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Abstract

This study experimentally investigates the interaction between firm's information acquisition choice and mandatory disclosure in the presence of proprietary costs. The results demonstrate that mandatory disclosure diminishes firm's incentive to acquire industry-wide demand information when information acquisition is costly and endogenous. Further, I also show that firm's production decision is improved by acquiring information. Taken together, although acquiring information improves firm's production decision, mandatory disclosure diminishes firm's incentive to do so, and thus, deteriorates firm's information environment. This leads to inefficient production, which in turn, might have a substantial impact on market outcomes.

Key Words: Information Acquisition; Mandatory Disclosure; Duopoly; Proprietary Cost; Experiment

JEL Classification: M41; M48

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1 Introduction

Regulatory agencies require listed companies to publicly disclose certain information. While such disclosure is regulated mainly in an attempt to protect decision makers in the capital market, disclosed information is also used by competitor firms in the product market. In fact, Graham et al. (2005) survey more than 400 corporate executives and find that the competitive disadvantage caused by disclosure, which is often referred to as a proprietary cost, is one of the main factors that firms are reluctant to voluntarily disclose private information.

Numerous theoretical studies examine the interaction between disclosure of information and product market competition, and provide important insights on the proprietary disclosure.[1] Darrough (1993) analyzes a two-stage duopoly model and demonstrates that when firms are engaged in Cournot competition under demand uncertainty, they would not commit to disclosure of industry-wide demand information due to the proprietary nature of this type of information. Suijs and Wielhouwer (2009) extend Darrough's (1993) model and show that although Cournot duopolists prefer not to disclose industry-wide demand information *ex ante*, mandatory disclosure requirements can enhance social welfare, which is measured by either consumer surplus or total surplus, especially in the case where products are perfect substitutes.

However, it is unclear whether mandating disclosure can achieve the in-

[1] See, for example, Darrough (1993), Sankar (1995), Clinch and Verrecchia (1997), Arya and Mittendorf (2007), Suijs and Wielhouwer (2009), and Bagnoli and Watts (2010). See also Vives (2001, Ch.8), and Christensen and Feltham (2003, Ch.15).

tended objective of improving social welfare when information acquisition by firms is endogenous and costly. Firms must often spend resources to obtain private information, and hence face a trade-off between the costs and benefits of information acquisition. In addition, if acquired information is disclosed, not only a firm which acquired costly information but also competitor firms in the product market can strategically use this information and make more informed decisions. Therefore, it is possible that the benefits of acquiring information relatively decrease when disclosure is mandated. The point is that mandatory disclosure of proprietary information might diminish firm's incentive to acquire such information, and in turn, have a substantial impact on market outcomes.

The objective of this paper is to examine the interaction between firm's information acquisition choice and mandatory disclosure in the presence of proprietary costs. More specifically, I develop a Cournot duopoly model with stochastic demand in which acquiring information is endogenous. Further, in order to test the theoretical predictions I use an experimental economics approach and conduct a series of experiments. In the experiments, participants take the role of either the firm or the rival, and the firm chooses whether or not to acquire costly information about unknown demand parameter.[2] I manipulate information acquisition cost (low or high) in two economic settings (disclosure is mandated or not). In the mandatory disclosure treatment, if

[2]While most theoretical studies that analyze a stochastic duopoly/oligopoly model consider two types of information: firm-specific cost information and industry-wide demand information, the key distinction is between firm-specific versus industry-wide information, not between cost versus demand information (see, Christensen and Feltham, 2003, Ch.15). In line with previous research, I interpret industry-wide information as pertaining to demand.

the firm chooses to acquire information, it receives a perfect signal about the true demand state and this signal is revealed to the public. That is, both the firm and the rival can learn the true demand state before making their production decisions. On the other hand, in the nondisclosure treatment, if the firm chooses to acquire information, only the firm can learn the true demand state and the rival remains uncertain about the state. Regardless of whether disclosure is mandated or not, if the firm chooses not to acquire information, both firms remain uncertain about demand state.

The main results are as follows. First, firms in the nondisclosure treatment tend to acquire information more frequently than those in the mandatory disclosure treatment. Second, firms acquire information more frequently when information acquisition cost is low. Third, when firms learn the true demand state through information acquisition or disclosure, they successfully adjust production levels depending on the state. Taken together, these results indicate that when firms compete in quantities, although acquiring information improves firms' production decisions, mandatory disclosure diminishes firms' incentives to do so, and as a result, lead to inefficient production decisions. In other words, when information acquisition is endogenous and costly, mandatory disclosure might have an unintended consequence that firms suffer deterioration in their information environments.[3]

As mentioned above, previous theoretical studies, such as Darrough (1993) and Suijs and Wielhouwer (2009), examine the interaction between disclo-

[3]In a different perspective, Pae (2000) analytically demonstrates that mandatory disclosure in a Cournot market under demand uncertainty might reduce social welfare. Pae (2000) focuses on the timing of firms' production decisions, not information acquisition process.

sure of information and product market competition. Furthermore, several studies report the results of experiments which are designed to test the theoretical predictions (Cason, 1994; Cason and Mason, 1999; Ackert et al., 2000). However, most of the existing literature takes firm's private information as exogenous. In other words, the interaction between firm's information acquisition choice and disclosure of information is typically ignored in the previous research. Conversely, there are several studies that examine information acquisition by firms in oligopolistic market, but the issue of disclosure is ignored (Li et al., 1987; Hwang, 1995; Hauk and Hurkens, 2001).

Notable exceptions are Kirby (2004) and Jansen (2008). Both papers simultaneously consider the problem of information acquisition and disclosure in oligopoly.[4] The contribution of this paper is to develop a simplified model and test the theoretical predictions by conducting controlled experiments.

As pointed out by Ackert et al. (2000), an experimental approach has several advantages in examining stochastic duopoly models. For example, researchers are able to create a controlled economic environment which they wish to examine, and can directly observe firms' behavior. In addition, researchers can compare the results under different conditions by manipulating the parameters of the environment.

The remainder of this paper is organized as follows. In section 2, I describe the model which provides the basis for experimental tests. In section 3, I describe the experimental design. Section 4 reports the results and Section 5 concludes this paper.

[4]In the context of the capital market, Pae (1999) also analyzes the problem of information acquisition and disclosure.

2 Model

Consider a single-period product market where two firms compete in quantities, i.e., Cournot duopoly market, under demand uncertainty. I distinguish the two firms: "the firm" and "the rival". Both firms are assumed to be risk-neutral. The market price, p, is determined by a stochastic linear inverse demand function:

$$p = a + \theta - (q_f + q_r), \tag{1}$$

where q_f (q_r) denotes the output of the firm (the rival). I assume that $a > 0$ is a constant and θ is a random variable distributed on a closed interval $[\underline{\theta}, \bar{\theta}]$ with $E(\theta) = 0$ and $Var(\theta) = \sigma^2$. In order to avoid yielding negative quantities in equilibrium, I also assume that $a + \underline{\theta} > 0$. For simplicity, the marginal cost of production is assumed to be zero for both firms. Hence, the profit of each firm is simply given by:

$$\pi_i = \{a + \theta - (q_f + q_r)\}q_i, \quad i = r, f. \tag{2}$$

The sequence of events is as follows. In the first stage, a regulatory agency decides whether or not to mandate disclosure of information about market demand. However, the regulatory agency is not explicitly modeled as an economic agent. That is, I take the disclosure regulation as exogenous. In stage 2, the firm chooses whether to acquire information at cost k, or not to acquire information. If the firm acquires information, a perfect signal about the true demand state is revealed to it. That is, the firm can observe the realized

value of θ. On the other hand, if the firm chooses not to acquire information, the firm remains uncertain about demand state. The information acquisition cost $k > 0$ is assumed to be a constant.[5] In stage 3, θ is realized and the firm receives a signal or not in accordance with its information acquisition choice. Furthermore, when disclosure is mandated, the signal that the firm acquired is also revealed to the rival. That is, if the firm chose to acquire information in stage 2, the rival can also observe the realized value of θ. I assume that disclosure is truthful. In the final stage, both the firm and the rival simultaneously choose their output levels, q_f and q_r, respectively.

There are four possible cases: (i) the firm acquires information under nondisclosure, (ii) the firm acquires information under mandatory disclosure, (iii) the firm does not acquire information under nondisclosure, and (iv) the firm does not acquire information under mandatory disclosure. Note that the firm is assumed not to voluntarily disclose the acquired signal when disclosure is not mandated, because the firm dose not have an incentive to do so (Darrough, 1993). Furthermore, even if disclosure is mandated, the firm is allowed to acquire no information. In this case, the disclosed message does not have information content at all. This assumption seems to be reasonable because forward-looking information is under consideration in this model. The game structure stated above is common knowledge. In the analysis, I only consider the case where each firm chooses its pure strategy and solve the game backward.

[5]To simplify the experimental task, only one firm makes the decision about information acquisition. In addition, I limit the set of information acquisition alternatives: acquiring a perfect signal at a constant cost or not acquiring any signals.

2.1 Equilibrium Strategies

First, consider the case (i): the firm acquires information under nondisclosure. In this case, the firm can condition its output choice on the signal value, but the rival cannot. Thus, the firm and the rival maximize their own expected profit in (3) and (4), respectively:[6]

$$\max_{q_f(\theta)} E(\pi_f|\theta) = E(\{a+\theta-(q_f(\theta)+q_r)\}q_f(\theta)|\theta), \tag{3}$$

$$\max_{q_r} E(\pi_r) = E(\{a+\theta-(q_f(\theta)+q_r)\}q_r). \tag{4}$$

Each firm's optimal output level is yielded by jointly solving the first-order condition for (3) and (4). Using this solution and taking expectation over θ yields the *ex ante* expected profit of each firm. Recall that the firm incurs information acquisition cost k. These results are summarized in the following lemma, where the superscript, AN, represents the case in which the firm acquires information under nondisclosure.

Lemma 1. *In the case where the firm acquires information under nondisclosure, the optimal output and the ex ante expected profit of each firm are as follows:*

$$q_f^{AN} = \frac{1}{3}a + \frac{1}{2}\theta \qquad q_r^{AN} = \frac{1}{3}a \tag{5}$$

$$E(\pi_f^{AN}) = \frac{1}{9}a^2 + \frac{1}{4}\sigma^2 - k \qquad E(\pi_r^{AN}) = \frac{1}{9}a^2. \tag{6}$$

Next, consider the case (ii): the firm acquires information under manda-

[6]Note that information acquisition cost is sunk at this stage.

tory disclosure. In this case, both firms can condition their output choices on the signal value. Therefore, the objective function of each firm is given by:

$$\max_{q_i(\theta)} E(\pi_i|\theta) = E(\{a+\theta-(q_f(\theta)+q_r(\theta))\}q_i(\theta)|\theta), \quad i=f,r. \tag{7}$$

By solving the two first-conditions for (7), both firms' optimal output levels and the *ex ante* expected profits are yielded as following lemma, where the superscript, AD, represents the case in which the firm acquires information under mandatory disclosure.

Lemma 2. *In the case where the firm acquires information under mandatory disclosure, the optimal output and the ex ante expected profit of each firm are as follows:*

$$q_f^{AD} = \frac{1}{3}a + \frac{1}{3}\theta \qquad q_r^{AD} = \frac{1}{3}a + \frac{1}{3}\theta \tag{8}$$

$$E(\pi_f^{AD}) = \frac{1}{9}a^2 + \frac{1}{9}\sigma^2 - k \qquad E(\pi_r^{AD}) = \frac{1}{9}a^2 + \frac{1}{9}\sigma^2. \tag{9}$$

Finally, consider the cases (iii) and (iv). These two cases are the same in the sense that the firm acquires no information, and hence, both firms remain uncertain about demand when they make production decisions. In other words, disclosure regulation does not affect firms' output choices. The objective function of each firm is as follows:

$$\max_{q_i} E(\pi_i) = E(\{a+\theta-(q_f+q_r)\}q_i), \quad i=f,r. \tag{10}$$

By solving (10), each firm's optimal output level and the *ex ante* expected profit are yielded as following lemma, where the superscript, ϕ, represents the case in which the firm acquires no information. Note that the firm does not incur information acquisition cost.

Lemma 3. *In the case where the firm acquires no information, the optimal output and the ex ante expected profit of each firm are as follows:*

$$q_f^\phi = \frac{1}{3}a \qquad q_r^\phi = \frac{1}{3}a \tag{11}$$

$$E(\pi_f^\phi) = \frac{1}{9}a^2 \qquad E(\pi_r^\phi) = \frac{1}{9}a^2. \tag{12}$$

The comparison among equations (5), (8), and (11) indicates that the firm adjusts its output level conditional on the signal value if it acquires information. This means that the acquired information is useful for production decision. However, the comparison between equations (6) and (9) suggests that the benefits of acquiring information relatively decrease when disclosure is mandated. This is because when acquired information is disclosed, the rival can also use the information and adjust its output as seen in equation (8).

Based on the above analysis, I investigate the information acquisition choice by the firm. The comparison among the expected profit of the firm gives the following proposition.

Proposition 1. *The information acquisition choice by the firm is as follows:*

1. *If $k \leq \frac{1}{9}\sigma^2$, then the firm acquires information regardless of whether disclosure is mandated or not.*

2. *If* $\frac{1}{9}\sigma^2 < k < \frac{1}{4}\sigma^2$*, then the firm acquires information under nondisclosure, but not under mandatory disclosure.*

3. *If* $\frac{1}{4}\sigma^2 \leq k$*, then the firm does not acquire information regardless of whether disclosure is mandated or not.*

Proposition 1 shows that mandatory disclosure narrows the set of parameters that the firm chooses to acquire information. This means that the firm's incentive to acquire information is diminished when disclosure is mandated. The proposition also suggests that given the magnitude of demand uncertainty, σ^2, the firm acquires more information when the information acquisition cost is low. Additionally, given the information acquisition cost, k, the firm acquires more information when the uncertainty of market demand increases.

2.2 Welfare Analysis

This subsection investigates the desirability of disclosure regulation. For this purpose, I consider consumer surplus and total surplus as measures of social welfare. In my model, the expected consumer surplus is given by:

$$E(CS) = \frac{1}{2}E(Q^2), \tag{13}$$

where $Q = q_f + q_r$. The expected total surplus is then defined as $E(TS) = E(\pi_f) + E(\pi_r) + E(CS)$. The expected consumer surplus and the expected

total surplus are calculated as follows:

$$E(CS^{AN}) = \frac{2}{9}a^2 + \frac{1}{8}\sigma^2 \qquad E(TS^{AN}) = \frac{4}{9}a^2 + \frac{3}{8}\sigma^2 - k \tag{14}$$

$$E(CS^{AD}) = \frac{2}{9}a^2 + \frac{2}{9}\sigma^2 \qquad E(TS^{AD}) = \frac{4}{9}a^2 + \frac{4}{9}\sigma^2 - k \tag{15}$$

$$E(CS^{\phi}) = \frac{2}{9}a^2 \qquad E(TS^{\phi}) = \frac{4}{9}a^2, \tag{16}$$

where the superscripts represent each case in previous subsection. The comparison of equations (14), (15), and (16) with proposition 1 obtains the following proposition.

Proposition 2. *Suppose that disclosure of industry-wide demand information is mandated.*

1. *If* $k \leq \frac{1}{9}\sigma^2$*, then social welfare is enhanced.*

2. *If* $\frac{1}{9}\sigma^2 < k < \frac{1}{4}\sigma^2$*, then social welfare is reduced.*

3. *If* $\frac{1}{4}\sigma^2 \leq k$*, then there is no change in social welfare.*

The firm's information acquisition choice creates the difference in economic consequences of mandatory disclosure. Given the magnitude of demand uncertainty, if information acquisition cost is sufficiently low, the firm acquires information about demand regardless of disclosure regulation. In this case, both the firm and the rival can successfully adjust their output levels under mandatory disclosure, and this leads to the improvement of social welfare. However, when the cost increases and reaches a certain level, the firm acquires information only if disclosure is not mandated. Thus, in making production decisions, both firms remain uncertain about demand

state under mandatory disclosure while at least the firm can adjust its output conditional on the acquired signal under nondisclosure. In other words, mandatory disclosure deteriorates the firm's information environment, and eventually total surplus is decreased. Finally, if information acquisition cost is above a certain level, the firm does not acquire information regardless of disclosure regulation. Therefore, mandatory disclosure regulation does not affect production activities and social welfare.

3 Experimental Design

Based on the model analyzed in the previous section, I conduct a series of experiments on Cournot duopoly market with stochastic demand. In the experiments, participants take the role of either the firm or the rival, and the firm chooses whether or not to acquire costly information about unknown demand parameter. I manipulate information acquisition cost (low or high) in two economic settings (disclosure is mandated or not).[7] The experimental design is summarized in Figure 1.

A total of four sessions (i.e., one session for each treatment) with 98 different participants were conducted. All sessions were held at Osaka University in January 2012. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Participants were recruited from undergraduate and master students from various departments.

Upon arrival at the lab, participants drew lots and were assigned the role

[7]Because it seems to be obvious that the firm does not acquire information if acquiring information is too expensive, I am not concerned with such case. That is, in the experiments I focus on the two cases, $k \leq \frac{1}{9}\sigma^2$ and $\frac{1}{9}\sigma^2 < k < \frac{1}{4}\sigma^2$, and refer to the former as "low cost" and the latter as "high cost", respectively.

Cell MD-LC Mandatory Disclosure, Low Cost (26)	Cell ND-LC Nondisclosure, Low Cost (24)
Cell MD-HC Mandatory Disclosure, High Cost (22)	Cell ND-HC Nondisclosure, High Cost (26)

Figure 1: Experimental design (Number of subjects in parentheses.)

either the firm or the rival. The assigned role was unchanged throughout the session. Then, they were assigned a computer screen and received a set of written instructions that was read aloud by the experimenter. The instructions used an economic frame (Huck, 2004). The sessions consisted of 22 rounds. At the beginning of each round, firm/rival pairs were randomly assigned. I used the random matching protocol in order to minimize potential repeated game effects (e.g., reputation) because the experiments are based on one shot model.

The steps of each round are as follows. First, the firm chooses whether or not to acquire costly information about the demand state. There are three possible states: Good, Medium, and Bad.[8] Next, the true demand state appears on the firm's computer screen or not in accordance with its own information acquisition choice. Further, in mandatory disclosure treatments (MD-LC and MD-HC) the true demand state also appears on the rival's computer screen only if the firm chose to acquire information. On the other hand, the rival cannot observe the state regardless of the firm's choice in nondis-

[8]In experimental instructions, I used terms "state 1", "state 2", and "state 3" to refer to Good, Medium, and Bad, respectively.

closure treatments (ND-LC or ND-HC). Finally, both firms simultaneously select their own output levels and earn the profits, respectively.

The sessions lasted about 2 hours including instruction time. After the instructions were read, I conducted one trial round and then started the first round. At the end of the session, participants were paid according to their total profits earned throughout 22 rounds. The average payoff was 3,825 Japanese Yen across all treatments.

Recall that the inverse demand function is given by:

$$p = a + \theta - (q_f + q_r).$$

In the experiment, I used the following parameters: $a = 180, \theta \in \{-60, 0, 60\}$. That is, the demand state Good means $\theta = 60$, and in the same way, Medium is $\theta = 0$ and Bad is $\theta = -60$, respectively. Further, in the low cost treatments (MD-LC and ND-LC) information acquisition cost k equals 100 while in the high cost treatments (MD-HC and ND-HC) it equals 500. For simplicity, participants choose their outputs among 25 and 95 at intervals of 5, i.e., $\{25, 30, 35, \ldots, 85, 90, 95\}$. In order to calculate profits, three types of payoff tables, which correspond to each demand state, are provided to participants. The theoretical predictions, which provide benchmarks for testing the experimental results, are summarized in Table 1.

Table 1: Theoretical predictions

Treatment	Information acquisition?	Demand state	The firm's output	The rival's output
MD-LC	Yes	Good	80	80
		Medium	60	60
		Bad	40	40
ND-LC	Yes	Good	90	60
		Medium	60	60
		Bad	30	60
MD-HC	No	Good	60	60
		Medium	60	60
		Bad	60	60
ND-HC	Yes	Good	90	60
		Medium	60	60
		Bad	30	60

Note:
Demand state: Good ($\theta = 60$), Medium ($\theta = 0$), Bad ($\theta = -60$).
Information acquisition cost: Low ($k = 100$), High ($k = 500$).

Table 2: Proportion of information acquisition

Treatment			
MD-LC	ND-LC	MD-HC	ND-HC
64.3%	89.4%	47.1%	54.5%
(100%)	(100%)	(0%)	(100%)

Note: Theoretical prediction in parentheses.

4 Results

4.1 Information Acquisition Choices

In this subsection, I examine the firm's information acquisition choice. Table 2 presents the proportion of information acquisition by the firm. The data shows that the proportion of information acquisition in the treatments MD-LC and ND-HC is less than the theoretical predictions, and in MD-HC the proportion is more than the prediction. As pointed out by Ackert et al. (2000), experimental results typically deviate from point predictions provided by a theory, because the theory relies on simplifying assumptions. Thus, I consider whether observed differences are in the expected direction rather than the point predictions.

First, I investigate the impact of mandatory disclosure on the firm's information acquisition choice. I compare the proportion of information acquisition between mandatory disclosure treatments and nondisclosure treatments. The proportion of acquiring information in ND-LC is greater than that in MD-LC. The difference is statistically significant at a conventional level ($p < 0.001$, Fisher's exact test). In addition, the data exhibits that

the proportion in ND-HC is slightly greater than that in MD-HC, and the difference is marginally significant ($p = 0.097$, Fisher's exact test).

Next, I report the results for the effect of information acquisition cost. I compare the proportion of information acquisition between low cost treatments and high cost treatments. The proportion in MD-LC is greater than that in MD-HC. Also, the proportion in ND-LC is greater than that in ND-LC. Both differences are statistically significant ($p < 0.001$, Fisher's exact test).

In sum, the results suggest that mandatory disclosure diminishes firm's incentive to acquire information. Further, increase in cost also affects firm's information acquisition choice negatively. These findings are consistent with the directional, theoretical predictions.

4.2 Production Decisions

4.2.1 The Effects of Information Acquisition

The model predicts that if the firm acquires information and learns the realized demand state before making its production decision, it can successfully adjust its output level depending on the state. To examine this prediction, I conduct Kruskal-Wallis tests and Scheffe's multiple comparison tests for output choices by the firms that acquired information. As the purpose of this subsection is concerned, I restrict the analysis to the firm's behavior. In all treatments the Kruskal-Wallis and multiple comparison results indicate that the differences among the outputs in each demand state (Good, Medium, or Bad) is statistically significant ($p < 0.001$ for every combination of two de-

Table 3: Output levels of informed firms

Demand state		Treatment			
		MD-LC	ND-LC	MD-HC	ND-HC
Good	Mean	82.9	90.3	81.9	86.7
	(SD)	(7.99)	(5.95)	(8.75)	(7.24)
	Median	80	95	80	85
	Nash prediction	80	90	80	90
Medium	Mean	62.0	60.1	61.5	60.7
	(SD)	(7.97)	(7.55)	(9.82)	(8.71)
	Median	60	60	60	60
	Nash prediction	60	60	60	60
Bad	Mean	39.7	33.6	39.9	30.3
	(SD)	(4.10)	(8.16)	(4.48)	(6.73)
	Median	40	30	40	30
	Nash prediction	40	30	40	30

Note: SD means standard deviation.

mand states). These suggest that the informed firm chooses different output level depending on the acquired signal.

In addition, I conduct Kruskal-Wallis tests for output choices by the firms that did not acquire information. As expected, in all treatments the null hypotheses that there is no differences among the outputs in each demand state is not rejected ($p = 0.558$ in MD-LC, $p = 0.556$ in ND-LC, $p = 0.636$ in MD-HC, and $p = 0.347$ in ND-HC). That is, the uninformed firm cannot adjust its output level conditional on the demand state. Taken together, these results demonstrate that the firm's production decision is improved by acquiring information.

Table 3 shows mean and median outputs of the informed firms. The data indicates that the informed firm increases output when demand state

is Good while it decreases output when demand state is Bad. Furthermore, the output level of the informed firm is well-predicted by the noncooperative Nash equilibrium. These findings support the theoretical predictions.

4.2.2 The effects of Mandatory Disclosure

Next, I consider the following issue: given that the firm acquired information, how does mandatory disclosure affect the firm's production decision? Table 3 shows that the informed firm increases output when demand state is Good while it decreases output when demand state is Bad. However, the data also suggests that the informed firms in the nondisclosure treatments (ND-LC and ND-HC) increase or decrease their output levels greater than those in the mandatory disclosure treatments (MD-LC and MD-HC).

First, I make a comparison between MD-LC and ND-LC. When the demand state is Good, the informed firm produces 82.9 units on average in the treatment MD-LC, which is less than 90.3 units in the treatment ND-LC. The difference is statistically significant at a conventional level ($p < 0.001$, Mann-Whitney test). On the other hand, when the demand state is Bad, the informed firm in MD-LC produces 39.7 units on average, which is more than 33.6 units in ND-LC. The difference is also significant ($p < 0.001$, Mann-Whitney test).

Next, I compare MD-HC to ND-HC. The difference of outputs between the two treatments is significant when the state is Bad, but it is not significant at a conventional level when the state is Good (the state Good: $p = 0.013$, the state Bad: $p < 0.001$, Mann-Whitney test).

These results suggest that when demand state is Good, the informed firms

Table 4: Output levels of informed rivals

Demand state		Treatment	
		MD-LC	MD-HC
Good	Mean	79.2	80.9
	(SD)	(10.82)	(10.32)
	Median	80	80
	Nash prediction	80	80
Medium	Mean	63.4	59.9
	(SD)	(8.78)	(7.88)
	Median	60	60
	Nash prediction	60	60
Bad	Mean	41.5	41.1
	(SD)	(7.15)	(7.77)
	Median	40	40
	Nash prediction	40	40

Note: ND-LC and ND-HC are omitted because the rival always remains uncertain about demand state.

in the mandatory disclosure treatments tend to produce less than those in the nondisclosure treatments on average. In contrast, when demand state is Bad, the informed firms in the mandatory disclosure treatments tend to produce more than those in nondisclosure treatments on average. This occurs because, given that the firm acquired information, the rival can also learn the true demand state and adjust its output under mandatory disclosure. That is, disclosure of demand information induces the rival to respond in the same direction, and this makes the firm's response to the acquired information relatively small as compared to a nondisclosure case (Darrough, 1993). The informed rivals' output levels are summarized in Table 4.

I conduct Kruskal-Wallis tests and Scheffe's multiple comparison tests for output choice by the informed rival. In both treatments the Kruskal-Wallis

and multiple comparison results indicate that the difference among the outputs in each demand state (Good, Medium, or Bad) is statistically significant ($p < 0.001$ for every combination of two demand states). These suggest that the informed rival adjusts its output level depending on the demand state as well as the informed firm does. The point is that the improvement of the rival's decision brings competitive disadvantages to the firm because both firms compete in the same market. This means that the benefits of acquiring information relatively decrease under mandatory disclosure.

5 Conclusion

The experimental results are largely consistent with theoretical predictions about information acquisition choices and production decisions. The results demonstrate that mandatory disclosure diminishes firm's incentive to acquire industry-wide demand information when information acquisition is costly and endogenous. Further, I also show that firm's production decision is improved by acquiring information. Taken together, although acquiring information improves firm's production decision, mandatory disclosure diminishes firm's incentive to do so, and thus, deteriorates firm's information environment. This leads to inefficient production, which in turn, might have a substantial impact on market outcomes.

However, although this paper finds consistent evidence of the relation between information acquisition and production decision, this paper cannot find experimental evidence consistent with theory with regard to social welfare (see Appendix, Table 6 and 7). This may be because outputs of both firms

tend to be greater than theoretical predictions when they are uninformed of demand state (see Appendix, Table 5). One possible reason is that the production cost is assumed to be zero in order to simplify the experiments, but this may lead participants to feel that losses due to overproduction are relatively small. Therefore, future research can modify the design and replicate the experiments. In addition, this paper uses random matching protocol in an attempt to test the static model. In reality, however, repeated interactions among the same players may be more appropriate. Further, repeated interactions can create an opportunity of tacit collusion, and thus, the results might be different from a static setting.

Appendix

A.1 Output Levels of Uninformed Firms and Rivals

Table 5: Mean Output levels of uninformed firms and rivals

		Treatment			
		MD-LC	ND-LC	MD-HC	ND-HC
The firm	Mean	76.2**	81.6**	72.0**	71.2**
	(SD)	(14.39)	(9.55)	(15.46)	(11.31)
The rival	Mean	62.2	66.4**	62.7	65.4*
	(SD)	(17.64)	(12.53)	(14.40)	(12.82)

Note: $*$, and $**$ represent the difference with Nash prediction, 60, is significant at the 5 percent, and 1 percent levels, respectively.

Table 6: Surplus in low cost treatments

Treatment		Profits		Consumer surplus	Total surplus
		The firm	The rival		
MD-LC	Mean	3604.6	3630.8	8136.6	15372.1
	(SD)	(2066.7)	(1875.38)	(4286.79)	(7747.22)
ND-LC	Mean	3575.4	3323.9	8480.0	15379.3
	(SD)	(2886.60)	(1747.00)	(3412.65)	(7390.76)

Table 7: Surplus in high cost treatments

Treatment		Profits		Consumer surplus	Total surplus
		The firm	The rival		
MD-HC	Mean	3726.8	3215.0	8607.6	15549.4
	(SD)	(3076.51)	(2629.59)	(2469.48)	(6403.63)
ND-HC	Mean	3211.5	3523.6	8140.1	14875.2
	(SD)	(2729.11)	(1750.82)	(3478.62)	(7295.11)

A.2 Profits, Consumer, and Total Surplus

Table 6 presents the both firms' profits, consumer surplus, and total surplus in the low cost treatments given the optimal information acquisition decisions (i.e., acquisition for both MD-LC and ND-LC). The theoretical predictions are as follows. The firm's profit: MD-LC $<$ ND-LC, the rival's profit: MD-LC $>$ ND-LC, consumer surplus: MD-LC $>$ ND-LC, total surplus: MD-LC $>$ ND-LC.

Table 7 presents the both firms' profits, consumer surplus, and total surplus in the high cost treatments given the optimal information acquisition decisions (i.e., no-acquisition for MD-HC and acquisition for ND-HC). The theoretical predictions are as follows. The firm's profit: MD-HC $<$ ND-HC, the rival's profit: MD-HC $=$ ND-HC, consumer surplus: MD-HC $<$ ND-HC,

total surplus: MD-HC < ND-HC.

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