Voluntary Disclosure under Imperfect Competition: Experimental Evidence

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Abstract: This study investigates disclosure behavior when a manager has incentives to influence the actions of a product market competitor in a Cournot duopoly. Theoretical research suggests that under various conditions the manager has incentives to withhold some signals and disclose others. Using an experimental economics method, we find support for partial information disclosure. Our results suggest that when the manager receives private information about industrywide cost, unfavorable (favorable) information is disclosed (withheld) and the competitor adjusts production accordingly. In contrast, when the manager receives private information about firm-specific cost, disclosure behavior is not affected by the favorableness of the information and the competitor's production decision is invariant to the disclosure choice.

JEL classification: D82, L10

Key words: information disclosure, private information, product market competitors

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Voluntary Disclosure Under Imperfect Competition:

Experimental Evidence

1. Introduction

This paper reports the results of two experiments designed to examine managers' disclosure strategies and the resulting reaction of product market competitors. Numerous theoretical studies examine the manager's incentives to voluntarily disclose private information.[1] Early papers find that full disclosure is the only possible equilibrium outcome when the discloser is known to possess information and disclosure is costless (Grossman, 1981; Milgrom, 1981). Later researchers relax the assumption of costless disclosure and allow for the possibility that the discloser is uninformed (Jovanovic, 1982; Vives, 1984; Darrough and Stoughton, 1990; Feltham and Xie, 1992). In either case, a threshold level for disclosure obtains and partial disclosure may result. Increases in market value result from information disclosures and decreases in market value from nondisclosures. In choosing a disclosure strategy, the manager considers the reactions of investors and rival firms.[2] For example, the manager may disclose favorable news in an attempt to maximize the capital market's valuation of the firm, but such disclosure may prompt a competitor to take actions that impose proprietary costs on the firm. Thus, the manager balances these forces when determining a disclosure strategy.

Theoretical studies recognize that disclosure and information-sharing incentives are sensitive to the precise context, including the competitiveness of the market, the nature of private information, and the market's uncertainty about whether the manager is informed. Darrough (1993) shows that incentives to disclose are affected by whether firms are engaged in Cournot or Bertrand competition. Sankar (1995) looks at a Cournot setting and demonstrates that managers'

incentives differ depending on whether they receive information about industry-wide or firm-specific conditions.[3] Dye (1985) and Jung and Kwon (1988) conclude that managers do not fully disclose private information when market participants are unsure of whether managers are informed.

The empirical literature on voluntary disclosure has produced mixed results. Early accounting studies (e.g., Patell, 1976; Penman, 1980) find a positive bias in management's earnings forecasts and conclude that only firms with good news release forecasts. Later studies (e.g., Lev and Penman, 1990; Clarkson, Kao, and Richardson, 1994) find that forecasts are unbiased on average. Unbiasedness suggests that firms disclose good news *and* bad news, the effects of which may offset each other. The mixed findings may arise because it is difficult to determine (control for) the proprietary costs resulting from the actions of rival firms.[4]

Other empirical studies use experimental methods to examine information disclosure behavior in settings with investors. King and Wallin (1990, 1991a, 1991b) conduct a series of experiments in which a manager is endowed with an asset and, in some cases, receives private information about its value. The manager makes a disclosure choice and then investors bid on the asset. Experimental findings support full disclosure when the manager is known to possess private information and antifraud rules are in place (see also Forsythe, Isaac, and Palfrey, 1989). The findings support partial disclosure when investors do not know whether the manager is informed.

In an extension of earlier experimental work, King and Wallin (1995) investigate disclosure equilibria in a setting with investors *and* an opponent (i.e., a competitor), though the opponent's behavior is specified exogenously. Their results support a model of partial disclosure

over one of full disclosure and are consistent with theoretical predictions (Wagenhofer, 1990). This paper has a similar focus. We empirically examine disclosure behavior in a Cournot duopoly in which the manager has incentives to influence the actions of a product market competitor. Unlike King and Wallin's setting, we do not exogenously specify the product market competitor's behavior. In our study participants take the role of either the manager or opponent and make production decisions strategically.

Sankar's (1995) model of voluntary disclosure in an imperfectly competitive product market provides the basis for empirical tests. This model is distinguished from other models predicting partial disclosure of information because it provides for cases in which firms selectively disclose depending on the nature of the information. The firm may or may not receive private information, which relates to firm-specific and industry-wide uncertainty. The model predicts that favorable news is disclosed and unfavorable news is withheld if the news is more informative of a firm-specific shock. By comparison, favorable news is withheld and unfavorable news is disclosed if the signal is more informative of an industry-wide shock. Thus the disclosure strategy varies across uncertainty and information conditions. The model also shows that in all cases disclosure increases with the probability that the manager receives private information. In the limit, full disclosure is predicted if the manager is known to possess private information with certainty.

Using an experimental economics approach, we conduct two experiments to investigate the manager's disclosure choice and the opponent's reaction. In experiment one (two), the manager chooses to disclose or withhold private information about industry-wide (firm-specific) cost and, in response, the opponent selects a production level. The manager's private information

is favorable (i.e., costs are less than expected) in some periods and unfavorable in others. Across both experiments, we manipulate the probability that the manager is informed.

The use of an experimental method offers several advantages. First, we are able to create a Cournot duopoly in which participants have defined roles (i.e., manager and competitor). Second, we have control over the manager's information set and can directly observe disclosure behavior. Third, we are able to manipulate the parameters of the environment, which enables us to observe the manager's disclosure strategy under different conditions. The results reported in this paper complement prior studies of naturally occurring markets and provide direction for future theoretical work.

The remainder of this paper is organized as follows. In Section 2, we provide an overview of the Sankar (1995) model, which is our underlying framework. In Section 3, we describe the experimental setting and present the experimental predictions. In Section 4, we report the empirical results. In the final section, we provide concluding remarks.

2. Framework

Two players, a manager and an opponent, participate in a Cournot quantity game with an uncertain marginal cost of production. The manager privately learns the marginal cost of production with probability q and may choose to disclose this information to the opponent. Disclosures are assumed to be truthful in all cases. The opponent receives no private information. The manager and the opponent then simultaneously choose their production levels, y_M and y_O, respectively. Output is sold at a constant price, P, which is determined by the aggregate output in

the market, $y = y_M + y_O$. The market price is a decreasing function of aggregate output and is expressed as

$$P = \gamma - (y_M + y_O) \tag{1}$$

where γ is a constant parameter for the industry. The expected profit for each player is

$$E(\pi_i) = [\gamma - E(y_M + y_O) - E(c)] * y_i \tag{2}$$

where I = M or O, $E(\cdot)$ is the expectations operator, and c is the player's marginal cost of production.[5] Each player's expected profit is increasing in own production and price. Because price is decreasing in aggregate output, each player's expected profit is decreasing in expected aggregate output. The manager, however, can devise a disclosure strategy that results in an increase in own production, while simultaneously decreasing aggregate output. In this framework there is an equilibrium threshold level of disclosure when production is nonnegative (for detail refer to the Appendix).

3. Research method and experimental predictions

3.1. Overview and design

We conduct two experiments, each consisting of six sessions. In experiment one, participants face uncertainty about common, industry-wide costs. In experiment two, they face uncertainty about unique, firm-specific costs. In both experiments, sessions are administered to participants in groups of eight. Four participants take the role of the manager and four of the opponent. Each period manager/opponent pairs are assigned, where player pairs represent

competing producers. Player pairs make production decisions across 16 periods and, each period, all units produced are sold to the experimenter. At the beginning of each period the manager receives a signal that indicates the player's cost per unit with fixed probability (q). Within each experiment, the signal may be characterized as favorable or unfavorable conditioned on the manager's expectation of cost. After receiving the signal, the manager determines the number of units to produce and then sends a message to the opponent. The message can convey the cost per unit or, alternatively, it can convey nothing (nondisclosure). Upon receipt of the message, the opponent makes a production decision. The experimenter then calculates the total production for each player pair and determines the price per unit. The selling price is communicated to player pairs, who compute their profits for the period.

In experiment one, the distribution of the marginal cost of production and the outcome (the cost per unit per period) are identical across the different player types (industry-wide cost). The manager is informed of the cost per unit with probability q. The opponent, on the other hand, is not aware of the cost unless it is disclosed by the manager. In experiment two, the distribution of the marginal cost of production and the outcome differ between player types (firm-specific cost). The manager's cost per unit is determined by sampling from a distribution that is known to both players and the manager is informed of the cost with probability q. By comparison, the opponent's cost is constant per period and both the opponent and manager are aware of this cost.

Within each experiment, we manipulate q (the probability that the manager is informed) across three levels: 100%, 90%, and 70%. An examination of q=100% allows us to determine whether full disclosure obtains when the manager is informed with certainty. An examination of q=90%,70% allows us to observe, under two different conditions, whether partial disclosure

obtains when the manager is not informed with certainty. Based on the experimental parameters (discussed below), the behavioral predictions are not affected by whether q=90% or 70%. By manipulating q (between 90% and 70%), we are able to determine whether the results are insensitive to the parameter value selected. The experimental design is summarized in Table 1.

3.2. Procedures

At the beginning of each session participants receive a set of instructions that are read aloud.[6] Participants are recruited from undergraduate and masters students and across the two experiments 92 of 96 participants are business or economics majors. Eight students took part in each session. In experiment one (two), students earned an average of $24.93 ($27.63) for participating approximately 90 minutes. The currency used in the experimental sessions is francs and francs are converted to dollars at the end of each session at an exchange rate of $0.0625. Participants are provided with an endowment of 30 francs for participating.

After completing the instructions, participants are randomly assigned a player role. Those assigned the role of the opponent complete the experiment in a separate room. At the beginning of each period, the experimenter in each room shuffles a deck of four cards numbered 1, 2, 3, and 4. Each participant receives a card which is used to assign manager/opponent pairs for the period. Participants with the same numbered card are paired with each other but are unable to identify the person with whom they are paired.

After player pairs are determined, the manager may be provided with a signal concerning the marginal cost of production. In experiment 1 the cost is common to the manager and the opponent and in experiment 2 the costs differ. Across both experiments, the marginal cost of

production is 2, 4, or 6 francs per unit. Participants are informed that the cost per period is drawn from a distribution in which each cost is equally likely and periods are independent.[7] Within each experiment, we manipulate the probability that the manager is informed (q): 100%, 90% or 70%. The probability remains constant throughout an experimental session and both players are aware of the probability.

After receiving a signal, the manager is allotted 45 seconds to determine the level of production as well as the message to send to the opponent. The message can indicate the cost per unit, if the manager is informed, or "?", if the manager is uninformed or chooses to withhold the information. Using index cards, the experimenter communicates the manager's message to the opponent. The opponent is allotted 30 seconds to determine the level of production, after which the experimenter computes the selling price for each player pair. The selling price is determined using the following relationship.

$$P = 20 - (y_M + y_O) \tag{3}$$

where the variables are as defined previously and each player's production is limited to 10 units per period. Player pairs are then informed of their selling price and instructed to compute profits for the period. After computing profits, player pairs are assigned for the next period.

At the conclusion of each experimental session, participants compute their earnings by summing their profits over the 16 periods and multiplying by the conversion rate. A post-experiment questionnaire is administered while the experimenters pay participants in cash.[8]

3.3. Predictions

For each experimental session, we can determine a threshold level of disclosure.[9] The threshold is the marginal cost of production at which the manager is indifferent between disclosing and withholding marginal cost. The manager's disclosure choice, in turn, leads to a prediction about the opponent's production decision. After learning of the manager's disclosure choice, the opponent may respond by varying production.

Within each experiment, the manager's disclosure strategy is affected by q (the probability that the manager is informed). In both experiments, full disclosure is predicted when q=100%. However, predicted disclosure strategies in the two experiments differ when q<100%. As compared to not disclosing, the opponent's production level is expected to fall in experiment one (two) when the marginal cost of production is 4 or 6 (2 or 4).

Partial disclosure is predicted when q=90%,70%. In experiment one, the manager is predicted to disclose marginal production costs of 4 or 6, which conveys an unfavorable signal. In experiment two, the manager is predicted to disclose marginal production costs of 2 or 4, which conveys a favorable signal. Across both experiments, the manager's disclosure is expected to lower the opponent's production level. The experimental predictions are summarized in Table 2.

4. Results

For each experiment, we conduct an analysis of variance (ANOVA) to determine whether the manager's disclosure strategy is affected by the signal received (marginal production cost 2, 4, or 6), the probability that the manager is informed (100%, 90%, or 70%), and the interaction. The former (denoted SIGNAL) is a within-subject variable and the latter (denoted PROB) is a

between-subject variable. The dependent measure is the proportion of times that the manager discloses a particular signal (e.g., for a given participant, the number of times that 2 is disclosed divided by the number of times that it is received).[10] Hence, the dependent measure is computed by summarizing observations across periods within a subject. This approach alleviates some concerns that arise because disclosure choices may not be independent over time.[11]

For each experimental session, we compute the opponent's production level for each disclosure choice (2, 4, and 6). We perform parametric, paired-t tests and nonparametric Wilcoxon matched-pairs signed-ranks tests to compare the average production level with that observed when the manager withholds disclosure. The comparisons allow us to determine whether the opponent increases or decreases production in response to the manager's disclosure choice.

4.1. Experiment one

The ANOVA results, shown in Panel A of Table 3, indicate that SIGNAL and PROB are significant at $p<0.03$ and the interaction is significant at $p=0.053$. The cell means, reported in Panel A of Table 4, provide insight into the results. First we examine the cell means for SIGNAL. The data are consistent with partial information disclosure and suggest that unfavorable information about industry-wide uncertainty (cost of 4 or 6) is more likely to be disclosed than favorable information (cost of 2). These findings provide support for the experimental predictions. We also note that disclosure is more likely as the information becomes less favorable. Next we examine the cell means for PROB and find that, when the manager is not informed with certainty, partial information disclosure is observed as expected. Post-hoc comparisons fail to

indicate significant differences in disclosure behavior at $p<0.05$ when the manager receives a signal of 4 or 6. This finding is consistent with experimental predictions, which suggest that disclosure behavior is similar when PROB=90%,70% (refer to Table 2). When the manager is known to be informed (PROB=100%), the predicted result is full disclosure. Contrary to our expectation, information is not fully disclosed and, in fact, disclosure is less likely than when the manager is not informed with certainty.

We also examine the opponent's reaction to the manager's disclosure choice. Panel A of Table 5 reports the average difference in the opponent's production between no disclosure and disclosure of 2, 4, and 6, respectively. When the mean difference in production is negative (positive), the opponent has lowered (raised) production in response to the manager's disclosure choice. The results indicate a significant decrease in the opponent's production when the manager discloses the least favorable signal (cost of 6) and a significant increase when the manager discloses the favorable signal (cost of 2). These findings are similar using parametric and nonparametric tests and are consistent with expectations. Note, however, that we do not observe a significant reaction by the opponent when the manager discloses a cost of 4.

4.2. Experiment two

Experiment two includes uncertainty about firm-specific cost. The ANOVA results, shown in Panel B of Table 3, indicate that none of the independent variables are significant at conventional levels. The cell means, shown in Panel B of Table 4, provide little support for the experimental predictions. Comparison of Panels A and B suggests that disclosure strategies in the

two experiments differ. However, in both experiments the manager chooses nondisclosure more often than disclosure when informed with certainty.

Panel B of Table 5 reports the opponent's reaction to the manager's disclosure choice. As can be seen, none of the pairwise comparisons are significant at conventional levels. The results are consistent across parametric and nonparametric tests. These findings suggest that the opponent's production decision is invariant to the manager's disclosure choice. Hence, the manager may perceive that disclosure behavior does not matter, which may provide an explanation for the ANOVA results discussed above (refer to Panel B of Table 3).

5. Conclusion

This study reports the results of two experiments designed to investigate disclosure behavior when the manager has incentives to influence the actions of a product market competitor in a Cournot duopoly. Testable predictions derive from Sankar's (1995) model of voluntary disclosure in an imperfectly competitive product market. In each experiment, the manager may receive private information about cost uncertainty, where the information is either favorable or unfavorable. We manipulate the probability that the manager is informed across sessions.

In experiment one, private information involves industry-wide cost. We find that when the manager is not informed with certainty, partial information disclosure obtains and the results are generally consistent with the experimental predictions. The manager discloses unfavorable information more frequently than favorable information and the opponent adjusts production accordingly. By comparison, when the manager is informed with certainty, the results are contrary to expectations. Observed disclosure occurs less frequently than when the manager is

not informed with certainty. In experiment two, private information involves firm-specific cost. We find that disclosure behavior is not affected by the favorableness of private information and that the opponent's production decision is invariant to the disclosure choice. As in experiment one, disclosure occurs less frequently when the manager is informed with certainty than when uncertainty is present.

Our findings highlight the importance of the nature of private information in understanding disclosure behavior. In general, archival studies using cross-sectional data do not identify the nature of private information, which may account for the conflicting findings. In the future, researchers should attempt to control for the type of information when examining voluntary information disclosure. Our findings also suggest that, in a setting with a product market competitor, additional research is necessary to understand disclosure behavior when the manager is informed with certainty. Surprisingly, we find that disclosure occurs relatively infrequently under such conditions. Future research may shed light on this issue.

Appendix

The purpose of this appendix is to demonstrate that the parameters used in the experimental setting are consistent with and generate the same predictions as Sankar's (1995) model of disclosure in an imperfectly competitive product market.

Prior to making a production choice, the manager (M) receives private information with probability q. The opponent (O) receives no private information. The equilibrium production choices for the two parties are given in Sankar's Lemma 1 on page 835 and are repeated here.

Optimal Outputs

I. Industry-wide uncertainty

(1) M receives signal S and discloses it

$y_M^*(S|S) = 3b^{-1}[a - E(c|S)]$

$y_O^*(S) = 3b^{-1}[a - E(c|S)]$

(2) M receives signal S and withholds it

$y_M^*(S|N) = 3b^{-1}[a - E(c|S) - (½)[E(c|S) - E(c|N)]]$

$y_O^*(S) = 3b^{-1}[a - E(c|N)]$

II. Firm-Specific uncertainty

(1) M receives signal S and discloses it

$y_M^*(S|S) = 3b^{-1}[a - 2E(c_M|S) + E(c_O|S)]$

$y_O^*(S) = 3b^{-1}[a - 2E(c_O|S) + E(c_M|S)]$

(2) M receives signal S and withholds it

$y_M^*(S|N) = 3b^{-1}[a - 2E(c_M|S) + E(c_O|S) + (½)[E(c_M|S) - E(c_M|N)]]$

$y_O^*(S) = 3b^{-1}[a - 2E(c_O|N) + E(c_M|N)]$

In all cases the optimal expected profit is a function of the square of the optimal output, i.e.,

$$E(\pi^* | \cdot) = b[y^*(\cdot)]^2$$

which is expression (5) from Sankar (1995).

The assumptions specific to our experimental setting are as follows:

(1) $b = 1$,

(2) $a = \gamma = 20$,

(3) $E(c_M | S) = S$ or perfect information, and

(4) $E(c_O | S) = C_O$ where C_O is a constant.

With the fourth assumption the opponent's private cost is not related to the manager's signal.

Given these assumptions, the expressions for optimal output can be rewritten as follows.

Optimal Outputs Given Our Assumptions

I. Industry-wide Uncertainty

(1) M receives signal S and discloses it

$y_M^*(S|S) = (1/3)[20 - S]$

$y_O^*(S) = (1/3)[20 - S]$

(2) M receives signal S and withholds it

$y_M^*(S|N) = (1/3)[20 - S - (½)[S - E(c|N)]]$

$y_O^*(S) = (1/3)[20 - E(c|N)]$

II. Firm-Specific Uncertainty

(1) M receives signal S and discloses it

$y_M^*(S|S) = (1/3)[20 - 2S + C_O]$

$y_O^*(S) = (1/3)[20 - 2C_O + S]$

(2) M receives signal S and withholds it

$y_M^*(S|N) = (1/3)[20 - 2S + C_O + (½)[S - E(c_M|N)]]$

$y_O^*(S) = (1/3)[20 - 2C_O + E(c_M|N)]$

Note that $E(c|N)$ and $E(c_M|N)$ are determined in equilibrium because the nondisclosure region (N) is determined in equilibrium. The expressions for $E(c|N)$ and $E(c_M|N)$ are

$$E(c|N) = \frac{qF(S|N)E(c|S\in N) + (1-q)C}{qF(S|N) + (1-q)}$$

and

$$E(c_M|N) = \frac{qF(S|N)E(c_M|S\in N) + (1-q)C_M}{qF(S|N) + (1-q)}$$

where $F(S|N)$ is the probability that an informed M does not disclose, $E(c|S\in N)$ is the expectation of signals which M will not disclose, and C is the average cost (the expectation when M is not informed).

Then using the cost distributions given in the paper the disclosure equilibrium can be characterized as follows.

Characterization of a Disclosure Equilibrium
Distribution: f = {1/3, 1/3, 1/3}

I. Industry-wide uncertainty

(1) Conjecture: M withholds signal 2 and discloses 4 and 6 when q<1.
$E(c|N) = (12 - 10q)/(3 - 2q)$

(2) Conjecture: M discloses all signals when q=1.

II. Firm-Specific uncertainty

(1) Conjecture: M withholds signal 6 and discloses 2 and 4 when q<1.
$E(c|N) = (12 - 6q)/(3 - 2q)$

(2) Conjecture: M discloses all signals when q=1.

These expressions are used to calculate $E(\pi^*|\cdot)$ when M discloses (D) and withholds (N) information. The point where $E(\pi^*|D)$ and $E(\pi^*|N)$ intersect is the threshold level of disclosure and is denoted s'.

Disclosure Thresholds

I. Industry-wide uncertainty

q = 0.70, s' = 3.125
q = 0.90, s' = 2.500
q = 1.00, s' = 2.000

II. Firm-Specific uncertainty

q = 0.70, s' = 4.875
q = 0.90, s' = 5.500
q = 1.00, s' = 6.000

Endnotes

1. A related literature examines information sharing. These papers often deal with the sharing of information among rival firms in oligopolistic product markets (e.g., Clarke, 1983; Gal-Or, 1985; Kirby, 1988). The type of information is an important determinant of a firm s strategic behavior in the presence of asymmetric information. In Cournot settings, firms agree to share firm-specific cost information, but not industry-wide demand information. Information sharing has also been examined experimentally by Isaac and Reynolds (1986). Our investigation is distinct from the information sharing approach which assumes that firms commit ex ante to share information. The disclosure decision cannot be altered after the private news is observed. As Okuno-Fujiwara, Postelwaite, and Suzumura (1990, p. 26) argue, the ex ante calculation is usually at variance with the calculation once the private information is known, at least for some realizations of the random variables.

2. The manager is presumed to act in the best interest of the firm.

3. The industrial organization literature recognizes that the nature of the information impacts whether competitive firms agree to share information. Vives (1990) points out that the United States courts views of information sharing by rival firms is affected by the nature of the information. The sharing of firm-specific information has been viewed with suspicion, whereas the sharing of aggregate information has raised few objections.

4. Other possible explanations for the inconsistent findings include different sample periods and measures of the market s earnings expectation.

5. Without loss of generality, fixed cost is assumed to be zero.

6. A copy of the instructions is available from the authors upon request.

7. We randomly determined the marginal cost of production per period before conducting the 12 experimental sessions. The pre-selected sequence was used across all sessions in order to maximize comparability. Cason and Friedman (1996) discuss the benefits of using a pre-selected sequence.

8. The responses on the post-experiment questionnaire indicate that participants found the experiment interesting and the monetary incentives motivating. Participants responded on a seven-point scale as to how interesting they found the experiment, where 1 = not very interesting and 7 = very interesting. In experiment one (two), the mean response was 5.38 (5.79). Participants also responded on a seven-point scale as to how they would characterize their earnings, where 1 = nominal amount and 7 = considerate amount. In experiment one (two), the mean response was 5.16 (4.97).

9. The experimental predictions (shown in Table 2) are from Sankar s (1995) Lemma (1) assuming that $b = 1$, $a = \gamma = 20$, perfect information, and the opponent s private cost is not

related to the manager s signal. See Appendix for detail.

10. Press (1972, pp. 264-265) warns that when using proportions as the dependent measure, variances are a function of treatment means, which implies heteroskedasticity. He recommends applying an arcsine, square-root transformation to circumvent the problem. Although not reported, the ANOVAs are repeated using the transformed dependent measure and inferences are unaffected.

11. The down side of our approach is that it reduces the number of observations that are available for analysis.

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Table 1
Experimental design

Experiment one

Cost Uncertainty	Probability the Manager is Informed (q)	Experimental Session
Industry-wide	100%	1-2
	90%	3-4
	70%	5-6

Experiment two

Cost Uncertainty	Probability the Manager is Informed (q)	Experimental Session
Firm-specific	100%	7-8
	90%	9-10
	70%	11-12

Table 2
Experimental predictions

Experiment one

Cost Uncertainty	q	Experimental Session	Disclosure Threshold	Signals Disclosed	Opponent's Production Reaction
Industry-wide	100%	1-2	2.000	2,4, and 6	same or lower
	90%	3-4	2.500	4 and 6	lower
	70%	5-6	3.125	4 and 6	lower

Experiment 2

Cost Uncertainty	q	Experimental Session	DisclosureThreshold	Signals Disclosed	Opponent's Production Reaction
Firm-specific	100%	7-8	6.000	2,4, and 6	lower or same
	90%	9-10	5.500	2 and 4	lower
	70%	11-12	4.875	2 and 4	lower

Notes: The opponent's production reaction assumes that the manager's disclosure choices are consistent with the experimental predictions.

Table 3
ANOVA results: The effect of PROB and SIGNAL on Disclosure

Panel A: Experiment one

Effect	degrees of freedom	sum of squares	F-statistic	p-value
Between-Subject Effect				
PROB	2	1.80	4.22	0.029
Error	21	4.46		
Within-Subject Effects				
SIGNAL	2	2.80	24.94	0.000
PROB x SIGNAL	4	0.57	2.55	0.053
Error	42	2.35		

Panel B: Experiment two

Effect	degrees of freedom	sum of squares	F-statistic	p-value
Between-Subject Effect				
PROB	2	0.41	1.17	0.330
Error	21	3.72		
Within-Subject Effects				
SIGNAL	2	0.12	0.47	0.630
PROB x SIGNAL	4	0.48	0.92	0.464
Error	42	5.52		

Notes: PROB is the probability that the manager is informed (100%, 90%, or 70%) and SIGNAL is the signal received by the manager (2, 4, or 6). The dependent variable is the proportion of times that the marginal cost of production is disclosed conditioned on the manager receiving a particular signal.

Table 4
The proportion of times that industry-wide information is disclosed

Panel A: Experiment one

PROB	Signal Received by the Manager			Total
	SIGNAL=2	SIGNAL=4	SIGNAL=6	
100%	0.28	0.35	0.53	0.38
90%	0.57	0.75	1.00	0.77
70%	0.16	0.60	0.92	0.56
Total	0.33	0.57	0.81	0.57

Panel B: Experiment two

PROB	Signal Received by the Manager			Total
	SIGNAL=2	SIGNAL=4	SIGNAL=6	
100%	0.50	0.29	0.35	0.38
90%	0.34	0.58	0.44	0.45
70%	0.56	0.68	0.46	0.57
Total	0.47	0.52	0.42	0.47

Table 5
A comparison of the opponent's production decision when information is disclosed versus withheld

Panel A: Experiment one

Comparison	Mean Difference in Production	t-statistic (p-value)	z-statistic (p-value)
Disclose0 vs. Disclose2	0.66 (n=18)	2.09 (0.026)	-2.01 (0.022)
Disclose0 vs. Disclose 4	0.29 (n=23)	1.36 (0.624)	-1.17 (0.121)
Disclose0 vs. Disclose6	-0.51 (n=23)	-1.98 (0.031)	-2.07 (0.019)

Panel B: Experiment two

Comparison	Mean Difference in Production	t-statistic (p-value)	z-statistic (p-value)
Disclose0 vs. Disclose2	-0.29 (n=22)	-0.89 (0.193)	-0.64 (0.260)
Disclose0 vs. Disclose4	-0.06 (n=23)	-0.27 (0.396)	-0.35 (0.364)
Disclose0 vs. Disclose6	0.19 (n=22)	0.46 (0.376)	-0.83 (0.204)

Notes: Disclose0 denotes that information about the marginal cost of production is withheld. Disclose2, Disclose4, and Disclose6 denote that the manager discloses a marginal cost of 2, 4, and 6, respectively. Paired t-tests and Wilcoxon matched-pairs signed-ranks tests are performed to compare the opponent's production decision when information is disclosed versus withheld. The p-values represent one-tailed values. The sample sizes vary across comparisons because certain costs were never disclosed to some opponents