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Strategic Disclosure of Demand Information by Duopolists: Theory and Experiment*

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Abstract

We study the strategic disclosure of demand information and product-market strategies of duopolists. In a setting where firms may fail to receive information, we show that firms selectively disclose information in equilibrium in order to influence their competitor's product-market strategy. Subsequently, we analyze the firms' behavior in a laboratory experiment. We find that subjects often use selective disclosure strategies, and this finding appears to be robust to changes in the information structure, the mode of competition, and the degree of product differentiation. Moreover, subjects in our experiment display product-market conduct that is largely consistent with theoretical predictions.

Keywords: duopoly, Cournot competition, Bertrand competition, information disclosure, incomplete information, common value, product differentiation, asymmetry, skewed distribution, laboratory experiment
JEL Codes: C92, D22, D82, D83, L13, M4

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1 Introduction

This paper studies strategies of firms in settings where a firm may not have complete information about the demand for its good. The firm may not be fully informed about how well new product characteristics match with consumers' tastes if the good is new, or if the good has changed. Alternatively, the market demand may be affected by exogenous shocks, such as the business cycle or the weather. For example, a firm may not know whether its market demand remains depressed (booming) or a recovery (recession) is imminent. In those cases, a firm can obtain information to learn about the market, and if it does, it can use this information to gain a strategic advantage. First, the firm can manage the beliefs of a competitor by disclosing or concealing its information. Second, the firm can use the information to make better-informed choices in the product market. In this paper, we study these strategic uses of a firm's demand information both theoretically as well as experimentally.

The analysis of the firms' disclosure incentives is relevant for developing antitrust policy and accounting rules. An antitrust authority is better equipped to determine how much information firms should be allowed to share, by understanding the disclosure incentives of competing duopolists (e.g., Kühn and Vives, 1995, and Kühn, 2001). Likewise, it is helpful to know how much information firms share voluntarily when one designs accounting rules that stipulate how much information firms are required to disclose (e.g., Verrecchia, 2001, and Dye, 2001).

If there are no verification and disclosure costs, and if it is known that firms have information, then often firms will disclose all information. Firms do so, since they cannot credibly conceal unfavorable news. This phenomenon is called the unraveling result (Milgrom, 1981, Milgrom and Roberts, 1986, Okuno-Fujiwara *et al.,* 1990, and Milgrom, 2008).[1] In the experimental literature, King and Wallin (1991a) find support for the unraveling of dividend information from a seller of an asset who faces investors.

By contrast, if a firm can fail to become informed, it is no longer known whether this firm is informed. Although information is verifiable, it is not verifiable whether or not a firm is informed. In such an environment the unraveling result may fail to hold since firms can credibly conceal unfavorable news by claiming to be uninformed, e.g., see Dye (1985), Farrell (1986), Jung and Kwon (1988), and Sankar (1995). In these models of unilateral disclosure, a Cournot oligopolist has an incentive to disclose bad news (low demand), and conceal good news (high demand) to discourage

[1] The assumption that information is verifiable, which we adopt in this paper, is consistent with some empirical findings (e.g., see Jansen, 2008).

its rivals. A Bertrand oligopolist only discloses good news (high demand) to induce the competitors to choose high prices. In an experiment with unilateral disclosure in a Cournot duopoly, Ackert *et al.* (2000) provide support for selective information disclosure. The experiment confirms that a Cournot duopolist unilaterally discloses bad news more frequently than it discloses good news about a common cost parameter.[2]

Theoretical studies of multilateral information disclosure typically focus on symmetric models. Darrough (1993) analyzes a symmetric model, and Jansen (2008) focuses on symmetric equilibria. These papers show that the optimal unilateral disclosure strategy is also an equilibrium strategy in symmetric settings of multilateral disclosure. That is, symmetric Cournot duopolists disclose low demand intercepts and conceal high intercepts, whereas Bertrand duopolists disclose only high intercepts. As far as we know, there are no experiments on multilateral disclosure in duopoly models.

Although the literature focuses on unilateral disclosure and strategic information exchange between symmetric firms, there exist important differences between firms in practice (e.g., established firms differ from new firms, and firms have different sizes and capabilities). Our paper intends to address this issue. We contribute to the literature in two ways. First, we contribute to the theoretical literature on multilateral information disclosure by analyzing the disclosure and product-market strategies of firms in asymmetric duopolies. Second, we contribute to experimental work on strategic information disclosure by studying multilateral disclosure, by analyzing the behavior of Bertrand duopolists, and by studying disclosure behavior of duopolists with differentiated goods in a laboratory.

A firm's disclosure of common demand information in a Cournot duopoly has two conflicting effects. First, the disclosure informs the firm's competitor about his payoff from the product market. In particular, if the firm discloses that demand is low (high), then its competitor learns that a relatively low (high) output level is profitable. Therefore, this effect gives the firm an incentive to disclose a low demand intercept and conceal a high intercept in order to discourage supply by its competitor.

However, there is an additional effect of demand disclosure. A firm that discloses information also informs its competitor about its conduct in the product market. In particular, if the firm discloses that it learned that demand is low (high), then it signals to the competitor that it will have a less (more) "aggressive" output strategy than an uninformed firm. This effect gives the firm an incentive to disclose a high

[2] Also King and Wallin (1991b) find experimental results consistent with selective disclosure. They do so in a set-up where investors are uncertain whether an asset's seller is informed or not.

demand intercept and conceal a low demand intercept. Such a disclosure strategy makes the firm's competitor pessimistic about the competitive pressure, and thereby discourages him to supply to the market (strategic substitutes).

In the aforementioned literature, the former effect outweighs the latter effect. In this paper, we derive precise conditions under which this result extends to asymmetric models. In particular, if the demand distribution is not too skewed towards low demand, or if firms do not differ too much from each other, then there exists an equilibrium in which both firms disclose low demand and conceal high demand.

In addition, we characterize situations where the latter effect of disclosure dominates the former, and a firm reverses its disclosure strategy. This happens if demand is sufficiently skewed towards low demand (such as, in periods of economic recession), and if one firm is likely to be informed while the other firm is unlikely to be informed. In this case, the former firm discloses only a low intercept whereas the latter firm discloses only a high demand intercept. If it is unlikely that a firm is informed and it is likely that the demand is low, then this firm is expected to be a soft competitor, since it is likely that the firm is uninformed and pessimistic. Disclosure of good news by this firm makes the competitor less "aggressive," since the news makes him realize that the firm will be less soft than expected.[3] Hence, if the firms' probabilities of receiving information are sufficiently different, then the firms' information disclosure choices may differ from the choices by identical firms.[4]

In a Bertrand duopoly, the effects from disclosing information about a common demand intercept are aligned. As before, the disclosure of high (low) demand information makes the competitor of a firm optimistic about his product market opportunities, which gives him the incentive to set a relatively high (low) price. In addition, the firm's disclosure of a high (low) demand intercept signals to the firm's competitor that it will have a less (more) "aggressive" pricing strategy than if it were uninformed. Also this belief update gives the competitor the incentive to set a relatively high (low) price. Both effects give the firm an incentive to disclose a high demand intercept and conceal a low intercept in order to encourage a high price by its competitor.

Our laboratory experiment analyzes the strategic information disclosure and prod-

[3] This happens for the following reasons. First, the competitor drastically updates his belief about the firm's conduct in the product market, and thereby expects fiercer competition. Moreover, the average competitor becomes only slightly more optimistic about his own opportunities in the product market, since it is very likely that the competitor was already informed about the size of the market.

[4] This observation is consistent with the observations in Hwang (1993, 1994). Hwang analyzes the information sharing incentives of precommitting firms (Kühn and Vives, 1995, Raith, 1996, and Vives, 1999), whereas we study the incentives for strategic disclosure.

uct market choices of firms in several duopolistic settings. In particular, we vary the mode of competition, the information structure, and the degree of product differentiation across seven treatments.[5]

We find that subjects often use selective disclosure strategies. The subjects in our treatments with Cournot (Bertrand) competition disclose information on low (high) demand intercepts significantly more often than information on high (low) demand intercepts. These observed tendencies suggests that subjects understand that disclosed information informs their competitor about demand, and they use their information strategically. The observed selective disclosure strategies give the subjects' competitor pessimistic (optimistic) beliefs about the market with Cournot (Bertrand) competition, and thereby make the competitor less "aggressive" in the product market if this were the only effect of information disclosure. Our finding appears to be robust to changes in the mode of competition, the information structure (i.e., changes from unilateral to bilateral disclosure, and from symmetric to asymmetric models), and the degree of product differentiation.

Finally, the subjects in our experiment display product-market conduct that is largely consistent with our theoretical predictions. Equilibrium product-market choices tend to be responsive to information, and (weakly) to the precision of information.

The paper is organized as follows. Section 2 describes the model. Section 3 derives the equilibrium strategies of firms, and states experimental hypotheses. Section 4 describes the design of our experiment, and it discusses the experimental results. Finally, Section 5 concludes the paper. The proofs of the paper's theoretical results, our test results, and the experiment's instructions are relegated to the Appendix.

2 The Model

Consider an industry where two risk-neutral firms interact in a three-stage game. Firms have symmetric demand functions, with intercept θ. This demand intercept is unknown to the firms.[6] The intercept is either low or high, i.e. $\theta \in \{\underline{\theta}, \overline{\theta}\}$ with $0 < \underline{\theta} < \overline{\theta}$, and θ is drawn with probability $q(\theta)$ where $0 < q(\theta) < 1$ and $q(\underline{\theta}) + q(\overline{\theta}) = 1$.

In stage 1, the firms can learn the demand realization from imperfect signals,

[5] Treatments 1-5 study Cournot duopolies, while Treatments 6-7 consider Bertrand duopolies. Our experiment covers unilateral disclosure (Treatments 1, 5 and 6), and bilateral disclosure in symmetric settings (Treatment 2 and 7), as well as asymmetric settings (Treatments 3-4). Finally, we consider the supply of a homogenous good (Treatments 1-4) as well as differentiated goods (Treatments 5-7).

[6] Naturally, this model is conceptually identical to a model with incomplete information about a common shock to the marginal production costs. Hence, all results hold for such a model as well.

(Θ_1, Θ_2). With probability a_i, firm i learns the true demand intercept, $\Theta_i = \theta$, but with probability $1 - a_i$ the firm receives the uninformative signal $\Theta_i = \varnothing$, where $0 < a_i < 1$ and $i = 1, 2$. These signals are independent, conditional on θ.

In stage 2, each firm chooses whether to disclose or conceal its signal. If a firm receives information about the demand intercept, then this information is verifiable. However, the fact whether or not a firm is informed is not verifiable. If firm i receives information $\Theta_i = \theta$, it chooses the probability with which it discloses this information, $s_i(\theta) \in [0, 1]$, i.e., with probability $s_i(\theta)$ firm i discloses θ, while with probability $1 - s_i(\theta)$ firm i sends uninformative message $\varnothing$ for $i = 1, 2$. An uninformed firm can only send message $\varnothing$. In other words, $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right]$ denotes firm i's disclosure strategy for $i = 1, 2$. Firms choose their disclosure strategies simultaneously.

In the final stage, firms simultaneously choose their output levels of substitutable goods, $x_i \geq 0$ for firm i (i.e., Cournot competition).[7] Firm i's inverse demand function is $\mathcal{P}_i^d(x_i, x_j) \equiv \theta - x_i - \delta x_j$, for $i, j \in \{1, 2\}$ with $i \neq j$, and $0 < \delta \leq 1$. Parameter δ stands for the degree of product substitutability.[8] Firm i has the constant unit cost of production $c_i \geq 0$. We assume that the firms' costs do not differ too much, and thereby focus on accommodating output strategies. Firm i's profit for output levels (x_i, x_j) and demand intercept θ is (for $i, j \in \{1, 2\}$ with $i \neq j$):

$$\pi_i(x_i, x_j; \theta) = (\theta - c_i - x_i - \delta x_j)\, x_i, \tag{1}$$

We solve the model backwards and use the perfect Bayesian equilibrium concept.

3 Theoretical Analysis

In this section we characterize the equilibrium output levels for given disclosure strategies. Subsequently, we characterize the equilibrium disclosure strategies. After analyzing the model with Cournot competition, we characterize the equilibrium strategies of Bertrand competitors. These analyses generate hypotheses for our experiment.

3.1 Equilibrium Outputs

First, we study the equilibrium outputs under complete information. Whenever one of the firms discloses the information θ, both firms know that the demand intercept

[7] In Section 3.3, we extend the model by considering price competition (i.e., Bertrand competition).

[8] For example, if $\delta = 1$ then the firms' goods are perfect substitutes, and if $\delta \to 0$ then in the limit the firms supply to independent markets.

is θ. Firm i's first-order condition of profit maximization with respect to x_i, given $\theta \in \{\underline{\theta}, \overline{\theta}\}$, is as follows (for $i, j = 1, 2$ and $i \neq j$):

$$2x_i(\theta) = \theta - c_i - \delta x_j(\theta) \tag{2}$$

The first-order conditions give the following equilibrium output for firm i:

$$x_i^f(\theta) = \frac{\theta - c_i}{2 + \delta} + \frac{\delta(c_j - c_i)}{4 - \delta^2}, \tag{3}$$

with $\theta \in \{\underline{\theta}, \overline{\theta}\}$ and $i, j \in \{1, 2\}$ with $i \neq j$. This is a standard result. After the disclosure of intercept θ, firm i's equilibrium profit equals: $\pi_i^f(\theta) = x_i^f(\theta)^2$ for $\theta \in \{\underline{\theta}, \overline{\theta}\}$ and $i = 1, 2$.

Second, we consider the equilibrium after no firm disclosed any information. In that case, an informed firm i with $\Theta_i = \theta$ assigns probability $A_j(\theta; s_j)$ to competing against an informed rival j ($\Theta_j = \theta$), and probability $1 - A_j(\theta; s_j)$ to facing an uninformed rival ($\Theta_j = \varnothing$), where:

$$A_j(\theta; s_j) \equiv \frac{a_j\left[1 - s_j(\theta)\right]}{1 - a_j s_j(\theta)}. \tag{4}$$

After an uninformative signal ($\Theta_i = \varnothing$), firm i expects the demand intercept:

$$E_j\{\theta|\varnothing; s_j\} \equiv Q_j(\underline{\theta}; s_j)\underline{\theta} + Q_j(\overline{\theta}; s_j)\overline{\theta}, \tag{5}$$

with posterior belief

$$Q_j(\theta; s_j) \equiv \frac{q(\theta)\left[1 - a_j s_j(\theta)\right]}{q(\underline{\theta})\left[1 - a_j s_j(\underline{\theta})\right] + q(\overline{\theta})\left[1 - a_j s_j(\overline{\theta})\right]}. \tag{6}$$

The uninformed firm i assigns probability $Q_j(\theta; s_j)A_j(\theta; s_j)$ to competing against an informed firm j with $\Theta_j = \theta$ for $\theta \in \{\underline{\theta}, \overline{\theta}\}$. With the remaining probability, $1 - E_j\{A_j(\theta; s_j)|\varnothing; s_j\}$, firm j is believed to be uninformed. Hence, if the beliefs of firm i are consistent with disclosure strategy s_j, then firm i's first-order conditions are as follows (for $i, j = 1, 2$ with $i \neq j$, and $\Theta_i \in \{\underline{\theta}, \overline{\theta}, \varnothing\}$ where $E_j\{\theta|\theta; s_j\} = \theta$):

$$2x_i^*(\Theta_i) = E_j\{\theta|\Theta_i; s_j\} - c_i - \delta E_j\left\{A_j(\theta; s_j)x_j^*(\theta) + \left[1 - A_j(\theta; s_j)\right]x_j^*(\varnothing)\middle|\, \Theta_i; s_j\right\}. \tag{7}$$

Condition (7) implies that the equilibrium output of an uninformed firm equals the conditionally expected output of an informed firm:

$$x_i^*(\varnothing; s_i, s_j) = E_j\left\{x_i^*(\theta; s_i, s_j)\middle|\, \varnothing; s_j\right\}. \tag{8}$$

After we define the function $\mathcal{D}$ as follows

$$\begin{aligned}\mathcal{D}(s_i, s_j) \equiv\ & 4 - \delta^2 \left[A_j(\underline{\theta}; s_j)Q_i(\overline{\theta}; s_i) + A_j(\overline{\theta}; s_j)Q_i(\underline{\theta}; s_i)\right] \\ & * \left[A_i(\underline{\theta}; s_i)Q_j(\overline{\theta}; s_j) + A_i(\overline{\theta}; s_i)Q_j(\underline{\theta}; s_j)\right] \qquad (9)\end{aligned}$$

we derive the equilibrium output from (7) and (8), by using (4) and (6).

Proposition 1 *If no firm disclosed information, and firms i and j have beliefs consistent with s_j and s_i, respectively, then the following holds for $i, j = 1, 2$ with $i \neq j$. The equilibrium output of firm i with information $\Theta_i = \theta$ equals:*

$$x_i^*(\theta; s_i, s_j) \equiv x_i^f(\theta) + \frac{\frac{\delta}{4-\delta^2} q(\widehat{\theta}) \left(\theta - \widehat{\theta}\right) \psi_i(s_i, s_j)}{\mathcal{D}(s_i, s_j) \prod_{h=1}^{2} \left[1 - a_h s_h(\theta)\right] E\{1 - a_h s_h(\theta)\}} \qquad (10)$$

where:

$$\begin{aligned}\psi_i(s_i, s_j) \equiv\ & \delta(1 - a_i)(1 - a_j)E\left\{\left[1 - a_i s_i(\theta)\right]\left[1 - a_j s_j(\theta)\right]\right\} \\ & +2(1 - a_j)\left[1 - a_i s_i(\underline{\theta})\right]\left[1 - a_i s_i(\overline{\theta})\right] E\{1 - a_j s_j(\theta)\} \\ & -\delta(1 - a_i)\left[1 - a_j s_j(\underline{\theta})\right]\left[1 - a_j s_j(\overline{\theta})\right] E\{1 - a_i s_i(\theta)\} \qquad (11)\end{aligned}$$

and $\mathcal{D}(s_i, s_j) > 0$ for $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$. In equilibrium, firm i with signal $\Theta_i \in \{\underline{\theta}, \overline{\theta}, \varnothing\}$ expects to earn the profit $\pi_i^*(\Theta_i; s_i, s_j) \equiv x_i^*(\Theta_i; s_i, s_j)^2$.

The sign of $\left(\widehat{\theta} - \theta\right) \cdot \psi_i(s_i, s_j)$ determines the sign of $x_i^f(\theta) - x_i^*(\theta; s_i, s_j)$, since all other terms are positive for $i = 1, 2$. This observation is important for the firm's incentive to disclose information, which we analyze in the next subsection.

3.2 Equilibrium Disclosure Strategies

Now we analyze the firms' incentives to strategically disclose information. That is, we look for strategies (s_i^*, s_j^*) that are optimal given beliefs consistent with (s_i^*, s_j^*).

Suppose that firm i's beliefs are consistent with strategy s_j^*, and firm j has beliefs that are consistent with s_i^*. Given these beliefs, the expected profit of firm i with $\Theta_i = \theta$ from disclosure probability $s_i(\theta)$ equals:

$$\Pi_i(\theta, s_i; s_i^*, s_j^*) = \pi_i^f(\theta) + \left[1 - s_i(\theta)\right]\left[1 - a_j s_j^*(\theta)\right]\left(\pi_i^*(\theta; s_i^*, s_j^*) - \pi_i^f(\theta)\right). \qquad (12)$$

Hence, the sign of firm i's marginal expected profit from changing $s_i(\theta)$ depends on the sign of the profit difference $\pi_i^f(\theta) - \pi_i^*(\theta; s_i^*, s_j^*)$. In turn, the sign of the output difference $x_i^f(\theta) - x_i^*(\theta; s_i, s_j)$ determines the sign of this profit difference, and thereby the incentive of firm i to disclose information θ.

We illustrate the firms' disclosure incentives by considering two extreme information-disclosure constellations. First, we consider full disclosure (i.e., $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (1,1)$ for $i = 1, 2$). Deviation from disclosing $\Theta_i = \theta$ only affects the competitor's output if the competitor is uninformed. In that case, the competitor supplies $E\{x_j^f(\theta)\}$ if firm i conceals its information, whereas he supplies $x_j^f(\theta)$ if firm i discloses its information. Firm i has the incentive to unilaterally deviate from full disclosure by concealing high-demand information. This reduces the competitor's output, and allows firm i to earn a higher expected profit by supplying more (strategic substitutes).[9]

Second, we consider full concealment. Prior beliefs $A_j(\theta; [0,0]) = a_j$ and $Q_j(\theta; [0,0]) = q(\theta)$ are consistent with full concealment, and firm i sets the equilibrium output:

$$x_i^*(\theta; [0,0], [0,0]) \equiv x_i^f(\theta) + \frac{\delta q(\widehat{\theta}) \left(\theta - \widehat{\theta}\right) [2(1-a_j) - \delta(1-a_i)a_j]}{\left(4-\delta^2\right)\left(4 - \delta^2 a_i a_j\right)} \tag{13}$$

for $i, j = 1, 2$ with $i \neq j$. For symmetric firms (i.e., $a_i = a_j$) this yields the incentive to unilaterally deviate from full concealment by disclosing a low demand intercept. By contrast, if the firms are asymmetric, i.e., a_i is low and a_j is high, firm i may have an incentive to deviate by disclosing a high demand intercept.[10] Yet, firm j has the incentive to unilaterally deviate from full concealment by disclosing a low intercept.[11]

The previous analysis suggests that there is always a firm with an incentive to disclose only low demand information. The following proposition confirms that this disclosure incentive is also present in equilibrium.

Proposition 2 *For any equilibrium, there exists a firm, i, such that this firm chooses the strategy $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (1,0)$.*

Hence, it is without loss of generality to restrict attention to equilibria in which one of the firms discloses only a low demand intercept. This simplifies the equilibrium analysis, which yields the following characterization.

[9] This can also be seen from (11), which simplifies to: $\psi_i([1,1],[1,1]) = 2(1-a_i)^2(1-a_j)^2 > 0$. Thereby, it gives deviation output: $x_i^*(\overline{\theta}; [1,1],[1,1]) > x_i^f(\overline{\theta})$.

[10] For example, if $\theta = \overline{\theta}$, a_j is close to 1, and a_i is close to 0 (and both firms conceal all information), then firm j expects an output close to $E\{x_i^f(\theta)\}$ from firm i. In turn, firm i expects that firm j is informed and will set its output approximately according to the best reply $x_j(\overline{\theta}) = [\overline{\theta} - c_i - \delta E\{x_i^f(\theta)\}]/2$. This output is higher than the output which firm j sets after disclosure of high demand information by firm i (i.e., $x_j^f(\overline{\theta})$). In other words, the unilateral disclosure of $\Theta_i = \overline{\theta}$ allows firm i to set a higher output, and thereby to reach a higher profit level.

[11] Subsequently, firm i supplies the output $x_i^f(\underline{\theta})$ instead of the higher output $E\{x_i^f(\theta)\}$.

Proposition 3 ***(a)*** *There exists an equilibrium with symmetric disclosure choices (i.e.,* $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right] = (1,0)$ *for* $i = 1,2$*) if and only if* $q(\underline{\theta})a_j\left[2+\delta\left(1-a_i\right)\right] \leq 2$ *for* $i, j = 1,2$ *with* $i \neq j$*;*
(b) *For some* $i, j = 1,2$ *with* $i \neq j$*, there exists an equilibrium with* $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right] = (0,1)$ *if and only if* $q(\underline{\theta})a_j(2+\delta) \geq 2$*;*
(c) *For some* $i, j = 1,2$ *with* $i \neq j$*, there exists an equilibrium with* $0 \leq s_i^*(\underline{\theta}) \leq 1$ *and*

$$s_i^*(\overline{\theta}) = \frac{1}{a_i}\left(1 - \frac{\delta(1-a_i)q(\underline{\theta})a_j}{2\left[1-q(\underline{\theta})a_j\right]}\right) \tag{14}$$

if and only if $2/(2+\delta) \leq q(\underline{\theta})a_j \leq 2/\left[2+\delta(1-a_i)\right]$.
(d) *No other equilibrium exists.*

Proposition 2 implies that the equilibrium of Proposition 3(a) is the only symmetric disclosure equilibrium that can exist. Proposition 3(a) gives two conditions for the existence of this equilibrium. In particular, the conditions hold if the distribution is not too skewed towards a low demand intercept (e.g., $q(\underline{\theta}) \leq \frac{2}{3}$).[12] For example, it is sufficient to have a symmetric density (i.e., $q(\underline{\theta}) = \frac{1}{2}$). Alternatively, if firms are symmetric (i.e., $a_i = a_j$), then the conditions of Proposition 3(a) are satisfied too.[13] Finally, product differentiation is favorable for the existence of the symmetric disclosure equilibrium. In particular, there exists a critical degree of substitutability, $\delta^* > 0$, such that the conditions of Proposition 3(a) are satisfied for all $\delta \leq \delta^*$.[14]

Conversely, the proposition shows that the equilibrium with symmetric disclosure choices need not always exist. In particular, if (i) the distribution of θ is skewed towards low intercepts (i.e., $q(\underline{\theta})$ is high), (ii) goods are close substitutes (i.e., δ is high), and (iii) it is very likely that one of the firms receives information while it is unlikely that the other firm receives information (e.g., a_j is high while a_i is low), then the symmetric disclosure equilibrium does not exist. Under those conditions, firm i has an incentive to unilaterally disclose good (conceal bad) news to make its rival realize (believe) that firm i will compete "aggressively" in the product market.

For intuition of these observations, suppose that the firms have beliefs consistent with the strategies $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right] = \left[s_j^*(\underline{\theta}), s_j^*(\overline{\theta})\right] = (1,0)$, and firm j chooses the strategy $\left[s_j^*(\underline{\theta}), s_j^*(\overline{\theta})\right] = (1,0)$. It is convenient to consider the extreme situation

[12] In the rewritten condition $q(\underline{\theta}) \leq 2/\left(a_j\left[2+\delta\left(1-a_i\right)\right]\right)$, the right-hand side is decreasing in a_j and δ, and increasing in a_i. This implies that $2/\left(a_j\left[2+\delta\left(1-a_i\right)\right]\right) > 2/3$.

[13] For $a_i = a_j$, the conditions reduce to $q(\underline{\theta})a\left[2+\delta\left(1-a\right)\right] \leq 2$. This condition holds, since its left-hand side is increasing in a for $0 < a < 1$ and therefore $q(\underline{\theta})a\left[2+\delta\left(1-a\right)\right] < 2q(\underline{\theta}) < 2$.

[14] The condition's left-hand side is increasing in δ, and it is smaller than 2 for $\delta = 0$.

where $q(\underline{\theta}) = 1 - \varepsilon$, and $a_i = \varepsilon$, $a_j = 1 - \varepsilon$, with $\varepsilon > 0$ small. In this situation, an uninformed firm i would expect a demand intercept of approximately $\frac{1}{2}\left(\underline{\theta} + \overline{\theta}\right)$, and the firm would consider it approximately equally likely to compete with an informed rival ($\Theta_j = \overline{\theta}$) as with an uninformed rival ($\Theta_j = \varnothing$).[15] Consequently, an uninformed firm i would supply approximately the amount $x_i^f\left(\frac{1}{2}\left(\underline{\theta} + \overline{\theta}\right)\right)$.[16]

First, we consider the incentive for firm i to unilaterally deviate by *disclosing a high demand intercept.* Take $\theta = \overline{\theta}$, and suppose that firm i received the informative signal, $\Theta_i = \overline{\theta}$. If firm i were to conceal its information, then firm j would expect to compete almost surely with an uninformed rival (since a_i is small), who sets $x_i^f\left(\frac{1}{2}\left(\underline{\theta} + \overline{\theta}\right)\right)$. Therefore, firm i's concealment of a high intercept would make firm j expect a relatively weak competitor. By contrast, the disclosure of the high demand intercept makes firm j realize that it faces a strong competitor, who sets the output level $x_i^f(\overline{\theta})$. Clearly, firm i's expected output from disclosure is greater than the expected output from concealment, i.e., $x_i^f(\overline{\theta}) > x_i^f\left(\frac{1}{2}\left(\underline{\theta} + \overline{\theta}\right)\right)$. Now, irrespective of whether firm i discloses or conceals, the competitor's best reply is approximately $2x_j \approx \overline{\theta} - c_j - \delta x_i$, since it is extremely likely that firm j is informed in the latter case (i.e., a_j is big). Whereas disclosure does not greatly affect firm j's beliefs about the demand, it has a substantial effect on firm j's beliefs about firm i's product market conduct. This gives firm j an incentive to contract its output. Hence, the unilateral disclosure of $\Theta_i = \overline{\theta}$ is profitable for firm i, given the proposed equilibrium beliefs.

Under the same conditions, firm i has the incentive to *conceal bad news.* Take $\theta = \underline{\theta}$, and suppose that firm i received a bad signal, $\Theta_i = \underline{\theta}$. Here, firm i's strategy can only have an effect on the firms' product-market conduct, if firm j is uninformed. In this case, a similar intuition applies as before. Although firm i's strategy has a negligible effect on firm j's beliefs about demand, it has a substantial effect on the firm's beliefs about the competitive pressure from firm i.[17] Concealment makes

[15] This is due to the fact that both a_j and $q(\underline{\theta})$ are high. In particular, the posterior probability $Q_j(\overline{\theta}; 1, 0)$ in (6) equals $1/(2-\varepsilon)$, and $A_j(\theta; 1, 0)$ in (4) gives $A_j(\underline{\theta}; 1, 0) = 0$ and $A_j(\overline{\theta}; 1, 0) = 1 - \varepsilon$. Clearly, for $\varepsilon \to 0$, these probabilities converge to $Q_j(\overline{\theta}; 1, 0) \to 1/2$ and $Q_j(\overline{\theta}; 1, 0)A_j(\overline{\theta}; 1, 0) \to 1/2$.

[16] An informed rival would know that the intercept is $\overline{\theta}$, whereas an uninformed rival would expect approximately the low intercept $\underline{\theta}$, since $q(\underline{\theta})$ is high and the concealment by firm i generates almost no additional information (a_i is low). Approximately, this gives the best reply functions: $2x_j(\overline{\theta}) \approx \overline{\theta} - c_j - \delta x_i(\varnothing)$ and $2x_j(\varnothing) \approx \underline{\theta} - c_j - \delta x_i(\varnothing)$ for firm j, and $2x_i(\varnothing) \approx (\underline{\theta} + \overline{\theta})/2 - c_i - \delta\left[x_j(\overline{\theta}) + x_j(\varnothing)\right]/2$ for firm i. Solving this system of equations gives $x_i^*(\varnothing; s_i^*, s_j^*) \approx x_i^f(\frac{1}{2}\left(\underline{\theta} + \overline{\theta}\right))$ for firm i.

[17] With or without disclosure by firm i, the competitor's best reply is approximately $2x_j \approx \underline{\theta} - c_j - \delta x_i$. This is due to the fact that a_i is low and $q(\underline{\theta})$ is high. In particular, the posterior probability $Q_i(\overline{\theta}; 1, 0)$ in (6) equals $\varepsilon / \left[(1-\varepsilon)^2 + \varepsilon\right]$, and $A_i(\theta; 1, 0)$ in (4) gives $A_i(\underline{\theta}; 1, 0) = 0$ and $A_i(\overline{\theta}; 1, 0) = \varepsilon$. Clearly, for $\varepsilon \to 0$, these probabilities converge to $Q_i(\overline{\theta}; 1, 0) \to 0$ and $Q_i(\overline{\theta}; 1, 0)A_i(\overline{\theta}; 1, 0) \to 0$. Whereas firm j anticipates the competitor's output $x_i^f(\underline{\theta})$ after disclosure, it expects approximately

uninformed firm j expect fierce quantity competition, and firm j reduces its output as a consequence. Firm j's relatively lower output enables firm i to expand its output, and thereby increase its expected profit.

Proposition 3(b) shows that the deviation strategies from above can be equilibrium strategies. An asymmetric equilibrium can only exist if the intercept distribution is skewed towards the low demand. That is, a necessary condition for the existence of this equilibrium is that $q(\underline{\theta}) > 2/(2+\delta)$.

Finally, Proposition 3(c) shows that there can exist equilibria in mixed strategies. As in part (b), an equilibrium in mixed strategies can only exist if the distribution of θ is skewed towards low intercepts (i.e., $q(\underline{\theta}) > 2/(2+\delta)$). Moreover, Proposition 3(c) implies that an equilibrium with full disclosure or full concealment by firm i can only exist in special cases. In particular, firm i discloses all (no) information in equilibrium if $q(\underline{\theta})a_j = 2/(2+\delta)$ (resp., $q(\underline{\theta})a_j = 2/\left[2+\delta\left(1-a_i\right)\right]$).

Proposition 3 has the following implication for the uniqueness of an equilibrium.

Corollary 1 ***(a)*** *For $q(\underline{\theta})\max\{a_1, a_2\} < 2/(2+\delta)$, the firms choose symmetric disclosure strategies (i.e., $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right] = (1,0)$ for $i = 1,2$) in the unique equilibrium.* ***(b)*** *For $q(\underline{\theta})a_i < 2/(2+\delta)$ and $q(\underline{\theta})a_j > 2/\left[2+\delta\left(1-a_i\right)\right]$ where $i, j = 1,2$ with $i \neq j$, the firms choose the strategies $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right] = (0,1)$ and $\left[s_j^*(\underline{\theta}), s_j^*(\overline{\theta})\right] = (1,0)$ in the unique equilibrium.*

Corollary 1(a) confirms the result of Darrough (1993). In the model with a symmetric distribution (i.e., $q(\underline{\theta}) = \frac{1}{2}$) and symmetric probabilities of receiving an informative signal ($a_i = a_j$), the symmetric equilibrium is unique. In our setting with a binary type space, the symmetry of the distribution is already sufficient for the uniqueness of the symmetric equilibrium.

In the setting where only one firm can become informed, we confirm Sankar (1995).

Corollary 2 (Sankar, 1995) *If $a_j = 0$, then firm i chooses strategy $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (1,0)$ in the unique equilibrium for $i, j = 1,2$ with $i \neq j$.*

Proof. For $a_j = 0$, (11) reduces to $\psi_i(s_i) = 2\left[1 - a_i s_i(\underline{\theta})\right]\left[1 - a_i s_i(\overline{\theta})\right] > 0$. Consequently, there only exists an equilibrium with $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (1,0)$. ■

In the context of a model with a symmetric distribution, Sankar (1995) argues that this result extends to settings with $a_j > 0$. Our contribution is to show that

the output $x_i^f\left(\frac{1}{2}\left(\underline{\theta}+\overline{\theta}\right)\right)$ after concealment.

this argument depends on the symmetry of the distribution. In particular, if the distribution is sufficiently skewed towards a low intercept, then the equilibrium with symmetric disclosure choices may not be unique or may not exist (Corollary 1(b)).

3.3 Bertrand Competition

This subsection analyzes the effects of changing from Cournot competition (strategic substitutes) to Bertrand competition (strategic complements). Inverting the system of inverse demand functions gives the following direct demand function:

$$D_i(p_i, p_j; \theta) \equiv \frac{1}{1-\delta^2}\left((1-\delta)\theta + \delta p_j - p_i \right) \tag{15}$$

for $i, j = 1, 2$ with $i \neq j$. Maximizing the expected value of profit $\pi_i = (p_i - c_i)\, D_i(p_i, p_j; \theta)$ and solving for the equilibrium gives the following result by focusing on accommodating pricing strategies (i.e., the substitutability parameter δ is sufficiently low).

Proposition 4 *If a firm disclosed θ, then firm i sets the equilibrium price:*

$$p_i^f(\theta) \equiv \frac{(1-\delta)\theta + c_i}{2-\delta} + \frac{\delta(c_j - c_i)}{4-\delta^2}. \tag{16}$$

If no firm disclosed information, and firms i and j have beliefs consistent with s_j and s_i, respectively, then the equilibrium price of firm i with information $\Theta_i = \theta$ equals:

$$p_i^*(\theta; s_i, s_j) \equiv p_i^f(\theta) - \frac{\delta \frac{1-\delta}{2-\delta} p(\widehat{\theta}) \left(\theta - \widehat{\theta}\right) \psi_i^b(s_i, s_j)}{\mathcal{D}(s_i, s_j) \prod_{h=1}^{2} \left[1 - a_h s_h(\theta)\right] E\{1 - a_h s_h(\theta)\}} \tag{17}$$

where $\psi_i^b(\bullet) > 0$ and $\mathcal{D}(\bullet) > 0$ for $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i, j = 1, 2$ with $i \neq j$. The equilibrium price of an uninformed firm equals $p_i^*(\varnothing; s_i, s_j) = E_j \{p_i^*(\theta; s_i, s_j) | \varnothing; s_j\}$ for $i, j = 1, 2$ with $i \neq j$. Firm i chooses the strategy $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (0, 1)$ in the unique equilibrium for $i = 1, 2$.

The intuition for this result is straightforward. The effects of information disclosure by Bertrand competitors reinforce each other, whereas demand disclosure by a Cournot competitor yields two conflicting effects. Disclosure of good news about the market size increases the competitor's price for two reasons. First, the competitor becomes more optimistic about the market opportunities (i.e., the demand), and raises its price. In addition, the competitor learns that the disclosing firm is informed about the fact that demand is high, and is therefore less "aggressive" than expected. Also this makes the competitor a softer price setter in the product market (strategic complements). The intuition for concealing bad news is analogous.

3.4 Hypotheses

Our theoretical results yield some hypotheses which we test afterwards. First, we derive the following testable hypothesis from Corollary 1 and Proposition 4.

Hypothesis 1 ***(a)*** *If demand is uniformly distributed ($q(\underline{\theta}) = \frac{1}{2}$) and firms compete in quantities (prices), then firms disclose information on low (high) demand intercepts more often than high (low) intercepts.*
(b) *If firms compete in quantities and the conditions of Corollary 1(b) are satisfied, then firm i (firm j) discloses information on high (low) demand intercepts more often than low (high) intercepts.*

Hypothesis 1(a) gives testable predictions for settings in which firms choose symmetric disclosure strategies in the unique equilibrium. Hypothesis 1(b) covers the settings in which the disclosure strategies differ in the unique equilibrium.

Second, we develop two testable hypotheses about the effects of information on the firms' product market strategies.[18] If firms compete in quantities and the demand distribution is uniform (i.e., $q(\underline{\theta}) = \frac{1}{2}$), then Proposition 1 implies for $i = 1, 2$:

$$x_i^*(\underline{\theta}; [1,0], [1,0]) < x_i^f(\underline{\theta}) < x_i^*(\varnothing; [1,0], [1,0]) < x_i^f(\overline{\theta}) < x_i^*(\overline{\theta}; [1,0], [1,0]). \tag{18}$$

Proposition 3 implies that firms choose the symmetric disclosure strategy profile $s_1 = s_2 = [1, 0]$ in the unique equilibrium if the demand distribution is uniform. A firm's incentive to conceal a high demand intercept follows from the last inequality of (18). By contrast, under the conditions of Corollary 1(b), firm i's equilibrium outputs can be ranked as follows:

$$x_i^f(\underline{\theta}) < x_i^*(\underline{\theta}; [0,1], [1,0]) < x_i^*(\varnothing; [0,1], [1,0]) < x_i^*(\overline{\theta}; [0,1], [1,0]) < x_i^f(\overline{\theta}). \tag{19}$$

In this case, Corollary 1(b) predicts that firm i discloses only high demand intercepts in the unique equilibrium. Firm i's incentive to conceal a low demand intercept follows from the first inequality in (19). Similarly, if firms compete in prices, then Proposition 4 implies the following ranking of equilibrium prices (for $i = 1, 2$):

$$p_i^f(\underline{\theta}) < p_i^*(\underline{\theta}; [0,1], [0,1]) < p_i^*(\varnothing; [0,1], [0,1]) < p_i^*(\overline{\theta}; [0,1], [0,1]) < p_i^f(\overline{\theta}). \tag{20}$$

Under Bertrand competition, Proposition 4 predicts that firms disclose only high demand intercepts in the unique equilibrium, i.e., $s_1 = s_2 = [0, 1]$. Firm i's incentive to conceal a low demand intercept follows from the first inequality in (20). We summarize these observations in the following hypothesis.

[18] See the Appendix for details on formal derivations.

Hypothesis 2 *Consider firm i with an informative signal ($\Theta_i = \theta$).*
(a) *If demand is high ($\theta = \overline{\theta}$) and it is drawn from the uniform distribution ($q(\underline{\theta}) = \frac{1}{2}$), and firms compete in quantities, then the firm's output without information disclosure is greater than the output with information disclosure.*
If demand is low ($\theta = \underline{\theta}$), and ***(b)*** *firms compete in quantities and the conditions of Corollary 1(b) are satisfied, or* ***(c)*** *firms compete in prices, then firm i's product market choice without information disclosure is greater than the choice with disclosure.*

The inequalities of (18), (19) and (20) also relate the equilibrium product market strategy of an uninformed firm to the strategies under complete information. The following hypothesis captures these rankings of equilibrium product-market choices.

Hypothesis 3 *The product-market choice of uninformed firm i is greater (smaller) than the choice of a firm with complete information about a low (high) demand, if:*
(a) *firms compete in quantities and demand is uniformly distributed ($q(\underline{\theta}) = \frac{1}{2}$), or*
(b) *firms compete in quantities and the conditions of Corollary 1(b) are satisfied, or*
(c) *firms compete in prices.*

The product-market choice of an uninformed firm is greater than the choice of a firm with complete information about a low demand intercept for the following reason. On the one hand, an uninformed firm is more optimistic about the demand than a firm that knows that demand is low. This gives an uninformed firm an incentive to choose a higher product-market variable. On the other hand, an uninformed firm expects tougher quantity (softer price) competition in the product market in comparison to a firm that faces a pessimistic competitor who knows that demand is low. This gives the uninformed firm an incentive to set a lower output (higher price). The two effects reinforce each other under Bertrand competition, and give $p_i^f(\underline{\theta}) < p_i^*(\varnothing;\cdot)$, as Hypothesis 3(c) states. By contrast, the effects are in conflict under Cournot competition. Under the conditions of Hypothesis 3(a)-(b), the former effect outweighs the latter. This yields the inequality $x_i^f(\underline{\theta}) < x_i^*(\varnothing;\cdot)$. The comparison of the product-market choice of an uninformed firm with the choice of a firm with complete information about high demand gives analogous effects.

Finally, we generate a testable hypothesis which relates to the effect of the likelihood of receiving information on a firm's equilibrium product-market choice.

Hypothesis 4 *For $i = 1, 2$, the product-market choice of firm i under incomplete information is decreasing in the firm's likelihood of receiving information, a_i, in the* *following instances.* ***(a)*** *Firms compete in quantities, demand is uniformly distributed* $(q(\underline{\theta}) = \frac{1}{2})$*, and the firm is uninformed* $(\Theta_i = \varnothing)$ *or the firm received high-demand information* $(\Theta_i = \overline{\theta})$ *and* $a_i \geq 0.3$*.* ***(b)*** *Firms compete in prices.*

The likelihood a_i affects the beliefs of firm i's competitor. In particular, for beliefs consistent with the equilibrium strategy and information concealment, an increase of a_i has two effects. On the one hand, an uninformed Cournot (Bertrand) competitor becomes more optimistic (pessimistic) about the size of demand in the market, since it is more likely that firm i is informed and conceals good (bad) news. This gives the Cournot (Bertrand) competitor an incentive to expand his output (reduce his price). On the other hand, in a Cournot (Bertrand) duopoly, firm i's competitor considers it more likely that firm i is informed about a high (low) demand intercept. That is, the competitor expects that firm i is relatively more "aggressive," which gives the competitor an incentive to reduce his output or price. If firms compete in quantities, and demand is uniformly distributed, the former effect tends to dominate the latter effect, and firm i reduces its output in response to the output expansion of its competitor. Under Bertrand competition, the two effects on the competitor's beliefs reinforce each other. They give the competitor an incentive to set a lower price, and firm i's best reply is to decrease its price as well.

4 Experimental Analysis

We conduct a lab experiment with seven different treatments. In our experiment, participants play variants of the duopoly games from Section 2 and 3.3. We start by describing and motivating the experimental design before we discuss the results.

4.1 Design

In the experiment, we simplify the model by imposing zero production costs ($c_1 = c_2 = 0$), and discrete disclosure choices ($s_i(\theta) \in \{0, 1\}$ for any θ and i). We set $\underline{\theta} = 240$ and $\overline{\theta} = 300$, and we truncate the inverse demand function to avoid negative profits.[19]

Subjects in each treatment of the experiment are randomly assigned to matching groups of six individuals. In each period, a subject is randomly assigned to another subject within his matching group, but we ensure that two subjects are never matched

[19] That is, $\mathcal{P}_i^d(x_i, x_j) = \max\{\theta - x_i - \delta x_j, 0\}$. Since $\underline{\theta}$ and $\overline{\theta}$ are sufficiently close to each other, this restriction has no effect on the equilibrium, and it was only rarely binding in the experiment (<1%).

in two consecutive periods. Subjects are made aware of the random matching, but they do not know the matching group size. This is done to avoid reciprocal behavior.[20]

4.1.1 Treatments

We vary the strategic product-market variables, the degree of substitutability (δ), firm 1's likelihood of receiving information (a_1), the prior demand probability $q(\underline{\theta})$, and the exchange rate of ECU/€ across treatments, to test our hypotheses. The exchange rates vary such that the subjects' expected earnings remain constant across treatments. We keep $a_2 = 0.9$ across treatments. Table 1 lists the different variables and parameter values in our seven treatments. By using these parameter values, we focus on settings with unique equilibria.

Table 1: Treatment overview – parameter values

	Strategic variable	δ	a_1	a_2	$q(\underline{\theta})$	Exchange Rate	Date
Treatment 1 (T1)	output	1	0	0.9	0.5	28,000 ECU/€	April 12, 2012
Treatment 2 (T2)	output	1	0.9	0.9	0.5	28,000 ECU/€	April 12, 2012
Treatment 3 (T3)	output	1	0.3	0.9	0.5	28,000 ECU/€	May 12, 2012
Treatment 4 (T4)	output	1	0.3	0.9	0.9	23,000 ECU/€	May 12, 2012
Treatment 5 (T5)	output	$\frac{1}{2}$	0	0.9	0.5	40,000 ECU/€	July 22, 2013
Treatment 6 (T6)	price	$\frac{1}{2}$	0	0.9	0.5	56,000 ECU/€	July 22, 2013
Treatment 7 (T7)	price	$\frac{1}{2}$	0.9	0.9	0.5	56,000 ECU/€	July 22, 2013

Treatments 1-4 adopt Cournot competition with homogeneous goods ($\delta = 1$). In Treatment 1, we set $a_1 = 0$. That is, we have a model of unilateral disclosure. Since the demand distribution is uniform (i.e., $q(\underline{\theta}) = 0.5$), and firm 2 receives information with a probability of 0.9, our setting is similar to one of the settings in Ackert *et al.* (2000).[21] Hence, we aim to replicate the findings of Ackert *et al.* with T1.

In Treatment 2, we modify the first treatment such that both firms have the same likelihood of learning the demand intercept, i.e., $a_1 = 0.9$ and $q(\underline{\theta}) = 0.5$. In this *ex*

[20]With this matching procedure we especially aim to prevent collusion, since collusion is most likely in small groups with repeated interaction, e.g., see Huck *et al.* (2004).

[21]The setting of T1 is strategically identical to Ackert *et al.* (2000), since the incentives are identical in both experiments. However, T1 differs in framing and procedures, e.g., Ackert *et al.* conduct a Pen&Paper experiment and subjects face uncertainty about industry-wide costs, which can take three different values. Table **??** in the Supplementary Appendix lists the main differences.

ante symmetric setting, we aim to test whether multilateral selective disclosure occurs in the way predicted by Corollary 1(a). In addition, it allows us to compare quantities between different treatments, and study the effects of changing a_1 (Hypothesis 4(a)).

In Treatment 3, we set $a_1 = 0.3$ while everything else remains as in T1 and T2. With this treatment we can test whether multilateral selective disclosure of low demand occurs in asymmetric settings with uniformly distributed demand. Moreover, the comparisons with T1 and T2 give further insights in the effects of varying a_1.

In Treatment 4, we modify T3 by setting $q(\underline{\theta}) = 0.9$. That is, we introduce skewness of the demand distribution. As follows from Corollary 1, this changes the unique equilibrium disclosure strategy of firm 1. Theory predicts that firm 1 discloses only a high demand intercept in T4, which we aim to verify with this treatment.

Treatments 5-7 adopt product differentiation ($\delta = \frac{1}{2}$). In Treatment 5, we modify T1 by introducing product differentiation (i.e., $a_1 = 0$, $q(\underline{\theta}) = 0.5$, and $\delta = \frac{1}{2}$). This allows us to verify whether the results from T1 are robust to a change in the degree of product substitutability. In addition, T5 serves as a link between T1-T4 and T6-T7.

Treatments 6 and 7 adopt competition in prices (Bertrand competition) with differentiated goods. Here, we use the direct demand function $D_i(p_i, p_j; \theta) \equiv \theta + p_j - 2p_i$ for $i, j = 1, 2$ and $i \neq j$ (i.e., $\delta = \frac{1}{2}$). In particular, Treatment 6 assumes unilateral disclosure, as in T5. By comparing behavior in T6 with behavior in T5, we are able to study the effects of changing the strategic variable in the product market.

Finally, Treatment 7 extends T6 by adopting multilateral disclosure, i.e., $a_1 = 0.9$, and $q(\underline{\theta}) = 0.5$. In other words, a_1 increases from 0 to 0.9 by moving from T6 to T7, and thereby T7 is the Bertrand counterpart of T2.

4.1.2 Parts within each Treatment

Each treatment consists of three different parts which are all slight modifications of the models from Sections 2 and 3.3. The three parts have different levels of complexity, as they introduce random variables and strategy choices step by step.

In Part I, subjects compete in a duopolistic market with full information (i.e., $a_1 = a_2 = 1$), and subjects make no disclosure choices (i.e., $s_1 = s_2 = 1$). This part consists of 20 independently repeated periods and is identical across treatments with the same intensity of competition.[22] At the beginning of each period, both subjects are informed about the realization of the random demand intercept θ. Sub-

[22] In T1-T3, Part I is *ex ante* identical. Part I of T4 is only strategically identical to Part I of T1-T3, since it has a different demand distribution. Part I of T6 is *ex ante* identical to Part I of T7.

sequently, they simultaneously choose output levels (T1-T5) or prices (T6-T7) from the interval $[0, 300]$. At the end of each period, we give feedback concerning chosen outputs (prices), the subject's price (demand), and the subject's profit. To start each treatment with this simple part has several advantages. First, participants familiarize themselves with the duopoly game. This is important, since subjects are not equipped with calculators, payoff tables or other auxiliary means in our experiment.[23] Therefore, we expect more noisy and suboptimal behavior in initial periods. Second, we can use observations from Part I for investigations of general interest, e.g., it allows us to examine the intensity of competition and learning in a complete-information setting.

In Part II, we introduce incomplete information about the demand intercept, and we allow subjects to make disclosure choices. At the beginning of each period in this part, subjects 1 and 2 independently learn the intercept with probability a_1 and a_2, respectively, which varies across treatments. Subsequently, both subjects simultaneously make their disclosure decisions. In contrast to the models of Sections 2 and 3.3, we restrict disclosure decisions to pure strategies. This does not restrict the equilibrium strategies, since we aim to test the emergence of unique equilibria in pure strategies for all treatments.[24] Finally, subjects simultaneously set their output levels or prices and receive feedback as in Part I. We repeat this procedure for 50 independent periods, in order to increase the likelihood for all subjects to experience all possible states of information at least once.[25] Part II constitutes the core of our experiment, as it allows us to observe disclosure decisions and product-market choices for various realizations of random variables.

Part III consists of a single period. Here, subjects have to make a disclosure decision prior to receiving their signal. That is, they have to formulate a full disclosure strategy, $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] \in \{0,1\} \times \{0,1\}$, indicating whether or not any particular demand intercept will be disclosed.[26] After posting the strategies, the intercept is drawn and messages are transferred. Finally, subjects simultaneously make their product market choices, and receive feedback as in Parts I and II. The observed strategies of this part allow a deeper inquiry into the subjects' disclosure behavior.

[23] Requate and Waichman (2011), and Gürerk and Selten (2012) explore the effects of the provision of payoff tables in experimental oligopolies. They find that provision has a considerable effect on initial behavior and it makes collusion more likely to occur.

[24] For the parameter choices of our treatments, mixed strategies affect the firm's choices neither along the equilibrium path, nor off the equilibrium path.

[25] The likelihood for specific informational settings is quite low in some treatments, due to a low a_1 or $q(\overline{\theta})$, since the demand intercept and signals are randomly drawn within all treatments.

[26] The strategy method was initially used by Selten (1967).

4.1.3 Background Information

All sessions of our experiment were conducted in the *Cologne Laboratory for Economic Research* at the University of Cologne. The experiment has been programmed with the experimental software *z-Tree* (Fischbacher, 2007). Participants were recruited via e-mail from a subject pool with about 5,000 registered subjects by using the *Online Recruitment System ORSEE* (Greiner, 2004).

Out of a preselected subsample of 1,900 students with a considerable background in business administration or economics, we randomly invited participants for the experiment.[27] We held seven sessions with 30 participants each. The share of male (110) and female (100) participants was almost equal and the average age was 24.7 years. Each subject was allowed to participate in one session only.

We paid each subject € 2.50 for showing up. During the course of the experiment, subjects could earn additional money, dependent on their decisions. In the experiment we used an experimental currency (ECU), which was converted to Euros (€) and paid in cash at the end of the experimental sessions. Average payments were approximately € 21 (including the participation fee). Since each session took about two hours, the resulting hourly earnings were approximately € 10 for each individual.

4.2 Experimental Results

In this section we make a descriptive analysis of the data generated by our experiment, and we test the hypotheses from the previous section.

Each treatment has 30 participants, i.e., 15 subjects with the role of firm 1 and 15 subjects as firm 2. Each treatment and role give 5 independent observations, since subjects are randomly matched in groups of 6 subjects. That is, an observation is the average of choices by subjects with a specific role over time in their matching group.[28]

As we only have a small number of observations we do not make normality assumptions. Instead, we analyze our data by using non-parametric tests. For comparisons within treatments, we use the Wilcoxon-Matched-Pairs-Signed-Rank test (Wilcoxon test), while we use the Mann-Whitney-Wilcoxon test (MWW test) for

[27] We invited students who were at least in their third semester and had been enrolled in one of the following courses of studies towards a Bachelor's, Master's or other comparable degree: business administration, business arithmetics, business informatics, economics, social sciences. The preselection has the following motivation. First, students with these backgrounds may be more representative of the business community than the general student population. Second, students with this background may have a greater ability to deal with the complexity of this game.

[28] Hence, all product-market choices reported below refer to average levels of matching groups.

between-treatment comparisons.[29] Typically, we test directional hypotheses, and thus we use the one-sided version of the previous tests in those cases.

4.2.1 Observations from Part I - Complete Information

In Part I of our experiment, the firms have complete information. We start by checking whether there are exogenous variations across treatments with the same mode of competition. We do so by analyzing treatments which are strategically identical in Part I (i.e., T1-T4 for Cournot competition with homogeneous goods, and T6-T7 for Bertrand competition with differentiated goods).

Table 2 summarizes the equilibrium product-market choices under complete information for all treatments. Table 3 lists the average product-market choices in Part I across all treatments. As can be seen, product-market choices are relatively close to the equilibrium values, and they do not differ much between the strategically identical treatments. By using one-on-one treatment comparisons with the two-sided MWW test, we find no statistically significant differences between any two strategically equivalent treatments for either low or high demand. Hence, we attribute differences between treatments in Parts II and III solely to the parameter variations.

Table 2: Equilibrium product-market choices under complete information

	T1	T2	T3	T4	T5	T6	T7
low demand ($\theta = \underline{\theta}$)	80	80	80	80	96	80	80
high demand ($\theta = \overline{\theta}$)	100	100	100	100	120	100	100

Note: The choices in T1-T5 (T6-T7) are output levels (prices).

Table 3: Average product-market choices in Part I

	T1	T2	T3	T4	T5	T6	T7
low demand ($\theta = \underline{\theta}$)	85.8	86.2	86.9	87.9	94.6	76.1	83.8
	(15.9)	(22.2)	(22.7)	(21.3)	(4.2)	(2.7)	(11.4)
high demand ($\theta = \overline{\theta}$)	108.4	107.6	111.5	114.2	127.9	102.6	112.0
	(16.8)	(24.3)	(22.8)	(40.0)	(10.6)	(13.9)	(15.0)

Note: Standard deviations are reported in parentheses.
The choices in T1-T5 (T6-T7) are output levels (prices).

Next, we investigate how competitively participants behave in Part I, by using pooled data from the *ex ante* identical Cournot treatments T1-T3, and the Bertrand

[29] For descriptions of the Wilcoxon and MWW tests, see, e.g., Siegel and Castellan (1988).

treatments T6-T7. For the Cournot treatments we can reject the hypothesis that chosen levels are lower (i.e., less competitive) than the respective Cournot equilibrium quantities in Table 2.[30] In fact, the chosen quantities tend to be a bit more competitive than predicted.[31] For Bertrand competition with low demand, we do not find significant differences between chosen and predicted prices.[32] For high demand draws, we can reject the hypothesis that price choices are lower (i.e., more competitive) than predicted with weak statistical significance.[33] The latter result is mainly driven by initial periods, as can be seen in the next paragraph.

Finally, we examine the extent to which learning takes place. One reason for having Part I is to familiarize subjects with the product-market game. Therefore, we expect deviations from the Nash equilibria to diminish over time. To our surprise, the initial product-market choices of subjects are on average already relatively close to the Nash equilibrium predictions of Table 2. For the Cournot treatments T1-T3, subjects choose an average production level of 86.7 units (SD:10.9) in the first five instances with low demand, which significantly decreases to 84.11 units (SD:7.9) in the later periods of Part I.[34] For high demand in those treatments, subjects start with 109.4 units (SD:9.5) on average, and continue with 108.6 units (SD:9.1) in the subsequent periods. The comparison of those two output levels gives no significant difference. In the Bertrand treatments (T6-T7), we conduct a similar analysis. With low demand, subjects start with average prices of 84.0 (SD:11.7) which is significantly higher than 75.8 (SD:7.9) in the subsequent periods.[35] With high demand, average initial prices of 112.8 (SD:16.5) are significantly higher than the average price of 101.7 (SD:13.2) in latter instances.[36] Thus, the price choices of Bertrand competitors become slightly more and the quantity choices of Cournot competitors become slightly less "aggressive" in the course of Part I. In summary, product market choices tend to converge to the predicted levels for both modes of competition.

[30] Wilcoxon tests, one-sided: p=0.0234 for low demand, p=0.0013 for high demand.

[31] Holt (1985) also finds a slighty more competitive behavior compared to the equilibrium prediction in his Cournot duopoly experiment. Holt reports that some subjects gave a "rivalistic" reasoning for this behavior, indicating that they are willing to take a small loss in order to harm the competitor. Thus, rivalistic behavior might be the reason for the markup in our data as well. Huck *et al.* (1999) make the same observation, especially when feedback about the competitors' quantities is provided.

[32] Wilcoxon test, two-sided (non-directional null-hypothesis), p=0.5751.

[33] Wilcoxon test, one-sided, p=0.0697.

[34] Wilcoxon test, one-sided, p=0.0219.

[35] Wilcoxon test, one-sided, p=0.0184.

[36] Wilcoxon test, one-sided, p=0.0026.

4.2.2 Observations on Disclosure Choices (H1)

Table 4 summarizes the unique equilibrium disclosure choices for T1-T7. Below we test whether the disclosure choices in our experiment are in line with these predictions.

Table 4: Disclosure frequencies in the unique equilibrium (in %)

	T1	T2	T3	T4	T5	T6	T7
Firm 1:							
low demand ($\Theta_1 = \underline{\theta}$)	—	100	100	0	—	—	0
high demand ($\Theta_1 = \overline{\theta}$)	—	0	0	100	—	—	100
Firm 2:							
low demand ($\Theta_2 = \underline{\theta}$)	100	100	100	100	100	0	0
high demand ($\Theta_2 = \overline{\theta}$)	0	0	0	0	0	100	100

Disclosure choices in Part II Table 5 gives the average disclosure frequencies of the subjects who received an informative signal from nature in Part II of the experiment.[37] The first and third rows of Table 5 suggest that the vast majority of firms in the treatments with Cournot competition (T1-T5) disclosed low demand. Conversely, the second and fourth rows illustrate that the vast majority of Bertrand competitors in T6-T7 disclosed high demand, as the theory predicts (Table 4).

A pairwise comparison of the frequencies from the first and second rows, and from the third and fourth rows, suggests that firms in T1-T5 disclose a low demand intercept more frequently than a high demand intercept. By contrast, firms in T6-T7 appear to disclose a high demand intercept more frequently than a low intercept. The following quantitative result is in line with these qualitative observations.

Result 1 ***(a)*** *In Cournot (Bertrand) markets with uniformly distributed demand, there is evidence that subjects disclose low (high) demand intercepts significantly more often than high (low) intercepts.*
(b) *In Cournot markets with skewed demand distribution and asymmetric signal distributions (T4), subjects with a high-demand signal show a lower than predicted frequency of disclosure.*

[37] We also analyze whether subjects change their disclosure behavior over time. We compare the subjects' average disclosure frequency in the first five instances where the subjects received a particular informative signal with the frequency in the last five instances where they observed this signal. Although the disclosure frequencies appear to increase, the changes are not statistically significant in most cases. For details, see Tables **??**-**??** in the Supplementary Appendix.

Table 5: Disclosure frequencies in Part II (in %)

	T1	T2	T3	T4	T5	T6	T7
Firm 1:							
low demand ($\Theta_1 = \underline{\theta}$)	—	85.5 (17.5)	87.7 (9.9)	93.5 (13.3)	—	—	41.9 (13.9)
high demand ($\Theta_1 = \overline{\theta}$)	—	56.1 (25.4)	56.5 (19.5)	36.6 (30.9)	—	—	84.5 (21.2)
Firm 2:							
low demand ($\Theta_2 = \underline{\theta}$)	97.8 (1.6)	85.5 (17.5)	87.9 (9.3)	84.7 (16.5)	81.8 (11.1)	38.9 (22.3)	41.9 (13.9)
high demand ($\Theta_2 = \overline{\theta}$)	46.4 (9.9)	56.1 (25.4)	34.4 (27.8)	32.6 (22.1)	13.6 (14.1)	94.7 (4.0)	84.5 (21.2)

Note: Standard deviations are reported in parentheses.
In T2 and T7 we do not distinguish between firms as they are ex ante identical.

Hypothesis 1(a) predicts that Cournot (Bertrand) competitors with a uniform demand distribution disclose low (high) demand intercepts more frequently than high (low) intercepts. In line with this hypothesis, we find in the Cournot treatments T1-T3 and T5 significantly higher disclosure frequencies for subjects with low-demand information.[38] This result is consistent with a finding by Ackert *et al.* (2000) who examine a unilateral disclosure setting. In addition, we extend their finding to a setting with differentiated goods (T5), and to multilateral settings for symmetric (T2) as well as asymmetric signaling technologies (T3). Further, we find in T6-T7 that the frequencies of disclosing a high demand intercept are significantly higher than the frequencies of disclosing low demand.[39] This is in line with Hypothesis 1(a) too.

Hypothesis 1(b) predicts that firm 1 (firm 2) in T4 discloses high (low) demand intercepts more frequently than low (high) intercepts. We find that firm 1 discloses a low demand intercept significantly more often than a high intercept, and we obtain a similar result for firm 2.[40] The latter result is consistent with Hypothesis 1(b), whereas the former result is not.

Result 1(a) suggests that the subjects understand that their disclosure reveals information to their competitor about the size of the market. That is, the subjects seem to understand the strategic value of managing the competitor's belief about the market. In addition, it gives experimental support for the theoretical finding that the

[38] We used one-sided Wilcoxon tests. The p-value in each treatment comparison is 0.0215, which is the best possible value attainable given the number of independent observations.

[39] Wilcoxon tests, one-sided, p-values=0.0215.

[40] Wilcoxon tests, one-sided: p=0.0339 for firm 1, p=0.0215 for firm 2.

disclosure behavior of Cournot competitors differs from that of Bertrand competitors (e.g., Darrough, 1993). However, there is no evidence that subjects understand that their disclosure reveals information about their own conduct, as Result 1(b) implies. These observations are consistent with the observations by Ackert *et al.* (2000). Also they find that subjects adjust their disclosure choices if they inform the competitor about the market (industry-wide information), whereas they do not adjust if disclosure informs the competitor about the discloser's conduct (firm-specific information). Ackert *et al.* make this observation in a model with unilateral disclosure of independently distributed costs, whereas we make our observation in a model with bilateral disclosure of a common demand intercept.

Disclosure choices in Part III For a deeper inquiry of the disclosure behavior, we asked the participants in Part III of each treatment for a complete disclosure strategy. Table 6 gives the frequencies of the individual disclosure-strategy choices for each treatment and role in Part III. Out of the 90 participants who had to make a disclosure decision in the Cournot treatments T1-T3 and T5, 42 subjects choose to disclose only if demand is low, which is the equilibrium disclosure strategy. Another 39 (7) subjects choose to disclose all (no) demand intercepts. The relatively high number of subjects who choose to disclose all information could be explained by an aversion to deception for those subjects (e.g., Gneezy, 2005). Subjects may interpret not informing their competitor as lying about the fact that they are informed. Just 2 subjects choose to disclose only a high demand intercept. In short, 90% of the subjects in Part III of T1-T3 and T5 disclose a low demand intercept, whereas less than 46% disclose a high intercept. This is in line with Hypothesis 1(a). Also the frequencies from the Bertrand treatments T6-T7 are in line with the aggregate disclosure predictions from Hypothesis 1(a), and they are consistent with our findings from Part II.[41]

For T4, Hypothesis 1(b) predicts that firm 1 discloses a high demand intercept more frequently than a low intercept, whereas firm 2 does the reverse. However, Table 6 indicates that firm 1 chooses to disclose low-demand information more often (i.e., in 80% of the cases) than high-demand information (by less than 27% of the subjects).[42]

[41] Out of the 45 subjects in T6-T7 who choose a disclosure strategy, 28 subjects choose to disclose only a high demand intercept, whereas no subject chooses to do the reverse. Further, 14 (3) subjects choose to disclose all (no) demand information. In other words, more than 93% of the subject choose to disclose a high demand intercept, whereas about 31% disclose a low intercept.

[42] From the 15 subjects with the role of firm 1, there are 2 subjects who choose to disclose only high demand, whereas 10 subjects choose to do the reverse. There are 2 (1) subjects with the role of firm 1 who commit to disclosing all (no) information.

Table 6: Frequencies of disclosure choices in Part III (in %)

		T1	T2	T3	T4	T5	T6	T7
Firm 1's strategy $[s_1(\underline{\theta}), s_1(\overline{\theta})]$								
"disclose nothing"	$[0,0]$	—	6.7	6.7	6.7	—	—	10
"disclose only low"	$[1,0]$	—	40	26.7	66.7	—	—	0
"disclose only high"	$[0,1]$	—	3.3	0	13.3	—	—	63.3
"disclose all"	$[1,1]$	—	50	66.7	13.3	—	—	26.7
Firm 1's disclosure frequency								
low demand ($\Theta_1 = \underline{\theta}$)		—	90	93.3	80	—	—	26.7
high demand ($\Theta_1 = \overline{\theta}$)		—	53.3	66.7	26.7	—	—	90
Firm 2's strategy $[s_2(\underline{\theta}), s_2(\overline{\theta})]$								
"disclose nothing"	$[0,0]$	0	6.7	26.7	6.7	0	0	10
"disclose only low"	$[1,0]$	46.7	40	60	66.7	66.7	0	0
"disclose only high"	$[0,1]$	0	3.3	0	0	6.7	60	63.3
"disclose all"	$[1,1]$	53.3	50	13.3	26.7	26.7	40	26.7
Firm 2's disclosure frequency								
low demand ($\Theta_2 = \underline{\theta}$)		100	90	73.3	93.3	93.3	60	26.7
high demand ($\Theta_2 = \overline{\theta}$)		53.3	53.3	13.3	26.7	33.3	100	90

Note: In T2 and T7 we do not distinguish between firms as they are ex ante identical.

Hence, the behavior of subjects in the role of firm 1 is inconsistent with the predicted behavior, whereas the behavior of firm 2 in T4 is consistent with our prediction.[43]

4.2.3 Observations on Product-Market Choices

Tables 7 and 8 summarize the average product-market choices in Part II of firm 1 and firm 2, respectively. These choices are output levels in T1-T5, whereas they are prices in T6-T7. We distinguish settings in which no messages were sent from settings of complete information. In the former situation, firms did neither send nor receive any informative message but they received a particular signal by nature. We list the average product-market choices for this setting in the first three columns of Tables 7

[43] Out of the 15 subjects with the role of firm 2, 10 subjects commit to disclosing only low demand intercepts, whereas no-one commits to the opposite strategy. Further, 4 (1) subjects in the role of firm 2 commit to disclose all (no) information. Hence, low demand intercepts are disclosed by 93% of the subjects, whereas high intercepts are disclosed by less than 27% of the subjects.

and 8.[44] We list the average product-market choices under complete information in the last two columns of Tables 7 and 8. Here, we pool data from instances in which firm 1, firm 2, and both firms sent an informative message.

Table 7: Average product-market choices of Firm 1 in Part II

	Incomplete Information			Complete Information	
	$\Theta_1 = \underline{\theta}$	$\Theta_1 = \varnothing$	$\Theta_1 = \overline{\theta}$	$\theta = \underline{\theta}$	$\theta = \overline{\theta}$
T1	—	105.3 (7.7)	—	85.2 (7.8)	108.5 (10.8)
T2	too few obs.	95.0 (11.4)	108.0 (6.1)	81.6 (2.6)	101.8 (4.1)
T3	too few obs.	99.9 (3.9)	112.7 (1.6)	80.9 (3.4)	104.3 (5.3)
T4	too few obs.	90.9 (11.0)	107.3 (10.3)	79.6 (11.1)	99.9 (11.7)
T5	—	120.5 (12.5)	—	95.9 (6.6)	125.1 (7.6)
T6	—	79.2 (3.9)	—	74.3 (7.2)	105.7 (6.9)
T7	75.8 (7.4)	82.5 (9.2)	too few obs.	78.3 (6.7)	106.5 (6.0)

Note: Standard deviations are reported in parentheses.
In T2 and T7 we do not distinguish between firms as they are ex ante identical.
The choices in T1-T5 (T6-T7) are output levels (prices).

Product-market choice of privately informed firms (H2) First, we analyze the effect of incomplete information on the product-market choices of informed firms. Our quantitative analysis gives the following result.

Result 2 *In Cournot markets, there is evidence that subjects who are privately informed about high demand produce a significantly higher output than subjects with complete information about high demand. In Bertrand markets there is no significant difference between prices of subjects with private and complete information about low demand.*

The pairwise comparison between the third and fifth columns of Tables 7 and 8 for T1-T3 and T5 suggests that a firm with a high-demand signal chooses a higher output level under incomplete information than under complete information. This is consistent with Hypothesis 2(a), and it suggests that a firm with high-demand information

[44]We do not have enough observations to give a meaningful average for subjects who have learned that demand is low (high) and have incomplete information in T1-T5 (respectively, T6-T7).

Table 8: Average product-market choices of Firm 2 in Part II

	Incomplete Information			Complete Information	
	$\Theta_2 = \underline{\theta}$	$\Theta_2 = \varnothing$	$\Theta_2 = \overline{\theta}$	$\theta = \underline{\theta}$	$\theta = \overline{\theta}$
T1	too few obs.	93.8 (6.3)	111.1 (9.4)	83.5 (4.5)	101.2 (11.2)
T2	too few obs.	95.0 (11.4)	108.0 (6.1)	81.6 (2.6)	101.8 (4.1)
T3	too few obs.	98.9 (10.1)	119.0 (24.4)	82.3 (4.6)	107.1 (11.7)
T4	too few obs.	92.8 (6.0)	109.4 (7.7)	77.9 (4.5)	110.1 (9.0)
T5	too few obs.	104.6 (4.3)	129.6 (11.3)	91.6 (7.2)	122.4 (17.9)
T6	76.3 (5.8)	87.5 (6.8)	too few obs.	80.8 (3.0)	104.3 (5.1)
T7	75.8 (7.4)	82.5 (9.2)	too few obs.	78.3 (6.7)	106.5 (6.0)

Note: Standard deviations are reported in parentheses.
In T2 and T7 we do not distinguish between firms as they are ex ante identical.
The choices in T1-T5 (T6-T7) are output levels (prices).

may have indeed an incentive to conceal its information. We also test whether there is a statistically significant difference between the product-market choices under incomplete and complete information. The tests confirm that outputs differ significantly for both firms in T2 and T3.[45]

Hypothesis 2(b) predicts that a firm 1 with a low-demand signal in T4 chooses a lower output level under complete information than under incomplete information. This requires that firm 1 did not receive an informative message by its competitor and successfully learned the market demand by nature. This situation is unlikely to occur for three reasons. First, firm 2 learns the market demand with 90% probability, and it will disclose low signals in equilibrium. Second, firm 1 has only a 30% probability of learning the market demand by nature. Finally, firm 1 often disclosed a low demand in the experiment. As a result, we lack sufficient observations to test Hypothesis 2(b).

With Bertrand competition, Hypothesis 2(c) predicts that the price of a firm with low-demand information is higher with incomplete information than with complete information. The pairwise comparison between the first and fourth columns of Tables 7 and 8 for T6 and T7 suggests that the reverse holds. However, from a statistical

[45] All p-values for the one-sided Wilcoxon tests in T2 and T3 are smaller than or equal to 0.0398. By contrast, the differences between $x_2^*(\overline{\theta};\cdot)$ and $x_2^f(\overline{\theta})$ are not significant in T1 (p-value=0.1124), and T4 (p-value=0.3429). Table 9 in the Appendix gives all the p-values for these tests.

point of view, the prices do not differ significantly in either treatment (Result 2).

Product-market choices of uninformed firms (H3) Next, we characterize the output choices of uninformed firms. Hypothesis 3 predicts that the product market choice of an uninformed firm should lie between the choices under complete information for T1-T3, T4 for firm 1, and T5-T7. In particular, the hypothesis predicts that the entries in the second column are greater (smaller) than the corresponding entries in the fourth (fifth) column. The qualitative pairwise comparisons of our data are consistent with the predicted rankings in all instances. Our statistical tests on the variable differences are largely in line with these observations, as we state below.

Result 3 *There is evidence that the product-market choices of uninformed subject i are significantly higher (lower) than the choices of subject i with complete information about a low (high) demand under the conditions of Hypothesis 3.*

We test whether and how the average product-market choice of an uninformed firm differs from the average product-market choices of a firm with complete information. The first and third (second and last) columns of Table 10 in the Appendix give the p-values for these comparisons when demand is low (high). The statistical inference yields significant results in most cases.[46] Hence, our observations are in line with Hypothesis 3 in almost all cases (Result 3).

The effect of a firm's own signal precision (H4) For a uniform demand distribution, Hypothesis 4 predicts that a firm's product-market choice under incomplete information tends to be decreasing in the firm's likelihood of receiving information. This is the case for an uninformed firm. In addition, it happens if a Cournot competitor is privately informed about high demand and it receives this information with a high likelihood, or a Bertrand competitor has private low-demand information.

In T1-T3, we vary firm 1's likelihood of receiving information (a_1) for a Cournot competitor with a uniform demand distribution, as Table 1 illustrates. There is a *ceteris paribus* increase in firm 1's likelihood by moving from T1 ($a_1 = 0\%$) via T3 ($a_1 = 30\%$) to T2 ($a_1 = 90\%$). Hence, a comparison of the first three rows of Table

[46]Except for two tests, our results are significant with p-values smaller than or equal to 0.0398 for the one-sided Wilcoxon tests. The two exceptions emerge for the comparisons of output choices by uninformed subjects with output choices under complete information about high demand. There, our results are not significant in T2 (p-value=0.1124), and weakly significant for firm 1 in T3 (p-value=0.0690). Table 10 in the Appendix gives all p-values for the one-sided Wilcoxon tests.

7 is relevant for testing Hypothesis 4(a). Indeed, the qualitative comparison of the incomplete-information entries in rows T1, T3 and T2 of Table 7 suggests a decreasing pattern. Likewise, a_1 increases from 0 to 0.9 for a Bertrand competitor by switching from T6 to T7. Hence, the comparison of the last two rows of Table 7 is relevant for Hypothesis 4(b). In contrast to the prediction of Hypothesis 4(b), the comparison of price choices under incomplete information (i.e., the second entry) in T6 and T7 of Table 7 suggests that firm 1's price increases in a_1. In addition to these qualitative comparisons, we perform quantitative tests. We summarize our test results as follows.

Result 4 *In Cournot markets, there is weak evidence that the output of subject i is decreasing in the subject's likelihood of receiving information, a_i, if the subject remained uninformed or concealed high demand. In Bertrand markets, there is no significant difference between the prices of subjects with different likelihoods of receiving information.*

Our test results for these comparisons are as follows. First, the decrease of outputs chosen by an uninformed firm 1 is weakly significant if the firm's signal precision a_1 increases from 0% to 90%.[47] For smaller increases of a_1, the decrease in output is statistically insignificant (see the first column of Table 11 in the Appendix for details). Second, also the decrease in output of privately informed firm 1 with $\Theta_1 = \overline{\theta}$ is weakly significant.[48] Hence, although the statistical inference is weaker, the qualitative and quantitative comparisons are in line with the prediction from Hypothesis 4(a).

Hypothesis 4(b) predicts that firm 1's prices are decreasing in signal precision a_1, whereas the qualitative comparison of average price choices in T6 and T7 of Table 7 suggests the reverse. Although the MWW test indicate that these prices do not significantly differ from one another, our finding is not in line with Hypothesis 4(b).[49]

5 Conclusion

This paper analyzes a theoretical model and an experiment to examine voluntary disclosure of demand information and product-market strategies in duopoly.

The model extends some existing theoretical models dealing with simultaneous disclosure choices by duopolists by allowing firms to be asymmetric. We identify conditions for a Cournot duopoly under which firms choose the usual selective disclosure

[47] One-sided MWW test: p-value=0.0586.
[48] One-sided MWW test: p-value=0.0872.
[49] Two-sided MWW test: p-value=0.9168.

strategy, with disclosure of low demand and concealment of high demand. In addition, we give conditions under which one firm in an asymmetric Cournot duopoly chooses the reverse information-disclosure strategy in equilibrium. Further, we show that Bertrand competitors disclose high-demand information and conceal low demand.

Our experiment considers information-disclosure and product-market choices, and the interaction between these choices too. The experiment's treatments consider unilateral disclosure, and bilateral disclosure in symmetric settings as well as asymmetric settings. Thereby, we replicate a result of Ackert *et al.* (2000), and we extend it by considering bilateral disclosure in addition to unilateral disclosure, Bertrand competition besides Cournot competition, and product differentiation.

A key finding is that subjects in the laboratory experiment often selectively disclose their information. This finding is robust to changes in the information structure, mode of competition, and the degree of product differentiation. On the one hand, the subjects' disclosure behavior suggests that the subjects understand that disclosed information informs their competitor about the competitor's demand. Their behavior suggests that they often try to make their competitor pessimistic about the size of market demand, and thereby obtain a strategic advantage. On the other hand, the subjects in our experiment did not seem to grasp that their disclosed information also gives a signal to their competitor about their product-market conduct. In Treatment 4, this signaling effect is dominant for firm 1, and theory predicts that this firm discloses high demand intercepts, while concealing low intercepts. However, the subjects tend to do the opposite in the laboratory. In a different context, also Ackert *et al.* (2000) observe that subjects in the laboratory tend to ignore the signaling role of their information. They make this observation in a model with unilateral disclosure of independently distributed costs, whereas we make our observation in a model with bilateral disclosure of a common demand intercept.

Moreover, our theoretical analysis tends to provide good qualitative predictions for behavior in a duopolistic product market with demand uncertainty. The product-market choices for subjects in our experiment tend to adjust to the subject's information, and they weakly adjust to the precision of information.

Our findings are particularly interesting as the trade-off between the effects from information disclosure is quite subtle, subjects in our experiment were not equipped with calculators or other auxiliary means, and they took little time for their decisions.

Appendix

This Appendix contains the proofs of Propositions 1-4, the derivations of Hypotheses 2 and 4, the tables with test statistics of Hypotheses 2-4, and the instructions of the experiment.

A Proofs of Propositions

Proof of Proposition 1

The equilibrium output levels follow from solving the system of equations (8) and (7) for $\Theta_i \in \{\underline{\theta}, \overline{\theta}\}$ and $i, j = 1, 2$ with $i \neq j$. Take $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i, j = 1, 2$ with $i \neq j$. Using (8) for firm j and the identity $Q_i(\theta; s_i) = 1 - Q_i(\widehat{\theta}; s_i)$, enables us to rewrite condition (7) for $\Theta_i = \theta$ as follows:

$$2x_i^*(\theta; s_i, s_j) = \theta - c_i - \delta x_j^*(\theta; s_j, s_i) + \delta\left[1 - A_j(\theta; s_j)\right] Q_i(\widehat{\theta}; s_i)\Delta_j(\theta; s_j, s_i) \quad \text{(A.1)}$$

where $\Delta_j(\theta; s_j, s_i) \equiv x_j^*(\theta; s_j, s_i) - x_j^*(\widehat{\theta}; s_j, s_i)$. After substituting an analogous condition of firm j for $x_j^*(\theta)$, we obtain the following:

$$\begin{aligned} x_i^*(\theta; s_i, s_j) \;=\; & x_i^f(\theta) + \frac{\delta}{4-\delta^2}\Big(2\left[1 - A_j(\theta; s_j)\right] Q_i(\widehat{\theta}; s_i)\Delta_j(\theta; s_j, s_i) \\ & -\delta\left[1 - A_i(\theta; s_i)\right] Q_j(\widehat{\theta}; s_j)\Delta_i(\theta; s_i, s_j)\Big) \quad \text{(A.2)} \end{aligned}$$

From (A.1) we derive the following expression for firm i's equilibrium output difference:

$$2\Delta_i(\theta; s_i, s_j) = \left(\theta - \widehat{\theta}\right) - \delta\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\Delta_j(\theta; s_j, s_i)$$

Solving for firm i's equilibrium output difference, Δ_i, gives the following:

$$\Delta_i(\theta; s_i, s_j) = \quad \text{(A.3)}$$
$$\frac{\left(2 - \delta\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\right)\left(\theta - \widehat{\theta}\right)}{4 - \delta^2\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\left[A_i(\theta; s_i)Q_j(\widehat{\theta}; s_j) + A_i(\widehat{\theta}; s_i)Q_j(\theta; s_j)\right]}$$

Equations (8), (A.2) and (A.3) define the equilibrium outputs of firm i if both firms do not disclose information. Now define $\mathcal{D}$ as in (9). By (A.2), (A.3), and (9), it is straightforward to show the following:

$$\frac{4-\delta^2}{\delta\left(\widehat{\theta}-\theta\right)}\mathcal{D}(s_i,s_j)\left[x_i^f(\theta)-x_i^*(\theta;s_i,s_j)\right]=$$

$$\begin{aligned}&2\left[1-A_j(\theta;s_j)\right]Q_i(\widehat{\theta};s_i)\left[2-\delta A_i(\underline{\theta};s_i)Q_j(\overline{\theta};s_j)-\delta A_i(\overline{\theta};s_i)Q_j(\underline{\theta};s_j)\right]\\&-\delta\left[1-A_i(\theta;s_i)\right]Q_j(\widehat{\theta};s_j)\left[2-\delta A_j(\underline{\theta};s_j)Q_i(\overline{\theta};s_i)-\delta A_j(\overline{\theta};s_j)Q_i(\underline{\theta};s_i)\right]\end{aligned}$$

By definitions (4) and (6), the components of the first term simplify as follows:

$$\begin{aligned}\left[1-A_j(\theta;s_j)\right]Q_i(\widehat{\theta};s_i) &= \frac{1-a_j}{1-a_js_j(\theta)}\cdot\frac{q(\widehat{\theta})\left[1-a_is_i(\widehat{\theta})\right]}{E\{1-a_is_i(\theta)\}}\\&=\frac{q(\widehat{\theta})\cdot(1-a_j)E\{1-a_js_j(\theta)\}\left[1-a_is_i(\underline{\theta})\right]\left[1-a_is_i(\overline{\theta})\right]}{\left[1-a_is_i(\theta)\right]\left[1-a_js_j(\theta)\right]E\{1-a_is_i(\theta)\}E\{1-a_js_j(\theta)\}}\\&=\frac{q(\widehat{\theta})\cdot(1-a_j)E\{1-a_js_j(\theta)\}\left[1-a_is_i(\underline{\theta})\right]\left[1-a_is_i(\overline{\theta})\right]}{\prod_{h=1}^2\left[1-a_hs_h(\theta)\right]E\{1-a_hs_h(\theta)\}}\end{aligned}$$

and (by using $Q_j(\underline{\theta};s_j)+Q_j(\overline{\theta};s_j)=1$)

$$\begin{aligned}&A_i(\underline{\theta};s_i)Q_j(\overline{\theta};s_j)+A_i(\overline{\theta};s_i)Q_j(\underline{\theta};s_j)\\&\quad=1-\left[1-A_i(\underline{\theta};s_i)\right]Q_j(\overline{\theta};s_j)-\left[1-A_i(\overline{\theta};s_i)\right]Q_j(\underline{\theta};s_j)\\&\quad=1-\frac{1-a_i}{1-a_is_i(\underline{\theta})}\cdot\frac{q(\overline{\theta})\left[1-a_js_j(\overline{\theta})\right]}{E\{1-a_js_j(\theta)\}}-\frac{1-a_i}{1-a_is_i(\overline{\theta})}\cdot\frac{q(\underline{\theta})\left[1-a_js_j(\underline{\theta})\right]}{E\{1-a_js_j(\theta)\}}\\&\quad=1-\frac{1-a_i}{E\{1-a_js_j(\theta)\}}\left(\frac{q(\overline{\theta})\left[1-a_js_j(\overline{\theta})\right]}{1-a_is_i(\underline{\theta})}+\frac{q(\underline{\theta})\left[1-a_js_j(\underline{\theta})\right]}{1-a_is_i(\overline{\theta})}\right)\\&\quad=1-\frac{(1-a_i)E\left\{\left[1-a_is_i(\theta)\right]\left[1-a_js_j(\theta)\right]\right\}}{E\{1-a_js_j(\theta)\}\left[1-a_is_i(\underline{\theta})\right]\left[1-a_is_i(\overline{\theta})\right]}\end{aligned}$$

The second term simplifies in a similar way. Hence, the equilibrium output $x_i^*(\theta;s_i,s_j)$ reduces to (10) where (11) defines ψ_i. This completes the proof.

Proof of Proposition 2

First, consider equilibrium strategies such that $\psi_j(s_j,s_i)=0$. That is, suppose that firm j chooses $\left[s_j(\underline{\theta}),s_j(\overline{\theta})\right]$ in equilibrium, and the firm has beliefs consistent with the competitor's strategy $\left[s_i(\underline{\theta}),s_i(\overline{\theta})\right]$, such that firm j is indifferent between disclosure and concealment of its information. Using (11), the equation $\psi_j(s_j,s_i)=0$ gives:

$$1-a_js_j(\overline{\theta})=\frac{\delta a_i(1-a_j)q(\underline{\theta})\left[1-a_is_i(\underline{\theta})\right]\left[1-a_js_j(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right]}{N}\tag{A.4}$$

where

$$N \equiv 2(1-a_i)E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right]-\delta a_i(1-a_j)q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\left[1-s_i(\underline{\theta})\right] \tag{A.5}$$

Feasibility (i.e., $1-a_js_j(\overline{\theta})>0$) implies that $N>0$. Substitution of (A.4) in (11) gives:

$$\psi_i(s_i,s_j)=q(\underline{\theta})\left[1-a_is_i(\underline{\theta})\right]\left[1-a_js_j(\underline{\theta})\right](1-a_j)\frac{1}{N}\left[\delta(1-a_i)B+C\right]$$

where

$$B \equiv N+q(\overline{\theta})\delta a_i(1-a_j)\left[1-a_is_i(\overline{\theta})\right]\left[1-s_i(\overline{\theta})\right] \tag{A.6}$$

and

$$\begin{aligned} C \quad \equiv \quad & 2\left[1-a_is_i(\overline{\theta})\right]\left(N+q(\overline{\theta})\delta a_i(1-a_j)\left[1-a_is_i(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right]\right) \\ & -\delta^2(1-a_i)a_i\left[1-a_js_j(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right]E\left\{1-a_is_i(\theta)\right\} \end{aligned} \tag{A.7}$$

To show that $\delta(1-a_i)B+C>0$, we rewrite (A.6) as:

$$\begin{aligned} B \quad = \quad & 2(1-a_i)E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\ & +\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \end{aligned}$$

and we rewrite (A.7) as follows:

$$\begin{aligned} C \quad = \quad & 4\left[1-a_is_i(\overline{\theta})\right](1-a_i)E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\ & -\delta^2a_i\left[1-s_i(\overline{\theta})\right](1-a_i)E\left\{1-a_is_i(\theta)\right\}\left[1-a_js_j(\underline{\theta})\right] \\ & -2q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\delta a_i(1-a_j)\left[1-a_is_i(\overline{\theta})\right]\left[1-s_i(\underline{\theta})\right] \\ & +2q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\delta a_i(1-a_j)\left[1-a_is_i(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right] \\ = \quad & \left(4\left[1-a_is_i(\overline{\theta})\right]-\delta^2a_i\left[1-s_i(\overline{\theta})\right]\right)(1-a_i)E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\ & +2\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)(1-a_i)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \\ = \quad & (1-a_i)\cdot\left[\left(4-\delta^2\right)\left[1-a_is_i(\overline{\theta})\right]+\delta^2(1-a_i)\right]E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\ & +(1-a_i)\cdot 2\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \end{aligned}$$

Hence,

$$
\begin{aligned}
\delta(1-a_i)B + C &= (1-a_i)(2+\delta)\cdot\left[(2-\delta)\left[1-a_is_i(\overline{\theta})\right]+\delta(1-a_i)\right] \\
&\quad * E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\
&\quad +(1-a_i)(2+\delta)\cdot\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \\
&\geq (1-a_i)(2+\delta)\cdot 2(1-a_i)E\{1-a_is_i(\theta)\}\left[1-a_js_j(\underline{\theta})\right] \\
&\quad +(1-a_i)(2+\delta)\cdot\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \\
&> (1-a_i)(2+\delta)\cdot\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[1-s_i(\underline{\theta})\right] \\
&\quad +(1-a_i)(2+\delta)\cdot\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[s_i(\underline{\theta})-s_i(\overline{\theta})\right] \\
&= (1-a_i)(2+\delta)\cdot\delta q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]a_i(1-a_j)\left[1-s_i(\overline{\theta})\right]\geq 0
\end{aligned}
$$

where the first inequality follows from $1-a_is_i(\overline{\theta})\geq 1-a_i$, the second inequality follows from (A.5) and $N>0$, and the last inequality follows per definition. This implies that if $\psi_j(s_j,s_i)=0$, then $\psi_i(s_i,s_j)>0$.

Second, consider equilibrium strategies such that $\psi_j(s_j,s_i)<0$. That is, $\left[s_j(\underline{\theta}),s_j(\overline{\theta})\right]=(0,1)$ in equilibrium and beliefs are consistent with this strategy and some strategy $\left[s_i(\underline{\theta}),s_i(\overline{\theta})\right]$. By using (11), the inequality $\psi_j(0,1,s_i(\underline{\theta}),s_i(\overline{\theta}))<0$ gives $a_j<a_j^H$ with:

$$
a_j^H \equiv a_i\frac{q(\underline{\theta})\left[1-a_is_i(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right]+q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\left[1-s_i(\underline{\theta})\right]}{q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\left[1-a_is_i(\underline{\theta})\right]} \tag{A.8}
$$

Suppose that $\psi_i(s_i(\underline{\theta}),s_i(\overline{\theta}),0,1)\leq 0$. Using (11), this inequality gives $a_j\geq a_j^L$ with:

$$
a_j^L \equiv \frac{2\left[1-a_is_i(\underline{\theta})\right]}{q(\overline{\theta})\left[2\left(1-a_is_i(\underline{\theta})\right)+\delta(1-a_i)\right]} \tag{A.9}
$$

Under these conditions, the existence of an equilibrium requires that $a_j^L\leq a_j^H$. By using (A.8), (A.9) and $q(\underline{\theta})=1-q(\overline{\theta})$, this inequality is equivalent to $\mathcal{A}(q(\overline{\theta}))\geq 0$, where:

$$
\begin{aligned}
\mathcal{A}(q(\overline{\theta})) &\equiv \left(\left[1-q(\overline{\theta})\right]\left[1-a_is_i(\underline{\theta})\right]\left[1-s_i(\overline{\theta})\right]+q(\overline{\theta})\left[1-a_is_i(\overline{\theta})\right]\left[1-s_i(\underline{\theta})\right]\right) \\
&\quad * a_i\left[2\left(1-a_is_i(\underline{\theta})\right)+\delta(1-a_i)\right]-2\left[1-a_is_i(\underline{\theta})\right]^2\left[1-a_is_i(\overline{\theta})\right]
\end{aligned}
$$

Notice that $\mathcal{A}$ is linear in $q(\overline{\theta})$. Evaluating $\mathcal{A}$ for $q(\overline{\theta})\to 1$ gives the following:

$$
\begin{aligned}
\mathcal{A}(1) &= \left[1-a_is_i(\overline{\theta})\right]a_i\left[1-s_i(\underline{\theta})\right]\left[2\left(1-a_is_i(\underline{\theta})\right)+\delta(1-a_i)\right] \\
&\quad -2\left[1-a_is_i(\underline{\theta})\right]^2\left[1-a_is_i(\overline{\theta})\right] \\
&= \left[1-a_is_i(\overline{\theta})\right](1-a_i)\left(\delta a_i\left[1-s_i(\underline{\theta})\right]-2\left[1-a_is_i(\underline{\theta})\right]\right) \\
&= -\left[1-a_is_i(\overline{\theta})\right](1-a_i)\left(2(1-a_i)+(2-\delta)a_i\left[1-s_i(\underline{\theta})\right]\right) \\
&< 0
\end{aligned}
$$

Clearly, a_j^L in (A.9) is decreasing in $q(\overline{\theta})$, and the extreme value for $q(\overline{\theta})$ at which $a_j^L = 1$ equals $\underline{q} \equiv \frac{2[1-a_i s_i(\underline{\theta})]}{2[1-a_i s_i(\underline{\theta})]+\delta(1-a_i)}$. Taking $q(\overline{\theta}) \to \underline{q}$ gives the following:

$$\begin{aligned}
\mathcal{A}(\underline{q}) &= \delta(1-a_i)\left[1-a_i s_i(\underline{\theta})\right] a_i \left[1-s_i(\overline{\theta})\right] \\
&\quad +2\left[1-a_i s_i(\underline{\theta})\right]\left[1-a_i s_i(\overline{\theta})\right] a_i \left[1-s_i(\underline{\theta})\right] - 2\left[1-a_i s_i(\underline{\theta})\right]^2 \left[1-a_i s_i(\overline{\theta})\right] \\
&= -\left[1-a_i s_i(\underline{\theta})\right]\left(2\left[1-a_i s_i(\overline{\theta})\right](1-a_i) - \delta(1-a_i)a_i\left[1-s_i(\overline{\theta})\right]\right) \\
&= -\left[1-a_i s_i(\underline{\theta})\right](1-a_i)\left(2(1-a_i)+(2-\delta)\,a_i\left[1-s_i(\overline{\theta})\right]\right) \\
&< 0
\end{aligned}$$

Then, linearity of $\mathcal{A}$ in $q(\overline{\theta})$ implies that $\mathcal{A} < 0$ for all $\underline{q} \leq q(\overline{\theta}) < 1$. However, this implies that $a_j^L > a_j^H$, and therefore $\psi_i(s_i(\underline{\theta}), s_i(\overline{\theta}), 0, 1) \leq 0$ is not possible. In other words, if $\psi_j(0, 1, s_i(\underline{\theta}), s_i(\overline{\theta})) < 0$ in equilibrium, then $\psi_i(s_i(\underline{\theta}), s_i(\overline{\theta}), 0, 1) > 0$.

In conclusion, in any equilibrium there is always a firm i with $\psi_i(s_i, s_j) > 0$. Then it follows from Proposition 1 that $x_i^*(\underline{\theta}; s_i, s_j) < x_i^f(\underline{\theta})$ and $x_i^*(\overline{\theta}; s_i, s_j) > x_i^f(\overline{\theta})$, which implies that the optimal disclosure strategy for firm i is $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = (1, 0)$.

Proof of Proposition 3

Due to Proposition 2, we assume that firm j chooses disclosure strategy $\left[s_j^*(\underline{\theta}), s_j^*(\overline{\theta})\right] = (1, 0)$, and firms have beliefs consistent with $\left[s_j^*(\underline{\theta}), s_j^*(\overline{\theta})\right]$ without loss of generality. Hence, we adopt this assumption throughout the proof. Then, for some strategy $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right]$, the function ψ_i from (11) reduces as follows:

$$\begin{aligned}
\psi_i([s_i(\underline{\theta}), s_i(\overline{\theta})], [1,0]) &= \delta(1-a_i)(1-a_j)\left(q(\underline{\theta})\left[1-a_i s_i(\underline{\theta})\right](1-a_j) + q(\overline{\theta})\left[1-a_i s_i(\overline{\theta})\right]\right) \\
&\quad +2(1-a_j)\left[1-a_i s_i(\underline{\theta})\right]\left[1-a_i s_i(\overline{\theta})\right]\left[q(\underline{\theta})(1-a_j)+q(\overline{\theta})\right] \\
&\quad -\delta(1-a_i)(1-a_j)\left(q(\underline{\theta})\left[1-a_i s_i(\underline{\theta})\right] + q(\overline{\theta})\left[1-a_i s_i(\overline{\theta})\right]\right) \\
&= (1-a_j)\left[1-a_i s_i(\underline{\theta})\right] \\
&\quad \cdot\left(2\left[1-a_i s_i(\overline{\theta})\right]\left[1-q(\underline{\theta})a_j\right] - \delta(1-a_i)q(\underline{\theta})a_j\right). \qquad \text{(A.10)}
\end{aligned}$$

(a) Also assume that firms have beliefs consistent with $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = [1, 0]$. Then Proposition 1 implies that $x_i^*(\underline{\theta}; [1,0], [1,0]) \leq x_i^f(\underline{\theta})$ and $x_i^*(\overline{\theta}; [1,0], [1,0]) \geq x_i^f(\overline{\theta})$ if and only if $\psi_i([1,0], [1,0]) \geq 0$. It follows from (A.10) that $\psi_i(1,0,1,0) \geq 0$ if and only if $2\left[1-q(\underline{\theta})a_j\right] \geq \delta q(\underline{\theta})(1-a_i)\,a_j$, which can be rewritten as $2 \geq q(\underline{\theta})a_j\left[2+\delta(1-a_i)\right]$. This proves part (a).

(b) Now suppose that firms have beliefs consistent with $\left[s_i(\underline{\theta}), s_i(\overline{\theta})\right] = [0, 1]$. Then it follows from Proposition 1 that it is optimal for firm i to conceal $\Theta_i = \underline{\theta}$ and disclose

$\Theta_i = \overline{\theta}$ if and only if $\psi_i([0,1],[1,0]) \leq 0$. By (A.10), the inequality $\psi_i([0,1],[1,0]) \leq 0$ holds if and only if $(2+\delta)q(\underline{\theta})a_j \geq 2$. This proves part (b)

(c) Here we assume that firms have beliefs consistent with some $\left[s_i^*(\underline{\theta}), s_i^*(\overline{\theta})\right]$. Then firm i is indifferent between disclosure and concealment if and only if $\psi_i([s_i^*(\underline{\theta}), s_i^*(\overline{\theta})],[1,0]) = 0$. Hence, (A.10) implies that the equation $\psi_i([s_i^*(\underline{\theta}), s_i^*(\overline{\theta})],[1,0]) = 0$ is equivalent to $0 \leq s_i^*(\underline{\theta}) \leq 1$ and:

$$s_i^*(\overline{\theta}) = \frac{1}{a_i}\left(1 - \frac{\delta(1-a_i)q(\underline{\theta})a_j}{2\left[1-q(\underline{\theta})a_j\right]}\right)$$

Feasibility requires that $s_i^*(\overline{\theta}) \geq 0$, which the reduces to $q(\underline{\theta})a_j\left[2+\delta(1-a_i)\right] \leq 2$, and $s_i^*(\overline{\theta}) \leq 1$, which reduces to $q(\underline{\theta})a_j(2+\delta) \geq 2$. This proves part (c).

(d) Finally, firm i can neither strictly prefer to disclose all demand information, nor can the firm strictly prefer to conceal all information. This observation is due to the fact that (11) can only have a single sign. This completes the proof.

Proof of Proposition 4

The proof is analogous to the proofs with Cournot competition (Propositions 1 and 3).

First, after disclosure of θ, profit maximization by firm i gives the best reply function $p_i = \frac{1}{2}\left[(1-\delta)\theta + c_i + \delta p_j\right]$ for $i,j = 1,2$ with $i \neq j$. Solving the system of equations yields the equilibrium price (16).

Second, if no firm disclosed information, and the firms have beliefs consistent with the disclosure strategies (s_j, s_i), then firm i's first-order condition is:

$$2p_i^*(\Theta_i) = (1-\delta)E_j\{\theta|\Theta_i; s_j\} + c_i + \delta E_j\left\{ A_j(\theta; s_j)p_j^*(\theta) + \left[1 - A_j(\theta; s_j)\right]p_j^*(\varnothing)\middle|\, \Theta_i; s_j\right\} \tag{A.11}$$

for $i,j = 1,2$ with $i \neq j$, and $\Theta_i \in \{\underline{\theta}, \overline{\theta}, \varnothing\}$ where $E_j\{\theta|\theta; s_j\} = \theta$. This condition implies that $p_j^*(\varnothing; s_j, s_i) = E_i\left\{p_j^*(\theta; s_j, s_i)\middle|\, \varnothing; s_i\right\}$. Using this equation and the identity $Q_i(\theta; s_i) = 1 - Q_i(\widehat{\theta}; s_i)$, enables me to rewrite condition (A.11) for $\Theta_i = \theta$ as follows (for $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i,j = 1,2$ with $i \neq j$):

$$2p_i^*(\theta; s_i, s_j) = (1-\delta)\theta + c_i + \delta p_j^*(\theta; s_j, s_i) - \delta\left[1 - A_j(\theta; s_j)\right]Q_i(\widehat{\theta}; s_i)\Delta_j^b(\theta; s_j, s_i) \tag{A.12}$$

where $\Delta_j^b(\theta; s_j, s_i) \equiv p_j^*(\theta; s_j, s_i) - p_j^*(\widehat{\theta}; s_j, s_i)$. After substituting an analogous condition of firm j for $p_j^*(\theta)$, I obtain the following:

$$\begin{aligned} p_i^*(\theta; s_i, s_j) &= p_i^f(\theta) - \frac{\delta}{4-\delta^2}\Big(2\left[1 - A_j(\theta; s_j)\right] Q_i(\widehat{\theta}; s_i)\Delta_j^b(\theta; s_j, s_i) \\ &\qquad + \delta\left[1 - A_i(\theta; s_i)\right] Q_j(\widehat{\theta}; s_j)\Delta_i^b(\theta; s_i, s_j)\Big) \quad \text{(A.13)} \end{aligned}$$

From (A.12) I derive the following expression for firm i's price difference in equilibrium:

$$2\Delta_i^b(\theta; s_i, s_j) = (1-\delta)\left(\theta - \widehat{\theta}\right) + \delta\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\Delta_j^b(\theta; s_j, s_i)$$

for $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i, j = 1, 2$ with $i \neq j$. Solving for firm i's price difference, Δ_i^b, gives the following:

$$\Delta_i^b(\theta; s_i, s_j) = \frac{(1-\delta)\left(2 + \delta\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\right)\left(\theta - \widehat{\theta}\right)}{\mathcal{D}(s_i, s_j)} \quad \text{(A.14)}$$

with $\mathcal{D}(s_i, s_j)$ as defined in (9), and for $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i, j = 1, 2$ with $i \neq j$. Equations (A.13) and (A.14) define the equilibrium outputs of informed firm i if both firms do not disclose information.

By (A.13), (A.14), it is straightforward to show that the following holds for any $\theta, \widehat{\theta} \in \{\underline{\theta}, \overline{\theta}\}$ with $\theta \neq \widehat{\theta}$, and $i, j = 1, 2$ with $i \neq j$:

$$\begin{aligned} &\frac{\left(4-\delta^2\right)\mathcal{D}(s_i, s_j)}{\delta(1-\delta)\left(\theta - \widehat{\theta}\right)}\left[p_i^*(\theta; s_i, s_j) - p_i^f(\theta)\right] = \\ &\quad - 2\left[1 - A_j(\theta; s_j)\right] Q_i(\widehat{\theta}; s_i)\left(2 + \delta\left[A_i(\theta; s_i)Q_j(\widehat{\theta}; s_j) + A_i(\widehat{\theta}; s_i)Q_j(\theta; s_j)\right]\right) \\ &\quad - \delta\left[1 - A_i(\theta; s_i)\right] Q_j(\widehat{\theta}; s_j)\left(2 + \delta\left[A_j(\theta; s_j)Q_i(\widehat{\theta}; s_i) + A_j(\widehat{\theta}; s_j)Q_i(\theta; s_i)\right]\right) \end{aligned}$$

As in the proof of Proposition 1, the components of the first term can be simplified by observing the following:

$$\left[1 - A_j(\theta; s_j)\right] Q_i(\widehat{\theta}; s_i) = \frac{q(\widehat{\theta}) \cdot (1-a_j)E\{1 - a_j s_j(\theta)\}\left[1 - a_i s_i(\underline{\theta})\right]\left[1 - a_i s_i(\overline{\theta})\right]}{\prod_{h=1}^2\left[1 - a_h s_h(\theta)\right] E\{1 - a_h s_h(\theta)\}}$$

and

$$A_i(\theta; s_i)Q_j(\widehat{\theta}; s_j) + A_i(\widehat{\theta}; s_i)Q_j(\theta; s_j) = 1 - \frac{(1-a_i)E\left\{\left[1 - a_i s_i(\theta)\right]\left[1 - a_j s_j(\theta)\right]\right\}}{E\{1 - a_j s_j(\theta)\}\left[1 - a_i s_i(\underline{\theta})\right]\left[1 - a_i s_i(\overline{\theta})\right]}$$

The second term simplifies in a similar way. Hence, the equilibrium price of firm i reduces to (17), where:

$$\begin{aligned} \psi_i^b(s_i, s_j) \equiv\ & 2\left[1 - a_i s_i(\underline{\theta})\right]\left[1 - a_i s_i(\overline{\theta})\right](1-a_j)E\{1 - a_j s_j(\theta)\} \\ & + \delta(1-a_i)E\{1 - a_i s_i(\theta)\}\left[1 - a_j s_j(\underline{\theta})\right]\left[1 - a_j s_j(\overline{\theta})\right] \\ & - \delta(1-a_i)E\left\{\left[1 - a_i s_i(\theta)\right]\left[1 - a_j s_j(\theta)\right]\right\}(1-a_j). \quad \text{(A.15)} \end{aligned}$$

Clearly, the first term of (A.15) is positive. The sum of the second and third terms of (A.15) is non-negative, since:

$$\begin{aligned}
&E\{1-a_i s_i(\theta)\}\,[1-a_j s_j(\underline{\theta})]\,\left[1-a_j s_j(\overline{\theta})\right]-E\left\{[1-a_i s_i(\theta)]\,[1-a_j s_j(\theta)]\right\}(1-a_j)\\
&\qquad=q(\underline{\theta})\,[1-a_i s_i(\underline{\theta})]\,[1-a_j s_j(\underline{\theta})]\left(\left[1-a_j s_j(\overline{\theta})\right]-(1-a_j)\right)\\
&\qquad\quad+q(\overline{\theta})\left[1-a_i s_i(\overline{\theta})\right]\left[1-a_j s_j(\overline{\theta})\right]\left([1-a_j s_j(\underline{\theta})]-(1-a_j)\right)\\
&\qquad=q(\underline{\theta})\,[1-a_i s_i(\underline{\theta})]\,[1-a_j s_j(\underline{\theta})]\,a_j\left[1-s_j(\overline{\theta})\right]\\
&\qquad\quad+q(\overline{\theta})\left[1-a_i s_i(\overline{\theta})\right]\left[1-a_j s_j(\overline{\theta})\right]a_j\,[1-s_j(\underline{\theta})]\\
&\qquad\geq 0.
\end{aligned}$$

Hence, $\psi_i^b(s_i,s_j)>0$ for any (s_i,s_j).

Finally, it is easy to derive the equilibrium profits of firm i with $\Theta_i=\theta$ by using the first-order conditions. In particular, the equilibrium profit is $\pi_i^f(\theta)\equiv\frac{1}{1-\delta^2}\left(p_i^f(\theta)-c_i\right)^2$ after disclosure, and it is $\pi_i^*(\theta;s_i,s_j)\equiv\frac{1}{1-\delta^2}\left(p_i^*(\theta;s_i,s_j)-c_i\right)^2$ after no disclosure. Hence, firm i's profit from disclosure is $\pi_i^f(\theta)$, while the firm's expected profit from concealment of θ is $a_j s_j(\theta)\pi_i^f(\theta)+[1-a_j s_j(\theta)]\,\pi_i^*(\theta;s_i,s_j)$. Consequently, the firm prefers disclosure if and only if $p_i^f(\theta)>p_i^*(\theta;s_i,s_j)$. From (17) it follows that $p_i^*(\underline{\theta};s_i,s_j)>p_i^f(\underline{\theta})$ and $p_i^*(\overline{\theta};s_i,s_j)<p_i^f(\overline{\theta})$ for any (s_i,s_j), which implies that $\left[s_i(\underline{\theta}),s_i(\overline{\theta})\right]=(0,1)$ is the dominant disclosure strategy for firm i (for $i=1,2$). This completes the proof.

B Derivations for Hypotheses

Hypotheses 1 and 2 follow immediately from the propositions. Below we provide the analytical derivations that underpin Hypotheses **??** and 4, respectively.

B.1 Derivations for Hypothesis 3

(a) First, we show that if $q(\underline{\theta}) = \frac{1}{2}$, then $x_i^*(\varnothing;[1,0],[1,0]) < x_i^f(\overline{\theta})$. If $q(\underline{\theta}) = \frac{1}{2}$, then we can rewrite the uninformed firm's equilibrium output as follows:

$$
\begin{aligned}
x_i^*(\varnothing;[1,0],[1,0]) &= E_j\left\{x_i^*(\theta;[1,0],[1,0])\right|\varnothing;[1,0]\} \\
&= q_j(\underline{\theta};1,0)x_i^f(\underline{\theta}) + q_j(\overline{\theta};1,0)x_i^f(\overline{\theta}) \\
&\quad - \left(\frac{q_j(\underline{\theta};1,0)}{(1-a_i)(1-a_j)} - q_j(\overline{\theta};1,0)\right)\frac{\frac{\delta}{4-\delta^2}\frac{1}{2}\left(\overline{\theta}-\underline{\theta}\right)\psi_i([1,0],[1,0])}{\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right)} \\
&= E_j\left\{x_i^f(\theta)\middle|\varnothing;[1,0]\right\} - \frac{\frac{a_i}{1-a_i}\frac{\delta}{4-\delta^2}\frac{1}{4}\left(\overline{\theta}-\underline{\theta}\right)\psi_i([1,0],[1,0])}{\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right)^2} \\
&< E_j\left\{x_i^f(\theta)\middle|\varnothing;[1,0]\right\} < x_i^f(\overline{\theta}).
\end{aligned}
$$

Second, we show that if $q(\underline{\theta}) = \frac{1}{2}$, then $x_i^f(\underline{\theta}) < x_i^*(\varnothing;[1,0],[1,0])$. As we show above, we can rewrite $x_i^*(\varnothing;[1,0],[1,0])$ as follows if $q(\underline{\theta}) = \frac{1}{2}$:

$$
\begin{aligned}
x_i^*(\varnothing;[1,0],[1,0]) &= E_j\left\{x_i^f(\theta)\middle|\varnothing;[1,0]\right\} - \frac{\frac{a_i}{1-a_i}\frac{\delta}{4-\delta^2}\frac{1}{4}\left(\overline{\theta}-\underline{\theta}\right)\psi_i([1,0],[1,0])}{\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right)^2} \\
&= x_i^f(\underline{\theta}) + q_j(\overline{\theta};1,0)\left[x_i^f(\overline{\theta}) - x_i^f(\underline{\theta})\right] \\
&\quad - \frac{\frac{a_i}{1-a_i}\frac{\delta}{(2-\delta)(2+\delta)}\frac{1}{4}\left(\overline{\theta}-\underline{\theta}\right)\psi_i([1,0],[1,0])}{\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right)^2} \\
&= x_i^f(\underline{\theta}) + \frac{\frac{1}{2}\left(\overline{\theta}-\underline{\theta}\right)}{\left(1-\frac{1}{2}a_j\right)(2+\delta)}\left(1 - \frac{\frac{a_i}{1-a_i}\frac{\delta}{2-\delta}\frac{1}{2}\psi_i([1,0],[1,0])}{\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right)}\right)
\end{aligned}
$$

which exceeds $x_i^f(\underline{\theta})$, since

$$
\frac{a_i}{1-a_i}\delta\frac{1}{2}\psi_i([1,0],[1,0]) - (2-\delta)\mathcal{D}([1,0],[1,0])\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right) < 0.
$$

The latter follows from a basic analysis of the inequality's left-hand-side. We can rewrite it as follows:

$$
\begin{aligned}
LHS &= \frac{1}{2}\delta a_i(1-a_j)\left[2\left(1-\frac{1}{2}a_j\right) + \frac{1}{2}\delta\left[1+(1-a_i)(1-a_j)\right] - \delta\left(1-\frac{1}{2}a_i\right)\right] \\
&\quad -(2-\delta)\left[4\left(1-\frac{1}{2}a_i\right)\left(1-\frac{1}{2}a_j\right) - \frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)\right]
\end{aligned}
$$

This expression is convex in a_i, and it is negative, since it is negative for the extreme values of a_i. In particular, if we evaluate the expression for $a_i = 0$, then it reduces to

$-(2-\delta)4\left(1-\frac{1}{2}a_j\right) < 0$. Moreover, if we evaluate the expression for $a_i = 1$, then we obtain: $2\left(1-\frac{1}{2}a_j\right)\left[\frac{1}{2}\delta(1-a_j)-(2-\delta)\right] \leq -\left(1-\frac{1}{2}a_j\right)(1+a_j) < 0$.

(b) Second, we show that $x_i^f(\underline{\theta}) < x_i^*(\varnothing; [0,1],[1,0]) < x_i^f(\overline{\theta})$ holds for firm i if the conditions of Corollary 1(b) are satisfied. Under these conditions, $\psi_i^b([0,1],[1,0]) < 0$, which implies that $x_i^f(\underline{\theta}) < x_i^*(\underline{\theta}; [0,1],[1,0])$ and $x_i^*(\overline{\theta}; [0,1],[1,0]) < x_i^f(\overline{\theta})$. Furthermore, equation (A.3) in the proof of Proposition 1 gives $\Delta_i(\overline{\theta}; [0,1],[1,0]) > 0$, which implies that $x_i^*(\underline{\theta}; [0,1],[1,0]) < x_i^*(\overline{\theta}; [0,1],[1,0])$. Hence, the following inequality emerges:

$$x_i^f(\underline{\theta}) < x_i^*(\underline{\theta}; [0,1],[1,0]) < x_i^*(\overline{\theta}; [0,1],[1,0]) < x_i^f(\overline{\theta}).$$

Due to (8), the output $x_i^*(\varnothing; [0,1],[1,0])$ is a convex combination of $x_i^*(\underline{\theta}; [0,1],[1,0])$ and $x_i^*(\overline{\theta}; [0,1],[1,0])$, which immediately gives (19).

(c) Finally, we show that $p_i^f(\underline{\theta}) < p_i^*(\varnothing; [0,1],[0,1]) < p_i^f(\overline{\theta})$ under Bertrand competition. Expression (17) implies the following inequality:

$$p_i^f(\underline{\theta}) < p_i^*(\underline{\theta}; [0,1],[0,1]) < p_i^*(\overline{\theta}; [0,1],[0,1]) < p_i^f(\overline{\theta}),$$

where the second inequality follows from the observation that $\Delta_i^b(\overline{\theta}; s_i, s_j)$ in (A.14) is positive. The price of an uninformed firm, $p_i^*(\varnothing; [0,1],[0,1])$, equals the conditionally expected value of the informed firm's prices, and thereby it is a convex combination of $p_i^*(\underline{\theta}; [0,1],[0,1])$ and $p_i^*(\overline{\theta}; [0,1],[0,1])$. This immediately gives (20).

B.2 Derivations for Hypothesis 4

(a) If demand is uniformly distributed ($q(\underline{\theta}) = \frac{1}{2}$), then firms disclose only information about low demand in the unique equilibrium, i.e., $[s_i(\underline{\theta}), s_i(\overline{\theta})] = [1,0]$ for $i = 1,2$. Hence, a firm's equilibrium outputs (10) simplify as follows (for $i, j = 1,2$ and $i \neq j$):

$$x_i^*(\underline{\theta}; [1,0],[1,0]) = x_i^f(\underline{\theta}) - \frac{\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\left[2-a_j-\frac{1}{2}\delta a_j(1-a_i)\right]}{(2-a_i)(2-a_j)-\frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)} \quad \text{(B.16)}$$

$$x_i^*(\overline{\theta}; [1,0],[1,0]) = x_i^f(\overline{\theta}) + \frac{\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}(1-a_i)(1-a_j)\left[2-a_j-\frac{1}{2}\delta a_j(1-a_i)\right]}{(2-a_i)(2-a_j)-\frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)} \quad \text{(B.17)}$$

Partial differentiation of (B.16) with respect to a_i gives the following:

$$\frac{\partial x_i^*(\underline{\theta}; [1,0],[1,0])}{\partial a_i} = \frac{-\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\mathcal{K}_1}{\left[(2-a_i)(2-a_j)-\frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)\right]^2}$$

where

$$\begin{aligned}\mathcal{K}_1 &\equiv \frac{1}{2}\delta^2 a_j \left[(2-a_i)(2-a_j) - \frac{1}{4}\delta^2 a_i a_j (1-a_i)(1-a_j)\right] \\ &\quad + \left[2 - a_j - \frac{1}{2}\delta a_j (1-a_i)\right]\left[2 - a_j + \frac{1}{4}\delta^2 a_j (1-2a_i)(1-a_j)\right] \\ &> 0.\end{aligned}$$

Hence, $\partial x_i^*(\underline{\theta}; [1,0],[1,0])/\partial a_i < 0$.

Similarly, partial differentiation of (B.17) with respect to a_i gives the following:

$$\frac{\partial x_i^*(\overline{\theta}; [1,0],[1,0])}{\partial a_i} = \frac{-\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}(1-a_j)\cdot \mathcal{K}_2}{\left[(2-a_i)(2-a_j) - \frac{1}{4}\delta^2 a_i a_j (1-a_i)(1-a_j)\right]^2}$$

where

$$\begin{aligned}\mathcal{K}_2 &\equiv [2 - a_j - \delta a_j (1-a_i)]\left[(2-a_i)(2-a_j) - \frac{1}{4}\delta^2 a_i a_j (1-a_i)(1-a_j)\right] \\ &\quad -(1-a_i)\left[2 - a_j - \frac{1}{2}\delta a_j (1-a_i)\right]\left[2 - a_j + \frac{1}{4}\delta^2 a_j (1-2a_i)(1-a_j)\right] \\ &= [2 - a_j - \delta a_j (1-a_i)](2-a_j) \\ &\quad -(1-a_i)^2 \frac{1}{2}\delta a_j \left(2 - a_j + \left[2 - a_j - \frac{1}{2}\delta a_j\right]\frac{1}{2}\delta(1-a_j)\right).\end{aligned}$$

It is straightforward to show that $\mathcal{K}_2$ is decreasing in a_j. This implies the following:

$$\mathcal{K}_2 \geq 1 - \delta(1-a_i) - \frac{1}{2}\delta(1-a_i)^2 \geq a_i - \frac{1}{2}(1-a_i)^2.$$

The right-hand-side of this inequality is positive if $a_i \geq 0.3$. Hence, $\partial x_i^*(\overline{\theta}; [1,0],[1,0])/\partial a_i < 0$ for all $a_i \geq 0.3$.

Finally, if $q(\underline{\theta}) = \frac{1}{2}$, then equations (8), (B.16) and (B.17) give:

$$\begin{aligned}x_i^*(\varnothing; [1,0],[1,0]) &= E_j\left\{x_i^*(\theta; [1,0],[1,0]) \middle| \varnothing; [1,0]\right\} \\ &= \frac{1-a_j}{2-a_j}x_i^*(\underline{\theta}; [1,0],[1,0]) + \frac{1}{2-a_j}x_i^*(\overline{\theta}; [1,0],[1,0]) \\ &= \frac{1-a_j}{2-a_j}x_i^f(\underline{\theta}) + \frac{1}{2-a_j}x_i^f(\overline{\theta}) \\ &\quad - \frac{\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\left[2 - a_j - \frac{1}{2}\delta a_j(1-a_i)\right]\left(\frac{1-a_j}{2-a_j} - \frac{(1-a_i)(1-a_j)}{2-a_j}\right)}{(2-a_i)(2-a_j) - \frac{1}{4}\delta^2 a_i a_j (1-a_i)(1-a_j)} \\ &= E_j\left\{x_i^f(\theta) \middle| \varnothing; [1,0]\right\} - \frac{\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\left[2 - a_j - \frac{1}{2}\delta a_j(1-a_i)\right]\cdot\frac{1-a_j}{2-a_j}a_i}{(2-a_i)(2-a_j) - \frac{1}{4}\delta^2 a_i a_j (1-a_i)(1-a_j)}\end{aligned}$$

Partial differentiation of this expression with respect to a_i gives the following:

$$\begin{aligned}\frac{\partial x_i^*(\varnothing;[1,0],[1,0])}{\partial a_i} &= \frac{-\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\mathcal{K}_1\cdot\frac{1-a_j}{2-a_j}a_i}{\left[(2-a_i)(2-a_j)-\frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)\right]^2} \\ &\quad -\frac{\frac{\delta(\overline{\theta}-\underline{\theta})}{2(4-\delta^2)}\left[2-a_j-\frac{1}{2}\delta a_j(1-a_i)\right]\cdot\frac{1-a_j}{2-a_j}}{(2-a_i)(2-a_j)-\frac{1}{4}\delta^2 a_i a_j(1-a_i)(1-a_j)},\end{aligned}$$

which is non-positive, since both terms are non-positive.

(b) Under Bertrand competition, the firms choose the disclosure strategies $[s_i(\underline{\theta}), s_i(\overline{\theta})] = [0,1]$ for $i = 1,2$ in the unique equilibrium. This simplifies the equilibrium prices as follows:

$$\begin{aligned}p_i^*(\underline{\theta};[0,1],[0,1]) &= p_i^f(\underline{\theta})+\delta\frac{1-\delta}{2-\delta}q(\overline{\theta})(\overline{\theta}-\underline{\theta}) \\ &\quad *\frac{(1-a_i)(1-a_j)\left[2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)\right]}{4\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_i)(1-a_j)} \qquad \text{(B.18)}\\ p_i^*(\overline{\theta};[0,1],[0,1]) &= p_i^f(\overline{\theta})-\delta\frac{1-\delta}{2-\delta}q(\underline{\theta})(\overline{\theta}-\underline{\theta}) \\ &\quad *\frac{2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)}{4\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_i)(1-a_j)} \qquad \text{(B.19)}\end{aligned}$$

Partial differentiation of (B.18) with respect to probability a_i gives the following:

$$\frac{\partial p_i^*(\underline{\theta};[0,1],[0,1])}{\partial a_i} = \frac{-\delta\frac{1-\delta}{2-\delta}q(\overline{\theta})(\overline{\theta}-\underline{\theta})(1-a_j)\cdot\mathcal{K}_3}{\left(4\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_i)(1-a_j)\right)^2}$$

where

$$\begin{aligned}\mathcal{K}_3 &\equiv \left(\left[2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)\right]+\delta q(\overline{\theta})a_j(1-a_i)\right) \\ &\quad *\left(4\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_i)(1-a_j)\right) \\ &\quad -(1-a_i)\left[2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)\right] \\ &\quad *\left(4q(\overline{\theta})a_i\left[1-q(\overline{\theta})a_j\right]+\delta^2 q(\overline{\theta})^2 a_j(1-a_i)(1-a_j)-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_j)\right) \\ &= \left[2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)\right] \\ &\quad *\left(4\left[1-q(\overline{\theta})\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_j(1-a_i)^2(1-a_j)\right) \\ &\quad +\delta q(\overline{\theta})a_j(1-a_i)\left(4\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_i a_j(1-a_i)(1-a_j)\right) \\ &= \left[2\left(1-q(\overline{\theta})a_j\right)+\delta q(\overline{\theta})a_j(1-a_i)\right]4\left[1-q(\overline{\theta})\right]\left[1-q(\overline{\theta})a_j\right] \\ &\quad +\delta q(\overline{\theta})a_j(1-a_i)\left(2\left[1-q(\overline{\theta})a_i\right]\left[1-q(\overline{\theta})a_j\right]-\delta^2 q(\overline{\theta})^2 a_j(1-a_i)(1-a_j)\right) \\ &\quad +2\delta q(\overline{\theta})a_j(1-a_i)\left[1-q(\overline{\theta})a_j\right]\left(1-q(\overline{\theta})\left[a_i+(1-a_i)\delta(1-a_j)\right]\right) > 0.\end{aligned}$$

This implies that $\partial p_i^*(\underline{\theta}; [0,1], [0,1])/\partial a_i < 0$.

Using (6), (B.18) and (B.19), we can rewrite the equilibrium price of an uninformed firm as follows:

$$\begin{aligned}
p_i^*(\varnothing; [0,1], [0,1]) &= Q_j(\underline{\theta}; [0,1]) p_i^*(\underline{\theta}; [0,1], [0,1]) + Q_j(\overline{\theta}; [0,1]) p_i^*(\overline{\theta}; [0,1], [0,1]) \\
&= Q_j(\underline{\theta}; [0,1]) p_i^f(\underline{\theta}) + Q_j(\overline{\theta}; [0,1]) p_i^f(\overline{\theta}) \\
&\quad -\delta \frac{1-\delta}{2-\delta} q(\underline{\theta}) q(\overline{\theta}) \frac{1-a_j}{1-p(\overline{\theta})a_j} (\overline{\theta} - \underline{\theta}) \\
&\quad * \frac{a_i \left[2\left(1 - q(\overline{\theta})a_j\right) + \delta q(\overline{\theta}) a_j (1-a_i)\right]}{4\left[1 - q(\overline{\theta})a_i\right]\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i a_j (1-a_i)(1-a_j)}
\end{aligned}$$

Partial differentiation of this expression with respect to probability a_i gives:

$$\frac{\partial p_i^*(\varnothing; [0,1], [0,1])}{\partial a_i} = \frac{-\delta \frac{1-\delta}{2-\delta} q(\underline{\theta}) q(\overline{\theta}) (\overline{\theta} - \underline{\theta}) \frac{1-a_j}{1-p(\overline{\theta})a_j} \cdot \mathcal{K}_4}{\left(4\left[1 - q(\overline{\theta})a_i\right]\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i a_j (1-a_i)(1-a_j)\right)^2}$$

where

$$\begin{aligned}
\mathcal{K}_4 &\equiv \left[2\left(1 - q(\overline{\theta})a_j\right) + \delta q(\overline{\theta}) a_j (1-a_i) - \delta q(\overline{\theta}) a_i a_j\right] \\
&\quad * \left(4\left[1 - q(\overline{\theta})a_i\right]\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i a_j (1-a_i)(1-a_j)\right) \\
&\quad + a_i \left[2\left(1 - q(\overline{\theta})a_j\right) + \delta q(\overline{\theta}) a_j (1-a_i)\right] \\
&\quad * \left(4q(\overline{\theta})\left[1 - q(\overline{\theta})a_j\right] + \delta^2 q(\overline{\theta})^2 a_j (1-a_i)(1-a_j) - \delta^2 q(\overline{\theta})^2 a_i a_j (1-a_j)\right) \\
&= \left[2\left(1 - q(\overline{\theta})a_j\right) + \delta q(\overline{\theta}) a_j (1-a_i)\right]\left(4\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i^2 a_j (1-a_j)\right) \\
&\quad - \delta q(\overline{\theta}) a_i a_j \left(4\left[1 - q(\overline{\theta})a_i\right]\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i a_j (1-a_i)(1-a_j)\right) \\
&= 2\left[1 - q(\overline{\theta})a_j\right]\left(4\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_i^2 a_j (1-a_j)\right) \\
&\quad + \delta q(\overline{\theta}) 4 a_j \left[1 - q(\overline{\theta})a_j\right]\left(1 - a_i\left[2 - q(\overline{\theta})a_i\right]\right) \\
&\geq 2\left[1 - q(\overline{\theta})a_j\right]\left(4\left[1 - q(\overline{\theta})a_j\right] - \delta^2 q(\overline{\theta})^2 a_j (1-a_j)\right) \\
&\quad - \delta q(\overline{\theta}) 4 a_j \left[1 - q(\overline{\theta})\right]\left[1 - q(\overline{\theta})a_j\right] \\
&\geq 2\left[1 - q(\overline{\theta})a_j\right]\left(4\left[1 - q(\overline{\theta})a_j\right] - 2q(\overline{\theta}) a_j \left[1 - q(\overline{\theta})\right] - q(\overline{\theta})^2 a_j (1-a_j)\right) \\
&\geq 2\left[1 - q(\overline{\theta})a_j\right]^2 \left(4 - q(\overline{\theta})\left[2 + a_j\right]\right) > 0.
\end{aligned}$$

Hence, $\partial p_i^*(\varnothing; [0,1], [0,1])/\partial a_i < 0$.

C Tables of Test Results

Table 9: p-values for comparing outputs with high-demand information in Part II

	Firm 1	Firm 2
	$x_1^*(\overline{\theta};\cdot) > x_1^f(\overline{\theta})$	$x_2^*(\overline{\theta};\cdot) > x_2^f(\overline{\theta})$
T1	—	0.1124
T2	0.0215	0.0215
T3	0.0215	0.0398
T4	0.0473	0.3429
T5	—	0.2501

Note: In T2 we do not distinguish between firms as they are ex ante identical. All p-values refer to one-sided Wilcoxon tests.

Table 10: p-values for comparing product market choices with complete information and no information in Part II

	Firm 1		Firm 2	
	$x_1^f(\underline{\theta}) < x_1^*(\varnothing;\cdot)$	$x_1^*(\varnothing;\cdot) < x_1^f(\overline{\theta})$	$x_2^f(\underline{\theta}) < x_2^*(\varnothing;\cdot)$	$x_2^*(\varnothing;\cdot) < x_2^f(\overline{\theta})$
T1	0.0215	0.0398	0.0215	0.0398
T2	0.0398	0.1124	0.0398	0.1124
T3	0.0215	0.0690	0.0215	0.0215
T4	0.0215	0.0215	0.0215	0.0215
T5	0.0215	0.0215	0.0215	0.0398
	$p_1^f(\underline{\theta}) < p_1^*(\varnothing;\cdot)$	$p_1^*(\varnothing;\cdot) < p_1^f(\overline{\theta})$	$p_2^f(\underline{\theta}) < p_2^*(\varnothing;\cdot)$	$p_2^*(\varnothing;\cdot) < p_2^f(\overline{\theta})$
T6	0.0398	0.0215	0.0398	0.0215
T7	0.0215	0.0215	0.0215	0.0215

Note: In T2 and T7 we do not distinguish between firms as they are ex ante identical. All p-values refer to one-sided Wilcoxon tests.

Table 11: p-values for comparing firm 1's outputs across T1-T3 in Part II

	Incomplete Information	
	$\Theta_1 = \varnothing$	$\Theta_1 = \overline{\theta}$
$x_1(\cdot;\text{T1}) > x_1(\cdot;\text{T3})$	0.1736	—
$x_1(\cdot;\text{T3}) > x_1(\cdot;\text{T2})$	0.3007	0.0872
$x_1(\cdot;\text{T1}) > x_1(\cdot;\text{T2})$	0.0586	—

Note: The p-values correspond to one-sided MWW tests.

D Instructions

These instructions are a translated version of the German instructions used in the treatments with Cournot competition and homogeneous goods (T1-T4). Naturally, neither the treatment names, nor the parameter values of the other treatments were part of the original instructions. The instructions for the remaining treatments (i.e., T5 with differentiated goods, and T6-T7 with Bertrand competition) are slight modifications of these instructions, and they are relegated to the Supplementary Appendix.[50]

D.1 Instructions General Information

Welcome to the experiment!

In this experiment, you can earn money. How much you will earn depends on your decisions as well as on the decisions taken by other participants. Regardless of your decisions during the experiment, you will receive an additional 2.50 Euro for your presence.

The experiment consists of three parts. Before each part, you receive precise instructions. All decisions taken during the course of this experiment are payout relevant. During the experiment, the currency ECU (Experimental Currency Units) is used. At the end of the experiment, all amounts in ECU are converted into Euro and paid to you in cash. The exchange rate is 1 Euro for {T1-T3: 28,000; T4: 23,000} ECU. Amounts are rounded up to full 10 Cent in your favor.

All decisions which you make during the experiment are anonymous. Your payout at the end of the experiment is confidential.

[50]The complete instructions of all treatments are available in German upon request (pollak@wiso.uni-koeln.de).

Please do not communicate any more with the other participants from now on. In case you have any questions, now or during the experiment, please raise your hand. Then we will come to you and answer your question. Please ensure additionally that your mobile phone is switched off. Material (books, lecture notes, etc.), which does not concern the experiment, may not be used during the experiment. Non-compliance with these rules can lead to exclusion from the experiment and all payouts.

The following instructions refer to the first part. After the end of the first part, you receive further instructions.

D.2 Instructions Part I

Part I of the experiment consists of 20 rounds which proceed in identical manner:

In this part of the experiment, you interact as producer with another participant, your competitor. Your competitor is randomly matched to you. Each round this random matching is done anew. We ensure that you never have the same competitor in two consecutive rounds.

You and your competitor produce identical goods for a common market. Each produced good is sold at market price.

The market price is computed from the market demand minus the quantity produced by you and your competitor:

⇒*Market Price = Market Demand – Your Quantity – Competitor's Quantity*

However, the market price cannot be smaller than zero. If the produced quantity exceeds the market demand, then the market price equals zero.

Each round the market demand is determined by chance. The market demand is low with a probability of {T1-T3: 50%; T4: 90%} and amounts to 240. With a probability of {T1-T3: 50%; T4: 10%} it is high and amounts to 300. The positive market price is thus given by:

⇒ if market demand is high:
Market Price = 300 – Your Quantity – Competitor's Quantity

⇒ if market demand is low:

Market Price = 240 – Your Quantity – Competitor's Quantity

At the beginning of each round, you learn after a few seconds whether the market demand is high or low. The competitor also learns whether the market demand is high or low. Afterwards, you choose your quantity (if applicable, including decimal places). The competitor chooses his quantity simultaneously. While making these choices, neither you nor your competitor can see what quantity the other chooses.

The market price is determined after you and your competitor have chosen the production quantities. Your profit is determined by your quantity, which is sold at market price. Neither you nor your competitor have to bear production costs.

$\Rightarrow$ *Profit = Market Price* $\times$ *Your Quantity*

At the end of each round, you will be informed about your profit for that round, the market price, and the chosen quantities.

At the end of the experiment, the profits over all rounds will be converted into EURO and paid out to you.

D.3 Quiz Part I

Please mark the correct answers

1. **The market demand is high and equals 300. You produce 140 goods and your competitor produces 120 goods:**
   (a) How high is the market price?
      i. 0
      ii. 20
      iii. 40
      iv. 160
      v. 180
      vi. None of the above
   (b) How high is your profit?
      i. 2,800
      ii. 5,600

   iii. 22,400
   iv. 25,200
   v. None of the above

2. **The market demand is low and equals 240. You produce 140 goods and your competitor produces 120 goods:**

   (a) How high is the market price?

      i. -20
      ii. 0
      iii. 60
      iv. 100
      v. 120
      vi. None of the above

   (b) How high is your profit?

      i. -2,800
      ii. 0
      iii. 8,400
      iv. 14,000
      v. 16,800
      vi. None of the above

3. **Who is your competitor?**

   (a) A random participant of this experiment is assigned to me over all rounds.

   (b) In each round, a random participant is assigned to me. It is possible that the same participant is assigned to me in consecutive rounds.

   (c) In each round, a random participant is assigned to me. It is excluded that the same participant is assigned to me in consecutive rounds.

   (d) None of the above

4. **Which round(s) are paid out at the end of the experiment?**

(a) All rounds

(b) A randomly picked round

(c) Only the last round

(d) None of the above

5. **Do you and/or your competitor know the market demand at the moment of quantity decisions?**

   (a) Nobody knows the market demand, because it is random.

   (b) Only I know the market demand.

   (c) Only my competitor knows the market demand.

   (d) My competitor and I know the market demand.

   (e) None of the above

D.4 Instructions Part II

This part of the experiment is an extension of the first part. From now on, you do not always know the market demand. If you do know the market demand, you can choose to announce it to the competitor. The same applies for your competitor. The matching of competitors is done as in Part I.

Part II of the experiment consists of 50 rounds with identical proceeding:

As in the first part, the market demand is high with a probability of {T1-T3: 50%; T4: 10%}, and low with a probability of {T1-T3: 50%; T4: 90%}. How high it is in the current round is not automatically apparent to you. **However, you and your competitor run a market analysis each round.** Whether it is successful is randomly determined in each round anew:

Independent of the current market demand, and the market analysis of the competitor, Your market analysis is successful or unsuccessful with a certain probability. In addition, you know the probability of success for the market analysis of your competitor, but you do not know his result. The same holds for your competitor.

The probabilities of success, depending on your role, are:

	Own market analysis		Competitor's market analysis	
	Successful	Not successful	Successful	Not successful
Role A	{T1:0%} {T2:90%} {T3-T4:30%}	{T1:100%} {T2:10%} {T3-T4:70%}	90%	10%
Role B	90%	10%	{T1:0%} {T2:90%} {T3-T4:30%}	{T1:100%} {T2:10%} {T3-T4:70%}

In case of a successful market analysis, you learn how high the market demand is. If you learned the level of the market demand, then it is correct in any case. In case the market analysis is not successful, you will not learn the market demand.

After the market analysis is conducted, you can costlessly inform your competitor about the market demand, provided that you learned it. Your competitor can also choose to inform you about the result of his market analysis. All information sent is always truthful. Sending false information is not possible.

- If you **know** whether the market demand is high, respectively low:
  - You can **"inform"** your competitor. Your competitor then knows for certain that the market demand is high, respectively low. In addition, he knows that you learned the market demand.
  - You can **"not inform"** your competitor. In this case, the competitor only knows the market demand, if his own market analysis was successful. The competitor does not know whether you learned the market demand.
- If you **do not know** whether market demand is high, respectively low:
  - You can solely **"not inform"** your competitor. In this case, the competitor only knows the market demand, if his own market analysis was successful. In addition, the competitor does not know whether you learned the market demand.

Only after you and your competitor have decided to "inform" / "not (to) inform" the other, information will be transferred.

In case you received information from the competitor and/or your own market analysis was successful, then you know the market demand. If you neither received information from the competitor nor was your own market analysis successful, then you do not know the market demand.

The further course of this part is identical to the first part. You and your competitor choose your quantities and are informed about the result for that round.

At the end of the experiment, the profits over all rounds are converted into EURO and paid out to you.

D.5 Quiz Part II

Please mark the correct answers

The market analysis has shown that the market demand is "high":

a. The market demand is probably high. However, market demand could be low, if the market analysis was wrong. This depends on chance.

b. The market demand is definitely high. My competitor also knows this, if his market analysis was successful.

c. The market demand is definitely low. My competitor also knows this, if his market analysis was successful.

d. The market demand is definitely high. In any case, this is also known to my competitor.

e. None of the above

My market analysis was not successful:

a. I do not know the market demand. My competitor definitely does not know the market demand.

b. I do not know the market demand. My competitor definitely knows the market demand.

c. When deciding on quantity, I only know the market demand if my competitor's market analysis was successful and he sent me information.

d. I know the market demand.

e. None of the above

Your competitor has announced that the market demand is "low":

a. The market demand is definitely low, as it is not possible to send false information.

b. The market demand could be high, if my competitor chose to send false information on purpose.

c. None of the above

D.6 Instructions Part III

This part is an extension of the experiment from Part II. Now, a department takes over the task to "inform"/ "not (to) inform" the competitor. You instruct the department in which cases the information should be transferred. The quantity decision is still taken by yourself. The same applies for your competitor. The probabilities for the market demand, your market analysis, and the market analysis of the competitor remain as in Part II. The matching of competitors is still determined randomly.

Part III of the experiment consists of <u>*one round*</u> *with the following proceeding:*

At the beginning of the round, you do not know the result of your market analysis. **However, you give binding instructions to your internal department about the instances in which it must inform the competitor about the market demand,** in case the market analysis is successful.

You have 4 options:

1. **Never inform**
   The competitor only knows the market demand, if his market analysis was successful. he does not know, whether you learned the market demand.

2. **Only inform if market demand is low**
   <u>Case 1: Market analysis is successful and market demand is low</u>
   Your competitor knows for certain, that the market demand is low. In addition, the competitor knows that you learned how high the market demand is.

Case 2: Market analysis is not successful and/or the market demand is high
The competitor only knows the market demand, if his own market analysis was successful. He does not know whether you learned the market demand.

3. **Only inform if market demand is high**
   Case 1: Market analysis is successful and market demand is high
   The competitor knows for certain, that the market demand is high. In addition, he knows that you learned how high the market demand is.
   Case 2: Market analysis is not successful and/or the market demand is low
   The competitor only knows the market demand, if his own market analysis was successful. he does not know whether you learned how high the market demand is.

4. **Always inform**
   Case 1: Market analysis is successful
   The competitor knows for certain, that the market demand is high/low. In addition, he knows that you learned the market demand.
   Case 2: Market analysis is not successful
   The competitor only knows the market demand, if his own market analysis was successful. he does not know whether you learned how high the market demand is.

Hereafter, you are informed, as before, whether your market analysis was successful and whether you received information from the competitor.

As in Part II, the decision about the production quantity follows. Subsequently, you are informed about the outcome of this round, as usual.

At the end of the experiment, the profits over all rounds are converted into EURO and paid out to you.

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