COMPETITIVE INTELLIGENCE AND DISCLOSURE*

by

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Current Draft: December 2011

Abstract: Competitive intelligence (CI) activities open new opportunities for firms to acquire and disclose information. We show that firms generally direct these activities to acquiring information that is asymmetrically useful to itself and its rival. We further show that disclosure of the acquired information depends on the relative usefulness of information to the rival firms and that it is generally less (more) likely in less (more) competitive markets when firms adopt product differentiation strategies. All of our main results hold even if a firm is uncertain about its information advantage.

Keywords: information sharing, product differentiation, Cournot competition, Bertrand competition, competitive intelligence

JEL Classification Codes: D43, L13, M41

* We thank Jennifer Altamuro, Anil Arya, Masako Darrough, Dick Dietrich, John Fellingham, Leslie Hodder, Pat Hopkins, Rick Johnston, Ranjani Krishnan, Brian Mittendorf, Marc Picconi, Doug Schroeder, Isabel Wang, Rick Young, workshop participants at The Ohio State University, participants at the 2011 American Accounting Association annual meeting and our discussant Leonidas Enrique de la Rosa for helpful discussions and comments. We gratefully acknowledge the financial support provided by the Krannert Graduate School of Management and Purdue University.

1. Introduction.

In recent years firms have invested heavily in competitive intelligence (CI) activities.[1] These activities are focused on developing information and insight about a firm's rivals, the firm's own customers or production costs, and, when necessary, processes for maintaining their secrecy. Much of the focus is on learning and analyzing rival business strategies and developing appropriate responses, but significant effort is also expended studying both the firm's and its rivals' customers and production processes.[2]

The objectives of this paper are to extend our understanding of *ex ante* disclosure policy choices to information environments that more closely capture the impact of corporate CI activities and to begin the examination of firms' strategic incentives to direct those activities to acquire specific information and create the resulting equilibrium information structure. We expect CI activities to produce information structures that differ from those examined previously (Gal–Or 1985, 1986, Darrough 1993 and Raith 1996, among others). The prior literature examines the private values case when a firm has private information about its own production costs and the common values case when a firm has private information about a demand parameter that impacts both its own and its rival's payoffs symmetrically.[3] We generalize the information structure to an intermediate values case in which the information is privately useful to the firm and (at least) partially useful to its rival to allow for an analysis of the firms' CI activities.

This structure leads to disclosure policy choices that are quite different from those in the prior literature. The most familiar result from this work, often referred to as the "flipping result," is that Cournot (Bertrand) competitors adopt a policy of disclosure (non–disclosure) when they have private information about costs but adopt a policy of not disclosing (disclosing) when they have private information about a common demand parameter (Gal–Or 1985, 1986 and Darrough 1993). Further, in the private and common values cases, the firms have a dominant strategy that does not depend on the degree of product heterogeneity or the firms' underlying level of uncertainty.

In the intermediate values information structure, however, regardless of whether firms have pri-

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[1] Fuld [2007] reports on the first survey of CI expenditures and estimates that Fortune 1000 firms spent approximately one billion dollars in 2006. He estimates expenditures on CI activities to grow ten-fold by 2012.

[2] Standard references to CI activities include Prescott and Miller [2001], Carr [2003], Fuld [2006], Liebowitz [2006], Davenport and Harris [2007], Fleisher and Bensoussan [2007] and Ayers [2008].

[3] Raith [1996] introduces imperfect signals and shows how a firm's disclosure policy is affected by both the quality of its signal and how correlated are the signals the firms receive.

vate information about customers or costs and regardless of whether they are Cournot or Bertrand competitors, each adopts a policy of disclosure in some circumstances and a policy of nondisclosure in others. Specifically, in less competitive markets (when firms are Cournot competitors), disclosure requires that the firm's private information be sufficiently asymmetrically useful to the firm and its rival. In contrast, in highly competitive markets (when firms are Bertrand competitors), disclosure requires that the firm's private information be sufficiently useful to both firms. Thus, in general, for parameters such that disclosure occurs in highly competitive markets, it does not occur in less competitive markets and vice versa.

Our analysis also provides initial insights into how the degree of product differentiation affects disclosure policy choices. We show that in less competitive industries, disclosure of either customer or cost information is more likely in more homogeneous product markets. However, in more competitive industries, customer information is less likely and cost information is more likely to be disclosed in more homogeneous product markets. Together, these results suggest that disclosure is generally less (more) likely in less (more) competitive markets when firms adopt differentiation strategies. Finally, we show that there are information structures that lead to asymmetric equilibrium disclosure choices in which one firm adopts a policy of disclosing its private information while the other does not. As a result, our analysis is also the first to provide insight into why not all firms in an industry choose the same disclosure policy.[4]

Having extended our understanding of how the firms' disclosure choices depend on their private information, we then turn to an examination of each firm's equilibrium CI activities. Our analysis indicates that each firm will direct its CI activities toward obtaining information that is predominantly useful to just one of the competing firms (either itself or its rival) instead of information that is relatively equally useful to both. That is, the firms will direct their CI activities to try to avoid the common values information structure. Further, we find that in less competitive industries, each firm intends to disclose the information it acquires regardless of whether it seeks information about customers or costs. In more competitive industries, this is also true when the firm seeks information about costs. However, if the firm seeks information about customers, it intends to not disclose it. This result suggests that regulators seeking to improve disclosure of information about revenues will find it more difficult to rely on private disclosure incentives to achieve their goal.

[4] Interestingly, some, but not all, accounting firms share client information using a third-party vendor as do many insurance firms (Huang 2011) and lenders through the use of credit bureaus (Pagano and Jappelli 1993).

Our results complement those in Jansen [2008] who studies information acquisition and *ex post* disclosure when firms seek information about a common demand intercept. He shows that if firms can invest to increase the likelihood of becoming informed, for a sufficiently flat cost function, *ex post* disclosure leads to greater expected profits than *ex ante* disclosure. Our analysis complements Jansen's by considering disclosure of either demand or cost information and generalizing the usefulness of a firm's private information to the two firms beyond the common values information structure. We also analyze the firm's decision about the type of information to acquire rather than the firm's decision to invest in the likelihood of acquiring a fixed piece of information.

Finally, we extend our analysis to incorporate the possibility that the firm is uncertain whether the information obtained through its CI activities is, in fact, private. One important reason why a firm may be uncertain about its information advantage is that it may be unable to ascertain whether its rival's CI activities have successfully uncovered the information the first firm thought was private. That is, if a firm gathers information about itself, it cannot be sure whether its rival's CI activities have uncovered the same information, and if it gathers information about its rival, it cannot be sure that the rival doesn't also know it. To address this issue, we extend our analysis to include the possibility that the firms' information may not be private. We find that all of our main results hold even if a firm is uncertain about its information advantage. In particular, information gathering choices and disclosure choices are unaffected by this type of uncertainty.

The remainder of the paper is organized as follows. Section 2 contains a description of our model and Section 3 analyzes the equilibrium choices by Cournot and Bertrand competitors as functions of the firms' private information and their disclosure policy choices. Section 4 examines equilibrium disclosure policy choices and Section 5 extends these results to the case when firms are uncertain as to whether their information is, in fact, private. Section 6 examines equilibrium CI choices and we conclude in Section 7.

2. Model

Competitive intelligence (CI) activities have resulted in profound changes in the type of private information available to firms and have opened new opportunities to focus on acquiring specific types of private information. Our objective is to extend our understanding of a company's disclosure choices to these new information structures and to begin the examination of equilibrium CI activity given the firms' subsequent incentives to disclose their private information. Prior work on disclosure policy (*e.g.*, Gal–Or 1985, 1986, Li 1985, Darrough 1993, Sankar 1995, Raith 1996,

summarized in Vives 2008) takes the firms' private information as exogenous, and generally focuses on a company's willingness to disclose private information about its own operations (the private or independent values case) or operational information that affects the payoffs of both firms equally (the common values case). This literature shows that the firms' disclosure policy adoption choices depend on whether the firm has private information about customers or costs and on whether the firms are Cournot or Bertrand competitors.[5]

We extend the information structures analyzed previously by introducing an intermediate values information structure, when a firm's private information is useful to both firms but may be asymmetrically useful to them.[6] Said more intuitively, we allow the firm's private information to give it greater insight into its own opportunities to sell its product (its production costs) than it gives the firm's rival about the rival's opportunities to sell its product (its production costs).[7] In both the private and common values structures studied previously, the strategic reasons for disclosure (affecting the rival's behavior in the product market) are obscured by the information effects of the disclosure. That is, the disclosure reveals value–relevant information about the firm that not only affects the strategic response of the firm's rival but may also be directly useful to the rival. By studying the intermediate values structure, we can examine how the relative importance of these two effects impacts the firm's disclosure policy. Then, having developed an understanding of the firms' disclosure policy choices in the different information environments, we analyze each firm's incentives to *strategically* acquire specific private information through their CI activities.

To highlight the importance of the alternative information structures, we employ virtually the same structure that is used when the private and common values cases are analyzed. In particular,

[5] There is an extensive literature that examines incentives to adopt a policy of disclosing the firm's private information prior to learning it (in contrast to the segment of the disclosure literature that examines *ex post* disclosure). In addition to the key papers mentioned in the text, some recent contributions to the *ex ante* disclosure literature include Maleug and Tsutsui [1996] who examine *ex ante* disclosure when the firms receive signals about the slope of the market demand curve, Arya and Mittendorf [2007] who examine the effect of third party information on *ex ante* disclosure policy choices, and Currarini and Feri [2007] who examine *ex ante* disclosure among subsets of rivals.

[6] This structure contains the private and common values structures as special cases but introduces the ability to vary how important the firm's private information is to understanding its customers (costs) and its rival's. Raith [1996] also generalizes the information structure used in Gal–Or [1985, 1986] and Darrough [1993] but does so in a very different way. Raith assumes that there is an underlying state of nature that affects firm profits, that each firm receives a noisy signal of that underlying state and that conditional expectations are linear. This allows him to distinguish between perfect and imperfect signals (which he shows is important) and to recover the private and common values information structures as special cases associated with specific restrictions on the correlation between firm signals. Our approach differs in that we do not require linear conditional expectations, focus on perfect signals and allow each firm's private information to differentially affect the firm's and its rival's profits. This difference allows us to characterize the firm's disclosure decision and how it depends on the relative usefulness of the information to the two firms.

[7] In concurrent work, Suijs and Wielhouwer [2010] study a special case of our intermediate values structure.

we assume that there are two firms that choose a disclosure policy prior to acquiring their private information. Subsequently, they follow their chosen disclosure policy and then compete in the product market. In section 6 we use this analysis to evaluate information acquisition choices. As is standard, we will analyze two versions of competition in the product market — one in which the firms are Cournot competitors and one in which they are Bertrand competitors.

More formally, let $d_i \in \{D, N\}$ represent the chosen disclosure policy where D (N) represents the choice to commit to disclose (not disclose). Each firm makes its disclosure choice without knowing the choice of its rival. Subsequently, the firms acquire their private information and then follow their chosen disclosure policies. Everything except the firms' private information is common knowledge. As a result, there are (potentially) two sources of information available to each firm. First, each firm has available the private information produced by its CI activities. Second, each firm may have its private information augmented by the information disclosure of its rival. We assume that, if made, the disclosure is truthful. The two firms compete in the product market by selling heterogeneous products and choose an amount to sell (Cournot competition) or a price to charge (Bertrand competition) to maximize expected profits conditional on their information. This structure is summarized by the time line in Figure 1.

The above structure is the standard one used in this literature (*e.g.*, Gal–Or 1985, 1986, Darrough 1993, Raith 1996) but our information assumptions will differ. In particular, we assume that a firm's private information is *either* a_i or c_i, for $i = 1, 2$, where the former is a demand parameter and the latter is a cost parameter. The demands for the firm's products are:[8]

$$p_i = \gamma_{ii} a_i + \gamma_{ij} a_j - q_i - t q_j \qquad i = 1, 2 \tag{1}$$

with $1 \geq \gamma_{ii}, \gamma_{ij} \geq 0$ for $i = 1, 2$ and $1 > t > 0$ to reflect the fact that the firms sell products consumers view as substitutes. Neither firm incurs any fixed costs and their marginal costs are $\delta_{11} c_1 + \delta_{12} c_2$ and $\delta_{21} c_1 + \delta_{22} c_2$ respectively.[9]

Prior to learning their private information, the firms have common priors. That is, both believe that the variables are drawn from known distributions with finite means and variances.

[8] These demands can be readily derived following the analysis in Vives [1984].

[9] The parameters $\gamma_{ii}, \gamma_{ij}, \delta_{ii}$ and δ_{ij} are included to allow us to generalize the information structures previously analyzed. In particular, if the firms have private information about customers, the private values structure is represented by $\gamma_{11} = \gamma_{22} = 1$ and $\gamma_{12} = \gamma_{21} = 0$ and the common values structure by $\gamma_{11} = \gamma_{22} = \gamma_{12} = \gamma_{21} = 1$. If the firms have private information about production costs, the private values structure is represented by $\delta_{11} = \delta_{22} = 1$ and $\delta_{12} = \delta_{21} = 0$ and the common values structure by $\delta_{11} = \delta_{22} = \delta_{12} = \delta_{21} = 1$.

Again to highlight the effects of alternative information structures on disclosure choices, we further assume that all four variables (a_1, a_2, c_1 and c_2) are independent.[10] To avoid problems with corner solutions, we assume that the smallest value of the intercept parameter for each firm exceeds the largest value that firm's marginal costs can take on.

Given this structure, we solve for a Bayes–Nash equilibrium of the model. As usual, we begin by solving the final stage of the game, when the firms compete in the product market. In Section 3.1, we assume that the firms compete by choosing quantities (Cournot competition), and then in Section 3.2 we assume that they compete by choosing prices (Bertrand competition). In both cases, we examine the effect of having private information about a demand parameter and then the effect of the firm having private information about a cost parameter.

3. Final Stage: Product Market Competition

When firms compete in their product markets, each chooses its profit–maximizing quantity or price after learning its private information, after following the disclosure strategy it chose prior to learning its private information, and after learning any information disclosed by its rival. Thus, its decision depends on its own private information (a_i or c_i), the disclosure strategy chosen by its rival, d_j, the information the rival's strategy requires disclosing, and its own disclosure strategy, d_i. Hence, there are sixteen possible information sets for firm i which we will represent by ϕ_i.[11]

3.1 Cournot Competition

If the firms are Cournot competitors, firm i solves $\max_{q_i} \mathrm{E}[(\gamma_{ii}a_i + \gamma_{ij}a_j - q_i - tq_j - \delta_{ii}c_i - \delta_{ij}c_j)q_i \mid \phi_i]$ which yields the first order condition $q_i = (1/2)\mathrm{E}[(\gamma_{ii}a_i + \gamma_{ij}a_j - tq_j - \delta_{ii}c_i - \delta_{ij}c_j) \mid \phi_i]$. The usual calculations yield the following Proposition that describes equilibrium quantity choices and profits in the last stage of our game.

Proposition 1: *If the firms are Cournot competitors, equilibrium quantities are*

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[10] These distributional assumptions differ from those made in the prior literature (*i.e.*, the random variables are normally distributed) and are made to simplify the analysis.

[11] The sixteen possible information sets are found by crossing the alternative private information combinations $\{(a_1, a_2), (a_1, c_2), (c_1, a_2), (c_1, c_2)\}$ with the different combinations of disclosure strategies the firms chose prior to learning their private information $\{(D, D), (D, N), (N, D), (N, N)\}$. Note that if the firm i has private information about customers, then ϕ_i always indicates that firm i knows c_i and vice versa.

$$q_i(D,D) = \frac{1}{(4-t^2)}\left[(2\gamma_{ii} - t\gamma_{ji})a_i + (2\gamma_{ij} - t\gamma_{jj})a_j - (2\delta_{ii} - t\delta_{ji})c_i - (2\delta_{ij} - t\delta_{jj})c_j\right]$$

$$q_i(D,N) = \frac{1}{(4-t^2)}\Big[(2\gamma_{ii} - t\gamma_{ji})a_i + (2\gamma_{ij} - t\gamma_{jj})\mathrm{E}[a_j \mid \phi_i] - (2\delta_{ii} - t\delta_{ji})c_i - (2\delta_{ij} - t\delta_{jj})\mathrm{E}[c_j \mid \phi_i]\Big]$$

$$q_i(N,D) = \frac{1}{2(4-t^2)}\Big[(4-t^2)(\gamma_{ii}a_i - \delta_{ii}c_i) + 2(\gamma_{ij} - t\gamma_{jj})a_j - t(2\gamma_{ji} - t\gamma_{ii})\mathrm{E}[a_i \mid \phi_j] - 2(2\delta_{ij} - t\delta_{jj})c_j + t(2\delta_{ji} - t\delta_{ii})\mathrm{E}[c_i \mid \phi_j]\Big]$$

$$q_i(N,N) = \frac{1}{2(4-t^2)}\Big[(4-t^2)(\gamma_{ii}a_i - \delta_{ii}c_i) - t(2\gamma_{ji} - t\gamma_{ii})\mathrm{E}[a_i \mid \phi_j] + 2(2\gamma_{ij} - t\gamma_{jj})\mathrm{E}[a_j \mid \phi_i] + t(2\delta_{ji} - t\delta_{ii})\mathrm{E}[c_i \mid \phi_j] - 2(2\delta_{ij} - t\delta_{jj})\mathrm{E}[c_j \mid \phi_i]\Big].$$

Equilibrium profits in this stage of the game are $\pi_i^C(d_i, d_j) = [q_i(d_i, d_j)]^2$ *for* $i = 1, 2; j \neq i$.

The equilibrium quantities in Proposition 1 show both the effect of the firm's private information and the effects of the firms' disclosure decisions. As long as γ_{ii}, and γ_{jj} (resp. δ_{ii} and δ_{jj}) are not zero, the firm's private information is always used in determining its own equilibrium output choice. Further, the impact of the firm's information on its output choice increases if these parameters are larger. Thus, the more useful the firm's private information is in reducing uncertainty about its own customers or costs, the more sensitive the firm's output choice is to its private information which increases the variability in the firm's realized profits. Below, we will show that this increased sensitivity increases the firm's expected profits and thus affects its willingness to adopt a policy of disclosing its private information.

3.2 Bertrand Competition

To compare equilibrium disclosure policies when firms are Bertrand rather than Cournot competitors, in this subsection, we assume that firms compete in the product market by choosing prices. To keep the comparison as clear as possible, we maintain the same information structure leaving all of the alternative prior disclosure decision possibilities unchanged. The only difference is that each firm chooses its profit–maximizing price rather than its profit–maximizing quantity.

We begin by inverting the demand curves, equations (1), to obtain[12]

$$q_i = \xi\big[(\gamma_{ii} - t\gamma_{ji})a_i - (\gamma_{ij} - t\gamma_{jj})a_j - p_i + tp_j\big] \qquad i = 1, 2; \quad j \neq i, \tag{2}$$

where $\xi \equiv 1/(1-t^2)$. Using these demand functions, firm i solves

$$\max_{p_i} \mathrm{E}[\xi\big[(\gamma_{ii} - t\gamma_{ji})a_i - (\gamma_{ij} - t\gamma_{jj})a_j - p_i + tp_j\big](p_i - \delta_{ii}c_i - \delta_{ij}c_j) \mid \phi_i]$$

which yields the first order condition

$$p_i = \frac{1}{2\xi}\mathrm{E}[(\gamma_{ii} - t\gamma_{ji})a_i - (\gamma_{ij} - t\gamma_{jj})a_j + tp_j + \xi(\delta_{ii}c_i + \delta_{ij}c_j)) \mid \phi_i].$$

Again, we rely on the firm's information, ϕ_i, to distinguish the alternative cases and the usual calculations yield the following Proposition.

Proposition 2: *If the firms are Bertrand competitors, equilibrium prices are*

$$\begin{aligned}
p_i(D,D) &= \frac{1}{(4-t^2)}\Bigg[\xi\Big(\big((2-t^2)\gamma_{ii} + t\gamma_{ji}\big)a_i + \big((2-t^2)\gamma_{ij} - t\gamma_{jj}\big)a_j\Big) \\
&\qquad + (2\delta_{ii} + t\delta_{ji})c_i + (2\delta_{ij} + t\delta_{jj})c_j\Bigg] \\
p_i(D,N) &= \frac{1}{(4-t^2)}\Bigg[\xi\Big(\big((2-t^2)\gamma_{ii} + t\gamma_{ji}\big)a_i + \big((2-t^2)\gamma_{ij} - t\gamma_{jj}\big)\mathrm{E}[a_j \mid \phi_i]\Big) \\
&\qquad + (2\delta_{ii} + t\delta_{ji})c_i + (2\delta_{ij} + t\delta_{jj})\mathrm{E}[c_j \mid \phi_i]\Bigg] \\
p_i(N,D) &= \frac{1}{2(4-t^2)}\Bigg[(4-t^2)\big(\xi(\gamma_{ii} - t\gamma_{ji})a_i + c_i\big) + 2((2-t^2)\gamma_{ij} - t\gamma_{jj})a_j \\
&\qquad + \xi\big(t((2-t^2)\gamma_{ji} - t\gamma_{ii})\mathrm{E}[a_i \mid \phi_j] - 2(2\delta_{ij} + t\delta_{jj})c_j - t(2\delta_{ji} + t\delta_{ii})\mathrm{E}[c_i \mid \phi_j]\big)\Bigg] \\
p_i(N,N) &= \frac{1}{2(4-t^2)}\Bigg[(4-t^2)\big(\xi(\gamma_{ii} - t\gamma_{ji})a_i + \delta_{ii}c_i\big) + \xi\Big(t\big((2-t^2)\gamma_{ji} - t\gamma_{ii}\big)\mathrm{E}[a_i \mid \phi_j] \\
&\qquad + 2\big((2-t^2)\gamma_{ij} - t\gamma_{jj}\big)\mathrm{E}[a_j \mid \phi_i]\Big) + t(2\delta_{ji} + t\delta_{ii})\mathrm{E}[c_i \mid \phi_j] + 2(2\delta_{ij} + t\delta_{jj})\mathrm{E}[c_j \mid \phi_i]\Bigg]
\end{aligned}$$

and equilibrium profits in this stage of the game are $\pi_i^B(d_i, d_j) = (\frac{1}{\xi})\big(p_i(d_i, d_j) - \mathrm{E}[c_i \mid \phi_i]\big)^2$ *for* $i = 1, 2; j \neq i$.

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[12] This highlights that the definitions of private and common values cases rely on the demand representation in equations (1). When we consider the inverse representation, equations (2), we see that the parameter restrictions described above do not produce situations in which a firm's demand depends only on its private information or on both firms' private information equally. As a result, there are at least two ways to define the private and common values cases. In this paper, we define them using the demand (equations (1)) rather than their inverses (equations (2)).

The equilibrium prices in Proposition 2 show both the effect of the firm's private information and the effects of the firms' disclosure decisions in much the same way that the equilibrium quantities show those effects when firms are Cournot competitors. As long as γ_{ii} and γ_{jj} (resp. δ_{ii} and δ_{jj}) are not zero, the firm's private information is always used in determining the firm's equilibrium price. Whether the firm is able to use its rival's information to tailor its equilibrium price to its customers (or costs) depends on the rival's disclosure decision. Again, for the reasons explained above, the direct benefits from the firm's private information are smaller if these parameters are smaller which reduces the firm's expected payoff from not disclosing and increases the firm's incentives to adopt a policy of disclosure.[13]

4. Stage 2: Disclosure Choices

The equilibrium quantities and profits described in Proposition 1 and the equilibrium prices and profits described in Proposition 2 are conditional on the firms having learned their private information and on following the alternative disclosure policy choices that they may have made. To determine the conditions under which the firms voluntarily commit to disclose their private information once they learn it, we must examine their *ex ante* disclosure incentives. By using the equilibrium choices from Propositions 1 and 2, we can describe the Bayes–Nash equilibrium of the second stage of our game as the equilibrium of the associated normal form game whose payoffs are the expected profits computed for each commitment decision.[14]

		Firm 2	
		D	N
Firm 1	D	$\mathrm{E}[\pi_1^k(D,D)], \mathrm{E}[\pi_2^k(D,D)]$	$\mathrm{E}[\pi_1^k(D,N)], \mathrm{E}[\pi_2^k(N,D)]$
	N	$\mathrm{E}[\pi_1^k(N,D)], \mathrm{E}[\pi_2^k(D,N)]$	$\mathrm{E}[\pi_1^k(N,N)], \mathrm{E}[\pi_2^k(N,N)]$

Comparisons of expected profits will depend on the *ex ante* variance of the demand or cost parameters because profits are proportional to the square of sales (Proposition 1) or mark–up

[13] Propositions 1 and 2 can also be used to understand *ex post* disclosure choices. The Propositions identify whether large or small values of a_i or c_i are "good news," that is, increase the firm's realized profits. If there is either a cost to disclosure or a positive probability that the firm does not have private information, the standard analyses can be used to show that the firm voluntarily discloses its private information if it sufficiently good news. Details are available from the authors upon request.

[14] We let $k = C, B$ designate Cournot and Bertrand competition respectively.

(Proposition 2). Given this, the main result of our analysis on disclosure is presented in Theorem 1.

Theorem 1: (a) *When the firms are Cournot competitors, disclosure of customer information is a dominant strategy for firm i* $(i = 1, 2\ i \neq j)$ *if*

$$\text{(C1)} \qquad (2\gamma_{ji}/t) < \gamma_{ii} \qquad \text{or} \qquad \left(\frac{2t}{8-t^2}\right)\gamma_{ji} > \gamma_{ii},$$

and disclosure of cost information is a dominant strategy for firm i if

$$\text{(C2)} \qquad (2\delta_{ji}/t) < \delta_{ii} \qquad \text{or} \qquad \left(\frac{2t}{8-t^2}\right)\delta_{ji} > \delta_{ii}.$$

(b) *When the firms are Bertrand competitors, disclosure of customer information is a dominant strategy for firm i* $(i = 1, 2\ i \neq j)$ *if*

$$\text{(C3)} \qquad \frac{(2-t^2)\gamma_{ji}}{t} > \gamma_{ii} > \frac{(6-t^2)\gamma_{ji}}{(8-3t^2)}$$

and disclosure of cost information is a dominant strategy for firm if

$$\text{(C4)} \qquad 2t\delta_{ji}/(8-3t^2) > \delta_{ii}.$$

Theorem 1 highlights an important difference between the prior results (Gal–Or 1985, 1986 and Darrough 1993) and those obtained with our more general information structure. In particular, Gal–Or and Darrough describe what is commonly referred to as the "flipping result": if the firms have private information about customers, each chooses to disclose if they are Bertrand competitors and each chooses to not disclose if they are Cournot competitors. If, however, the firms have private information about their own costs, each chooses to not disclose if they are Bertrand competitors and each chooses to disclose if they are Cournot competitors.

In contrast, our results show that regardless of whether firms have private information about customers or costs and whether they are Cournot or Bertrand competitors, there are *always* parameter values for which the firms adopt a policy of disclosing their private information and parameter values for which the firms choose not to adopt a policy of disclosure. This is most easily seen in Figures 2–4 which provide a graphical representation of conditions (C1)–(C4). The figures (conditions) indicate that in less competitive markets (when firms are Cournot competitors), disclosure requires that the firm's private information be sufficiently more useful to one firm than to the other

(see Figure 2). However, in highly competitive markets (when firms are Bertrand competitors), disclosure requires that the firm's private information be sufficiently useful to both firms (see Figures 3 and 4). Thus, in general, for parameters such that disclosure occurs in highly competitive markets, it does not occur in less competitive markets and vice versa.

One way to develop intuition for this new "flipping result" is to note that disclosure creates value if it increases the *ex ante* variability of the firm's equilibrium quantity (price). Increased variability is valuable because profits are convex and so expected profits exceed profits evaluated at the average quantity (price). The firm earns the former if it discloses whereas the firm earns the latter without disclosure because the rival's output (price) can vary with the value of the disclosing firm's private information only if that information is, in fact, disclosed. From Proposition 1, firm i's equilibrium output varies more in its private information (a_i or c_i) when γ_{ii} and γ_{ji} (resp. δ_{ii} or δ_{ji}) are very different. In contrast, from Proposition 2, firm i's equilibrium price varies more when γ_{ii} and γ_{ji} (resp. δ_{ii}, δ_{ji}) are both large. The difference is solely due to the fact that equilibrium choices are strategic substitutes with Cournot competition but strategic complements with Bertrand competition.

To clarify, observe that there are two sources of benefits/costs that accrue to the disclosing firm. First, the disclosure provides the rival with information about its own customers or costs that can it can use to tailor its quantity or price choice to the actual market conditions it faces (*i.e.*, the information effect). Second, the disclosure provides the rival with information about the disclosing firm's customers or costs, and this information allows the rival to more accurately infer the disclosing firm's profit–maximizing quantity or price choice as well as how the disclosing firm would respond to the rival's choice (*i.e.*, the strategic effect).

The magnitude of the information effect is measured by γ_{ji} (δ_{ji}) because this coefficient determines how useful firm i's private information is to its rival. The sign and magnitude of the strategic effect depend on both how important firm i's information is to itself, γ_{ii} (δ_{ii}), and whether the firms' choices are strategic substitutes or complements. In either case, if firm i's information is disclosed, it causes its choice and its rival's to move in the same direction (relative to its expected value). With strategic substitutes, if firm i's information is disclosed, it reduces its expected profits because the strategic effect dampens the direct effect of the firm having private information on its expected profits. That is, if i's private information leads to an increase in output, it does so for the rival, too, and this dampens the direct effect on firm i's profits. In contrast, with strategic

complements, the strategic effect enhances the direct effect — if i's private information leads to an increase in price, it does so for the rival, too, but this effect enhances rather than diminishes the effect on firm i's profits. Thus, under Cournot competition, if firm i's private information has very different usefulness to the two firms, either the strategic effect dominates the information effect (when the information is predominantly useful only to firm i), or the information and strategic effects dominate the direct effect (when the information is predominantly useful only to firm i's rival). Under Bertrand competition, the effects from disclosure are greatest when firm i's private information is useful to both firms rather than predominantly useful to only one. Summarizing, the more likely it is that the firm's CI activities produce information that concentrates on one of the firms' customers or costs and not the other's (*i.e.*, the information is asymmetrically useful), the more likely (less likely) it is that the firms adopt a policy of disclosing their private information when the market is less (more) competitive.

Our results also indicate that there are equilibria in which one firm adopts a policy of disclosing its private information while the rival adopts a policy of not disclosing. Thus, unlike the prior literature, our analysis is consistent with the general observation that not all firms in the same industry adopt the same disclosure policy. For example, if firms are in less competitive industries and one firm has private information about its own costs while the other has private information about market demand (rather than specifically about its own customers), then our results suggest that the first is inclined to adopt a policy of disclosure whereas the second is inclined to adopt a policy of not disclosing its private information. In contrast, if the firms are in more competitive industries, the second is inclined to adopt a policy of disclosure while the first is not.

Theorem 1 also suggests a number of new empirical implications based on our insights into the firms' incentives to adopt a policy of disclosure. For example, our results show that in less competitive industries, there are no substantive differences in disclosure choices when firms have private information about customers rather than production costs. In contrast, firms in more competitive industries are more likely to offer voluntary disclosures of cost information than customer information. Taken together, these results offer an explanation for why regulators focus on revenue recognition requirements. They may also provide some insight into why a majority of SEC enforcement actions focus on reported revenue (Dechow et al. 2011, Plumlee and Yohn 2010).

Our results are also among the first to provide insight into how product heterogeneity impacts

disclosure decisions.[15] In particular, in less competitive industries, disclosure of customer or cost information is more likely in markets with more homogeneous products. In more competitive markets, disclosure of cost information is also more likely in markets with more homogeneous products but disclosure of customer information is *less* likely. Thus, except when the firms are Bertrand competitors deciding whether to disclose information about customers, the more homogeneous the products, the greater are the strategic benefits to disclosure. Intuitively, the more similar are the products the firms sell, the more sensitive the firm's choice (price or quantity) is to its rival's choice. This increased sensitivity enhances the value of providing the rival with information that it uses to tailor its production or pricing decisions to its market conditions.[16] Thus, our analysis offers the empirical prediction that firms that adopt product differentiation strategies are less likely to voluntarily disclose private information about customers or costs whereas firms that adopt cost leadership strategies are more likely to provide such voluntary disclosures.

To gain additional insight into firms' disclosure choices, we next examine some special cases. The proofs of these Corollaries follow from the conditions in Theorem 1 after substituting the appropriate parameter restrictions.[17]

Corollary 1 (Cournot Competition):

(a) *For the common values information structure, the unique equilibrium has both firms adopting a policy of not disclosing their private information about customers or production costs.*

(b) *For the private values information structure, the unique equilibrium has both firms adopting a policy of disclosing their private information about customers or production costs.*

(c) *For the symmetric intermediate values information structure, the unique equilibrium has both firms adopting a policy of disclosing their private information about customers if* $\gamma \equiv \gamma_{ij} = \gamma_{ji} < t/2$ *and adopting a policy of disclosing their private information about their production costs if* $\delta \equiv \delta_{ij} = \delta_{ji} < t/2$. *Otherwise, they adopt a policy of not disclosing their private information.*

Corollary 2 (Bertrand Competition):

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[15] The following results follow from differentiating the critical values in conditions (C1)–(C4).

[16] The information effect of disclosure is (roughly) independent of the degree of product heterogeneity and thus the effect of product heterogeneity predominantly works through the strategic effect of disclosure.

[17] Recall that the common values information structure has $\gamma_{ii} = \gamma_{ij} = \delta_{ji} = \delta_{jj} = 1$ or $\delta_{ii} = \delta_{ij} = \delta_{ji} = \delta_{jj} = 1$; the private values information structure has $\gamma_{ii} = \gamma_{jj} = 1,\ \gamma_{ij} = \gamma_{ji} = 0$ or $\delta_{ii} = \delta_{jj} = 1,\ \delta_{ij} = \delta_{ji} = 0$; and the symmetric intermediate values case has $\gamma_{ii} = \gamma_{jj} = 1$ and $\gamma = \gamma_{ij} = \gamma_{ji}$ or $\delta_{ii} = \delta_{jj} = 1$ and $\delta = \delta_{ij} = \delta_{ji}$),

(a) *For the common values information structure, the unique equilibrium has both firms adopting a policy of disclosing their private information about customers but not disclosing their private information about production costs.*

(b) *For the private values information structure, the unique equilibrium has both firms adopting a policy of not disclosing their private information about customers but disclosing their private information about production costs.*

(c) *For the symmetric intermediate values information structure, the unique equilibrium has both firms adopting a policy of disclosing their private information about customers if* $\gamma \equiv \gamma_{ij} = \gamma_{ji} > t/(2-t^2)$ *and adopt a policy of not disclosing otherwise. In contrast, the firms never adopt a policy of disclosing their private information about their production costs.*

Corollaries 1.a, 1.b, 2.a and 2.b show that the prior results of Gal–Or and Darrough obtain as special cases of our more general analysis of equilibrium incentives to disclose. Interestingly, Corollaries 1.c and 2.c show that, in the symmetric case, disclosure depends on the relation between firm heterogeneity (the magnitude of γ) and product heterogeneity (the magnitude of t). Our results also show that equilibrium disclosure policy choices are surprisingly robust. In particular, they do not depend on the firms' original uncertainty regarding customers or production costs, the firms' prior variances $\mathrm{Var}[a_i]$ or $\mathrm{Var}[c_i]$. That is, when a firm's priors are such that the amount of uncertainty is small (the variance is small), its decision to disclose is the same as it would have been had its priors been such that the amount of uncertainty is large.

Finally, and perhaps more interesting, we observe that it is possible that one firm's CI activities produce information about customers while the other firm's CI activities produce information about production costs. In this mixed case, Theorem 1 again provides the conditions under which firms do (do not) adopt a policy to disclose (summarized in Corollary 3).

Corollary 3: *If firm 1 has private information about customers (production costs) and firm 2 has private information about production costs (customers), the unique equilibrium has each firm disclosing its private information if conditions* (C1) or (C3) (C2 or C4) *hold; neither firm disclosing if the conditions do not hold; and disclosure by only the firm whose condition holds otherwise.*

5. Uncertain Private Information

Theorem 1 characterizes each firm's disclosure choice under the assumption that the firms are certain that their private information is, in fact, private. There are, however, features of CI activities that suggest that firms may not be certain that their information is private. For example, when firms direct significant effort to acquiring information about their rivals, they may remain unsure whether the acquired information is known to the rival. Similarly, firms expend considerable

effort trying to ensure that certain information is not acquired by their rivals but cannot be certain that they have maintained their corporate secrets and thus may not know whether their rivals have acquired/know this information. Given this, we extend our analysis to allow for the possibility that a firm is uncertain as to whether or not the information it has is, in fact, private.

We maintain all of the assumptions made previously but augment them by assuming that the firm's information is private with probability $\rho_i > 0$. For any disclosure choice by the firm's rival (d_j), firm i's payoff from adopting a policy of disclosure is

$$\rho_i \mathrm{E}_i^k[\pi_i(D, d_j)] + (1 - \rho_i)\mathrm{E}_i^k[\pi_i(D, d_j)],$$

and firm i's payoff from adopting a policy of not disclosing is

$$\rho_i \mathrm{E}_i^k[\pi_i(N, d_j)] + (1 - \rho_i)\mathrm{E}_i^k[\pi_i(D, d_j)].$$

Since the second terms in the two expressions are the same, comparing the two expressions is equivalent to comparing $\mathrm{E}_i^k[\pi_i(D, d_j)]$ and $\mathrm{E}_i^k[\pi_i(N, d_j)]$. Since this is exactly the comparison behind the proof of Theorem 1, we have shown

Theorem 2: *As long as there is a positive probability that the firm's information is, in fact, private ($1 \geq \rho_i > 0$), then the firms' equilibrium disclosure choices are the same as when the firms are certain that their information is private.*

Intuitively, the firm bases its disclosure choice only on the possibility that its information is, in fact, private. If it is not private, disclosure has no impact. Consequently, we obtain the same result as before: As long as there is a chance that the firm's information is private, it adopts a policy of disclosing its private information if the conditions in Theorem 1 hold. Uncertainty about the privacy of the firm's information does not affect the firm's disclosure policy choice and thus will not affect how it directs its CI activities and internal accounting system's acquisition of information. That is, Theorem 2 ensures that each firm's equilibrium information acquisition activities will not be affected by any uncertainty regarding whether or not their information is private.

6. Stage 1: Competitive Intelligence Decisions

In the previous section, we developed the implications of the firms disclosure and production (pricing) decisions for every possible information allocation so that we can study the firm's choice of CI activity. More specifically, we model the firm's decision as a choice of how useful the information

it seeks is to itself and its rival.[18] Thus, a firm seeking information about customers (costs) chooses to seek information with the characteristics described by γ_{ii}, γ_{ji} $(\delta_{ii}, \delta_{ji})$.[19] We will refer to the firm seeking rather than acquiring information because the firm may not always find the information it seeks to acquire.

We also simplify our distributional assumptions by adding the requirements that $a_1 =^d a_2$ and $c_1 =^d c_2$. Assuming that the random variables have the same means simplifies expressions considerably, and assuming that they have the same variance allows us to focus on the impact of disclosure choices on information acquisition decisions. Because a firm's expected payoffs are proportional to the variance of its private information, if the variances are not equal, information acquisition choices will be biased toward information with the greatest variance.[20] In addition, in our common values information structure, we assume that $\gamma_{ii} = \gamma_{jj} = 1/2$ rather than 1 so that the total demand for a firm's product isn't larger in the common values structure than it is in the private or reverse values information structures.[21] Finally, we begin by assuming that all CI activities are equally costly and not so expensive as to dissuade the firms from seeking to acquire private information. Assuming that they are equally expensive allows us to focus on benefits of alternative CI choices (the impact on the subsequent disclosure and production (pricing) decisions) rather than on balancing the benefits and costs of alternative CI activities.

Theorem 3: (a) *When firms are Cournot competitors, regardless of whether they direct their CI activities to acquire customer or cost information, they try to acquire information that they subsequently wish to disclose and do so by seeking information that is as asymmetrically useful to the firms as possible.*

(b) *When firms are Bertrand competitors and direct their CI activities to acquire customer information, they try to acquire information that they subsequently wish to keep private and do so by seeking information that about customers that is as asymmetrically useful to the two firms as possible. If they direct their CI activities to acquire cost information, they try to acquire information that they subsequently wish to disclose and do so by seeking information that is as asymmetrically useful to the two firms as possible.*

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[18] That is, we assume that a firm seeking information about customers obtains information about customers (a firm seeking information about costs obtains information about costs), but can neither ensure that it can acquire information that is particularly useful to one or both of the firms.

[19] For example, if the firm seeks customer information that is roughly equally useful to both firms, it seeks information with $\gamma_{ii} \approx \gamma_{ji}$ but if it seeks cost information that is particularly useful to itself, it seeks information with $\delta_{ii} \approx 1;\ \delta_{ji} \approx 0$.

[20] For example, if $\text{Var}[a_i] > \text{Var}[a_j]$ (resp. $\text{Var}[c_i] > \text{Var}[c_j]$), then both firms would generally have incentives to seek information about a_i (resp. c_i) solely because the variance is larger.

[21] This issue does not arise in the prior stages of our analysis because in those stages of the game the analysis is done for a fixed information structure.

Theorem 3 provides some interesting insights into the benefits of alternative CI activities. In particular, there is a strong bias toward seeking information that is useful to the firm itself regardless of the subsequent decision to disclose. Doing so provides the firm with the ability to tailor its production or pricing decision to the current market conditions which increases the firm's expected profits. Interestingly, once the information is available, in three of the four cases, the firm subsequently discloses it to its rival. The only case in which the firm does not subsequently disclose the information it seeks is when the firms are Bertrand competitors and the firm seeks information about its own customers.[22]

Having obtained the results in Theorem 3, we complete the analysis of a firm's equilibrium CI activities by considering the effects of differential costs of the alternative CI activities. When we introduce differential costs of alternative CI activities, it is immediate that if the CI activity chosen is less expensive than the activity not chosen as per Theorem 3, there are no effects on the conclusions described in that theorem. Said differently, if it is less expensive to acquire information that is solely useful to the firm itself, all of the results in Theorem 3 continue to hold. However, if the cost of acquiring information that turns out to be useful to both firms is sufficiently less expensive, then the conclusions in Theorem 3 will reverse—each firm will direct its CI activity toward acquiring information that is useful to both firms.

The proof of Theorem 3 also shows that the difference in expected profits associated with the alternative CI activities depends on the degree of product heterogeneity. In particular, in less competitive markets, the difference is decreasing in the degree of product heterogeneity. Thus, in less competitive markets, smaller differences in the cost of alternative CI activities are needed for firms adopting differentiation strategies to direct their CI activities toward acquiring information that is useful to both the firm and its rival which they subsequently choose not to disclose. In more competitive markets, the same result holds if the firm seeks information about production costs. If, however, the firm seeks information about customers, the difference in expected profits is also declining in the degree of product heterogeneity but in this case, firms adopting differentiation strategies are more likely to seek information that is useful to the firm itself and subsequently disclose it.

While one might reasonably expect that most management accounting activities are likely

[22] This feature reinforces our earlier conclusion that our analysis offers a potential explanation for the need to mandate and monitor revenue disclosures.

to provide information about the firm's own costs, firms do engage in a variety of information activities that likely produce cost information that is useful to both the firm and its rival. For example, Bower [2009] provides a number of examples of oil companies whose test drilling activities provide information useful in determining the value of alternative oil fields—information about both the amount of oil in the field as well as information about the costs of extraction. Since it is frequently the case that multiple oil companies have drilling rights on different plots all of which provide access to the same oil field, information acquired by one is likely to be of use to its rivals. In such cases, it seems reasonable that the cost of acquiring information that is useful to both the firm and its rival may be sufficiently less than the cost of acquiring information that is solely useful to the acquiring firm so as to alter the conclusions in Theorem 3 and lead to the firm seeking information that is useful to both itself and its rival.

7. Conclusions

The objective of this paper is to extend our understanding of disclosure policy choices to information environments that more closely capture the results of corporate competitive intelligence (CI) activities and to begin the examination of how the firm directs those activities to develop its private information. Since these activities produce information structures that differ from those analyzed previously (*e.g.* Gal–Or 1985, 1986, Darrough 1993 and Raith 1996), we generalize the information structure so that a firm's private information is both potentially useful to itself and (at least) partially useful to its rival.[23]

We find that there are situations in which firms adopt a policy of disclosure and others where they do not, regardless of whether they have private information about customers or costs and regardless of whether they are Cournot or Bertrand competitors in their product market. We are also the first to show that there are asymmetric equilibria in which only one firm adopts a policy of disclosure.

We use our results on disclosure choices to show that there is no difference in disclosure of customer or cost information in less competitive industries but that there is a greater tendency to disclose cost rather than customer information in more competitive industries. Thus, our results suggest why regulators may need to (and do) focus on revenue recognition and disclosure requirements and may provide insight into why a majority of SEC enforcement actions focus on reported

[23] Our generalization has the private values and common values structures studied previously as special cases.

revenue (Dechow et al. 2011, Plumlee and Yohn 2010).

Further, in contrast to the prior literature, we show that a firm's disclosure choice also depends on how similar the products the two firms sell are. In less competitive industries, disclosure is more likely the less heterogenous the products are, regardless of whether the firm's private information is about customers or costs. The same is true in more competitive industries when the firm has private information about costs. If, however, the firms have private information about customers, disclosure becomes *less* likely when the products are less heterogeneous. Thus, our analysis suggests that disclosure is less likely in less competitive markets and more likely in more competitive markets when firms adopt differentiation strategies.

We use our results on disclosure choice to analyze strategic CI decisions — how firms choose the type of information that they will try to acquire. We find that absent differences in the costs of acquiring information, in most circumstances, firms seek to acquire information about customers or costs that they subsequently intend to disclose. Only in more competitive industries when firms seek information about customers do they target information that they subsequently intend to keep private. Again, this last result suggests why there may be a need for regulators to focus on revenue disclosures. Finally, we show that all of our results extend to the more realistic situation in which firms are uncertain as to whether their information is, in fact, private. So long as there is some chance that their information is, in fact, private, the firms' disclosure choices and CI activity choices remain unchanged.

In closing, we note that our analysis may also contribute to our understanding of voluntary horizontal and vertical disclosure in supply chains with multiple retailers (Li 2002, Zhang 2002, Ha and Tong 2008, Li and Zhang 2008, and Arya and Mittendorf 2011). The general structure of these models has downstream retailers with private information about a common demand parameter and an upstream (monopolist) manufacturer. Li [2002] and Zhang [2002] show that retailers are unwilling to adopt a policy of disclosure in the presence of a manufacturer who can and does take advantage of their private information when it was disclosed. Intuitively, the monopolist manufacturer extracts all of the expected benefits (and then some) associated with information sharing. Our analysis highlights the importance of firm and product heterogeneity on the horizontal disclosure policy decision of retailers. Since firm heterogeneity generally inhibits the manufacturer's ability to extract retailers' profits, extending the analysis of vertical and horizontal disclosure to the more general information structures considered in this paper should produce added insight into

disclosure in supply chains. Further, since the manufacturer has (at least limited) ability to alter both product and firm heterogeneity, our analysis offers an opportunity to evaluate the usefulness of such strategies in encouraging disclosure.

8. Appendix

Proof of Proposition 1: Firm i solves $\max_{q_i} \mathrm{E}[(\gamma_{ii}a_i + \gamma_{ij}a_j - q_i - tq_j - \delta_{ii}c_i - \delta_{ij}c_j)q_i \mid \phi_i]$ which yields the first order condition $q_i = (1/2)\mathrm{E}[(\gamma_{ii}a_i + \gamma_{ij}a_j - tq_j - \delta_{ii}c_i - \delta_{ij}c_j) \mid \phi_i]$. Each of the cases differ in that the firms' information sets are different. For example, if both have committed to disclose, then both know a_i, a_j, c_i and c_j. In other words, the firms play a game of complete information and we obtain the standard result for $q_i(D, D)$. If firm i has committed to disclose but firm j has not, then firm i does not learn a_j and/or c_j. As a result, firm i's first order condition becomes $(1/2)(\gamma_{ii}a_i + \gamma_{ij}\mathrm{E}[a_j] - t\mathrm{E}[q_j] - \delta_{ii}c_i - \delta_{ij}\mathrm{E}[c_j])$ and firm j's remains the same. Solving produces $q_i(D, N)$ and, by symmetry $q_i(N, D)$. The final case, when both firms commit not to disclose, the first order conditions are again $(1/2)(\gamma_{ii}a_i + \gamma_{ij}\mathrm{E}[a_j] - t\mathrm{E}[q_j] - \delta_{ii}c_i - \delta_{ij}\mathrm{E}[c_j])$. Solving this pair of equations yields $q_i(N, N)$. In each case, substituting the equilibrium quantities into the firm's objective function produces the expression for profits given in the Proposition. ∎

Proof of Proposition 2: Following the same steps as in the proof of Proposition 1 yields the result. ∎

Proof of Theorem 1: (a) *Cournot Competition*: Our proof strategy is to show that $\mathrm{E}[\pi_i^C(D, N)] > \mathrm{E}[\pi_i^C(N, N)]$ and then that $\mathrm{E}[\pi_i^C(D, D)] > \mathrm{E}[\pi_i^C(N, D)]$ which are the conditions required for disclosure to be the dominant strategy. Similarly, reversing the inequalities yields the conditions required for non–disclosure to be the dominant strategy. Direct computations show that[24]

$$\begin{aligned}\mathrm{E}[\pi_i^C(D, N)] - \mathrm{E}[\pi_i^C(N, N)] &= \mathrm{E}[\pi_i^C(D, D)] - \mathrm{E}[\pi_i^C(N, D)] \\ &= \left(\frac{-t}{4(4-t^2)^2}\right)\Big[(-2\gamma_{ji} + t\gamma_{ii})(-8\gamma_{ii} + 2t\gamma_{ji} + t^2\gamma_{ii})\mathrm{Var}[a_i] \\ &\qquad + (-2\delta_{ji} + t\delta_{ii})(-8\delta_{ii} + 2t\delta_{ji} + t^2\delta_{ii})\mathrm{Var}[c_i]\Big].\end{aligned}$$

Thus, if (C1) holds, disclosure of private information about customers is firm 1's dominant strategy. If (C1) fails, non–disclosure is firm 1's dominant strategy. Similarly, if (C2) holds, disclosure of private information about production costs is firm 1's dominant strategy. If (C2) fails, non–disclosure is firm 1's dominant strategy.

(b) *Bertrand Competition*: Following the same reasoning as in part (a),

$$\begin{aligned}&\mathrm{E}[\pi_i^B(D, N)] - \mathrm{E}[\pi_i^B(N, N)] = \mathrm{E}[\pi_i^B(D, D)] - \mathrm{E}[\pi_i^B(N, D)] \\ &= \left(\frac{-t}{4(1-t^2)^3(4-t^2)^2}\right)\Big[\big((-2+t^2)\gamma_{ji} + t\gamma_{ii}\big)(8\gamma_{ii} + t(-6+t^2)\gamma_{ji} - 3t^2\gamma_{ii})\mathrm{Var}[a_i] \\ &\qquad + \left(\frac{t}{4(1-t^2)(4-t^2)^2}\right)(2\delta_{ji} + t\delta_{ii})(-8\delta_{ii} + 2t\delta_{ji} + 3t^2\delta_{ii})\mathrm{Var}[c_i]\Big].\end{aligned}$$

[24] In the following expression, only one of the variances is non–zero, the one associated with the firm's private information. We write the expression with both variances for convenience and to illustrate the similarities in the conditions that lead to the firm choosing to disclose its private information about customers or about costs.

Thus, if (C3) holds, disclosure of private information about customers is firm 1's dominant strategy. If (C3) fails, non–disclosure is firm 1's dominant strategy. Similarly, if (C4) holds, disclosure of private information about production costs is firm 1's dominant strategy. If (C4) fails, non–disclosure is firm 1's dominant strategy. ∎

Proof of Theorem 3: (a) *Cournot Competitors*: First, note that if the firms' CI activities result in subsequently adopting a policy of disclosure, each firm's payoff is independent of exactly what information is acquired by each. The reason is that if they both adopt a policy to disclose, when each chooses its equilibrium quantity, each does so knowing all of the relevant market parameters. Further, Theorem 1 informs us that each firm has a dominant strategy given its information endowment. Thus, we need only compare a firm's expected profits given disclosure with its expected profits given no disclosure. Using the results from Theorem 1 and Proposition 1,[25]

$$\begin{aligned}
&\mathrm{E}[\pi_1^C(D,D)]-\mathrm{E}[\pi_1^C(N,N)] \\
&\quad=\left(\frac{1}{4(4-t^2)^2}\right)\Big[t(2\gamma_{ji}-t\gamma_{ii})((-8+t^2)\gamma_{ii}+2t\gamma_{ji})\mathrm{Var}[a_i]+4(2\gamma_{ij}-t\gamma_{jj})^2\mathrm{Var}[a_j] \\
&\qquad t(2\delta_{ji}-t\delta_{ii})((-8+t^2)\delta_{ii}+2t\delta_{ji})\mathrm{Var}[c_i]+4(2\delta_{ij}-t\delta_{jj})^2\mathrm{Var}[c_j]\Big].
\end{aligned}$$

Since this difference is monotone in $\gamma_{ii}, \gamma_{ji}, \delta_{ii}$ and δ_{ji}, we only need consider the extremes, when each is zero or one.

Consider first the firm's CI decision when it focuses on customer information. We compute the difference in expected profits in the private values and common values cases.[26]

$$\begin{aligned}
&\mathrm{E}[\pi_1^C(D,D)\mid \text{private values}]-\mathrm{E}[\pi_1^C(N,N)\mid \text{common values}] \\
&\quad=\left(\frac{1}{16(4-t^2)^2}\right)\Big[\big((8+4t)\mathrm{E}[a_i]\big)^2+(48+24t^2-t^4)\mathrm{Var}[a_i]\Big]>0.
\end{aligned}$$

Following the same reasoning if the firm's CI activities focus on cost information yields the same expression (with $E[c_i]$ and $\mathrm{Var}[c_i]$ replacing $\mathrm{E}[a_i]$ and $\mathrm{Var}[a_i]$ respectively). Thus, the firm's expected profits if it seeks private values information exceed its expected profits if it seeks common values information and so the firm seeks information that leads to subsequent disclosure. Further, this conclusion holds whether the firm seeks customer or cost information.

(b) *Bertrand Competitors*: Following the same reasoning as above, the results from Theorem 1 and Proposition 1 yield the following:

$$\begin{aligned}
&\mathrm{E}[\pi_1^C(D,D)]-\mathrm{E}[\pi_1^C(N,N)] \\
&\quad=\left(\frac{-1}{4(1-t^2)(4-t^2)^2}\right)\Big[t(-2+t^2)\gamma_{ji}+t\gamma_{ii})((8-3t^2)\gamma_{ii}-t(6-t^2)\gamma_{ji})\mathrm{Var}[a_i] \\
&\qquad+4((-2+t^2)\gamma_{ij}+t\gamma_{jj})^2\mathrm{Var}[a_j]-t(2\delta_{ji}+t\delta_{ii})((-8+3t^2)\delta_{ii}+2t\delta_{ji})\mathrm{Var}[c_i] \\
&\qquad\quad+4(2-t^2)\delta_{ij}+t\delta_{ji})\mathrm{Var}[c_j]\Big].
\end{aligned}$$

[25] In the expression below, two of the four variances are zero depending on whether the firm focuses on information about its customers or costs.

[26] For the common values case, to ensure that expected profits aren't larger simply because the demand intercept is $a_i + a_j$ whereas it is only a_i in the private values case, we use $(1/2)(a_i + a_j)$.

Again, since this difference is monotone in $\gamma_{ii}, \gamma_{ji}, \delta_{ii}$ and δ_{ji}, we only need consider the extremes, when each is zero or one.

Consider first the firm's CI decision when it focuses on customer information. The difference in expected profits in the common and private values cases is

$$\mathrm{E}[\pi_1^C(D,D) \mid \text{common values}] - \mathrm{E}[\pi_1^C(N,N) \mid \text{private values}] = \left(\frac{-t^2(4-3t^2)}{4(1-t^2)(4-t^2)^2}\right)\mathrm{Var}[a_i] < 0.$$

Since this difference is negative, the firm's expected profits if it seeks common values information are smaller than if it seeks private values information and so the firm seeks information that is associated with a policy of not disclosing when its CI decision is focused on customer information. Now, consider the firm's CI decision when it focuses on cost information. The difference in expected profits in the private and common values cases is

$$\mathrm{E}[\pi_1^C(D,D) \mid \text{private values}] - \mathrm{E}[\pi_1^C(N,N) \mid \text{common values}] = \left(\frac{48-40t^2+15t^4}{16(1-t^2)(4-t^2)^2}\right)\mathrm{Var}[c_i] > 0.$$

Since this difference is positive, the firm's expected profits if it seeks private values information are greater than if it seeks common values information and so the firm seeks information that leads to subsequent disclosure when its CI decision is focused on cost information. ∎

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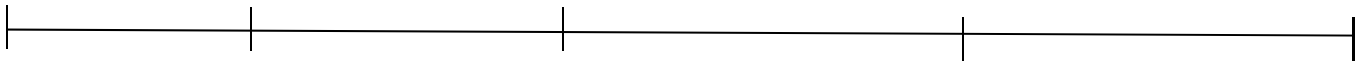
Figure 1
Time Line of Events



Firms choose their CI activities

Firms select their disclosure policies ($d \in \{D, N\}$)

Each firm acquires information about its rival's customers or production costs

Firms follow their adopted disclosure policy regarding the disclosure of their information

Firms compete in their product markets either by choosing the amount they wish to sell or the price they wish to charge and earn the associated profits

Figure 2
Equilibrium Disclosure Choice
Cournot Competition

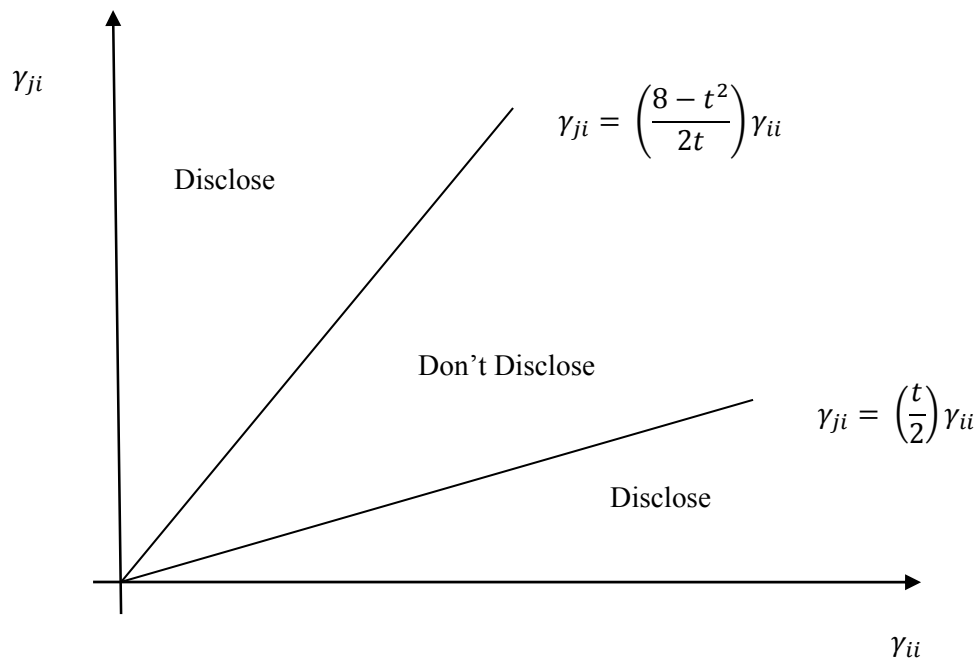


Figure 2 represents the inequalities associated with Condition (C1), the condition for disclosing/not disclosing firm *i*'s private information about its customers. Condition (C2), the condition for disclosing/not disclosing firm *i*'s private information about its costs is obtained by substituting δ for γ in the figure.

Figure 3
Equilibrium Disclosure Choice
Bertrand Competition Customer Information

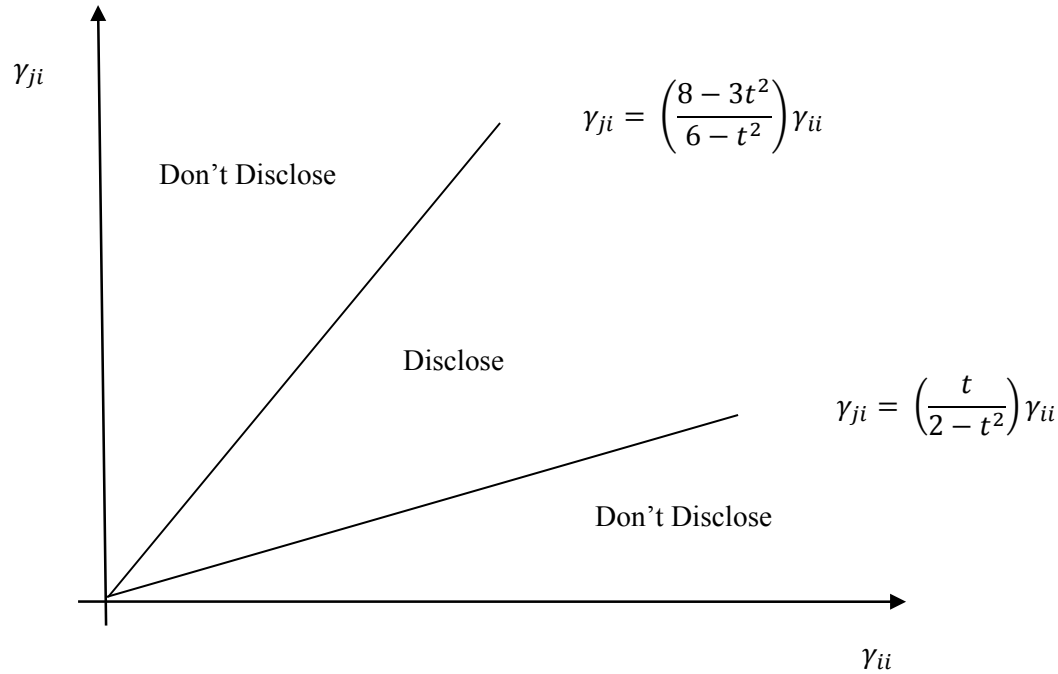


Figure 3 represents the inequalities associated with Condition (C3), the condition for disclosing/not disclosing firm *i*'s private information about its customers.

Figure 4
Equilibrium Disclosure Choice
Bertrand Competition Cost Information

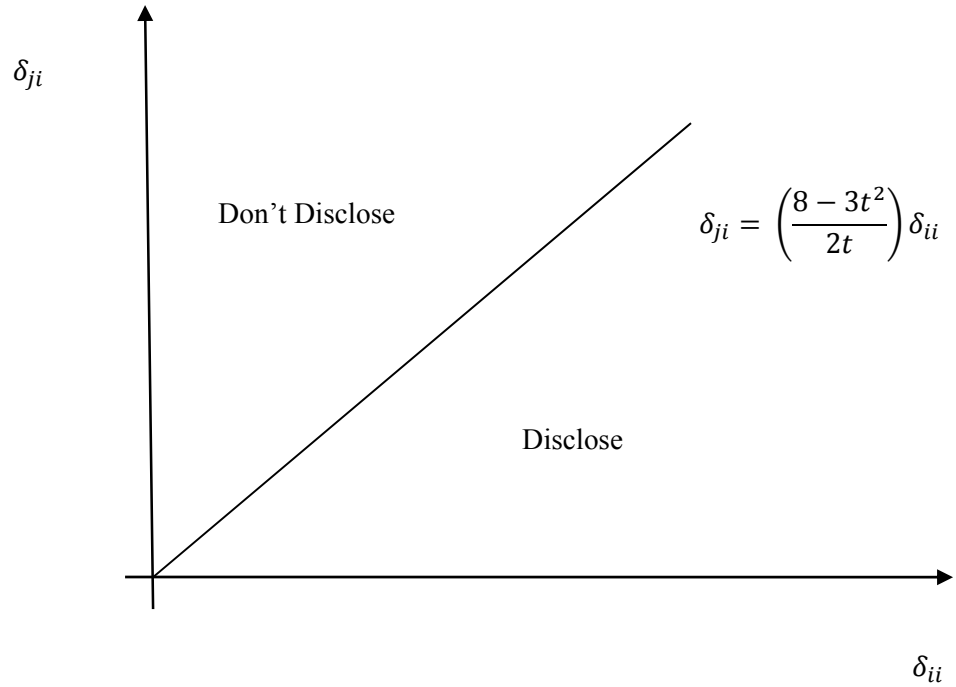


Figure 4 represents the inequality associated with Condition (C4), the condition for disclosing/not disclosing firm *i*'s private information about its customers.