Voluntary Disclosure of Negative Information: Experimental Analysis

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Abstract

We study sellers' willingness to voluntarily disclose negative information about product's quality and its effect on sellers' profit and social welfare. We design an experiment where the seller sends a cheap-talk message about its product's quality and buyers use this information, as well as the product's price set by the seller, to determine whether to purchase the product. We show that sellers did use cheap-talk messages to communicate their low quality; revealing negative information had mostly insignificant effect on profit, and its effect on total welfare was positive.

Keywords: Negative Information, Lemon Market, Experiments

JEL Codes: C9, D21, L15

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1 Introduction

One of the most common settings with asymmetric information in economic literature is a setting where sellers know the quality of the product they sell while buyers do not know the quality of the product they consider to buy. The literature studying this setting is well-established and has focused primarily on tension between customers who want more information on quality and low-quality sellers who would like to hide it (Dranove and Jin, 2010).

More recently, however, some of the attention in the literature started to turn towards incentives of low-quality sellers to *reveal* rather than *hide* negative information about their product's quality. Board (2009) has shown that in the framework with risk-neutral buyers where information disclosure is costless, credible, and verifiable, low-quality sellers may disclose their types if the loss from lower perceived value is smaller than the gain from decreased competition with high-quality sellers. Guo and Zhao (2009) have considered a duopoly setting where private information can be credibly and truthfully, though not costlessly, disclosed. In their setting, duopoly sellers can voluntarily disclosing quality information even when the quality is not the highest, in order to achieve differentiation and avoid direct competition. In presence of frictions, such as search or marching frictions, Kim (2012) and Gardete (2013) have shown that low-quality sellers may want to reveal their types because it can either reduce the search cost for buyers or increase competition between buyers and, therefore, increase sellers' profit.

Shapiro and Huh (2018), which is the most relevant work for the current paper, pushed the focus on low-quality sellers to the extreme, in a sense that they develop a framework where there is no market frictions and no tools that would allow high-quality sellers to signal their quality and separate. In Shapiro and Huh (2018), hereafter SH, there is no certification available, no repeated interaction, no brands, and no reputation. The only way sellers can affect buyers' beliefs about product's quality is by sending a cheap-talk message. Thus, any strategy, including a message, employed by high-quality sellers can be costlessly imitated by low-quality sellers. SH show that in their framework there are equilibria where low-quality sellers separate with positive probability instead of imitating high-quality sellers. There are two factors that can incentivize low-quality sellers to reveal negative information are. First, revealing one's quality, whether it is low or high, reduces the risk associated with the purchase, and increases buyers willingness to pay if buyers are risk or loss-averse. Second, revealing one's quality allows a seller to differentiate one's product from the competitor's, thereby softening the competition and increasing one's profits.

In this paper, we design and conduct an experiment that is closely based on the SH framework and study the following questions: in the framework where the only way to communicate one's quality is a cheap-talk message will we observe low-quality sellers sending a message that communicates having a low-quality product? How revealing negative information affects sellers' profits and the overall welfare?

The experiment is designed as follows. Depending on a treatment there were either one seller (monopoly treatments) or two sellers (duopoly treatments) on the market. Sellers were either participants (human treatments), or computers who were programmed to play according to equilibrium strategies (robot treatments). In every treatment there were exactly two buyers per market. The timing was as follows. First, sellers observe the quality of their product — high or low — and buyer's prior beliefs about products having high quality. Sellers can send one of the two messages: "*I sell a high-quality product*" or "*I sell a low-quality product*". Second, the pricing stage begins. In the pricing stage sellers observe their own message and, in duopoly treatments, the message of the other seller. Based on this information sellers determine the price of their product. Finally, buyers observe the prior probability of the product being a high-quality as well as all the information provided by the sellers, i.e. prices and messages. In the monopoly treatments buyers then decide whether to purchase the product or not. In the duopoly treatments buyers decide whether to purchase the product, and from which seller to purchase it.

By design, messages sent by sellers are cheap-talk messages and do not directly affect sellers' profit. Furthermore, we used "strangers"-design wherein groups were randomly re-assigned at the beginning of each period and thus sellers could not build reputation for honesty, and buyers could not punish sellers for dishonesty. Nonetheless, low-quality sellers being honest about their quality was common across treatments. While human sellers were less honest — we will use term honest specifically to refer to low-quality sellers revealing the low-quality of their product — than in equilibrium, propensity to reveal negative information was positive throughout all treatments and for all parameter values.

The effect of revealing negative information on profit was very modest and mostly statistically insignificant. There were three parameter combinations when the effect of revealing negative information on profit was significantly positive and two parameter combinations when it was significantly negative. In all other instances, it was insignificant. From a theoretical point of view, in the SH-framework's equilibrium low-quality sellers are indifferent between low- and high-quality messages and send both messages with positive probability. This result is consistent with theoretical predictions and, most importantly, indicates that, contrary to expectations, revealing negative information does not negatively affect seller's profit.

The effect of revealing negative information on welfare depends on whether we account for buyers' risk-attitude or not. If we measure welfare using combined buyers' and sellers' payoffs then in the monopoly treatments the effect is positive and is significant for many parameter values. In monopoly treatments, the only factor that mattered for social welfare is whether the product was purchased or not. Revealing one's low-quality greatly increased buyers' willingness to purchase the product, especially, when the likelihood of high-quality products was low. For duopoly treatments, on the other hand, the effect on welfare was less pronounced. Revealing negative information would attract many buyers towards purchasing a product from a low-quality seller. That would negatively affect social welfare as high-quality products were less likely to be purchased. If, however, we account for buyers' risk-attitude and the fact that buyers experience disutility when purchasing the product of uncertain quality then it changes the result. Purchasing the product from a low-quality seller whose quality is known adds extra social benefit as it removes any risk associated with a purchase. When this effect is taken into account then revealing negative information has mostly positive impact on social welfare.

Finally, for duopoly treatments we study whether revealing negative information can be used as a tool to introduce product differentiation and soften the competition between the two sellers. From theoretical point of view, if both sellers send the same messages then buyers have the same beliefs about both products' quality and will purchase the cheapest. In equilibrium, it would result in Bertrand competition and zero profit for sellers. When, on the other hand, the sellers send two different messages it creates product differentiation as now more loss-averse buyers would prefer a safer product, the one with a known but lower quality, and less loss-averse buyers would prefer a product with uncertain but higher expected quality. It turns out that when buyers observe different messages their demand becomes less price sensitive than when the two messages are the same. If, however, we look at whether less intensive competition results in a higher joint profit for the two sellers the answer is negative. In treatments with human sellers, joint profit was not significantly higher after two different messages. Similarly to the welfare analysis, the reason is that in the asymmetric case of different messages many buyers would choose to purchase a product with known low-quality. It limited profitability of the asymmetric-message case since the price of known low-quality product was lower.

2 Literature Review

One of the first experimental studies of the setting with asymmetric quality information was done in Miller and Plott (1985). In their experiment sellers had unobservable initial quality which they could improve upon by adding units of quality. The latter decision was observable by buyers and was designed in such a way that would allow for signalling equilibria. Both separating equilibrium — including the most efficient separating equilibrium — and pooling equilibria were observed. Lynch et al. (1986) develop an experiment based on the standard "lemon" market model as benchmark and test how a possibility of warranties or advertisement affects the benchmark outcome. Thus, differently from our model there was no cheap-talk communication, and the market organization was modeled to match the perfectly competitive environment.

The question of information disclosure in the experiments with asymmetric quality information has also been studied since the eighties. A well-known theoretical result, called unraveling, is that if sellers can truthfully and costlessly reveal their quality then in equilibrium we should expect full disclosure. Forsythe et al. (1989) studies this argument in the auction setting, where an auctioneer could reveal the true quality or choose to auction his object using blind bidding. While not instantaneously the full disclosure equilibrium was attained via the standard unraveling mechanism. King et al. (1991) reached a similar conclusion. They showed that unless buyers have no knowledge of disclosure options, the sellers moved towards full disclosure. In a more recent work, however, Jin et al. (2015) showed that receivers are not sufficiently skeptical about the non-disclosure. That makes non-disclosure optimal for senders when the underlying state is intermediate rather than high. Jin et al. (2015) still report convergence towards full-disclosure equilibrium but at a slow rate. In a labor-market setting where the private information can be disclosed but at a cost, Benndorf et al. (2015) as well Benndorf (2018) also observe unraveling though not as frequent as equilibrium would predict. The experimental papers on unraveling differ from our setup in that the sender, or the informed party, had an option of truthfully reveal the private information. In our setting such option as the cheap-talk is the only was of communicating quality.

Forsythe et al. (1999) consider a setting where a seller of financial asset can send a cheap-talk message about the quality of his asset. The message is a subset of qualities, rather than the exact quality, and depending on parameters it can be either anything (cheap-talk treatment) or it has to include the true quality (antifraud treatment). They show that buyers tend to believe the cheap-talk messages and overpay the product. Thus, the cheap-talk treatment produced a different outcome than no-communication treatment. Furthermore, just like in our experiment, in the cheap-talk treatment not all sellers were exaggerating their quality. That included instances where low- and medium-quality sellers would honestly report their quality, i.e. the subset of announced qualities consisted of one element — the true quality. Siegenthaler (2017) used a theoretical framework of Kim (2012) to experimentally show that cheap-talk communication can reduce market inefficiency in the lemon market setting and alleviate the adverse selection. Just like in Kim (2012), he considers the setting with search and matching market frictions and confirms the theoretical predictions of Kim (2012). Specifically, that there exists partially separating equilibrium with informative cheap-talk communication. Our setting is different in that we do not introduce market frictions to our experimental design. Outside of experimental setting, Elfenbein et al. (2018) used eBay data on charitable giving to verify whether cheap-talk messages affect probability of sales and the purchasing prices. They found that during the post-Katrina period auctions with cheap-talk (or unverifiable) charitable messages have lower probability of sale than auctions linked to verifiable charitable contributions. Outside of post-Katrina period, cheap-talk had no effect (or a weak positive effect) on a listing's sale probability or price. That is, people respond to cheap talk messages both in experimental and real life settings.

All of the studies above either looked at the monopoly setting or the setting which was close to perfect competition. There are also papers the look at the matter of disclosure and asymmetric quality information in the duopoly setting. Experimental papers with duopoly/oligopoly setting focused on disclosure of information among sellers about, for example, the industry-wide conditions and document subjects being strategic in which information they disclose (Ackert et al., 2000; Jansen and Pollak, 2015). Pigors and Rockenbach (2016) look at firms' honesty towards the third party (workers) that are not present in the experiment but can reduce sellers' cost. They show that in duopoly setting being honest is profitable. Finally, Dulleck et al. (2011) look at market with credence goods where a seller can over- or undertreat the consumer without the consumer realizing it. In particular, they look at the monopoly setting versus setting with multiple sellers and show that the competition drives down the prices but does not yield higher efficiency.

3 Theoretical Framework and Experimental Design

3.1 Theoretical Background

The experimental design is based on the Shapiro and Huh (2018), hereafter SH, framework. The simplified SH framework that was used as a basis for the experimental design is as follows. There is a seller who sells a product with exogenously given quality, which can be either v_L or v_H with $v_L < v_H$. The probability of the product being of high quality is q. Buyers do not observe seller's quality. Seller's cost is set equal to zero regardless of quality. Depending on the treatment, there can be either one seller (*monopoly* treatments) or two sellers (*duopoly* treatments) per group.

The SH-framework, as applied to our experimental setting, is as follows. The game starts with the messaging stage. A seller observes the quality of his product, which can be high or low, buyers' prior beliefs about his product being of high quality, q, and in some treatments the quality of the competitor's product. The seller then sends one of the two messages: "*I sell a high-quality product*", which we will denote as mH or "*I sell a low-quality product*", which we will denote as mL. The message is public and is cheap-talk as it has no direct effect on payoffs. After sending the message the pricing stage begins. In the monopoly setting the seller sets the price. In the duopoly setting, the seller observes the message of another seller and then sets the price, i.e., in the duopoly setting prices are set simultaneously but after both sellers send their public messages. Finally, it is buyers' stage. There are two buyers. Each buyer observes the message and the price of each seller. The buyer then decides whether to purchase the product and, in the case of the duopoly, from which seller to purchase the product.

The seller's payoff is the number of sales times price

$$\pi_s = Sales \cdot p_s;$$

the buyer's realized payoff is the quality of the purchased product minus the price paid

$$\pi_b = v - p_s.$$

In the SH framework buyers were assumed to be loss-averse with the reference point being the expected quality. Let μ be a buyer's beliefs about purchased product's quality, v be actual quality and p the price at which the product is purchased. Then buyer's ex-post utility is

$$u_b(v,p,\mu) = \begin{cases} v - p & \text{if } v \geq E_m v \\ v - p + b(v - E_m v) & \text{if } v < E_m v \end{cases} \quad (1)$$

Here b is the degree of loss-aversion. When calculating equilibrium strategies we assumed that $b \sim U[0, B]$. We set $B = 2.8$ to match the median loss-aversion in South Korea, which is 1.4 (Wang et al., 2017). $E_m v$ is expected quality of the product given message m. In the case of two qualities v_L and v_H, if q_{Lm} is probability of low-quality product v_L given message m then then $E_m v = q_{Lm} v_L + (1 - q_{Lm}) v_H$.

The theoretical equilibrium of the model is as follows. In the case of the monopoly, the seller of the high-quality product sends message m_H with probability 1. The seller of low-quality product sends message m_L with probability λ and message m_H with probability $1 - \lambda$. Message m_L is interpreted as revealing negative information. The low-quality seller is indifferent between either of the messages. Given seller's strategy, in equilibrium buyers' beliefs are: if the message is m_L then $q_{LL} = Pr(v = v_L | m = m_L) = 1$, if the message is m_H then

$$q_{LH} = Pr(v = v_L | m = m_H) = \frac{(1-\lambda)(1-q)}{(1-\lambda)(1-q) + q}, \tag{2}$$

Taking expectations, the buyer's ex-ante utility conditional on m_H is

$$Eu_b(v, p, q_{LH}) = q_{LH} v_L + (1 - q_{LH}) v_H - p + q_{LH} \cdot b \cdot (v_L - q_{LH} v_L - (1 - q_{LH}) v_H).$$

The last term is calculated based on the fact that the probability of buying the low quality product after the high-quality message — and receiving a loss — is q_{LH}, and that the loss is equal to $(v_L - E_m v)$. The buyer will purchase the product if $Eu_b(v, p, q_{LH}) > 0$ and, therefore, the demand function is given by $D_{q_{LH}}(p) = \Pr\{b | Eu_b(v, p, q_{LH}) \geq 0\}$. One can then use standard maximization problem to calculate the optimal equilibrium price.

In the case of duopoly, the equilibrium is as follows. A high-quality seller sends message m_H with probability 1, and a low-quality seller randomizes between m_L and m_H with probabilities λ and $1 - \lambda$. Buyers' beliefs are similar to those in the monopoly setting: if the message from seller i is m_L they expect the quality of seller i's product is v_L with probability 1. If the message is m_H they expect quality to be v_L with probability q_{LH}, where q_{LH} is given by (2). Then at the pricing stage if both messages are the same, i.e. if messages are either (m_L, m_L) or (m_H, m_H), then sellers play Bertrand equilibrium and charge prices zero. This is because from buyers' point of view the two sellers are identical and they purchase the cheapest product. If messages are different then the sellers play a version of a pricing game with horizontally differentiated products and charge non-zero prices (p_L, p_H) that we calculate given the equilibrium derived in SH. Prices are non-zero because more loss-averse buyers will prefer the m_L-product as this is the product that does not have quality uncertainty. Less loss-averse buyers will prefer the m_H-product as this is the product with higher expected quality and they are less sensitive to quality uncertainty. Finally, given the messages and pries buyers choose whether to buy the product from seller 1 or seller 2.[1]

[1] In the SH's equilibrium in the duopoly framework it was assumed that all buyers purchase the product. In the actual experiment where duopolistic sellers were played by computers 5.47% of buyers did not purchase anything.

3.2 Experimental Design and Procedures

3.2.1 Treatments and Parameter Values

In total, 5 treatments were conducted. The first four treatments differed in whether it is monopoly or duopoly and whether sellers were played by a computer or by actual participants:

- (MR), or monopoly-robot treatment: one seller played by a computer;
- (MH), or monopoly-human treatment: one seller played by a participant;
- (DR), or duopoly-robot treatment: two sellers played by a computer;
- (DH), or duopoly-human treatment: two sellers played by participants.

In the duopoly treatment above the product's quality is pure private information in that not only buyers but also other sellers do not observe it. In addition, the fifth treatment was conducted where in the duopoly setting two sellers were played by participants and they could observe each other's quality:

- (DHi), or duopoly-human treatment where quality information observable by a competitor.

In the computerized treatments, the computer played equilibrium strategies as derived in the SH paper. The (DHi) treatment does not have a robot equivalent since the SH framework assumed pure private values, and, in general, an equilibrium analysis of the setting without pure private values is more complicated even for the two-type case.

For each of the five treatments the values of q were taken from the set of $\{0.15, 0.3, 0.5, 0.7\}$ and the values of v_L and v_H were such that v_H/v_L was either 2.75 or 4.25. The numerical values were chosen so that the whole range of q is covered and so that theoretical equilibrium with negative information exists for as many parameter values as possible.[2] From theoretical point of view, the equilibrium is fully determined by q and v_H/v_L, though in the monopoly and duopoly settings equilibria would differ. With four values of q and two values of v_H/v_L there are, in total, eight $(q, v_H/v_L)$ pairs. Every treatment had 24 rounds with each $(q, v_H/v_L)$ pair being used three times.

The actual numerical values of v_L and v_H do not matter for theoretical equilibrium. In experiment we determined them as follows. Values of v_L were drawn from a uniform distribution and then v_H was calculated given v_L and the quality ratio v_H/v_L. The boundaries of the uniform distribution differed across treatments and were set in such a way so that cash payouts would be roughly similar across treatments.[3]

Computerized sellers were programmed to play according to the equilibrium strategies, as described in the previous section. The high-quality seller would always send message mH and the

Thus the is assumption is reasonably accurate.

[2] The only instance when the equilibrium with negative information does not exist is the (MR) treatment with $q = 0.7$.

[3] For (MR) v_L was generated using $U[4850, 5350]$; for (MH) using $U[5000, 5500]$; for (DR) using $U[1400, 1900]$; for (DH) using $U[3300, 3800]$ and for (DHi) using $U[2000, 2500]$.

low-quality seller randomized between mL and mH with probabilities λ and $1-\lambda$, where the value of λ is calculated according to the equilibrium of the SH framework. In the (MR) treatment, a seller sending message mL would charge price $p_L = v_L$. Given the equilibrium strategy, buyers face no uncertainty about the product quality and, therefore, their willingness to pay is equal to the product equality. A seller sending message mH would charge price p_H that is optimal given theoretical buyers' demand and $v_L < p_H < v_H$. In the case of (DR), computerized sellers would set price 0 after (mL, mL) and (mH, mH). After (mL, mH) the sellers would set positive price p_L and p_H that are determined according to the equilibrium of SH. Price $p_L < v_L$ and price p_H can be either greater than or less than v_L and is always less than v_H. For example, for pair $(q, v_H/v_L) = (0.3, 4.25)$ the price values were $p_L \approx 0.99v_L$ and $p_H \approx 1.28v_L$. For pair $(q, v_H/v_L) = (0.7, 2.75)$ the price values were $p_L \approx 0.18v_L$ and $p_H \approx 0.75v_L$.

3.2.2 Procedures

We conducted 8 experimental sessions at Seoul National University in Seoul, Korea. 120 university students were recruited for the 8 sessions of 5 treatments.[4] Each session hired 12 or 16 subjects depending on the treatment and took about an hour. The subjects were recruited through online and offline advertisements.[5] For each session, subjects were seated in the laboratory according to the order of arrival to the session. As the session started, the experimenter read out loud the experimental instructions and subjects were also instructed about the experiment in written form. As the subjects signed the consent forms, the experiment started.

Each treatment had eight markets at every period. Each market consists of two buyers, zero human sellers in (MR) and (DR), one human seller in (MH), and two human sellers in (DH) and (DHi). Thus, in (MR) and (DR) treatments there were 16 subjects, in (MH) there were 24 subjects and in (DH) and (DHi) there were 32 subjects.

Each treatment started with subjects reading the instructions. Instructions were in Korean language. Subject were also given Korean translation of English terms displayed on the monitor. After reading instruction, participants had a chance to ask questions.

The experiment was used designed using software zTree (Fishbacher, 2007). First, participants played three practice rounds. The values for v_L in practice rounds were set in $[0, 10]$ to clearly separate the practice rounds and actual rounds. Practice rounds were programmed in such a way that in human treatments each subject had a chance to play both roles – of a seller and of a buyer – at least once. In robot treatments, all subjects played only buyers during practice rounds. After the practice rounds the actual experiments starts. As mentioned earlier, each treatment had 24 rounds. The order in which pairs $(q, v_H/v_L)$ were used was determined at random, however, each pair was used exactly three times.

[4]For each of the treatment (MH), (DH), and (DHi), we ran two sessions and for (MR) and (DR), one session were conducted for each.

[5]The online advertisement was made via *snulife.com* and the posters were posted around the campus for the offline advertisement.

In each treatment, subjects were given three practice periods in which they experienced all the decision-making stages they would go through in a period. Then, 24 actual periods were conducted for the data collection and the payment.

In human treatments, subjects' role was determined randomly every period. In robot treatments, all subjects were buyers. The timing was as follows. First, sellers would see their quality, how much buyers valu it, as well as value of q. In (MH) each seller was told that he/she is the only seller in the market. In (DH) and (DHi) each seller was told that there was another seller on the market, and in (DHi) each seller could also see the quality of the other seller. Sellers had a binary choice of sending message "*I sell a high-quality product*" or "*I sell a low-quality product*". Second, after selecting the messages the pricing screen would appear. Sellers would observe their own message and the message of their competitor in the duopoly treatment. Sellers had to enter the price for their product. The price upper limit was v_H. That is, sellers could set price above v_L but not above v_H. After sellers enter their choices of prices the seller's stage ends. Naturally, there was no seller's stage in (MR) and (DR). In the buyer's stage, buyers would observe all the messages and the price. In monopoly treatments they could decide whether to purchase the product or not. In duopoly treatments they could decide whether to buy from seller 1 or seller 2 or not buy anything at all. Once buyers' decision was entered, the profit screen would appear. Sellers would learn how much they sold, how much their competitors sold and their own profit. Buyers would learn the quality of the product they purchased and their profit and the quality of the other seller's product. Then, one period would end and another would follow until it repeat 24 times.

Among 24 actual periods, 4 periods were randomly drawn for payoffs at the end of the session.[6] Subjects were paid either in cash at the end of the session or via bank transfer after the session.

4 Sellers' Behavior. Revealing Negative Information

In what follows we will use the following notations: m_i, where $i \in \{L, H\}$, means the seller sent message i. Thus, m_L stands for message "*I sell a low-quality product*" and m_H stands for message "*I sell a high-quality product*". Let v_i, where $i \in \{L, H\}$, to denote the seller's actual quality. We say that the seller reveals negative information if the low-quality seller sends low message, m_L. Finally, we use vR to denote the quality ratio v_H/v_L. For monopoly and duopoly settings the theoretical equilibrium is fully determined by q and vR.

4.1 Propensity to Reveal Negative Information

First, we look at whether subjects chose to disclose negative information. Table 1 shows proportion of low-quality sellers that sent message m_L. It follows from Table 1 that revealing negative information was very common across all treatments and happened for almost all values of q and vR. This

[6] We asked 4 subject volunteers to draw 4 random numbers which determined the 4 paying periods out of 24 periods.

	q				vR		Diff
	0.15	0.3	0.5	0.7	2.75	4.25	
(MR)	0.97	0.76	0.30	0.00	0.71	0.56	-
(MH)	0.59	0.43	0.18	0.15	0.52	0.30	**
(MR)-(MH)	***	***	-	-			
(DR)	0.62	0.62	0.45	0.28	0.52	0.56	-
(DH)	0.59	0.30	0.21	0.03	0.43	0.24	***
(DHi)	0.47	0.44	0.33	0.22	0.40	0.39	-
(DR)-(DH)	-	***	**	***			
(DR)-(DHi)	*	**	-	-			
(DH)-(DHi)	-	-	-	**			
(DHi)-L	0.50	0.45	0.22	0.28	0.43	0.41	-
(DHi)-H	0.39	0.40	0.39	0.16	0.34	0.34	-

Table 1: Propensity to reveal negative information conditional on being low-quality type. ***/**/* means significance at 1%/5%/10% level. '-' means the difference is insignificant. The significance is estimated using the proportion test. Rows (DHi)-L and (DHi)-H measure propensity of low-quality seller to reveal negative information when the competitor had low and high quality respectively. Column difference shows whether the difference in propensity to reveal negative information in $vR = 2.75$ and $vR = 4.25$ cases was statistically significant.

is despite the fact that there was no direct cost associated with misleading buyers and pretending to be of a high-type. Treatments (MR) and (DR), where computerized sellers played according to equilibrium, showed that in equilibrium sellers are less likely to reveal negative information when q is higher. In human treatments we observe similar pattern. Intuitively, when q is high then it is less beneficial to reveal negative information as buyers were more likely to believe m_H. Comparing robot and human-treatments, we see that human sellers' propensity to reveal negative information is lower. The only exception was the (MH) treatment where $q = 0.7$. In the monopoly treatments the difference was significant for values of $q = 0.15$ and $q = 0.3$. In duopoly treatments, the difference between (DR) and (DH) was significant for all values of q but 0.15[7]

When comparing propensity to reveal negative information across different values of vR we see that in all human treatments subjects were more likely to reveal negative information for low values of vR. The trade-off is as follows. When vR is high, buyers have higher quality uncertainty (e.g. as measured by variance of the quality) so revealing negative information has stronger effect on increasing buyers' willingness-to-pay. At the same time benefits of pretending to be of a high-quality type are higher. As we see from Table 1 the latter effect dominates in (MH) and (DH) making the difference statistically significant. In (DHi) the propensity to reveal negative information is the same for low and high vR.

[7]While, for the sake of completeness, we provide statistical analysis of the difference between (DR) and (DHi) the equilibrium strategies used for (DR) were calculated under assumption that sellers do not know each other quality.

Finally, by looking at the last two rows we see that with one exception of $q = 0.5$ sellers in the (DHi) treatment were more likely to reveal negative information when their competitor was of low-quality. On one hand, this is counter-intuitive as one reason to reveal negative information is to differentiate seller's product from that of the competitor. When the competitor's quality is v_H it is almost certain that the competitor would send message m_H thereby allowing the seller to introduce product differentiation by sending m_L. Nonetheless, as Table 2 shows, the (DHi) treatment was the most successful in creating message-based product-differentiation. The frequency with which both sellers sent the same messages, i.e. (m_L, m_L) or (m_H, m_H), is lowest in (DHi) for every q and vR with the only exception being $(DH, q = 0.15)$. Since cheap-talk messages is the only non-price factor that can vary between the two sellers, the theory predicts — and we will verify it using experimental data later — that demand is more price-sensitive when the two messages are the same. In (DHi) knowing each other's quality allowed sellers to be more successful in coordinating on sending different cheap-talk messages.

	q				**vR**	
	0.15	0.3	0.5	0.7	2.75	4.25
(DR)	0.54	0.54	0.71	0.83	0.65	0.67
(DH)	0.48	0.63	0.81	0.96	0.74	0.70
(DHi)	0.54	0.52	0.58	0.81	0.63	0.60

Table 2: Frequency of both sellers sending the same message.

Table 3 shows the results of fixed-effect xtlogit regressions with the dependent variable being whether the seller reveals negative information and independent variables being q, vR as well as whether the competitor's quality is low. In all treatments but (DHi) the only variables observable by the seller at the messaging stage are q and vR. In treatment (DHi), the seller also knows the quality of the competitor. Technically, the seller also knows the quality of his product but the dependent variable is defined only for low-quality sellers — in order to reveal negative information one needs to have it — so there is no variations in terms of sellers' actual quality.[8]

Consistently with theoretical predictions and the univariate analysis, the likelihood of high-quality product negatively impacts propensity to reveal negative information. When the likelihood of high-quality is low, sellers are more likely to be honest. When it is high, sellers find it beneficial to imitate high-quality sellers and are less likely to be honest. Similarly, in (MH) and (DH) when vR is high — so that benefits of imitating high-quality sellers are higher — sellers were less likely to be honest. And, just like it was in the case of univariate analysis, this effect disappears in (DHi). Finally, in (DHi) the quality of the competitor did not have any significant effect on seller's

[8]By design, the panel was not balanced as subjects' roles were randomly re-assigned every period. In the case of robot treatments, where there was no human sellers, for the purpose of fixed-effects analysis the seller's id was associated with the group number. For example, in (MR) robot-seller's actions in, say, Group 1 was treated as the same seller throughout all rounds.

willingness to reveal negative information.

	(MR)	(MH)	(DR)	(DH)	(DHi)
q	-12.67***	-4.175**	-2.232***	-7.641***	-3.925***
	(-5.23)	(-1.99)	(-2.82)	(-5.06)	(-3.54)
vR	-1.146**	-0.881**	0.0689	-0.434*	-0.0936
	(-2.44)	(-2.26)	(0.38)	(-1.66)	(-0.39)
IsCLow			-0.113	0.210	0.163
			(-0.36)	(0.45)	(0.40)
pseudo R^2	0.590	0.245	0.043	0.329	0.111
N	109	64	227	172	177

Table 3: Regression analysis using fixed-effect xtlogit. The dependent variable is whether a (low-quality) seller sent message m_L. ***/**/* means significance at 1%/5%/10% level. t-statistics is parenthesis.

Result 1: *Revealing negative information was very common across all treatments. Human sellers were revealing negative information less frequently than robot sellers who were playing equilibrium strategies.*

Result 2: *Sellers were more likely to reveal negative information when the prior probability of high-quality product, q, was lower. In (MH) and (DH) sellers were more likely to reveal negative for the low value of vR.*

Result 3: *In the (DHi)-treatment the frequency of two sellers sending two different messages was the highest.*

4.2 Effect of Revealing Negative Information on Profit

Next, we look at the effect of revealing negative information on profit. On one hand, intuition suggests sellers who reveal their negative information should earn lower profit. On the other hand, in the SH-model the equilibrium strategy of low-quality seller involves mixing between low- and high-quality messages, that is, the sellers are indifferent between the two. The theoretical prediction, therefore, is that revealing negative information should not have a significant effect on profit.

Table 4 shows the difference in profits of sellers who reveal negative information and sellers who do not reveal. Profit values were normalized by v_L. Since only low-quality sellers have negative information to reveal, Table 4 includes low-quality sellers only. That does not create selection-bias issues as quality was assigned randomly. The positive (negative) entry means that sellers who revealed negative information earned higher (lower) profit on average. Whether the difference is significant was tested using Wilcoxon signrank test, and its results are reported in Table 4 as well.

	q				vR	
	0.15	0.3	0.5	0.7	2.75	4.25
(MR)	1.75**	0.17	-0.67**	-	-0.46	-0.50
(MH)	-0.01	-0.42*	0.23	0.593	-0.11	-0.16
(DR)	0.074	0.35**	0.19	0.12***	0.11	0.30
(DH)	-0.33	-0.18	-0.31	-0.71	-0.30	-0.54
(DHi)	-0.10	-0.47**	-0.14	-0.11	-0.35	-0.11

Table 4: Each cell shows the difference between average profits of those low-quality sellers who reveal negative information (send message m_L) and those who do not reveal (send message m_H). Positive (negative) sign means that the profit of those who reveal is higher (lower). The profit values were normalized with respect to v_L. Thus, a normalized value of v_L is 1; a normalized value of v_H is either 2.75 or 4.25; a low-quality seller who sells two items at $p = v_L$ earns normalized profit of 2. Wilcoxon ranksum test was used to see if the difference is significant. ***/**/* means significance at 1%/5%/10% level. '-' means that no low-quality seller revealed negative information.

Note that since only low-quality sellers were used for Table 4 sample sizes are naturally larger for lower values of q and smaller for higher values of q.

Looking at robot treatments we see that in (MR) revealing negative information resulted in significantly higher profit when $q = 0.15$. The difference is very large and is equal to 1.75. Given that the normalized price charged by a robot-seller who sent message m_L is equal to 1 and given that there are two buyers for each seller, so that the maximum possible profit is 2, it means that sellers who sent message m_H almost never made any sales. As q goes higher the profit difference declines and when $q = 0.5$ it becomes significantly negative. While it is intuitive that revealing negative information is more likely to be most beneficial for low q's we do not observe it in other treatments. As for the (DR) treatment, we also see that revealing negative information has positive effect on profit and the difference is significant for $q = 0.3$ and $q = 0.7$.

In human treatments, the effect of revealing negative information is noticeably less pronounced. There are both positive and negative entries. With few exceptions, most entires are insignificant even at 10% level. That means that there is no significant difference in profits of those who reveal and those who do not reveal negative information. The two instances when the difference was significant are (MH, $q = 0.3$) at 10% level, and (DHi, $q = 0.3$) at 5% level. In both instances, the difference was negative, that is sellers revealing negative information earned lower profit. Comparing robot and human treatments, we see that in human duopoly treatments honest low-quality sellers earned less than in (DR). The primary reason for that, as we will discuss later in more details, is that human sellers, unlike robot-sellers, were not playing Betrand equilibrium after same messages, (m_H, m_H) and (m_L, m_L). That decreased a relative profitability of the low-quality message.

Table 5 shows results of multivariate analysis of the effect of revealing negative information on profits. Again, on low-quality sellers for the fixed-effect panel-data regression. With the exception of the (DR) treatment revealing negative information does not have significant impact on seller's profit.

	(MR)	(MH)	(DR)	(DH)	(DHi)
q	1.771***	0.315	0.121	0.799*	-0.170
	(3.83)	(0.50)	(0.87)	(1.91)	(-0.57)
vR	0.164	-0.00215	0.0157	0.0638	-0.0823
	(1.65)	(-0.01)	(0.50)	(0.66)	(-1.07)
pNSeller	0.573	0.0468	1.098***	-0.208*	-0.160*
	(0.96)	(0.22)	(6.77)	(-1.76)	(-1.75)
Reveal	0.236	-0.0315	0.196***	-0.225	-0.194
	(0.91)	(-0.10)	(3.14)	(-1.17)	(-1.28)
mComp			0.167***	-0.182	0.0322
			(2.76)	(-1.01)	(0.25)
pNComp			-0.118	0.594***	0.358***
			(-0.78)	(5.91)	(4.87)
qualityComp					0.153
					(1.28)
Const	-0.109	1.505**	-0.288**	0.167	0.873***
	(-0.16)	(2.58)	(-2.08)	(0.43)	(3.12)
N	109	109	227	225	237

Table 5: Multivariate analysis of the effect of revealing negative information on profit using fixed-effect panel-data regression. The dependent variable is seller's profit normalized by v_L. *pNSeller* is normalized price charged by the seller; *pNComp* is a normalized price charged by the competing seller; *Reveal* is a dummy variable equal to 1 if the seller revealed negative information; *mComp* is a dummy variable equal to 1 if the competitor sent message m_H; *qualityComp* is the dummy variable equal to 1 if the competitor has high quality. ***/**/* correspond to 1%/5%/10% significance level. t-statistics is in parenthesis.

This is consistent with what we observed in Table 4. Furthermore, we see that the competitor's message had little impact on the seller's profit with the exception of the (DR) treatment. We also, though, not reported on the paper did regression analysis for fixed values of q — it does not create endogeneity bias because q is exogenously determined. It does not lead to different results with the (DR) treatment being the only treatment where *Reveal* is significant.

Result 4: *Revealing negative information had modest impact on profit and most of the time, with a notable exception of the (DR) treatment, the impact was statistically insignificant. This is consistent with interpretation that sellers are indifferent between sending high-quality and low-quality messages.*

Result 5: *Even though it is not statistically significant, in duopoly treatments revealing negative information was less profitable in human treatments than in robot treatments. The reason is that human sellers did not play Bertrand equilibrium after the same-message-history.*

4.3 Revealing Negative Information and Welfare

In this section, we study the effect of revealing negative information on social welfare. To calculate social welfare we will use two different approaches. Under the first approach, we define social welfare equal to the sum of monetary profits of sellers and buyers. The advantage of this approach is that it is straightforward to implement as we can observe profit. The disadvantage is that this approach does not take account an important beneficial aspect of revealing negative information, which is that it removes quality uncertainty. A product with revealed negative information offers lower return (the product's quality is known to be low) with no risk (product's quality is known). Loss-averse buyers might find this more valuable than a product with higher but uncertain expected quality. Thus, under the second approach we define social welfare as a sum of sellers' monetary profits and buyers' utilities.

The first approach is implemented as follows. For each group (one/two sellers and two buyers) in a given treatment in a given period, we calculate group's welfare as average of seller(s)'s and buyers' normalized profits. Profits are normalized with respect to v_L. In treatments with computerized sellers their profits are calculated and treated in the same way as profits of human sellers. The second approach is implemented in a similar fashion but with one major difference: instead of using profits we use utilities. Since, unlike profits, utilities are not directly observed they are calculated based on the SH-framework's assumptions. We assume that sellers are risk-neutral and their utility is equal to their profits. When a buyer purchases a product from a seller who sent message m_L we assume that the buyer does not face any product uncertainty and, therefore, the buyer's utility is equal to the buyer' profit. In terms of equation (1), the second line is never realized since the product's quality is equal to what buyers expect. When a buyer purchases a product from a seller who sent message m_H there are two possibilities. Either the purchased product is of a high quality and then there is no loss and buyer's utility is equal to the buyer's profit (the first line in (1)), or the purchased product is of low quality in which case the buyer experiences loss $b(v_L - E_m v)$ (the second line in (1)). The value of b is set equal to the median value for South Korean population ($b = 1.4$). The value of $E_m v$ is calculated as $q_{LH}v_L + q_{LH}v_H$, where q_{LH} is the probability of getting the low quality product conditional on m_H. For robot treatments, we set q_{LH} equal to equilibrium values of q_{LH}. For human treatments, we set q_{LH} equal to the *actual* experimental value of q_{LH} in a given treatment for given values of q and vR. We use actual q_{LH} rather than equilibrium q_{LH} as human sellers did not play according to equilibrium strategies.

Since in order to reveal negative information one needs to have it, in the case of monopoly we only analyze welfare in groups where the actual seller's quality is v_L. In the case of duopoly, we analyze groups where exactly one seller has low quality, i.e. (v_L, v_H), and where two sellers have low-quality, (v_L, v_H). Ignoring uncertainty, in the first case, the monetary welfare of socially efficient outcome is $2v_H$; and in the second case it is $2v_L$.

Table 6 shows the difference in social welfare in groups where negative information was revealed and when it was not revealed. The positive entry means that social welfare is higher if the low-quality seller revealed negative information. Only groups were exactly one seller had low quality were used for welfare calculations, i.e., v_L for monopoly, and (v_L, v_H) for duopoly. All profits (and utilities) are normalized with respect to v_L. Unnormalized welfare of the socially efficient outcome in the monopoly case is v_L and in the duopoly case is $2v_H$. After normalization it becomes 1 in the monopoly case, and $2 \cdot vR$ in the duopoly case.

Several observation can be made based on Table 6. First, in the monopoly setting the effect of revealing negative information is welfare improving. That holds regardless of whether Profit or Utility is used for welfare calculations. This is because in the monopoly setting revealing negative information greatly increases buyers' propensity to purchase the product. For example, in the (MH) treatment with $q = 0.15$ an m_H product was purchased only 60% of the time while an m_L product was purchased 80% of the time; for $q = 0.3$ the numbers are roughly the same and equal to 73% for both m_L and m_H products; for $q = 0.5$ and $q = 0.7$ the m_L product was again more likely to be purchased: 61% of m_H products vs 75% of m_L were purchased when $q = 0.5$, and 59% of m_H products vs 100% of m_L products were purchased when $q = 0.7$. Since purchase of the product is a major contributor to the social welfare, it is not surprising that for the monopoly the effect is mostly positive. Looking at utility, rather than profit, further reinforces a socially beneficial effect of revealing negative information. In the case of monopoly now all entries are positive and significant at 1% level.

For the duopoly setting the results are more mixed. In the case of profits there are some negative entries, including two entries when the negative difference is statistically significant. The reason is as follows. In the case of duopoly welfare is determined by two factors: how many products were purchased and products of which quality were purchased. This is different from the monopoly where the second factor did not play any role since only v_L sellers were included. It turns out that in the duopoly setting revealing negative information had very modest effect on the first factor, as buyers

Table 6: **Welfare Effect of Revealing Negative Information when exactly one seller has low quality.**

Panel A: Profit (Reveal) - Profit(Not Reval)

	q				vR	
	0.15	0.3	0.5	0.7	2.75	4.25
(MR)	0.583**	0.185**	-0.01	-	-0.06	0.101**
(MH)	0.140*	0.005	0.092	0.272	0.063	0.098
(DR)	0.281	-0.16	-0.54**	0.133	0.004	-0.44**
(DH)	0.409	-0.26	-0.00	-	0.170	-0.13
(DHi)	-0.18	-0.21	0.024	-0.49	-0.03	-0.25

Panel B: Utility (Reveal) - Utility(Not Reval)

	q				vR	
	0.15	0.3	0.5	0.7	2.75	4.25
(MR)	0.583**	1.065***	1.318***	-	0.924***	1.569***
(MH)	0.625***	0.570***	0.752***	1.292**	0.675***	0.769***
(DR)	0.372	0.450	-0.22	0.719	0.363	0.111
(DH)	0.935***	-0.01	0.397	-	0.546***	0.344
(DHi)	0.016	0.106	0.581	-0.07	0.350	0.178

Table 6: Difference in average (normalized by v_L) social welfare when a seller reveals negative information vs when a seller does not. For monopoly only groups with v_L are included. For duopoly only groups with (v_L, v_H) are included. Positive sign means that social welfare in groups where negative information was revealed is higher. Wilcoxon ranksum test is used to see if the difference is significant: ***/**/* means that the difference is significant at 1%/5%/10% level. '-' means that there was no sellers who revealed negative information.

were very likely to make a purchase regardless of whether the negative information was revealed or not. For example, 5.47% of buyers did not purchase anything at all in the (DR) treatment and 12.76% in the (DH) treatment, which is much lower than 17.45% of non-purchasers in the (MR) treatment or 37.50% of non-purchasers in the (MH) treatment.

It is the second factor, i.e. products of which quality were purchased, that played a major role in determining the welfare effect of negative information. Consider, for example, the case of (DR)-treatment with $q = 0.5$, where revealing negative information resulted in significantly lower social welfare. In this particular case, every buyer purchased a product regardless of whether the negative information was revealed or not. Thus the first factor was not a contributor to any difference in welfare. What made a difference is that when a low-quality seller revealed to have negative information buyers were more likely to purchase the low-quality product. Specifically, if the low-quality seller revealed negative information then 75% of buyers would purchase the low-quality product. That is buyers preferred a safe option. In contrast, when the the low-quality seller did not reveal negative information so that the two messages are (m_H, m_H) then only 33% of buyers purchased the low-quality product. As evidenced from Table 6 such preferences for certainty resulted in buyers forfeiting possibility of getting a high-quality product in order to purchase a product with certain but low quality which ended up having negative effect on welfare.

Looking at Panel B, where we used utility rather than monetary profit to calculate welfare, a beneficial effect of revealing negative information, as one would expect, is much stronger. In Panel B most entries are positive and no negative difference is statistically significant. The effect of revealing negative information is the strongest in Monopoly treatments, where it is positive and statistically significant in every instance. In the duopoly the effect of revealing negative information is also primarily positive, though the difference is significant in only two instances.

Table 7: Welfare Effect of Revealing Negative Information when two sellers have low quality.

Panel C: Profit (Reveal) - Profit(Not Reval)

	q				**vR**	
	0.15	0.3	0.5	0.7	2.75	4.25
DR	0.028	-0.02	-0.05	-0.18	-0.04	0.043
DH	-0.04	0.058	0.035	0.05	0.054	-0.02
DHi	0.008	-0.00	0.15	0.15*	0.031	0.067**

Panel D: Utility (Reveal) - Utility(Not Reval)

	q				**vR**	
	0.15	0.3	0.5	0.7	2.75	4.25
DR	0.389***	0.596***	0.582*	0.642	0.411***	0.848***
DH	0.472***	0.333***	0.870**	0.564	0.369***	0.491***
DHi	0.234***	0.389***	0.502	0.328	0.219**	0.610***

Table 7: Difference in average (normalized by v_L) social welfare when a seller reveals negative information vs when a seller does not. Only groups where both sellers have low quality are included. Positive sign means that social welfare in groups where negative information was revealed is higher. Wilcoxon ranksum test is used to see if the difference is significant: ***/**/* means that the difference is significant at 1%/5%/10% level. '-' means that there was no sellers who revealed negative information.

Finally, Table 7 shows the effect of revealing negative information when both sellers have low-quality. Then, just as in the case of monopoly the second factor, i.e. which quality was purchased, becomes irrelevant as both products have low quality. Then removing uncertainty has major impact on utility-based welfare: most entries are positive and significant at 1% level. The effect on profit-based welfare is relatively weak. Most entries are close to zero, whether positive or negative, and the difference is significant in only two instances.

Result 6: *In the monopoly treatments, revealing negative information is welfare-improving both in* *terms of monetary payoffs and in terms of utilities.*

Result 7: *In the duopoly treatments, the effect of revealing negative information is weaker. A positive welfare effect of removing quality uncertainty is weakened by buyers purchasing (inefficient) low-quality product more frequently.*

4.4 Duopoly. Product Differentiation

In the theoretical framework with two sellers, the equilibrium outcome of the pricing subgame, i.e. the subgame that arises after both sellers sent their messages, varied depending on whether the two messages were the same or not. In the pricing subgame after either (m_H, m_H) or (m_L, m_L), the equilibrium outcome was the Bertrand competition with zero profit, as both products are informationally the same and all buyers purchase the cheapest product. In the pricing subgame after (m_L, m_H), however, products became horizontally differentiated. Less loss-averse buyers would prefer the product with uncertain but higher expected quality, more loss-averse buyers would prefer the product with lower but certain quality. Buyers' demand after (m_L, m_H) is, therefore, less price-sensitive which results in softer competition and positive profits for both sellers. In fact, as argued in the SH, the product differentiation is one of the reasons why sellers would choose to disclose negative information. Empirical evidence supporting the differentiation motive behind disclosure of negative information was given in Jin and Sorensen (2006).

As one would expect, however, in the experimental data human sellers did not play Bertrand competition. The average normalized price charged by sellers was 1.57 after (m_H, m_H), 0.81 after (m_L, m_L), and no human seller set the price equal to zero, which was their marginal cost. In this section we analyze whether, nonetheless, the subgame after different messages did result in softer competition or, more specifically, whether buyers' demand was less price-sensitive after (m_L, m_H) than after (m_H, m_H).

To see whether the intensity of price competition depends on whether sellers sent the same or different messages, we look at sales made by a more expensive seller. As a benchmark, in the most extreme case of Bertrand competition, a more expensive seller would make zero sales. We define a more expensive seller as the one who offers a lower expected consumer surplus. If messages are (m_H, m_H) or (m_L, m_L) then we assume buyers have the same beliefs about product's quality and, therefore, a more expensive seller is a seller who charges a higher price. If messages are (m_L, m_H) then buyers' beliefs about seller's quality depend on his message as follows. Buyers' beliefs about the product's expected quality of the m_L-seller are equal to v_L. Buyers' beliefs about the product's expected quality of the m_H-seller are equal to $E_m v = q_{LH} v_L + (1 - q_{LH}) v_H$. As before, the value of q_{LH} is calculated as $\Pr(v = v_L | m = m_H)$ based on the actual experimental data for each $(q, v_H/v_L)$ pair. That is, for each $(q, v_H/v_L)$ pair q_{LH} is the share of low-quality sellers among those who sent message m_H.

Table 8 shows average sales made by a more expensive seller for each of three messaging histories: (m_H, m_H), (m_L, m_H), (m_L, m_L). In the case of (m_L, m_H), which is the only asymmetric case, we

Δ **CS** $= [\max\{E_{m_1}v_1 - p_1, E_{m_2}v_2 - p_2\}$- $\min\{E_{m_1}v_1 - p_1, E_{m_2}v_2 - p_2\}]/v_L$												
	(DR)				**(DH)**				**(DHi)**			
	(0,1]	**(1,2]**	**(2,3]**	**> 3**	**(0,1]**	**(1,2]**	**(2,3]**	**> 3**	**(0,1]**	**(1,2]**	**(2,3]**	**> 3**
(m_H, m_H)	*	*	*	*	0.25	0.18	0.00	0.00	0.37	0.00	0.17	0.00
(m_L, m_H)	0.98	1.36	*	*	0.89	0.27	0.00	*	0.81	0.44	0.00	*
m_L**-sale**	0.98	1.36	*	*	1.23	0.29	0.00	*	1.08	0.53	0.00	*
m_H**-sale**	*	*	*	*	0.40	0.00	0.00	*	0.19	0.00	0.00	*
(m_L, m_L)	*	*	*	*	0.31	0.00	*	*	0.07	0.00	*	0.00

Table 8: Average sales made by a more expensive seller. The maximum number of sales a seller can make is 2. A seller is defined as more expensive if he offers lower expected consumer surplus (CS). CS is normalized by v_L. Thus, column $(0, 1]$ is average sales made by a more expensive seller when a difference in CS between two sellers is less than v_L, column $(1, 2]$ is when it is betwen v_L and $2v_L$ and so on. Rows (m_H, m_H), (m_L, m_H) and (m_L, m_L) correspond to sellers' messages. In the (m_L, m_H) case, row m_L-sale (m_H-sale) shows average sales by a more expensive seller when a more expensive is the seller who sent message m_L (m_H). * means no observation for a given cell.

also separately look at whether a more expensive seller who made a sale was the one that sent message m_L or message m_H. Recall that the maximum number of sales a seller can make is 2.

As a benchmark, we look at (DR)-treatment, where prices are determined according to the equilibrium. After (m_H, m_H) and (m_L, m_L) prices are equal to zero, so we do not have a more expensive seller.After (m_L, m_H), a more expensive seller is an m_L-seller who nonetheless makes positive sales. Buyers are willing to forgo expected surplus for the sake of certain quality. Same holds for other treatments. Comparing m_L-sale and m_H-sale rows across all three duopoly treatment, we see that buyers were overwhelmingly more likely to sacrifice the expected surplus in favor of purchasing the m_L-product as it offered more quality certainty. Thus, as one would expect, quality uncertainty was a factor in determining buyers' purchasing behavior by pushing them towards a purchase of more certain product.

Looking at (m_H, m_H) and (m_L, m_L) rows we see that same messages did not result in Bertrand's type of demand in that more expensive sellers made positive sales. The effect was more prominent in the (m_H, m_H)-case than in the (m_L, m_L)-case perhaps because buyers expected that more expensive product is more likely to have higher quality. Nonetheless, the average sales made by more expensive sellers in either (m_H, m_H) or (m_L, m_L) cases were much lower than in the (m_L, m_H) case.[9] That means that, as expected, price was a less crucial factor in the (m_L, m_H)-case than in the case where both messages were equal.

Table 9 showes results of fixed-effect xtlogit regression where the dependent variable is equal to 1 if a buyer purchased the product from a more expensive seller. Variable ΔCS is difference in

[9]The only exception is the (DHi)-treatment in the $(2, 3]$ column where in 1 out of 6 instances a more expensive seller made a sale.

	(DR)		(DH)		(DHi)	
q	-4.311**	-4.311**	-1.262*	-0.556	-0.313	0.0640
	(-2.05)	(-2.05)	(-1.78)	(-0.71)	(-0.49)	(0.09)
vR	-1.840*	-1.840*	0.331*	0.339*	0.0477	0.0408
	(-1.81)	(-1.81)	(1.65)	(1.68)	(0.27)	(0.22)
ΔCS	5.429**	5.429**	-0.694**	-0.217	-0.818***	-0.292
	(2.11)	(2.11)	(-2.50)	(-0.67)	(-2.85)	(-0.93)
ΔCS*IsSame		0		-0.989**		-1.680***
		(.)		(-2.34)		(-3.64)
N	132	132	380	380	380	380

Table 9: Fixed-effect xtlogit regression of buyers' willingness to purchase from a more expensive seller. The dependent variable is equal to 1 if a given buyer purchased from a more expensive seller and 0 otherwise. Variable ΔCS is the difference in consumers' expected surpluses as defined in Table 8. Variable ΔCS*IsSame is the interaction terms of ΔCS and a dummy variable that is equal to 1 if both sellers send the same message. In the (DR)-treatment variable ΔCS*IsSame was omitted due to collinearity.

expected consumer surplus. It is defined as in Table 8 and is non-negative. Variable ΔCS*IsSame is the interaction term of ΔCS and the dummy variable $IsSame$ that is equal to 1 if the two messages are the same.[10] As one can immediately see the interaction term ΔCS*IsSame is negative and significant at 1% level in (DH) and (DHi) treatments. It means that buyers are more sensitive to differences in expected consumer surplus when both sellers send the same two message. This is consistent with the notion that the demand is less price-sensitive after the (m_L, m_H) messages than after the (m_H, m_H) or (m_L, m_L) messages.

	q				vR	
	0.15	0.3	0.5	0.7	2.75	4.25
DR	-0.72***	-0.70***	-0.56***	-0.48***	-0.58***	-0.72***
DH	-0.08	0.007	0.154	-0.01	-0.08	0.185
DHi	0.105	0.309	-0.03	-0.20	0.045	0.069

Table 10: Difference between joint profits of two sellers when the two messages are the same, i.e. (m_H, m_H) or (m_L, m_L), and when the two messages are different, i.e. (m_L, m_H). Negative values mean that the joint profit is higher when the two messages are different. The profit is normalized by the expected quality, $E_m v = q_{LH} v_L + (1 - q_{LH})v)H$, where the value of q_{LH} is calculated as $\Pr(v = v_L | m = m_H)$ based on the actual experimental data for each $(q, v_H/v_L)$ pair. *** means significance at 1% level of the Wilcoxon ranksum test.

[10] As a robustness check we also run regressions with the interaction term of ΔCS and the dummy variable equal to 1 if (m_H, m_H). Results are very similar.

Finally, Table 10 shows that even though the post-(m_L, m_H) competition is less intense, in that demand is less price-sensitive, it did not result in higher joint profits. Each cell in Table 10 shows the difference in joint profits of two sellers when the two messages are the same, i.e. (m_H, m_H) or (m_L, m_L), and when the two messages are different, i.e. (m_L, m_H). Negative entries would mean that the joint profit after (m_L, m_H) is higher. The only time we have significantly negative entries, is in the DR-treatment where computerized sellers were programmed to play Bertrand equilibrium if both messages are the same and would earn zero profit. In treatments with human sellers, however, there are both positive and negative entries and none is significant. The primary reason why we do not observe higher joint profit after (m_L, m_H) is that, first, in our experiment the competition after the same messages was not as severe as Bertrand and sellers were making positive profit. Second, as we showed earlier, buyers were more willing to purchase product with the message m_L. Compared to the (m_H, m_H) outcome, that would negatively affect sellers' profit as the price of m_L product was usually below v_L.

Result 8: *In all duopoly treatments, buyers are more likely to sacrifice their expected consumer surplus in exchange of buying the product of certain quality.*

Result 9: *Different messages resulted in less intense price competition, but not in higher joint profits.*

5 Buyers' Behavior

In this section, we take a look at buyers' purchase decisions and profits across the treatments along with gender analysis. In the analysis, we control for the factors that could affect buyers' decisions such as the probability of high quality product in the market, q, the difference in values for high- and low-products as a ratio, $vR = vH/vL$, and the messages sent by the sellers.

5.1 Buying decision

Table 11 presents buyers' propensity to buy given the messages sent by sellers. In the monopoly treatments buyers received either m_H or m_L, whereas in the duopoly treatments the messages were one of the following three: two m_H's, two m_L's, or the combination of one m_H and one m_L. These cases for having different messages from the sellers were reflected in the table while for the duopoly treatments, for brevity sake, only the significance in the differences between (m_L, m_H) and (m_H, m_H) was included.[11]

First, the messages have stronger impact on buyers' willingness to buy in monopoly than in duopoly. This is because in duopoly propensity to buy any product (either from Seller 1 or Seller 2) was high regardless of the messages. Messages were more likely to determine which seller to purchase

[11] The comparison with (m_L, m_L) is less interesting in the cheap-talk setting.

		Mean	q				vR		Diff
			0.15	0.3	0.5	0.7	2.75	4.25	
MR	mL	0.853	0.875	0.840	0.786	no obs	0.794	0.912	*
	mH	0.810	0.417	0.565	0.902	0.948	0.855	0.766	*
	mL-mH	-	***	***	-	-	-	**	
MH	mL	0.754	0.820	0.694	0.722	0.700	0.786	0.705	-
	mH	0.570	0.565	0.617	0.564	0.547	0.607	0.541	-
	mL-mH	***	***	-	-	-	**	*	
MR-MH	mL	**	-	-	-	-	-	***	
	mH	***	-	-	***	***	***	***	
DR	mLL	0.911	0.933	0.889	0.875	no obs	0.875	0.938	-
	mLH	0.939	0.909	0.955	0.964	0.938	0.956	0.922	-
	mHH	0.959	0.818	1.000	0.983	0.963	0.970	0.948	-
	mLH-mHH	-	-	-	-	-	-	-	
DH	mLL	0.875	0.875	0.833	1.000	no obs	0.885	0.833	-
	mLH	0.907	0.920	0.861	1.000	0.750	0.960	0.862	*
	mHH	0.857	0.909	0.778	0.816	0.924	0.862	0.852	-
	mLH-mHH	-	-	-	**	-	*	-	
DHi	mLL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-
	mLH	0.926	0.864	0.913	1.000	0.944	0.986	0.868	***
	mHH	0.871	0.824	0.947	0.852	0.868	0.941	0.800	***
	mLH-mHH	-	-	-	**	-	-	-	
DR-DH	mLH	-	-	-	-	-	-	-	
	mHH	***	-	***	***	-	***	**	
DR-DHi	mLH	-	-	-	-	-	-	-	
	mHH	***	-	-	***	**	-	***	
DH-DHi	mLH	-	-	-	-	-	-	-	
	mHH	-	-	**	-	-	*	-	

Table 11: Propensity to buy by Message. Mean values are reported in the table. Wilcoxon test is used to see if the difference is significant. ***/**/* means that the difference is significant at 1%/5%/10% level. '-' means no significance.

from rather whether to purchase or not. In the monopoly, on the other hand, messages were more likely to determine whether a buyer purchases at all or not. Thus, there are more instances where the difference between m_L and m_H in the monopoly case is significant than between (m_L, m_H) and (m_H, m_H) in the case of duopoly.

Second, buyers were more likely to take a risk with robots and purchase the product after m_H in (MR) and (m_H, m_H) in (DR). However, since Table 11 does not control for prices one cannot determine whether the difference is due to buyers' trusting robot sellers or robot sellers charging lower prices. In treatments with human sellers, comparing propensity to buy after m_L vs m_H in monopoly and (m_L, m_H) vs (m_H, m_H) in duopoly we see that having m_L message increased propensity to buy. The differences are not necessary significant but are positive in all but one cases ($q = 0.3$, (DHi) treatment).

Finally, as expected, in the case of monopoly positive effect on buying propensity is particularly pronounced for low values of q and high value of vR, which is when the m_H message is riskier. For example, when vR=4.25, buyers with m_H buy significantly less than with m_L. Unlike the monopoly treatments, within each of the duopoly treatments messages affect little on buying decisions for different vR's, except in DH with vR=2.75. The effect of vR on buying decision is significant in the duopoly human treatments of DH with (m_L, m_H) and DHi with both (m_L, m_H) and (m_H, m_H). This suggests that with a higher vR, buyers buy less to avoid the risk of getting deceived.

		Buy				
	MR	**MH**		**DR**	**DH**	**DHi**
	(1)	(2)		(3)	(4)	(5)
q	7.031***	1.300	**q**	1.652	2.719**	1.460
	(2.80)	(1.33)		(0.89)	(2.38)	(1.40)
vR	0.737	0.413***	**vR**	-0.145	0.307	-0.570
	(1.37)	(2.69)		(-0.37)	(1.12)	(-1.61)
m	-0.433	0.023	**mHH**	0.413	0.151	-14.84***
	(-0.63)	(0.10)		(0.47)	(0.30)	(-23.17)
np	-4.97	-1.833***	**mHL**	0.541	0.559	-14.62***
	(-1.63)	(-5.14)		(0.24)	(1.16)	(-25.14)
Const	2.682*	1.541***	**npMax**	0.046	-0.432	-0.065
	(1.78)	(2.75)		(0.04)	(-1.53)	(-0.25)
			npMin	-0.451	-1.357***	-1.482***
				(-0.19)	(-2.84)	(-3.18)
			Const	2.46	2.097**	20.32***
				(1.39)	(2.32)	(14.70)
N	384	384	**N**	384	384	384
Pseudo R^2	0.149	0.241	**Pseudo** R^2	0.026	0.162	0.250

Table 12: Logit regressions of buying decision. np, $npMax$ and $npMin$ are normalized prices. mHH and mHL are dummy variables for the case that both sellers send mH and the case in which one seller sends mH and the other send mL, respectively. These are also used in the following analysis. Coefficient estimates are reported in the table and t-statistics are in parentheses. Standard errors are clustered at the subject level. ***/**/* means significance at 1%/5%/10% level.

Next, we explore what affect buyers' decisions among the potential factors.[12] Buyers' decisions are affected by not only the messages and prices suggested by sellers but also the exogenous factors

[12]Note that we use the OLS and logit regressions with clustered standard errors at the subject level for the completeness with the later section where gender is controled. Another reason to use logit instead of fixed-effect logit is that 'xtlogit, fe' did not give any results for the DHi treatment since the estimation was never-ending due to the "not concave" error occurred in the iterations for the estimation.

such as q and vR. Thus, we take into account for all these factors in Table 12. For the duopoly treatments in which there are two messages and two prices from duopolists, we take into account both if the messages signal high or low $((m_H, m_H)$ and $(m_H, m_L))$ and how high and low suggested prices ($npMax$ and $npMin$) affect buyers' decisions. Table 12 shows that buyers differently react to the exogenous and endogenous factors in the monopoly and the duopoly. In column (1) and (2) of the monopoly results, buyers seem to respond to the market conditions reflected by q and vR while their decisions are also affected by sellers' pricing with human sellers in column (2). The latter, i.e., the effect from sellers' pricing, is also observed in columns (3) to (5) for duopoly in which buyers' decisions are affected by the minimum prices of duopoly human sellers. This suggests that buyers react to exogenous market conditions with robot sellers whereas endogenous factors from sellers' messaging and pricing matter more with human sellers. In particular, the column (5) for DHi shows clear evidence that buyers reacted to both of sellers' messaging and pricing.

The above analysis on buyers' decision making can be summarized as follows:

Result 10: *Buyers are more likely to purchase in duopoly than in monopoly. Buyer are more likely to purchase products from robot sellers than from human sellers.*

Result 11: *In treatments with human sellers, buyers are less likely to purchase if no message m_L is available. That is, after m_H in (MH), and (m_H, m_H) in (DH) and (DHi). The effect is particular pronounced when the risk of buying after m_H is high, that is q is low or vR is high.*

Result 12: *Exogenous market conditions affect buyers' decisions with robot sellers whereas endogenous factors affect buyers' decisions with human sellers.*

5.2 Buyers' profit

In our experiment, buyers' profits are determined by both their buying decision and the differences between the prices and their values for the products. The mean values of normalized profits using vL are reported in Table 13. First, the mean of buyers' profit is significantly higher with m_H than with m_L in the monopoly treatments and with (m_H, m_H) than with (m_L, m_H) in the duopoly treatments. Also, these profits are significantly higher with m_H or (m_H, m_H) in the robot treatments than in the human treatments. This seems to be driven by buyers' higher propensity to buy from robot sellers than from humans as discussed in the previous section.

Second, when we compare buyers' profits for the different q values, for q=0.15 buyers' profits are higher with m_H in MR than in MH whereas those are higher with (m_H, m_H) in DR than in DH and DHi for all q's. In other words, buyers who received a message saying that the product is of high quality earn higher profits from the robot sellers than from the human. However, the profit comparisons between different messages within the treatments do not always show significant differences: yet it is significant for all q's in DR and for the low q's in MR, MH and DH.

For the higher value of vR, it is more likely that buyers' risk of getting deceived becomes higher but at the same time the rewards from obtaining a high-quality product are higher as well. This

Table 13: Buyers' profit by message

		Mean	q				vR		Diff
			0.15	0.3	0.5	0.7	2.75	4.25	
MR	mL	0.000	0.000	0.000	0.000	no obs	0.000	0.000	-
	mH	1.016	0.749	0.676	1.106	1.170	1.041	0.992	-
	mL-mH	***	***	*	-	-	***	-	
MH	mL	0.334	0.223	0.269	0.676	0.506	0.329	0.342	*
	mH	0.409	0.149	0.125	0.504	0.659	0.419	0.400	-
	mL-mH	*	**	-	-	-	-	-	
MR-MH	mL	***	***	***	**	-	***	***	
	mH	***	**	-	-	-	***	-	
DR	mLL	0.911	0.933	0.889	0.875	.	0.875	0.938	-
	mLH	0.697	0.730	0.444	0.593	1.485	0.864	0.519	***
	mHH	2.506	1.136	2.088	2.813	2.831	2.020	3.013	***
	mLH-mHH	***	***	***	***	***	***	***	
DH	mLL	0.492	0.563	0.264	0.322	.	0.549	0.248	-
	mLH	0.507	0.573	0.244	0.925	0.182	0.351	0.642	-
	mHH	0.761	0.418	0.679	0.545	1.071	0.705	0.812	-
	mLH-mHH	-	*	-	-	-	-	-	
DHi	mLL	0.779	0.682	0.940	0.500	0.960	0.844	0.706	**
	mLH	0.559	0.270	0.498	0.972	0.506	0.623	0.499	**
	mHH	0.934	0.390	0.624	0.954	1.319	0.895	0.974	-
	mLH-mHH	-	-	-	-	**	-	-	
DR-DH	mLH	**	-	-	-	-	***	**	
	mHH	***	***	***	***	***	***	***	
DR-DHi	mLH	-	**	*	-	***	**	-	
	mHH	***	***	***	***	***	***	***	
DH-DHi	mLH	-	*	***	-	-	**	-	
	mHH	-	-	-	**	-	**	-	

Notes: Profits are normalized using vL. Mean values are reported in the table. ***/**/* means that the difference is significant at 1%/5%/10% level. '-' means no significance.

may explain why the results for buying decisions in Table 11 does not seem closely associated with the results for profits in Table 13.

The regression results on buyers' profits are presented in Table 14. The results show that the probability of high quality product, q, is a significant factor in determining buyers' profit regardless of the market structure. The most interesting part is that sellers' messaging and pricing differently affect buyers' profits between monopoly and duopoly. In both monopoly and duopoly, sellers' messages are significant in determining buyers' profit with robot sellers whereas this factor is not significant with human sellers. In contrast, sellers' prices are significant in determining buyers' profits with human sellers in both monopoly and duopoly whereas this is not always true with

Table 14: OLS regressions of buyers' profit

	Normalized profit					
	MR	**MH**		**DR**	**DH**	**DHi**
	(1)	(2)		(3)	(4)	(5)
q	0.872**	1.513***	**q**	2.070***	1.344***	1.408***
	(2.67)	(5.10)		(5.75)	(3.30)	(4.66)
vR	0.014	0.206**	**vR**	0.522***	0.272***	0.065
	(0.34)	(2.58)		(5.79)	(4.01)	(0.81)
m	0.847***	1.161	**mHH**	1.123***	0.268	0.178
	(4.92)	(1.40)		(6.79)	(1.38)	(1.07)
np	-1.191	-0.529***	**mHL**	1.526***	-0.034	-0.194
	(-0.49)	(-8.11)		(4.99)	(-0.23)	(-1.38)
Const	-0.068*	-0.214	**npMax**	-1.827***	-0.078	0.067
	(-0.21)	(-0.82)		(-5.38)	(-0.80)	(0.78)
			npMin	-0.279	-0.809***	-0.561***
				(-0.50)	(-4.89)	(-4.23)
			Const	-1.484***	0.056	0.355
				(-4.57)	(0.24)	(1.28)
N	384	384	**N**	384	384	384

Notes: Coefficient estimates are reported in the table and t-statistics are in parentheses. Standard errors are clustered at the subject level. ***/**/* means significance at 1%/5%/10% level.

robot sellers. This suggests that buyers less trust human sellers' words.

Result 13: *Buyers' profits are higher with* m_H *in the monopoly but not necessarily higher with* (m_H, m_H) *in the duopoly.*

Result 14: *Buyers' profits are higher with robot sellers than with human sellers, which is mainly driven by the difference in their profits with* m_H *and* (m_H, m_H) *in the monopoly and the duopoly, respectively.*

Result 15: *Unlike the case with robot sellers, cheap-talk messages do not affect buyers' profits with human sellers while prices do.*

6 Miscellaneous

6.1 Comparison between monopoly and duopoly

In this section, we pool the data from monopoly and duopoly treatments and compare how the outcomes differed between the two market structures. Table 15 compares buyers' propensity to purchase the product (regardless of the cheap-talk message), buyers' profit, sellers' profit and welfare

	Mean	q				vR		
Panel A: Propensity to Buy								
	Mean	0.15	0.3	0.5	0.7	2.75	4.25	Diff
Monopoly	0.725	0.729	0.677	0.740	0.755	0.753	0.698	*
Duopoly	0.907	0.892	0.903	0.913	0.920	0.936	0.878	***
M-D	***	***	***	***	***	***	***	
Panel B: Buyers' Profit (normalized by vL)								
	Mean	0.15	0.3	0.5	0.7	2.75	4.25	Diff
Monopoly	0.521	0.187	0.251	0.741	0.906	0.529	0.514	***
Duopoly	1.032	0.604	0.734	1.189	1.600	0.949	1.114	*
M-D	***	***	***	***	***	***	***	
Panel C: Sellers' Profit (normalized by vL)								
	Mean	0.15	0.3	0.5	0.7	2.75	4.25	Diff
Monopoly	1.787	1.545	1.487	1.917	2.200	1.632	1.943	**
Duopoly	0.689	0.603	0.643	0.725	0.786	0.622	0.757	
M-D	***	***	***	***	***	***	***	
Panel D: Welfare (normalized by vL)								
	Mean	0.15	0.3	0.5	0.7	2.75	4.25	Diff
Monopoly	2.309	1.732	1.738	2.658	3.107	2.161	2.456	
Duopoly	1.721	1.207	1.378	1.914	2.386	1.571	1.872	
M-D	***	***	***	***	**	***	***	

Table 15: Comparison of outcomes in monopoly and duopoly treatments. Wilcoxon ranksum test is used to see if the difference is significant: ***/**/* means significance at 1%/5%/10% level. Welfare is calculated using profits and is not adjusted for risk.

in monopoly and duopoly treatments. Column "Mean" uses all data from monopoly and all duopoly treatments. Columns with q and vR use data from monopoly and duopoly treatments for given values of q and vR respectively. Rows "M-D" show where the difference between monopoly and duopoly was significant. Finally, column "Diff" shows whether the difference between $vR = 2.7$ and $vR = 4.25$ was significant. As before, ***/**/* means significance at 1%/5%/10% level of the Wilcoxon ranksum test.

Panel A shows that buyers were more likely to a purchase in duopoly treatment rather than the monopoly treatment. Furthermore, for high values of vR, which correspond to higher level of risk, buyers were less likely to purchase the product. The profit comparison between monopoly and duopoly treatments is as expected: buyers' had a higher profit in duopoly and sellers' had a higher profit in monopoly. Furthermore, higher value of q and, therefore, a higher likelihood of more valuable high-quality product, had a positive effect on both buyers' and sellers' profits. In the case of duopoly both buyers' and sellers' have higher profit when $vR = 4.25$ then when $vR = 2.75$ which is corollary of the fact that there is more gains to trade when vR is higher. In the case of monopoly, however, buyers' profit was slightly lower for $vR = 4.25$ which is consistent with the fact that buyers were less likely to purchase the product.

Finally, the welfare in monopoly is higher than the welfare in duopoly. While somewhat counter-intuitive this is due to the aforementioned fact that revealing negative information in the duopoly setting made buyers gravitate towards low-quality products. Given that Panel D used monetary profit to calculate welfare, and given that purchase of low-quality products results in lower welfare gains we have that welfare in the duopoly setting was actually lower than in the monopoly setting.

Result 16: *Buyers' profits are higher in duopoly than in duopoly and are higher with high q's in both monopoly and duopoly. Sellers' profits are higher in monopoly and are also higher with high q's.*

Result 17: *Buyers are more likely to purchase in duopoly than in monopoly, however, a higher likelihood of trade does not result in higher duopoly's welfare. The welfare in duopoly is lower than in monopoly as buyers have preferences over products with low-quality message, which are of a lower quality.*

6.2 Gender comparison

We have investigated gender differences in both sellers' and buyers' behaviors. For the sellers, their decision on revealing negative information and the corresponding profits have been reported by gender in Table 16. Only the results for the low-quality sellers in the human treatments are included in the table. We find no significant differences in any comparisons for the sellers unlike the buyers' results in Table 17.

Both buyers' propensity to buy and their profits given sellers' messages are presented by gender in Table 17. The propensities to buy differ between male and female except in MH. Male buyers buy more often with m_H in MR and with any messages in DR than female buyers whereas this is not true in all human treatments where with m_H female buyers have higher propensities to buy. In DH and DHi female buyers with (m_H, m_H) buy significantly more often than male buyers. Moreover, male buyers are more likely to purchase products from robot sellers than female buyers whereas female buyers are more so with human sellers (yet note that the difference between gender groups in MH is insignificant).

When looking at buyers' profits, however, the significant differences in buying decisions between male and female buyers do not necessarily result in different profits. In addition, male buyers differentiate their buying decisions with m_H and (m_H, m_H) between the robot and the human

Table 16: Low-quality sellers' propensity to reveal negative information and profits by gender

Reveal	**Female**	**Male**	**Diff**	**Profit**		**Female**	**Male**	**Diff**
MH	0.422	0.391	-	**MH**	Not reveal	1.654	1.767	-
					Reveal	1.554	1.565	-
					NR-R	-	-	
DH	0.357	0.500	-	**DH**	Not reveal	1.150	0.985	-
					Reveal	0.838	0.606	-
					NR-R	-	-	
DHi	0.440	0.528	-	**DHi**	Not reveal	0.827	0.904	-
					Reveal	0.725	0.595	-
					NR-R	-	-	

Notes: Profits are normalized using vL. Mean values are reported in the table. '-' means no significance.

treatments and therefore, successfully attain higher profits from robot sellers than from human sellers in both the monopoly and the duopoly. This is less clear for female buyers in the duopoly treatments.

Result 18: *Female buyers are less likely to buy from robot sellers than the male whereas they are more likely to buy from human sellers than the male.*

Result 19: *Gender difference explains little about buying decision and profits.*

7 Conclusion

In this paper we provide an experimental study of sellers' incentives to disclose negative information about their product. Following the Shapiro and Huh (2018) theoretical framework we consider a setting where a seller can communicate the quality of his product using cheap-talk message only. We consider treatments where sellers are played by computers so that the focus is on buyers' behavior as well as treatments where both sellers and buyers are played by experiments' participants. In addition to robot/human variation, we also vary the market structure and information across treatments. Specifically, the seller can be a monopolist or a duopolist and, in the case of duopoly, seller's quality can be either pure private information, i.e. known only to the seller himself, or it can be known by the competing seller as well.

We show that revealing negative information occurred in all treatment and virtually all parameter values. While earlier experimental papers have documented many instances where private information is communicated honestly despite monetary incentives to lie, e.g. due to lying aversion or guilt aversion, we show that subjects' willingness to be honest varies with experimental parameters, such as probability of high-quality product, and between treatments, e.g. between monopoly and duopoly. Furthermore, propensity to reveal negative information varies according to

Table 17: Buyers' propensity to buy and profits by gender

Buy		Female	Male	Diff	**Profit**		Female	Male	Diff
MR	mL	0.908	0.783	**	**MR**	mL	0.000	0.000	-
	mH	0.729	0.917	***		mH	0.896	1.172	-
	mL-mH	***	**			mL-mH	***	***	
MH	mL	0.761	0.750	-	**MH**	mL	0.459	0.249	-
	mH	0.613	0.541	-		mH	0.466	0.369	-
	mL-mH	-	***			mL-mH	-	*	
MR-MH	mL	**	-		**MR-MH**	mL	***	***	
	mH	*	***			mH	-	***	
DR	mLL	0.813	0.950	-	**DR**	mLL	0.813	0.950	-
	mLH	0.818	1.000	***		mLH	0.644	0.723	-
	mHH	0.917	0.978	**		mHH	2.629	2.452	-
	mLH-mHH	-	-			mLH-mHH	***	***	
DH	mLL	0.857	0.889	-	**DH**	mLL	0.460	0.517	-
	mLH	0.911	0.905	-		mLH	0.417	0.572	-
	mHH	0.907	0.810	**		mHH	0.939	0.595	**
	mLH-mHH	-	*			mLH-mHH	-	-	
DHi	mLL	1.000	1.000	-	**DHi**	mLL	0.909	0.663	-
	mLH	0.960	0.890	-		mLH	0.733	0.381	**
	mHH	0.922	0.840	*		mHH	0.960	0.919	-
	mLH-mHH	-	-			mLH-mHH	-	*	
DR-DH	mLH	-	***		**DR-DH**	mLH	-	**	
	mHH	-	***			mHH	***	***	
DR-DHi	mLH	**	***		**DR-DHi**	mLH	-	**	
	mHH	-	***			mHH	***	***	
DH-DHi	mLH	-	-		**DH-DHi**	mLH	*	-	
	mHH	-	-			mHH	-	**	

Notes: Profits are normalized using vL. Mean values are reported in the table. ***/**/* means that the difference is significant at 1%/5%/10% level. '-' means no significance.

the theoretical predictions of the SH framework: higher probability of high-quality products makes revealing negative information less likely and does higher benefits of lying, i.e. higher v_H/v_L.

Furthermore, while conventional wisdom holds that negative information hurts sellers, the effect on revealing negative information on profit was mostly statistically insignificant. That is, contrary to expectations revealing negative information was not actually hurting truth tellers. At the same time, the effect on welfare was more pronounced. In the monopoly setting, the effect on welfare was mostly positive. Revealing negative information increased buyers' willingness to purchase the product thereby increasing welfare. In the case of duopoly, however, the effect was much weaker. The reason is that buyers gravitated towards purchasing product with announced low quality and that had negative effect on welfare.

Overall, our paper contributes to the literature on information disclosure by focusing on, previously understudied, incentives of low-quality sellers' to provide truthful information to buyers. These incentives exist in absence of standard tools such as reputation, certification or costly signaling, and with no search or matching frictions. We show that honesty may work as an effective communication strategy and it goes beyond purely theoretical reasons.

References

[1] Ackert, Lucy F., Bryan K. Church, and Mandira Roy Sankar. " Voluntary disclosure under imperfect competition: experimental evidence." *International Journal of Industrial Organization* 18.1 (2000): 81-105.

[2] Benndorf, Volker, Dorothea Kubler, and Hans-Theo Normann. "Privacy concerns, voluntary disclosure of information, and unraveling: An experiment." *European Economic Review* 75 (2015): 43-59.

[3] Benndorf, Volker. "Voluntary disclosure of private information and unraveling in the market for lemons: An experiment." *Games* 9.2 (2018): 23.

[4] Board O (2009) "Competition and disclosure." *J. Ind. Econ.* 57(1):197–213.

[5] Dulleck, Uwe, Rudolf Kerschbamer, and Matthias Sutter. "The economics of credence goods: An experiment on the role of liability, verifiability, reputation, and competition." *American Economic Review* 101.2 (2011): 526-55.

[6] Dranove, David, and Ginger Zhe Jin (2010) "Quality disclosure and certification: Theory and practice." *Journal of Economic Literature* 48(4): 935-63.

[7] Elfenbein, Daniel W., Raymond Fisman, and Brian McManus. *Does Cheap Talk Affect Market Outcomes? Evidence from eBay.* No. w24437. National Bureau of Economic Research, 2018.

[8] Forsythe, Robert, R. Mark Isaac, and Thomas R. Palfrey. "Theories and tests of "blind bidding" in sealed-bid auctions." *The Rand Journal of Economics* (1989): 214-238.

[9] Forsythe, Robert, Russell Lundholm, and Thomas Rietz. "Cheap talk, fraud, and adverse selection in financial markets: Some experimental evidence." *The Review of Financial Studies* 12.3 (1999): 481-518.

[10] Gardete PM (2013) Cheap-talk advertising and misrepresentation in vertically differentiated markets. *Market. Sci.* 32(4):609–621.

[11] Guo L, Zhao Y (2009) Voluntary quality disclosure and market interaction. *Market. Sci.* 28(3):488–501.

[12] Jansen, Jos, and Andreas Pollak. "Strategic disclosure of demand information by duopolists: Theory and experiment." *MPI Collective Goods Preprint* 2015/09 (2015).

[13] Jin GZ, Sorensen AT (2006) Information and consumer choice: the value of publicized health plan ratings. *J. Heal. Econ.* 25(2):248–275.

[14] Jin, Ginger Zhe, Michael Luca, and Daniel Martin. *Is no news (perceived as) bad news? An experimental investigation of information disclosure.* No. w21099. National Bureau of Economic Research, 2015.

[15] Kim K (2012) Endogenous market segmentation for lemons. *RAND J. Econ.* 43(3):562–576.

[16] King, Ronald R., and David E. Wallin. "Market?induced information disclosures: An experimental markets investigation." *Contemporary Accounting Research* 8.1 (1991): 170-197.

[17] Lynch, Michael, et al. "Product quality, consumer information and "lemons" in experimental markets." (1986): 251-306.

[18] Miller, Ross M., and Charles R. Plott. "Product quality signaling in experimental markets." *Econometrica: Journal of the Econometric Society* (1985): 837-872.

[19] Pigors, Mark, and Bettina Rockenbach. "The competitive advantage of honesty." *European Economic Review* 89 (2016): 407-424.

[20] Shapiro D, and David Huh (2018) Incentives of Low-Quality Sellers to Disclose Negative Information, Working paper.

[21] Siegenthaler, Simon. "Meet the lemons: An experiment on how cheap-talk overcomes adverse selection in decentralized markets." *Games and Economic Behavior* 102 (2017): 147-161.

[22] Wang, Mei, Marc Oliver Rieger, and Thorsten Hens (2017) "The impact of culture on loss aversion." *Journal of Behavioral Decision Making*, 30.2 (2017): 270-281.

Appendix

A Experimental Instructions

Thank you for participating in our experiment. Before we start the session, please your cell phone on silent and put away all your belongings. The whole session will take about an hour. You will participate in the experiment through the computer in front of you. Any conversation with other participants will be strictly prohibited from now on.

Please read the experimental instructions carefully and sign the consent form as you agree to participate in this experiment.

(Enough time was given to subjects.)

This experiment will be conducted in English through the computer. Three practice periods will be given before the actual periods start. Your performance in practice periods does not affect your final payoff. The actual periods can determine your final payoff and will be given 24 times. At the end of the experiment, your payoff will be determined according to your performance during the 24 actual periods plus the show-up fee of 5,000KRW. Among the 24 actual periods, 4 periods will be randomly selected and the sum of those 4 periods payoffs will be your payoff besides the show-up fee. The highest of 15,000KRW and the lowest of 10,000KRW in total will be paid as your final payoff.

If you have any questions regarding this experiment, please ask now.

If you agree to participate in this experiment, please hand in the signed consent form to us.

[Practice periods]

The language used in the experiment is English. For you to better understand this session, you will be given three practice periods. Your performance in practice periods does not affect your final payoff. Also, the details of the information such as numbers shown in the screen are irrelevant to what you would see in the actual periods. Please make your decision within the given time shown on the upper right corner of the screen. Let us start the practice periods.

(Three practice periods proceed.)[13]

All practice periods have been completed. Before we start the actual periods, do you have any questions?

[13] In the practice round, subjects experience both roles of a seller and a buyer with the parameter values irrelevant with the actual periods. Therefore, the screen layouts for the practice periods are the same with those in actual periods, except the parameter values.

[Actual periods]

Now, we are about to start the 24 periods that can affect your final payoff. Your decisions and performance in each period can affect your final payoff at the end of the experiment, please make decisions carefully. Please make your decision within the given time shown on the upper right corner of the screen and press Continue button afterwards. Let us start the actual periods.

(Twenty-four actual periods proceed: the details of the instructions shown on the screen can be found in section A.1.)

You completed all the periods of this session. Now, you will answer a set of demographic questions. As you complete the questionnaire, we will determine the 4 paying periods out of 24 actual periods by a lottery. You will be paid on your way out according to your performance in the selected four periods plus the show-up fee.

Thank you for participating in our experiment.

A.1 Selected screenshots

Figure 1: Monopoly - Instructions

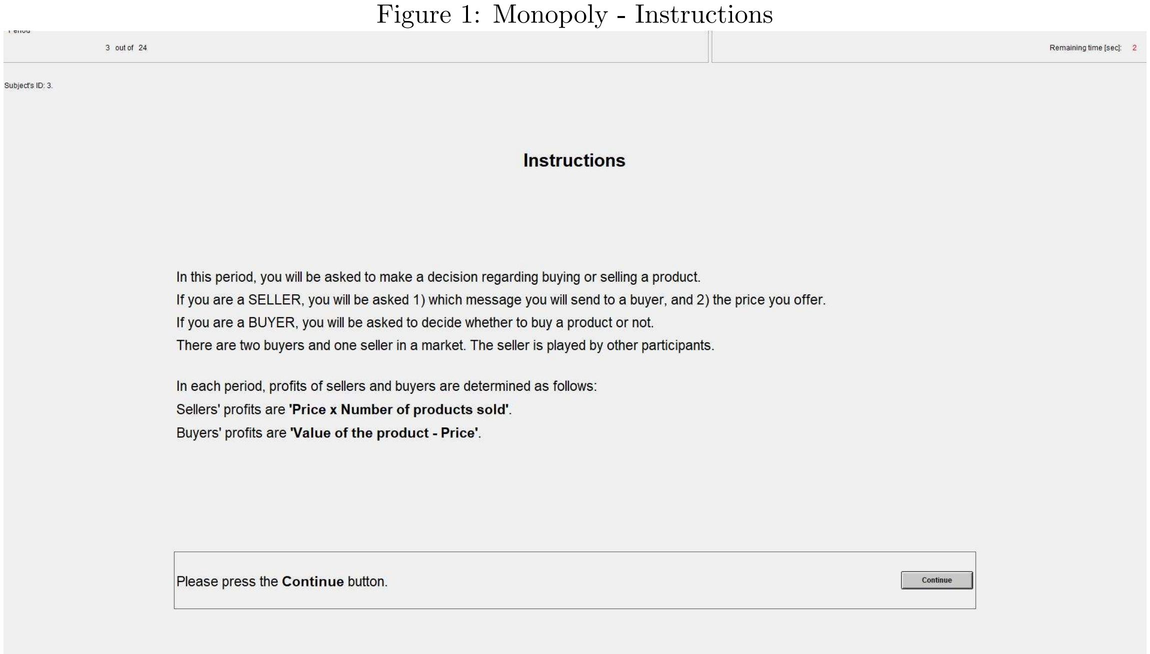

Figure 2: Monopoly - Seller's sending a message

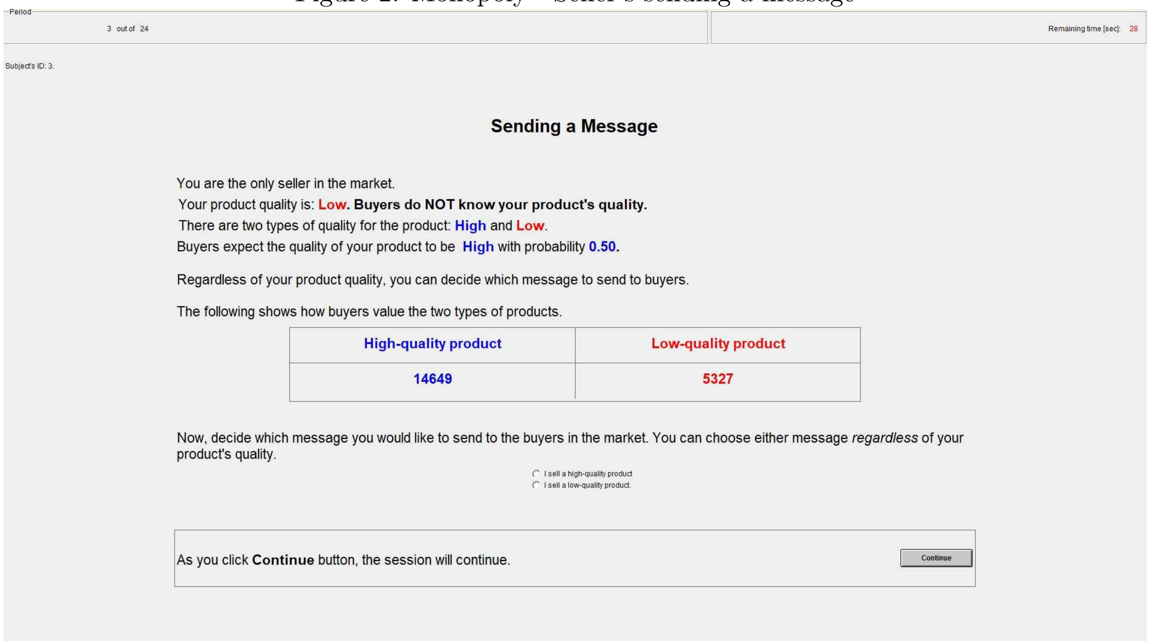

Figure 3: Monopoly - Seller's setting a price

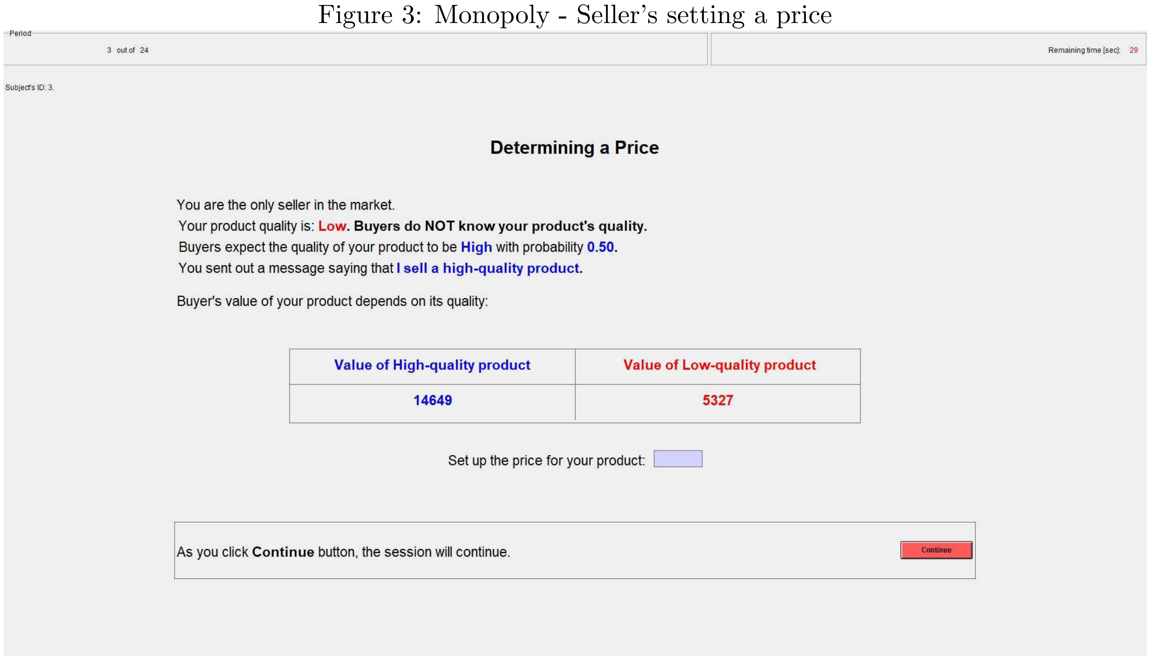

Figure 4: Monopoly - Buyer's buying decision

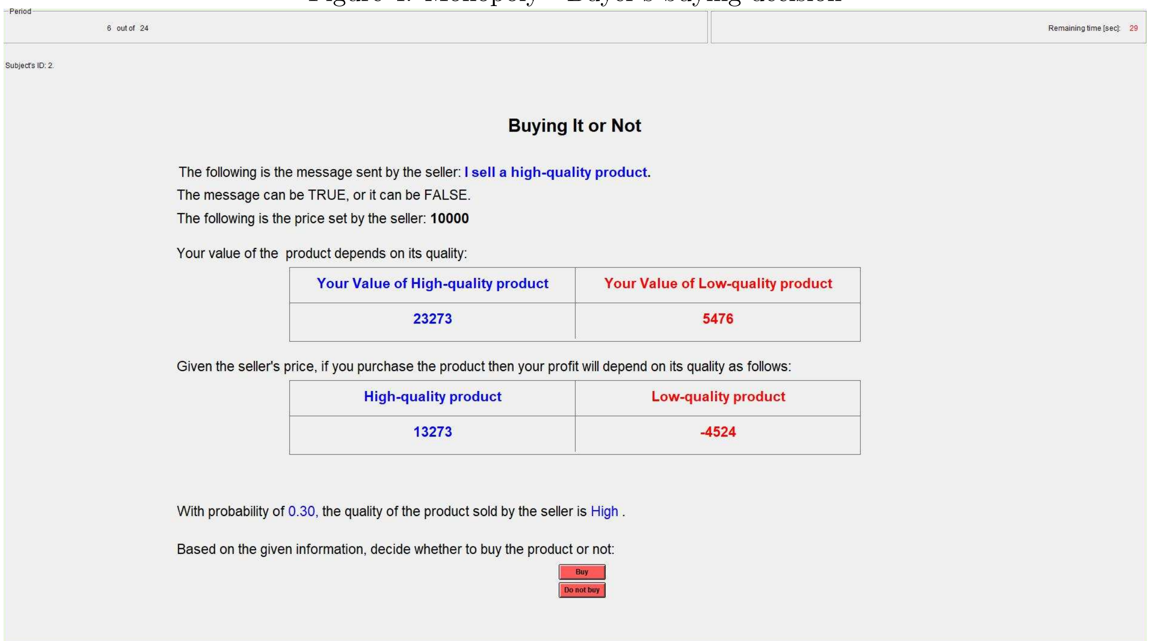

Figure 5: Monopoly - results

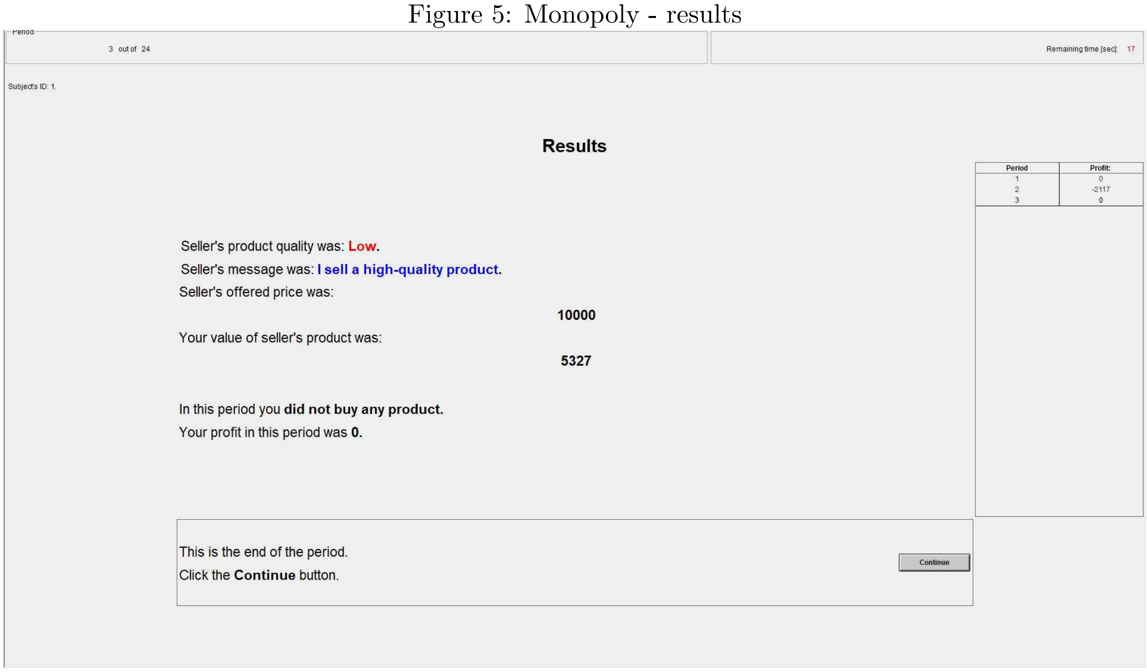

Figure 6: Duopoly - Instructions

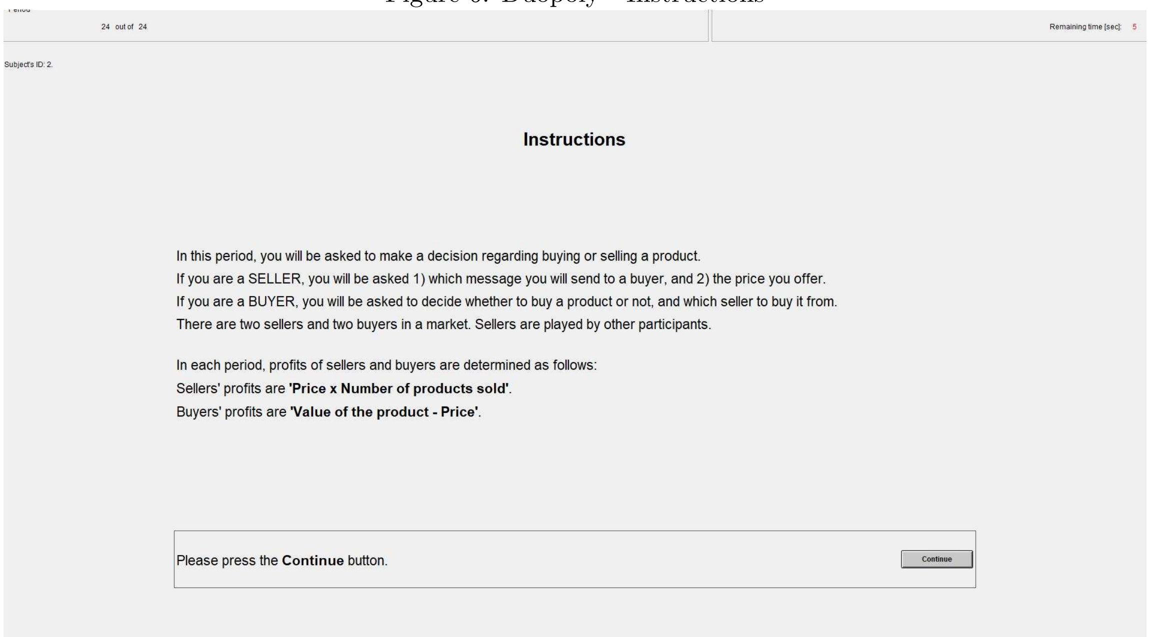

Figure 7: Duopoly - Seller's sending a message

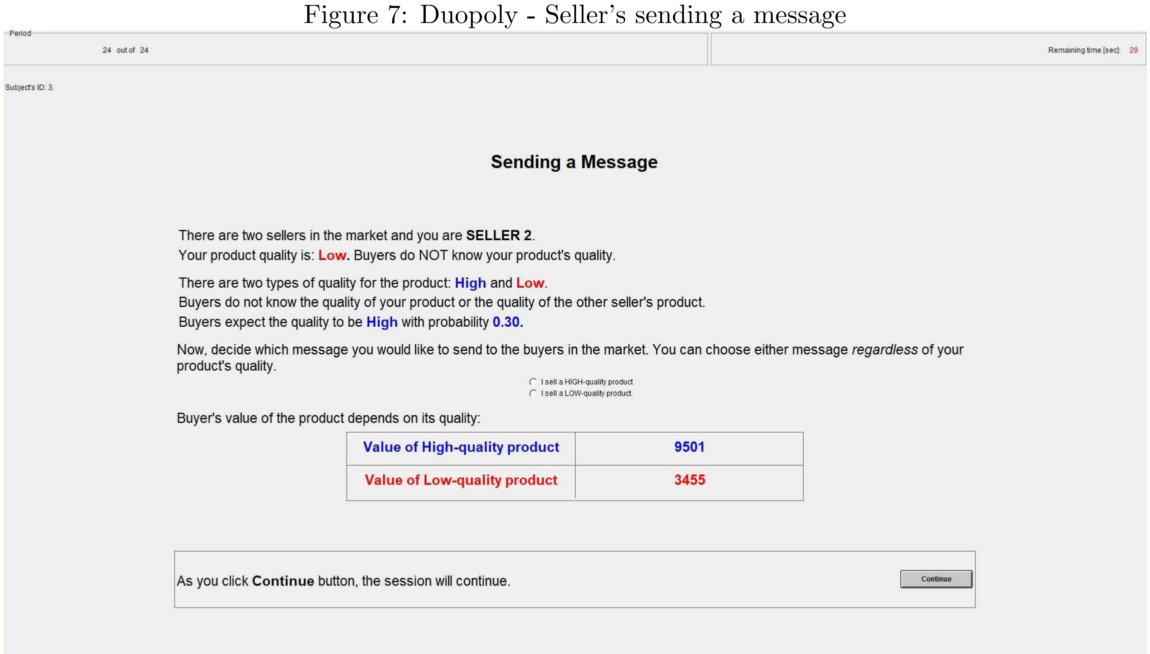

Figure 8: Duopoly - Seller's setting a price

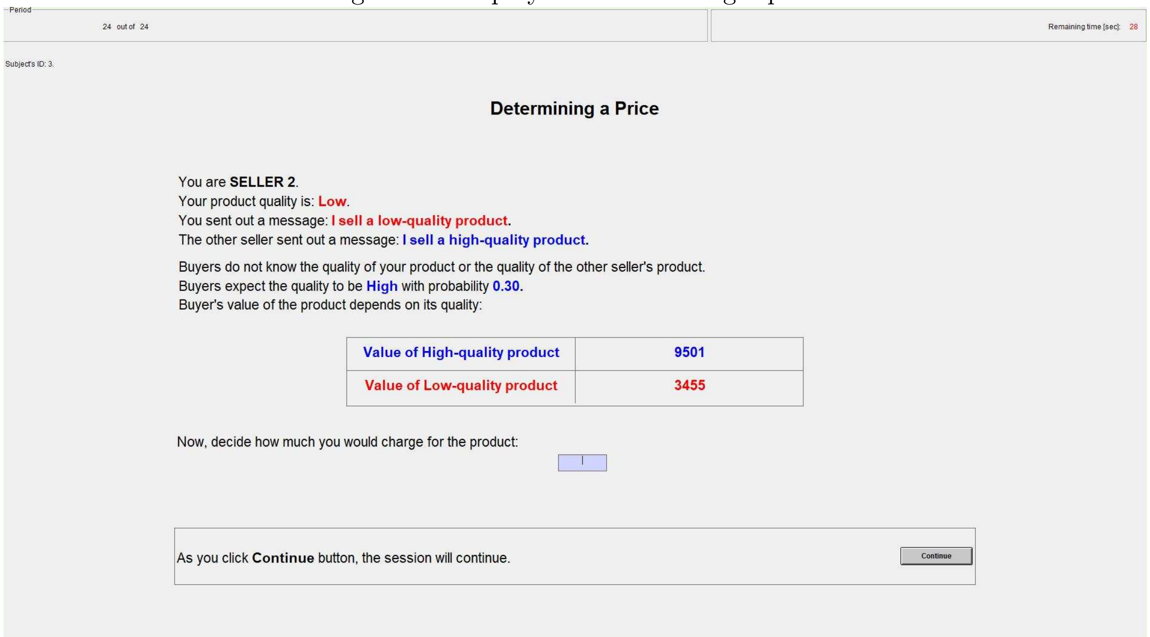

Figure 9: Duopoly - Buyer's buying decision

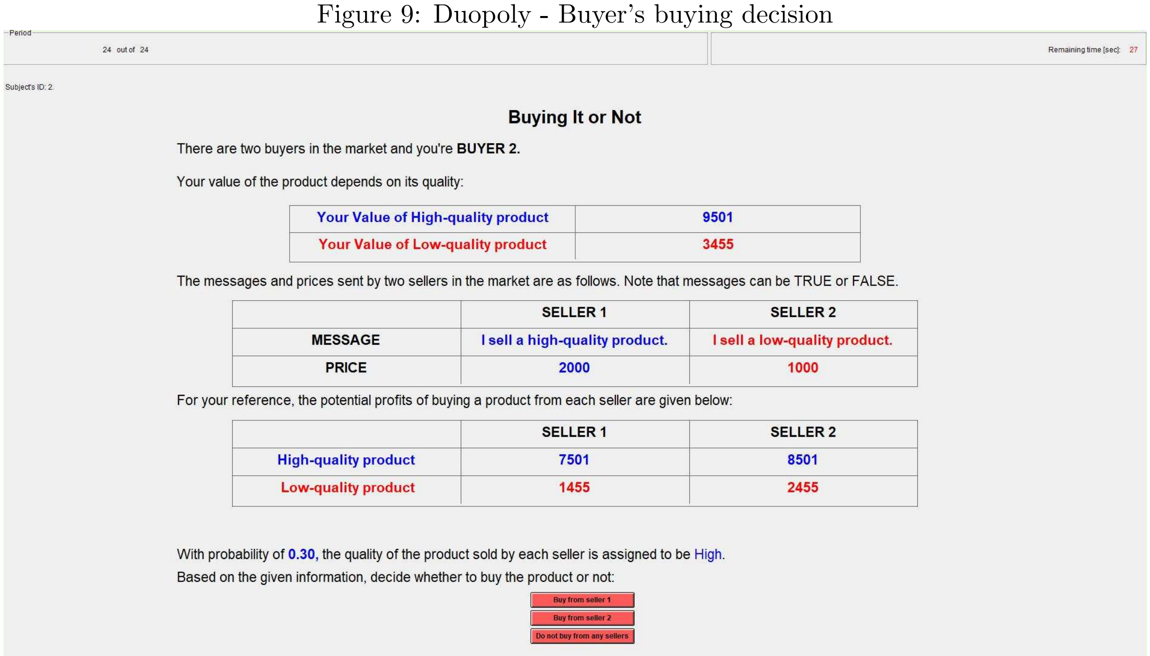

Figure 10: Duopoly - results