

Zaby, Alexandra; Güth, Werner; Pull, Kerstin; Stadler, Manfred

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## Compulsory Disclosure of Private Information - Theoretical and Experimental Results for the Acquiring-a-Company Game

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# Compulsory Disclosure of Private Information

## Theoretical and Experimental Results for the “Acquiring-a-Company” Game

Werner Güth\*, Kerstin Pull<sup>b</sup>, Manfred Stadler<sup>‡</sup>, and Alexandra Zaby<sup>‡</sup>

### Abstract

Based on the “acquiring-a-company” game (Samuelson and Bazerman, 1985) we theoretically and experimentally analyze the effects of compulsory information disclosure. Specifically, investigating within-subjects symmetric versus asymmetric information of buyers and sellers allows to predict and test how becoming informed affects seller and buyer decisions as well as the frequency of acquisitions. The theoretical and experimental results suggest a welfare-enhancing effect of compulsory information disclosure.

Keywords: Acquisition of a firm, compulsory disclosure of private information, experimental economics

JEL Classification: C 91, D 61, D 82

\* Max Planck Institute of Economics, Strategic Interaction Group, Kahlaische Straße 10, D-07745 Jena, Germany. e-mail: gueth@econ.mpg.de.

<sup>b</sup> University of Tübingen, School of Business and Economics, Nauklerstraße 47, D-72074 Tübingen, Germany. e-mail: kerstin.pull@uni-tuebingen.de.

<sup>‡</sup> University of Tübingen, School of Business and Economics, Mohlstraße 36, D-72074 Tübingen, Germany. e-mail: manfred.stadler@uni-tuebingen.de.

<sup>‡</sup> University of Tübingen, School of Business and Economics, Mohlstraße 36, D-72074 Tübingen, Germany. e-mail: alexandra.zaby@uni-tuebingen.de.

## 1. Introduction

Insider information might preclude trade (see, e.g., Akerlof, 1970) and reduce welfare. For example, in the context of mergers and acquisitions asymmetric information may prevent desirable takeovers. One institutional measure to allow desirable trade and transactions is the compulsory disclosure of private information, i.e., a legal obligation on the informed party to reveal its superior information.

The European Union lately issued two central directives related to the acquisition of firms: the *Transparency Directive*<sup>1</sup> and the *Takeover-Bid Directive*<sup>2</sup>. The main intention of the Transparency Directive is to improve investor protection and market confidence. It tries to simplify access to corporate information across EU member states, discourage secret stock building in listed companies, and reduce legal uncertainty.<sup>3</sup> The goal of the Transparency Directive is therefore to mitigate the problem of asymmetric information for buyers/investors.

The Takeover-Bid Directive improves the information rights of shareholders who may be affected by their share prices, both when opting out before a take-over and when maintaining their status. It requires that “*a decision to make a [takeover] bid is made public without delay*”<sup>4</sup>. Furthermore “*an offerer is required to draw up and make public in good time an offer document containing the information necessary to enable the holders of the offeree company’s securities to reach a properly informed decision on the bid.*”<sup>5</sup> Hence, potential investors intending to acquire a firm have to publicly place their takeover bid and disclose further information in the offer document.

Implementing these two directives suggests that compulsory disclosure is seen as an effective policy measure to reduce asymmetric information and enable desirable takeovers. Yet it is difficult to assess the effectiveness of compulsory disclosure in serving this task due to the lack of available data. Therefore an experimental approach appears like an adequate first step to analyze this issue empirically.<sup>6</sup>

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<sup>1</sup>Directive 2004/109/EC on the harmonisation of transparency requirements in relation to information about issuers whose securities are admitted to trading on a regulated market.

<sup>2</sup>Directive 2004/25/EC on takeover bids.

<sup>3</sup>This is achieved by “*establishing requirements in relation to the disclosure of periodic and ongoing information about issuers whose securities are already admitted to trading on a regulated market*” (see Directive 2004/109/EC, §1.)

<sup>4</sup>Directive 2004/25/EC, §6(1).

<sup>5</sup>Directive 2004/25/EC, §6(2).

<sup>6</sup>When seen as an exercise to test the (game-) theoretical prediction, the theory does not exclude experimental falsification. However, when viewing our study as a testbed experiment to explore the effects of an institutional change the usual external and internal validity problem arises.

We theoretically and experimentally explore the effects of compulsory disclosure of information on the decisions of a seller and a buyer engaged in bilateral trade.<sup>7</sup> Extending the scenario discussed by Samuelson and Bazerman (1985), we distinguish two settings with asymmetric information, namely

- one with only the seller and
- one with only the buyer

knowing the value of the firm. Since we are interested in the effects of compulsory information disclosure, we analyze the *transition effect* from each of the two asymmetric information cases to the setting where both parties are informed about the firm’s value. Previous experimental studies focus on specific information constellations of the “acquiring-a-company” game (either only the seller is informed, Ball et al., 1991, Selten et al., 2005, Foreman and Murnighan, 1996, Dittrich et al., 2012, Grosskopf et al., 2007, or only the buyer is informed, Chlass, 2013) and not on the transition from asymmetric to complete information, i.e., we experimentally investigate the effects of compulsory disclosure in this context.

The remainder of the paper is organized as follows. Section 2 introduces the possible institutional settings together with their game theoretic benchmark solutions and welfare implications. The hypotheses to be tested experimentally are stated in Section 3. Section 4 describes the experimental design. Experimental results are illustrated and statistically analyzed in Section 5. Section 6 concludes.

## 2. The “acquiring-a-company” game

This game involves a (potential) seller  $S$  and a (potential) buyer  $B$ . The seller owns a company he evaluates by  $qv$ , where  $q \in (0, 1)$  is an exogenously given and commonly known parameter and  $v \in (0, 1)$  is the value of his company for the buyer to whom he wants to sell it. Thus evaluations of the firm are perfectly and linearly correlated, and due to  $q < 1$  trade is welfare enhancing. If  $p$  denotes the price for selling the company to  $B$ , the gains from trade are  $v - p$  for  $B$  and  $p - qv$  for  $S$  such

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<sup>7</sup>It should already be noted here that in our theoretical and experimental analysis we maintain the unitary actor assumption of one individual potential buyer and one individual potential seller. Thus we cannot comment on cases where some shareholders opt out and others maintain their status and on how this depends on information conditions. Our contribution thus does not explore the efficacy of the EU Directives, but only the effect of compulsory disclosure on the decisions of one seller and one buyer engaged in bilateral trade.

that the surplus amounts to  $(1 - q)v$ . We assume throughout that  $v$  is randomly distributed according to the uniform density on the support  $[0, 1]$  and that there is common (knowledge of) risk neutrality. As Samuelson and Bazerman (1985) we assume that

- (i) buyer  $B$  proposes a price  $p \in [0, q]$  which
- (ii) seller  $S$  can accept ( $\delta(p) = 1$ ) or reject ( $\delta(p) = 0$ ), the latter resulting in zero payoffs for both parties. Altogether the payoff is  $\delta(p)(v - p)$  for  $B$ , and  $\delta(p)(p - qv)$  for  $S$ .

Theoretically one can distinguish four different information structures. There is no information at all about the realization of  $v$  in the baseline

**Scenario (NN):** Neither buyer nor seller know the realization of  $v$ .

Since  $v$  is uniformly distributed on the unit interval, the seller's expected payoff in case of  $\delta(p) = 1$  is

$$E\pi_S(p) = p - q/2$$

so that  $S$  would accept ( $\delta^*(p) = 1$ ) only if  $p \geq q/2$ . Since the buyer expects

$$E\pi_B(p) = 1/2 - p$$

from trade, the optimal price offer of  $B$  is  $p^{NN} = q/2$ .  $S$  will accept this offer, leading to trade. The expected payoffs for buyer and seller are

$$E\pi_B^{NN} = (1 - q)/2 \quad \text{and} \quad E\pi_S^{NN} = 0. \quad (1)$$

Buyer  $B$  exploits ultimatum power and acquires the total expected surplus  $(1 - q)/2$  from trade.

The information structure analyzed by Samuelson and Bazerman (1985) is

**Scenario NI:** Seller  $S$  is perfectly informed about  $v$ , whereas it is commonly known that buyer  $B$  expects  $v$  to be generated according to the uniform density on  $[0, 1]$ .

Clearly,  $\delta^*(p) = 1$  is optimal only if  $p/q \geq v > 0$ . The buyer's expected payoff thus depends on the chosen price  $p$

$$E\pi_B = \int_0^{p/q} (v - p) dv = \frac{(1 - 2q)p^2}{2q^2}.$$

In case of  $q \leq 1/2$ , the optimal price offer by the buyer is  $p^{NI} = q$ . The expected payoffs for the buyer and the seller are

$$E\pi_B^{NI} = (1 - 2q)/2, \quad E\pi_S^{NI} = q/2, \quad (2.1)$$

i.e., there is welfare-enhancing trade as in Scenario **NN**, but with more balanced gains from trade.

In case of  $q > 1/2$ , however,  $E\pi_B < 0$  for  $p > 0$  so that the optimal price offer of  $B$  is  $p^{NI} = 0$ . Similar to the “lemon problem” (Akerlof, 1970), there is no trade due to adverse selection and the (expected) payoffs are

$$E\pi_B^{SB} = 0, \quad E\pi_S^{SB} = 0. \quad (2.2)$$

In the third

**Scenario IN** only the buyer is aware of  $v$  while it is commonly known that the seller expects  $v$  to be generated according to the uniform density on  $[0, 1]$ .

The seller obviously expects the price to be below the value, i.e.,  $v > p$ . Therefore the expected payoff for the seller is

$$E\pi_S = \int_p^1 (p - qv)dv = p - \frac{q}{2} - (1 - \frac{q}{2})p^2.$$

Due to  $q < 1$ , this payoff function is concave in  $p$  and positive in the interval  $p \in (\frac{q}{2-q}, 1)$ , rendering  $p^{IN} = \frac{q}{2-q}$  the buyer’s optimal price offer. The expected payoffs for buyer and seller are

$$E\pi_B^{IN} = \int_{q/(2-q)}^1 (v - q/(2-q))dv = \frac{2(1-q)^2}{(2-q)^2}, \quad E\pi_S^{IN} = 0. \quad (3)$$

The expected payoff for  $B$  is lower than in scenario **NN** for all  $q > 0$ , due to trade being restricted to  $v \geq p^{IN} = q/(2-q) > 0$ . This solution is partly  $v$ -revealing: in case of a 0-offer the seller concludes that  $v < p^{IN}$ , whereas from observing  $p = p^{IN}$  he infers that  $v \geq p^{IN}$ , i.e., whether trade occurs depends on  $v$ .

In the fourth

**Scenario II** both, buyer and seller, know  $v$ .

The buyer exploits ultimatum power by offering  $p^{II} = qv$  yielding the expected payoffs

$$E\pi_B^{II} = (1-q)/2, \quad E\pi_S^{II} = 0, \quad (4)$$

coinciding with those in scenario **NN**. The same expected payoffs, however, rely on a crucial difference in that seller  $S$  earns nothing for all  $v \in (0, 1)$  in scenario **II**, whereas in scenario **NN** his payoff  $q(1/2 - v)$  is  $v$ -dependent and specifically negative for  $v > 1/2$ .

The results of all scenarios are summarized in Table 1: the seller is ex ante best off when privately informed about  $v$ , i.e., with exclusive information. Otherwise, his

expected payoff is zero. The buyer is best off when both players are either informed or uninformed about  $v$ .

|                                |     | Seller is informed about $v$   |  |
|--------------------------------|-----|--|--|
|                                |     | no   | yes  |
| Buyer is informed<br>about $v$ | no  | $(p^{NN}, E\pi_B^{NN}, E\pi_S^{NN}) =$<br>$(\frac{q}{2}, \frac{1-q}{2}, 0)$ <b>NN</b>              | $(p^{NI}, E\pi_B^{NI}, E\pi_S^{NI}) =$<br>$(0, 0, 0)$ for $q > \frac{1}{2}$<br>$(q, \frac{1-2q}{2}, \frac{q}{2})$ for $q \leq \frac{1}{2}$ <b>NI</b> |
|                                | yes | $(p^{IN}, E\pi_B^{IN}, E\pi_S^{IN}) =$<br>$(\frac{q}{2-q}, \frac{2(1-q)^2}{(2-q)^2}, 0)$ <b>IN</b> | $(p^{II}(v), E\pi_B^{II}, E\pi_S^{II}) =$<br>$(qv, \frac{1-q}{2}, 0)$ <b>II</b>  |

Table 1: Benchmark solutions regarding prices and payoffs for  $B$  and  $S$

### 3. Compulsory disclosure of information

Compulsory disclosure as for example prescribed by the Transparency Directive and the Takeover-Bid Directive can be captured by a transition from scenario **IN** or **NI** to information structure **II**, where  $v$  is commonly known. Informing potential buyers (sellers), as captured by the change from scenario **NI** (**IN**) to **II**, theoretically increases the expected surplus from trade, i.e., the sum of the expected buyer and seller payoff.<sup>8</sup>

The experimental data contains only ex-post realized payoffs which sum up to  $v(1 - q)$  if a matched pair of a buyer and seller agreed on trade. To use something more dependent on the decisions of participants we focus on two measures: (i) the sum of negative payoffs and (ii) the frequency of trade. The latter's explanatory power regarding welfare is straightforward: in **NI** as well as in **IN** asymmetric information restricts trade to cases where parameter values of  $q$  and  $v$  satisfy the critical thresholds identified in the theoretical analysis.<sup>9</sup> Clearly, more information on either side should lead to more trade. As an increasing level of  $q$  hampers trade, this parameter is crucial for how many acquisitions are realized. Due to this critical role of  $q$  we will investigate the decisions made for alternative levels of  $q$  separately.

The first measure, the sum of negative payoffs, reflects erroneous decisions, i.e., either buyer participants propose too high prices or seller participants accept too low prices. Complete information renders the game less complex and should therefore

<sup>8</sup>In the **NI** scenario this effect is subject to  $q > 1/2$ .

<sup>9</sup>Generally for the seller it is optimal to accept only if  $p/q \geq v$ , whereas in scenario **IN** trade is restricted to  $v \geq q/(2 - q)$ .

reduce negative payoffs. According to these measures the benchmark predicts that compulsory information disclosure will increase trade and decrease negative payoffs.

**Hypothesis 1.** *Eliminating asymmetric information should enhance the frequency of trade and reduce negative payoffs.*

Eliminating asymmetric information further affects the payoffs of buyer and seller: while the buyer’s payoff increases for all levels of  $q$ , the seller’s payoff decreases for low levels,  $q \leq 1/2$ . This leads to

**Hypothesis 2a.** *Eliminating asymmetric information for the potential buyer should increase the payoff of the buyer but decrease the payoff of the seller for low levels  $q \leq 1/2$  only.*

When also becoming informed about  $v$  the seller does not gain, whereas the buyer’s payoff increases. This gives us

**Hypothesis 2b.** *Eliminating asymmetric information for the potential seller increases the payoff of the buyer, while the payoff of the seller is left unchanged.*

Altogether, we expect compulsory disclosure to increase welfare, with buyers gaining and sellers possibly losing.

#### 4. Experimental design and setup

The experimental treatments are the institutional transitions from one scenario with one-sided information, **NI** or **IN**, to scenario **II**, where both, seller and buyer, are informed about the value of the firm. Implemented in a within-subjects design, treatment (**IN**  $\rightarrow$  **II**) features the change from scenario **IN** to scenario **II**, and treatment (**NI**  $\rightarrow$  **II**) the transition from scenario **NI** to scenario **II**.

Participants are permanently in role  $B$ , a potential buyer, or in role  $S$ , a potential seller, to which they are randomly assigned at the beginning of the experiment. In treatment (**IN**  $\rightarrow$  **II**), participants first play three rounds of **IN** (phase 1), followed by three rounds of **II** (phase 2). In treatment (**NI**  $\rightarrow$  **II**), participants first play three rounds of **NI** (phase 1), followed by three rounds of **II** (phase 2). Thus in both treatments, (**IN**  $\rightarrow$  **II**) and (**NI**  $\rightarrow$  **II**), participants play the “acquiring-a-company” game for a total of six rounds, three rounds each in phase 1 and phase 2.

In each of the three rounds, participants are confronted with one of three possible  $q$ -levels,  $q \in \{0.35, 0.45, 0.55\}$ . The informed party, i.e.,  $B$ -participants in **IN**,



$S$ -participants in **NI**, and both,  $B$ - and  $S$ -participants, in **II**, are subsequently confronted with 15 randomly drawn realizations of  $v$ . These realizations, including their order of appearance as well as the order of the three  $q$ -levels, were drawn before the experiment and held constant over all treatments and sessions. In phase 1 the informed side of the market states a price for every  $v$ : informed  $B$ -participants (scenario **IN**) state the buying price  $BP$  they are willing to pay, and informed  $S$ -participants (scenario **NI**) state their minimum price  $SP$  at which they are willing to sell the company. In phase 2 (scenario **II**) both are informed about  $v$  and state a (minimum) price for every one of the 15 random  $v$ -values. Hence, in **IN**  $B$ -participants make 45 decisions, in **NI**  $S$ -participants make 45 decisions, and in **II** both,  $B$ - and  $S$ -participants, make 45 decisions. The uninformed party in phase 1, however, can only state one (minimum) price in every round, knowing only the distribution of  $v \in [0, 100]$ , but not its realized value.

If the price offer exceeds the acceptance threshold, i.e., the minimum price of the potential seller, the company is sold at the offered price, otherwise there is no trade. The resulting payoffs,  $(v - BP)$  for buyers and  $(BP - qv)$  for sellers, are specified formally as well as verbally in the instructions (see Appendix). To avoid learning there was no feedback between rounds. At the end of the experiment, each  $B$ -participant was randomly matched with an  $S$ -participant, and for each round one realization of  $v$  was randomly chosen for payment, i.e., participants were paid for six decisions.

All sessions started with a set of control questions clarifying and testing whether the decision tasks and the calculation of payoffs were fully understood by the participants. To emphasize that negative payoffs were possible, an appropriate example was included in the control questions. After all participants had answered all control questions correctly, three trial rounds took place to ensure that participants understood the consequences of own and others' decisions.

After completion of phases 1 and 2 of the experiment, participants were asked to fill out a postexperimental questionnaire designed to collect demographic information and elicit participants' risk tolerance (see Holt and Laury, 2002).

In the experiment, payoffs were calculated in Experimental Currency Units (ECU) and converted into euros at a given exchange rate ( $6 \text{ ECU} = 1 \text{ euro}$ ) at the end of the experiment. Besides a show-up fee of 5 euros, participants received their payoff earned by 6 randomly drawn decisions (one for each of the six rounds) as well as the reward for the lottery question in the postexperimental questionnaire assessing risk tolerance. The experiment was programmed in  $z$ -tree (see Fischbacher,

2007). We ran 3 sessions with 32 participants each for each treatment. Participants were students of Friedrich Schiller University Jena (Germany). On average, one session lasted about 90 minutes. The average payment of participants amounted to 16.36 euros including the show-up fee and the reward for the lottery question. Earnings ranged from 5.10 to 47.30 euros.

When payoffs (not including the show-up fee and the reward for the lottery question) summed up to a negative value, participants could either pay their debt out of pocket or work it off by completing an effort task (i.e., counting the letter “t” in a text).<sup>10</sup> All 8 (8.3%) participants confronted with negative payoffs chose to work off their debt.

## 5. Experimental results

### 5.1. Descriptives

We start with descriptive results concerning phase 1 in both treatments, i.e., either only the seller is informed about the value of the firm (phase 1 in treatment  $(\mathbf{NI} \rightarrow \mathbf{II})$ ) or only the buyer is informed (phase 1 in treatment  $(\mathbf{IN} \rightarrow \mathbf{II})$ ).

In phase 1 of treatment  $(\mathbf{NI} \rightarrow \mathbf{II})$ , informed sellers set a minimum price  $SP$  for all 15 randomly drawn  $v$ -values while participants in the role of buyers choose only one price  $BP$  in every round. Figures 1a (1b) depict the mean choices of  $BP$  and  $SP$  in the three rounds of phase 1 depending on the value of the firm: the horizontal lines represent the respective means of buyer (seller) prices whereas the markers on the increasing functions represent the mean values of seller (buyer) prices.<sup>11</sup>

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<sup>10</sup>For every completed extra exercise participants could work off 5 euros. As the negative payoff could not be compensated by the show-up fee and the reward for the lottery question in the postexperimental questionnaire, participants who chose to work received a positive payoff in the end.

<sup>11</sup>Note that in the cases where the same  $v$ -value was randomly drawn twice so that two mean values of  $SP$  ( $BP$ ) exist for one value of  $v$ , the mean of the two is depicted in Figure 1a (1b).

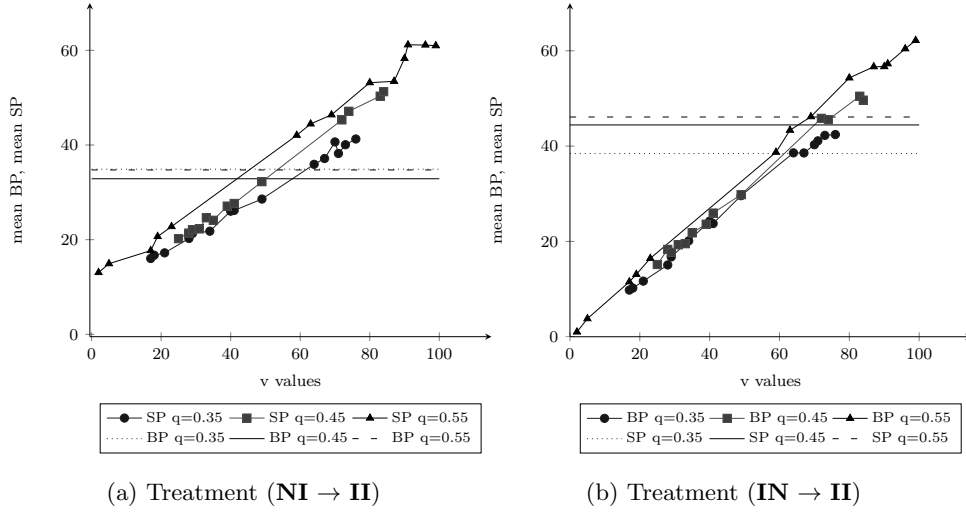


Figure 1: Means of  $BP$  and  $SP$  in phase 1

In both treatments (minimum) prices of the informed party increase in  $v$  and  $q$ . For an interpretation of this result, recall that the payoff for a seller is  $(BP - qv)$ , i.e., decreasing in  $q$  and  $v$ . Given that payoffs become negative when  $BP < qv$ , informed seller participants apparently understood the interplay of own payoff with parameters  $q$  and  $v$ : to avoid negative payoffs, they chose a higher price acceptance level  $SP$  for higher values of  $q$  and  $v$ . In treatment ( $\mathbf{IN} \rightarrow \mathbf{II}$ ) informed buyers anticipated this so that their mean offers display the same dependency on parameters  $v$  and  $q$ , see Figure 1b.

Note that trade did not take place in all depicted cases, but only if  $BP \geq SP$ . This is the case to the left of the intersection points of the respective  $BP$  and  $SP$  curves in Figure 1a and to the right of the intersection points of the curves depicting the means of  $BP$  and  $SP$  in Figure 1b. Thus, comparing the treatments, trade is more frequent in treatment ( $\mathbf{NI} \rightarrow \mathbf{II}$ ) than in treatment ( $\mathbf{IN} \rightarrow \mathbf{II}$ ), where the informed seller sets higher acceptance levels in fear of a loss. Graphically, negative payoffs are realized to the left of all combinations with  $BP = v$ . Given only combinations of  $BP$  and  $SP$  where trade is successful, negative payoffs in phase 1 are most prominent for low  $v$ -values in treatment ( $\mathbf{NI} \rightarrow \mathbf{II}$ ).

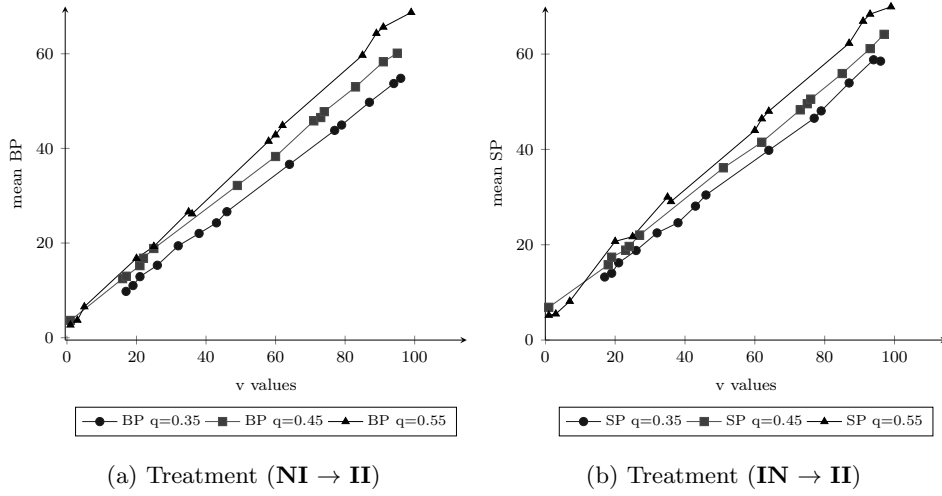


Figure 2: Means of  $BP$  and  $SP$  in phase 2

When becoming informed in phase 2, buyers (sellers) set a (minimum) price knowing the value of the firm. Figures 2a and 2b show that price decisions in phase 2 display the same dependencies on parameters  $q$  and  $v$  as those of the unilaterally informed sellers (buyers) in phase 1. Adapting their minimum price decisions the newly informed sellers decrease their acceptance levels for low firm values and increase it for high firm values (Figure 2b) while newly informed buyers decrease their price offers for low  $v$ -values and increase them for high  $v$ -values (Figure 2a). As for the sake of clarity the corresponding decisions of buyers and sellers are omitted in Figures 2a and 2b, it is difficult to conclude from these descriptive results whether or not compulsory information disclosure reduces negative payoffs.

### 5.2. Erroneous decisions and the frequency of trade

Hypothesis 1 postulates that compulsory information disclosure reduces the sum of negative payoffs and increases the frequency of trade. For treatment (NI → II), where the seller gains information from compulsory disclosure, the changes in the sum of negative payoffs are depicted in Table 2. The reduction of negative payoffs resulting from erroneous decisions is highest for  $q = 0.55$ , what fulfills condition  $q > 1/2$  where the benchmark solution predicts the strongest welfare enhancement.

|                                 | $q = 0.35$    | $q = 0.45$    | $q = 0.55$    |
|---------------------------------|---------------|---------------|---------------|
| Phase 1 $\sum$ negative payoffs | -4,908.10 (4) | -2,669.45 (4) | -7,192.85 (6) |
| Phase 2 $\sum$ negative payoffs | 0 (0)         | -504.10 (7)   | -54.00 (6)    |
| $\Delta$ (phase 2-phase 1)      | 4,908.10      | 2,165.35      | 7,138.85      |

Table 2: Sum of negative payoffs (no. of cases with negative payoffs) in phases 1 and 2 in treatment (**NI**  $\rightarrow$  **II**)

The total number of cases with negative payoffs reveals that more information does not necessarily decrease the number of erroneous decisions but renders these decisions less fatal in that the resulting negative payoffs are closer to zero.<sup>12</sup> Thus, more information leads to better decisions resulting in less negative payoffs.

As a clear indicator of welfare we refer to the frequency of trade which we calculate for every possible level of  $q$  separately. As  $q$  varied per round, we identify the number of decisions potentially leading to trade in one round: given 15 decisions per participant we have – in a session consisting of 32 participants – 480 decisions per round. For the three sessions of every treatment this provides 1,440 possible acquisitions for every level of  $q$ . Table 3 displays the frequencies of trade using the number of possible acquisitions as a basis.

|         | $q = 0.35$ | $q = 0.45$ | $q = 0.55$ |
|---------|------------|------------|------------|
| Phase 1 | 63.5%      | 51.8%      | 48.7%      |
| Phase 2 | 56.8%      | 52.4%      | 52.2%      |

Table 3: Relative frequencies of trade in treatment (**NI**  $\rightarrow$  **II**)

Except for  $q = 0.35$  more information leads to more trade in treatment (**NI**  $\rightarrow$  **II**). However, these descriptive results do not withstand a statistical test comparing differences line- and column-wise.

<sup>12</sup>Of course, other regarding concerns like inefficiency concerns can justify such seemingly “erroneous” decisions.

|    | $q = 0.35$ |       |      | $q = 0.45$ |       |       | $q = 0.55$ |       |       |
|----|------------|-------|------|------------|-------|-------|------------|-------|-------|
|    | +          | −     | n.s. | +          | −     | n.s.  | +          | −     | n.s.  |
| BP | 20.0%      | 73.3% | 6.7% | 46.7%      | 46.7% | 6.6%  | 40.0%      | 46.7% | 13.3% |
| SP | 46.7%      | 46.7% | 6.6% | 40.0%      | 46.7% | 13.3% | 33.3%      | 60.0% | 6.7%  |

Table 4: Effect of compulsory disclosure on BP and SP in treatment (**NI**  $\rightarrow$  **II**)

As trade takes place whenever  $BP > SP$ , increasing buyer and/or decreasing seller prices enhance trade. Table 4 displays the significant changes of (minimum) prices when moving from phase 1 with asymmetric information to phase 2 with symmetric information (Mann-Whitney tests, highest  $p$ -value  $\leq 0.04$ ). Prices can increase, column “+”, or decrease, column “−”; insignificant comparisons are listed in column “n.s.”. For every level of  $q$  we compare the 15 decisions of the informed sellers in phase 1 with their 15 decisions in phase 2 and the one decision of the uninformed buyers in phase 1 with their 15 decisions in phase 2. Take for example buyer prices for  $q = 0.35$ : 20% of the comparisons result in buyer prices significantly increasing from phase 1 to phase 2 whereas in 73.3% of the comparisons of BP in phase 1 with BP in phase 2 buyer prices significantly decrease with more information.

Theoretically buyer prices should decrease with more information while seller acceptance levels should remain unchanged.<sup>13</sup> However, the comparisons above indicate that both, buyer and seller prices, decrease due to compulsory information disclosure: becoming informed about the true value of the firm buyers offer less, while sellers choose lower acceptance levels when also buyers become informed. While the latter effect enhances trade, decreasing buyer prices work in the opposite direction, hampering trade. This interplay of two opposing effects could be responsible for the insignificant results of compulsory information disclosure on the frequency of trade.

For Hypothesis 1 we thus conclude

**Result 1a.** *In treatment (**NI**  $\rightarrow$  **II**) compulsory disclosure decreases the sum of negative payoffs for all levels of  $q$ . While the frequency of trade does not significantly change, buyer and seller prices significantly decrease with more information.*

Analyzing Hypothesis 1 using treatment (**IN**  $\rightarrow$  **II**), where the seller gains information through compulsory disclosure, we again investigate the sum of negative

<sup>13</sup>Solving  $BP_{II} < BP_{NI}$  leads to  $v < 1$  what is always fulfilled, whereas  $SP_{II} = SP_{NI} = qv$ .

payoffs. Table 5 describes the results. Negative payoffs are smaller than in treatment (**NI**  $\rightarrow$  **II**) and are even further reduced by compulsory information disclosure.

|                                 | $q = 0.35$ | $q = 0.45$ | $q = 0.55$ |
|---------------------------------|------------|------------|------------|
| Phase 1 $\sum$ negative payoffs | -50.00     | -76.10     | -176.55    |
| Phase 2 $\sum$ negative payoffs | 0          | -75.65     | -96.20     |
| $\Delta$ (phase 2-phase 1)      | 50.00      | 0.45       | 80.35      |

Table 5: Comparison of the sum of negative payoffs in phases 1 and 2 in treatment (**IN**  $\rightarrow$  **II**)

From Table 6 one can calculate that the relative frequency of trade increases when moving from phase 1 to phase 2 for all levels of  $q$ : by 25.9% for  $q = 0.35$  (Mann-Whitney test,  $p\text{-value} \leq 0.01$ ), by 20.2% for  $q = 0.45$  (Mann-Whitney test,  $p\text{-value} \leq 0.01$ ), and by 10% for  $q = 0.55$  (Mann-Whitney test,  $p\text{-value} \leq 0.02$ ). Overall information disclosure induces more trade with the effect becoming weaker the higher the level of  $q$  (the decrease from 59.9% for  $q = 0.35$  to 50.5% for  $q = 0.55$  is significant with  $p\text{-value} \leq 0.05$ , Mann-Whitney test). Unlike in treatment (**NI**  $\rightarrow$  **II**) compulsory disclosure clearly enhances welfare.

|         | $q = 0.35$ | $q = 0.45$ | $q = 0.55$ |
|---------|------------|------------|------------|
| Phase 1 | 33.5%      | 30.0%      | 40.5%      |
| Phase 2 | 59.4%      | 50.8%      | 50.5%      |

Table 6: Relative frequencies of trade in treatment (**IN**  $\rightarrow$  **II**)

As before (Table 4) analyzing the significant changes of (minimum) prices when moving from phase 1 to phase 2 leads to the frequencies presented in Table 7 (Mann-Whitney tests, highest  $p\text{-value} \leq 0.03$ ).

|    | $q = 0.35$ |       |      | $q = 0.45$ |       |       | $q = 0.55$ |       |       |
|----|------------|-------|------|------------|-------|-------|------------|-------|-------|
|    | +          | -     | n.s. | +          | -     | n.s.  | +          | -     | n.s.  |
| BP | 46.7%      | 46.7% | 6.6% | 46.7%      | 46.7% | 6.6%  | 46.7%      | 53.3% | 0.0%  |
| SP | 33.3%      | 60.0% | 6.7% | 26.7%      | 53.3% | 20.0% | 26.7%      | 53.3% | 20.0% |

Table 7: Effect of compulsory information of BP and SP in treatment (**IN**  $\rightarrow$  **II**)

Half of the comparisons regarding buyer prices reveal a significant increase

whereas the other half shows a significant decrease. Apparently buyers were confronted with two opposing incentives which can be identified by the theoretical analysis: (i) for low  $v$ -values buyer prices and seller acceptance levels are predicted to decrease with more information, whereas (ii) for high  $v$ -values both are predicted to increase with compulsory information disclosure.<sup>14</sup> Investigating the proposed effects empirically makes it necessary to look at the data for  $v \geq 50$  and  $v < 50$  separately. Table 8 presents the results of possible comparisons in the restricted data samples (Mann-Whitney tests, highest  $p$ -value  $< 0.014$ ).<sup>15</sup>

|             | $q = 0.35$ |        |       | $q = 0.45$ |        |       | $q = 0.55$ |        |       |
|-------------|------------|--------|-------|------------|--------|-------|------------|--------|-------|
|             | +          | −      | n.s.  | +          | −      | n.s.  | +          | −      | n.s.  |
| $v < 50$    |            |        |       |            |        |       |            |        |       |
| BP          | 33.3%      | 67.7%  | 0.0%  | 0.0%       | 100.0% | 0.0%  | 33.3%      | 67.7%  | 0.0%  |
| SP          | 0.0%       | 100.0% | 0.0%  | 0.0%       | 100.0% | 0.0%  | 0.0%       | 100.0% | 0.0%  |
| $v \geq 50$ |            |        |       |            |        |       |            |        |       |
| BP          | 67.7%      | 0.0%   | 33.3% | 67.7%      | 0.0%   | 33.3% | 75.0%      | 25.0%  | 0.0%  |
| SP          | 100.0%     | 0.0%   | 0.0%  | 67.7%      | 0.0%   | 33.3% | 50.0%      | 0.0%   | 50.0% |

Table 8: Effect of compulsory information on BP and SP in treatment (**IN**  $\rightarrow$  **II**), restricted sample

The proposed effects find strong empirical support: (i) for low  $v$ -values we have clear evidence that buyer prices and seller acceptance levels mostly decrease significantly, (ii) for high  $v$ -values  $BP$  and  $SP$  both significantly increase due to compulsory information disclosure. Overall the results presented in Table 7 suggest that the negative effect of compulsory disclosure is strongest for sellers' minimum prices, while for buyer prices two counter effects compensate each other. The probability of trade is thus enhanced rather than hampered by more information. This gives us

**Result 1b.** *In treatment (**IN**  $\rightarrow$  **II**) compulsory disclosure significantly increases the frequency of trade what can be explained by the increase (decrease) of buyer prices and seller acceptance levels for high (low) values of the firm.*

<sup>14</sup>Solving  $BP_{II} > BP_{IN}$  leads to  $v > 1/(2 - q)$ , solving  $SP_{II} > SP_{IN}$  leads to  $v > 1/2$ .

<sup>15</sup>To illustrate our procedure, take for example the first decision of the round with  $q = 0.35$  in phase 1. It is compared with the first decision of the round with  $q = 0.35$  in phase 2. Given that both decisions have different underlying  $v$ -values, part of them may be dropped when restricting the sample to high or low  $v$ -values. As a consequence a comparison of all decisions is no longer possible in the restricted samples.



### 5.3. Payoffs of buyers and sellers

Let us now turn to the payoffs of buyers and sellers (Hypotheses 2a and 2b). Our analysis suggests that in treatment (**NI**  $\rightarrow$  **II**) the seller suffers from information disclosure for low levels of parameter  $q$ ,  $q \leq 1/2$ , whereas the formerly uninformed buyer gains for all  $q$ -levels (Hypothesis 2a). Empirically, in phase 2 buyers' payoffs are significantly higher than in phase 1 for all  $q$ -levels ( $p$ -value  $\leq 0.01$ ) whereas sellers' payoffs are significantly lower ( $p$ -value  $\leq 0.02$ ) for  $q \in \{0.35, 0.55\}$ ; the difference for  $q = 0.45$  is insignificant (Mann-Whitney tests). This only partly supports Hypothesis 2a as sellers' payoffs are expected to decrease only for low levels of parameter  $q$ .

**Result 2a.** *In treatment (**NI**  $\rightarrow$  **II**) compulsory disclosure significantly increases the payoff of the less informed party, whereas the payoff of the better informed party significantly decreases.*

For treatment (**IN**  $\rightarrow$  **II**) theoretically buyers' payoffs should increase, whereas sellers should not gain from becoming informed (Hypothesis 2b). According to the experimental data, however, sellers' payoffs significantly increase when buyers' private information is disclosed (Mann-Whitney test,  $p$ -value  $\leq 0.02$ ), while buyers' payoffs do not significantly change. This finding contradicts Hypothesis 2b and is summarized in

**Result 2b.** *In treatment (**IN**  $\rightarrow$  **II**), compulsory disclosure significantly increases the payoff of the less informed party, whereas the payoff of the better informed party does not significantly change.*

Overall, compulsory disclosure profits the party becoming informed, while it might be harmful for the party which loses its information advantage.

## 6. Conclusion

We theoretically and experimentally investigate the welfare and payoff implications of institutional changes trying to reduce the negative effects associated with insider information, suggested for example by the EU Takeover-Bid Directive and the EU Transparency Directive. By beginning with market scenarios characterized by asymmetric information and switching to scenarios where this private information becomes commonly known, we enrich the analysis by Samuelson and Bazerman (1985) and subsequent studies. Although a better informed seller represents the

more natural setting of private information, the profitability of a firm may also depend on external events about which the potential buyer could be better informed. For example, a potential buyer may have learned that a major customer, e.g., a public authority or a large commercial customer, has decided to increase its demand for the firm's deliveries before the seller himself learns about this.

We identify two positive effects of compulsory information disclosure. On the one hand it crowds out erroneous decisions resulting in negative payoffs, especially when non-informed buyers become informed. On the other hand it increases welfare by enhancing trade, with this effect being most prominent when sellers become informed. In both settings compulsory disclosure significantly increases the payoff of the less informed party. Only in case of an initially uninformed buyer the payoff of the better informed party, the seller, decreases significantly when providing complete information.

Overall, our theoretical and experimental results support policy measures aiming at compulsory information disclosure, as more information enforces accurate decisions and enhances trade.

## Appendix

### INSTRUCTIONS

#### General information

Thank you for participating in this experiment. Please remain silent and turn off your mobile phones. Please read the instructions carefully and note that they are identical for each participant. From now on, you may not talk to other participants. In case you do not follow these rules, we will have to exclude you from the experiment as well as from any payment. You will receive 5 euros for participating in this experiment. The participation fee and any additional amount of money you will earn during the experiment will be paid out to you in cash at the end of the session. All participants will be paid individually, i.e., no other participant will know how much you earned. All monetary amounts in the experiment will be paid in ECU (experimental currency units). At the end, all earned ECUs will be converted into euros using the following exchange rate:

$$6 \text{ ECU} = 1 \text{ euro.}$$

#### Procedure

The experiment consists of the following parts: control questions, six rounds divided into two phases, and a final questionnaire. Before starting the first phase, three practice rounds will be held. After completing phase 1, you will receive the instructions for the second phase. At the beginning of the experiment, each participant is randomly assigned one out of two possible roles. One half of the participants will be assigned the role of a buyer, B; the other half will be assigned the role of a seller, S. You will remain in the role you have been assigned throughout the experiment, i.e., in phase 1 and phase 2.

At the end of the experiment, for each of the six rounds, one of your decisions is selected to determine your payment, i.e., one decision per round. If you suffer a loss in the six selected decisions, you can pay for it in cash or balance it by completing additional tasks at the end of the experiment. Please note that these tasks can only be used to compensate for possible losses, but not to increase your earnings. Additionally, you will receive a payment for one task from the questionnaire part.

Hence, you will receive the participation fee and payment for the questionnaire part in any case.

### **Detailed description of the experiment**

The experiment consists of two phases, each consisting of three rounds.

The procedure of a round in phase 1 is structured as follows:

1. The computer randomly selects 15 values of  $v$  between 0 and incl. 100 ( $v = 0, 1, \dots, 100$ ). In this case, each value  $v$  between 0 and 100 can be selected with equal probability.
2. The value  $v$  is ONLY announced to the participants  $[(NI \rightarrow II): \text{in role } S]$   $[(IN \rightarrow II): \text{in role } B]$ .
3. Decisions of the participants.

The participant in role B chooses a buying price BP between 0 and incl. 100 ( $0 \leq BP \leq 100$ ).

The participant in role S chooses a minimum selling price SP between 0 and incl. 100 ( $0 \leq SP \leq 100$ ).

In each of the three rounds of phase 1 only the participants  $[(NI \rightarrow II): \text{in role } S]$   $[(IN \rightarrow II): \text{in role } B]$  are confronted with 15 randomly selected values of  $v$ . These informed participants select  $[(NI \rightarrow II): \text{a selling price } SP]$   $[(IN \rightarrow II): \text{a buying price } BP]$  particularly for each of the 15 values of  $v_1, v_2, \dots, v_{15}$ . In other words, the participants  $[(NI \rightarrow II): \text{in role } S]$   $[(IN \rightarrow II): \text{in role } B]$  determine in total 15  $[(NI \rightarrow II): \text{minimum selling prices}]$   $[(IN \rightarrow II): \text{buying prices}]$ , which can also be identical. The uninformed participants  $[(NI \rightarrow II): \text{in role } B]$   $[(IN \rightarrow II): \text{in role } S]$  make only one decision per round: they decide at which  $[(NI \rightarrow II): \text{buying price } BP]$   $[(IN \rightarrow II): \text{minimum selling price } SP]$  they would be willing to  $[(NI \rightarrow II): \text{buy}]$   $[(IN \rightarrow II): \text{sell}]$ . At the end of the experiment, one of the values of  $v$  is randomly selected for each round. Based on that value, the earnings for sellers S and buyers B are determined.

If the buying price BP offered by B is less than the minimum selling price SP by seller S, no sale takes place and no gains from the trade are generated, i.e., the

earnings of S and B are 0.

If the buying price BP offered by B is higher than or equal to the minimum selling price SP, seller S accepts the bid made by buyer B, and the following earnings result from these choices:

The buyer receives the random value  $v$  minus the offered buying price BP.

The seller receives the buying price BP proposed by B minus a share in the amount of  $x\%$  of the random value  $v$ .

The amount of  $x\%$  varies in the three rounds of a phase and can either correspond to 35%, 45%, or 55%, while the sequence of these three  $x$ -values is determined randomly.

Therefore, the earnings in the event of a trade can be summarized as follows:

B receives  $(v - BP)$ ,

S receives  $(BP - x\%v)$ ,

where  $x\%$  may correspond to either 35%, 45%, or 55%.

Please note that profits from the sale are only positive for both participants – buyer B and seller S – if the randomly selected value  $v$  is higher than the buying price BP and this, in turn, is higher than  $x\% v$  ( $v > BP > x\%v$ ).

If  $v$  is less than BP, buyer B receives a negative payoff due to the purchase. If BP is less than  $x\% v$ , seller S receives a negative payoff due to the sale.

Therefore, seller S owns a good that has value  $v$  for buyer B but is less valuable for the latter, namely  $x\%$  of value  $v$ . Depending on the buying price BP, on  $x\%$  and on the value  $v$ , it can be advantageous for S to sell to B.

You will receive the instructions for phase 2 at the end of phase 1.

Before phase 1 of the experiment begins, we will ask you to answer a few control questions to help you better understand the rules of the experiment. This will be followed by practice rounds, to become familiar with the structure of the experiment. If you have any questions, please raise your hand.

## Instructions for phase 2

In each of the three rounds of phase 2, both participants (in role S and B) are confronted with 15 values of  $v$  randomly drawn by the computer. Participants in role B decide on a buying price BP for each of the 15 values of  $v_1, v_2, \dots, v_{15}$ , and participants in role S choose a minimum selling price SP for each of the 15 values. At the end of the experiment, one of these values  $v$  is randomly selected for each round and then used to determine the earnings of sellers S and buyers B as in phase 1. The difference to phase 1 consists only in the fact that all participants – instead of just the participants  $[(NI \rightarrow II): \text{in role } S]$   $[(IN \rightarrow II): \text{in role } B]$  – make their decisions in each of the three rounds based on knowing the 15 different values of  $v$ .

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