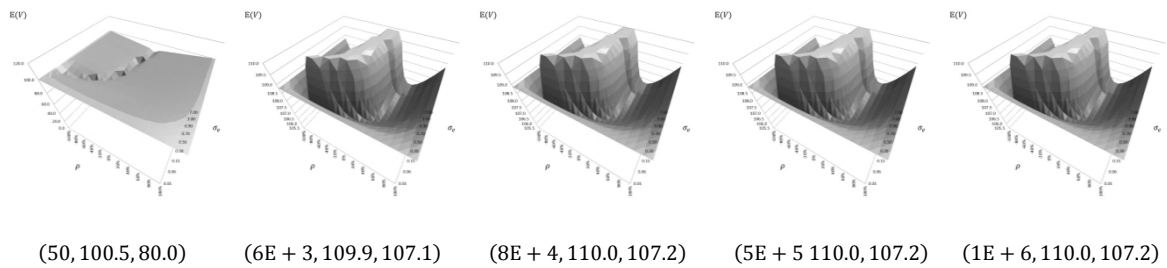
Panel B: Disclosure-strategy sensitivity *w.r.t.* interest rate (r).



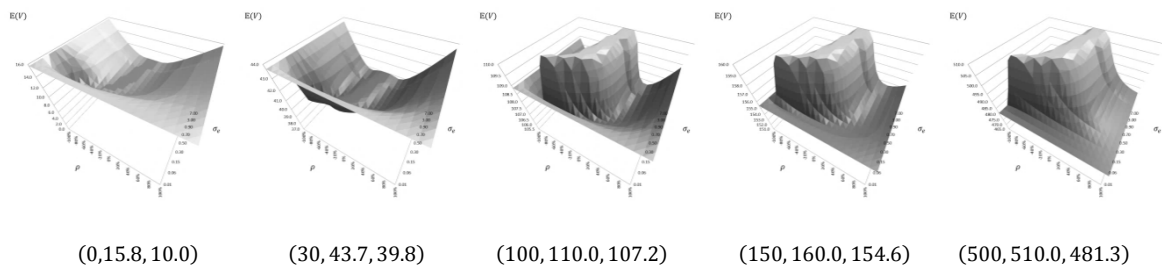
Panel C: Disclosure-strategy sensitivity *w.r.t.* risk aversion(α).



Panel D: Disclosure-strategy sensitivity *w.r.t.* market participation(n).



Panel E: Disclosure-strategy sensitivity *w.r.t.* liability per share(L).



Panel F: Disclosure-strategy sensitivity *w.r.t.* bankruptcy-cost-to-liability ratio(c).

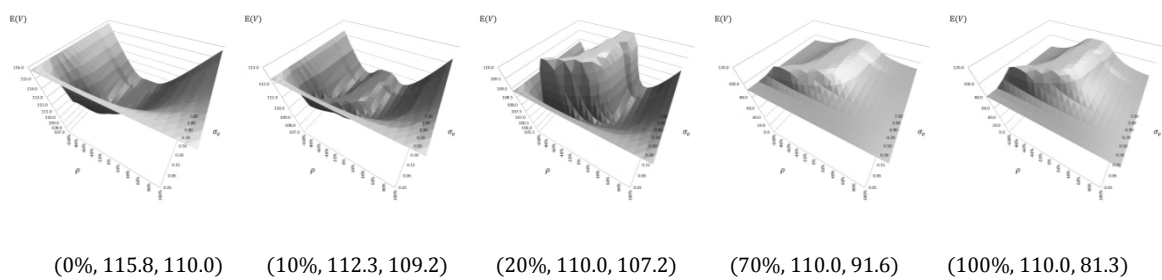
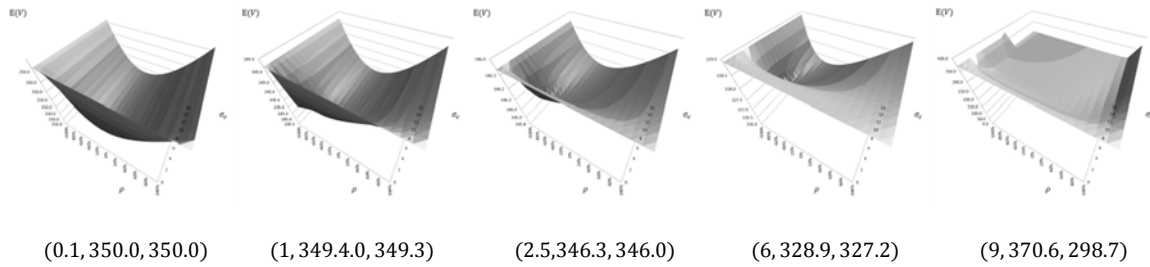


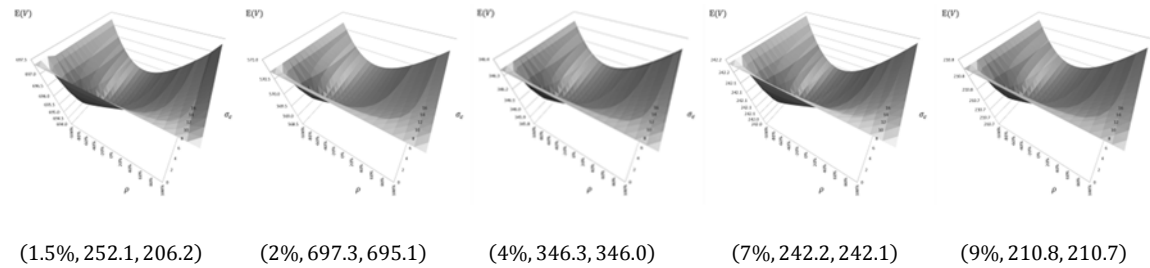
Figure 3. Comparative statics of disclosure-strategy for insignificant bankruptcy cost regime

Panels A to F show the results of static comparative analysis of how disclosure performance [the surface of the expected firm value *w.r.t* the information disclosure quality(ρ, σ_ε)] changes *w.r.t* parameter changes. The insignificant bankruptcy cost scenario in Figure 1 (B) is used as the benchmark. The first elements of the triplets represent the value of the changing parameter; the second one is the maximum of expected firm value; the third one is the minimum of expected firm value.

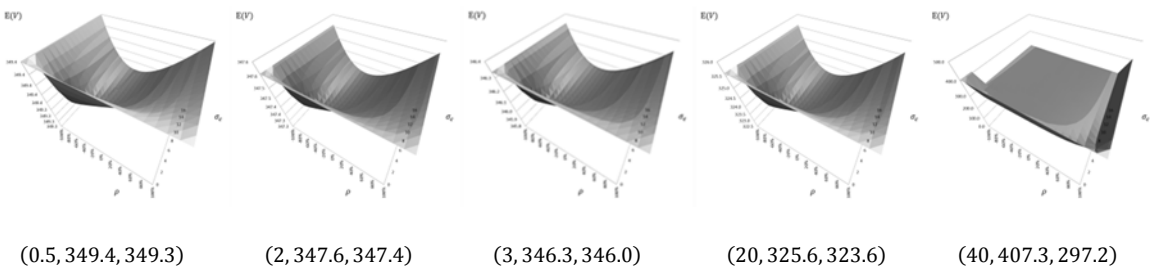
Panel A: Disclosure-strategy sensitivity *w.r.t.* standard deviation of payoff shock (σ_ε).



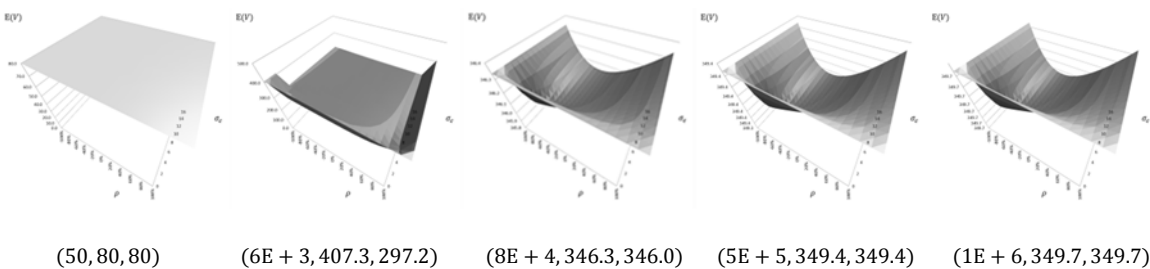
Panel B: Disclosure-strategy sensitivity *w.r.t.* interest rate (r).



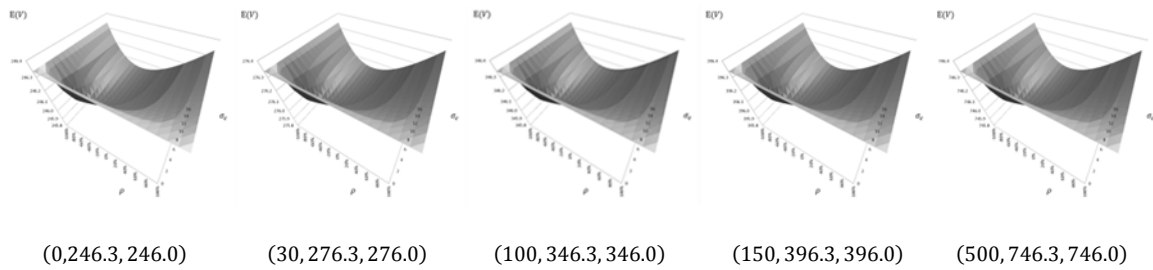
Panel C: Disclosure-strategy sensitivity *w.r.t.* risk aversion(α).



Panel D: Disclosure-strategy sensitivity *w.r.t.* market participation (n).



Panel E: Disclosure-strategy sensitivity *w.r.t.* liability per share (L).



Panel F: Disclosure-strategy sensitivity *w.r.t.* bankruptcy cost liability ratio (c).

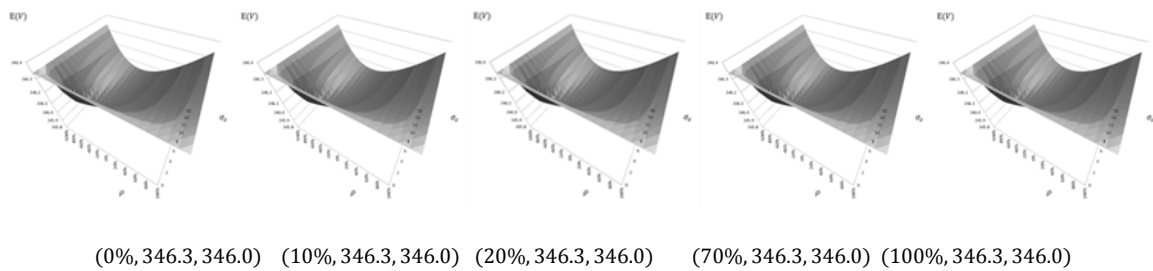


Figure 4. Surface of manager's expected utility *w.r.t.* information disclosure quality (ρ, σ_e)

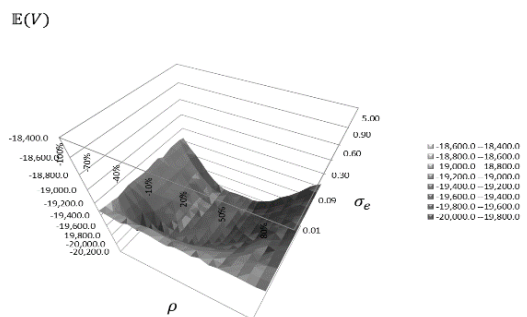


Figure 4.A

Significant bankruptcy cost regime

($x_{t-1} = \$0.4, \sigma_e = \$0.1, r = 4\%, \alpha = 3, n = 80,000,$
 $L = \$100, c = 20\%$) with manager's increasing
 absolute risk aversion ($a = 1, b = 210, \gamma = 2$)

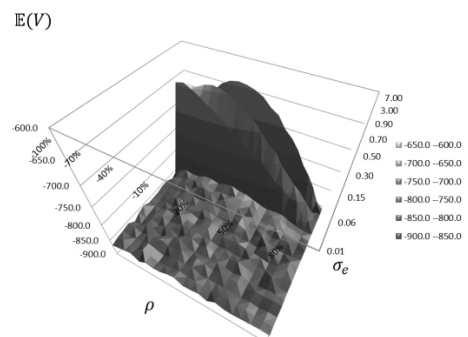


Figure 4.B

Insignificant bankruptcy cost regime

($x_{t-1} = \$10, \sigma_e = \$2.5, r = 4\%, \alpha = 3, n = 80,000,$
 $L = \$100, c = 20\%$) with manager's increasing
 absolute risk aversion ($a = 1, b = 210, \gamma = 2$)