Online Appendix I: Proofs for Article "Competition and Price Transparency in the Market for Lemons: Experimental Evidence"

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Abstract

This online appendix contains the proofs of Propositions 1 to 3 of the article "Competition and Price Transparency in the Market for Lemons: Experimental Evidence" and the theoretical predictions for all experimental treatments.

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1 Proofs

Let $\mu^* = (c_H - v_L)/(v_H - v_L)$ be the buyers' belief at which an offer of c_H yields an expected profit of 0, i.e., $v_H \mu^* + v_L(1 - \mu^*) - c_H = 0$. Further, let $\mu_T = c_H/v_H$ be the buyers' belief at which a take-it-or-leave-it offers (occurring in stage T in the finite horizon setting) of 0 and c_H yield the same expected payoff, i.e., $(1 - \mu_T)v_L = \mu_T v_H + (1 - \mu_T)v_L - c_H$.

1.1 Exclusive Bargaining

The proof of Proposition 1 (treatment *Exclusive*) is given in Deneckere and Liang (2006) Proposition 1, including a proof that the equilibrium is unique.

1.2 Exclusive Bargaining with T stages

In the exclusive bargaining game with T stages (treatment *Exclusive* T), there exists an essentially unique perfect Bayesian equilibrium with the following features: (i) the buyer offers 0 in all stages $t = 1, \ldots, T$. (ii) The low-type seller's acceptance probabilities up to stage $T - 1$ are such that the buyer's belief satisfies $\mu_{T-1} \leq \mu_T$, while the buyer's belief must be μ_T in the final stage T. The low-type seller accepts with probability 1 in stage T. (iii) The high-type seller rejects all offers.

Note that there cannot be a stage t at which the buyer strictly prefers to offer c_H. If this were the case, the low-type seller would reject all previous offer below c_H and hence offering c_H in t would yield a negative expected payoff to the buyer (since $v_H q + v_L(1 - q) - c_H < 0$). Thus, if an offer of c_H is made with positive probability in some stage t, there must be at least one alternative optimal offer below c_H in t. In addition, an offer of c_H in t will only be made if the low-type seller has accepted with positive probability in a previous stage $t' < t$ (i.e., the buyer has updated his belief) where the offer in t' must be strictly larger than 0 (otherwise the low-type seller would reject). Suppose now that there is an equilibrium in which an offer above c_H occurs with positive probability. We have shown that in each stage, it must also be an optimal strategy to offer below c_H. So, the expected payoff of the buyer in such an equilibrium can be expressed as the payoff in case the buyer always chooses an optimal offer below c_H. These offers are rejected by the high-type seller. Since at least one offer (the one in t') exceeds 0, the buyer trades with the low-type seller at a price strictly above 0 with strictly positive probability. It is then obvious that the implied expected payoff for the buyer is strictly below the expected payoff of the strategy to offer 0 in all stages (the low-type accepts the offer of 0 in the last stage with probability 1). Hence, there is no equilibrium at which c_H is offered with positive probability and the unique optimal strategy for the buyer must be to offer 0 in all stages. This is not surprising as Samuelson (1984) has shown that the buyer's optimal trading mechanism is to make a take-it-or-leave-it offer to the seller, which in the absence of time frictions is equivalent to offering 0 in all stages. The acceptance probabilities of the low-type seller support the buyer's equilibrium offers. In particular, they are such that the buyer's belief is exactly μ_T in stage T such that the buyer is willing to mix between 0 and c_H. The latter is necessary to deter deviations above an offer of 0 in the previous stages: the low-type seller is willing to reject such offers, knowing that in the final stage the buyer will put a positive probability on the offer c_H, and hence the buyer has no incentive to deviate from the zero offer sequence to begin with.

1.3 Competitive Bargaining with Private Offers

We prove Proposition 2 (treatment *Private*). To see why trade with the high-type seller occurs with positive probability, note that the low-type seller will eventually accept an offer with probability 1, see Proposition 2 in Hörner and Vieille (2009a). If not, then only the losing offer of $c_L = 0$ would be offered, in which case any buyer could profitably deviate by offering just slightly more than 0. It follows that the buyers' belief to face a high-type seller increases over time, converging to 1, and thus there exists a buyer in some stage ℓ with belief μ_ℓ sufficiently large such that offering c_H yields a strictly positive profit. At the same time, delaying such an offer indefinitely implies that the continuation equilibrium payoff converges to 0. This is a contradiction.

We next show that the behavior described in Proposition 2 indeed constitutes a perfect Bayesian equilibrium. Let $\tilde{p}$ be the price a buyer needs to offer such that a low-type seller is indifferent between accepting and rejecting $\tilde{p}$, anticipating that the same buyer will offer c_H as his next offer n stages in the future and all buyers in between offer c_H with probability λ^* and a losing offer otherwise. We get

$$\tilde{p} = r^n(1-\lambda^*)^{n-1}c_H + r\lambda^* c_H \sum_{l=0}^{n-2} r^l(1-\lambda^*)^l = r^n(1-\lambda^*)^{n-1}c_H + r\lambda^* c_H \frac{1-r^{n-1}(1-\lambda^*)^{n-1}}{1-r(1-\lambda^*)}.$$

Choose λ^* such that a buyer with belief μ^* who offers $\tilde{p}$ (accepted with probability 1 by the low-type seller) and offers c_H the next time he is called to make an offer has an expected profit of 0. That is, λ^* solves

$$(1-\mu^*)(v_L-\tilde{p})+r^n\mu^*(1-\lambda^*)^{n-1}(v_H-c_H)=0. \tag{1}$$

Suppose $\lambda^*=0$, then the left-hand side strictly exceeds 0. To see this, note that for $\lambda^*=0$ the left-hand side of (1) becomes $(1-\mu^*)(v_L-r^n c_H)+r^n\mu^*(v_H-c_H)$. After plugging in μ^*, this expression is strictly larger than 0 whenever $v_L(1-r^n)>0$. This holds for any n. Thus, $\lambda^*>0$ must hold, as otherwise (1) cannot be satisfied. Similarly, the left-hand side is strictly below 0 when $\lambda^*=1$ (note that $\tilde{p}>r^n c_H>v_L$). Hence, $\lambda^*<1$ holds as well.

Finally, choose the probability λ_2 with which the buyer in stage 2 offers c_H such that the expected payoff of the low-type seller is v_L when rejecting the offer she receives in stage 1. Hence, λ_2 solves

$$v_L=c_H\left(r\lambda_2+r^2(1-\lambda_2)\lambda^*+r^3(1-\lambda_2)(1-\lambda^*)\lambda^*+r^4(1-\lambda_2)(1-\lambda^*)^2\lambda^*+\dots\right)$$

which simplifies to

$$v_L=rc_H\lambda_2+\frac{r^2c_H\lambda^*(1-\lambda_2)}{1-r(1-\lambda^*)}. \tag{2}$$

One can show that $0<\lambda_2<\lambda^*$. In particular, if one assumes that $n-1$ buyers mix according to λ^* and the remaining buyer only makes losing offers (i.e., $n-1$ buyers choose c_H with probability λ^* and a losing offer otherwise and the remaining buyer chooses an offer of v_L or less), we get an expected future payoff of exactly v_L for the low-type seller who rejects the offer in stage 1. Thus, if all n buyers (instead of just $n-1$) mix according to λ^*, the expected future payoff of the low-type seller exceeds v_L. It follows that in order for (2) to be satisfied, we need $\lambda_2<\lambda^*$. Also note that as n grows large, the difference between the case when $n-1$ and n buyers mix according to λ^* becomes negligible and in fact the expected payoff of the low-type seller is very close to v_L even if n buyers mix according to λ^*. For n sufficiently large, the two probabilities λ_2 and λ^* are therefore arbitrarily close. Further, suppose that $\lambda_2=0$, then, as n approaches infinity (note that then $\lambda^*=((1-r)v_L)/(r(c_H-v_L)))$, we find that the right-hand side of (2) becomes rv_L which is smaller than v_L. Thus, by increasing λ_2, which puts more weight on the first term of the right-hand side rc_H (which exceeds v_L), there must be a $\lambda_2>0$ for which (2) is satisfied. Therefore, there exists λ_2 such that $0<\lambda_2<\lambda^*$ if n is sufficiently large.

Consider now the behavior stated in Proposition 2. Clearly, λ_2 guarantees that the expected payoff of the low-type seller when rejecting in stage 1 equals v_L. It is thus optimal for the low-type seller to mix between accepting and rejecting the offer of v_L in stage 1, and it is also optimal to reject any offer of v_L or below in the next stages. The high-type seller also behaves optimally, given that only an offer above c_H gives her a positive payoff. The buyers in stages $\ell \geq 2$ would need to offer at least $\tilde{p}$ to be accepted by the low-type seller (lower offers would be rejected, followed by the deviating buyer putting a higher probability on c_H in his next turn). But λ^* ensures that $\tilde{p}$ yields an expected profit of 0 and hence is not a profitable deviation. So, for these buyers it is indeed optimal to mix between c_H (with an expected payoff of 0) and a losing offer. The buyer in stage 1 would only need to make an offer of slightly below $\tilde{p}$ to screen out the low-type seller (since $\lambda_2 < \lambda^*$). But we have shown that for n sufficiently large λ_2 is close to λ^* and hence $q < \mu^*$ implies that buyer 1 also has no profitable deviation. Offering less than v_L will also give buyer 1 a payoff of 0, since it will be rejected by the low-type seller. This holds because λ_2 and λ^* together imply an expected continuation payoff for the low-type seller of v_L when rejecting the offer in stage 1. We have thus identified an equilibrium. For the parameters in the experiment, we obtain $\lambda^* = 0.236$ and $\lambda_2 = 0.042$. The low-type seller's probability of accepting offer $p_1 = v_L$ is $a_1 = 5/12$ such that $\mu_2 = \mu^* = 6/13$.

It remains to show that the equilibrium is essentially unique. We use a series of steps to make this point.

Step 1: In any equilibrium, the upper bound on beliefs is μ^*.

Suppose to the contrary that there exists a buyer i_ℓ for whom $\mu_\ell > \mu^*$. Let $\bar{\mu}$ be the limit of μ_ℓ, assume that $\bar{\mu} > \mu^*$, and choose a history h_ℓ where μ_ℓ is close to the limit $\bar{\mu}$. We claim that buyer i_ℓ makes a winning offer c_H with probability 1. Because $\bar{\mu} > \mu^*$ buyer i_ℓ's equilibrium payoff is larger than 0 and hence he will not make a losing offer. Hence, an alternative offer $p_\ell < c_H$ must be accepted with positive probability by the low-type seller. Because μ_ℓ is close to the limit $\bar{\mu}$, offer p_ℓ must be offered with a small probability for the belief of buyer $i_{\ell+1}$ not to exceed the limit $\bar{\mu}$. Since the same is true for buyer $i_{\ell+1}$, the low-type seller expects to receive a winning offer of c_H with a probability close to 1. So, p_ℓ must be close to c_H in order to be accepted and in fact above v_L. But $p_\ell \in (v_L, c_H)$ cannot be optimal, because if the offer is rejected the game ends in the next stage with high probability, and the offer leads to a negative payoff if it is accepted. Hence, buyer i_ℓ makes a winning offer c_H. Notice that the above argument is adapted from Hörner and Vieille (2009b) for the case of an infinite stream of buyers. However, for any r, as long as we choose n large enough, the probability of a buyer to return to make another offer is sufficiently close to 0 such that we can use the same reasoning for finite but large n.

Consider now the last buyer i_t that makes an offer p_t different from c_H with positive probability. By construction this implies that $\mu_{t+1} = \bar{\mu}$. As before, $p_t \in (v_L, c_H)$ must hold since the next offer is c_H. But such an offer yields a negative payoff to buyer i_t. Hence, buyer i_t submits only losing and winning offers such that $\mu_{t+1} = \mu_t$. Hence, $\mu_t = \bar{\mu} > \mu^*$ and thus buyer i_t's expected payoff is positive, which implies that he makes the winning offer c_H with probability 1, a contradiction with the way we defined buyer i_t. We conclude that in any equilibrium, there is no stage ℓ with $\mu_\ell > \mu^*$.

Step 1 implies that in any equilibrium there exists a buyer $i_{\bar{\ell}}$ with $\bar{\ell} > 1$ such that $\mu_\ell = \mu^*$ for all $\ell \geq \bar{\ell}$, where, once the earliest stage $\bar{\ell}$ for which this is true has been reached, the buyers randomize between the winning offer of c_H and a losing offer.

Step 2: We have $\bar{\ell} = 2$.

Suppose that $\bar{\ell} > 2$. Consider buyer $i_{\bar{\ell}-1}$. By definition, $\mu_{\bar{\ell}-1} < \mu^*$. It must be that buyer $i_{\bar{\ell}-1}$ puts positive probability on an offer that is both acceptable only to the low-type seller and that is accepted by the low type seller with positive probability such that $\mu_{\bar{\ell}} = \mu^*$. Since the expected payoff of any buyer in stages $\ell \geq \bar{\ell}$ is equal to 0 (by the optimality of offering c_H and the definition of belief μ^*), the buyer at $\bar{\ell}-1$ cannot make a serious offer that exceeds v_L (in case of acceptance, his payoff is negative; in case of a rejection his expected payoff is 0). Hence, in stage $\bar{\ell} - 2$, due to the breakdown probability $1 - r$, the low-type seller must be willing to accept an offer strictly less than v_L. So, the expected equilibrium payoff of the buyer at stage $\bar{\ell} - 2$ is positive. Therefore, the buyer at stage $\bar{\ell} - 2$ does not make a losing offer. He also does not make a winning offer of c_H since $\mu_{\bar{\ell}-2} < \mu^*$. Thus, the low-type seller must be indifferent between accepting and rejecting buyer $i_{\bar{\ell}-2}$'s offer, which is strictly below v_L. But then buyer $i_{\bar{\ell}-2}$ has a profitable deviation to slightly raise his offer to be accepted with probability 1. To prevent such deviations, it must be that $\bar{\ell} = 2$, i.e., there is no stage $\bar{\ell} - 2$.

Step 3: The buyer in stage 1 randomizes between a losing offer in $[0, v_L)$ and an offer of v_L and the low-type seller accepts the offer of v_L such that $\mu_2 = \mu^*$.

We have already shown that $\mu_2 = \mu^*$. Thus, the low-type seller accepts an offer from the first buyer with positive probability smaller than 1. This offer must be v_L, otherwise, if the offer is below v_L, the first buyer could profitably deviate by offering a slightly higher price than the acceptable equilibrium price and force the low-type seller to accept with probability 1. Buyer i_1's expected payoff from offering a price in the interval (v_L, c_H) is negative, again because the expected payoff is 0 once μ^* has been reached. Hence in any equilibrium, the offer that is accepted in stage 1 must be v_L. Note that this implies that the equilibrium outcome is unique, but the belief $\mu_2 = \mu^*$ can be reached by different combinations of buyer i_1 randomizing between v_L and a losing offer and the low-type seller's acceptance probability of the offer v_L. The acceptance probability a_1 in the proposition is for the case when the first buyer offers v_L with probability 1.

This concludes the proof of Proposition 2. Notice that we have not specified the equilibrium for the case when n is small relative to r. The derivation of the equilibrium in this case is beyond the scope of the present paper. We conjecture that the equilibrium will involve features of the exclusive bargaining equilibrium, including some form of screening. It is also worth stating that such an equilibrium is likely to have an efficiency level that lies in between the case of exclusive bargaining with no competition between buyers and our case where competition is strong with n being large relative to r (here efficiency is the same as with an infinite stream of buyers). Hence, qualitatively, the predictions in Corollary 1 would hold even when n is low relative to r.

1.4 Competitive Bargaining with Private Offers and T stages

In the bargaining game with private offers and T stages (treatment *Private* T), there exists an essentially unique perfect Bayesian equilibrium with the following features: (i) The buyer in stage T randomizes between the offers c_H and 0 with probability λ_T on the offer of c_H such that $\lambda_T c_H = v_L$. (ii) The buyer in $T-1$ offers v_L. (iii) The buyers in stages $t < T-1$ offer v_L or below. (iv) The low-type seller's cumulative acceptance probability up to stage $T-1$ is such that the buyer's belief satisfies $\mu_{T-1} \leq \mu^*$. (v) In stage $T-1$ the low-type seller accepts the offer of v_L with a probability such that the buyer's posterior belief is $\mu_T = c_H/v_H$. (vi) In stage T the low-type seller accepts all offers. (vii) Finally, the high-type seller only accepts offers of c_H or higher.

Proof. Note that Stage T must be reached on the equilibrium path. If not, then at some stage $t' < T$ a buyer must offer c_H or more with probability 1. But this cannot be the case, as then the low-type sellers would reject all offers up to stage t' and the offer c_H would not be profitable for the buyer. So, consider the last stage T. Only an offer of 0 (accepted by the low-type) or c_H (accepted by both types) can be optimal for the buyer. Moreover, if buyer i_T offered 0 for sure, buyer i_{T-1} would make an offer slightly above 0 to force acceptance with probability 1 by the low-type seller. This would imply that $\mu_T = 1$, which leads to a contradiction since the last buyer should offer c_H in this case. If buyer i_T offered c_H for sure, the low-type seller, anticipating that an offer of c_H will be made for sure in the last stage, would reject all previous offers below c_H and hence the belief in stage T would be below μ^*. This would contradict the optimality of offering c_H. Hence, the only remaining possibility is that the buyer in stage T randomizes between 0 and c_H. The belief must thus be μ_T such that $\mu_T(v_H - c_H) + (1 - \mu_T)(v_L - c_H) = (1 - \mu_T)(v_L - 0)$, i.e., $\mu_T = c_H/v_H$.

Next consider stage $T - 1$. It must be the case that $\mu_{T-1} < \mu_T$. Otherwise the buyer in stage $T - 1$ would offer c_H, which would imply $\mu_T = 1$ (if $\mu_{T-1} > \mu_T$ offering c_H is strictly optimal; if $\mu_{T-1} = \mu_T$ the low-type seller wouldn't accept an offer of 0 in $T-1$ since we have shown that c_H follows with strictly positive probability). Hence, the low-type seller must be indifferent between accepting and rejecting the offer p_{T-1} so that the belief moves from a belief below μ_T to μ_T. This implies $p_{T-1} = v_L$. For any lower offer the buyer could slightly increase the offer and be accepted with probability 1. Any offer strictly between v_L and c_H is not profitable for buyer i_{T-1}. Hence, $\lambda_T c_H = v_L$ and $\mu_{T-1} \leq \mu^*$. Otherwise the offer of c_H would yield a positive expected payoff to buyer i_{T-1}, while the equilibrium offer of v_L yields a payoff of 0.

Finally, the behavior in stages $t < T - 1$ cannot involve offers above v_L (such an offer would be accepted with probability 1) and the low-type seller only accepts offers of v_L with a probability such that the belief never exceeds μ^* before stage $T - 1$ is reached. In other words, the equilibrium is essentially unique because the buyers' expected payoff is 0 in stages 1 to $T - 1$ in any equilibrium and in stage $T - 1$ the belief moves to $\mu_T = c_H/v_H$ for any $\mu_{T-1} \in [q, \mu^*]$, followed by an offer of c_H with probability $\lambda_T = v_L/c_H$. □

1.5 Competitive Bargaining with Public Offers

The proof of Proposition 3 (treatment *Public*) is divided into a series of steps. Let μ_l be the prior belief on the high-type (common to all buyers) after history h_l.

Step 1: If μ_l is close enough to 1, then independently of the history h_l, the price offered by buyer i_l is $p_l = c_H$, which is accepted for sure.

To see this, notice that the best-case scenario for buyer i_l when offering below c_H is to get $(1 - \mu_l)(v_L - 0) + r^n \mu_l(v_H - c_H)$, which for μ_l sufficiently large is less than the expected payoff from offering c_H given by $(1 - \mu_l)(v_L - c_H) + \mu_l(v_H - c_H)$.

Let $\hat{\mu}$ be the infimum over the beliefs μ_l that satisfy $(1 - \mu_l)v_L + r^n \mu_l(v_H - c_H) < (1 - \mu_l)(v_L - c_H) + \mu_l(v_H - c_H)$ (such a μ_l exists by Step 1) and for which an offer c_H follows independently of the history. That is, whenever $\mu_l > \hat{\mu}$, then independent of the history the buyer offers c_H.

Step 2: If $\mu_l \leq \hat{\mu}$, then offer p_l cannot lead to a posterior $\mu_{l+1} \in (\hat{\mu}, 1]$.

By step 1, if $\mu_{l+1} > \hat{\mu}$, buyer i_{l+1} will offer $p_{l+1} = c_H$ (note that all buyers must have the same beliefs if offers are public). Thus, if the posterior is $\mu_{l+1} \in (\hat{\mu}, 1]$, the low-type seller must be willing to accept p_l even when knowing that the next offer will be c_H. This implies $p_l \geq rc_H$, because otherwise the low-type seller would reject p_l. Since $rc_H > v_L$, the offer p_l yields a negative expected payoff and will never be offered, a contradiction.

Step 3: The threshold belief is $\hat{\mu} = \mu^*$.

By the definition of $\hat{\mu}$, for any $\epsilon > 0$, there exists a history h_l such that given $\mu_l = \hat{\mu} - \epsilon$, $p_l < c_H$ is optimal. By step 2, the offer p_l can only lead to $\mu_{l+1} \in [\hat{\mu} - \epsilon, \hat{\mu}]$. This implies that the probability of sale when offering p_l tends to 0 for small ϵ, and so does the expected payoff from offering p_l. (Notice that it could be that buyer i_l makes offer p_l to induce a finer screening in the hope of trading in stage $l + n$, or $l + 2n$, etc. with a higher certainty to be facing a high-type seller. A simple way to show that this cannot be the case is to observe that because the probability of sale is very small, the increase in the belief toward the high-type seller in case of rejection does not justify the waiting cost due to r.) So, because the buyer must not strictly prefer to make offer $p_l = c_H$ at belief $\hat{\mu} - \epsilon$, we need $v_H(\hat{\mu} - \epsilon) + v_L(1 - \hat{\mu} + \epsilon) - c_H \leq 0$, which implies $v_H\hat{\mu} + v_L(1 - \hat{\mu}) - c_H \leq 0$ as ϵ goes to 0. Conversely, because offer c_H is optimal at belief $\hat{\mu} + \epsilon$, it must also be that $v_H(\hat{\mu} + \epsilon) + v_L(1 - \hat{\mu} - \epsilon) - c_H \geq 0$ for any $\epsilon > 0$ and thus $v_H\hat{\mu} + v_L(1 - \hat{\mu}) - c_H \geq 0$. Hence, $v_H\hat{\mu} + v_L(1 - \hat{\mu}) - c_H = 0$ which is the definition of μ^*.

Step 4: Suppose that given history h_l, we have $\mu_l < \mu^*$ and the equilibrium is such that p_l leads to $\mu_{l+1} = \mu^*$. Then all subsequent offers are equal to 0, i.e., $p_t = 0$ for all $t \geq l+1$.

Suppose to the contrary that not all future offers are equal to 0. Then the buyer in stage l must offer $p_l > 0$. Offering $p_l = 0$ leads to a rejection with probability 1, because the seller knows that an offer above 0 will be made with strictly positive probability in at least one of the subsequent stages. Let $\bar{p}$ be the supremum over all such offers $p_l > 0$. Choose an ϵ small enough such that $\bar{p} - 2\epsilon > 0$ and choose the history h_l such that $p_l > \bar{p} - \epsilon$. Suppose that buyer i_l deviates and offers $\bar{p} - 2\epsilon < p_l$. If $\mu_{l+1} \geq \mu^*$ (after the deviation), this is a profitable deviation since the price offered is lower than p_l and the probability of acceptance by the low-type seller has weakly increased. If $\mu_{l+1} < \mu^*$, the low-type seller gets $\bar{p} - 2\epsilon$ when accepting the offer and cannot hope for more than an expected payoff of $r\bar{p}$ when rejecting the offer. Since the low-type seller is supposed to be willing to reject, this is a contradiction for ϵ small enough.

Step 5: If $\mu_l < \mu^*$, then $p_l = 0$ and $\mu_{l+1} = \mu^*$.

By step 2 we have $\mu_{l+1} \leq \mu^*$. Suppose first that $\mu_{l+1} < \mu^*$. The offer p_l must be below c_H, as an offer of c_H would give a negative expected payoff to the buyer. The offer $p_l < c_H$ cannot be accepted with probability 1 by the low-type seller, because the belief cannot move beyond μ^*. Next, p_l can also not be rejected with probability 1. To see this, note that then there must be some offer $p_t > p_l$ with $t > l$ that occurs with positive probability along the equilibrium path and is accepted with a probability such that the buyers' belief moves to $\mu_{n+1} = \mu^*$ (clearly, if belief μ^* is never reached, any buyer could profitably offer $v_L - \epsilon$, which would be accepted by a low-type seller). Further, $p_t \leq v_L$ to ensure a non-negative expected payoff of buyer i_t. But then buyer i_l is not willing to make the losing offer p_l, because a deviation to $p_l = p_t - \epsilon > rp_t$ is accepted for sure by the low-type seller in stage l. Finally, it could be that the low-type seller is indifferent between accepting and rejecting p_l. But then the buyer could also deviate and slightly raise the offer to guarantee acceptance by the low-type seller at a negligible price increase. This exhausts all possibilities.

So it must be that $\mu_{l+1} = \mu^*$. In this case, step 4 implies that the low-type seller cannot hope for more than an offer of 0 in the future. Hence, the offer that moves the belief to μ^* must be 0 as well (any higher offer would be accepted with probability 1).

This proves Proposition 3: all offers are 0 and the belief jumps to μ^* in stage 1. It is clear that the low-type seller is indifferent between accepting and rejecting the zero offers and hence her behavior is optimal. The high-type seller always rejects, since the offers are below her reservation cost. For the buyers, the equilibrium prescribes that any deviation from the zero price sequence to an offer of $p' \in (0, v_L)$ is deterred by the next buyer who would observe the deviation and mix between 0 and c_H (at belief μ^*, c_H yields an expected payoff of 0) with probability x on the offer c_H such that $xrc_H \geq p'$ and hence the seller would reject p'.

1.6 Competitive Bargaining with Public Offers and T stages

In the bargaining game with public offers and T stages (treatment *Public T*), there exists an essentially unique perfect Bayesian equilibrium with the following features: (i) In each stage $t = 1, \ldots, T$, the offer is $p_t = 0$. (ii) The low-type seller's acceptance probabilities up to stage $T-1$ are such that the buyers' belief satisfies $\mu_{T-1} \leq \mu^*$. (iii) In stage $T-1$ the low-type seller accepts the offer of 0 with a probability such that the buyer's posterior belief is $\mu_T = c_H/v_H$. (iv) In stage T the low-type seller accepts the offer of 0 with probability 1. Finally, the high-type seller rejects all offers of 0.

Proof. In stage T, only an offer of 0 (accepted by the low-type) or c_H (accepted by both types) can be optimal for the buyer. In contrast to *Private* T, the offer p_{T-1} cannot be v_L. To show this, suppose $p_{T-1} = v_L$. Consider a deviation by the buyer in stage $T-1$ to a slightly lower offer $p' < v_L$. This deviation is profitable if the low-type seller's acceptance probability is at least as large as when offering v_L. Suppose therefore that the acceptance probability for $p_{T-1} = p'$ is lower than the one for $p_{T-1} = v_L$. Now, because offers are observed, in equilibrium *any* offer in stage $T-1$ must be accepted by the low-type seller such that $\mu_T = c_H/v_H$ (only then the buyer in stage T can mix between 0 and c_H, and he must be willing to do so deter off-equilibrium offers). This implies that the belief in stage T after offer p' is $\mu' < c_H/v_H$. This cannot be part of an equilibrium: The buyer in stage T would strictly prefer an offer of 0 to an offer of c_H and hence the low-type seller would have been better off accepting the offer $p_{T-1} = p'$ with probability 1, a contradiction. The same argument holds for any $p_{T-1} > 0$. Now, note that the buyer in stage $T-1$ could in principle offer v_L and then we would observe the corresponding mixing between 0 and c_H of the buyer in stage T. But, clearly, the buyer in $T-1$ prefers to offer 0, as this maximizes his payoff given that the acceptance probability is the same for all offers below v_L. (With private offers offering below v_L is not possible, because the buyer in stage T does not observe the offer p_{T-1} and hence the buyer in $T-1$ can guarantee acceptance with probability 1 an raise his payoff by slightly increasing his offer.) It follows that the offer in stage T is also equal to 0, otherwise the low-type seller would not accept in stage $T-1$. But then the offer in stage $T-2$ must be equal to 0 as well. Repeating this argument shows that all offers must be 0. Any deviation to an offer of $p' \in (0, v_L)$ is deterred by the last buyer putting positive probability on offer c_H. The equilibrium is essentially unique: Trade can occur with any of the buyers in stages 1 to $T-1$ at a price of 0 as long as $\mu_{T-1} \in [q, \mu^*]$, but in any equilibrium all offers are 0, the high-type seller doesn't trade, and the low-type seller trades with probability 1, where a significant portion of the acceptance probability occurs in stage T. □

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Hörner, Johannes and Nicolas Vieille, "Public vs. private offers in the market for lemons," *Econometrica*, 2009, *77* (1), 29–69.

_ **and** _ , "Public vs. private offers: The two-type case to supplement "Public vs. private offers in the market for lemons"," *Econometrica*, 2009, *77* (1), 29–69.

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Online Appendix II:

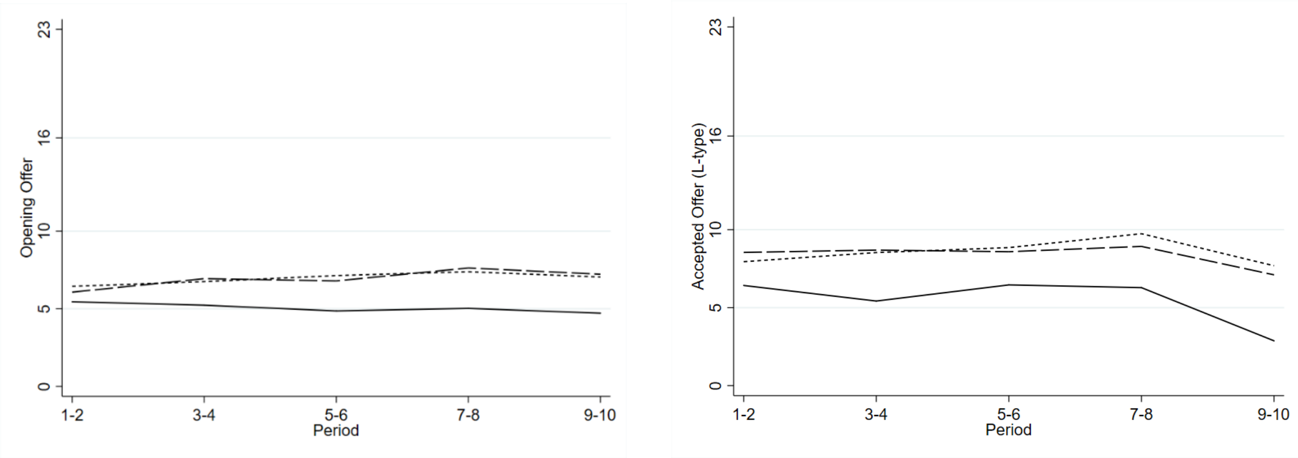
Additional Analyses and Experimental Instructions for Article "Competition and Price Transparency in the Market for Lemons: Experimental Evidence"

by Olivier Bochet and Simon Siegenthaler

A.1: Period Effects

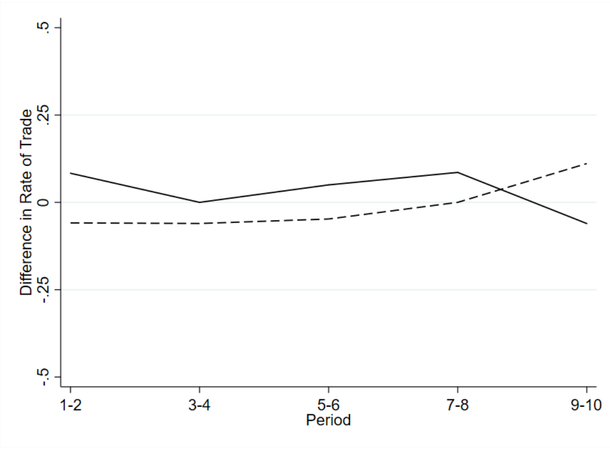
Figure A.1.1 below depicts the average opening offer and average prices accepted by L-type sellers over the 10 periods of an experimental session. The solid line depicts treatment *Exclusive*, the dashed line treatment *Private*, and the dotted line treatment *Public*. The figures show that behavior is stable across periods and similar in the competitive bargaining treatments.

Figure A.1.1: Opening Offers and Accepted Offers over Periods



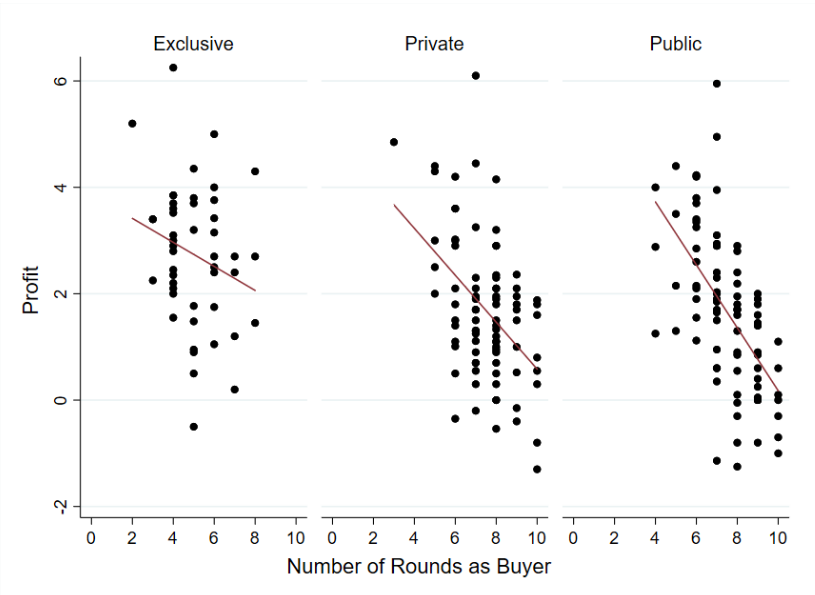
Examining the rate of trade across period is less straightforward, because they depend on the maximum length of a bargaining game as determined by the breakdown probability, in addition to subjects' behavior over time. However, because the distribution of breakdown periods was held constant across treatments, we can compare the difference (rather than the level) in the rate of trade between treatments. Figure A.1.2 shows that the difference between treatments *Private* and *Public* in the rate of trade for L-type sellers (solid line) and H-type sellers (dashed line) is small in all periods and there is no time trend for either seller type.

Figure A.1.2: Difference in Rates of Trade over Periods



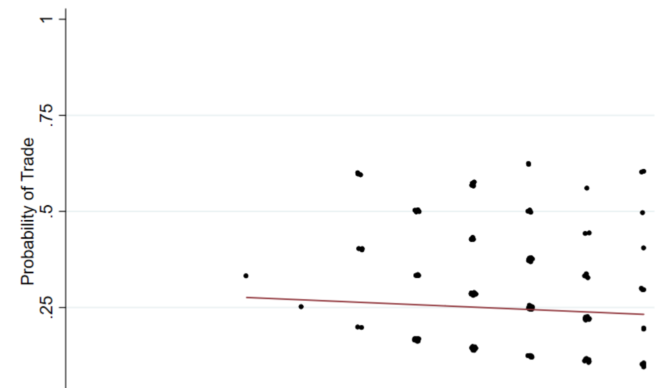
A related question is whether individual behavior was affected by the number of times a subject acted in the role of a buyer or seller. Indeed, sellers tend to earn more on average due to their information advantage. This is confirmed in figure A.1.3 below, depicting the average profit as a function of the number of times a subject played in the role of a buyer (each dot represents and individual).

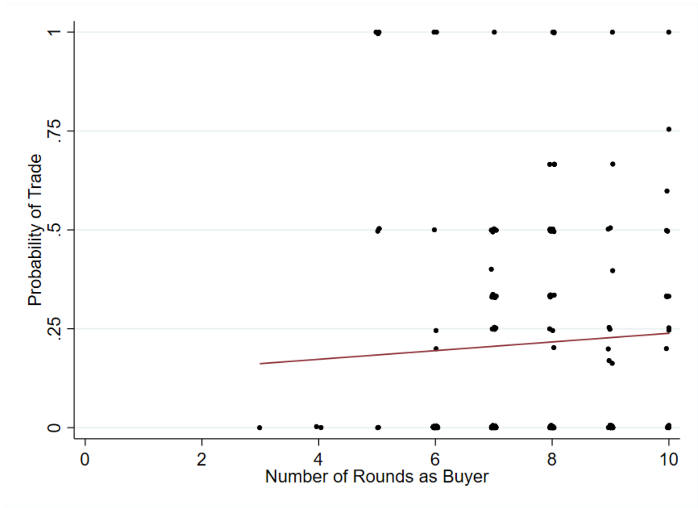
Figure A.1.3: Profit Depending on Number of Rounds as Buyer



Individuals who are often in the role of a buyer tend to earn less. Do such individuals behave differently? The figures below show that, at least in terms of the achieved rates of trade, buyers don't behave differently depending on the frequency with which they were assigned the role of a buyer or seller.

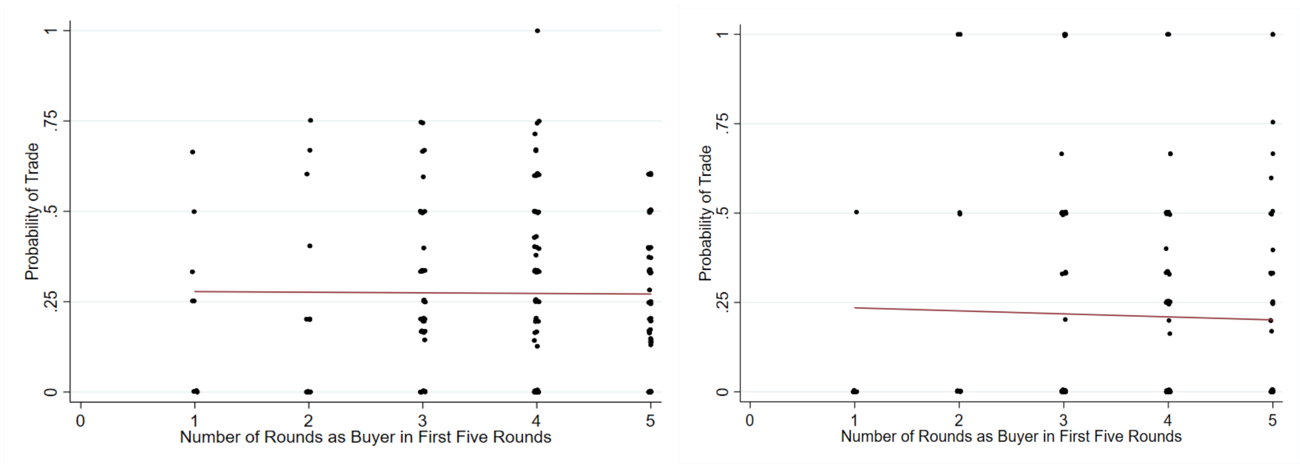
Figure A.1.4: Buyers' Rate of Trade with L-type Sellers (left) and H-type Sellers (right)





Finally, one may wonder if individuals who were allocated the role of a buyer more often than others early in the experiment behave differently. Figure A.1.5 below shows that this is not the case when looking at their probability of trade. The figure is identical to Figure A.1.4 except that the horizontal axis is now the frequency with which a subject was assigned the role of a buyer in the first five rounds only.

Figure A.1.5: Buyers' Rate of Trade with L-type Sellers (left) and H-type Sellers (right) Depending on Roles Allocated Early in Experiment



A.2: Location Effects

Our main data set was collected at the University of Bern. For a set of robustness checks we collected further data at the University of Valencia. In order to be able to compare the two data sets we also collected data for treatments *Private* and *Public* in Valencia. That is, our data for these treatments consists of 8 independent matching groups from Bern (96 subjects) and 6 independent matching groups from Valencia (72 Subjects).

In this appendix, we demonstrate that there are no major differences in behavior between the data from Bern and Valencia. Figure A.2.1 shows the average opening and accepted offers with the corresponding 95% confidence intervals. We can neither detect a difference between locations nor for any given location a significant effect of offer transparency.

Figure A.2.1: Opening Offers and Accepted Offers by Location

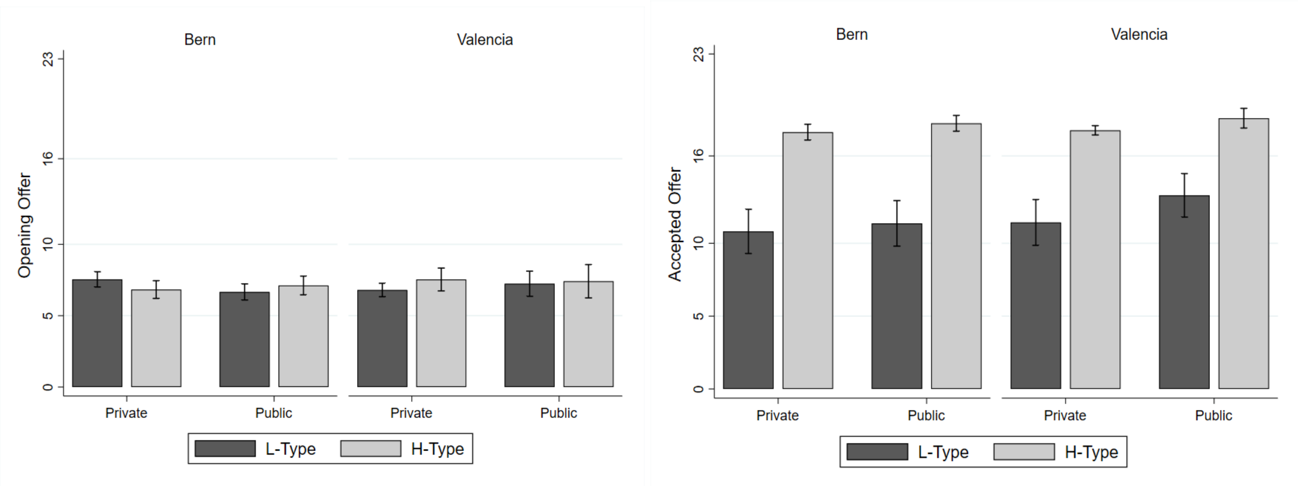
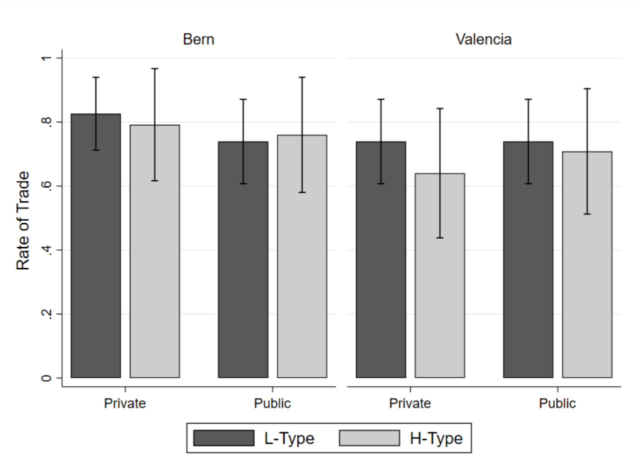


Figure A.2.2 shows the rates of trade by location (and seller type). There are no significant effects based on location. In treatment *Public* the rate of trades are very similar. In treatment *Private*, we see slightly lower rates of trade in Valencia than in Bern (not significant at the 10% level). More importantly, however, in a given location, there are no significant differences in the rates of trade between treatments *Private* and *Public*. That is, result 3 on the effect of offer transparency in the main text holds independently for the data collected in Bern and Valencia.

Figure A.2.2.: Rates of Trade by Location



A.3: Instructions

Welcome to this experiment. Please read the following instructions carefully as your decisions in the experiment will affect your final earnings.

Throughout the experiment, we will not speak of Euros, but rather of ECU (Experimental Currency Units). At the end of the experiment the total amount of ECU you earned will be converted to EUR at the **exchange rate ECU 1 = EUR 0.5.** You will also receive a **show up fee** of **EUR 10.** You will be paid your earnings in cash, privately at the end of the session.

You will make all your decisions through the computer terminal. Please do not talk to or attempt to communicate with other participants during the session. Please also do not ask questions aloud. If you have a question, raise your hand and a member of the experimenter team will come to you. All personal electronic devices should remain switched off until the end of the experiment.

The experiment will have three parts. For each part you will receive instructions explaining how you make decisions and how your decisions influence your earnings. In case you make losses during the experiment, the show up fee will be used to pay for the losses.

[Treatment Private and Public]

<u>*Rounds, Buyers, and Sellers*</u>
Part 1 of the experiment will have **10 rounds.** In each round you will be in a group **consisting of 4 participants: 1 seller and 3 buyers.** You will be assigned the role of the seller or the role of one of the buyers. New groups will be randomly formed in each round. That is, the **participants that are in the same group as you change from one round to another.** Your role will also be randomly assigned, that is, when you are a buyer in one round you may be a seller in the next round and vice versa when you are a seller. You will not get to know the identity of the participants you interact with, neither during nor after the experiment. Similarly, no participant will get to know your identity.

<u>*Types*</u>
The seller can be of two different types: **type H** or **type L.** The probability that a seller will be of type H is **1/3** (33.33%) and the probability that a seller will be of type L is **2/3** (66.67%). A type H seller can produce a high quality good at a cost of **16.** A type L seller can produce a low quality good at a cost of **0.** A buyer's valuation for the high quality good is **23.** A buyer's valuation for the low quality good is **10.** Only the seller will know his/her type. **The buyers will make price offers without knowing for sure the seller's type.**

<u>*Buying and Selling*</u>
Buyers will make price offers to acquire the good from the seller. Offers must be **between 0 and 23** and can be as exact as to the first decimal place. The buyers will be assigned an **ID number 1, 2 or 3.** The buyer with ID number 1 (in short, buyer 1) will make the first offer to the seller. The seller can **accept or reject** the offer. If the seller rejects the first offer, buyer 2 can make an offer to the seller, which can again be accepted or rejected. If the offer is rejected, it is buyer 3's turn to make an offer. If the offer is again rejected, buyer 1 can make a second offer and so on. Hence, buyers make offers in sequence, one after the other, buyer 1 first, then buyer 2, then buyer 3, then again buyer 1, buyer 2, buyer 3, and so on.

Probability that the Market Closes Before the Good Is Sold
Each time the seller rejects an offer, there is a probability that the market closes and no further offers can be made. The probability that the **market closes after a rejection is 10%.** The number of stages before the market closes is thus not always the same and you won't know exactly when the market will close. You only know that after a rejected offer, the next buyer cannot always make new offer (he/she can do so with a probability of 90%). If the market closes before the seller accepts an offer, the good is not produced (and not sold). **Then, the seller and all buyers earn 0.**

Earnings if the Seller Accepts an Offer
If the seller accepts an offer, he/she produces the good and sells it to the buyer who made the offer. The seller's payoff is equal to the offer he/she accepted minus his/her production costs, while the buyer's payoff is equal to his/her valuation for the good minus the agreed price:

Seller's Payoff	**=**	**Accepted Offer – Production Cost**
Buyer's Payoff	**=**	**Valuation of the Good – Accepted Offer**

The buyer's valuations and the seller's production costs are summarized below:

Seller's cost of producing the high quality good (type H)	=	16
Seller's cost of producing the low quality good (type L)	=	0
Buyer's valuation for the high quality good	=	23
Buyer's valuation for the low quality good	=	10

The other buyers **whose offers are not accepted** (or who never got to make an offer) earn **a payoff of 0.**

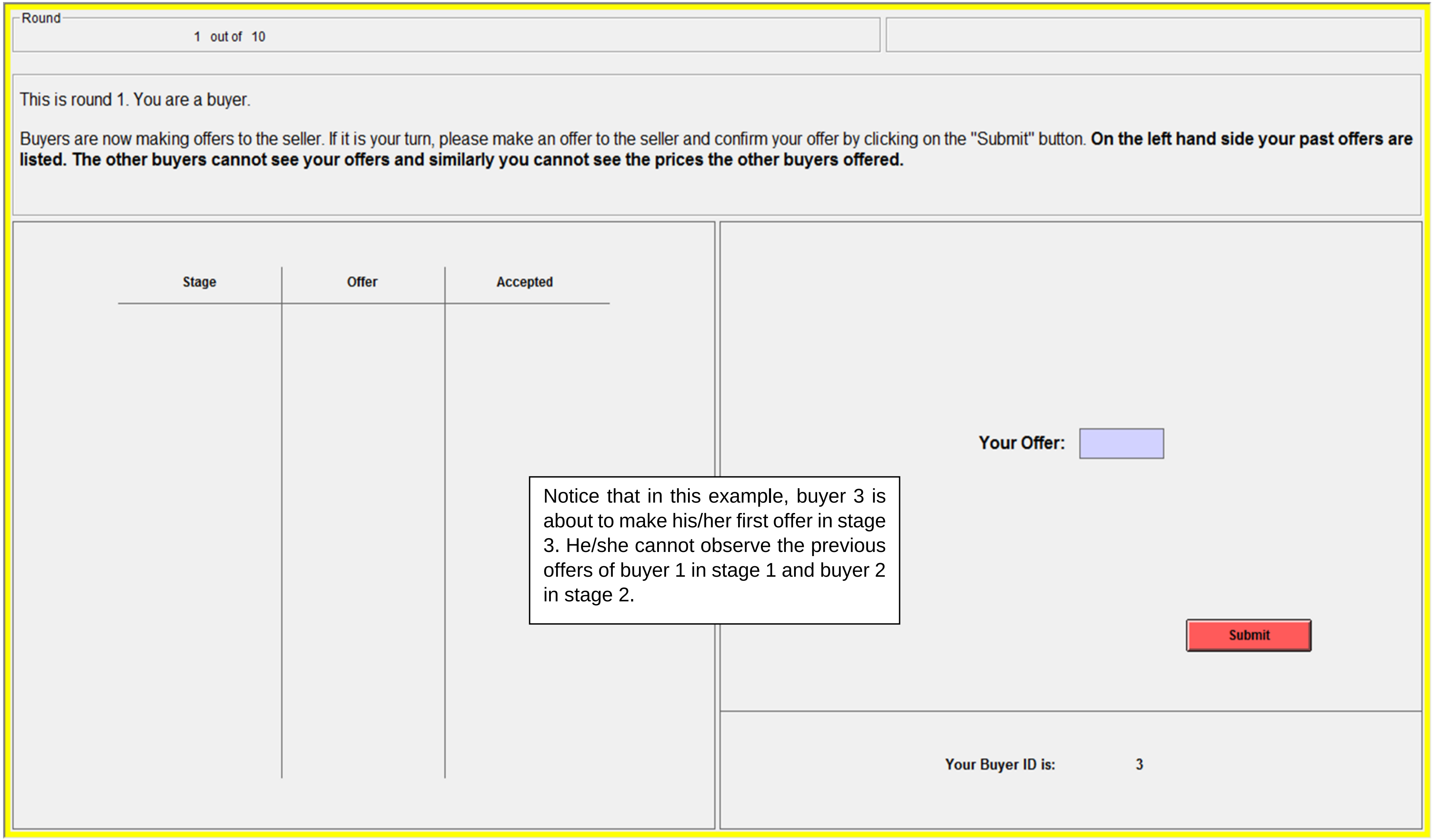
Once the seller has sold the good or the market has closed, the computer randomly forms new groups (consisting of 1 seller and 3 buyers) and the next round is entered. Part 1 of the experiment ends after round 10.

Example
Suppose offers 1, 2, 3, and 4 were rejected by the seller. If the market closes after stage 4, everyone would earn 0. Suppose the market doesn't close after stage 4. In stage 5 the next buyer (with ID number 2) offers 5.7 and the seller accepts. If the seller is of type L, buyer 2 would earn 10 – 5.7 = 4.3, the seller would earn 5.7 – 0 = 5.7, and the other two buyers would earn 0. What would the earnings be if the seller is of type H? Then, buyer 2 would earn 23 – 5.7 = 17.3 and the seller would earn 5.7 – 16 = –10.3 (that is, he/she would lose 10.3 ECU). A type H seller should thus not accept offers below 16. Buyers can also make losses if they acquire a low quality good for a price of more than 10.

A Final Important Remark
[Treatment Private:] The seller will see a table listing all offers. Buyers will only see their own previous offers. Hence, **when a buyer makes his/her offer, he/she does not know the previous offers made by the other buyers.**

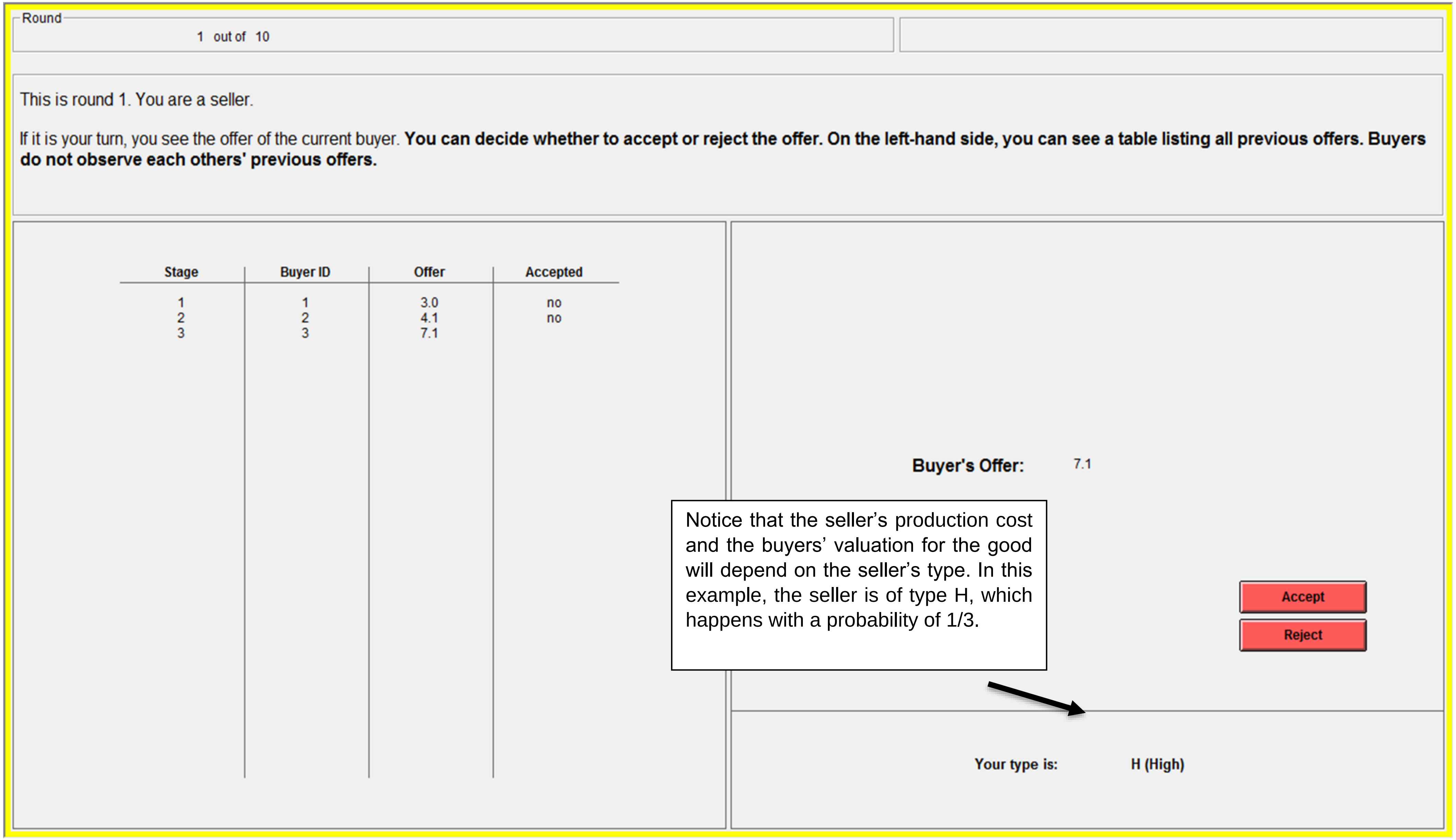
[Treatment Public:] The seller and the three buyers will see a table listing all offers. Hence, **when a buyer makes his/her offer, he/she knows the previous made by the other buyers** (as well as his/her own previous offers).

Buyer’s Screen *[Treatment Private]*

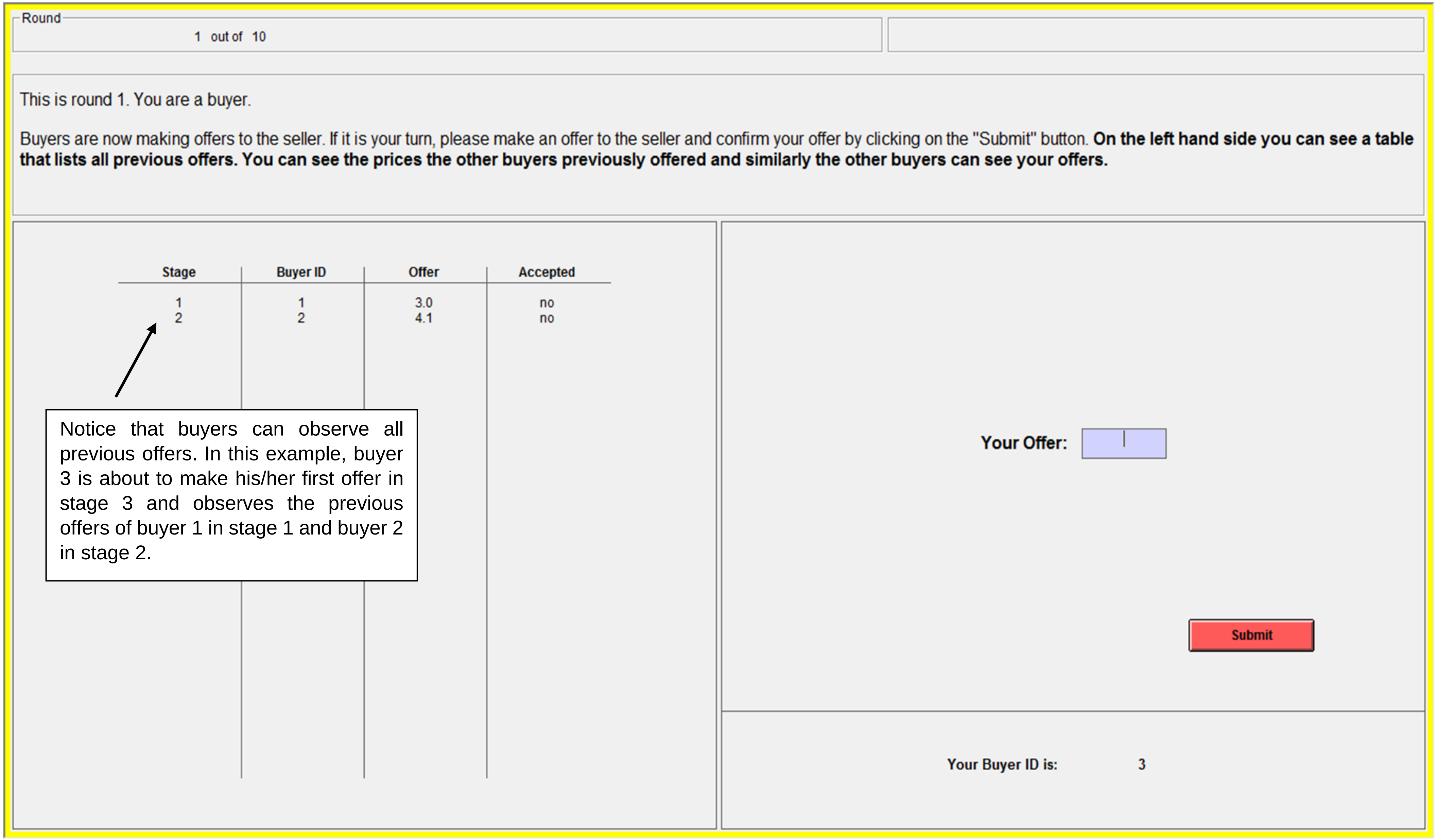


Notice that in this example, buyer 3 is about to make his/her first offer in stage 3. He/she cannot observe the previous offers of buyer 1 in stage 1 and buyer 2 in stage 2.

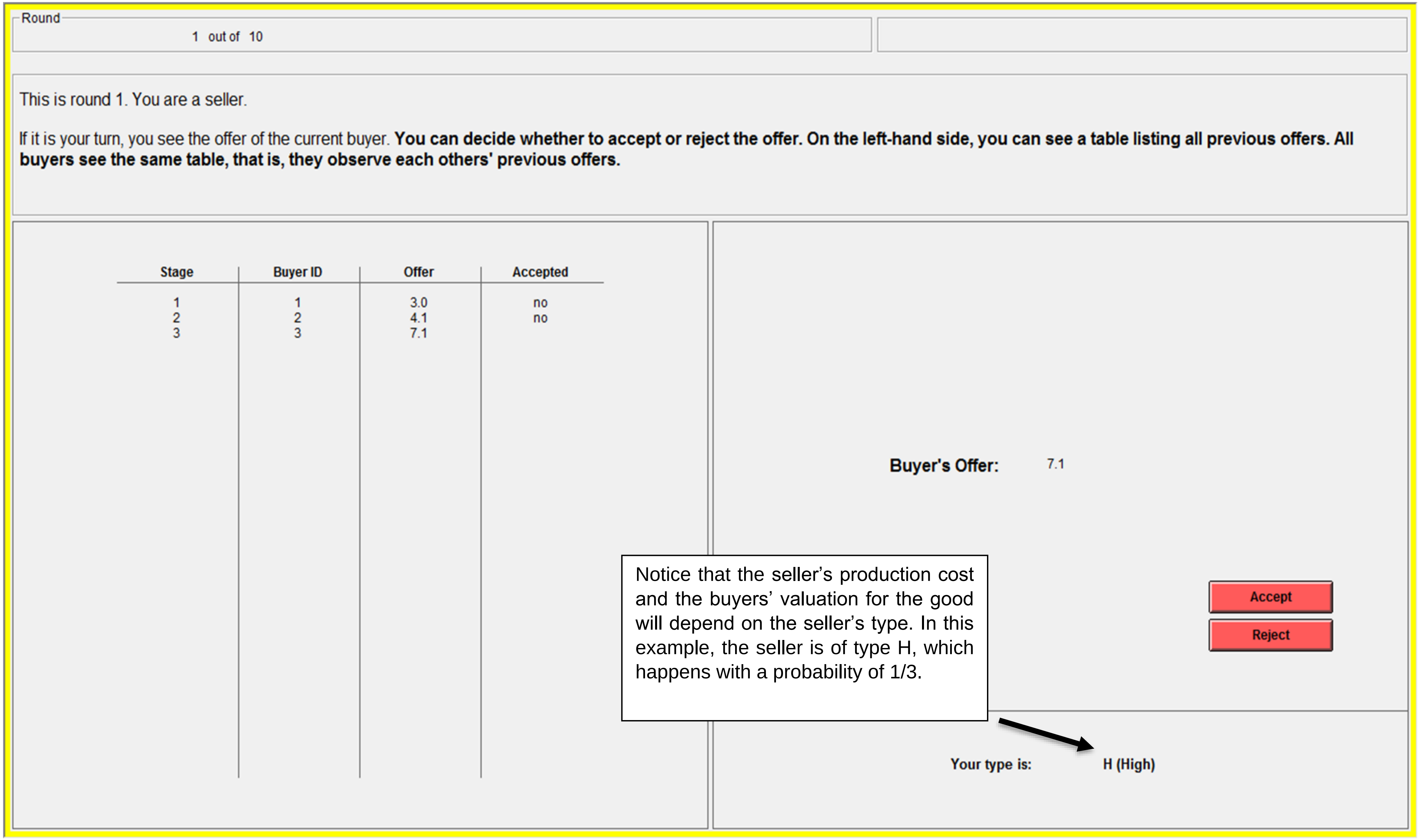
Seller's Screen *[Treatment Private]*



Buyer’s Screen *[Treatment Public]*



Seller's Screen *[Treatment Public]*



[Treatment Exclusive]

We will now describe the general setting you will face during the experiment. The same decision situation (explained below) will be repeated for **10 periods**. In each period, you will be matched into pairs. Each pair consists of a **buyer** and a **seller**. **In each period new pairs will be formed randomly.** That is, participants that are in the same pair will generally not be in the same pair in the next period. Note that at the beginning of the experiment, participants will be randomly divided into two **blocks of six**. The pairs of buyers and sellers are randomly formed within each of the two blocks, but a participant in one block will never meet a participant in the other block.

Your role (buyer or seller) is randomly determined at the beginning of each period. When you are a buyer in one period you may be a seller in the next one and likewise when you are a seller. You will not get to know the identity of the buyers or sellers you interact with, neither during nor after the experiment. Similarly, no participant will get to know your identity.

The decision situation will be the same for all 10 periods. We will now describe one such period. After the buyer and the seller have been matched, they face the following situation. The seller can be of two different types: **type H** or **type L**. A seller of type H can only produce a high quality good at cost **16**. A seller of type L can only produce a low quality good at cost **0**. The buyer's valuation for the high quality good is **23**. The buyer's valuation for the low quality good is **10**.

The seller knows whether she is of type H or type L and therefore also knows how much the good is worth to the buyer. However, **the buyer does not know the seller's type** and hence, the buyer does neither know whether his valuation for the good is 23 or 10 nor whether the cost of the seller to produce the good is 16 or 0. The type of the seller will be determined randomly according to the following probabilities (at the beginning of each period and for every pair): **the probability that the seller is of type H (high cost / high quality good) is 1/3 (33.33%) and the probability that the seller is of type L (low cost / low quality good) is 2/3 (66.67%).**

To acquire the good, **the buyer makes offers** to the seller. The offers must be between 0 and 23 and can be as exact as to the first decimal place. Upon seeing the buyer's offer, the **seller can accept or reject** the offer. **If the seller rejects the offer**, the buyer can make another offer to the seller which can again be accepted or rejected. If the offer is rejected, the buyer makes another offer and so on.

Importantly, if the seller rejects an offer, there is a **probability that the buyer cannot make a further offer.** This probability is 0.1 (10%). Correspondingly, the **continuation probability** is **0.9 (90%).** Hence, if the seller rejects an offer of a buyer, the probability that the buyer can make another offer is 0.9. **If the trading process ends before trade has occurred, the good is not produced (and not traded) and the seller and buyer both earn 0.**

For instance, suppose the buyer has made the first offer and this offer was rejected. Then, the process ends with a probability of 0.1 or the buyer can make a second offer with a probability of 0.9. So the probability that the buyer will be able to make a third offer (given that the seller rejects the first two offers) is 0.9*0.9=0.81. The probability that the buyer will be able to make a fourth offer is $0.9*0.9*0.9=0.9^3=0.729$. This shows that the number of stages before the market closes varies from period to period and is determined by the continuation probability. In any given stage, the probability to reach the next stage is 90%.

If the seller accepts the offer, she produces the good and sells it to the buyer at the agreed price. The seller and the buyer earn a payoff according to the description below. They then wait until all other pairs have finished their trading processes.

If an offer is accepted, the payoff of the seller and the buyer are determined as follows.

Buyer's payoff = Valuation of the Good - Accepted Offer

Seller's payoff = Accepted Offer - Production Cost

For convenience the valuations and costs are summarized below:

Buyer's valuation for the high quality good = 23

Buyer's valuation for the low quality good = 10

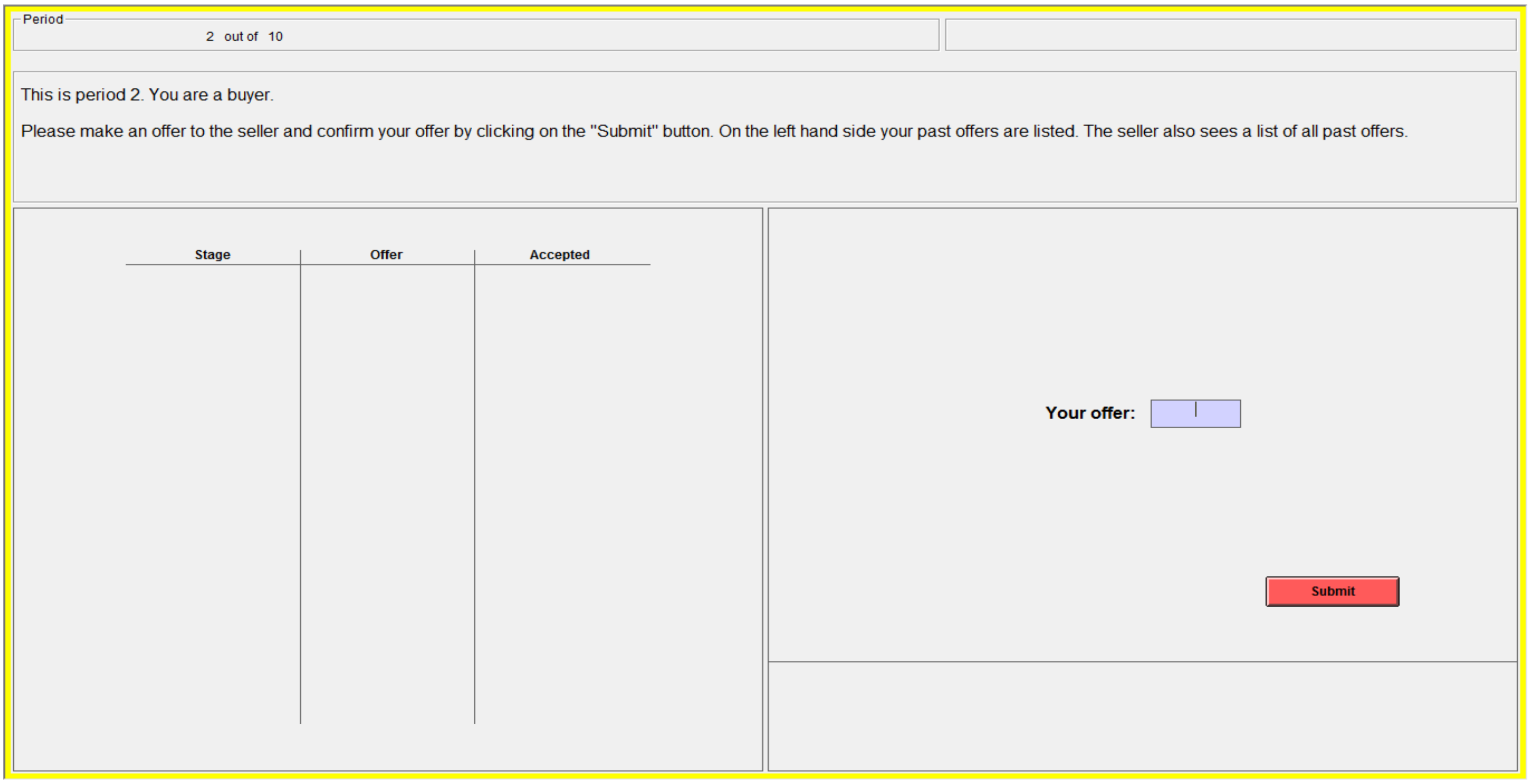
Seller's cost of producing the high quality good = 16

Seller's cost of producing the low quality good = 0

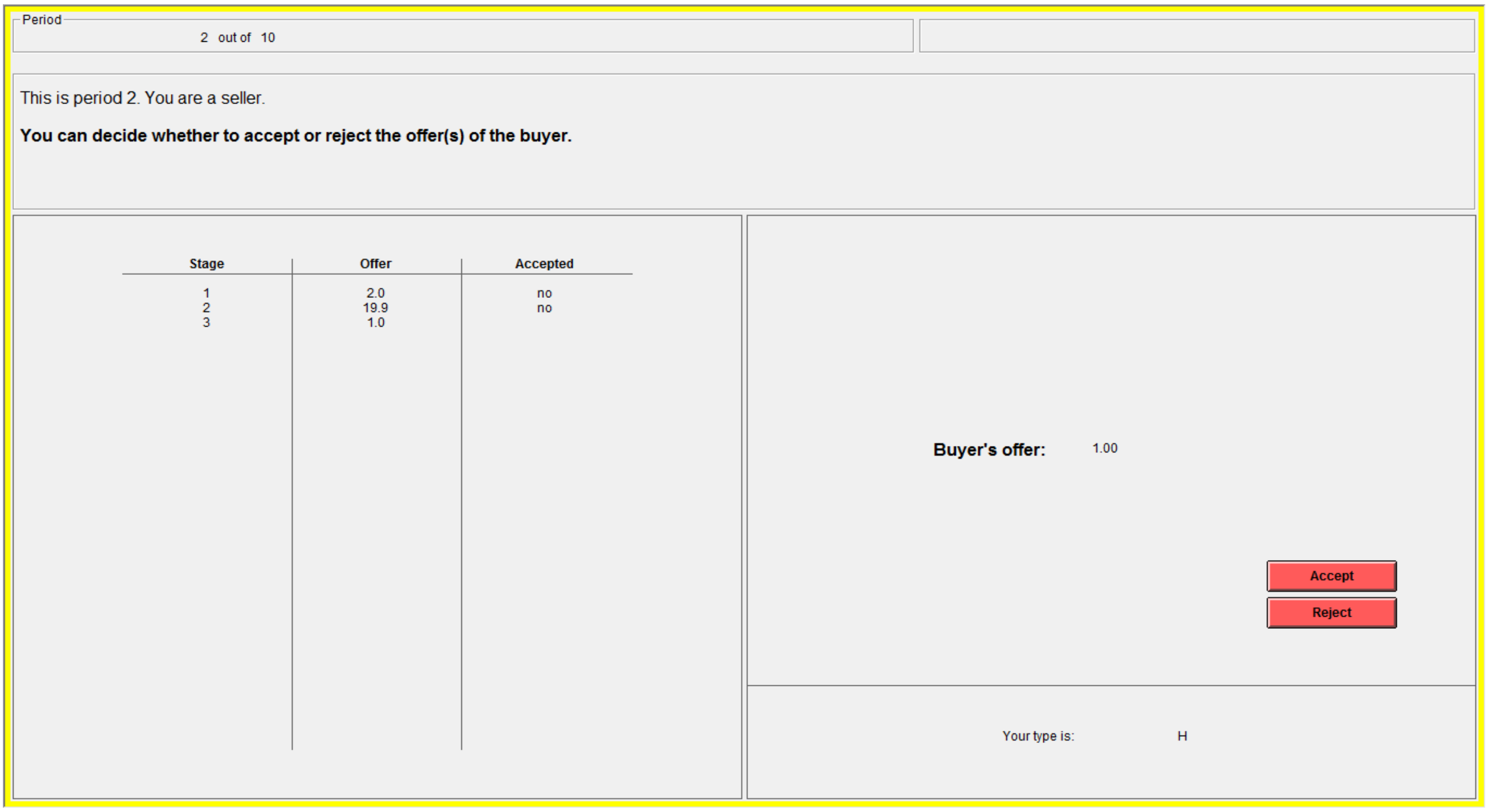
As an example, consider a buyer who offers a price of 9 and a seller who accepts this offer. If the seller is a type L (low quality) seller, her payoff is (Accepted Offer – Production Cost) = 9-0 = 9. The buyer's payoff is (Valuation – Accepted Offer) = 10-9 = 1. On the other hand, if the seller is a type H (high quality) seller, her payoff if she accepts the offer is (Accepted Offer – Production Cost) = 9-16 = -7. The buyer's payoff in this case is (Valuation – Accepted Offer) = 23-9 = 14.

Once all groups have traded the good at some price or the trading process has ended otherwise (recall, the stage at which this happens is determined by the continuation probability), the computer randomly determines your role (buyer or seller) in the next period and matches new pairs of buyers and sellers. Then the next period starts. The experiment ends after period 10.

Buyer's Screen *[Treatment Exclusive]*



Seller's Screen *[Treatment Exclusive]*



[Treatment Private Strategy]

<u>Rounds, Buyers, and Sellers</u>

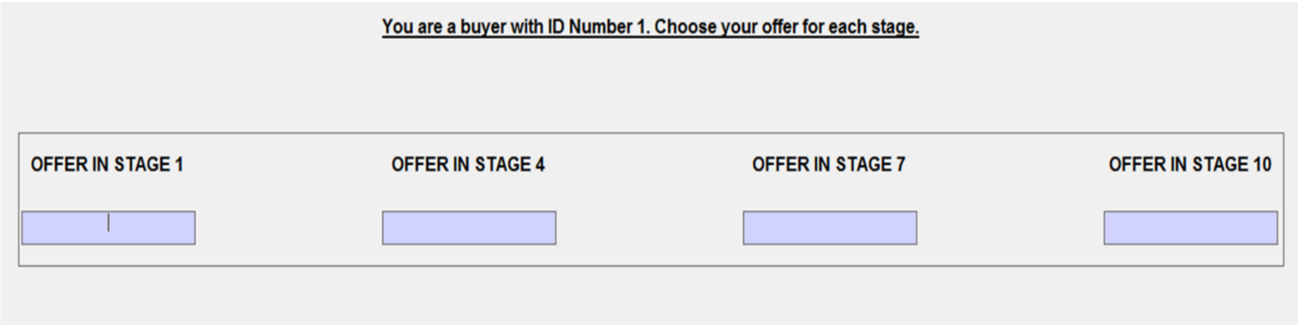
Part 1 of the experiment will have **15 rounds.** In each round you will be in a group **consisting of 4 participants: 1 seller and 3 buyers.** You will be assigned the role of the seller or the role of one of the buyers. New groups will be randomly formed in each round. That is, the **participants that are in the same group as you change from one round to another.** Your role will also be randomly assigned, that is, when you are a buyer in one round you may be a seller in the next one and vice versa when you are a seller. You will not get to know the identity of the participants you interact with, neither during nor after the experiment. Similarly, no participant will get to know your identity.

<u>Types</u>

The seller can be of two different types: **type H** or **type L.** The probability that a seller will be of type H is **1/3** (33.33%) and the probability that a seller will be of type L is **2/3** (66.67%). A type H seller can produce a high quality good at a cost of **16.** A type L seller can produce a low quality good at a cost of **0.** A buyer's valuation for the high quality good is **23.** A buyer's valuation for the low quality good is **10.** Only the seller will know his/her type. **The buyers will make price offers without knowing for sure the seller's type.**

Buyers' Offers

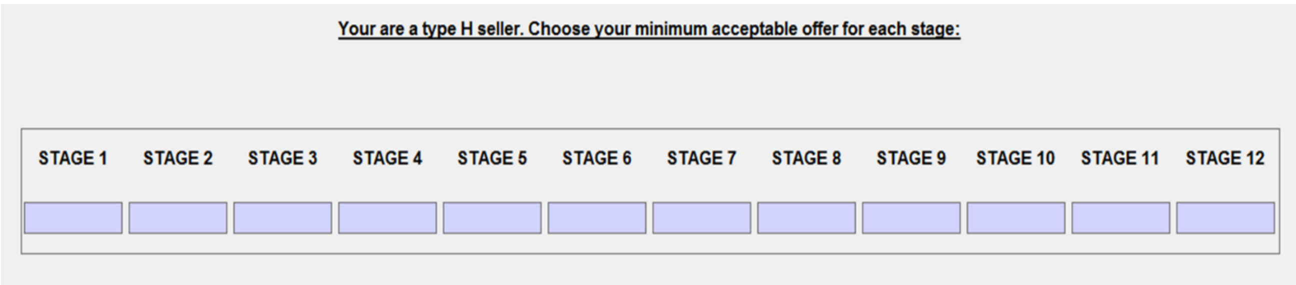
Buyers will make price offers to acquire the good from the seller. Offers must be **between 0 and 23** and can be as exact as to the first decimal place. The buyers will be assigned an ID number 1, 2 or 3. The buyer with **ID number 1** (in short, buyer 1) will choose offers for **stage 1, stage 4, stage 7, stage 10** and so on. The buyer with **ID number 2** will choose offers for **stage 2, stage 5, stage 8, stage 11** and so on. The buyer with **ID number 3** will choose offers for **stage 3, stage 6, stage 9, stage 12** and so on. The figure below shows the computer screen of a participant in the role of buyer 1.



Similarly, at the start of a round, the buyer with ID number 2 will choose his/her offers for stage 2, stage 5, stage 8, and stage 11, and the buyer with ID number 3 will choose his/her offers for stage 3, stage 6, stage 9, and stage 12. Note that buyers choose their offers without knowing the offers the other buyers are choosing.

Seller's Minimum Acceptable Offers

The seller will choose **"minimum acceptable offers"** for *each stage* 1, 2, 3, … The minimum acceptable offer has to be a number between 0 and 23 (again to the first decimal place). The figure below shows the computer screen of a seller.



When Is the Good Sold?

Once all decisions are made, the computer will compare the buyers' offers with the seller's minimum acceptable offers. The computer will begin with stage 1, then stage 2, and so on. If in a given stage the **buyer's offer is *below* the seller's minimum acceptable offer, the offer is *rejected*** and the computer continues to the next stage. If in a given stage the **buyer's offer *exceeds or is equal to* the minimum acceptable offer, the offer is *accepted*.** The good is then sold to the respective buyer at the offered price.

Can the Market Close even if the Good Is not Sold?

Each time the seller rejects an offer (that is, the buyer's offer is below the minimum acceptable offer), there is a probability that the market closes and no further offers can be made. The **probability that the market closes after each rejection is 10%.** The number of stages before the market closes is thus not always the same and you won't know exactly when the market will close. If the market closes before the seller accepts an offer, the good is not produced and not sold. **Then, the seller and all buyers earn 0.**

It is possible that by stage 12 no offer has been accepted *and* the market hasn't closed yet. In this case, we will ask you at the start of stage 13 to choose new offers (as a buyer) or new minimum acceptable offers (as a seller). In particular, you would then make choices for the next 12 stages (stages 13 to 24). If by stage 24, still no offer has been accepted and the market hasn't closed yet, you will make new choices for stages 25 to 36, and so on.

Earnings if the Seller Accepts an Offer

If the seller accepts an offer, he/she produces the good and sells it to the buyer who made the offer. The seller's payoff is equal to the offer he/she accepted minus his/her production costs, while the buyer's payoff is equal to his/her valuation for the good minus the agreed price:

Seller's Payoff = Accepted Offer – Production Cost

Buyer's Payoff = Valuation of the Good – Accepted Offer

The buyer's valuations and the seller's production costs are summarized below:

Seller's cost of producing the high quality good (type H) = 16

Seller's cost of producing the low quality good (type L) = 0

Buyer's valuation for the high quality good = 23

Buyer's valuation for the low quality good = 10

The other buyers **whose offers are not accepted** (or who never got to make an offer) earn **a payoff of 0.**

Example:

The table below shows an example of the seller's and the buyers' decisions (the numbers are chosen arbitrarily and do *not* indicate how you should behave in the experiment). The computer will compare the buyers' offers with the seller's minimum acceptable offers to determine which buyer trades with the seller in which stage and at what price.

Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Seller (minimum acceptable offer)	6	3	8	17	5.2	12	8	20.7	10	9	10	5
Buyer with ID 1 (offer)	5			15			10			9.1		
Buyer with ID 2 (offer)		1			5.7			8			6	
Buyer with ID 3 (offer)			7.7			17			19			21

In stage 1, the buyer with ID number 1 offered 5, which is below the minimum acceptable offer of 6. So, the offer is rejected. In stage 2, the buyer with ID number 2 offered 1, which is below the minimum acceptable offer of 3 and so it is again rejected. In stage 3, the buyer with ID number 3 offered 7.7, again below the minimum acceptable offer of 8. In stage 4, the buyer with ID number 1 offered 15, again below the minimum acceptable offer of 17. In stage 5, the buyer with ID number 2 offered 5.7, which exceeds the minimum acceptable offer of 5.2. Hence, the good is sold to the buyer with ID number 2 in stage 5 at a price of 5.7 (assuming the market hasn't closed before stage 5).

If the seller is of type L, his/her payoff would be *Accepted Offer - Production Cost = 5.7 – 0 = 5.7*. Buyer 2's payoff would be *Valuation of the Good - Accepted Offer = 10 – 5.7 = 4.3.* Buyer 1 and buyer 3 would earn 0. What would the earnings be if the seller were of type H? Then, buyer 2 would earn 23 – 5.7 = 17.3 and the seller would earn 5.7 – 16 = –10.3 (that is, he /she would lose 10.3 ECU). A type H seller should thus not accept offers below 16. Buyers can also make losses if they acquire a low quality good at a price above 10.

Once the seller has sold the good or the market has closed, the computer randomly forms new groups (consisting of 1 seller and 3 buyers) and the next round is entered. Part 1 of the experiment ends after round 15.

[Treatment Public Strategy]

Rounds, Buyers, and Sellers

Part 1 of the experiment will have **15 rounds.** In each round you will be in a group **consisting of 4 participants: 1 seller and 3 buyers.** You will be assigned the role of the seller or the role of one of the buyers. New groups will be randomly formed in each round. That is, the **participants that are in the same group as you change from one round to another.** Your role will also be randomly assigned, that is, when you are a buyer in one round you may be a seller in the next one and vice versa when you are a seller. You will not get to know the identity of the participants you interact with, neither during nor after the experiment. Similarly, no participant will get to know your identity.

Types

The seller can be of two different types: **type H** or **type L.** The probability that a seller will be of type H is **1/3** (33.33%) and the probability that a seller will be of type L is **2/3** (66.67%). A type H seller can produce a high quality good at a cost of **16.** A type L seller can produce a low quality good at a cost of **0.** A buyer's valuation for the high quality good is **23.** A buyer's valuation for the low quality good is **10.** Only the seller will know his/her type. **The buyers will make price offers without knowing for sure the seller's type.**

Buyers' Offers

Buyers will make price offers to acquire the good from the seller. Offers must be **between 0 and 23** and can be as exact as to the first decimal place. The buyers will be assigned an ID number 1, 2 or 3. The buyer with **ID number 1** (in short, buyer 1) will choose offers for **stage 1, stage 4, stage 7, stage 10** and so on. The buyer with **ID number 2** will choose offers for **stage 2, stage 5, stage 8, stage 11** and so on. The buyer with **ID number 3** will choose offers for **stage 3, stage 6, stage 9, stage 12** and so on. The figure below shows the computer screen of a participant in the role of buyer 1.

You are a buyer with ID Number 1. Choose your offers for each stage:

OFFER IN STAGE 1: ____

PREVIOUS OFFER	OFFER IN STAGE 4	OFFER IN STAGE 7	OFFER IN STAGE 10
0 - 2			
2.1 - 4			
4.1 - 6			
6.1 - 8			
8.1 - 10			
10.1 - 12			
12.1 - 14			
14.1 - 16			
16.1 - 18			
18.1 - 20			
20.1 - 23			

Notice that in the above figure buyer 1 has to make **a single offer for stage 1** ("OFFER IN STAGE 1"). On the other hand, buyer 1 has to make 11 offers in stage 4, 7 and 10. The reason is that there he/she has to **choose offers *conditional* on the previous offer.** In stage 4, the previous offer is the offer that buyer 3 chose for stage 3. In stage 7, the previous offer is the one made in stage 6. In stage 7, it is the one made in stage 6, and in stage 10, it is the one made in stage 9. When you make your choices you won't know what these previous offers will be (they will be chosen by other participants). Therefore, we ask you to make offers for different ranges or intervals of the previous offer: in the first row ("PREVIOUS OFFER 0 - 2"), a buyer will choose an offer for the case when the previous offer turns out to be between 0 and 2; in the second row, a buyer will choose an offer in case the previous offer is between 2.1 and 4; and so on until the last row where the previous offer is between 20.1 and 23.

In the exact same way, the buyers with ID number 2 and 3 will also make their offers conditional on the offer made by the previous buyer in the preceding stage. For instance, buyer 2 will be making offers for stage 2 conditional on the offer in stage 1, for stage 5 conditional on the offer in stage 4, for stage 8 conditional on the offer in stage 7, etc. The computer screen for buyer 2 is shown below. The screen for buyer 3 will look similar.

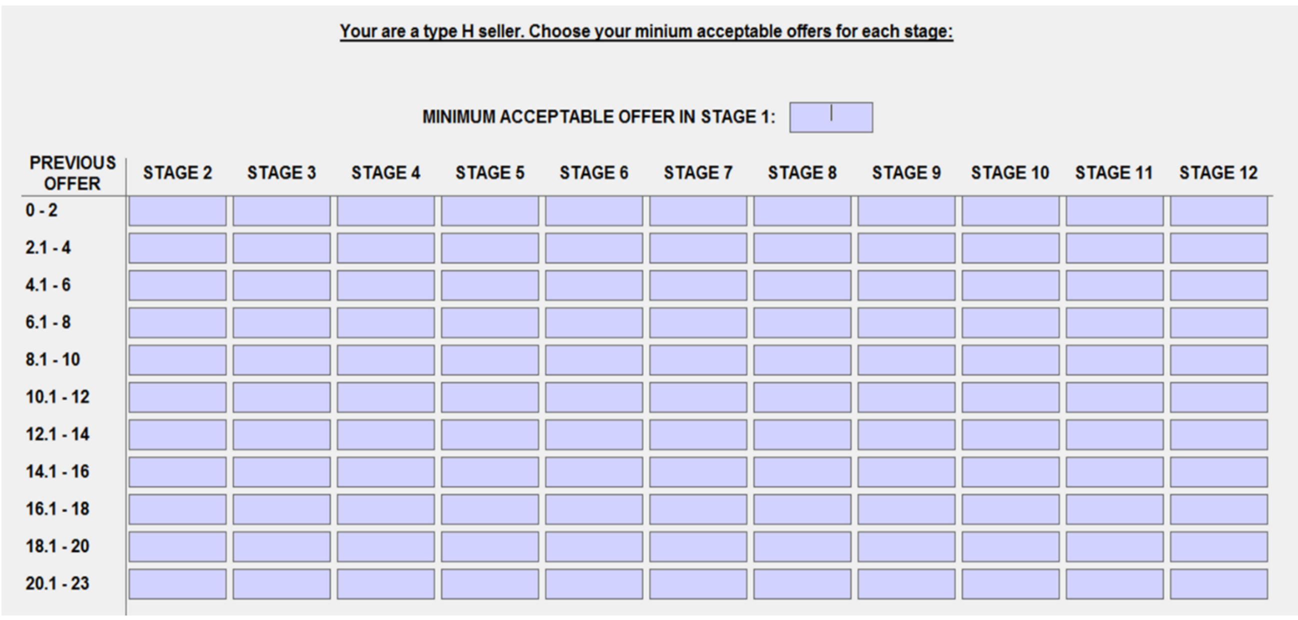
You are a buyer with ID Number 2. Choose your offers for each stage.

PREVIOUS OFFER	OFFER IN STAGE 2	OFFER IN STAGE 5	OFFER IN STAGE 8	OFFER IN STAGE 11
0 - 2				
2.1 - 4				
4.1 - 6				
6.1 - 8				
8.1 - 10				
10.1 - 12				
12.1 - 14				
14.1 - 16				
16.1 - 18				
18.1 - 20				
20.1 - 23				

Importantly, **buyer 1's offer in stage 1** (which is *not conditional* on a previous offer) **will determine which future offers will be "relevant."** For example, if buyer 1 chooses an offer of 3.7 in stage 1, then the offer that will be relevant in stage 2 is the one buyer 2 made for the case when the previous offer is between 2.1 and 4 (because 3.7 is between 2.1 and 4). If buyer 1 instead chose an offer of 18.3 in stage 1, then the relevant offer in stage 2 is the one buyer 2 made for the case when the previous offer is between 18.1 and 20. In this way, we will determine which offer is the relevant one in stage 2. The relevant offer in stage 2 will then in turn determine which offer is selected as the relevant one in stage 3. This process continues stage by stage, i.e., the relevant offer in stage 3 determines which offer is selected as the relevant one in stage 4, which in turn determines the relevant offer in stage 5, etc.

Seller's Minimum Acceptable Offers

The seller will choose **"minimum acceptable offers"** for *each stage* 1, 2, 3, … The minimum acceptable offer has to be a number between 0 and 23 (to the first decimal place). The figure below shows the computer screen of a seller. In stage 1, the seller has to make only one minimum acceptable offer (this is because there is no previous offer). In all other stages, a seller will choose 11 minimum acceptable offers, each *conditional* on the offer made by the previous buyer in the preceding stage. For example, the previous offer in stage 2 (column "STAGE 2") is the one made by buyer 1 in stage 1. Which of the minimum acceptable offers will be "relevant" is determined in the same way as we explained for the buyers: the buyer's offer in stage 1 determines which minimum acceptable offer is selected as the relevant one in stage 2, the buyer's offer in stage 2 determines the relevant minimum acceptable offer in stage 3, and so on.



Your are a type H seller. Choose your minium acceptable offers for each stage:

MINIMUM ACCEPTABLE OFFER IN STAGE 1:

PREVIOUS OFFER	STAGE 2	STAGE 3	STAGE 4	STAGE 5	STAGE 6	STAGE 7	STAGE 8	STAGE 9	STAGE 10	STAGE 11	STAGE 12
0 - 2											
2.1 - 4											
4.1 - 6											
6.1 - 8											
8.1 - 10											
10.1 - 12											
12.1 - 14											
14.1 - 16											
16.1 - 18											
18.1 - 20											
20.1 - 23											

When Is the Good Sold?

Once all decisions are made, the computer will compare the buyers' offers with the seller's minimum acceptable offers. The computer will begin with stage 1, then stage 2, and so on. If in a given stage the **buyer's (relevant) offer is *below* the seller's (relevant) minimum acceptable offer, the offer is *rejected*** and the computer continues to the next stage. If in a given stage the **buyer's (relevant) offer *exceeds or is equal to* the (relevant) minimum acceptable offer, the offer is *accepted*.** The good is then sold to the respective buyer at the offered price.

Can the Market Close even if the Good Is not Sold?

Each time the seller rejects an offer (that is, the buyer's relevant offer is below the relevant minimum acceptable offer), there is a probability that the market closes and no further offers can be made. The **probability that the market closes after each rejection is 10%.** The number of stages before the market closes is thus not always the same and you won't know exactly when the market will close. If the market closes before the seller accepts an offer, the good is not produced and not sold. **Then, the seller and all buyers earn 0.**

It is possible that by stage 12 no offer has been accepted *and* the market hasn't closed yet. In this case, we will ask you at the start of stage 13 to choose new offers (as a buyer) or new minimum acceptable offers (as a seller). In particular, you would then make choices for the next 12 stages (stages 13 to 24). If by stage 24, still no offer has been accepted and the market hasn't closed yet, you will make new choices for stages 25 to 36, and so on.

Earnings if the Seller Accepts an Offer

If the seller accepts an offer, he/she produces the good and sells it to the buyer who made the offer. The seller's payoff is equal to the offer he/she accepted minus his/her production costs, while the buyer's payoff is equal to his/her valuation for the good minus the agreed price:

Seller's Payoff = Accepted Offer – Production Cost

Buyer's Payoff = Valuation of the Good – Accepted Offer

The buyer's valuations and the seller's production costs are summarized below:

Seller's cost of producing the high quality good (type H)	=	16
Seller's cost of producing the low quality good (type L)	=	0
Buyer's valuation for the high quality good	=	23
Buyer's valuation for the low quality good	=	10

The other buyers **whose offers are not accepted** (or who never got to make an offer) earn **a payoff of 0.**

Example:

Suppose that the sellers and the three buyers in a group have submitted their choices. The computer will then determine which buyer acquires the good in which stage and at what price (the numbers in the example are arbitrary and do *not* indicate how you should behave in the experiment):

- Suppose that in stage 1 buyer 1's offer is 5 and the seller's minimum acceptable offer is 6. Since the buyer's offer is below the minimum acceptable offer (5 < 6), the offer is rejected and the computer continues to check offers in stage 2.
- Suppose that in stage 2 buyer 2's offer is 1 and the seller's minimum acceptable offer is 3 *for*

the case when the previous offer is between 4.1 and 6. This is the relevant case given that the offer in stage 1 was 5. The buyer's offer is below the minimum acceptable offer (1 < 3). Hence, the buyer's offer is again rejected.

- Suppose that in stage 3 buyer 3's offer is 15 and the seller's minimum acceptable offer is 17 *for the case when the previous offer is between 0 and 2.* This is the relevant case given the offer of 1 in stage 2. The buyer's offer is below the minimum acceptable offer (15 < 17). Hence, the buyer's offer is again rejected.
- Suppose that in stage 4 buyer 1's offer is 5.7 and the seller's minimum acceptable offer is 5.2 *for the case when the previous offer is between 13.1 and 15.* This is the relevant case given the offer of 15 in stage 3. The offer of 5.7 exceeds the minimum acceptable offer of 5.2. The offer is thus accepted.

Hence, the good is sold to the buyer with ID number 1 in stage 4 at a price of 5.7 (assuming the market hasn't closed before stage 4). If the seller is of type L, his/her payoff would be *Accepted Offer - Production Cost = 5.7 – 0 = 5.7*. Buyer 1's payoff would be *Valuation of the Good - Accepted Offer = 10 – 5.7 = 4.3.* Buyer 2 and buyer 3 would earn 0. What would the earnings be if the seller is of type H? Then, buyer 1 would earn 23 – 5.7 = 17.3 and the seller would earn 5.7 – 16 = –10.3 (that is, he/she would lose 10.3 ECU). A type H seller should thus not accept offers below 16. Buyers can also make losses if they acquire a low quality good at a price above 10.

Once the seller has sold the good or the market has closed, the computer randomly forms new groups (consisting of 1 seller and 3 buyers) and the next round is entered. Part 1 of the experiment ends after round 15.