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VOLUNTARY DISCLOSURE WITH A STRATEGIC OPPONENT*

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This paper analyzes voluntary disclosure strategies of a privately informed firm when the information is relevant for the market price of the firm and also for an opponent. Favorable information increases the market price but might induce the opponent to take a discrete action that imposes proprietary costs on the firm. It is shown that there is always a full-disclosure equilibrium. There can exist partial-disclosure equilibria with two nondisclosure intervals. Comparative statics show some counter-intuitive results, e.g., higher proprietary costs or higher risk of an adverse action can make disclosure of favorable information more or less likely.

1. Introduction

This paper analyzes disclosure strategies of a firm endowed with private information which is valuable to both the financial market and an opponent. The market revises the price of the firm contingent on the disclosure decision observed. The opponent decides to take a beneficial action only if the information is favorable. This action imposes proprietary costs on the disclosing firm. One example of such a setting is the existence of a rival firm which chooses to enter the firm's market if the firm makes high profits. The proprietary cost is the loss in profits due to the increased competition. Another example is that of a political agency which decides to impose political costs on the firm, if the firm has favorable information. Political costs include reductions of profits due to regulation, union demands, or adverse media reports.

Disclosure strategies are derived as part of a sequential equilibrium. It is shown that there is never a nondisclosure equilibrium, and there always exists a full-disclosure equilibrium. Hence, the existence of proprietary costs does not necessarily imply nondisclosure. In addition to a full-disclosure equilib-

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rium, there can exist partial-disclosure equilibria which consist of two distinct nondisclosure intervals. They are necessary to balance the beliefs of the uninformed players upon observing nondisclosure. One interval includes very unfavorable information, which mainly stems from concerns about the market reaction. The other interval includes information upon which the opponent would want to take the adverse action, but does not if the information is withheld. Hence, the firm is successful in deterring the opponent from imposing the proprietary cost. Even if the firm is essentially interested in only one of these two concerns, it must maintain the second nondisclosure interval. Otherwise a partial-disclosure equilibrium cannot be sustained.

Although there is always a full-disclosure equilibrium, partial-disclosure equilibria have some intuitive properties which suggest that there are nontrivial instances in which they are played. One such property is that the firm always prefers the partial-disclosure equilibrium.

The basic literature on voluntary disclosure if the firm is only concerned about its market price includes Akerlof (1970), Grossman (1981), Milgrom (1981), and Milgrom and Roberts (1986). They show that there is a sequential equilibrium with full disclosure. Jovanovic (1982), Verrecchia (1983), and Dye (1986) introduce exogenous disclosure costs. They assume that these costs are incurred if, and only if, the firm discloses. For a certain class of cost functions, including constant costs, they show that there is never a full-disclosure equilibrium, and there exists a partial-disclosure equilibrium with only favorable information being disclosed. For very high costs this extends to a nondisclosure equilibrium.

These findings are in contrast to those derived in this paper, and are driven by the assumption that the act of disclosing information results in a disclosure cost. This is true for printing costs, for instance. However, in this paper proprietary costs are due to a strategic discrete decision by an opponent who uses all information available. So, if the firm does not disclose, it still can incur proprietary costs, since the opponent might take an adverse action based on the information conveyed by nondisclosure. Conversely, disclosure can result in no proprietary costs if the information disclosed deters the opponent from taking an adverse action. This paper deals with such costs and their influence on disclosure decisions.

A recent paper by Darrough and Stoughton (1990) addresses a similar problem, in a setting in which there is a threat of entry into a monopolist's market. The main difference from this paper is that they analyze only binary private information.[1] For instance, in a binary-information setting partial disclosure cannot be a pure equilibrium strategy, since it would coincide with

[1]Another difference is that this paper explicitly considers three players. For a discussion of the Darrough and Stoughton (1990) paper, see Verrecchia (1990).

full disclosure. Therefore, many of their results are 'knife-edge' cases which include mixed strategies. They are also able to show the existence of nondisclosure equilibria, a result which does not extend to a continuum of information. This paper deals with continuous information, and finds partial equilibria in pure strategies. More intuitive results and more interesting comparative statics can be derived.

The remainder of the paper is organized as follows. Section 2 sets up the basic model. Section 3 derives the main results on equilibrium disclosure strategies. Section 4 provides comparative statics for the proprietary costs and threshold values, and a discussion of the sensitivity of the results with regard to the firm's objectives and the availability of precommitment. Finally, section 5 contains conclusions.

2. The model

The model consists of three players: the firm, an opponent, and a group of (unanimous) investors referred to as the (financial) market. The firm is endowed with private information which is relevant to the market in assessing the firm's price. It is also relevant to the opponent, which can be envisaged as a rival firm that potentially enters the firm's market or a political agency that potentially takes some adverse action against the firm.

The firm possesses an information system which generates a realization

$$y \in Y = \left[\underline{y}, \bar{y}\right],$$

which is observed only by the firm.[2] The distribution over Y is common knowledge. Firm value is denoted by P over Y. Assume $\mathrm{d}P/\mathrm{d}y > 0$, that means information can be ordered in a sense that higher y are more favorable in a sense that they increase firm value. Assume for simplicity that the decision makers in the firm are risk-neutral, so their utility increases linearly with the price P of the firm.[3]

[2] The assumption that the information set is compact is important in the model as some conditions depend on the bounds. However, this is because firm value is a direct function of the information realization [see eq. (1)]. All derived conditions are conditions on firm value, and it is reasonable to assume it to be bounded. An infinite-information set can be modelled by $P = \mathrm{E}[u \mid y]$, where u is a random variable determining firm value [see, e.g., Verrecchia (1983)].

[3] Hereinafter the term 'firm' will be used for the decision maker(s) in the firm, which is usually a manager, but may be the owner. If there are conflicts of interest between the manager and the owner(s) of the firm, then the assumption on the utility function requires the existence of an incentive for the manager to increase firm value. Whether this derives from owning and maybe selling stock, negotiating better terms of loan contracts, or from a bonus plan, is not an issue. It should be mentioned, though, that conflicts of interest can cause the implementation of contracts, including commitments to disclosure strategies, different from those derived here.

The firm has to decide if it wants to disclose the information realization y. The disclosure is observed by both the market and the opponent. Disclosure decisions are restricted to be either the truthful revelation of the observed y or nondisclosure. This requires that there exists a (costless) verification mechanism in order to deter lying if disclosure occurs. One might think of including the information in the audited financial statement.

A *disclosure strategy* is defined by a nondisclosure set $N \subseteq Y$ such that any $y \in N$ is not disclosed. The complementary set is the disclosure set $D \subseteq Y$, with $D = Y \setminus N$. Any $y \in D$ will be disclosed. A strategy is called a *nondisclosure strategy* if D is of measure zero or, equivalently, if almost all $y \in N$, and a *full-disclosure strategy* if N is of measure zero. If both N and D are of strictly positive measure, then the strategy is a *partial-disclosure strategy*. Attention is restricted to pure strategies.[4]

Upon observing the disclosure decision taken by the firm, the market reacts with a change in firm value. The resulting market price of the firm P is assumed to be of the form

$$P(y) = y \qquad \text{for all } y. \tag{1}$$

This assumption helps to keep the analysis tractable and to concentrate on the main issues because it allows for exploiting the property that for any $Z \subset Y$

$$P(Z) = P[\mathrm{E}(y) \mid y \in Z] = \mathrm{E}[P(y) \mid y \in Z] = \mathrm{E}(Z), \tag{2}$$

where E denotes the expectation operator. The last term $\mathrm{E}(Z)$ is used as a shorthand notation for the conditional expectation $\mathrm{E}[y \mid y \in Z]$. The notation of using sets as arguments will also be used for other functions defined on Y. The market is only interested in not being misled by the firm's disclosure decision about the actual occurrence of y. Upon observing disclosure the information asymmetry is resolved, so the firm value will be set to y. Rational expectations on nondisclosure imply a firm value of $\mathrm{E}(N)$ if N is the nondisclosure set of an equilibrium strategy.

[4]Mixed strategies are somewhat unstable as they give no strict advantage to using them instead of any other mixture of the actions involved [see Harsanyi and Selten (1988, pp. 14–16)]. This paper uses the convention that as long as there exist pure strategies equilibria, there is no need to consider mixed strategies. Mixed strategies involving different actions on information sets with measure zero are not considered 'genuine' mixed strategies. An example for such a strategy in a full-disclosure case may be a strategy with an arbitrary mixture of disclosure and nondisclosure of $y = \underline{y}$.

The opponent must decide whether it wants to take an action which has an adverse effect on the firm. A cost $C > 0$ is imposed on the firm if, and only if, the opponent takes the adverse action. C is called a *proprietary cost*. As the market is able to observe or anticipate the action of the opponent, it consequently values the firm at $P - C$ if there is an adverse action. The decision of the opponent is modelled by a binary function b on Y, where $b = 1$ if the action is taken and $b = 0$ otherwise. It is assumed that the more favorable the information (or firm value), the more the opponent is inclined to take the adverse action. Contingent on the disclosure decision by the firm the decision is determined as

$$b(y) = \begin{cases} 0 & \text{for all} \quad y < K, \\ 1 & \text{for all} \quad y \geq K, \end{cases}$$
$$b(N) = \begin{cases} 0 & \text{for all} \quad \mathrm{E}(N) < K, \\ 1 & \text{for all} \quad \mathrm{E}(N) \geq K. \end{cases} \tag{3}$$

For the measure zero event $y = K$, the decision $b(K) = 1$ is fixed arbitrarily.[5] The value K can be interpreted as the reservation cost to the opponent, and from the firm's point of view it indicates the (ex ante) risk that the action is taken. K will be referred to as the *threshold value*. For example, if the opponent is a potential entrant, it will enter the incumbent's market if the information is sufficiently favorable that the entrant expects to at least cover its entry costs, which might be an investment in production facilities or marketing start-up costs. If the opponent is a political agency, it might impose political costs on the firm if the benefits of doing so are greater than the losses, measured in votes or financial support.

In order to exclude uninteresting cases, assume

$$\underline{y} < K < \bar{y}. \tag{4}$$

This assures that there exists information such that the opponent switches decisions. Otherwise the model reduces to the basic disclosure game [see, e.g., Milgrom (1981) and Milgrom and Roberts (1986)], for which there only exists a full-disclosure equilibrium (under the assumptions made in this paper).

3. Equilibrium disclosure strategies

The firm, in pursuing the maximization of its net market price, has two basic objectives which it wants to achieve by selecting its disclosure strategy. First,

[5] Mixed strategies are not considered in this paper.

the firm wishes to deter the opponent from taking the adverse action in order to avoid the proprietary cost C. This means that it has an incentive to disclose only unfavorable information, if any. Second, the firm is interested in a high market price which can be induced by disclosing favorable information. The resulting disclosure will be a trade-off between these two forces.

The solution concept applied is that of a sequential equilibrium.[6] A disclosure strategy is part of a *sequential equilibrium*: (i) if the firm maximizes its net market price given the market's and the opponent's strategies and (ii) if the market and the opponent employ strategies and beliefs such that they are not misled about the information for any decision by the firm. Since the structure of the game is such that both the market and the opponent act on the same information set, it is reasonable to restrict their beliefs to be the same and to assume this to be common knowledge.[7]

This means that if the firm discloses information y, then the firm value will be $y - b(y)C$, and if it does not disclose, then it will be $\mathrm{E}(N) - b(N)C$. If a disclosure strategy is part of an equilibrium, then N must be determined such that the firm has an incentive to disclose any $y \in D$ and to withhold any $y \in N$, taking into account the resulting firm value. The equilibrium nondisclosure set N is then implicitly given by

$$N = \{ y \mid y - b(y)C < \mathrm{E}(N) - b(N)C \}. \tag{5}$$

3.1. Full disclosure

The first result is very general, requiring no restrictions whatsoever on the prior distribution function on Y, the proprietary cost C, and the threshold value K.

Proposition 1. (i) *There exists a sequential equilibrium with full disclosure, and* (ii) *nondisclosure is never part of a sequential equilibrium.*

The proof is in the appendix. Part (i) says that there always exists a sequential equilibrium that includes a full-disclosure strategy. This means that introducing proprietary costs that depend on a strategic action chosen by an opponent may nonetheless result in a full-disclosure equilibrium. The driving

[6]See Kreps and Wilson (1982). Here it eliminates implausible Nash equilibria such as the one in which the opponent and the market ignore any information provided by the firm, and (hence) the firm has no incentive to disclose information (given that the opponent would not enter on nondisclosure).

[7]This derives from the common knowledge assumption about the structure of the game. Kreps and Wilson (1982) impose it by restricting beliefs to be lexicographic consistent. Otherwise it may be that the firm believes that the opponent acts according to one set of equilibrium beliefs and the market according to another set, which may induce the firm to play a strategy different from any equilibrium strategy. A solution including this possibility must be chosen from an enlarged set of game solutions [see, e.g., Bernheim (1984)].

force behind this result is *skeptical beliefs* held by the opponent and the market. They are defined as the worst information, seen from the firm's perspective. There are two candidates for the worst event.[8] It is either $y = \underline{y}$, the lowest firm value under no adverse action, or the lowest value for which the adverse action occurs, which is $y = K$. Firm value in this case is $K - C$, which can be smaller than $\underline{y}$ if K is relatively low and/or C is relatively high. The uninformed players can trigger full disclosure by assuming the lower of $\underline{y}$ and $K - C$ to indicate the withheld information.

It is interesting to compare this result to a situation in which proprietary costs are incurred if, and only if, there is disclosure. Using the assumptions imposed here, the nondisclosure set can be defined as

$$N = \{ y \mid y - C < \mathrm{E}(N) \}.$$

For $C > 0$ there exists a sequential partial-disclosure equilibrium. That is, the probability of nondisclosure is positive. However, there is also a full-disclosure equilibrium in which uninformed players believe $\underline{y} - C$ (or a lower value) if nondisclosure occurs.[9] But these are out-of-equilibrium beliefs and are not played with probability one. For example, suppose the firm deviates from the equilibrium strategy and does not disclose. Then the out-of-equilibrium beliefs are incorrect. In particular, consider the case in which the firm has received $y = \underline{y}$. If it deviates and does not disclose, then the proprietary costs *by definition* are not incurred. Hence, the worst that can happen is a market value of $\underline{y}$, but never $\underline{y} - C$. This means that the out-of-equilibrium beliefs are not sequentially rational, and the full-disclosure Nash-equilibrium is not a sequential equilibrium. Alternatively, if there is a strategic opponent imposing the proprietary cost C, the situation is different because then such beliefs can be justified. In this event there is a sequential full-disclosure equilibrium.

Proposition 1(ii) gives another general result on the emerging equilibria: There never exists a nondisclosure equilibrium. The proof simply requires looking for realizations of y which the firm has an incentive to disclose if the other players assume the firm never discloses: that is, act with $b(Y)$ and generate $P = \mathrm{E}(Y)$. Such y always exist. This result is particularly interesting for $\mathrm{E}(Y) < K$, since in that case disclosure might induce proprietary costs while not disclosing avoids the proprietary costs with probability one. The reason for disclosure stems from the fact that the firm can do better revealing *some* private information.

[8]This is different from a setting with no proprietary costs where skeptical beliefs are always $y = \underline{y}$ [see Milgrom and Roberts (1986)]. The beliefs $y = \underline{y}$ also induce full disclosure for situations in which the restriction on K [eq. (4)] is not satisfied. Otherwise, skeptical beliefs depend on the values of C and K.

[9]If $\underline{y} = -\infty$ [as in Verrecchia (1983)], then these beliefs cannot exist and there is no full-disclosure Nash-equilibrium.

3.2. Partial disclosure

Besides the full-disclosure equilibrium there might exist an additional equilibrium, based on a partial-disclosure strategy. The next result shows properties of this equilibrium and conditions for its existence and nonexistence.

Proposition 2. (i) *If there exists an equilibrium strategy in which the measure of the nondisclosure set N is positive, then $N = [\underline{y}, d_1) \cup [K, d_2)$; moreover, $d_1 = \mathrm{E}(N) < K$ and $b(N) = 0$.* (ii) *A partial-disclosure equilibrium exists if* $\mathrm{E}(Y) < K$ *and* $C > \bar{y} - \underline{y}$; *it has* $N = [\underline{y}, d_1) \cup [K, \bar{y}]$ *and* $\mathrm{E}(N) < \mathrm{E}(Y)$. (iii) *A partial-disclosure equilibrium does not exist if either* (a) $\mathrm{E}(Y) < K$ *and* $C < K - \mathrm{E}(Y)$ *or* (b) $\mathrm{E}(Y) > K$ *and* $C > \bar{y} - \underline{y}$.

The proof is in the appendix. Part (i) describes two basic features of partial-disclosure equilibria. One is that there will be no entry (with probability one) if the firm does not disclose. The other is that a nondisclosure set always consists of two distinct nontrivial intervals of information. The lower interval of N, denoted by N_1, starts with the most unfavorable information $\underline{y}$ and is open on its upper bound d_1 which is equal to the expected value of the information in the nondisclosure set $\mathrm{E}(N)$. The upper interval N_2 starts with the threshold value K and extends to an upper bound d_2 which can be the most favorable information, but need not be.

To understand these properties consider the partial-disclosure equilibrium depicted in fig. 1. The firm value in equilibrium is indicated by the solid lines. In the nondisclosure set, firm value is a constant because the market reacts such that $P = \mathrm{E}(N)$ while the opponent does not take the adverse action. In the set $D_1 = [\mathrm{E}(N), K)$, the market price induced by disclosure is greater than $\mathrm{E}(N)$ and the firm has an incentive to disclose since the opponent refrains from choosing the adverse action. For information more favorable than K, firm value would still go up, but now the opponent imposes C on the firm. So the firm is better off not disclosing information up to $y = \mathrm{E}(N) + C$. For information better than that, the market price outweighs the proprietary costs so that the firm incurs C rather than not disclosing the information and sticking to $\mathrm{E}(N)$.

The reason that $\mathrm{E}(N) > \underline{y}$ and $\mathrm{E}(N) > K - C$ is because the opponent does not take the adverse action upon nondisclosure. Hence, $\mathrm{E}(N)$ is the conditional average of all $y \in N$, which are indicated in fig. 1 by the broken lines. There cannot be a partial-disclosure equilibrium in which the opponent takes the action upon nondisclosure because then the firm would always disclose any $y \in [\underline{y}, K)$, which would destroy the equilibrium.

From fig. 1 it can also be seen that a partial-disclosure equilibrium must consist of two distinct intervals. There cannot be more intervals because of the behavior of $y - b(y)C$; $\mathrm{E}(N)$ cuts off values less than $\mathrm{E}(N)$ and values less

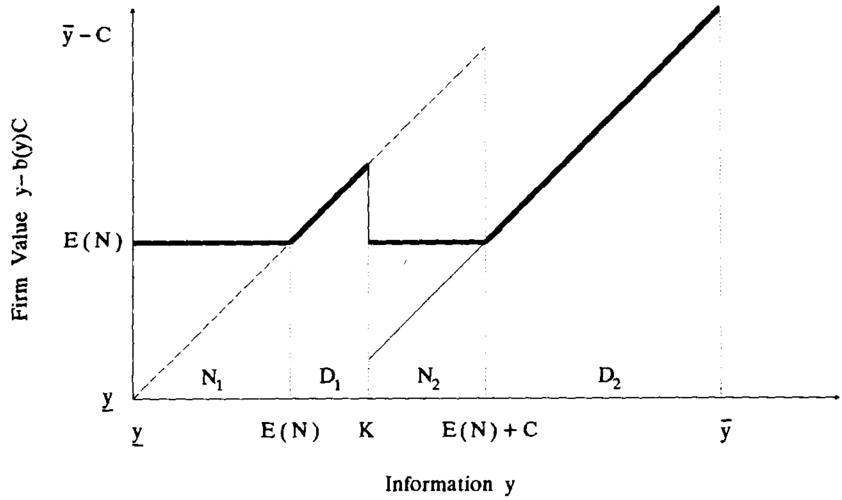

Fig. 1. A partial-disclosure strategy.

than $\mathrm{E}(N)+C$ for $y \geq K$. Intuitively, there cannot be a single interval because if there was, then the uninformed players could revise their beliefs iteratively downwards to the worst case, and full disclosure could be achieved by the well-known unraveling process [see Akerlof (1970)].

The next two parts of Proposition 2 give sufficient conditions for the existence and nonexistence of a partial-disclosure equilibrium. Part (ii) describes an existence condition. If

$$\mathrm{E}(Y) < K \quad \text{and} \quad C > \bar{y} - \underline{y}, \tag{6}$$

then there exists a partial-disclosure equilibrium with a particular property, namely there is only one disclosure interval which includes average information, and the most favorable information is not disclosed. Condition (6) restricts both C and K, but while the restriction on the proprietary cost C is independent of the underlying distribution of information, the threshold value K depends on the average information. If $\mathrm{E}(Y) < K$, then the opponent would not take the adverse action given the prior distribution of y. Such a situation is favorable for the firm because it becomes less likely that it suffers the proprietary cost C. For instance, in an entry setting this would relate to a less competitive environment. The existence condition also requires the proprietary cost C to be very large. Then the firm gives priority to avoiding the adverse action, and it is successful since with its equilibrium strategy it avoids the proprietary cost with probability one. It discloses only information that does not induce the adverse action, and from part (i) of the proposition it follows that the adverse action is also not taken if it does not disclose. Nevertheless, market forces are strong enough to induce some disclosure; full nondisclosure would not be credible. The disclosure set includes average information, and in particular the information $y = \mathrm{E}(Y)$. So, nondisclosure comes at a 'cost', as the market values the firm with $\mathrm{E}(N) < \mathrm{E}(Y)$.

Finally, part (iii) of Proposition 2 states two sufficient conditions for the nonexistence of partial-disclosure equilibria. Again, both conditions contain restrictions on C and K. The first condition covers the situation in which the risk of an adverse action is relatively small, $\mathrm{E}(Y) < K$. If the proprietary cost also is very small, $C < K - \mathrm{E}(Y)$, then a partial-disclosure equilibrium cannot exist because C does not prevent the firm from disclosing any favorable information $y \geq K$. Recognizing this, the market can reduce its beliefs to $\underline{y}$ which induces full disclosure. The higher the threshold value K, the higher the proprietary cost C can be since the high firm value for which the cost will be incurred outweighs the higher cost.

The second condition deals with the situation in which it is *a priori* very likely that the opponent takes the adverse action, which occurs if the threshold value is $K < \mathrm{E}(Y)$. If the firm did not disclose at all, the opponent would find it worthwhile to take the action. If, in addition, the proprietary cost C is very high, then a partial-disclosure equilibrium also cannot exist. The reason for this result is that C is so high that the firm would never want to disclose any $y \geq K$ for any $\mathrm{E}(N)$, but in order to deter the opponent from taking the

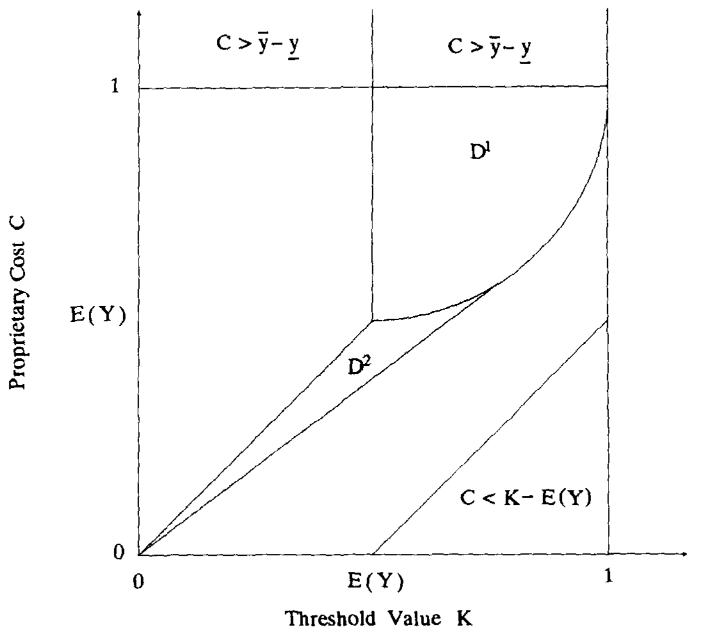

Fig. 2. Disclosure strategies for the example.

adverse action it wants to disclose unfavorable information, regardless of its negative impact on the market price. But such incentives support the beliefs of the opponent that it should take the action if nondisclosure occurs. Since a property of a partial-disclosure equilibrium is that the adverse action is not taken when there is no disclosure, such an equilibrium cannot exist. Essentially, the firm has no chance to deter the adverse action for $y \geq K$, and the market, recognizing this situation, triggers full disclosure.

3.3. An example

All conditions for existence and nonexistence are only sufficient. To see this consider the following example. Let the support of the information be $Y = [0, 1]$, and assume a uniform distribution over Y. This gives $\mathrm{E}(Y) = 0.5$, which is the critical value for K. Fig. 2 depicts partial-disclosure equilibria in the (K, C) space, and shows the restrictions implied by the sufficient conditions given in Proposition 2. Recall that the threshold value K is restricted to lie within the support of information $Y = [0, 1]$ in eq. (4), since for other K there are no partial-disclosure equilibria.

For any constellation of K and C there is a full-disclosure equilibrium. Values of (K, C) which also give rise to partial-disclosure equilibria lie in the two shaded areas. The equilibria in the area indicated by D^1 consist of only one disclosure interval; the upper nondisclosure interval includes all very favorable information. D^1 is also the area in which the proprietary cost can be avoided with probability one. Equilibria in the area D^2 have the property that the upper nondisclosure bound is strictly less than the most favorable information. There thus exist two distinct disclosure intervals.

The existence condition for a partial-disclosure equilibrium in Proposition 2(ii) is shown in fig. 2 as the upper part in the area D^1 for which $C > \bar{y} - Y$. If this holds, then the partial-disclosure strategy consists of only one disclosure interval including average information. The same restriction on the proprietary cost C combined with $\mathrm{E}(Y) < K$ is sufficient that a partial-disclosure equilibrium does not exist. The second nonexistence condition in Proposition 2(iii) cuts off a lower triangle with $C < K - \mathrm{E}(Y)$ in fig. 2. So, all conditions are far from being necessary.

3.4. Choice of equilibria

As in other games with multiple equilibria the question arises as to which equilibrium will eventually emerge.[10] This constitutes a problem if the firm

[10] This section discusses some reasons why a partial-disclosure equilibrium may be played. Since there is always a full-disclosure equilibrium, this is especially important because otherwise the model could not explain actual observations of nondisclosure. See Verrecchia (1990) for a discussion of this point.

does not disclose. Nondisclosure can be the equilibrium strategy in a partial-disclosure equilibrium, or it can be a deviation from the full-disclosure equilibrium. In the first case, the uninformed players should react such that firm value becomes $P = \mathrm{E}(N)$, and in the second case such that it becomes the $\min\{\underline{y}, K - C\}$. Imposing additional restrictions on the out-of-equilibrium beliefs does not help. Out-of-equilibrium beliefs are required only for the full-disclosure equilibrium as nondisclosure occurs with probability zero. Hence, restricting them leaves a partial-disclosure equilibrium unaffected. And the supporting out-of-equilibrium beliefs for the full-disclosure equilibrium are plausible, as is discussed in the proof of Proposition 1(i).

The sequence of the moves gives the firm the power to enforce the full-disclosure equilibrium. It only needs to disclose any information. The sequentially rational reaction of the opponent and the market ensures that they continue to hold correct beliefs. The problem of the multiplicity of equilibria could easily be resolved if the firm preferred the full-disclosure equilibrium. However, this is (strictly) not the case. By construction of a partial-disclosure equilibrium, the firm strictly prefers nondisclosure of any $y \in N$ and is indifferent between disclosure and nondisclosure for $y \in D$.

The firm cannot enforce the partial-disclosure equilibrium because the uninformed players have some power to influence the firm's choice. For instance, if uninformed players impose their skeptical beliefs if there is nondisclosure, they might force the firm to fully disclose. If the opponent and the market prefer the partial-disclosure equilibrium, as does the firm, then it outcome-dominates the full-disclosure equilibrium, and it is reasonable to expect it to be chosen. But this is not the case, either. While it may be argued that the market is indifferent between the two equilibria, the opponent has a strict preference for the full-disclosure equilibrium because it forgoes some profitable opportunities in a partial-disclosure equilibrium. They occur if $y \in N_2 = [K, d_2)$, because the opponent does not take the action even though it would be profitable to do so, were the information available. So, the *ex ante* expected value for the opponent in a partial-disclosure equilibrium is lower than in the full-disclosure equilibrium. Therefore, a general decision on the emerging equilibrium cannot be achieved without imposing more structure on the preferences of the opponent and the market.[11]

[11]For example, let the market be indifferent between the two equilibria, and let the opponent's utility be $b(y)[y - K]$. Equilibrium strategies are denoted by FU for full disclosure and PA for partial disclosure. Denote $N_1 = [\underline{y}, \mathrm{E}(N))$ and $N_2 = [K, d_2)$. In the case of $\underline{y} < K - C$, the opponent is indifferent between playing FU and PA since if the firm plays FU the utility is the same, if the firm plays PA the expected forgone utility is $\mathrm{E}(N_2) - K$ for either case, as well, because the opponent's response to nondisclosure is $b(N) = 0$ in both equilibrium strategies. Since PA is a dominant strategy for the firm, the only equilibrium in equilibrium strategies is partial disclosure. Now let $\underline{y} > K - C$, for which the opponent takes the action on nondisclosure given its strategy FU. Then PA becomes also strictly dominant for the opponent, as it loses more by playing FU if the firm plays PA. It would take the adverse action if $y \in N_1$ and lose $K - \mathrm{E}(N_1) > \mathrm{E}(N_2) - K$ as N_2 is 'closer' to K. Therefore, again the partial-disclosure equilibrium emerges. Under alternative assumptions one might invoke the criterion of risk dominance [see Harsanyi and Selten (1988)].

Arguing from a different perspective, a partial-disclosure equilibrium has an intuitively appealing feature. It can be reached by a dynamic learning process by the uninformed players. Consider a process which starts with the prior beliefs of $\mathrm{E}(Y)$ upon nondisclosure and revises these beliefs after concluding how the firm responds to them, until stable beliefs are reached. If both the full- and partial-disclosure equilibria exist only the partial-disclosure equilibrium can be supported by this dynamic process.

4. Discussion

4.1. Comparative statics

This section derives comparative statics on the equilibrium strategies, in particular the partial-disclosure strategies. It assumes the prevalence of a partial-disclosure equilibrium if one exists, since otherwise the discussion would be uninteresting. Consider the threshold value K first. A lower K indicates that the opponent is *ex ante* more inclined to take the action, which means the risk that the firm incurs the proprietary cost is higher. In general, lower K and higher risk, respectively, *increase* the likelihood that only a full-disclosure equilibrium exists [this comes from the relation to $\mathrm{E}(Y)$ in Proposition 2]. If the risk of the adverse action is high, then the firm cannot do much to deter it, so it is more concerned about the market valuation which induces full disclosure. On the other hand, if the risk is relatively low and the proprietary cost C is high, then the firm can disclose in a way which effectively avoids the cost.

Varying K in the low-risk region only [$K > \mathrm{E}(Y)$] gives the opposite result. Consider partial equilibria with only one disclosure interval. The nondisclosure set is $N = [\underline{y}, \mathrm{E}(N)) \cup [K, \bar{y}]$. It is easy to see that an increase in risk (a lower K) leads to less expected disclosure. Since the firm wants to deter the adverse action, it withholds any information $y \geq K$. But a greater upper nondisclosure interval N_2 induces a greater lower nondisclosure interval N_1, as well, to balance the expectation $\mathrm{E}(N)$. But recall that this is only valid within the range of these particular partial-disclosure equilibria. It does not compare partial- to full-disclosure equilibria.

The effects of different values of the proprietary cost C depend on the values of K. For low risk of an adverse action, disclosure jumps from full to partial disclosure if C increases. Then there can exist a region of partial disclosure with two disclosure intervals. The nondisclosure set is $N = [\underline{y}, \mathrm{E}(N)) \cup [K, \mathrm{E}(N) + C)$ which gives less disclosure for increasing C. If the upper disclosure interval vanishes, then C has no more effect on disclosure. In a high-risk setting, an increase in C also leads to a jump from full to partial disclosure. However, increasing the cost C further, the equilibrium switches back to full disclosure. So, there is no uniform tendency.

The price function was restricted to $P(y)=y$ for all y. The results are easily extended to a linear transformation, $P(y)=P_0+P_1 y$ with $P_1>0$. The parameter P_0 can be interpreted as the absolute firm value. A change of P_0 shifts the whole interval Y upwards or downwards. The parameter P_1 captures the relative change of firm value as compared to the proprietary cost. Varying P_1 changes the relative importance of the effects of informing the opponent and the market. The description of the nondisclosure set changes to

$$N=\{y \mid P_0+P_1 y-b(y)C<P_0+P_1\mathrm{E}(N)-b(N)C\}. \tag{5'}$$

The first observation is that the absolute term P_0 cancels out. Therefore, absolute firm value is irrelevant for the disclosure strategy in equilibrium. The effect of P_1 can be assessed by dividing the inequality in (5′) by P_1, which leads to a substitution of C/P_1 for the cost C in the original eq. (5). Hence, an increase in P_1 is equivalent to a decrease in the relevant proprietary cost, and vice versa. The comparative statics for this were discussed above.

4.2. *Maximizing intrinsic firm value*

Suppose the only objective of the firm is to maximize intrinsic *future* firm value. It is not interested at all in its *current* market price. This could arise if the owner is not seeking to sell his or her shares, if the firm needs no outside capital, or if the manager is not evaluated contingent on firm value. Then the only aim is to deter the opponent from taking the adverse action. This goal can be formally captured by setting $P_1=0$. The following result obtains.

Proposition 3. (i) *There exists a sequential equilibrium with full disclosure and* $b(N)=1$. (ii) *If* $\mathrm{E}(Y)<K$, *then there exists a sequential equilibrium with nondisclosure and* $b(N)=0$.

The proof is in the appendix. Proposition 3 first shows that the equilibria are independent of the proprietary cost C. The firm wants to deter the opponent from taking the action no matter how high or low C is. Part (i) says that the full-disclosure equilibrium from Proposition 1 carries over to this case. Again, there exist other equilibria for certain situations. If the threshold value K is relatively high so that the opponent would not take the action for a nondisclosure strategy, this strategy constitutes another equilibrium. It effectively reduces to zero the probability of incurring the proprietary cost. However, if the risk of an adverse action is relatively high, then the firm always wants to disclose information to avoid the adverse action which is any $y\in[\underline{y}, K)$. Hence, in this case nondisclosure is not an equilibrium strategy.

Neither equilibrium is unique; there exist infinitely many equilibria for each case. Instead of full disclosure, any disclosure strategy with $[\underline{y}, K)\subseteq D$ results in an outcome-equivalent equilibrium. The disclosure of $y \in [\underline{y}, K)$ fully reveals any information needed by the opponent. Hence, these equilibria can be called revealing equilibria. The nondisclosure equilibrium for $E(Y) < K$ is a nonrevealing equilibrium. Other outcome-equivalent equilibria can be constructed by disclosing appropriate y with $b(y) = 0$, such that $b(N) = 0$ is preserved. An example of such a nonrevealing equilibrium is the strategy with $D = [E(N), K)$ described in Proposition 2(ii) for $P_1 > 0$.

The problem of the choice of equilibria exists here, too. The firm strictly prefers a nonrevealing equilibrium, while the opponent prefers a revealing equilibrium. An interesting observation is that for $E(Y) \geq K$ the *ex ante* firm value for $P_1 = 0$ is less than what the firm can achieve for $P_1 > 0$, *if* there is a partial-disclosure equilibrium. The firm, concerned only with avoiding the proprietary cost, might perform worse in equilibrium than if it was also concerned with the market reaction. The reason for this is that under $P_1 = 0$ the incentives to disclose exist only for information which deters the adverse action, and this is unfavorable information $y \in [\underline{y}, K)$. A partial-disclosure equilibrium cannot exist because nondisclosure fully reveals that some $y \geq K$ has been realized. On the other hand, if the firm has an interest in its market price, there may be an incentive to voluntarily disclose very favorable information despite the adverse action by the opponent, and there may be an incentive to withhold very unfavorable information because of a low firm value. If nondisclosure occurs, an uninformed player cannot conclude that the firm must have either purely favorable or unfavorable information. And this is a necessary condition for the existence of a partial-disclosure equilibrium.

Assume, for instance, that the firm can inform each uninformed player separately so that one player cannot observe information disclosed to the other player. Then the market always triggers a full-disclosure strategy by holding skeptical beliefs with $E(N) = \underline{y}$, and the opponent acts as described in Proposition 3. For $E(Y) \geq K$ the firm wishes it had no selective information transmission opportunity available, while it prefers such an opportunity for $E(Y) < K$ if a nonrevealing equilibrium is played.

Comparing the result in Proposition 3 to the results for $P_1 > 0$ shows that the equilibria change. Nondisclosure, for instance, becomes an equilibrium in many circumstances. But observe that the earlier results are valid for any value of $P_1 > 0$. Hence, the slightest perturbance by current market-price concerns eliminates the results in Proposition 3. Looking at this result from a different perspective, it is often suggested that firms try to pursue the goals of long-term shareholders for which only the future value matters ($P_1 = 0$) and short-term shareholders which are interested in the current market price of the firm ($P_1 > 0$). If the firm uses a weight $k \in (0, 1)$ to aggregate these two goals,[12]

[12]See Miller and Rock (1985).

then still $kP_1 + (1-k)0 > 0$, and the main results go through. Hence, the assumption $P_1 = 0$ is very unlikely to occur in reality.

4.3. Precommitment

Equilibrium disclosure strategies, generally, are different from a strategy which minimizes the *probability of incurring proprietary costs*. Often, the trade-off results in incurring proprietary costs in order to provide favorable information to the market. In a full-disclosure equilibrium there is always the risk that the opponent takes the adverse action and imposes the proprietary cost on the firm. Even in partial-disclosure equilibria with two disclosure intervals this possibility exists. The only equilibrium strategy for which no adverse action occurs is the partial-disclosure equilibrium with only one disclosure interval.

The strategies which minimize the expected proprietary costs for $\mathrm{E}(Y) < K$ are nondisclosure or any nonrevealing disclosure strategy [see the discussion of Proposition 3(ii)]. For $\mathrm{E}(Y) \geq K$, it is a disclosure strategy with $N = [\underline{y}, d)$, and the upper bound d chosen such that $\mathrm{E}(N)$ is maximized under the condition that $b(N) = 0$. This gives $\mathrm{E}(N)$ slightly below K. But note that this is not an equilibrium strategy because it demands that the firm discloses only such $y \geq d > K$ for which the adverse action is induced with probability one. The firm would always want to deviate for such information. Hence, this strategy is only credible if the firm can *precommit* to use it.

How can the availability of precommitment affect the results, in general? A precommitment can be credible only if it is made *ex ante*, that is, before the firm observes the realization y from the information system. Allowing precommitments to arbitrary strategies, it is obvious that it is (weakly) preferable to always precommit, because the firm can precommit to the equilibrium strategy. For example, the availability of precommitments solves the problem of the multiplicity of equilibria. Since the firm always prefers a partial-disclosure equilibrium to a full-disclosure equilibrium, it can enforce it by precommitting to it.

It might be very costly to enforce arbitrary precommitments. Therefore the following discussion restricts attention only to precommitments the compliance with which can be observed by the uninformed players themselves. These are the full-disclosure and full-nondisclosure strategies. Contrary to partial disclosure, any deviation from one of these two strategies will be detected by the opponent and the market, and if there exist sufficient penalties, both can be enforced easily. Assume that renegotiation is not possible.

Results depend only on the relation between $\mathrm{E}(Y)$ and K. Consider first $\mathrm{E}(Y) < K$, i.e., the opponent is not very likely to take the adverse action. The firm has an incentive to precommit to nondisclosure for any value of the proprietary cost C. Nondisclosure is strictly preferred to the full-disclosure equilibrium because it leads to a firm value of $E(Y)$, whereas full disclosure results in $E(Y)-[1-F(K)]C$. For relatively high C there also exists a partial-disclosure equilibrium. If it has two distinct disclosure intervals, then there still exists the possibility of entry, which gives an *ex ante* firm value of $E(Y)-F(D_2)C<E(Y)$. For higher C than these, there is a partial-disclosure equilibrium with only one disclosure interval which has the property that the opponent does not take the adverse action with probability one, leaving the firm indifferent between precommitment to nondisclosure and this equilibrium. However, as there is always a chance that the full-disclosure equilibrium emerges, precommitment is still preferable.

Now consider $E(Y)>K$. The full-disclosure equilibrium leads to an *ex ante* expected firm value of $E(Y)-[1-F(K)]C$. A precommitment to full nondisclosure would lead the opponent to take the action, which resulted in a decrease of firm value to $E(Y)-C$. So it is not desirable. A precommitment to full disclosure, on the other hand, has no advantage over simply playing the equilibrium strategy, as the result is the same. However, it might exclude the possibility that a partial-disclosure equilibrium emerged for some parameter constellations, which is strictly preferable to full disclosure. This discussion highlights the fact that precommitting to *simple* strategies may be advantageous in some cases, while it is not in other cases.

5. Conclusion

This paper considers a game-theoretic setting with a privately informed firm, an opponent, and a financial market. The opponent can be a rival firm which decides if it should enter the market, or it can be some political agency which might impose costs on the firm via regulation changes or other actions. The market updates its assessment of the firm value after observing the disclosure decision using rational expectations. Its only objective is that it not be misled by the firm about the information, on average. The firm faces a trade-off in its decision on disclosure of its private information, as it wants both to induce a high market price and to avoid proprietary costs. Disclosure of favorable information induces a higher market price of the firm but can incur proprietary costs via an adverse action of the opponent, and vice versa.

Two general results are shown: first, there always exists a full-disclosure equilibrium and, second, there never exists a nondisclosure equilibrium. This is true for any level of proprietary costs and any level of risk that the opponent takes the adverse action. In addition to the full-disclosure equilibria there can be partial-disclosure equilibria. Sufficient conditions for their existence and nonexistence are shown. The disclosure strategy in such an equilibrium has two nondisclosure intervals, one includes the most unfavorable information, the other extends over some middle range and possibly up to the most favorable information. Hence, there may be one or two disclosure intervals. It is argued that partial-disclosure equilibria have some intuitive properties. They are preferred by the firm, and they are limiting results of a learning process. Therefore, in a situation in which both a full- and a partial-disclosure equilibrium exist one can expect the partial-disclosure equilibrium to occur.

Partial-disclosure equilibria exist if the risk of the adverse action is rather low *ex ante*, and the proprietary costs are rather high. Then the firm's priority is to deter the opponent from taking the action, and this can be achieved with partial disclosure. Partial disclosure always lowers the probability that the opponent takes its adverse action, but it cannot always achieve a probability of zero.

Comparative statics discuss the effects of varying the levels of proprietary costs and the threshold value. There are some results which show that the trade-off results are somewhat different than what might be expected. For instance, it is not always true that higher proprietary costs or higher risk that the opponent takes the adverse action lead to less disclosure of favorable information. The result usually depends on both parameters.

This has an interesting application to the effect of political costs on voluntary disclosure.[13] The political cost hypothesis usually states: The higher the risk that political costs are incurred (measured by some proxy), the less likely the firm discloses favorable information. This hypothesis is supported by the results of this paper if the political costs are very high and the risk is rather low. However, unfavorable information is also increasingly withheld to balance the nondisclosure of favorable information. Moreover, if the political costs are not very high, then a change in the risk has no effect on the disclosure behavior. This result extends to the case if the risk of political costs is relatively high already. Hence, in general, empirical studies might wish to assess the level of political costs in order to make the political cost hypothesis more precise.[14]

The model uses a rather simple setting. For instance, one may argue that the assumption of fixed proprietary costs is too restrictive. The costs might be modelled by an exogenous function contingent on the information disclosed or inferred. They might even be endogenously determined by imposing more structure to the setting. For example, assume the firm is a monopoly, and there exists a rival firm threatening to enter, in which case a duopoly arises.[15]

[13]See, e.g., Chow and Wong-Boren (1987), Wong (1988a, b), Watts and Zimmerman (1986, ch. 10).

[14]It may be argued that a political agency does not react strategically but is functionally fixated. Let this behavior be formalized as follows: When the firm discloses then the opponent reacts correctly with $b(y)$; however, for nondisclosure it reacts with $b(Y)$ instead of $b(N)$. Then it can be shown that for high risk, which is $\mathrm{E}(Y) > K$, there is always only a full-disclosure equilibrium. And for low risk all results on partial-disclosure equilibria go through, and full disclosure is only an equilibrium strategy if $\underline{y} < K - C$.

[15]See Milgrom and Roberts (1982) with a signaling model. Disclosure in this setting is modelled in Darrough and Stoughton (1990). Similar models appear in Dontoh (1988), Clarke (1983), and Gal-Or (1986).

However, extensions like this add only to the complexity without leading to different results because the main assumption driving the results of this paper is the behavior of the net firm value contingent on the information. Firm value increases with more favorable information, and if the opponent takes the adverse action then firm value discretely drops to a lower level before it rises again. This two-peak shape is sufficient to retain all major results, such as the existence of full-disclosure equilibria and nonexistence of nondisclosure equilibria, and if there is a partial-disclosure equilibrium, then it has two nondisclosure intervals. Varying the proprietary cost function has an effect only on the sufficient conditions for the existence and nonexistence of partial-disclosure equilibria.[16]

Possible extensions include the introduction of an information asymmetry about C or K which are assumed to be common knowledge in this paper. The partial-disclosure strategies might be affected by this additional information asymmetry. Other extensions are the introduction of additional costs (information-acquisition costs, disclosure costs), multiple information, or multiple periods. But generally, it is very likely that the insights into the trade-off modelled here remain unchanged.

Appendix

A.1. Proof of Proposition 1

(i) *Case 1*: $\underline{y} < K - C$. Suppose the beliefs of the opponent and the market in case of nondisclosure are $y = \underline{y}$. This results in the following nondisclosure set:

$$N = \left\{ y \mid y - b(y)C < \underline{y} \right\} = \varnothing .$$

This is because all y such that $b(y) = 0$ are greater or equal to $\underline{y}$. The lowest y with $b(y) = 1$ is $y = K$, for which the initial condition implies $y - C \geq K - C > \underline{y}$. Hence, the firm has a strict incentive to disclose all y except for $y = \underline{y}$ for which it is indifferent. The out-of-equilibrium beliefs are plausible or intuitive [see, e.g., Cho and Kreps (1987)] as $y = \underline{y}$ is the information for which the firm can gain most (i.e., not lose) by deviating. For any other information a deviation would make the firm strictly worse off than playing the equilibrium strategy.

[16] For example, suppose the proprietary cost is a fixed percentage c of y, $c \in (0,1)$. If the firm discloses a $y \geq K$ the firm value becomes $y(1 - c)$. Applying the methods used for the proofs it is easy to see that Proposition 1 and Proposition 2(i) go through without a change. The nondisclosure set N is defined as $N = \{ y \mid y[1 - b(y)c] < \mathrm{E}(N)\}$. A nonexistence result in the spirit of Proposition 2(iii), case (a) gives the sufficient condition $\mathrm{E}(Y) < K$ and $c < 1 - \mathrm{E}(Y)/K$. And partial disclosure equilibria do exist. E.g., let $Y = [0,1]$, and the distribution over Y be uniform. Then for $K = 0.7$ and any $c > 0.53$, a partial disclosure equilibrium has $N = [0, 0.475) \cup [0.7, 1]$.

Case 2: $\underline{y} \geq K - C$. Fix the beliefs in case of nondisclosure to $y = K$ which is the lowest value of y such that $b(y) = 1$. The nondisclosure set is

$$N = \{ y \mid y - b(y)C < K - C \} = \varnothing .$$

By the assumption for case 2 the inequality cannot be fulfilled for any y, which results in full disclosure. Also here, the out-of-equilibrium beliefs of $y = K$ are plausible as it is the only information for which a deviation by the firm does not result in a strict disadvantage.

(ii) The proof shows that given the uninformed players believe in nondisclosure, the firm will always deviate for some information. Therefore, nondisclosure cannot be an equilibrium.

Case 1: $\mathrm{E}(Y) \geq K$. Assume nondisclosure, then $b(Y) = 1$, and the firm has an incentive to disclose any

$$y \in [\mathrm{E}(Y), \bar{y}] .$$

Case 2: $\mathrm{E}(Y) < K$. Then nondisclosure would result in $b(Y) = 0$. But there exists a set $[\mathrm{E}(Y), K)$ with the property that $b(y) = 0$ for all these y contained in the set which is not empty because $\mathrm{E}(Y) < K$. The firm has an incentive to disclose these y since disclosure increases firm value. Q.E.D.

A.2. Proof of Proposition 2

(i) According to the definition

$$N = \{ y \mid y - b(y)C < \mathrm{E}(N) - b(N)C \} .$$

To show that N consists of two intervals note that $\mathrm{E}(N) - b(N)C$ is a constant. Consider some y, for which $b(y) = 0$. This y must be in the set $[\underline{y}, K]$. Then N contains an interval $[\underline{y}, \min\{ K, \mathrm{E}(N) - b(N)C \})$, which is a lower interval, if the set is well defined (i.e., the lower bound is less than or equal to the upper bound). Similarly, for y with $b(y) = 1$, N contains another interval,

$$[K, \min\{ \mathrm{E}(N) - b(N)C + C, \bar{y} \}),$$

if it is well defined. Hence, any nondisclosure set in which N has positive measure can consist of no more than two intervals (or convex sets), or

$$N = [\underline{y}, d_1) \cup [K, d_2), \qquad \underline{y} < d_1 \leq K < d_2 .$$

Before $d_1 < K$ can be shown it is necessary to prove $b(N) = 0$ first. Suppose to the contrary, $b(N) = 1$. Then the firm has an incentive to disclose y which satisfy

$$y - b(y)C \geq \mathrm{E}(N) - b(N)C = \mathrm{E}(N) - C.$$

Hence it would disclose any $y \geq \mathrm{E}(N)$, and since $\mathrm{E}(N) < d_2$ by definition of N, there exist such $y \in N$. Thus, such a set N cannot be part of an equilibrium. To see that $d_1 < K$, note that $b(N) = 0$ implies that $\mathrm{E}(N) < K$. Then, by definition of N, $d_1 = \mathrm{E}(N) < K$.

Remark: The set N is not necessarily unique. Uniqueness depends on the distribution function over Y. [A similar observation has been made by Dye (1986).]

(ii) If some y is to be disclosed it must satisfy $y - b(y)C \geq \mathrm{E}(N) \geq \underline{y}$ [since $b(N) = 0$]. Assume that

$$\bar{y} - C < \underline{y},$$

then there cannot exist an upper disclosure interval

$$D_2 = [d_2, \bar{y}].$$

Hence, the nondisclosure set must be of the form

$$N = [\underline{y}, \mathrm{E}(N)) \cup [K, \bar{y}].$$

Since the upper interval of N does not move it must be that $\mathrm{E}(N) > \underline{y}$, implying that also the lower interval of N is not an empty set. Moreover, N must consist of two distinct intervals, as at least $y \in [\mathrm{E}(Y), K)$ are disclosed [recall that $\mathrm{E}(Y) < K$ by assumption, so this set is well-defined]. This readily implies $\mathrm{E}(N) < \mathrm{E}(Y)$ and $b(N) = 0$, as $b(Y) = 0$. Since only $y < K$ will be disclosed the opponent will not take the action with probability one.

(iii) Suppose there exists a partial-disclosure equilibrium with

$$N = [\underline{y}, \mathrm{E}(N)) \cup [K, d_2), \qquad \underline{y} < \mathrm{E}(N) < K < d_2.$$

By definition, $K < d_2 = \min\{\mathrm{E}(N) + C, \bar{y}\}$.

Consider (a) $\mathrm{E}(Y) < K$ and $C < K - \mathrm{E}(Y)$. Since the lower interval starts with $\underline{y}$ up to the expected value of N it must be that $\mathrm{E}(N) \leq \mathrm{E}(Y)$. For $C < K - \mathrm{E}(Y)$ the upper interval vanishes, as $\mathrm{E}(N) + C \leq \mathrm{E}(Y) + C < K$. The lower interval remains, but $N = [\underline{y}, \mathrm{E}(N))$ can only be fulfilled if $N = \varnothing$.

Otherwise there would always be some $y \in N$ which the firm wanted to disclose. But $N = \varnothing$ contradicts the property that N has positive measure in a partial-disclosure equilibrium.

(b) $\mathrm{E}(Y) > K$ and $C > \bar{y} - \underline{y}$. By definition of N, it contains all $y \geq K$ for which

$$y - C < E(N) < K.$$

$\bar{y} \in N$ if $\bar{y} - C < \mathrm{E}(N)$. Combined with the assumption

$$\bar{y} - C \leq \underline{y} < \mathrm{E}(N) < K < \mathrm{E}(Y),$$

this implies that all $y \geq K$ are in N. Since $K < \mathrm{E}(Y)$ it follows that $\mathrm{E}(N) \geq \mathrm{E}(Y) > K$ which is a contradiction. Q.E.D.

A.3. Proof of Proposition 3

(i) Let $b(N) = 1$. This induces disclosure of any $y \in [\underline{y}, K)$ for which $b(y) = 0$, in order to deter the adverse action. $[\underline{y}, K) \subseteq D$, however, reinforces the beliefs $b(N) = 1$. The disclosure strategy of any $y \geq K$ is arbitrary, as $b(y) = b(N) = 1$. Therefore, full disclosure is an equilibrium strategy.

(ii) Suppose the opponent believes in a nondisclosure equilibrium, then $b(N) = b(Y) = 0$ because $\mathrm{E}(Y) < K$. The firm cannot be better off by disclosing any y, hence, there is no advantage from deviating from a nondisclosure strategy. This confirms the beliefs of the opponent. Q.E.D.

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