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Uninformed buyers and market efficiency

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Uninformed buyers and market efficiency

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Abstract

Empirical evidence shows that low cost of signaling interest in offers, e.g. applying for jobs, can result in a significant number of inappropriate signals. This paper provides a theoretical explanation for this observation as an equilibrium outcome of a model with utility maximizing fully rational agents that decide to signal their interest without knowing whether the offer suits them or not. We show that falling transaction costs can decrease market efficiency and social welfare. We use the model framework to study policy implications and argue that the generally held view that online tools reduce market frictions and enhance efficiency and welfare might be misleading.

Keywords: Posted offer markets; Capacity constraint; Information frictions; Noisy decision making; Uninformed signaling

JEL codes: C72, D47, D83, E24

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1 Introduction

The Internet has brought new market-places, promising far greater efficiency, based on the net's ability to gather in the same virtual place, at hardly any cost, lots of information and processing power and vast numbers of potential buyers and sellers.

The Economist, "How to be perfect", February 10, 2000

The notion that more information leads to more efficient market outcomes is taken as given in the scientific as well as the general society. This paper takes up this idea and presents a dynamic game of incomplete information to investigate equilibrium behavior and outcomes when signaling is not very costly. In contrast to the notion above, we show that low costs of market participation can deteriorate market efficiency and social welfare.

In general, in posted offer markets buyers need to signal their interest. However, these signals can be inappropriate in two ways. Either the buyer does not meet the seller's requirements or, after learning more about the offer, the buyer withdraws. For the former one, there is empirical evidence from labor markets, e.g. Kuhn (2014), showing that the submitted applications are often indeed inappropriate.

The main goal of this paper is to provide a rationale for this finding. We develop a simple theoretical model and show that the significant number of inappropriate signals observed in data can be rationalized as an equilibrium outcome. The main mechanism can be described as follows. When observing a posted offer, a potential buyer can exert effort to learn whether it meets her preferences and if she meets the requirements of the seller. Hence she learns whether a deal is possible. If she does not exert effort, she can signal her interest uninformed. However, in this case achieving a deal might be impossible what renders her initial signal inappropriate.

In particular, falling cost of signaling interest, which can be considered as transaction cost or cost of market participation, can result in a switch from an equilibrium in which buyers conduct research before signaling their interest to an equilibrium with uninformed signaling. This might cause substantial welfare losses for both sellers and buyers since uninformed buyers increase the market congestion and force sellers to consider more buyers. This equilibrium exists whenever the costs of participation are sufficiently low. Genesove and Han (2012), Kroft and Pope (2014), Kuhn and Mansour

(2014) show that the introduction of online services has indeed reduced costs of communication and search and has enabled more agents to participate in both sides of the market.

This paper is related to various strands of the literature. Our paper features one representative capacity constrained seller who interacts with potentially uninformed buyers. Hence the paper is related to the literature on information frictions without capacity constrained sellers (Varian, 1980, Burdett and Judd, 1983) as well as on capacity constrained sellers dealing with fully informed buyers (Burdett, Shi and Wright, 2001). In this sense, our paper is closely related to Lester (2011) who combines both aspects. However, we differ in two important ways. First, we disregard the impact of uninformed buyers on price formation and focus solely on the cost of matching. We measure market efficiency by total expected costs of generating a match. This is feasible since we neglect sorting and therefore quality of matches such that the total surplus from achieving a match is constant. Second, we endogenize the buyers' decision of information acquisition. In our model buyers base this decision on the trade-off between the cost of research and signaling. Therefore we also contribute to the literature on targeted search.

The paper is organized as follows. In section two we describe the model. Section three provides the model's solution. In section four we discuss the results and study the implications for efficiency and welfare. Section five includes comments on policy implications and sketches possible extensions. Section six concludes.

2 Model description

The basic structure of the model is the following. On a market, sellers post offers to which buyers can react. Each seller posts one offer and each buyer wants to accept only one offer.[1] If an offer is accepted by a buyer, a deal is achieved and the price is determined by Nash bargaining. Only if a deal is achieved, the involved buyer and seller realize a surplus.[2] All Buyers have identical willingnesses to pay and all sellers identical

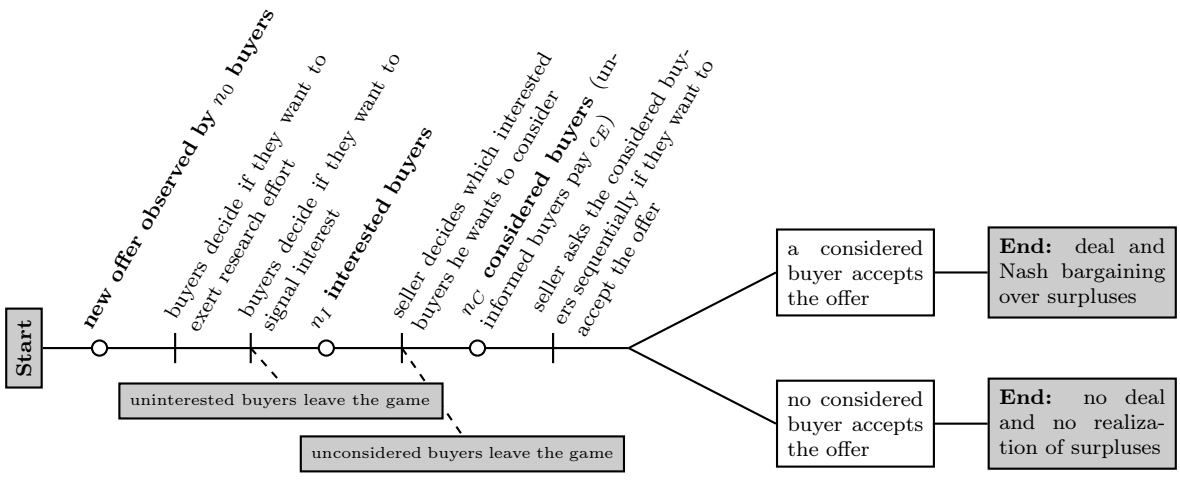
[1] Markets that fit to this structure are the labor market, the housing market, the private second-hand car market and others.

[2] The term *surplus* captures the benefits from achieving a deal for the seller and the respective buyer disregarding the costs they have incurred so far. In contrast, the term *payoff* is used to refer to the surplus less the costs.

reservation prices. Both are public knowledge. Since the outcome of the bargaining process, the price, can be anticipated, the surpluses are known. Furthermore, we argue that the reactions of buyers to offers are not strategically connected. This allows us to consider one representative offer.

In the following, the model is described in detail. Figure 1 provides an overview of the time flow and the decisions of the players. There are n_0 potential buyers seeking to accept one offer. Let $\overline{B}$ be the willingness to pay of each of the potential buyers. Furthermore, p denotes the probability of mutual acceptance, i.e. the buyer likes the offer and the seller likes the buyer[3]. The overall probability of a deal is given by the product qp, where q captures additional noise. For example, despite mutual acceptance a buyer declines an offer after having already accepted another offer before. If a match is established, the price P is determined by Nash bargaining between the seller and the respective buyer. The buyer's surplus is then given by $\overline{B} - P$. The seller has the reservation price $\underline{S}$ such that his surplus is $P - \underline{S}$. Both $\overline{B}$ and $\underline{S}$ (as well as β, the bargaining power of the seller) are common knowledge such that the price P is accurately anticipated by the seller and the buyers. Therefore it is not necessary to model the bargaining process explicitly.

Figure 1: Time structure of the model.



[3]In ? (?), there is uncertainty about the prices posted by the sellers. We model the uncertainty with regard to characteristics of the offers, for example the proximity of a flat to the nearest bus stop, holding the prices of the offers constant. Note that our model can be also interpreted exactly like in ? (?)

Before a pair of seller and buyer is found, the following decisions are due. After observing the offer, every potential buyer can choose to exert effort to learn if the offer resembles her preferences with certainty. The chance of learning that an offer meets her preferences is given by p. Exerting effort implies costs c_E. If no effort is exerted, potential buyers gain no new knowledge. After this decision, every potential buyer can signal interest in the offer. Signaling interest is necessary if the buyer wants to achieve a deal. Signaling interest leads to costs c_I. Potential buyers who do not signal interest drop out of the game with all costs incurred so far. The number of interested buyers is denote by n_I.

The seller observes n_I but is unable to distinguish between interested buyers. From the interested buyers the seller has to select buyers he wants to consider as potential contractual partners. We denote the number of considered buyers by n_C. Obviously $n_0 \geq n_I \geq n_C$ has to hold. Due to the seller's inability to distinguish between interested buyers, he selects n_C considered buyers randomly.[4] By considering a buyer, the seller learns if the buyer meets his preferences. However, considering one buyer implies costs c_C for the seller. In the last step, the seller asks considered buyers who meet his preferences sequentially in random order if they want to accept the offer. He does so until one asked buyer accepts the offer or until every asked buyer has declined.

We assume that the seller can consider n_C buyers only once. This assumption can be justified in the following ways. First, one can assume that after n_C buyers are selected, the pool of buyers who have signaled interest is lost. Second, the seller might be interested in comparing the candidates to each other and might face decreasing average costs when considering more buyers due to fixed costs. An example can be an assessment center where inviting an additional candidate lowers the average costs. We would like to point out that this assumption rules out the possibility that the seller considers candidates sequentially which is less costly than considering more candidates at once.

To allow the asked buyers to make sound decisions, we assume that interested buyers learn whether the offer matches their preferences when becoming a considered buyer – if they have not exerted effort before. In this case they also pay costs c_E. Table 1 gives an overview of the parameters used in the model.

[4]This can be interpreted such that the seller uses a heuristic which does not depend on the characteristics of the interested buyers (like first-come first-served or random selection).

Table 1: Overview of the models parameters

n_0	total number of potential buyers
n_I	number of interested buyers
n_C	number of considered buyers
$\overline{B}$	willingness to pay of potential buyers
$\underline{S}$	reservation price of the seller
p	probability of mutual acceptance
q	noise
c_E	the buyers' costs of exerting effort
c_I	costs of signaling interest
c_C	the seller's costs of considering one interested buyer

3 Solution

The applied equilibrium concept is a perfect Bayesian equilibrium (PBE). The equilibriums are found by backward induction. All buyers and the seller make their decisions under uncertainty about the behavior of other players. Thus every player holds a belief about the behavior of other players. Obviously, these beliefs must be true and justify the strategies of the players which form a Nash equilibrium.

Let P be the price determined by Nash bargaining between the seller and a buyer. Furthermore, let $\widetilde{p}$ be the seller's belief that a randomly selected interested buyer will accept the offer when asked. Hence, the seller's expected payoff is given by

$$E\pi_S = \left(1 - (1 - q\widetilde{p})^{n_C}\right)(P - \underline{S}) - n_C \cdot c_C \ . \tag{1}$$

The interpretation of equation 1 is straightforward. The seller will realize the surplus $P - \overline{S}$ only if he finds a buyer who meets his preferences and accepts his offer. Given a randomly selected buyer, this happens with probability $q\widetilde{p}$. Thus the counter probability $1 - q\widetilde{p}$ to the power of n_C is the probability that there is no deal possible with any of the n_C considered buyers. This means that at least one deal is realized with probability $1 - (1 - q\widetilde{p})^{n_C}$. Therefore, this is the probability of realizing the surplus. Furthermore, the seller pays constant marginal costs c_C for each considered buyer. Maximizing over

n_C leads to the optimal number of considered buyers

$$n_C^*(q\widetilde{p}) = \begin{cases} 1 & \text{if} \quad q\widetilde{p} = 1 \ , \\ \ln\left(-\frac{c_C}{(P-\underline{S})\ln(1-q\widetilde{p})}\right)\frac{1}{\ln(1-q\widetilde{p})} & \text{if} \quad q\widetilde{p} < 1 \ . \end{cases} \tag{2}$$

If the characteristics of buyers do not matter for the seller, i.e. $q = 1$, and he believes that each of the interested buyers will accept the offer for sure, i.e. $\widetilde{p} = 1$, it is obviously optimal to consider and ask only one interested buyer. For $q\widetilde{p} < 1$, the seller can increase the probability of achieving a deal by considering more buyers, yet this is costly. Note that we are assuming that n_C^* is always a feasible strategy. This means the buyer is never constrained by the number of interested buyers such that $n_C^* < n_I$.

When considering the options of the buyers, note that there exist only two viable strategies. They can either exert effort and then signal interest conditional on the newly obtained information or they can decide to remain uninformed and signal interest unconditionally.[5] The first strategy is denoted as ANTE and the latter as POST according to the time of exerting effort relative to the time of signaling interest.

First, assume that every buyer plays the strategy ANTE. To determine when this is an equilibrium, we compare a buyer's payoff if she plays ANTE and if she does not, given all other buyers play ANTE. If playing ANTE, an individual buyer incurs cost c_E for sure. In addition, if she learns that she likes the offer, she will signal interest, pay cost c_I and obtain the surplus only if she is considered and asked. If she learns the opposite, she drops out of the game. Therefore the expected payoff sketched above is

$$\begin{aligned} E\pi_B^{ANTE} = &- c_E + pr(\text{like}) \cdot \Big(-c_I + pr(\text{cons.}) \cdot pr(\text{asked}|\text{cons.}) \cdot \big(\overline{B} - P\big)\Big) \\ &+ (1 - pr(\text{like})) \cdot 0 \ . \end{aligned} \tag{3}$$

Given every buyer plays ANTE, $\widetilde{p} = 1$ must be true because only the willing buyers signal interest. However, since the seller has preferences over buyers, the number of considered buyers is just a function of q, see equation 2. Hence the probability of being considered is $\frac{n_C^*}{n_I}$ with $n_I = (n_0 - 1)p + 1$. This is the expected number of buyers

[5] There exist three other possible strategies that can be discarded: Buyers can exert effort and signal interest unconditionally either always or never. This is clearly not optimal. The last option is that buyers do not exert effort and are never signaling interest. This is ruled out by assuming $\overline{B} - P$ to be sufficiently large such that every buyer will always haven an incentive to play the game.

signaling interest from the perspective of an individual buyer who has signaled interest herself (given all buyers play ANTE).

To show that there exists a PBE where every buyer plays ANTE one needs to show that no individual buyer has an incentive to deviate and to play POST. This leads to the following condition which is derived in section A.1 in the appendix:

$$(1-p)c_I \geq \left(1 - \frac{n_C^*(q)}{(n_0-1)p+1}\right) c_E \ . \tag{4}$$

The inequality states that a buyer should stick to playing ANTE if the expected costs she can save by keep playing ANTE (left hand side) exceed the expected costs she can save by switching to POST (right hand side). Equation 4 implies that there exists a PBE where every buyer plays ANTE – what is also the shared belief of all buyers and the seller ($\widetilde{p} = 1$) – and the seller considers $n_C^* = 1$ interested buyers. Let this equilibrium be denoted as the ANTE PBE.

Similar to the obtained ANTE PBE, there exists a POST PBE where all buyers play POST – what is the common belief of all buyers and the seller – and the seller considers $n_C^*(p)$ interested buyers (since $\widetilde{p} = p$ is true if buyers signal interest uninformed). The condition under which this equilibrium exists (equation 5, see below) is obtained by comparing an individual buyer's payoff from playing POST (like all other buyers) to her payoff when unilaterally switching to ANTE (see section A.2 in the appendix) is of the form

$$(1-p)c_I \leq \left(1 - \frac{n_C^*(qp)}{n_0}\right) c_E \ . \tag{5}$$

The interpretation is similar to the one of equation 4. However, in this case the expected costs can be minimized by sticking to the strategy POST. Additionally, the right hand side is slightly different because the probability of being considered in the POST PBE is different than in the ANTE PBE. Here, the buyer will consider more interested buyers since $\widetilde{p} = p < 1$ and the number of interested buyers is n_0 since all potential buyers signal interest. This is larger than pn_0 as before.

The inequalities specified by equations 4 and 5 can be solved for c_I. By doing so, one

obtains two critical values of c_I that determine which equilibrium is reached.[6]

$$\text{ANTE PBE:} \qquad c_I \geq \Omega^A \equiv \frac{1}{1-p} \cdot \left(1 - \frac{n_C^*(q)}{(n_0-1)p+1}\right) c_E \tag{6}$$

$$\text{POST PBE:} \qquad c_I \leq \Omega^P \equiv \frac{1}{1-p} \cdot \left(1 - \frac{n_C^*(qp)}{n_0}\right) c_E \tag{7}$$

For values of c_I below Ω^P, the POST PBE is reached. If c_I exceeds Ω^A, the ANTE PBE is reached. The boundaries capture the buyers' efforts to minimize costs. Exerting effort allows a buyer to save the costs c_I in those cases where she does not like the offer. This possibility matters especially if the cost of signaling interests are rather large compared to the cost of effort (in the ANTE PBE). The reverse logic is true in the POST PBE. Now note that $\Omega^A \geq \Omega^P$ is always true. Only in the limit case assuming a large number of potential buyers, both bounds converge to the same value (from below, see section B in the appendix) such that the gap between them closes:[7]

$$\lim_{n_0 \to \infty} \Omega^P = \lim_{n_0 \to \infty} \Omega^A = \frac{c_E}{1-p} \equiv \Omega \tag{8}$$

Disregarding the limit case, the gap between them can be filled by considering mixed strategies. Let the strategy of the buyers be $\sigma(r) = r \cdot ANTE + (1-r) \cdot POST$. With probability r the buyer will play ANTE and with probability $1-r$ POST. Since $\sigma(1) =$ ANTE and $\sigma(0) =$ POST is true, the ANTE PBE and the POST PBE can be expressed with the strategy $\sigma(r)$ as well. Assume that every buyer plays $\sigma(r)$. This implies that the belief of the seller is given by $\widetilde{p} = r + (1-r)p$. When picking a random interested buyer, this buyer has played ANTE with probability r and likes the offer, but may only accept it with probability p whenever she has played POST (with probability $1-r$). The expected payoff of one individual buyer is thus given by

$$E\pi_B^{\sigma(r)} = r \cdot \left(-c_E + p \cdot \left(-c_I + \frac{n_C^*(q\widetilde{p})}{n_I} \cdot \gamma \cdot \left(\overline{B} - P\right)\right)\right) \quad \ldots \tag{9}$$

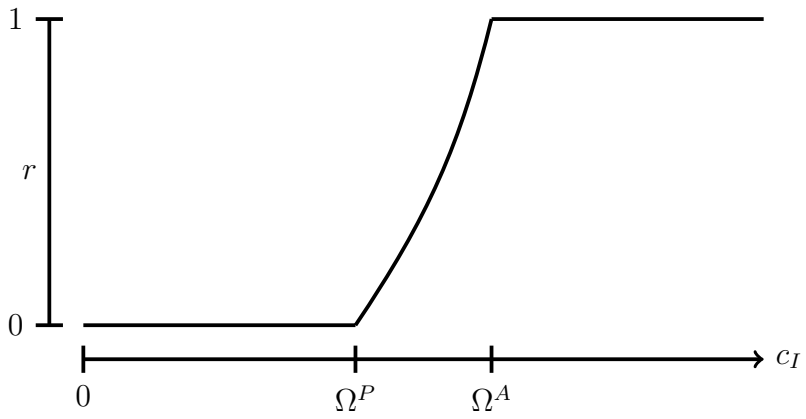
$$+ (1-r)\left(-c_I + \frac{n_C^*(q\widetilde{p})}{n_I} \cdot \left(-c_E + \gamma \cdot p \cdot \left(\overline{B} - P\right)\right)\right) \tag{10}$$

[6] *Reached* means *existent* here. There is no problem of equilibrium selection since $\Omega^P < \Omega^A$ is always true. More precisely, parametrizations where $\Omega^P < \Omega^A$ is violated are ruled out by the assumption that the seller is never constrained by the number of interested buyers when choosing n_C.

[7] Recall that in the case of Ω^P, the value $n_C^*(p)$ does not depend on n_0.

where γ is the probability of being asked as specified in section A.1 in the appendix. This probability is a function of q, p and r. Furthermore, the expected number of interested buyers is $n_I = n_0 \left(r \cdot p + (1 - r)\right)$. Now consider the incentives of one individual buyer to change her strategy $\sigma(r)$ to another $\sigma(r')$ given all other buyers stick to $\sigma(r)$. One can show that for each c_I between Ω^P and Ω^A, there exists a unique r such that the expected payoff of every individual buyer does not depend on her chosen strategy $\sigma(r')$. Hence, every buyer is indifferent between every possible strategy and there exists a unique MIXED PBE for each $c_I \in \left[\Omega^P, \Omega^A\right]$ where all buyers play the strategy $\sigma(r^*)$. This is also the common belief of all buyers and the seller and the seller considers $n_C^*(q\widetilde{p})$ interested buyers where $\widetilde{p}$ is given by $r + (1 - r)p$. Intuitively, r^* falls if c_I is falling from Ω^A to Ω^P such that the MIXED PBE characterizes a smooth transition between the two pure strategy equilibriums. This is captured by figure 2.[8] In addition, refer to section B in the appendix for a more general display of the values of Ω^A and Ω^P and how these boundaries vary with different parameter values.

Figure 2: Solution of the model: Equilibrium values of r given c_I.



4 Efficiency and welfare analysis

Concerning efficiency, it is crucial to note that the total surplus is given by $\overline{B} - \underline{S}$. The price P only affects the distribution of this total surplus between the seller and the buyer. Thus the efficiency of the market as a matching mechanism can be measured

[8] Figure 2 is only a sketch. However, note that r is not falling linearly between Ω^A and Ω^P.

by the total costs which arise in the different equilibriums. Costs consist of the specific individual costs c_E, c_I and c_C which are paid by the buyers and the seller. In addition, there is a chance that no deal is achieved if all considered buyers decline the offer or do not meet the seller's preferences or both. The total costs in the ANTE PBE, the POST PBE as well as the expected total costs in the general MIXED PBE are given below.

$$C^{ANTE} = n_C^*(q) \cdot c_C + n_0 \cdot c_E + n_0 \cdot p \cdot c_I + (1-q)^{n_C^*(q)}(\overline{B} - \underline{S}) \tag{11}$$

$$C^{POST} = n_C^*(qp) \cdot c_C + n_0 \cdot c_I + n_C^*(qp) \cdot c_E + (1-qp)^{n_C^*(qp)}(\overline{B} - \underline{S}) \tag{12}$$

$$EC = n_C^*(q\widetilde{p})c_C + n_0 \Bigg(r\left(c_E + pc_I\right) + (1-r)\Bigg(c_I + \underbrace{\frac{n_C^*(q\widetilde{p})}{n_0\left(rp + (1-r)\right)}}_{n_I} c_E \Bigg)\Bigg) \ldots$$

$$+ (1 - q\widetilde{p})^{n_C^*(q\widetilde{p})}(\overline{B} - \underline{S}) \tag{13}$$

The expressions $(1-q)^{n_C^*(q)}$ in equation 11, $(1-qp)^{n_C^*(qp)}$ in equation 12 and $(1-q\widetilde{p})^{n_C^*(q\widetilde{p})}$ in equation 13 are probabilities of not realizing the total surplus $\overline{B} - \underline{S}$. For clarity, recall that n_C^* is a function of q and $\widetilde{p} = r + (1-r)p$. Note that r and c_I form a bijection such that for every c_I there is a unique r (and vice versa) implying there exists a unique equilibrium – see figure 2 and the related discussion. In other words, there is no problem of equilibrium selection.

In the following, we discuss the scenario with decreasing c_I what can lead to a transition from an ANTE PBE to a POST PBE if the initial level of $c_I > \Omega^A$. See figure 2. The first insight one can draw is that in the limit case $n_0 \to \infty$ considered above (implying $\Omega^A = \Omega^P = \Omega$), total costs rise when transiting from the ANTE to the POST PBE. This is shown by equation 16 below. Moreover, the increase in total costs corresponds to a decrease in market efficiency. Note that this decrease is even present if one disregards the costs that arise if no match is achieved.

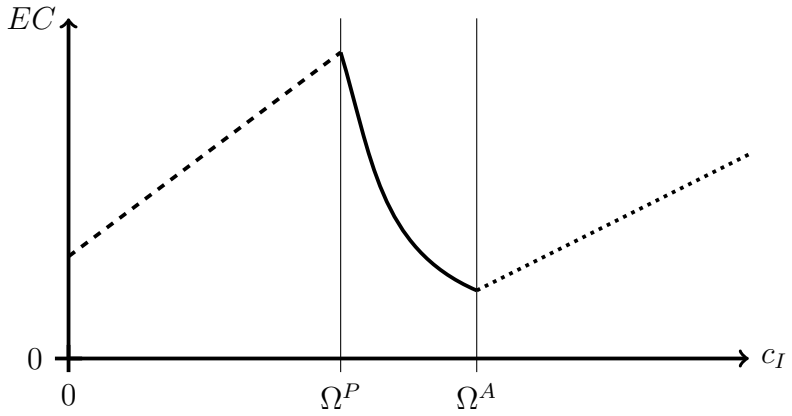
$$\begin{aligned} C^{ANTE}\Big|_{c_I=\Omega} &= n_C^*(q)c_C + n_0 c_E + \frac{n_0 p c_E}{1-p} + (1-q)^{n_C^*(q)}(\overline{B} - \underline{S}) \\ &= n_C^*(q)c_C + \frac{n_0 c_E}{1-p} + (1-q)^{n_C^*(q)}(\overline{B} - \underline{S}) \end{aligned} \tag{14}$$

$$C^{POST}\Big|_{c_I=\Omega} = n_C^*(qp)c_C + \frac{n_0 c_E}{1-p} + n_C^*(qp)c_E + (1-qp)^{n_C^*(qp)}(\overline{B} - \underline{S}) \tag{15}$$

$$C^{POST}\Big|_{c_I=\Omega} > C^{ANTE}\Big|_{c_I=\Omega} \tag{16}$$

The identified loss in efficiency at the transition between the equilibriums remains present if one looks at the MIXED PBE. Figure 3 shows the values of total expected costs EC given c_I. The only change is that the increase of total expected costs is now characterized by a smooth transition instead of an instantaneous jump. It is quite

Figure 3: Efficiency of the market: Total expected costs EC given c_I.



intuitive that falling costs c_I have a larger impact on EC in the POST PBE than in the ANTE PBE. This can be seen by the steeper slope of the dashed line compared to the dotted one. In the POST PBE every buyer signals interest, whereas in the ANTE PBE it is only the fraction pn_0. Also, the total expected costs fall if there is no change of the equilibrium. This corresponds to the generally held view presented in the introduction that falling costs of market participation lead to increased efficiency. Here however, efficiency can fall if the costs of participation fall. The reason is the following: Falling costs do not only lower the costs of the involved players, but also lead to a change in the equilibrium behavior of these players. The overall magnitude of the increase of total costs between Ω^A and Ω^P depends on c_C since the seller will consider more buyers and, furthermore, on the surplus which may be lost $\overline{B} - \underline{S}$.

Whether the minimal total expected costs are reached at $c_I = 0$ or $c_I = \Omega^A$ depends on the choice of the parameters. Addressing this question, one has to think about the feasible values of c_I. First, given the mentioned examples of markets, it is reasonable to believe that the costs of signaling interest have fallen in the last years. However, the

assumption that the costs c_I are close or equal to zero is quite strong and clearly false for the markets presented so far. Second, in the real world there are both informed as well as uninformed buyers. This is backed by the empirical literature and can be considered as a hint that either the range of relevant values of c_I lays around the interval $[\Omega^P, \Omega^A]$ or that agents are heterogeneous in terms of c_I.

Now we take a look at the impact of the transition between the equilibria on the seller's and the buyers' individual payoffs. Equation 17 compares the expected costs of the seller in both equilibriums. It can easily be seen that the seller is always hurt by a switch from the ANTE to the POST PBE since he has to consider more buyers and even may lose his surplus. In the POST PBE, the seller has to identify buyers with correct preferences. Beforehand this was done by the buyers themselves.

$$\underbrace{n_C^*(q)c_C + (1-q)^{n_C^*(q)}(P-\underline{S})}_{=C_S^{ANTE}} \quad < \quad \underbrace{n_C^*(qp)c_C + (1-qp)^{n_C^*(qp)}(P-\underline{S})}_{=C_S^{POST}} \tag{17}$$

From the buyers' perspective, reconsidering the limit case given by equations 14 and 15 allows the conclusion that individual buyers are also hurt by the transition.

$$\underbrace{\frac{n_0 c_E}{1-p} + (1-q)^{n_C^*(q)}(\overline{B}-P)}_{=C_B^{ANTE}|_{c_I=\Omega}} \quad < \quad \underbrace{\frac{n_0 c_E}{1-p} + n_C^* c_E + (1-qp)^{n_C^*(qp)}(\overline{B}-P)}_{=C_B^{POST}|_{c_I=\Omega}} \tag{18}$$

Obviously, this increase in costs translates directly into falling payoffs of buyers. In contrast to the case of the seller where the costs in both pure strategy equilibirums are flat, the costs of buyers fall if c_I falls within both pure strategy equilibriums.

These findings lead to the conclusion that the transition from the ANTE to the POST PBE implies welfare losses. This is even true if welfare is measured by the Pareto criterion, since the seller and every buyer suffer from falling expected payoff for values of c_I sufficiently close to the critical thresholds. The impact of the transition on utilitarian welfare is quite simple. Since the total surplus is fixed, the sum of individual expected payoffs is given by the inverse of total expected costs (see figure 3). Given utilitarian welfare, the loss of welfare is even more persistent than for the Pareto criterion and all POST PBE might lead to lower welfare than an adequate ANTE PBE – meaning c_I close to but above Ω^A.

5 Discussion

The policy implications that can be drawn from the model are apparent. The costs of signaling interest have to be increased when there are a lot of uninformed buyers on the market. As an example, the main goal of application fees that are due when applying for universities is to create an incentive for applicants to inform themselves such that the fee is not wasted. Generally, an external regulator or sellers can increase the costs of applying to force self selection of buyers when there are too many inappropriate applications. Practical measures to increase the costs of applying apart from fees are rules that limit the number of applications that can be sent within a certain time span directly. This is easy to introduce on online marketplaces and would increase the opportunity costs of signaling interest greatly. A similar yet more refined rule would be to allow buyers to assign some sort of tokens to sent applications. Limiting the buyers' endowments, they are forced to send informative signals.

Since the critical boundaries are characterized by relative costs, another way to leave a POST equilibrium is to lower the costs of research effort. The following example illustrates a reason why these costs are higher than commonly assumed and how they can be lowered. On many marketplaces, timing is crucial. Expressing your interest for an apartment in a densely populated city two days after the offer was posted will not trigger a reply from the seller since he has already received numerous applications in the first two hours. Hence, assessing whether the offer meets your preferences, this means checking public transportation in the neighborhood, the provided facilities and much more, is costly in terms of time and therefore lowers your chance of achieving a deal. This can be overcome by submitting the applications to the seller once a day in random order. A similar intervention was the change in the ordering of the working papers in the NBER newsletter (Feenberg et al., 2015). Initially, the sequence of papers was based on the date of submission. Realizing that papers in the top part of the list – those were submitted last – receive more downloads, the sequence is now totally random.

Apart from the costs, the ANTE PBE becomes more likely if the overall chances to achieve a deal can be increased. This channel can be seen in the graphs in section B in the appendix. If the total number of potential buyers rises, the boundaries rise as well and the area in the parameter space in which POST will be played is larger. Therefore, lowering the number of buyers can improve the situation. Note that a decrease in

the number of potential buyers can also be achieved by increasing the supply, yet this channel is not modeled here.

When talking about policy implications, the question at hand is why some marketplaces have settled in the POST domain and are unable or not willing to raise the costs of participation. There exist several explanations. First, regulation by legislators may prevent the self regulation of markets. In the case of the housing market, the price mechanism that could lower the number of interested buyers cannot work due to rent control. On top of that, other channels that might increase the overall costs of participation and induce buyers to get informed ex ante are also often blocked. For example, a German court forced a real estate agent to cease charging buyers for showing them the offered apartments[9]. Second, the incentives of the operators of the considered marketplaces are often not well aligned with those of the users. Often, these markets are operated neither by the sellers, nor by the buyers but by some third party. Furthermore, these third parties – like websites which host posted offers – generate profit from traffic and not primarily from established matches. This is important since nowadays these online services are used extensively. The described situation cannot be overcome by increasing competition among the operators of these marketplaces due to high initial market entry costs, increasing returns to scale or the desire of buyers to shop at one place.

An extension that seems to be interesting is to allow buyers to send informative signals to senders. In reality, determined buyers applying for a job include their polished résumé and buyers who seek to rent an apartment their credit rating. This extension would work in favor of the story presented here. The option to send informative signals does only create an additional stage of wasteful rent seeking. Therefore, since there are more interested buyers in the POST equilibrium than in the ANTE equilibrium, the costs of the additional rent seeking are larger in the POST equilibrium. Next, after this modification one can consider heterogeneous buyers who differ in their ability to send informative signals.

[9]The agent charged around 35 EUR. Decided the 15th of June 2016, by the Land court in Stuttgart, State of Baden-Württemberg, Germany. File reference 38 O 73/15 Kfh and 38 O 10/16 Kfh.

6 Conclusion

The aim of this paper is to shed more light on the empirical evidence that many replies to posted offers are inappropriate. We interpret this evidence as potential buyers signaling their interest without being informed about the particular content of the offer. The driving force behind the decision of the buyers to remain uninformed is to save the cost of research effort when the overall chances to achieve a deal are low. If this is the case, buyers change their behavior such that they signal interest whenever possible and only probe an offer when given the chance to accept it. As a result, sellers are confronted with numerous applications that may be inappropriate. This can be considered as a new aspect of a congestion externality. Signaling interest worsens the situation of all other buyers who have signaled interest, but does also lead to higher costs for the seller who has to identify truly interested buyers. More specifically, our model shows that falling costs of signaling interest, which can be considered as transaction costs and costs of market participation, can induce a switch from an equilibrium with ex ante research to an equilibrium with ex post research. This switch is harmful for all buyers and sellers. Furthermore, it leads to a loss of efficiency and welfare in terms of utilitarian welfare and the Pareto criterion.

Summing up, our model shows that the generally held view that falling transaction costs improve market efficiency can be fallacious and the opposite can occur. A possible conclusion is that the growing use of online services that lowers the costs of market participation and increases the amount of transmittable information can lead to efficiency losses.

A Equilibrium conditions

A.1 Derivation of equation 4

As described in section 3, assume that every buyer plays ANTE. The expected payoff of one individual buyer is given by

$$\begin{aligned} E\pi_B^{ANTE} &= -c_E + pr(\text{like}) \cdot \Big(-c_I + pr(\text{cons.}) \cdot pr(\text{asked}|\text{cons.}) \cdot \big(\overline{B} - P\big)\Big) + (1 - pr(\text{like})) \cdot 0 \\ &= -c_E + p\left(-c_I + \frac{n_C^*(q)}{(n_0 - 1)p + 1}\ \gamma\ \big(\overline{B} - P\big)\right) \end{aligned} \tag{19}$$

where $n_C^*(q)$ is the optimal number of considered buyers set by the seller ($\widetilde{p} = 1$ holds as only informed buyers signal interest) and γ is the probability of being asked given being considered. In the following we derive this probability in an intuitive way. Imagine that out of the n_C buyers, the seller draws one buyer randomly. If she meets the seller's preferences and she accepts the offer (with probability p) a deal is made. If the drawn buyer does not meet the seller's preferences or she declines the offer, the seller will draw randomly a next buyer and so on.

Hence, one considered buyer can be asked first, second or later. Compared to being asked first, being asked second or even later requires three things. First, all other considered buyers drawn and asked beforehand must have turned down the offer. Second, this particular buyer must not have been drawn before and third, she actually has to be drawn second (third, etc.) and asked. The following formula captures this argument and gives the probability that a considered buyer is asked as the l^{th} person.

$$pr\left(l^{\text{th}} \text{ person asked}|\text{cons.}\right) = \overbrace{\prod_{k=1}^{l-1} \frac{n_C - k}{n_C + 1 - k}}^{\substack{\text{Not been drawn} \\ \text{the first } l-1 \\ \text{times}}} \cdot \overbrace{(1 - qp)^{l-1}}^{\text{no deal so far}} \cdot \overbrace{\frac{1}{n_C + 1 - l}}^{\substack{\text{being} \\ \text{drawn the} \\ l\text{th time}}} \cdot q \ \equiv \Lambda(l)$$

Note that here in the ANTE case the probability p in the expression above equals one. Since being asked at all can happen by being asked first, second and so on, the

probability of being asked at all γ is given by

$$\gamma = \sum_{l=1}^{n_C} \Lambda(l) \ .$$

The expected payoff given by equation 19 must exceed the ones from all possible unilateral deviations. The seller is already playing the best response. However, an individual buyer might decide to deviate and play POST instead of ANTE.[10] The expected payoff from doing so is

$$E\pi_B^{ANTE'} = -c_I + \frac{n_C^*(q)}{(n_0-1)p+1}\Big(-c_E + p\gamma\left(\overline{B}-P\right)\Big).$$

The buyer always faces costs c_I, but will only have to pay c_E is she is considered. In this case, she can obtain the surplus if she is considered and asked and if she likes the offer. The characterized deviation is not profitable if $E\pi_B^{ANTE} \geq E\pi_B^{ANTE'}$ holds. The inequality can be reduced to

$$\begin{aligned} E\pi_B^{ANTE} &\geq E\pi_B^{ANTE'}, \\ (1-p)c_I &\geq \left(1 - \frac{n_C^*(q)}{(n_0-1)p+1}\right) c_E \ . \end{aligned}$$

A.2 Derivation of equation 5

Assume all buyers play POST. The expected payoff of one individual buyer is given by

$$\begin{aligned} E\pi_B^{POST} &= -c_I + pr(\text{cons.}) \cdot \Big(-c_E + pr(\text{asked}|\text{cons.}) \cdot pr(\text{like}) \cdot \left(\overline{B}-P\right)\Big) + (1 - pr(\text{cons.})) \cdot 0 \\ &= -c_I + \frac{n_C^*(qp)}{n_I}\Big(-c_E + \gamma p\left(\overline{B}-P\right)\Big) \end{aligned}$$

where γ is as derived in section A.1.

Now consider that an individual buyer thinks about playing ANTE instead of POST.

[10] Recall that the deviation of dropping out of the game (never exerting effort and never signaling interest) is excluded by assumption.

This deviation implies the following payoff:

$$E\pi_B^{POST'} = -c_E + p \cdot \left(-c_I + \frac{n_C^*(qp)}{n_0} \gamma \left(\overline{B} - P \right) \right)$$

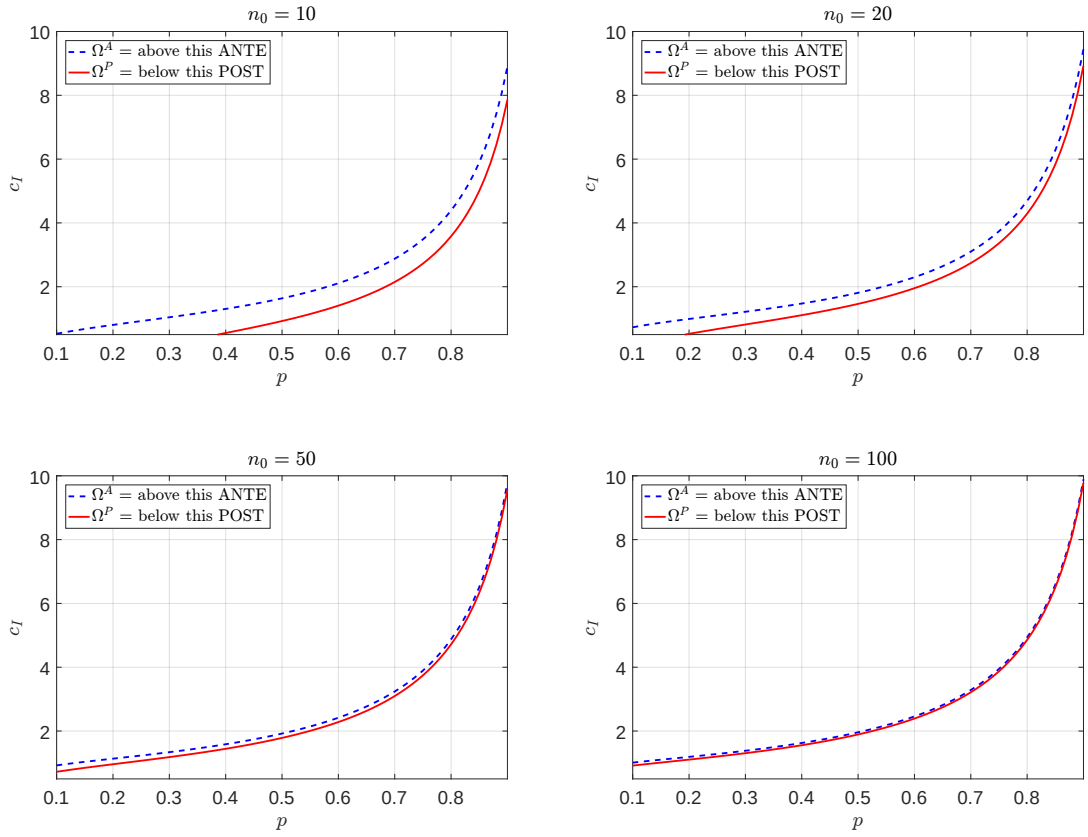
The buyer will signal interest if she learns that she likes the offer (with probability p). $n_I = n_0$ still holds given she has learned that she likes the offer and also q is unaltered since the seller's strategy is held fixed. Simplifying $E\pi_B^{POST} \geq E\pi_B^{POST'}$ leads to the inequality

$$(1-p)c_I \leq \left(1 - \frac{n_C^*(qp)}{n_0} \right) c_E \ . \tag{20}$$

B Curvature of Ω^A and Ω^P dependent on n_0, p

The graphs below are generalizations of figure 2. In figure 2, the boundaries Ω^A and Ω^P (see equations 6 and 7) are realizations of specific values of q and p. Figure 4 shows the boundaries for different values of p holding q fixed, whereas each graph is based on a different n_0. The dashed lines represent Ω^A and the solid ones Ω^P. Three insights can

Figure 4: Values of Ω^A and Ω^P for different values of p.



be drawn: First, the domain where the POST PBE exists (the spaces $0 \leq c_I \leq \Omega^P$) grows if p rises. This is straightforward since exerting effort becomes less valuable if buyers will like the offer with a higher probability. Second and third, holding p fixed, the boundaries rise and converge to the same value for rising numbers n_0. This is shown in equation 8.

References

Burdett, K. and Judd, K. L. (1983). Equilibrium Price Dispersion. *Econometrica*, *51*(4), 955–969.

Burdett, K., Shi, S. and Wright, R. (2001). Pricing and Matching with Frictions. *Journal of Political Economy*, *109*(5), 1060–1085.

Feenberg, D. R., Gangulli, I., Gaule, P. and Gruber, J. (2015). It's Good to be First: Order Bias in Reading and Citing NBER Working Papers. *NBER Working Paper Series*, 35.

Genesove, D. and Han, L. (2012). Search and matching in the housing market. *Journal of Urban Economics*, *72*(1), 31–45.

Kroft, K. and Pope, D. G. (2014). Does Online Search Crowd Out Traditional Search and Improve Matching Efficiency? Evidence from Craigslist. *Journal of Labor Economics*, *32*(2), 259–303.

Kuhn, P. (2014). The internet as a labor market matchmaker: How effective are online methods of worker recruitment and job search? *IZA World of Labor*(May), 1–10.

Kuhn, P. and Mansour, H. (2014). Is Internet Job Search Still Ineffective? *The Economic Journal*, *124*(581), 1213–1233.

Lester, B. (2011). Information and Prices with Capacity Constraints. *American Economic Review*, *101*(4), 1591–1600.

Varian, H. B. (1980). A Model of Sales. *The American Economic Review*, *70*(4), 651–659.