Voluntary Disclosure with a Potential Competitor

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Abstract

This paper analyzes a firm's incentives to disclose private information on market demand and its cost when there is a potential entrant. In such a situation, revelation of the state by the incumbent affects the entry decision. The model illustrates that there is a unique fully revealing disclosure equilibrium in which every type of the incumbent, except the high demand-high cost type (the most favorable state for the entrant), is transparent. This result is due to the strong incentive of the high demand-high cost type to be nontransparent in any equilibrium candidate in order to discourage entry. This keeps other types from being nontransparent so that they can prevent pooling with the high demand-high cost type. The full disclosure equilibrium ceases to be unique when the incumbent needs external financing in the form of risky debt. It creates a second force affecting the disclosure policy, which is the incumbent's own profitability. The incumbent type with the least prospects (the low demand-high cost type) may get an incentive to pool with the high demand-high cost type to issue debt less costly.

JEL codes: M41, L13, G39

A Introduction

In today's financial system, firms accessing capital markets are required to follow mandatory disclosure rules set by corresponding regulatory institutions like the Securities and Exchange Commission (SEC). In addition to this, some firms but not all make voluntary disclosures such as management forecasts, press releases, etc. This action makes sense when one takes into consideration the informational asymmetry existing between managers and other stakeholders about value-relevant firm related information. Thus, these voluntary disclosures could be aiming at minimizing the 'lemons problem' of Akerlof (1970) as much as possible. However, a puzzling empirical fact is that firms' voluntary disclosure policies differ a lot in terms of the amount and types of disclosures supplied. While some firms are known for being transparent others are likely to be much more silent (Lang, 1998 and Watson *et al.,* 2002). A challenging task for researchers is to determine and understand the underlying incentives behind these varying actions of voluntary disclosure.

Several attempts have been made in different scenarios relating voluntary disclosure. This paper studies voluntary disclosure policy of an incumbent firm when there is a potential entrant into the market. The incumbent firm holds private information about the market demand and its own production

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cost. Both the market demand and incumbent's production cost can be high or low. The incumbent can choose a different disclosure policy depending on the combination of the demand and its own cost state since the state she is in affects the entry probability of the entrant. While a high (low) market demand increases (decreases) the entry probability, a low (high) cost incumbent discourages (encourages) entry. However, the analysis shows that there exists a unique fully revealing disclosure equilibrium in which every type of the incumbent, except the high demand-high cost type, are transparent. The high demand-high cost type is indifferent between a transparent and nontransparent disclosure policy in this equilibrium. The key point behind this result is that the high demand-high cost type or the most favorable state from the viewpoint of the entrant is likely to be nontransparent in any equilibrium candidate. By committing to a nontransparent disclosure policy, the high demand-high cost type tries to decrease the entry probability. She would succeed in this attempt if any other type of incumbent, which is in a less favorable state for the entrant, also prefers to be nontransparent in equilibrium. However, it is not optimal for any other type of incumbent to be pooled with the high demand-high cost type. When they are nontransparent like the high demand-high cost type, this would lead to an increase in the entry probability of the entrant compared to the entry probability when they are transparent. Thus, all of the incumbent types disclose their private information in equilibrium due to the strong incentive of the high demand-high cost type to withold information which leaves this type as indifferent at the end. Yet, the unique fully revealing equilibrium of the model reinforces the 'paradox' that empirically, while some firms are transparent, others prefer to stay silent.

Additional to being at variance with empirical observation, the statement that even the incumbent with the least prospects (low demand-high cost type) decides to reveal her type, is atypical. Particularly, this is very questionable if there exists a third party assessing the incumbent in terms of profitability like her financiers or the financial market. Taking this effect into account, the model is then extended to the case of risky debt issuance by the incumbent. In such a scenario, since the riskier the incumbent from the viewpoint of the debtholders the more costly the debt issuance is, low demand-high cost type would become very cautious disclosing her type. This is due to the fact that the debtholders become claimants to the profit of the incumbent due to the limited liability in case of a default. Additional to the earlier fully revealing equilibrium, this extended model yields an equilibrium in which high demand-high cost and low demand-high cost types do not disclose their types and hold the same level of debt whereas the other two types reveal their information. In this equilibrium, the low demand-high cost type prefers to pool with the high demand-high cost type, whose profits are higher than hers, because she can decrease her debt amount to be paid back. As before, the high demand-high cost type would like to camouflage herself due to the entrant's higher probability of entry in her state. That is to say, these two types pool together because low demand-high cost type can deceive the debtholders and issue debt less costly and high demand-high cost type succeeds in misleading the entrant about her true state. And, the other two types (low demand-low cost and high demand-low cost types) prefer to seperate themselves because pooling benefit them neither from the debt nor the entry side. The equilibrium decisions of these two types to disclose or not are very much dependent on each other. They may prefer to be nontransparent only if the other is nontransparent especially when the product market structure is such that the marginal effect of cost is higher than the marginal effect of demand on profits which make them the

most advantegous two types both in terms of profitability and (lower) entry likelihood. Accordingly, the characteristics of equilibria change depending on the profit ordering of the states (types) which is determined by the marginal effects of cost vs demand.

The main contribution of this paper to the existing literature is, analyzing disclosure incentives of an incumbent firm when market demand (industry-wide) and cost (firm-specific) information co-exist. Although there has been extensive research about voluntary disclosure of demand or cost information in oligopoly markets, the simultaneous effect of demand and cost on voluntary disclosure has been neglected. These models study the optimal disclosure policy of either demand or cost information in Cournot or Bertrand competition settings. Their results change depending on the assumed competition structure. However, the main result of the full-disclosure equilibrium of the present model does not depend on any competition structure but is very general. Additionally, the previous models assume a binary decision of entry for the entrant. The entrant either enters or stays out depending on the disclosure decision of the incumbent. However, the current model assumes a random entry cost. The entrant enters into the market with some probability depending on her expected profit upon entry which is contingent on the information disclosed. This construction also avoids the necessity of assuming fixed proprietary costs which is common in similar models. Last but not least, the model also considers the case of risky debt issuance by the incumbent which is expected to have an effect on the disclosure policy. The extended model clearly illustrates that a second effect in addition to the entry effect exists in influencing the disclosure policy. This second effect is the incumbent's own profitability which has an effect on her riskiness (cost of debt issuance) and in turn on her disclosure policy. With this new effect, incumbent types who are fully disclosing before may get new incentives to pool with the high demand-high cost type. This is particularly true for the type with the lowest profits, the low demand-high cost type. This impact of (risky) debt issuance on disclosure policy in an entry game has not been much covered in the earlier literature.

The next section provides more detailed information regarding the earlier literature and restates the contributions of this paper.

B Prior Research

The earliest studies on voluntary disclosure are Grossman (1981) and Milgrom (1981). They analyze disclosure policy when a firm is evaluated by the financial market. In this case, the only equilibrium is full disclosure. Afterward, the optimal disclosure of market demand or cost information has been extensively examined beginning with Vives (1984) and Gal-or (1985, 1986). The main results are disclosure of (concealing) market demand is optimal with Bertrand (Cournot) competition. Conversely, disclosure of (concealing) cost information is optimal with Cournot (Bertrand) competition.

Mostly related papers to the current one are Darrough and Stoughton (1990), Wagenhofer (1989), Hwang and Kirby (2000) and Pae (2002). Darrough and Stoughton (1990) considers an entry game like

in this paper in which the incumbent holds private information only about market demand. [1] Different than this paper, the incumbent is evaluated both by the entrant and financial market contingent on disclosed information. They assume binary entry decision for the entrant which is not the case in the current model. Wagenhofer (1989) deals with a similar problem but considers continuous private (market demand) information of the incumbent which is more general than binary information structure of Darrough and Stoughton (1990). Hwang and Kirby (2000) study a game where firms in an oligopolistic market hold private information about their own cost levels and new entry to the market is also possible. Pae (2002) is the single paper which considers the disclosure of market demand and cost information simultaneously. He considers an incumbent firm which operates in the market as a monopolist and becomes privately informed about the market demand and its production cost in the first period. In the second period, a new firm which is uninformed enters to the market. The incumbent prefers to fully disclose its private information in equilibrium like in the current model. The reason behind this result is the inter-temporal incentives of the incumbent. By disclosing full information, the incumbent nullifies its self-defeating intertemporal incentives by which she tries to deceive the entrant about the real state. The present paper offers an alternative explanation for the full-disclosure equilibrium with a signalling game. As opposed Pae (2002) who is restricted to the case of Cournot competition, the results of this paper hold in a more general competitive market setup. Additionally, Pae (2002) assumes no entry cost for the entrant which implies the entrant always enters in the second period. This is also not the case in this model which assumes a random entry cost.

Related to the intersection of debt and information disclosure, Dasgupta and Shin (1999) show that a higher debt level of the uninformed rival can lead to more information disclosure by the informed firm in a duopoly market. Their result is very much related to the well-known result of Brander and Lewis (1986) which is, leverage makes a firm more agressive and to produce more in oligopolistic product markets. This paper, on the other hand, shows that financing of the incumbent with (risky) debt causes less information disclosure in an entry game as the fully revealing equilibrium ceases to be unique.

C The Model

The model is a Bayesian Game with signalling. There are two players. The first player is an incumbent firm which holds a monopoly position in a product market. The second player is an entrant firm which is willing to enter this market. In the beginning, nature chooses the type of the incumbent. There are four possible types of incumbent that correspond to combinations of two different demand and cost levels. After observing her type, the incumbent determines her disclosure policy which can be disclosing the state (both cost and demand state) or witholding all information. The profit of the incumbent is affected by her disclosure policy through the potential entrant's decision. While a high (low) market demand increases (decreases) the entry probability, a low (high) cost incumbent discourages (encourages) entry. The entrant disburses a random cost of K to enter the market with continuous cumulative distribution

[1] Darrough and Stoughton (1990) does not call the private information as the market demand but as favorable vs unfavorable information.

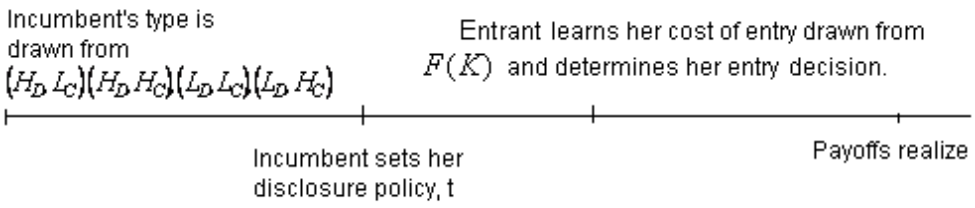

Figure 1: Timeline of events in the model

function, $F(K)$. That means the entrant always enters into the market with some probability. An important assumption in this setting is that the entrant becomes informed about the state once she enters the market even when the incumbent has chosen non-transparency.

Outlining the timeline of events once again: First, nature chooses the incumbent's type. Then the incumbent determines her disclosure policy which can be either disclosing the state or withholding all information, after learning the state she is in. Thus, disclosure policy of the incumbent is a binary decision. The variable $t \in \{0, 1\}$ indicates the disclosure decision of the incumbent, with $t = 1$ standing for full disclosure. Following the incumbent's move, the entrant learns his entry cost drawn from $F(K)$ and decides whether to enter or not. Finally, payoffs realize in the product market. Figure 1 summarizes the timeline of events.

The states or the types of the incumbent are denoted by ω where $\omega \in \{1, 2, 3, 4\}$. Each state, from 1 to 4, occur with probabilities α, β, θ and μ which are common knowledge. Type 1 corresponds to the high demand-low cost state (H_D, L_C) whereas type 2 corresponds to the high demand-high cost state (H_D, H_C). Similarly, type 3 refers to the low demand-low cost state (L_D, L_C), whereas type 4 corresponds to the low demand-high cost state (L_D, H_C). The profit of the incumbent in state ω is denoted $\pi_I(\omega)$ when the entrant enters and $\Pi(\omega)$, when she does not. Here, $\Pi(\omega)$ refers to the monopoly profit in state ω. The profit of the entrant in state ω is denoted $\pi_E(\omega)$, when she is in the market. It is clear that the monopoly profit is larger than the duopoly profit in ω, $\Pi(\omega) > \pi_I(\omega)$. Additionally, it is possible to order monopoly (duopoly) profits in different states.

The best possible state for the incumbent is the high demand-low cost state $\omega = 1$ whereas, the worst possible state is low demand-high cost, $\omega = 4$. Thus, the monopoly and duopoly profits of the incumbent can be ordered as $\pi_I(1) \geq \pi_I(2) \geq \pi_I(4)$ ($\Pi(1) \geq \Pi(2) \geq \Pi(4)$) and $\pi_I(1) \geq \pi_I(3) \geq \pi_I(4)$ ($\Pi(1) \geq \Pi(3) \geq \Pi(4)$). However, it is not possible to make a comparison between $\pi_I(2)$ and $\pi_I(3)$ ($\Pi(2)$ and $\Pi(3)$). In a similar fashion, the profits of the entrant can be ordered as $\pi_E(2) \geq \pi_E(1) \geq \pi_E(3)$ and $\pi_E(2) \geq \pi_E(4) \geq \pi_E(3)$. The entrant benefits from a high demand state but suffers from a low-cost competitor. Thus, one cannot compare the profits of $\pi_E(1)$ and $\pi_E(4)$ like in the case of incumbent with $\pi_I(2)$ and $\pi_I(3)$. The complete ordering of incumbent's and entrant's profits depends on the marginal effects of cost and demand.

Both players are risk neutral and maximize their expected terminal payoff. That is to say, the incumbent decides on her disclosure policy to maximize her expected payoff and the entrant determines her entry probability such that she enters the market only if she obtains positive payoff.

Last but not least, an important assumption in the model is truthful and costless disclosure. It is reasonable to assume that firms truthfully disclose, especially if they are subject to auditing.

D Strategic Analysis

D.1 Disclosure Decision

Backwards induction is used in order to determine the Perfect Bayesian-Nash equilibria of the game. First, the entry decision of the entrant in terms of probabilities is determined. The entrant knows the type of the incumbent with probability one when she encounters a transparent incumbent. In this situation, she enters into the market with probability $F(\pi_E(\omega))$ where $\omega \in \{1, 2, 3, 4\}$. Hence, she enters only when her cost of entry is less than her payoff. On the other hand, the entrant forms posterior beliefs according to Bayes' rule at each information set where she encounters a non-transparent incumbent. The posterior beliefs are denoted by $q(\omega|t = 0)$ where $t = 0$ indicates a nontransparent disclosure policy. Now, the entrant enters the market with probability $F(\sum_{\omega=1}^{4} q(\omega|t = 0)\pi_E(\omega))$. Accordingly, she takes into consideration her expected payoff after seeing a non-transparent incumbent and enters the market when she obtains positive payoff.

Now turn to the incumbent's disclosure decision. Intuitively, the disclosure decision of the incumbent depends mainly on the entrant's decision. When the entrant is more likely to enter, the incumbent is more likely to conceal information. This fact creates strong incentive for the high demand-high cost type ($\omega = 2$) to choose a nontransparent policy. This is because the entrant can obtain the highest possible profit when the incumbent is of type 2. On the other hand, the low demand-low cost type ($\omega = 3$) is the least likely type to prefer a nontransparent policy since it is not a profitable state for the entrant. This intuition is formalized in the following proposition.

Proposition 1. *There exist a PBE where all types are transparent. In this equilibrium, only type* 2 *is indifferent between a transparent and nontransparent disclosure policy. The consistent equilibrium belief is* $q(2|t = 0) = 1$.

Proof. We show that the proposed equilibrium strategies constitute best responses for each type under the equilibrium beliefs which are consistent with the equilibrium strategies.
For type 1 which is the high demand-low cost type the payoff of transparency must be at least as high as the payoff of nontransparency. This leads to the following inequality:

$$F(\pi_E(1))\pi_I(1) + (1 - F(\pi_E(1)))\Pi(1) \geq F(\pi_E(2))\pi_I(1) + (1 - F(\pi_E(2)))\Pi(1) \tag{1}$$

In this inequality, the entrant uses her equilibrium beliefs when she faces a nontransparent incumbent. The inequality becomes:

$$[F(\pi_E(2)) - F(\pi_E(1))]\Pi(1) \geq [F(\pi_E(2)) - F(\pi_E(1))]\pi_I(1) \tag{2}$$

It is clear that $\Pi(1) \geq \pi_I(1)$ .That means eq.(2) always holds if $F(\pi_E(2)) \geq F(\pi_E(1)) \Leftrightarrow \pi_E(2) \geq \pi_E(1)$ which is actually the case.
A very similar argument holds for the other types. Type 2, which is the high demand-high cost type, is indifferent between transparency and nontransparency that is,

$$F(\pi_E(2))\pi_I(2) + (1 - F(\pi_E(2)))\Pi(2) = F(\pi_E(2))\pi_I(2) + (1 - F(\pi_E(2)))\Pi(2) \tag{3}$$

The payoffs of transparent and nontransparent disclosure policies for type 2 are equal under the equilibrium beliefs.
Like type 1, the low demand-low cost type ($\omega = 3$) also prefers transparency:

$$F(\pi_E(3))\pi_I(3) + (1 - F(\pi_E(3)))\Pi(3) \geq F(\pi_E(2))\pi_I(3) + (1 - F(\pi_E(2)))\Pi(3) \tag{4}$$

which leads to:

$$[F(\pi_E(2)) - F(\pi_E(3))]\Pi(3) \geq [F(\pi_E(2)) - F(\pi_E(3))]\pi_I(3) \tag{5}$$

which holds since $F(\pi_E(2)) \geq F(\pi_E(3)) \Leftrightarrow \pi_E(2) \geq \pi_E(3)$.
Finally, the low demand-high cost type ($\omega = 4$) prefers transparency:

$$F(\pi_E(4))\pi_I(4) + (1 - F(\pi_E(4)))\Pi(4) \geq F(\pi_E(2))\pi_I(4) + (1 - F(\pi_E(2)))\Pi(4) \Rightarrow \tag{6}$$

$$[F(\pi_E(2)) - F(\pi_E(4))]\Pi(4) \geq [F(\pi_E(2)) - F(\pi_E(4))]\pi_I(4) \tag{7}$$

Eq.(7) holds since $F(\pi_E(2)) \geq F(\pi_E(4)) \Leftrightarrow \pi_E(2) \geq \pi_E(4)$. ■

Proposition 1 shows the existence of a full disclosure equilibrium. Furthermore, the next proposition illustrates that this is the unique equilibrium of the game in pure strategies. The insight behind this result can be summarized as follows: Revealing her state is a dominant strategy for the low demand-low cost type ($\omega = 3$) since it is the least profitable state for the entrant. Conversely, the high demand-high cost type ($\omega = 2$) would like to withold the information especially when the other types are also nontransparent. By committing to a nontransparent disclosure policy, she tries to discourage entry since it is the most promising state for the entrant. Anticipating this, the other types avoid to be pooled with the high demand-high cost type by disclosing their state. They prefer disclosure since getting pooled with the high demand-high cost type would lead to an increase in the entry probability compared to when they are transparent. Here, Proposition 2 follows.

Proposition 2. *The equilibrium of Proposition 1 is the unique equilibrium in pure strategies.*

Proof. In PBE the equilibrium beliefs need to be consistent with the equilibrium strategies. In other

words, on the equilibrium path players hold the right beliefs. While keeping this in mind, one should also realize that the high demand-high cost type ($\omega = 2$) always weakly prefers to be nontransparent in any other equilibrium candidate. This is due to the fact that $F(\pi_E(2)) \geq F(\sum_{\omega=1}^{4} q(\omega|t=0)\pi_E(\omega)) \Leftrightarrow \pi_E(2) \geq \sum_{\omega=1}^{4} q(\omega|t=0)\pi_E(\omega)$.
On the other hand, the low demand-low cost type ($\omega = 3$) always weakly prefers to be transparent since $F(\sum_{\omega=1}^{4} q(\omega|t=0)\pi_E(\omega)) \geq F(\pi_E(3)) \Leftrightarrow \sum_{\omega=1}^{4} q(\omega|t=0)\pi_E(\omega) \geq \pi_E(3)$.
With the above facts, there remain three equilibrium candidates except the one in proposition 1. These are that either one of the types 1 or 4 is nontransparent, and both 1 and 4 are nontransparent at the same time:

a) The equilibrium candidate in which high demand-low cost and high demand-high cost types ($\omega = 1$ and $\omega = 2$) are nontransparent cannot realize. In this equilibrium consistent posterior beliefs are: $q(1|t=0) + q(2|t=0) = 1$, $q(3|t=0) = 0$ and $q(4|t=0) = 0$. For $\omega = 1$, these beliefs imply $F(\pi_E(1)) < F(q(1|t=0)\pi_E(1) + q(2|t=0)\pi_E(2)) \Leftrightarrow \pi_E(1) < q(1|t=0)\pi_E(1) + q(2|t=0)\pi_E(2) \Leftrightarrow \pi_E(1) < \pi_E(2)$. This inequality implies that the payoff of a transparent policy is larger or equal than the payoff of a nontransparent policy for type 1. This contradicts the proposed equilibrium and the beliefs.

b) The same logic is true for the equilibrium candidate in which low demand-high cost and high demand-high cost types ($\omega = 4$ and $\omega = 2$) are nontransparent: In this case, the consistent posterior beliefs are $q(4|t=0) + q(2|t=0) = 1$, $q(3|t=0) = 0$ and $q(1|t=0) = 0$ which implies $F(\pi_E(4)) < F(q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2)) \Leftrightarrow \pi_E(4) < q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2) \Leftrightarrow \pi_E(4) < \pi_E(2)$. Thus, type $\omega = 4$ prefers to be transparent which is a contradiction.

c) The last equilibrium candidate that requires inspection is where all three types, except 3, are nontransparent. The consistent beliefs are: $q(4|t=0)+q(2|t=0)+q(1|t=0,D) = 1$ and $q(3|t=0) = 0$. In this equilibrium, for types 1 and 4 the payoff of nontransparency should be larger or equal than the payoff of transparency:

$$\begin{aligned} &F(\pi_E(4)) \geq F(q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2) + q(1|t=0)\pi_E(1)) \\ &\Leftrightarrow \pi_E(4) \geq q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2) + q(1|t=0)\pi_E(1) \end{aligned} \tag{8}$$

and

$$\begin{aligned} &F(\pi_E(1)) \geq F(q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2) + q(1|t=0)\pi_E(1)) \\ &\Leftrightarrow \pi_E(1) \geq q(4|t=0)\pi_E(4) + q(2|t=0)\pi_E(2) + q(1|t=0)\pi_E(1) \end{aligned} \tag{9}$$

.
Solving both inequalities simultaneously yields: $q(2|t=0) \leq q(1|t=0)\frac{\pi_E(4)-\pi_E(1)}{\pi_E(2)-\pi_E(4)}$ and $q(2|t=0) \leq (1 - q(1|t=0))\frac{\pi_E(1)-\pi_E(4)}{\pi_E(2)-\pi_E(4)}$. It is unclear whether $\pi_E(1) \geq \pi_E(4)$ or $\pi_E(4) \geq \pi_E(1)$. However, either way it implies $q(2|t=0) \leq 0$. So, the only plausible posterior probability (belief) distribution is $q(2|t=0) = 0$ and $q(1|t=0) + q(4|t=0) = 1$ which is not consistent with the proposed equilibrium where all three types 1, 2 and 4 are nontransparent. ■

Up to now, the solution of the disclosure policy game has offered only one answer. According to the model, all types of firms prefer to be transparent. However, casual observation suggests that fully seperating equilibrium is not very common. This result reinforces the 'paradox' that empirically, while some firms are transparent, others prefer to stay silent. This unrealistic aspect leads to questioning the assumptions of the model. In view of that, a firm is not solely evaluated by its competitors but usually there exists a third party assessing the incumbent in terms of profitability like her financiers or the financial market. If such a third party existed, the incumbent with the least prospects (the low demand-high cost type) would think twice before disclosing her type. This is due to the fact that the debtholders become claimants to the profit of the incumbent owing to the limited liability in case of a default. This implies that as the riskier the incumbent from the viewpoint of the debtholders the more costly the debt issuance is. This effect can now prevent the low demand-high cost type being transparent and provide incentives to pool with the high demand-high cost type which is less riskier from the viewpoint of debtholders. Taking this effect into account, the next section considers the case of risky debt issuance by the incumbent.

E The Model with Risky Debt Issuance

The basic idea of the model is the same as before except that the incumbent needs to raise some external financing denoted I in the form of standard debt with face value of D in order to start production. In a situation of such a borrowing by the incumbent, consider the case that the debt is riskless. Since the incumbent is prosperous and can pay back her debt in this scenario, the debtholders are not concerned about profitability of the incumbent. That is also why the incumbent does not consider the debtholders when deciding about her disclosure policy. One can easily show that the fully revealing equilibrium of the original model continues to be unique when the incumbent issues riskless debt. But this result changes when the debt becomes risky. The debtholders then become concerned about profitability of the incumbent because in some states the incumbent can default and instead of the face value of debt they get incumbent's profits due to limited liability. In this respect, the debtholders would ask a higher face value of debt back from the incumbent who is riskier or obtains lower profits. In return, the incumbent would take into consideration the debtholders' attitude when determining her disclosure policy. The incumbent type who would be most concerned about this is the one with the least prospects or low demand-high cost type.

In this regard, it is assumed that the incumbent defaults when she does not obtain the monopoly profit ($\Pi(\omega)$) but the duopoly profit ($\pi_I(\omega)$). In other words, the incumbent defaults when the entrant enters the market and debtholders get the duopoly profit, $\pi_I(\omega)$ after such a default.[2] To get such a default scheme, the external financing parameter I should lie in some interval such that $\min \Pi(\omega) = \Pi(4) > I > \max \pi_I(\omega) = \pi_I(1)$[3].

[2]This assumption can be relaxed in a way that while some incumbent types are always sound some default upon entry. But since the ones who default first would be the least profitable ones, the main result of the model would go through.

[3]The first inequality should be satisfied such that I is sufficiently smaller than the left-hand side. The precise threshold is given by the participation constraint of the debtholders $F(\pi_E(\omega))\pi_I(\omega) + (1 - F(\pi_E(\omega)))\min(D, \Pi(\omega)) \geq I$ from which

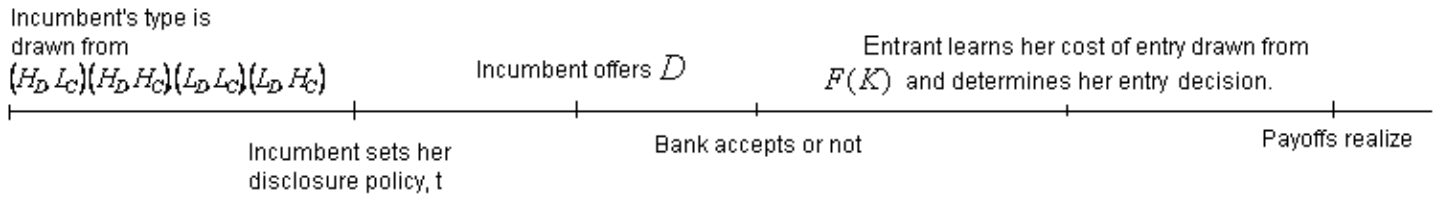

Figure 2: Timeline with the risky debt

The timeline of events changes as follows: First, nature chooses the incumbent's type as before and then incumbent becomes informed. Then again, the incumbent determines her disclosure policy which still has the same structure. Now, after deciding for disclosure policy, the incumbent offers a debt level of D in return of her borrowing I to the investors. The investors can say yes or no to D. This offered debt level D can also be observed by the entrant. Thus, debt level D serves as an additional common signal together with the disclosure policy, $t \in \{0, 1\}$. Following incumbent's moves, the entrant learns his entry cost drawn from $F(K)$ and decides whether to enter or not as in the original model. Finally, payoffs realize in the product market. Figure 2 summarizes the new timeline of events.

The property that the entrant can also observe the debt level D can be considered as natural when the debt in question is a public debt. Thus, one can regard the debt here as a corporate bond.

E.1 Debt Level

The debt level serves as an additional signal given that the incumbent preferred nontransparency in the earlier stage. Hence, the entrant and the debtholders form posterior beliefs according to Bayes' rule after observing both the transparency policy and the offered debt level, D. Define behavior strategies ξ_ω and $\sigma_\omega(D)$ for disclosure policy and choice of debt level, respectively. The posterior beliefs are equal to: $q(\omega|t = 0, D) = \frac{(1-\xi_\omega)\sigma_\omega(D)P(\omega)}{P(t=0,D)}$. Realize that the offered debt level plays no signalling role after transparency since the type of the incumbent is already revealed.
After observing a transparent incumbent, the debtholders accept the debt offer D in state ω if,

$$F(\pi_E(\omega))\pi_I(\omega) + (1 - F(\pi_E(\omega)))D \geq I. \tag{10}$$

This equation is the participation constraint of the debtholders and the incumbent would offer the minimum debt level D pushing the debtholders to the break even point. Thus, the face value of debt to be offered by a transparent incumbent in state ω is

$$D(t = 1) = \frac{I - F(\pi_E(\omega))\pi_I(\omega)}{1 - F(\pi_E(\omega))}. \tag{11}$$

$I \leq \Pi(\omega)\frac{1}{\upsilon}$ where $\upsilon = \frac{1-F(\pi_E(\omega))\frac{\pi_I(\omega)}{I}}{1-F(\pi_E(\omega))} > 1$

On the other hand, the participation constraint of the debtholders after observing a nontransparent incumbent reads as follows,

$$F(\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_E(\omega)) \left[\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_I(\omega)\right] + \left[1 - F(\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_E(\omega))\right] D \geq I. \quad (12)$$

Here, $F(\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_E(\omega))$ is the entry probability as in the original model. Given that the entrant is in the market, the incumbent defaults and the debtholders receive the expected duopoly profit of the incumbent. The debtholders should at least break even in expectation given the posterior beliefs. Then, the face value of debt to be offered by a nontransparent incumbent can be found as

$$D(t=0) = \frac{I - F(\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_E(\omega)) \left[\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_I(\omega)\right]}{\left[1 - F(\sum_{\omega=1}^{4} q(\omega|t=0,D)\pi_E(\omega))\right]} \quad (13)$$

by setting inequality (12) to I.

E.2 Equilibria

This section shows that fully revealing disclosure equilibrium ceases to be unique when there is risky debt issuance in the picture. Risky debt creates a second effect additional to the original entry effect. The second effect is the incumbent's own profitability. Without any risky debt, all incumbent types except the type in the most profitable state for the entrant (the high demand-high cost type) preferred full disclosure. Basically, they did avoid being pooled with the high demand-high cost type in order to minimize the entry probability. And, there was no device to assess incumbent's profitability. This changes if the incumbent needs to borrow some amount from a third party. Then, especially the incumbent type with the least expected profitability (low demand-high cost) would sometimes like to be nontransparent and camouflage herself in order to decrease the punishment by the debtholders even at the cost of being pooled with the high demand-high cost type.

In this respect, the next pages show the existence of an equilibrium in which the high demand-high cost and low demand-high cost types do not disclose their types and hold the same level of debt whereas the other two types reveal their information, which is additional to the still existing fully revealing disclosure equilibrium.

Proposition 3 states the condition that the duopoly profit of the high demand-high cost type, $\pi_I(2)$ should satisfy for the existence of a fully revealing disclosure equilibrium. This condition is necessary to ensure that the low demand-low cost ($\omega = 3$) and low demand-high cost ($\omega = 4$) types do not obtain any benefits from being nontransparent. In other words, $\pi_I(2)$ should be small enough such that the gain of these two types due to obtainment of debt less costly by pooling with the more profitable high demand-high cost ($\omega = 2$) type is smaller than the loss due to more likely presence of the entrant. One can realize that if the profit ordering of the incumbent is such that, $\pi_I(1) \geq \pi_I(3) \geq \pi_I(2) \geq \pi_I(4)$

meaning that the marginal effect of cost is more significant than the the marginal effect of demand, the low demand-low cost ($\omega = 3$) type would have then no gain by pooling from the debt side since she becomes more profitable than the high demand-high cost ($\omega = 2$) type. In this case, the condition on $\pi_I(2)$ stemming from the incentive compatibility of the low demand-low cost ($\omega = 3$) type becomes redundant.

Proposition 3. *There exists a PBE where all types are transparent and each hold a different level of debt which is given by equation 11 given that,*
$\pi_I(2) \leq \min\left(\left[1 - \frac{F(\pi_E(3))}{F(\pi_E(2))}\right]\Pi(3) + \frac{F(\pi_E(3))}{F(\pi_E(2))}\pi_I(3), \left[1 - \frac{F(\pi_E(4))}{F(\pi_E(2))}\right]\Pi(4) + \frac{F(\pi_E(4))}{F(\pi_E(2))}\pi_I(4)\right)$. *Only type 2 is indifferent between a transparent and nontransparent disclosure policy. The consistent equilibrium belief is* $q(2|t=0, \frac{I - F(\pi_E(2))\pi_I(2)}{1-F(\pi_E(2))}) = 1$ *for the equilibrium debt level of type 2.*

Proof. Check that the proposed equilibrium strategies form best responses for each type. The plausible out-of-equilibrium beliefs are given as $q(2|t=0, D) = 1$ for any offered debt level, D.
Starting with type 1, her payoff of transparency is: $[1 - F(\pi_E(1))]\left[\Pi(1) - \frac{I - F(\pi_E(1))\pi_I(1)}{1-F(\pi_E(1))}\right]$. Realize that when the entrant is in the market which occurs with probability $F(\pi_E(1))$, the incumbent goes bankrupt and obtains a zero payoff. The alternative payoff when type 1 is nontransparent and offers the equilibrium debt level of type 2 which is $\frac{I - F(\pi_E(2))\pi_I(2)}{1-F(\pi_E(2))}$, is given as: $[1 - F(\pi_E(2))]\left[\Pi(1) - \frac{I - F(\pi_E(2))\pi_I(2)}{1-F(\pi_E(2))}\right]$. Notice that the equilibrium belief is at work in this payoff. Then, type 1 prefers to be transparent given the following inequality holds:

$$[1 - F(\pi_E(1))]\left[\Pi(1) - \frac{I - F(\pi_E(1))\pi_I(1)}{1 - F(\pi_E(1))}\right] \geq [1 - F(\pi_E(2))]\left[\Pi(1) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] \Leftrightarrow \quad (14)$$

$$F(\pi_E(2))\left[\Pi(1) - \pi_I(2)\right] \geq F(\pi_E(1))\left[\Pi(1) - \pi_I(1)\right] \quad (15)$$

The left hand side of inequality 15 is always strictly bigger than the right hand side meaning that type 1 prefers to disclose. Given the out-of equilibrium beliefs, there is also no better deviation for type 1. If she was nontransparent and offered a debt level which is smaller than the equilibrium debt level of type 2, the debtholders would not accept the offer and type 1 would obtain a zero payoff. If she was nontransparent and offered a larger debt level than the equilibrium level of type 2, this would decrease the right hand side of inequality 15.
Coming to the next one, type 2 is indifferent between two disclosure policies with the following equality,

$$[1 - F(\pi_E(2))]\left[\Pi(2) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] = [1 - F(\pi_E(2))]\left[\Pi(2) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] \quad (16)$$

Like type 1, she has also no better deviation with the given out-of-equilibrium beliefs.
Next, type 3 prefers transparency to being nontransparent and offering the equilibrium debt level of type 2 if,

$$[1 - F(\pi_E(3))]\left[\Pi(3) - \frac{I - F(\pi_E(3))\pi_I(3)}{1 - F(\pi_E(3))}\right] \geq [1 - F(\pi_E(2))]\left[\Pi(3) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] \Leftrightarrow \quad (17)$$

$$F(\pi_E(2))\left[\Pi(3) - \pi_I(2)\right] \geq F(\pi_E(3))\left[\Pi(3) - \pi_I(3)\right] \quad (18)$$

Realize that the above inequality always holds when the marginal effect of cost is more significant than the the marginal effect of demand and so $\pi_I(3) \geq \pi_I(2)$. Otherwise, it holds given that $\pi_I(2) \leq \left[1 - \frac{F(\pi_E(3))}{F(\pi_E(2))}\right] \Pi(3) + \frac{F(\pi_E(3))}{F(\pi_E(2))}\pi_I(3)$.
Finally, type 4 prefers revealing her type to being nontransparent and offering the equilibrium debt level of type 2 given that,

$$[1 - F(\pi_E(4))] \left[\Pi(4) - \frac{I - F(\pi_E(4))\pi_I(4)}{1 - F(\pi_E(4))}\right] \geq [1 - F(\pi_E(2))] \left[\Pi(3) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] \Leftrightarrow \quad (19)$$

$$F(\pi_E(2)) \left[\Pi(4) - \pi_I(2)\right] \geq F(\pi_E(4)) \left[\Pi(4) - \pi_I(4)\right] \quad (20)$$

This inequality holds when $\pi_I(2) \leq \left[1 - \frac{F(\pi_E(4))}{F(\pi_E(2))}\right] \Pi(4) + \frac{F(\pi_E(4))}{F(\pi_E(2))}\pi_I(4)$. ■

The next proposition determines the certain range the profit of the high demand-high cost type ($\pi_I(2)$) should be situated in for the existence of a PBE where the high demand-high cost ($\omega = 2$) and low demand-high cost ($\omega = 4$) types pool together. The conditions on $\pi_I(2)$ stem from incentive compatibility (IC) constraints of each type. Depending on profit ordering which changes whether the demand or the cost effect is more significant, the IC constraints of some types become redundant. This is true when cost effect is more significant. In this case, the profit ordering of the incumbent and the entrant is given as $\pi_I(1) \geq \pi_I(3) \geq \pi_I(2) \geq \pi_I(4)$ and $\pi_E(2) \geq \pi_E(4) \geq \pi_E(1) \geq \pi_E(3)$, respectively. One can realize that types 1 and 3 have no incentives to hide their types and pool with types 2 and 4 with such a profit ordering since they are more advantageous by having a higher profitability and lower entry likelihood.

Proposition 4. *There exists a PBE where types 2 and 4 are nontransparent and offer the same level of debt, $\bar{D}$ which is determined by equation 13 and equilibrium beliefs given that $\pi_I(2)$ lie in a specific range determined below. The other two types are transparent and debt level of each is given by equation 11. The equilibrium beliefs are $q(2|t = 0, \bar{D}) + q(4|t = 0, \bar{D}) = 1$.*

Proof. Check again whether the proposed equilibrium strategies are best responses for each type. The out-of-equilibrium beliefs are given as $q(2|t = 0, D) = q(2|t = 0, \bar{D})$, $q(4|t = 0, D) = q(4|t = 0, \bar{D})$ and $q(2|t = 0, D) + q(4|t = 0, D) = 1$ for any other offered debt level, D.
For type 1, the payoff of transparency versus the payoff of nontransparency when offering the equilibrium debt level, $\bar{D}$ of types 2 and 4 is represented with the following inequality:

$$[1 - F(\pi_E(1))] \left[\Pi(1) - \frac{I - F(\pi_E(1))\pi_I(1)}{1 - F(\pi_E(1))}\right] \geq [1 - F(E\pi_E)] \left[\Pi(1) - \frac{I - F(E\pi_E)E\pi_I}{1 - F(E\pi_E)}\right] \Leftrightarrow \quad (21)$$

$$F(E\pi_E) \left[\Pi(1) - E\pi_I\right] \geq F(\pi_E(1)) \left[\Pi(1) - \pi_I(1)\right] \quad (22)$$

where $E\pi_E = q(2|t = 0, \bar{D})\pi_E(2) + q(4|t = 0, \bar{D})\pi_E(4)$ and $E\pi_I = q(2|t = 0, \bar{D})\pi_I(2) + q(4|t = 0, \bar{D})\pi_I(4)$ which are expected profits of the incumbent and the entrant with equilibrium beliefs. This equilibrium always holds given that the profit ordering of the entrant is such that $\pi_E(2) \geq \pi_E(4) \geq \pi_E(1) \geq \pi_E(3)$ meaning that the cost effect is more significant than the demand effect in determining the profits. This is because type 1 has no incentives to become nontransparent either from the entry or debt side with such

a profit ordering. Otherwise, it should hold that $\pi_I(2) \leq \pi_I(4) + \frac{F(E\pi_E)[\Pi(1)-\pi_I(4)]-F(\pi_E(1))[\Pi(1)-\pi_I(1)]}{F(E\pi_E)q(2|t=0,\bar{D})} = C_1$. Realize that there is also no better deviation with the given out-of-equilibrium beliefs which is valid for all types.

On the other hand, type 2 prefers to be nontransparent and offer the debt level, $\bar{D}$ if the following inequality holds:

$$[1 - F(E\pi_E)] \left[\Pi(2) - \frac{I - F(E\pi_E)E\pi_I}{1 - F(E\pi_E)}\right] \geq [1 - F(\pi_E(2))] \left[\Pi(2) - \frac{I - F(\pi_E(2))\pi_I(2)}{1 - F(\pi_E(2))}\right] \Leftrightarrow \quad (23)$$

$$F(\pi_E(2)) \left[\Pi(2) - \pi_I(2)\right] \geq F(E\pi_E) \left[\Pi(2) - E\pi_I\right] \quad (24)$$

This inequality holds when $\pi_I(2) \leq \Pi(2)\frac{F(\pi_E(2))-F(E\pi_E)}{F(\pi_E(2))-q(2|t=0,\bar{D})F(E\pi_E)} + \frac{F(E\pi_E)q(4|t=0,\bar{D})\pi_I(4)}{F(\pi_E(2))-q(2|t=0,\bar{D})F(E\pi_E)} = C_2$.

Next, type 3 reveals her type instead of being nontransparent and offering the equilibrium debt level of types 2 and 4, $\bar{D}$ given that the respective payoff is large enough:

$$[1 - F(\pi_E(3))] \left[\Pi(3) - \frac{I - F(\pi_E(3))\pi_I(3)}{1 - F(\pi_E(3))}\right] \geq [1 - F(E\pi_E)] \left[\Pi(3) - \frac{I - F(E\pi_E)E\pi_I}{1 - F(E\pi_E)}\right] \Leftrightarrow \quad (25)$$

$$F(E\pi_E) \left[\Pi(3) - E\pi_I\right] \geq F(\pi_E(3)) \left[\Pi(3) - \pi_I(3)\right] \quad (26)$$

This inequality always holds given that the incumbent's profit ordering is such that $\pi_I(1) \geq \pi_I(3) \geq \pi_I(2) \geq \pi_I(4)$ implying that the cost effect has a more significant role than the demand effect in determining the profits. This is because $E\pi_E \geq \pi_E(3)$ and $E\pi_I \leq \pi_I(3)$. However, if demand effect becomes more significant than the cost effect $\pi_I(2)$ should satisfy that $\pi_I(2) \leq \pi_I(4) + \frac{F(E\pi_E)[\Pi(3)-\pi_I(4)]-F(\pi_E(3))[\Pi(3)-\pi_I(3)]}{F(E\pi_E)q(2|t=0,\bar{D})} = C_3$.

Finally, for type 4 the payoff of nontransparency with the debt level, $\bar{D}$ should be larger than the payoff of transparency:

$$[1 - F(E\pi_E)] \left[\Pi(4) - \frac{I - F(E\pi_E)E\pi_I}{1 - F(E\pi_E)}\right] \geq [1 - F(\pi_E(4))] \left[\Pi(4) - \frac{I - F(\pi_E(4))\pi_I(4)}{1 - F(\pi_E(4))}\right] \Leftrightarrow \quad (27)$$

$$F(\pi_E(4)) \left[\Pi(4) - \pi_I(4)\right] \geq F(E\pi_E) \left[\Pi(4) - E\pi_I\right] \quad (28)$$

This gives the following condition: $\pi_I(2) \geq \pi_I(4) + \frac{[F(E\pi_E)-F(\pi_E(4)][\Pi(4)-\pi_I(4)]}{F(E\pi_E)q(2|t=0,\bar{D})} = C_4$.

In summary, depending on the marginal effects of demand and cost which determines the ultimate profit ordering, the equilibrium conditions that $\pi_I(2)$ should satisfy change. Given that the cost effect is more significant, $\pi_I(2)$ should lie in the range of $C_4 \leq \pi_I(2) \leq C_2$. On the other hand, when demand effect becomes more dominant, it should hold that $C_4 \leq \pi_I(2) \leq \min(C_1, C_2, C_3)$.

■

F Conclusion

This paper examines a firm's incentives to disclose private information on market demand and its cost when there is a potential entrant. It is shown that there exists a unique fully revealing disclosure equilibrium in which every type of the incumbent, except the high demand-high cost type, are transparent. The high demand-high cost type is in the most favorable state for the entrant. For that reason, she tries to decrease the entry probability by committing to a nontransparent disclosure policy. And, it is not optimal for any other type to be pooled with the high demand-high cost type since it increases the entry likelihood. However, pooling of some types may occur when the incumbent needs external financing in the form of risky debt. In this case, since the riskier the incumbent from the viewpoint of the debtholders the more costly the debt issuance is, the incumbent type especially with the least prospects (the low demand-high cost type) would not always prefer to reveal her type. This means there exists an equilibrium in which high demand-high cost and low demand-high cost types do not disclose their types and hold the same level of debt whereas the other two types reveal their information. The existence of this second type of equilibrium depend on the duopoly profit of the high demand-high cost type $\pi_I(2)$ which should lie in a specific range. This range changes with the structure of the product market whether the demand or the cost plays a more important role to determine the profits.

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