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Abstract

This study experimentally investigates the interaction between firms' information acquisition decisions and disclosure. In particular, I focus on a Cournot duopoly market under industry-wide demand uncertainty. The results demonstrate that acquiring industry-wide demand information improves firms' production decisions in that firms can adjust their quantity levels depending on the market demand. However, disclosure diminishes a firm's incentive to acquire such information. This is because once the information, which a firm acquired at a cost, is subsequently disclosed, a rival firm can take a free ride on the disclosed information and make a more informed decision. Hence, disclosure decreases the benefit of acquiring information for the disclosing firm. Taken together, although acquiring information improves production decisions, disclosure decreases the incentive to do so and thus, deteriorates a firm's internal information environment. This leads to inefficient production, which in turn might have a substantial impact on market outcomes.

Keywords: Information acquisition; Disclosure; Duopoly; Experiment

JEL Classification: L13; M41; M48

[†]The former title is "The Impact of Mandatory Disclosure on Information Acquisition: Theory and Experiment."

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1 Introduction

Numerous theoretical studies examine the interaction between information disclosure and product market competition and provide important insights on proprietary disclosures.[1] Darrough (1993) analyzes a two-stage duopoly model. She demonstrates that when firms engage in Cournot competition under industry-wide demand uncertainty, they would not commit to disclosing demand information because of its proprietary nature. Suijs and Wielhouwer (2014) extend Darrough's (1993) model. They show that although Cournot duopolists prefer not to disclose demand information *ex ante*, mandatory disclosure requirements can enhance social welfare, especially when products are good substitutes. These suggest that disclosure regulation will be socially desirable in Cournot duopoly under demand uncertainty.[2]

I argue that it is unclear whether mandating disclosure can achieve the intended objective of improving social welfare when information acquisition is endogenous and costly. Of course, an antecedent of information disclosure is that firms must have acquired and possessed information to disclose. Firms must often spend resources to obtain private information and thus face a trade-off between the cost and benefit of information acquisition. In addition, if the acquired private information is subsequently disclosed, not only the firm that acquired the information at a cost but also its competitors can strategically use this information and make more informed decisions. Therefore, mandatory disclosure potentially decreases the benefits of acquiring information. In this way, mandatory disclosure of proprietary information diminishes a firm's incentive to acquire such information, and hence, its internal information environment deteriorates compared to the case where disclosure regulation does not exist. This might lead to a substantial impact on market outcomes.

The objective of this study is to experimentally investigate the interaction between firms' information acquisition decisions and disclosure. The experiment is based on a simplified version of Miwa's (2019) model. Miwa (2019) analyzes a Cournot duopoly model with stochastic demand in which acquiring information is endogenous. I conduct a controlled experiment to test the theoretical predictions derived from the model.

[1] See, for example, Vives (1984), Gal-Or (1985), Kirby (1988), Vives (1990), Darrough (1993), Sankar (1995), Raith (1996), Clinch and Verrecchia (1997), Pae (2000), Pae (2002), Arya and Mittendorf (2007), Hughes and Williams (2008), Arya, Frimor, and Mittendorf (2010), Bagnoli and Watts (2010), Corona and Nan (2013), Suijs and Wielhower (2014), Bagnoli and Watts (2015), and Hughes and Pae (2015).

[2] Most theoretical studies that analyze a stochastic oligopoly model consider two types of information, i.e., firm-specific cost information and industry-wide demand information. However, the key distinction is between firm-specific and industry-wide information, not cost versus demand information (Christensen and Feltham 2003, pp.544-545). In line with previous research, I interpret industry-wide information as demand-related.

In the experiment, I manipulate the information acquisition cost (low versus high) in two economic settings (disclosure versus nondisclosure). Hence, the experiment consists of four treatments: disclosure and low cost (DL), nondisclosure and low cost (NL), disclosure and high cost (DH), and nondisclosure and high cost (NH). To simplify the setting, participants take the role of either a *firm* or a *rival*. Only the firm participants have a choice of whether or not to acquire information about unknown demand parameters at a cost. In nondisclosure conditions (i.e., treatments NL and NH), if a firm chooses to acquire information, it receives a perfect signal about the true demand state of the market before making a production decision. In contrast, the paired rival does not receive any signals and remains uncertain about the market demand. In disclosure conditions (i.e., treatments DL and DH), on the other hand, if a firm chooses to acquire information, both the firm and the paired rival receive a perfect signal. That is, demand information that the firm acquired at a cost is disclosed to the rival. In this way, both the firm and the rival learn the true demand state of the market before making their production decisions. Regardless of whether the acquired information is disclosed or not, only a firm bears the information acquisition cost when it chooses to acquire information. The cost is either high or low, depending on the experimental treatments. If a firm chooses not to acquire information, both the firm and the paired rival remain uncertain about the market demand in all treatments.

The main results are as follows. When firms learn the true demand state of the market through information acquisition, they successfully adjust their production levels depending on the market demand. Specifically, if a firm acquires information and learns that the demand state is good (bad), it increases (decreases) its quantity level. When firms do not acquire information and remain uncertain about the market demand, they cannot adjust production levels depending on the market demand. These indicate that acquiring demand information improves firms' production decisions.

However, the results show that if the demand information is disclosed to a rival, the rival can also adjust its quantity level depending on the market demand. This means that disclosure allows the rival to take a free ride on the paired firm's costly information acquisition. In other words, if a firm acquires information at a cost but must disclose it afterward, the benefit of acquiring such information is reduced. In fact, firms in nondisclosure conditions tend to acquire information more frequently than those in disclosure conditions. This indicates that disclosure negatively affects firms' information acquisition decisions. In addition, as expected, firms acquire information more frequently when the information acquisition cost is low.

This study has several contributions to the literature. First, it contributes to the theoretical literature on information disclosure in an oligopoly market. Previous theoretical studies examine how product market competition affects firms' disclosure decisions (e.g., Vives 1984; Gal-Or 1985; Darrough 1993; Sankar 1995; Raith 1996; Pae 2000; Arya and Mittendorf 2007, Hughes and Williams 2008; Bagnoli and Watts 2010; Suijs and Wielhouwer 2014). Most existing literature treats firms' private information as exogenous and does not consider the interaction between firms' information acquisition decisions and disclosure. Several theoretical studies simultaneously consider the problem of information acquisition and disclosure in an oligopoly market (e.g., Kirby 2004; Jansen 2008; Ganuza and Jansen 2013; Miwa 2019).[3] In particular, Miwa (2019) analyzes a Cournot duopoly model under demand uncertainty and shows that disclosure negatively affects firms' incentives for acquiring information. This study tests and provides support for the theoretical predictions. The results demonstrate that although acquiring information improves firms' production decisions, disclosure diminishes firms' incentives to do so. The results suggest that when information acquisition is endogenous and costly, mandatory disclosure might have the unintended consequence of deteriorating firms' internal information environment and leading to inefficient production decisions.

The second contribution is that this study complements prior archival-based research by conducting a controlled experiment to test the theoretical predictions. In recent years, numerous archival-based studies find that product market competition affects firms' decisions about information disclosure (e.g., Bhojraj, Blacconiero, and D'Souza 2004; Guo, Lev, and Zhou 2004; Dedman and Lennox 2009; Li 2010; Cheng, Man, and Yi 2013; Ali, Klasa, and Yeung 2014; Dhaliwal, Huang, Khurana, and Pereira 2014). However, theoretical predictions derived from the existing disclosure models are very sensitive to some assumptions, such as types of information and competition (Suijs and Wielhouwer 2014). This makes it difficult to test the theoretical predictions using archival-based data directly. For example, Dedman and Lennox (2009) find that firms are more likely to withhold information when the competition is intense in the industry, but they state that "we do not attempt to test predictions of a specific theoretical model of disclosure" (p.214). This study uses an experimental economics approach and conducts a controlled experiment, which allows the direct test of the theoretical model. As Ackert, Church, and Sankar (2000) point out, an experimental approach has several advantages in examining dis-

[3] Several studies examine information acquisition by firms in an oligopoly market, though they do not consider the issue of disclosure (e.g., Li, McKelvey, and Page 1987; Hwang 1995; Hauk and Hurkens 2001).

closure models.[4] For example, researchers can create a controlled economic environment they wish to examine and directly observe firms' behavior. In addition, researchers can compare the results under different conditions by manipulating the parameters of the environment.

Third, this study contributes to the growing literature on the relationship between firms' internal and external reporting. Zimmerman's (2014) textbook states that "the internal and external reports are closely linked" (p.6) and points out that managers of large U.S. firms typically use the same accounting procedures for both internal and external reporting. Hemmer and Labro (2008) argue that financial reporting requirements and managerial decision making are closely related, and they develop a model to examine the optimal relation between regulated financial reporting systems and unregulated management accounting information systems. Schneider and Scholze (2015) analyze segment disclosure in an entry game and show that disclosure regulation that needs more transparency, such as management approach for segment reporting, might negatively affect firms' information environment. Recent archival studies also suggest the link between internal information systems and external reporting. For example, Dorantes, Li, Peters, and Richardson (2013) find that the implementation of enterprise systems, including enterprise resource planning (ERP) and supply chain management system (SCM), improves firms' internal information environment, and this leads to the improvement of the quality of management forecasts. Shroff (2017) finds that exogenous changes in accounting rules affect firms' investment decisions. This is an interesting result because accounting rules that are set for external financial reporting also affect firms' internal decision making. Shroff (2017) argues that this is because some changes in accounting rules alter firms' internal information environment and consequently affect their investment decisions. This study provides additional insights by examining the relationship between information acquisition decisions (internal reporting) and disclosure (external reporting) in the presence of product market competition. This study shows that, in some situations, mandatory disclosure requirements negatively affect firms' incentives for acquiring information, which in turn deteriorate firms' internal information environment.

The remainder of this paper is organized as follows. Section 2 presents an overview of Miwa's (2019) model that provides the basis for the experimental tests. Section 3 explains the experimental design. Section 4 reports the results, and Section 5 concludes this paper.

[4] Several experimental studies investigate disclosure in duopoly markets (Cason 1994; Cason and Mason 1999; Ackert et al. 2000). However, they do not consider firms ' information acquisition decisions preceding the disclosure.

2 Theoretical background

I present an overview of Miwa's (2019) model that provides the basis for the experimental tests. Consider a single-period product market where two firms compete in quantities (i.e., a Cournot duopoly market) under demand uncertainty. Assume that the market price p is determined by the following inverse demand function

$$p = \alpha - q_1 - q_2, \tag{1}$$

where q_1 and q_2 denote firm 1's and firm 2's quantity levels, respectively.[5] The demand intercept α is

$$\alpha = \bar{\alpha} + \Delta\alpha_1 + \Delta\alpha_2, \tag{2}$$

where $\bar{\alpha} > 0$ is a constant, and $\Delta\alpha_i$ is normally distributed with mean zero and variance $s > 0$, i.e., $\Delta\alpha_i \sim N(0, s), i = 1, 2$. It is assumed that $\Delta\alpha_1$ and $\Delta\alpha_2$ are independent.[6] For simplicity, the marginal cost of production is zero for both firms.

Each firm i acquires a signal ξ_i about $\Delta\alpha_i$, which is costly and noisy. Specifically,

$$\xi_i = \Delta\alpha_i + \varepsilon_i, \tag{3}$$

where ε_i is a noise term and $\varepsilon \sim N(0, e_i)$. To acquire the signal, firm i must bear the information acquisition cost K_i, which is assumed to be linear in $1/e_i$. Let $k > 0$ be a constant and define $\eta_i \equiv s/(s + e_i)$. Then, the information acquisition cost K_i can be written as

$$K_i\left(\eta_i\right) = \frac{k\eta_i}{s(1 - \eta_i)}. \tag{4}$$

Following Miwa (2019), $\eta_i \in [0, 1)$ is interpreted as the quality of the signal ξ_i. The higher η_i is, the more valuable the signal is. This is because firm i relies more on the signal to update the prior belief when η_i is high, given that $\mathrm{E}[\Delta\alpha_i \mid \xi_i] = \eta_i\xi_i$. Whether the signal acquired by firm i is disclosed or not is modeled as probability $\theta_i \in [0, 1]$. That is, firm i's signal ξ_i is

[5]Miwa (2019) includes a parameter that represents the degree of substitution between firm 1's and firm 2's products in the model. For simplicity, I assume that the two firms' products are homogeneous in this study.

[6]Miwa (2019) includes a parameter representing the degree of correlation between the two firms' demand intercepts. Hence, his model can describe situations where the firms face industry-wide or firm-specific uncertainty depending on the correlation. In this study, I focus on the case of industry-wide uncertainty.

publicly disclosed with probability θ_i and concealed with probability $1-\theta_i$. I assume that the probability θ_i is exogenous, and disclosure is truthful. When firm i's signal ξ_i is disclosed, firm j can observe and use the signal for its production decision. Both firms are assumed to be risk neutral and maximize their own expected profits.

2.1 Information acquisition decisions

Firm i's *ex ante* expected profit can be expressed as

$$\begin{aligned} \mathrm{E}\left[\pi_i^{\dagger}\right] &= \theta_i \left(\theta_j \mathrm{E}\left[\pi_i^{dd}\right] + (1-\theta_j)\,\mathrm{E}\left[\pi_i^{d\phi}\right]\right) \\ &\quad + (1-\theta_i)\left(\theta_j \mathrm{E}\left[\pi_i^{\phi d}\right] + (1-\theta_j)\,\mathrm{E}\left[\pi_i^{\phi\phi}\right]\right). \end{aligned} \tag{5}$$

The superscript d (ϕ) denotes disclosure (nondisclosure). Firm i chooses the quality of the signal to maximize the *ex ante* expected profit net of the information acquisition cost. Therefore, assuming that the optimal signal quality η_i^* is obtained by an interior solution, the following first-order condition holds.

$$\frac{\partial}{\partial \eta_i}\left(\mathrm{E}\left[\pi_i^{\dagger}\right] - K_i(\eta_i)\right)\Big|_{\eta_i=\eta_i^*} = 0. \tag{6}$$

Consider the effect of disclosure on firms' information acquisition decisions. From the above condition, one can obtain that $\partial\eta_i^*/\partial\theta_i < 0$.[7] This indicates that firms acquire less precise information when the acquired information is disclosed. In other words, disclosure negatively impacts firms' information acquisition decisions.[8] In addition, regarding the effect of the information acquisition cost, one can obtain that $\partial\eta_i^*/\partial k < 0$.

2.2 Production decisions

Why does disclosure negatively affect firms' information acquisition decisions? To clarify the logic, consider the case where (i) both firms do not disclose their signals, and (ii) firm i discloses its signal ξ_i, but firm j does not. When both firms do not disclose their signals, firm i's and firm

[7]See Miwa (2019) for the technical details.

[8]Similarly, one can show that $\partial\eta_i^*/\partial\theta_j = 0$, and hence firm i's information acquisition decision is independent of firm j's disclosure in this setting.

j's expected profits can be calculated as

$$\mathrm{E}\left[\pi_i^{\phi\phi}\right] = \frac{1}{9}\left(\bar{\alpha}^2 + \frac{9}{4}s\eta_i\right), \qquad \mathrm{E}\left[\pi_j^{\phi\phi}\right] = \frac{1}{9}\left(\bar{\alpha}^2 + \frac{9}{4}s\eta_j\right). \tag{7}$$

When only firm i discloses its signal ξ_i, firm i's and firm j's expected profits are as follows.

$$\mathrm{E}\left[\pi_i^{d\phi}\right] = \frac{1}{9}\left(\bar{\alpha}^2 + s\eta_i\right), \qquad \mathrm{E}\left[\pi_j^{\phi d}\right] = \frac{1}{9}\left(\bar{\alpha}^2 + \frac{9}{4}s\eta_j + s\eta_i\right). \tag{8}$$

The difference between $\mathrm{E}\left[\pi_i^{\phi\phi}\right]$ and $\mathrm{E}\left[\pi_i^{d\phi}\right]$ exhibits the profit reduction for firm i caused by disclosing the signal ξ_i. In contrast, the difference between $\mathrm{E}\left[\pi_j^{\phi\phi}\right]$ and $\mathrm{E}\left[\pi_j^{\phi d}\right]$ exhibits the additional profit for firm j that it can earn by taking a free ride on firm i's signal ξ_i.

The point is that the benefit of acquiring information for each firm comes from adjusting its production level through observing the signal. When both firms do not disclose their signals, each firm observes only its own signal. In this case, firm i's and firm j's optimal quantity levels are calculated as

$$q_i^{\phi\phi}(\xi_i) = \frac{1}{3}\left(\bar{\alpha} + \frac{3}{2}\eta_i\xi_i\right), \qquad q_j^{\phi\phi}(\xi_j) = \frac{1}{3}\left(\bar{\alpha} + \frac{3}{2}\eta_j\xi_j\right). \tag{9}$$

On the other hand, when only firm i discloses its signal ξ_i, firm j can also observe firm i's signal ξ_i. Thus, firm i's and firm j's optimal quantity levels are as follows.

$$q_i^{d\phi}(\xi_i) = \frac{1}{3}\left(\bar{\alpha} + \eta_i\xi_i\right), \qquad q_j^{\phi d}(\xi_j, \xi_i) = \frac{1}{3}\left(\bar{\alpha} + \frac{3}{2}\eta_j\xi_j + \eta_i\xi_i\right). \tag{10}$$

Note that firm i's expected profit for each case can be expressed as follows.

$$\mathrm{E}\left[\pi_i^{\phi\phi}\right] = \left(\mathrm{E}\left[q_i^{\phi\phi}\right]\right)^2 + \mathrm{Var}\left[q_i^{\phi\phi}\right], \tag{11}$$

$$\mathrm{E}\left[\pi_i^{d\phi}\right] = \left(\mathrm{E}\left[q_i^{d\phi}\right]\right)^2 + \mathrm{Var}\left[q_i^{d\phi}\right]. \tag{12}$$

The expected quantity level for each case is equal and constant (i.e., $\mathrm{E}\left[q_i^{\phi\phi}\right] = \mathrm{E}\left[q_i^{d\phi}\right] = (1/3)\bar{\alpha}$). Thus, the key here is the variance of the quantity. From equations (9) and (10), firm i adjusts its quantity level according to the signal value ξ_i. Such adjusting behavior increases the variance of the quantity, which in turn increases the expected profit. However, comparing equations (9) and (10) indicates that the extent to which firm i adjusts its quantity level (i.e., the weight on ξ_i) becomes smaller when firm i discloses its signal.

To explain the mechanism, consider the case where firm i obtains a signal $\xi_i > 0$. Observing $\xi_i > 0$ means that the market demand is likely higher than the prior expectation, so firm i increases its quantity level. As seen in equation (10), if the signal is disclosed, firm j also observes it and increases its quantity level. That is, firm j can take a free ride on the signal disclosed by firm i. Given that firms' products are strategic substitutes in this model, an increase in production by firm j leads to a decrease in production by firm i. Thus, firm i increases its quantity level, but the extent of the increase is not as large as under nondisclosure.

Conversely, when firm i obtains a signal $\xi_i < 0$, this means that the market demand is likely lower than the prior expectation. Thus, firm i decreases its quantity level. If the signal is disclosed, firm j also decreases its quantity level. This leads to an increase in production by firm i because of the effect of strategic substitutes. Thus, in this case, firm i decreases its quantity level, but the extent of the decrease is not as large as under nondisclosure.

In sum, acquiring information (i.e., a signal on the market demand) is beneficial for firm i because it allows firm i to adjust its production level depending on the market demand. However, disclosure of firm i's signal reduces the extent to which firm i can adjust their production levels (i.e., the variance of firm i's quantity), and this leads to a decrease in firm i's expected profit. In other words, disclosure decreases the benefit of acquiring information. Therefore, when the acquired information is disclosed, each firm acquires less precise information compared to the case of nondisclosure.

3 Experimental design

I conduct an experiment on a Cournot duopoly market with stochastic demand. The experiment is based on a simplified version of Miwa's (2019) model. To make the experiment simple enough for participants to understand, I simplify some aspects of the model. In the experiment, the information acquisition decision is a binary choice: whether or not to acquire information. Specifically, if a firm chooses to acquire information, it bears the information acquisition cost and receives a perfect signal about the actual demand state of the market. If a firm chooses not to acquire information, it does not receive any signals and remains uncertain about the market demand. Furthermore, participants take the role of either a *firm* or a *rival*. Only the firm participants have a choice of whether or not to acquire information. The information acquisition cost, denoted by k, is a constant.

I manipulate the information acquisition cost (low versus high) in two economic settings (disclosure versus nondisclosure). Hence, the experiment consists of four treatments: disclosure and low cost (DL), nondisclosure and low cost (NL), disclosure and high cost (DH), and nondisclosure and high cost (NH). The experiment includes four sessions (one for each treatment), with 98 participants. Table 1 summarizes the experimental design.

Insert Table 1 about here.

I held all sessions at Osaka University in January 2012. I programmed and conducted the experiment with the z-Tree software package (Fischbacher 2007). I recruited participants among the undergraduate and master students from various departments. Upon arrival at the lab, participants drew lots and were assigned the role of either a firm or a rival, which did not change throughout the session. Participants were then assigned a computer screen and received a set of written instructions that the experimenter read aloud. 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 to minimize potential repeated game effects (e.g., reputation) because the experiment is based on a one-shot model.

Each round includes the following steps. First, a firm participant chooses whether or not to acquire information about the market demand, about which there are three possible states: Good, Medium, and Bad.[9] The three demand states occur with equal probability. Next, the true demand state appears on the firm participant's computer screen if he or she decided to acquire the information. Furthermore, in disclosure conditions (i.e., treatments DL and DH), the true demand state also appears on the paired rival participant's computer screen only if the firm participant chose to acquire the information. In contrast, the rival participant cannot observe the demand state in nondisclosure conditions (i.e., treatments NL or NH), regardless of the paired firm participant's choice.[10] Finally, both the firm and the rival participants simultaneously select their quantity levels and earn profits.

The sessions lasted about 2 hours, including instruction time. After the instruction was read, I conducted one trial round and then started the first round. At the end of the session, participants

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

[10]Note that a firm participant can choose not to acquire information even in disclosure conditions. It can be interpreted that the disclosed information has no information content in this case.

were paid according to their total profits earned throughout the 22 rounds. The average cash payment was 3,825 yen (about 47.8 dollars) across all treatments.

As stated earlier, there are three demand states in the experiment: Good, Medium, and Bad. Specifically, the inverse demand function for each state is as follows.

$$p = 240 - q_f - q_r \quad \text{when the demand state is Good,} \tag{13}$$

$$p = 180 - q_f - q_r \quad \text{when the demand state is Medium, and} \tag{14}$$

$$p = 120 - q_f - q_r \quad \text{when the demand state is Bad,} \tag{15}$$

where q_f and q_r denote a firm's and a rival's quantity levels, respectively. In low-cost conditions (i.e., treatments DL and NL), the information acquisition cost is $k = 100$ while in high-cost conditions (i.e., treatments DH and NH), it is $k = 500$. For simplicity, participants choose their quantity levels in intervals of 5, i.e., $\{25, 30, 35, \ldots, 85, 90, 95\}$, between 25 and 95. I used three types of payoff tables to calculate profit, which corresponded to each demand state, which were provided to participants.

Tables 2 and 3 summarize the theoretical predictions that provide the benchmarks for testing the experimental results. The experiment is designed to test the following hypotheses, following the model discussed in Section 2. My first two hypotheses relate to firms' information acquisition decisions. In particular, I focus on the effects of disclosure and the information acquisition cost. The model suggests that disclosure negatively impacts firms' information acquisition decisions. Furthermore, as an intuitive consequence, I predict that increasing the information acquisition cost also negatively affects firms' information acquisition decisions.

Hypothesis 1. *Compared to when the acquired information is disclosed, the proportion of firms acquiring information is greater when the acquired information is not disclosed.*

Hypothesis 2. *Compared to when the information acquisition cost is high, the proportion of firms acquiring information is greater when the information acquisition cost is low.*

Insert Tables 2 and 3 about here.

Next, I focus on firms' production decisions. The model suggests that acquiring information is beneficial for a firm because it allows the firm to adjust its production level depending on the market demand. Note that this adjusting behavior increases the variance of the quantity, which in turn increases the expected profit. However, if the acquired information is disclosed, a rival can also use the information and adjust its production level. In sum, disclosure triggers the rival's reaction that reduces the extent to which the firm can adjust its production level, leading to a decrease in the firm's expected profit that disclosed the information. This explains why disclosure decreases the benefit of acquiring information. Therefore, my hypotheses on firms' production decisions are as follows.

Hypothesis 3. *If a firm acquires information, it adjusts its production level depending on the demand state. While the firm increases the quantity when the state is Good, it decreases the quantity when the state is Bad.*

Hypothesis 4. *If a firm acquires information, and the information is disclosed, the paired rival also adjusts its production level depending on the demand state. While the rival increases the quantity when the state is Good, it decreases the quantity when the state is Bad.*

Hypothesis 5. *Given that a firm acquires information, compared to when the acquired information is disclosed, the extent to which the firm adjusts its production level is greater when the acquired information is not disclosed.*

4 Results

4.1 Information acquisition decisions

In this subsection, I examine firms' information acquisition decisions. Table 4 presents the proportion of firms acquiring information. Because each experimental session consisted of 22 rounds and there might exist some learning effects, I present the data for the first and last halves, in addition to the data for all rounds.

Insert Table 4 about here.

First, I investigate the impact of disclosure. I compare the proportion of information acquisition between disclosure and nondisclosure conditions. The proportion of firms acquiring information in treatment NL is greater than that in DL. The difference is statistically significant

(p-value < 0.001 for both all rounds and last-half samples, Fisher's exact test).[11] In addition, the data shows that the proportion in treatment NH is greater than that in DH, and the difference is marginally significant for all rounds sample (p-value $= 0.097$, Fisher's exact test). For last-half sample, the proportion in treatment NH is slightly greater than that in DH, but the difference is not significant (p-value $= 0.385$, 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- and high-cost conditions. The proportion in treatment DL is greater than that in DH. Additionally, the proportion in treatment NL is greater than that in NL. The differences are statistically significant (all p-values < 0.001, Fisher's exact test).

In sum, the results suggest that disclosure decreases a firm's incentive to acquire information. Furthermore, increasing the cost also negatively affects a firm's information acquisition decision. These findings are consistent with the direction in the theoretical predictions and provide support for Hypotheses 1 and 2.

The regression results of probit models also confirm these findings. Table 5 presents the estimated coefficients from pooled probit and random effects probit models. The dependent variable is an indicator variable that equals one if a firm acquires information, and zero otherwise. The main independent variables are *Disclosure* and *Cost*. The variable *Disclosure* is an indicator variable that equals one in disclosure conditions (i.e., treatments DL and DH), and zero otherwise. Similarly, the variable *Cost* is an indicator variable that equals one in high-cost conditions (i.e., treatments DH and NH), and zero otherwise. Specifications 2 and 4 include the variable *Round* to capture some learning effects. In all specifications, the estimated coefficient on *Disclosure* is negative and statistically significant. This implies that disclosure has a negative impact on firms' information acquisition decisions. The coefficient on *Cost* is also negative and statistically significant. This indicates the negative effect of increasing the information acquisition cost. Furthermore, the coefficient on the interaction term between *Cost* and *Round* is negative and significant under the random effects probit model. This captures that in high-cost conditions, the proportion of information acquisition tends to decrease over time, as seen in Figure 1.

Insert Table 5 and Figure 1 about here.

[11] The reported p-values are adjusted for multiple testing using Hochberg's method.

4.2 Production decisions

4.2.1 The effect of information acquisition

In this subsection, I investigate how information acquisition and disclosure affect firms' production decisions. First, I examine the effect of information acquisition. The model and Hypothesis 3 predict that if a firm acquires information, it can adjust its production level depending on the demand state. Hereafter, firms that acquire information are referred to as *informed* firms. Similarly, firms that do not acquire information are referred to as *uninformed* firms.

Table 6 and Panel A of Figure 2 present informed firms' production decisions. The data indicates that informed firms increase their quantity levels when the demand state is Good, while they decrease when the demand state is Bad. Furthermore, the informed firms' quantity levels are well predicted by the theoretical model (see Table 2 and Panel A of Figure 1).

Insert Table 6 and Figure 2 about here.

I conduct Kruskal-Wallis test and Steel-Dwass multiple comparison test of informed firms' production decisions. In all treatments, the Kruskal-Wallis and multiple comparison results indicate that the differences among the quantity levels in each demand state (Good, Medium, or Bad) are statistically significant (p-values < 0.001 for every combination of two demand states). These suggest that informed firms choose different quantity levels depending on the market demand and provide support for Hypothesis 3.

Table 7 and Panel B of Figure 2 present uninformed firms' production decisions. I conduct Kruskal-Wallis test for uninformed firms' production decisions. As expected, the null hypotheses that there are no differences among the quantity levels in each demand state are not rejected in all treatments (p-value $= 0.558$ in DL, p-value $= 0.556$ in NL, p-value $= 0.636$ in DH, and p-value $= 0.347$ in NH). That is, uninformed firms cannot adjust their output levels to match the market demand. In sum, these results demonstrate that acquiring information improves firms' production decisions.

Insert Table 7 about here.

4.2.2 The effect of disclosure

Next, I investigate the effect of disclosure. Given that a firm acquires information, the paired rival can receive the same signal and become *informed* in disclosure conditions, but it cannot in nondisclosure conditions. The model and Hypothesis 4 predict that a rival also adjusts its production level depending on the demand state if the paired firm acquired information in disclosure conditions. Table 8 and Panel A of Figure 3 present rivals' production decisions when the paired firms acquired information (i.e., *informed* rivals' production decisions). The data indicates that informed rivals increase their quantity levels when the demand state is Good, while they decrease when the demand state is Bad, in the same way as informed firms. I conduct Kruskal-Wallis test and Steel-Dwass multiple comparison test for informed rivals' production decisions. In treatments DL and DH, the Kruskal-Wallis and multiple comparison results indicate that the difference in quantity levels in each demand state (Good, Medium, or Bad) is statistically significant (p-value < 0.001 for every combination of two demand states). On the other hand, in nondisclosure conditions, rivals cannot become informed even if the paired firms acquired information. Hence, they cannot adjust production levels depending on the market demand (see Table 8 and Panel B of Figure 3).

Insert Table 8 and Figure 3 about here.

This finding is confirmed by the results of panel regression presented in Table 9. The dependent variable is rivals' quantity levels. The variable *Acquisition* is an indicator variable that equals one if the paired firm acquires information, and zero otherwise. The variable *Good* (*Bad*) is an indicator variable that equals one if the actual demand state is Good (Bad), and zero otherwise. The coefficient on the interaction term between *Acquisition* and *Good* is positive and statistically significant in disclosure conditions. In addition, the coefficient on the interaction term between *Acquisition* and *Bad* is negative and statistically significant in disclosure conditions. On the other hand, in nondisclosure conditions, the coefficients on these interaction terms are not statistically significant. The results provide support for Hypothesis 4.

Insert Table 9 about here.

Because of the effect of strategic substitutes, the extent to which an informed firm can adjust its production level is predicted to be smaller if the paired rival uses the disclosed signal and adjusts its production level in the same direction. Table 6 and Figure 2 show that informed firms increase their quantity levels when the demand state is Good and decrease when the demand state is Bad. However, the data also suggest that informed firms in nondisclosure conditions (i.e., treatments NL and NH) increase or decrease their quantity levels more than those in disclosure conditions (i.e., treatments DL and DH).

First, I compare treatments DL and NL. When the demand state is Good, informed firms produce an average of 82.9 units in treatment DL, which is less than the 90.3 units produced in treatment NL. The difference is statistically significant (p-value < 0.001, Mann-Whitney test). On the other hand, when the demand state is Bad, informed firms in treatment DL produces an average of 39.7 units, which is more than the 33.6 units in treatment NL. The difference is also significant (p-value < 0.001, Mann-Whitney test). Next, I compare treatments DH and NH. The difference in quantity level between the two treatments is significant when the state is Bad, but not significant when the state is Good (Good: p-value $= 0.013$, Bad: p-value < 0.001, Mann-Whitney test).

The results of panel regression presented in Table 10 confirm the above finding. The dependent variable is firms' quantity levels. In both disclosure and nondisclosure conditions, the coefficient on the interactive term between *Acquisition* and *Good* is positive and statistically significant. However, the coefficient on the interactive term in disclosure conditions is smaller than that in nondisclosure conditions. Similarly, in both disclosure and nondisclosure conditions, the coefficient on the interactive term between *Acquisition* and *Bad* is negative and statistically significant. However, the absolute value of the coefficient in disclosure conditions is smaller than that in nondisclosure conditions.

Insert Table 10 about here.

These results suggest that when the demand state is Good, informed firms in disclosure conditions tend to produce less than those in nondisclosure conditions. In contrast, informed firms in disclosure conditions tend to produce more than those in nondisclosure conditions when the demand state is bad. Given that a firm acquired information, the paired rival can also learn the true demand state and adjust its production level. That is, disclosing the demand information induces the rival to respond in the same direction, thus making the firm's response to the acquired information relatively small compared to the nondisclosure case because of the effect of strategic substitutes. Thus, rivals' improved production decisions create a competitive disadvantage for the paired firms because both compete in the same market. Therefore, the benefit of acquiring information decreases if the acquired information is disclosed. The results provide support for Hypothesis 5.

4.3 Discussion

In this subsection, I discuss the experimental results that seem inconsistent with the theoretical predictions. First, the study does not find experimental evidence consistent with the theory concerning social welfare (see Table 11). This may be because both firms and rivals tend to have higher outputs than the theoretical predictions when both are uncertain about the demand state (see Table 12). One possible reason is that the production cost is assumed to be zero in the experiment. I assume that the production cost is zero to avoid some effects of loss aversion and simplify the experiment. However, this assumption may lead participants to perceive that losses from overproduction are relatively small.

Insert Tables 11 and 12 about here.

Next, I consider firms' information acquisition decisions. Although the results on firms' information acquisition decisions are consistent with the *direction* in the theoretical predictions and provide support for the hypotheses, the result for each treatment deviates from the *point* predictions derived from the theory. First, in treatment DH, the point prediction is that no firms acquire information. However, the experimental result indicates that nearly half of the firms acquire information. This deviation from the point prediction might be explained by risk aversion. By acquiring information, a firm can observe the actual demand state and thus resolve uncertainty about the demand. Furthermore, the untabulated result shows that compared to when firms do not acquire information, the variance of rivals' quantity is significantly lower when firms acquire information in disclosure treatments. This suggests that acquiring and disclosing the information is useful for a firm to anticipate the rival's strategy.

In treatments DL and NH, the point prediction is that all firms acquire information. In contrast, the result shows that only slightly more than half of the firms acquire information. A certainty effect might explain this deviation from the point prediction. The certainty effect is a phenomenon that "people overweight outcomes that are considered certain, relative to outcomes which are merely probable" (Kahneman and Tversky 1979, p.265). In my experiment, it is uncertain whether firms can enjoy the intended benefit of information acquisition. This is because, even if firms resolve uncertainty about the demand by acquiring information, they still face uncertainty about rivals' behavior. The issue of uncertainty about rivals' behavior might become pronounced for firms, especially in nondisclosure conditions, because firms cannot provide information that influences the rivals' behavior. Even though disclosure would be useful in anticipating the rivals' behavior, some degree of uncertainty still remains. On the other hand, it is certain that firms must bear the information acquisition cost if they acquire information. The certainty effect suggests that firms consider the information acquisition cost that must be borne with certainty to be more important than the uncertain benefits of acquiring information.

5 Conclusion

The experimental results are largely consistent with the theoretical predictions about information acquisition choices and production decisions. The results demonstrate that disclosure decreases a firm's incentive to acquire industry-wide demand information when information acquisition is costly and endogenous. Furthermore, I also show that firms improve their production decisions by acquiring information. Thus, although acquiring information improves firms' production decisions, disclosure decreases a firm's incentive to do so and thus harms the firm's information environment. This leads to inefficient production, which in turn might have a substantial impact on market outcomes.

This study has several limitations. For example, as discussed in the previous section, the assumption that the production cost is zero may unintentionally affect participants' behavior. Furthermore, I point out that participants' information acquisition decisions can be explained in terms of risk aversion or a certainty effect. Therefore, future research can modify the design and replicate the experiments to test these possibilities. In addition, this study uses a random matching protocol to test the static model; however, repeated interactions among the same players may provide a more appropriate reflection of reality. Repeated interactions can create the opportunity for tacit collusion, and thus the results might be different from the static setting.

References

[1] Ackert, L. F., B. K. Church, and M. R. Sankar. 2000. Voluntary Disclosure under Imperfect Competition: Experimental Evidence. *International Journal of Industrial Organization* 18(1): 81-105.

[2] Ali, A., S. Klasa, E. Yeung. 2014. Industry Concentration and Corporate Disclosure Policy. *Journal of Accounting and Economics* 58(2-3): 240-264.

[3] Arya, A., and B. Mittendorf. 2007. The Interaction among Disclosure, Competition between Firms, and Analyst Following. *Journal of Accounting and Economics* 43(2-3): 321-339.

[4] Arya, A., H. Frimor, and B. Mittendorf. 2010. Discretionary Disclosure of Proprietary Information in a Multisegment Firm. *Management Science* 56(4): 645-658.

[5] Bagnoli, M., and S. G. Watts. 2010. Oligopoly, Disclosure, and Earnings Management. *The Accounting Review* 85(4): 1191-1214.

[6] Bagnoli, M., and S. G. Watts. 2015. Competitive Intelligence and Disclosure. *RAND Journal of Economics* 46(4): 709-729.

[7] Bhojraj, S., W. G. Blacconiero, and J. D. D'Souza. 2004. Voluntary Disclosure in a Multi-Audience Setting: An Empirical Investigation. *The Accounting Review* 79: 921-947.

[8] Cason, T. N. 1994. The Impact of Information Sharing Opportunities on Market Outcomes: An Experimental Study. *Southern Economic Journal* 61(1): 18-39.

[9] Cason, T. N., and C. F. Mason. 1999. Information Sharing and Tacit Collusion in Laboratory Duopoly Markets. *Economic Inquiry* 37(2): 258-281.

[10] Cheng, P., P. Man, and C. H. Yi. 2013. The Impact of Product Market Competition on Earnings Quality. *Accounting and Finance* 53(1): 137-162.

[11] Christensen, P. O., and G. A. Feltham. 2003. *Economics of Accounting: Volume I - Information in Markets*. Kluwer Academic Publishers.

[12] Clinch, G., and R. E. Verrecchia. 1997. Competitive Disadvantage and Discretionary Disclosure in Industries. *Australian Journal of Management* 22(2): 125-137.

[13] Corona, C., and L. Nan. 2013. Preannouncing Competitive Decisions in Oligopoly Markets. *Journal of Accounting and Economics* 56(1): 73-90.

[14] Darrough, M. N. 1993. Disclosure Policy and Competition: Cournot vs. Bertrand. *The Accounting Review* 68(3): 534-561.

[15] Dedman, E., and C. Lennox. 2009. Perceived Competition, Profitability and the Withholding of Information about Sales and the Cost of Sales. *Journal of Accounting and Economics* 48(2-3): 210-230.

[16] Dhaliwal, D., S. Huang, I. K. Khurana, and R. Pereira. 2014. Product Market Competition and Conditional Conservatism. *Review of Accounting Studies* 19(4): 1309-1345.

[17] Dorantes, C-A., C. Li, G. F. Peters, and V. J. Richardson. 2013. The Effect of Enterprise Systems Implementation on the Firm Information Environment. *Contemporary Accounting Research* 30(4): 1427-1461.

[18] Fischbacher, U. 2007. z-Tree: Zurich Toolbox for Ready-Made Economic Experiments. *Experimental Economics* 10(2): 171-178.

[19] Gal-Or, E. 1985. Information Sharing in Oligopoly. *Econometrica* 53(2): 329-343.

[20] Ganuza, J-J., and J. Jansen. 2013. Too Much Information Sharing? Welfare Effects of Sharing Acquired Cost Information in Oligopoly. *Journal of Industrial Economics* 61(4): 845-876.

[21] Guo, R., B. Lev, and N. Zhou. 2004. Competitive Costs of Disclosure by Biotech IPOs. *Journal of Accounting Research* 42(2): 319-355.

[22] Hauk, E., and S. Hurkens. 2001. Secret Information Acquisition in Cournot Markets. *Economic Theory* 18(3): 661-681.

[23] Hemmer, T., and E. Labro. 2008. On the Optimal Relation between the Properties of Managerial and Financial Reporting Systems. *Journal of Accounting Research* 46(5): 1209-1240.

[24] Huck, S. 2004. Oligopoly. in Friedman, D. and A. Cassar eds. *Economics Lab: An Intensive Course in Experimental Economics*. London and New York: Routledge.

[25] Hughes, J. S., and S. Pae. 2015. Discretionary Disclosure, Spillovers, and Competition. *Review of Accounting Studies* 20(1): 319-342.

[26] Hughes, J. S., and M. G. Williams. 2008. Commitments and Disclosure in Oligopolies. *The Accounting Review* 83(1): 111-132.

[27] Hwang, H-S. 1995. Information Acquisition and Relative Efficiency of Competitive, Oligopoly and Monopoly Markets. *International Economic Review* 36(2): 325-340.

[28] Jansen, J. 2008. Information Acquisition and Strategic Disclosure in Oligopoly. *Journal of Economics and Management Strategy* 17(1): 113-148.

[29] Kahneman, D., and A. Tversky. 1979. Prospect Theory: An Analysis of Decision under Risk. *Econometrica* 47(2): 263-291

[30] Kirby, A. J. 1988. Trade Association as Information Exchange Mechanisms. *RAND Journal of Economics* 19(1): 138-146.

[31] Kirby, A. J. 2004. The Product Market Opportunity Loss of Mandated Disclosure. *Information Economics and Policy* 16(4): 553-577.

[32] Li, L., R. D. McKelvey, and T. Page. 1987. Optimal Research for Cournot Oligopolists. *Journal of Economic Theory* 42(1): 140-166.

[33] Li, X. 2010. The Impacts of Product Market Competition on the Quantity and Quality of Voluntary Disclosures. *Review of Accounting Studies* 15(3): 663-711.

[34] Miwa, K. 2019. Welfare Effects of Endogenous Information Acquisition and Disclosure in Duopoly Markets. *European Accounting Review* 28(5): 1011-1026.

[35] Pae, S. 2000. Information Sharing in the Presence of Preemptive Incentives: Economic Consequences of Mandatory Disclosure. *Review of Accounting Studies* 5(4): 331-350.

[36] Pae, S. 2002. Optimal Disclosure Policy in Oligopoly Markets. *Journal of Accounting Research* 40(3): 901-932.

[37] Raith, M. 1996. A General Model of Information Sharing in Oligopoly. *Journal of Economic Theory* 71(1): 260-288.

[38] Sankar, M. R. 1995. Disclosure of Predecision Information in a Duopoly. *Contemporary Accounting Research* 11(2): 829-859.

[39] Schneider, G. T., and A. Scholze. 2015. Mandatory Disclosure, Generation of Decision-Relevant Information, and Market Entry. *Contemporary Accounting Research* 32(4): 1353-1372.

[40] Shroff, N. 2017. Corporate Investment and Changes in GAAP. *Review of Accounting Studies* 22(1): 1-63.

[41] Suijs, J., and J. L. Wielhouwer. 2014. Disclosure Regulation in Duopoly Markets: Proprietary Costs and Social Welfare. *European Accounting Review* 23(2): 227-255.

[42] Vives, X. 1984. Duopoly Information Equilibrium: Cournot and Bertrand. *Journal of Economic Theory* 34(1): 71-94.

[43] Vives, X. 1990. Trade Association Disclosure Rules, Incentives to Share Information, and Welfare. *RAND Journal of Economics* 21(3): 409-430.

[44] Zimmerman, J. L. 2014. *Accounting for Decision Making and Control* (8th ed.). Irwin /McGraw Hill Publishing Company, New York, NY.

Figure 1: Proportion of information acquisition, by treatment

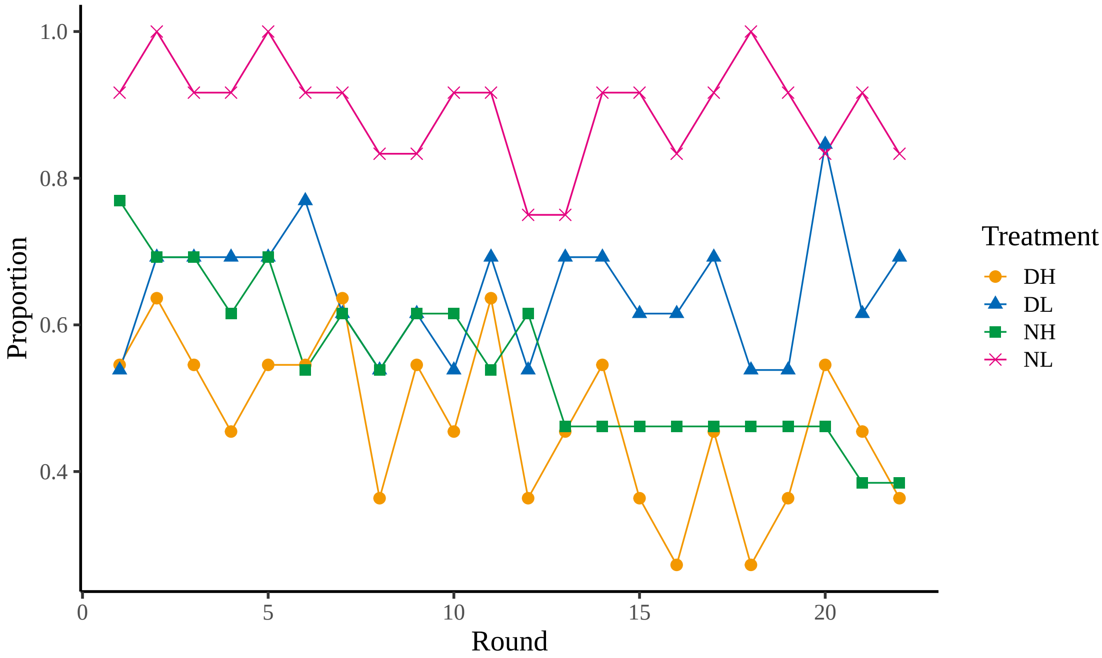
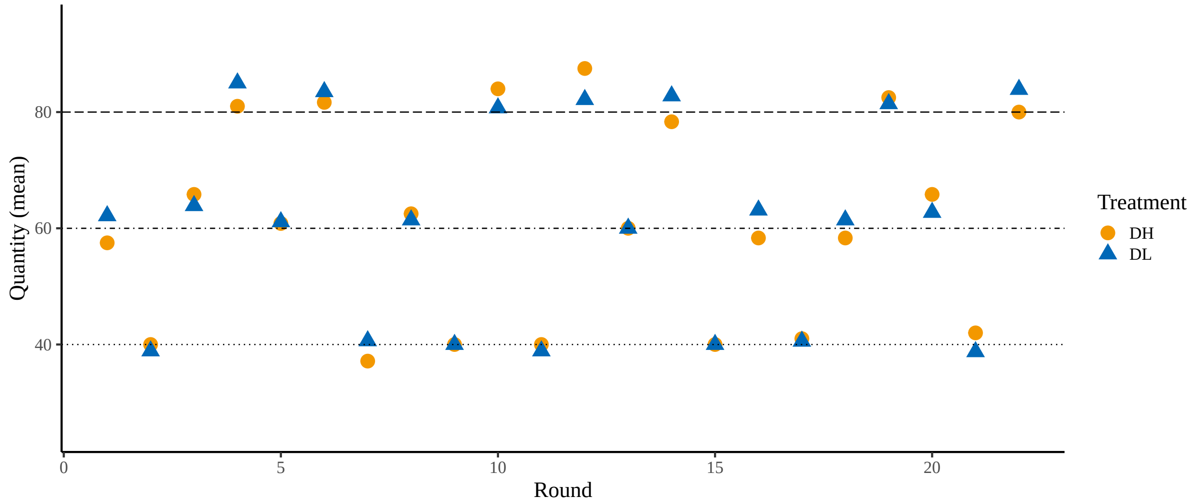
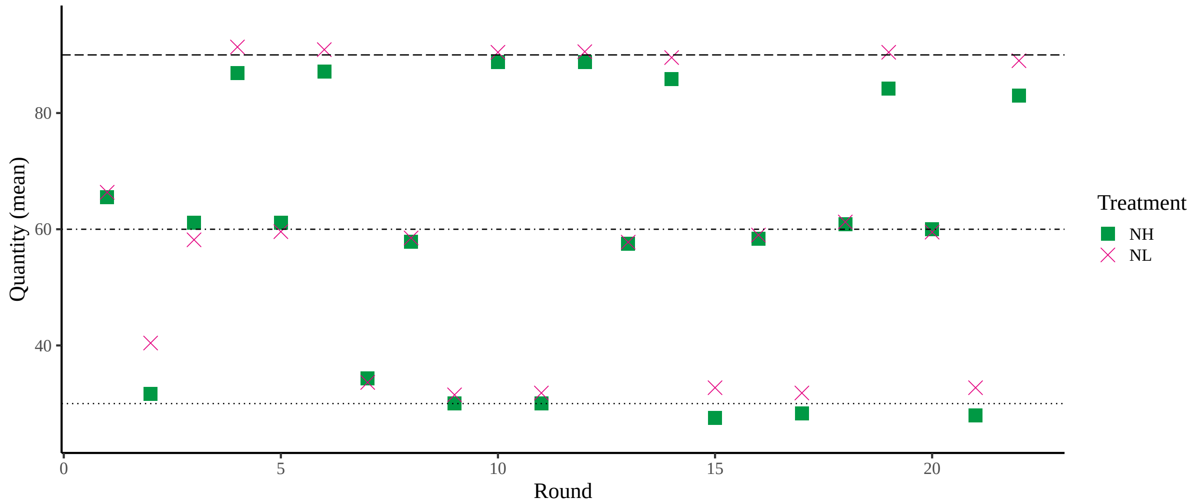


Figure 2: Informed firms' quantity levels

Panel A: Disclosure conditions



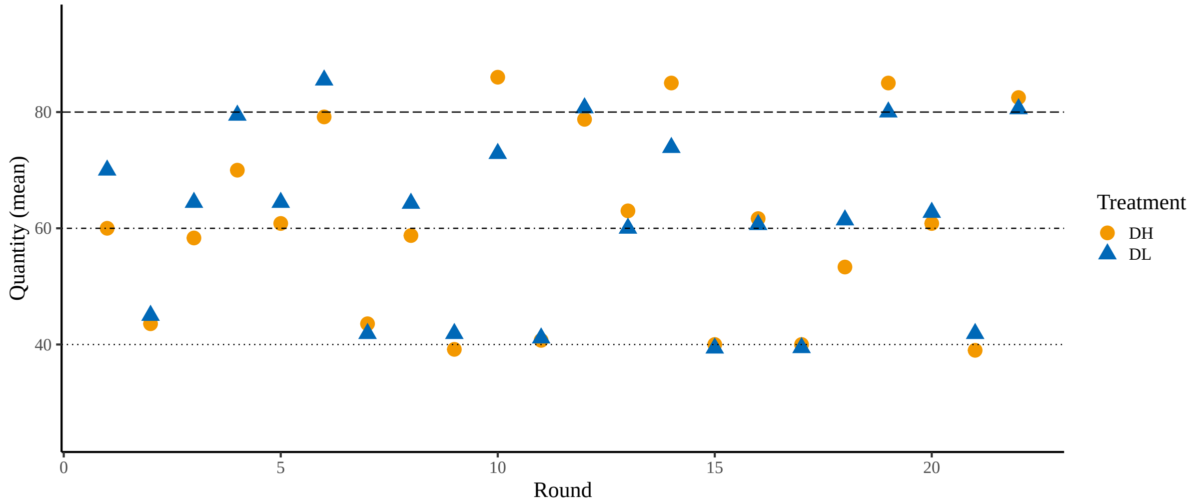
Panel B: Nondisclosure conditions



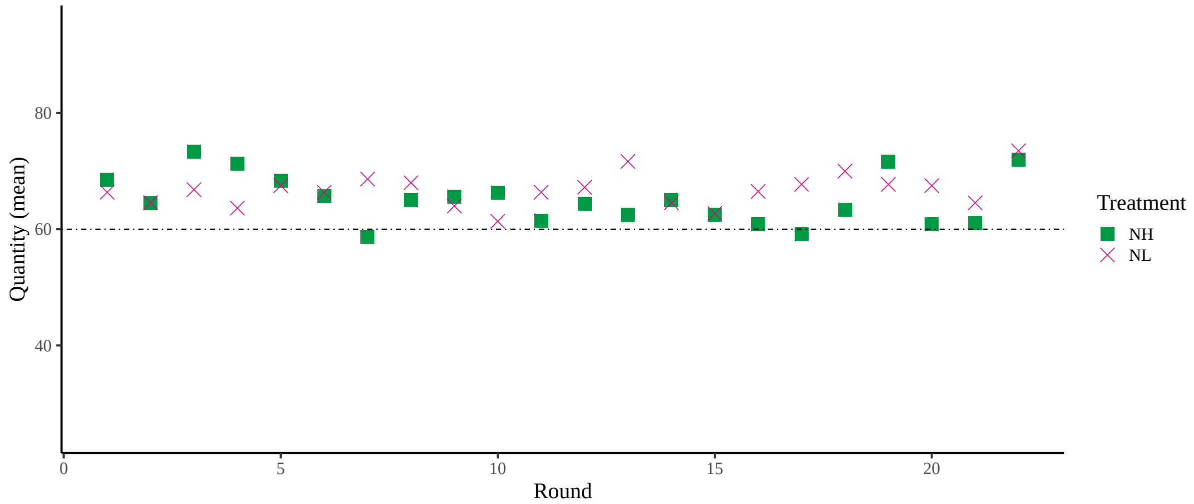
Note: The dashed line shows the predicted quantity level when the demand state is Good for each condition. The dot-dashed line shows the predicted quantity level when the demand state is Medium for each condition. The dotted line shows the predicted quantity level when the demand state is Bad for each condition. Across all treatments, the actual demand state is Good in rounds 4, 6, 10, 12, 14, 19, and 22; Medium in rounds 1, 3, 5, 8, 13, 16, 18, and 20; Bad in rounds 2, 7, 9, 11, 15, 17, and 21.

Figure 3: Rivals' quantity levels when the paired firms acquired information

Panel A: Disclosure conditions



Panel B: Nondisclosure conditions



Note: The dashed line shows the predicted quantity level when the demand state is Good for each condition. The dot-dashed line shows the predicted quantity level when the demand state is Medium for each condition. The dotted line shows the predicted quantity level when the demand state is Bad for each condition. Note that in nondisclosure conditions, rivals are always uncertain about the demand state regardless firms' information acquisition decisions. Across all treatments, the actual demand state is Good in rounds 4, 6, 10, 12, 14, 19, and 22; Medium in rounds 1, 3, 5, 8, 13, 16, 18, and 20; Bad in rounds 2, 7, 9, 11, 15, 17, and 21.

Table 1: Experimental design

	Information acquisition cost	
	Low ($k = 100$)	High ($k = 500$)
Disclosure	DL 26 participants	DH 22 participants
Nondisclosure	NL 24 participants	NH 26 participants

Table 2: Theoretical predictions: Information acquisition and quantity level

			Quantity	
Treatment	Information acquisition	Demand	Firm	Rival
DL	Yes	Good	80	80
		Medium	60	60
		Bad	40	40
NL	Yes	Good	90	60
		Medium	60	60
		Bad	30	60
DH	No	Good	60	60
		Medium	60	60
		Bad	60	60
NH	Yes	Good	90	60
		Medium	60	60
		Bad	30	60

Table 3: Theoretical predictions: Profit and consumer surplus

Treatment	Demand	Profit		Consumer surplus
		Firm	Rival	
DL	Good	6300	6400	12800
	Medium	3500	3600	7200
	Bad	1500	1600	3200
	Expectation	3767	3867	7733
NL	Good	8000	5400	11250
	Medium	3500	3600	7200
	Bad	800	1800	4050
	Expectation	4100	3600	7500
DH	Good	7200	7200	7200
	Medium	3600	3600	7200
	Bad	0	0	7200
	Expectation	3600	3600	7200
NH	Good	7600	5400	11250
	Medium	3100	3600	7200
	Bad	400	1800	4050
	Expectation	3700	3600	7500

Note: In treatments DL, NL, and NH, both firms' profits and consumer surplus are calculated, given that a firm acquires information, and a firm's profit is the profit after subtracting the information acquisition cost. In treatment DH, both firms' profits and consumer surplus are calculated, given that a firm does not acquire information.

Table 4: Information acquisition by firms

Panel A: Proportion of information acquisition

	All rounds	First half	Last half
DL treatment	64.3%	64.3%	64.3%
NL treatment	89.4%	91.7%	87.1%
DH treatment	47.1%	53.7%	40.5%
NH treatment	54.5%	62.9%	46.2%

Panel B: Fisher's exact test with p-values adjusted by Hochberg's method

	All rounds	First half	Last half
	p-value	p-value	p-value
DL vs. NL	< 0.001	< 0.001	< 0.001
DH vs. NH	0.097	0.269	0.385
DL vs. DH	< 0.001	0.269	< 0.001
NL vs. NH	< 0.001	< 0.001	< 0.001

Table 5: Probit models: Information acquisition by firms

	Probit		Random effects probit	
	(1)	(2)	(3)	(4)
Disclosure	-0.880**	-1.073**	-1.681**	-1.942***
	(0.378)	(0.422)	(0.662)	(0.719)
Cost	-1.134***	-0.862**	-1.912***	-1.410**
	(0.385)	(0.413)	(0.659)	(0.714)
Disclosure × Cost	0.694	0.695	1.184	1.217
	(0.544)	(0.550)	(0.924)	(0.961)
Round		-0.016		-0.021
		(0.019)		(0.018)
Disclosure × Round		0.016		0.018
		(0.019)		(0.018)
Cost × Round		-0.024		-0.049***
		(0.019)		(0.018)
Constant	1.248***	1.436***	2.285***	2.578***
	(0.293)	(0.340)	(0.501)	(0.559)
Log (pseudo)likelihood	-639.996	-632.256	-420.007	-405.434
Observations	1078	1078	1078	1078

Note: The dependent variable is an indicator variable that equals one if a firm acquires information, and zero otherwise. Reported results are estimated coefficients. Standard errors in parentheses. In specifications (1) and (2), standard errors are clustered at the participant level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Informed firms' quantity levels

Treatment		Demand		
		Good	Medium	Bad
DL	Mean	82.9	62.0	39.7
	(SD)	(8.06)	(8.03)	(4.14)
	Median	80	60	40
	Observations	58	67	59
NL	Mean	90.3	60.1	33.6
	(SD)	(5.99)	(7.60)	(8.22)
	Median	95	60	30
	Observations	74	85	77
DH	Mean	81.9	61.5	39.9
	(SD)	(8.88)	(9.94)	(4.54)
	Median	80	60	40
	Observations	34	39	41
NH	Mean	86.7	60.7	30.3
	(SD)	(7.32)	(8.78)	(6.80)
	Median	85	60	30
	Observations	48	59	49

Table 7: Uninformed firms' quantity levels

Treatment		Demand Good	Demand Medium	Demand Bad
DL	Mean	78.0	77.0	73.4
	(SD)	(13.0)	(12.9)	(17.3)
	Median	75	75	75
	Observations	33	37	32
NL	Mean	84.5	79.5	80.7
	(SD)	(6.85)	(8.79)	(14.3)
	Median	85	85	85
	Observations	10	11	7
DH	Mean	72.9	72.8	69.7
	(SD)	(14.8)	(15.1)	(17.0)
	Median	70	70	67.5
	Observations	43	49	36
NH	Mean	73.0	70.4	70.0
	(SD)	(10.1)	(12.7)	(11.1)
	Median	70	70	70
	Observations	43	45	42

Table 8: Rivals' quantity levels when the the paired firms acquired information

Treatment		Demand		
		Good	Medium	Bad
DL	Mean	79.2	63.4	41.5
	(SD)	(10.9)	(8.85)	(7.21)
	Median	80	60	40
	Observations	58	67	59
NL	Mean	66.2	68	65.5
	(SD)	(12.3)	(12.0)	(11.6)
	Median	62.5	65	60
	Observations	74	85	77
DH	Mean	80.9	59.9	41.1
	(SD)	(10.5)	(7.99)	(7.87)
	Median	80	60	40
	Observations	34	39	41
NH	Mean	67.8	66.1	62.0
	(SD)	(9.33)	(13.8)	(11.2)
	Median	70	70	60
	Observations	48	59	49

Table 9: The effect of information acquisition on rivals' production decisions

	(1) Disclosure conditions	(2) Nondisclosure conditions
Acquisition	0.686	0.514
	(2.464)	(1.768)
Good	1.015	3.967
	(1.669)	(2.954)
Bad	1.001	-0.717
	(1.802)	(2.385)
Acquisition × Good	16.067***	-3.394
	(1.868)	(3.444)
Acquisition × Bad	-22.350***	-2.114
	(2.015)	(2.744)
Constant	61.835***	65.755***
	(1.376)	(1.434)
Individual FE	Yes	Yes
adj. R^2	0.506	0.023
Observations	528	550

Note: The dependent variable is rivals' quantity levels. Standard errors (clustered at the participant level) in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: The effect of information acquisition on firms' production decisions

	(1) Disclosure conditions	(2) Nondisclosure conditions
Acquisition	-12.975***	-11.779***
	(3.354)	(2.823)
Good	0.686	2.697**
	(1.446)	(1.244)
Bad	-3.546	-0.178
	(2.662)	(1.608)
Acquisition × Good	19.906***	25.965***
	(1.928)	(1.782)
Acquisition × Bad	-18.240***	-28.032***
	(2.825)	(2.211)
Constant	74.715***	72.156***
	(1.982)	(1.870)
Individual FE	Yes	Yes
adj. R^2	0.677	0.862
Observations	528	550

Note: The dependent variable is firms' quantity levels. Standard errors (clustered at the participant level) in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Profit and consumer surplus

Treatment		Profit		Consumer surplus
		Firm	Rival	
DL	Mean	3604.6	3630.8	8136.6
	(SD)	(2066.7)	(1875.38)	(4286.8)
NL	Mean	3575.4	3323.9	8480.0
	(SD)	(2886.6)	(1747.0)	(3412.7)
DH	Mean	3726.8	3215.0	8607.6
	(SD)	(3076.5)	(2629.6)	(2469.5)
NH	Mean	3211.5	3523.6	8140.1
	(SD)	(2729.1)	(1750.8)	(3478.6)

Note: In treatments DL, NL, and NH, samples are restricted to informed firms and the paired rivals. In treatment DH, samples are restricted to uninformed firms and the paired rivals. For low-cost conditions, the model predicts that a firm's profit: DL $<$ NL, the rival's profit: DL $>$ NL, consumer surplus: DL $>$ NL. For high-cost conditions, the model predicts that the firm's profit: DH $<$ NH, the rival's profit: DH $=$ NH, consumer surplus: DH $<$ NH.

Table 12: Quantity levels of uninformed firms and the paired rivals

Treatment		Quantity	
		Firm	Rival
DL	Mean	76.2	62.2
	(SD)	(14.4)	(17.6)
	Median	75	60
	Observations	102	102
NL	Mean	81.6	64.8
	(SD)	(9.55)	(15.8)
	Median	85	65
	Observations	28	28
DH	Mean	72.0	62.7
	(SD)	(15.5)	(14.4)
	Median	70	65
	Observations	128	128
NH	Mean	71.2	65.5
	(SD)	(11.3)	(13.9)
	Median	70	65
	Observations	130	130