Costly Disclosures in a Voluntary Disclosure Model with an Opponent

Jeroen Suijs[1] [2]

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Abstract

This paper analyzes voluntary disclosure equilibria when the voluntary disclosure model presented in WAGENHOFER (1990) is modified so as to include fixed disclosure costs as used in VERRECCHIA (1983). It turns out that incorporating both disclosure and proprietary costs rules out full disclosure equilibria. Moreover, it yields additional disclosure equilibria that differ significantly from the equilibria in VERRECCHIA (1983) and WAGENHOFER (1990). Thus, in the extended model the firm is provided with additional incentives to withhold its private information from the public.

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[1] CentER Accounting Research Group, Tilburg University, PO Box 90153, 5000 LE, Tilburg, The Netherlands. Phone: ++31 13 4663334, fax: ++31 13 4663066, e-mail: j.p.m.suijs@kub.nl

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1 Introduction

Voluntary disclosure models serve to analyze disclosure strategies of privately informed firms in particular settings. In many such models, full disclosure of private information is an equilibrium strategy (see, for instance, GROSSMAN (1981), MILGROM (1981), JOVANOVIC (1982), MILGROM and ROBERTS (1986), and WAGENHOFER (1990)). From a theoretical point of view, such equilibria are interesting in that firms are voluntarily willing to disclose all their private information, leaving no need for any mandatory disclosures. In reality, however, one observes that firms are subject to mandatory disclosures. The existence of such disclosure rules would thus indicate that firms do have incentives to withhold information from the public. Such partial disclosure equilibria occur, for instance, in the disclosure models of VERRECCHIA (1983) and WAGENHOFER (1990), which both introduce costs of disclosure.

In VERRECHIA (1983) the firm incurs disclosure costs if, and only if, it discloses its private information. In general, these disclosure costs can be interpreted as the costs arising from preparing and disseminating the information or, more importantly, the contracting of an auditor. The latter cost driver is particularly interesting given the assumption that disclosures are truthful,[1] for auditing is one way to make voluntary disclosures credible to the public. In the partial disclosure equilibrium that arises, bad information is kept private while good information is publicly disclosed. Moreover, as the costs of disclosure increase, more and more information becomes not valuable enough for disclosure, resulting in a full nondisclosure equilibrium in the end.

WAGENHOFER (1990) analyzes voluntary disclosure strategies of a firm that is faced with a strategic opponent like a competing firm, say. In this model the firm possesses private information that is valuable to the financial market as well as to the opponent. While the market uses any publicly disclosed information to revise the value of the firm, the opponent may find the disclosed information sufficiently valuable to take an adverse action that imposes costs on the firm. These indirect costs of disclosure are referred to as proprietary costs. When determining its disclosure strategy, the firm thus weighs out the benefits of a better firm value against the possibility of incurring proprietary costs.

In WAGENHOFER (1990) it is shown that a full disclosure equilibrium always exists and that a partial disclosure equilibrium may exist, albeit not frequently. In a partial disclosure equilibrium, nondisclosure of information avoids incurring proprietary costs. Moreover, the firm nondiscloses its information either if it is bad, or if it is good but not good enough to accept the proprietary costs that will result from a public disclosure. Furthermore, it is shown that a full nondisclosure

[1] The same assumption applies to the model of WAGENHOFER (1990) and the model presented in this paper.

strategy can never be part of an equilibrium.

This paper combines the models of VERRECCHIA (1983) and WAGENHOFER (1990) so as to incorporate both disclosure and proprietary costs. It will be shown that the presence of both cost drivers gives rise to types of disclosure equilibria that differ from the types arising in VERRECCHIA (1983) and WAGENHOFER (1990). Consequently, the firm has a greater incentive to nondisclose its private information.

2 A Voluntary Disclosure Model

The game theoretical model used to model the firm's disclosure decision is based on WAGENHOFER (1990) and includes three risk neutral decision makers: the firm, an opponent, and the financial market. The firm possesses private information, which is described by a continuous random variable $\tilde{y}$ that attains values in the interval $Y = (\underline{y}, \overline{y})$. The probability distribution function of $\tilde{y}$ is denoted by F and is assumed to be common knowledge. The realization of $\tilde{y}$ is denoted by y and is private information for the firm and not known to either the opponent or the financial market. Examples of what this private information can represent are R&D expenses, production costs, or product quality. In fact, it can be given any meaning as long as it can be represented by a one-dimensional compact interval. So, what the private information cannot contain is information about both quality *and* costs.

The private information y determines firm value $v(y) \in \mathbb{R}_+$. We assume that $v(y)$ is strictly increasing in y. Hence, one can characterize $\underline{y}$ as relatively bad and $\overline{y}$ as relatively good information. Furthermore, since v is assumed to be strictly increasing, one may assume without loss of generality that $v(y) = y$ for all $y \in Y$.[2]

The game is played in two stages. In the first stage, the firm decides whether or not it discloses its private information to the public. The fixed costs of making a public disclosure are denoted by $C_d \geq 0$ and these costs do not depend on the contents of the information released. Moreover, a public disclosure is assumed to contain truthful information only and is observed by both the opponent and the financial market.

In the second stage, the opponent and the financial market observe the firm's disclosure decision and update their beliefs about the value of the firm. Furthermore, the opponent decides whether it is beneficial to take an adverse action. In this regard, it is again assumed that taking

[2] For if $v(y) \neq y$ for some $y \in Y$, we can consider the information set $Y' = \{v(y) | y \in Y\}$. Since v is strictly increasing there is a one-to-one correspondence between Y and Y'. By defining $v'(y) = y$ for all $y \in Y'$ we obtain the desired result.

the action is profitable if and only if the opponent believes that firm value exceeds some threshold value $K \in Y$. So, one can represent the opponent's action by the function

$$b(y) = \begin{cases} 0, & \text{if } y < K, \\ 1, & \text{if } y \geq K, \end{cases} \tag{1}$$

where y denotes the opponent's beliefs about firm value. In case the adverse action is undertaken, i.e. $b(y) = 1$, the firm incurs proprietary costs $C_p \geq 0$.

Summarizing, there are two types of costs that affect the firm's disclosure decision: disclosure costs and proprietary costs. Whether or not the firm incurs proprietary costs, depends on the opponent's beliefs about firm value. The firm, however, can influence these beliefs by disclosing its private information. When making such a public disclosure, the firm incurs disclosure costs. Thus, one can regard disclosure costs as direct costs of disclosure and proprietary costs as indirect costs of disclosure.

The objective of the firm is to maximize the expected firm value as perceived by the financial market. A disclosure strategy for the firm prescribes for each possible realized firm value y of $\tilde{y}$ whether it is disclosed or not.[3] For this purpose, let $D \subset Y$ denote the subset of realized firm values that the firm publicly discloses, and let $N = Y \backslash D$ be the subset of realizations that are withheld from the public. Given the disclosure strategy of the firm, the beliefs about firm value of both the opponent and the financial market are determined as follows. If realized firm value y belongs to D, the information is disclosed and the beliefs about firm value equal y. If $y \in N$, the information is withheld and the beliefs about firm value equal the expected firm value conditional on observing nondisclosure. In case nondisclosure occurs with zero probability, then the conditional expectation cannot be calculated and the beliefs about firm value may be any value $\beta \in Y$. So, the beliefs about firm value equal

$$E(\tilde{y}|\tilde{y} \in N) = \begin{cases} \dfrac{1}{\int_N dF(y)} \displaystyle\int_N y dF(y), & \text{if } \mathbb{P}(\tilde{y} \in N) > 0, \\ \beta, & \text{if } \mathbb{P}(\tilde{y} \in N) = 0, \end{cases}$$

where $\beta \in Y$. Given these beliefs, the firm's payoff then equals $y - C_d - b(y)C_p$ if $y \in D$ and $E(\tilde{y}|\tilde{y} \in N) - b(E(\tilde{y}|\tilde{y} \in N))C_p$ if $y \in N$. Note that the models of VERRECCHIA (1983) and WAGENHOFER (1990) arise as special cases by setting $C_p = 0$ and $C_d = 0$, respectively.

A disclosure strategy constitutes a sequential equilibrium (cf. KREPS and WILSON (1982)) if the firm has an incentive to disclose any $y \in D$ and to withhold any $y \in N$, while taking into

[3] Similar to WAGENHOFER (1990), attention is restricted to pure strategies only.

account the beliefs of the opponent and the financial market. The equilibrium nondisclosure set N is thus implicitly given by

$$N = \{y \in Y \,|y - C_d - b(y)C_p < E(\tilde{y}|\tilde{y} \in N) - b(E(\tilde{y}|\tilde{y} \in N))C_p\}$$

One speaks of a full disclosure equilibrium and a full nondisclosure equilibrium if $N = \emptyset$ and $N = Y$, respectively. When neither case applies, one speaks of a partial disclosure equilibrium.

In our model, one can distinguish two extreme cases. At one extreme, proprietary costs are absent, i.e. $C_p = 0$. In that case the model coincides with VERRECCHIA (1983), and the disclosure equilibria take the form $N = (\underline{y}, d)$, $d \in Y$, i.e. only bad information is nondisclosed. At the other extreme, disclosure costs are absent, i.e. $C_d = 0$, so that the model coincides with WAGENHOFER (1990). In that case, a full disclosure equilibrium always exists and a full nondisclosure equilibrium never exists. Furthermore, partial disclosure equilibria take the form $N = (\underline{y}, d_1) \cup [K, d_2)$, where $\underline{y} < d_1 < K$ and $K < d_2 \leq \overline{y}$. Hence, both bad and good information is withheld. The following theorem describes the disclosure equilibria for the intermediate cases. The proof is provided in the appendix.

Theorem 2.1 Let $C_d > 0$ and $C_p > 0$. Then

(1) a full disclosure strategy is never part of a sequential equilibrium,

(2) a full nondisclosure equilibrium exists if either $E(\tilde{y}) < K \leq E(\tilde{y}) + C_d$ and $C_d + C_p \geq \overline{y} - E(\tilde{y})$, or $E(\tilde{y}) \geq \max\{K, K - C_d + C_p, \overline{y} - C_d\}$,

(3) if a partial disclosure equilibrium exists, $N = (\underline{y}, d_1) \cup [K, d_2)$ where $\underline{y} \leq d_1 \leq K$ and $K \leq d_2 \leq \overline{y}$.

Note that Theorem 2.1 holds for any disclosure costs $C_d > 0$, even if they are relatively small compared to the proprietary costs C_p. Let us illustrate Theorem 2.1 with an example.

Example 2.2 Consider a firm whose private information $\tilde{y}$ is uniformly distributed on the interval $(0, 1)$. First, let us consider the equilibria for the models introduced in VERRECCHIA (1983) and WAGENHOFER (1990), respectively. If proprietary costs $C_p = 0$, we obtain the model of VERECCHIA (1983). The partial disclosure equilibrium equals

$$N = (0, 2C_d), \tag{2}$$

i.e. only information better than $2C_d$ is disclosed. Note that a full nondisclosure equilibrium arises if $C_d \geq 0.5$. If disclosure costs $C_d = 0$, we obtain the model of WAGENHOFER (1990). In that

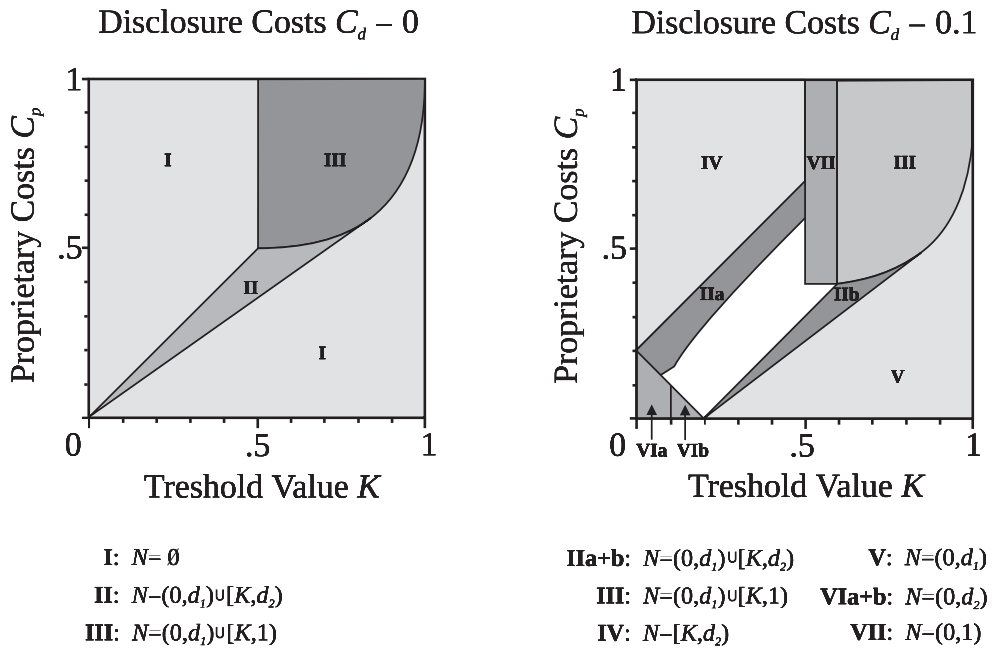

FIGURE 1: The existence of partial disclosure equilibria in relation to the values of K and C_p when $C_d = 0$ (left panel) and $C_d = 0.1$ (right panel).

case, full disclosure of information is an equilibrium strategy. A partial disclosure equilibrium may exist and is either one of two types, namely

$$N = (0, d_1) \cup [K, d_2) \text{ or } N = (0, d_1) \cup [K, 1). \tag{3}$$

Since nondisclosure is only beneficial if it deters proprietary costs, also bad information has to be withheld from the public. For if the opponent observes nondisclosure, he does not know whether the reason for nondisclosure is that the firm has bad information, or that it wants to avoid incurring proprietary costs. Partial dislcosure equilibria, however, need not exist. Their existence depends on the values of the parameters C_p and K. The left panel of Figure 1 depicts the existence of partial disclosure equilibria for $0 \leq C_p \leq 1$ and $0 \leq K \leq 1$.

Next, consider the case that both disclosure and proprietary costs may be positive, i.e. $C_d > 0$ and $C_p > 0$. The right panel of Figure 1 depicts the existence of partial disclosure equilibria if $C_d = 0.1$. Note that in case $C_d = 0$, we obtain the model of VERRECCHIA (1983) and the only equilibrium nondisclosure sets that can arise, are indeed of the form $N = (0, d)$ (see areas V, VIa, and VIb in Figure 1).

Comparing the structure of the disclosure equilibria in the several models reveals the following

differences. First, a full disclosure equilibrium does not exist in our model. This is due to the fact that such an equilibrium cannot occur in VERRECCHIA (1983), which features a similar fixed cost of disclosure as our model.

Second, for any value of disclosure costs $C_d > 0$, a full nondisclosure equilibrium exists for the appropriate values of K and C_p. From Figure 1 it follows that in case $C_d = 0.1$, a full nondisclosure equilibrium arises when $0.5 < K \leq 0.6 = E(\tilde{y}) + C_d$ and $C_p \geq 0.4 = \overline{y} - E(\tilde{y}) - C_d$. This result contrasts the result in VERRECCHIA (1983), where a full nondisclosure equilibrium only arises when the disclosure costs C_d are sufficiently high, that is $C_d \geq 0.5$ (see (2)).

Third, as opposed to the partial disclosure equilibria in WAGENHOFER (1990), where $0 < d_1 < K$ and $K < d_2 \leq 1$, the inequalities regarding d_1 and d_2 are not strict inequalities anymore. This implies that also partial disclosure equilibria of the form $N = (0, d_1)$, $N = (0, d_2)$, and $N = [K, d_2)$ may exist. Note, however, that the former two are similar to the equilibrium nondisclosure set in VERRECCHIA (1983).

The final major difference is found in the opponent's action when he observes nondisclosure. In WAGENHOFER (1990), nondisclosure implies that the opponent does not undertake the adverse action, so that the firm does not incur any proprietary costs. In our model, however, this is not necessarily the case. Consider, for instance, an equilibrium of the form $N = [K, d_2)$. Now, when the opponent observes nondisclosure, firm value is believed to be $0.5(K + d_2)$, so that the opponent imposes proprietary costs on the firm by taking his adverse action. Since nondisclosure is no means to avoid incurring proprietary costs, only the fixed disclosure costs drive nondisclosure, just as in VERRECCHIA (1990). In VERRECCHIA (1990), however, only relatively bad information is nondisclosed (see (2)). So why do firms disclose relatively bad information in this case? The reason for this is straightforward. When $N = [K, d_2)$ is an equilibrium, one can derive that $C_p \geq 2C_d + K$, which implies that the proprietary costs C_p exceed the disclosure costs C_d. So, it is beneficial for a firm to disclose its bad information at costs C_d in order to avoid the higher proprietary costs C_p.

Finally, note that proprietary costs are not only imposed on a nondisclosing firm when $N = [K, d_2)$, but also in the areas IIa and VIa in Figure 1 with nondisclosure sets $N = (0, d_1) \cup [K, d_2)$ and $N = (0, d_2)$, respectively. So, although the reason for nondisclosure in these equilibria is the same as in VERRECCHIA (1983), namely avoiding disclosure costs, the presence of proprietary costs in our model yields equilibria that differ in structure from the equilibria in VERRECCHIA (1983).

3 Conclusion

VERRECCHIA (1983) and WAGENHOFER (1990) present voluntary disclosure models in which partial disclosure of private information can be an equilibrium strategy. The two models differ in the driving force behind these partial disclosure equilibria. In VERRECCHIA (1983), the incentive for nondisclosure is disclosure costs, while in WAGENHOFER (1990), this incentive is proprietary costs, i.e. costs imposed by an adverse action of an opponent. In this paper we analyzed a voluntary disclosure model that incorporates both disclosure costs and proprietary costs. It was shown that additional equilibrium disclosure strategies arise that differ from the ones arising in VERRECCHIA (1983) and WAGENHOFER (1990): full disclosure equilibria cease to exist while full nondisclosure equilibria may arise. Furthermore, when disclosure costs drive nondisclosure, we have seen, for instance, that nondisclosing only mediocre information can be an equilibrium; an equilibrium that is excluded in both VERRECCHIA (1983) and WAGENHOFER (1990).

So, even though only one of the two cost drivers may provide the firm with an incentive to nondisclose its private information, the sheer presence of the other cost driver gives rise to *new* disclosure equilibria. Taking into account both disclosure and proprietary costs, increases the firm's incentives to withhold its private information from the public.

Appendix

PROOF OF THEOREM 2.1: For the proof of (1), suppose the firm plays a full disclosure strategy yielding a firm value of $y - C_d - b(y)C_p$ for each $y \in Y$. Furthermore, let β denote the sequentially rational beliefs of the opponent and the financial market when they observe nondisclosure. I will show that there exists an information set $N \subset Y$ of positive measure for which the firm prefers nondisclosure.

To constitute a full disclosure equilibrium, the firm must prefer disclosure to nondisclosure whatever its private information, that is $y - C_d - b(y)C_p \geq \beta - b(\beta)C_p$ for all $y \in Y$. Since nondisclosure yields a true firm value of $y - b(y)C_p$ for all $y \in Y$, the worst possible sequentially rational beliefs of the opponent and the market are $\min\{y - b(y)C_p | y \in Y\}$. Hence, $\beta \geq \min\{y - b(y)C_p | y \in Y\}$. Next, define

$$N = \begin{cases} (\underline{y}, \underline{y} + C_d), & \text{if } \arg\min\{y - b(y)C_p | y \in Y\} = \underline{y}, \\ (K, K + C_d), & \text{if } \arg\min\{y - b(y)C_p | y \in Y\} = K - C_p. \end{cases}$$

First, $C_d > 0$ implies that N has strictly positive measure. Second, since $\beta \geq \min\{y - b(y)C_p | y \in Y\} > y - C_d - b(y)C_p$ for all $y \in N$, the firm prefers nondisclosure whenever its private

information belongs to N. Hence, full disclosure cannot be part of a sequential equilibrium.

For the proof of part (2), note that in a full nondisclosure equilibrium $N = (\underline{y}, \overline{y})$ and $E(\tilde{y}|\tilde{y} \in N) = E(\tilde{y})$. Full nondisclosure is an equilibrium strategy if a public disclosure of any firm value $y \in (\underline{y}, \overline{y})$ results in a firm value less than or equal to $E(\tilde{y}|\tilde{y} \in N) - b(E(\tilde{y}|\tilde{y} \in N))C_p = E(\tilde{y}) - b(E(\tilde{y}))C_p$.

Let us start with the case that $b(E(\tilde{y})) = 0$, that is $E(\tilde{y}) < K$. Then for $y \in (\underline{y}, K)$ it must hold that $y - C_d \leq E(\tilde{y})$, which is equivalent to $K \leq E(\tilde{y}) + C_d$. For $y \in [K, \overline{y})$ it must hold that $y - C_d - C_p \leq E(\tilde{y})$, which is equivalent to $C_d + C_p \geq \overline{y} - E(\tilde{y})$.

Next, let us consider the case that $b(E(\tilde{y})) = 1$, that is $E(\tilde{y}) \geq K$. Then for $y \in (\underline{y}, K)$ it must hold that $y - C_d \leq E(\tilde{y}) - C_p$, which is equivalent to $E(\tilde{y}) \geq K - C_d + C_p$. For $y \in [K, \overline{y})$ it must hold that $y - C_d - C_p \leq E(\tilde{y}) - C_p$, which is equivalent to $E(\tilde{y}) \geq \overline{y} - C_d$.

To prove part (3), take $y \in N$. Since y is not publicly disclosed it must hold true that $E(\tilde{y}|\tilde{y} \in N) - b(E(\tilde{y}|\tilde{y} \in N))C_p \geq y - C_d - b(y)C_p$. If $y < K$ then $\hat{y} - C_d - b(\hat{y})C_p < y - C_d - b(y)C_p$ for all $\hat{y} \in (\underline{y}, y)$, which implies that $\hat{y} \in N$. A similar argument holds for $y \geq K$. Then $\hat{y} - C_d - b(\hat{y})C_p < y - C_d - b(y)C_p$ for all $\hat{y} \in [K, y)$, which implies that $\hat{y} \in N$. □

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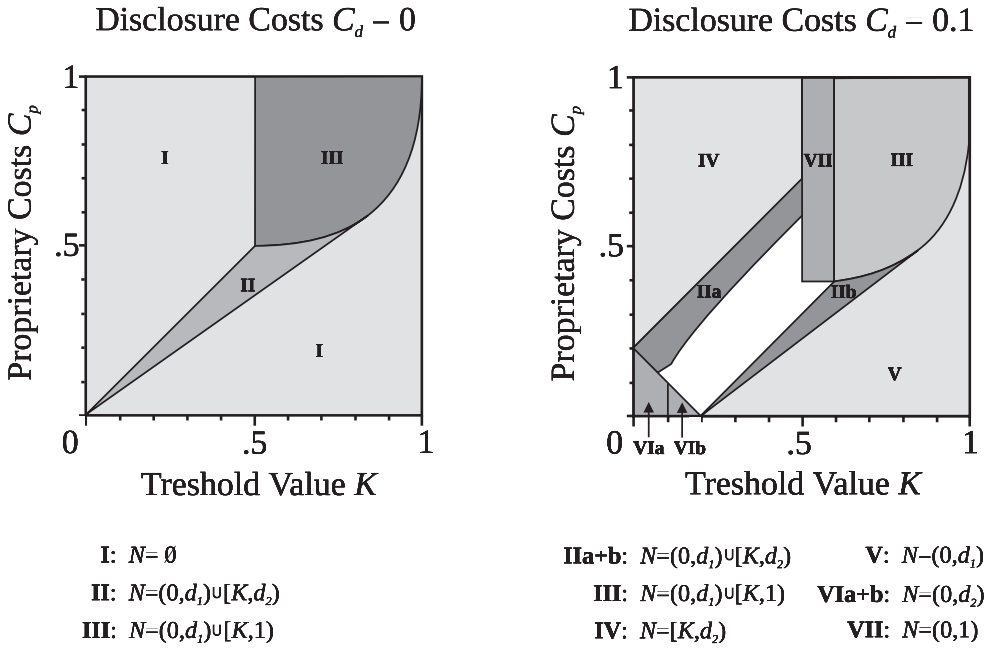

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