# Reputation and Search

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**Abstract**

This paper examines welfare effects of reputation-building behavior in a large market where there are many sellers and buyers and buyers have to search for sellers. Sellers compete for buyers by their reputations, and reputations play a role in allocating buyers across sellers. It is shown that reputation-building behavior distorts allocation as well as transfer. The result contrasts with the case where there is only one long-lived seller.

## 1 Introduction

In a large economy, reputation affects the possibility of finding a match in the future. If a restaurant has a good reputation, then the restaurant attracts more customers than other restaurants that do not have good reputations. However, often reputation is false. Some restaurants are thought of as better than they really are. If there were only one restaurant and one customer, then the false reputation would only affect transfer between the restaurant and the customer. However, in a large economy where there are many restaurants and customers and customers have to search for restaurants, this is not the end of the story. The restaurant may attract more customers than it can serve because of the false reputation. As a result, some of potential customers end up with not getting meal, and some of other restaurants end up with being vacant. Here, false reputation distorts allocation and reduces total production. Thus, the effort to establish good reputation may have negative effects on the economy, though by its own it may be good. This paper

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investigates welfare consequences of reputation-building behavior in a large society.

Towards this purpose, I propose a competitive search model of reputation where search is directed to reputations. This is a simple two period model. There are continuously distributed sellers and buyers. Buyers are identical. There are two types of sellers: good and normal. Good sellers can produce high quality goods without any cost. Normal sellers also can produce high quality goods with some cost. Normal sellers can produce low quality goods without any cost. Seller's type does not vary across periods.In the first period, sellers decide the quality of goods they produce. In the second period, sellers and buyers meet in a competitive search market. More precisely, first sellers post prices. Buyers observe the prices, and also quality of a good each seller has produced in the first period. Then buyers decide with whom they want to trade. If a seller attracts more buyers (by either having a good history or low price) on average, then it is more easier for the seller to sell her good, and harder for buyers to purchase goods from sellers. After being matched, sellers again decide quality of goods. Since second period is the last period, only good sellers produce high quality goods in equilibrium.

The main result of this paper is that the mimicking behavior may reduce the total output in the second period. This result contrasts with the case of one long-lived seller. In the absence of search friction, reputation of a seller only affects the transfer between the seller and the buyer in the second period. In this case, mimicking behavior is trivially good because it increases production in the first period. However, if reputation has a function to allocate buyers across sellers, then the false reputation of a normal seller distorts matching, as well as transfer. In particular, normal sellers who have produced high quality goods enjoy the same probability of being purchased as good sellers. As a result, the more normal sellers produce high quality goods in the first period, the more frequent the "bad" trades happen in the second period. However, it is also shown that even if this negative effect is taken into account, in equilibrium the mimicking behavior is too less than efficient level if discount factor is less than one.

The model also predicts that producing a high quality goods results in a higher probability of being matched in the future. The prediction is consistent to some empirical findings that past behavior affects the possibility of finding a match in the future. There is evidence that past criminals suffer from longer unemployment spells (see Waldfogel [22] and Imai and Krishna [11]). The same phenomenon is also exhibited in eBay (see Resnick and Zeckhauser [17]).

To my best knowledge, this paper is the first attempt to apply competitive search model to analyze reputation-building behavior[1]. Competitive search models provide a natural modeling tool to model reputation in a large society. By making use of competitive search, this models capture the ideas that buyers observe reputations of sellers and decide with whom they want to purchase, sellers compete for buyers by publicly observable reputation, and reputation plays a role in allocating buyers across sellers.

This paper relates to two strands of literature. The first strand of literature is on reputation. For a general survey, see Mailath and Samuelson [14]. Ely and Välimäki [8] and Ely, Fudenberg and Levine [7] study negative effects of reputational concern on the long-lived agent. However, they deal with the case where there is one long-lived player and the allocational role of reputation is not considered. Reputation in a large society is examined by papers including Tirole [21], Ahn and Suominen [2], Dixit [6] and Bandyopadhyay [3][2]. These papers assume the matching process is random. On the other hand, I assume the matching process is directed. This assumption allows me to capture competition among sellers. Hörner [10] and Rob and Sekiguchi [18] study competition and reputation. [18] deals with a case where there are two sellers who compete for continuously distributed buyers, and there is no search friction. [10] deals with the case where both sellers and buyers are continuously distributed. However, [10] does not consider the allocational role of reputation and hence does not sheds light on the negative effect of reputation-building behavior[3].

The second is competitive search literature. Among them, Delacroix and Shi [5], Menzio [15], Kennes and Schiff [12] and Kim and Kircher [13] are closely related because individuals who offer prices (labeled as "sellers" in [5, 12] and this paper while as "firms" in [15, 13]) have private information. However, none of them considers the possibility that buyers direct their search to past behavior of sellers.

# 2 The Model

Time is two period. There are two types of individuals: sellers and buyers. Measure of sellers is normalized to be one. Measure of buyers is one in the

[1] About competitive search models, see Moen [16] and Acemoglu and Shimer [1]. Kennes and Schiff [12] study reputation in competitive search markets, but in a different context. In particular, the quality of goods is not a decision of sellers.

[2] See also Takahashi [20].

[3] There are some other differences in models. This paper focuses on mimicking behavior in which normal (strategic) types try to mimic good types, while [10] focuses separating behavior in which strategic types try to separate themselves from bad types. Also, [10] assumes one-to-many matching and his results depends on this assumption in a crucial way. On the other hand, I assume matching is one-to-one.

first period. In the second period, there are infinite measure of potential buyers who can enter the market freely by paying a fixed cost $k$.

Buyers are identical and short-lived. Sellers are long-lived. Sellers are either one of these two types: good or normal. Among measure one of sellers, $\alpha_g$ of sellers are good and $\alpha_n = 1 - \alpha_g$ of sellers are normal. Types does not vary across periods. Sellers sell either high or low quality goods. Good sellers can produce high quality goods without cost. Normal sellers can produce either high or low quality goods. They can produce low quality goods without cost and high quality goods with cost $c$. The utilities to consume high and low quality goods are denoted by $v_h$ and $v_\ell$ respectively. I put the following assumption which says to produce high quality goods by themselves are always better in terms of social welfare.

$$c < v_h - v_\ell. \tag{1}$$

The quality of good is observable, but not verifiable.

In the first period, all sellers match with buyers. Sellers choose quality of goods knowing their own types. Sellers sell the goods with price $p_1$. Since the quality is not verifiable, $p_1$ cannot be contingent on quality of goods.

In the beginning of second period, quality of goods each seller has produced are publicly observed. Denote $\theta \in \{H, L\}$ be the quality of goods that a seller has produced in the first period. Each buyer infers sellers' type by the information on histories. Notice, if a seller has produced a low quality good, then it reveals that the seller is normal type. Each seller posts and commits to the price she want to sell her good. Again, the price cannot be contingent on the quality.

Buyers search for sellers, observing the pair of history and price. The search process is modeled as a standard competitive search introduced by Moen [16] and Acemoglu and Shimer [1], except that now search is directed to histories of sellers as well as prices. Sellers post and commit to the price that the seller want to sell her goods. Here, sellers cannot commit to the quality of goods, but can commit to the price[4]. Suppose there are "submarkets" which consist of sellers who have the same history $q \in \{H, L\}$ and posted the same price $p \in [0, \infty)$. Buyers observe the distribution of sellers over submarkets. Then they decide to which submarket to enter. Buyers can enter at most one submarket.

Denote the ratio of buyers to sellers by $\lambda \in [0, \infty]$, and refer it as queue-length. This ratio varies in general with submarkets, and is determined in equilibrium. If a seller faces a ratio of $\lambda$, then she meets (and trades with) a

[4]This assumption is reasonable. Restaurants post and commit the price, but the prices typically do not vary according to whether customers like the meal or no.

buyer with probability $\mu(\lambda)$. Analogously, if a buyer faces $\lambda$, then he meets a seller with probability $\eta(\lambda)$. We put the following assumptions on $\mu$ and $\eta$.

**Assumption 1.** *$\mu$ and $\eta$ are twice continuously differentiable with respect to $\lambda$. $\mu' > 0$, $\mu'' < 0$, $\eta' < 0$, $\eta'' > 0$, $\lim_{\lambda \to 0} \eta(\lambda) = 1$, $\lim_{\lambda \to \infty} \eta(\lambda) = 0$ and*

$$\eta(\lambda) = \frac{\mu(\lambda)}{\lambda}. \tag{2}$$

The assumption that $\mu$ is increasing in $\lambda$ captures the idea that relatively more buyers make it easier for sellers to sell their goods. (2) is a condition on consistency that requires the measure of sellers who find their buyers must coincide with the measure of buyers who find their sellers. Notice, left hand side is the measure of sellers who find their buyer and right hand side is the measure of buyers who find their sellers. Notice, matching technologies are the same for every submarket.

# 3 The Second Period

This section considers about second period. In this section, first, I define and derive the equilibrium. Then I show the equilibrium is constraint efficient. Finally, I show that reputation-building behavior has a negative impact on the market.

## 3.1 Equilibrium

### 3.1.1 Definition

Following the literature of competitive search (see, for example, Burdett, Shi and Wright [4] and Galenianos and Kircher [9]), I focus on a symmetric equilibrium where actions of sellers only depend on her type and history, and do not depend on the character of each seller.

In equilibrium, good sellers produce high quality goods and normal sellers produce low quality goods in the second period. This is trivial and hence this condition is omitted from the definition of equilibrium.

Let $x \in [0, 1]$ be the portion of normal sellers who have produced high quality goods in the first period. In this section, $x$ is treated as given. In the next section, $x$ is derived as a part of equilibrium. Let $m_H$ be the measure of sellers who have produce high quality goods in the first period. Clearly,

$$m_H(x) = \alpha_g + \alpha_n x. \tag{3}$$

Let $m_L(x) = 1 - m_H(x)$. Notice that individuals observe $m_H(x)$ and be able to infer $x$. This differs from the case where the game is played by one player.

Individuals form beliefs on the types of sellers, observing histories and prices. For a given $x$, denote by $b_g(q,p;x)$ the posteriors that a seller in submarket $q \times p \in \{H, L\} \times [0, \infty)$ is good. The beliefs are defined for all prices, not only prices that are posted in equilibrium.

Denote by $V(q,p;x)$ the expected value of a match in submarket $q \times p$. Then, we have

$$V(q,p;x) = b_g(q,p;x)v_h + (1 - b_g(q,p;x))v_\ell. \tag{4}$$

Let the function $\Lambda : \{H, L\} \times [0, \infty) \times [0,1] \to [0, \infty]$ denote the queue length associated with submarket $q \times p$ for a given $x$. The expected payoff of sellers is given by

$$\mu(\Lambda(q,p;x))p. \tag{5}$$

Given the posterior $(b_g, b_n)$, the expected payoff of buyers is given as

$$\eta(\Lambda(q,p;x))[V(q,p;x) - p]. \tag{6}$$

Notice, given that beliefs are defined for all prices, $V, \pi$ and $u$ are also defined for all prices, not only prices that are posted on equilibrium.

**Definition 1.** *For any $x \in [0,1]$, an* equilibrium in the second stage *is measures $P_H$ and $P_L$ on $[0, \infty)$, $\Lambda : \{H, L\} \times [0, \infty) \times [0,1] \to [0, \infty]$ and $b_g : \{H, L\} \times [0, \infty) \times [0,1] \to [0,1]$ with the following properties.*

1. *Seller Optimality: If $p_q^* \in \mathrm{supp} P_q$, then for all $p \in [0, \infty)$,*

$$\mu(\Lambda(q,p^*;x))p^* \geq \mu(\Lambda(q,p;x))p \tag{7}$$

*for $q \in \{H, L\}$.*

2. *Buyer Optimality and Free Entry: For all $q \times p \in \{H, L\} \times [0, \infty)$,*

$$\eta(\Lambda(q,p;x))[V(q,p;x) - p] \leq k. \tag{8}$$

*with equality if $\Lambda(q,p;x) > 0$.*

3. *Consistent Beliefs: For all $p$,*

$$b_g(L,p;x) = 0. \tag{9}$$

*Also,*

$$\int_0^\infty b_g(H,p;x)dP_H(p) = \alpha_g. \tag{10}$$

*4. Market Clearing:*

$$\int_0^\infty dP_H(p) = m_H(x), \tag{11}$$

$$\int_0^\infty dP_L(p) = 1 - m_H(x). \tag{12}$$

Here, $P_q$ is the distribution of posted prices. Seller optimality implies that if a price $p_q^*$ is posted, then the price has to maximize payoff of the seller. Buyer optimality implies that if a buyer visits to a submarket, then the expected payoff for the buyer must be equal to the entry cost. Notice that $u > k$ cannot be the case in equilibrium. This is because if this were the case, then the submarket would attract more buyers and reduce the expected payoff of the submarket. The condition holds defined for every $q \times p \in \{H, L\} \times [0, \infty)$, not only on the support of $P_q$. This requirement is in the spirit of subgame perfection. Sellers expect a queue length $\Lambda(q, p; x)$ larger than zero only if there is a buyer who is willing to trade with him. Moreover, the seller expects the highest queue length for which she can find such a buyer. This means that she expects buyers to queue up for her good until it is no longer profitable for them to do so.

The third conditions impose some restrictions into beliefs. If a seller has produced a low quality good in the first period, then it is commonly known that the seller is normal type. Also, there are $\alpha_g$ of good sellers, and they have produced high quality goods in the first period. Beliefs must be consistent with them.

Hereafter, I focus on a *pooling* equilibrium that beliefs only depend on the history of sellers, and do not depend prices[5]. This property requires that defection is observed, then people believe it purely from mistakes that do not depend on types.

**Definition 2.** *A* pooling equilibrium with no signaling price *is an equilibrium where beliefs $b_g(q, p; x)$ satisfies for any $p^i, p^j \in [0, \infty)$,*

$$b_g(q, p^i; x) = b_g(q, p^j; x) \tag{13}$$

*for any $q \in \{H, L\}$ and $x \in [0, 1]$.*

Notice, any equilibrium satisfies the above property for $q = L$. No signaling price property implies

$$b_g(H, p; x) = \frac{\alpha_g}{\alpha_g + \alpha_n x}, \quad \forall p \in [0, \infty). \tag{14}$$

[5]Delacroix and Shi [5] study the case where sellers communicate with buyers through prices.

This is immediate from (13), (11) and (10). To abuse notation, hereafter the argument of price is omitted. This implies that

$$V(H;x) = \frac{\alpha_g}{\alpha_g + \alpha_n x} v_h + \frac{\alpha_n x}{\alpha_g + \alpha_n x} v_\ell, \tag{15}$$

$$V(L;x) = v_\ell. \tag{16}$$

It will be shown that the belief supports constraint efficient allocation as an equilibrium.

#### 3.1.2 Existence

Sellers' objective is to maximize her expected payoff

$$\mu(\Lambda(q,p;x))p.$$

Given buyers' beliefs, (8) pins down queue length $\Lambda$ as a function of price $p \in [0,\infty)$. Therefore, sellers' problem is written as

$$\max_{\lambda \in [0,\infty]} \mu(\lambda)V(q;x) - k\lambda \tag{17}$$

where $V(q;x)$ is given by (15) and (16).

The first order condition gives

$$\mu'(\lambda)V(q;x) = k. \tag{18}$$

Since $\mu'' < 0$, the second order is trivially satisfied. The solution exists and is unique. This implies that every seller within the same history chooses the same queue length and hence the same price. Moreover, the posted prices do not depend on types. Thus no signaling price property is satisfied.

As a summary, we have the following proposition.

**Proposition 1.** *There exists a unique pooling equilibrium with no signaling price. The queue length function solves*

$$\mu'(\lambda)V(q;x) = k$$

*where*

$$V(H;x) = \frac{\alpha_g}{\alpha_g + \alpha_n x} v_h + \frac{\alpha_n x}{\alpha_g + \alpha_n x} v_\ell,$$
$$V(L;x) = v_\ell.$$

Denote $\pi(q;x)$ the expected payoff of a seller who has produced a good with quality $q \in \{H, L\}$. Notice the payoff does not depend on types.

## 3.2 Efficiency

The main result in this section is that the equilibrium is constraint efficient for any given $x \in [0,1]$.

**Proposition 2.** *The equilibrium is constraint efficient for any given $x$.*

Here, the constraints include that planner can *not* force normal type sellers to produce high quality goods[6]. Planner also faces constraints that individuals face, *i.e.* informational friction and search friction. Especially, the planner cannot observe type of sellers and only utilize histories of first period. These constraints imply that planner can choose the queue length $\lambda_H$ and $\lambda_L$ separately, depending on history of sellers. The objective of planner is to maximize total output

$$W_2(\lambda_H, \lambda_L; x) \equiv m_H(x)[\mu(\lambda_H)V(H;x) - k\lambda_H] + \\ m_L(x))[\mu(\lambda_L)V(L;x) - k\lambda_L]. \tag{19}$$

Then, the proposition is shown as follows.

**Proof.**

$$\frac{dW_2}{d\lambda_q} = m_q(x)[\mu'(\lambda_H)V(H;x) - k]. \tag{20}$$

*for* $q \in \{H, L\}$. □

The result is common in the competitive search literature. Notice, this claim is for fixed $x$.

## 3.3 Welfare Impacts on the Reputation Building Behavior

Here how the reputation-building behavior affects total output in the second period. Denote the total production in the second production in equilibrium by

$$\overline{W}_2(x) \equiv \max_{\lambda_H, \lambda_L \in [0,\infty]} W_2(\lambda_H, \lambda_L; x). \tag{21}$$

Then, the proposition is given as follows.

**Proposition 3.** $\overline{W}_2(x)$ *is decreasing in $x$*

[6]Hence, the notion of constraint is stronger than usual sense where planner faces only constraints that individuals face.

**Proof.** *First, notice that* $\overline{W}_2(x)$ *is expressed as*

$$\overline{W}_2(x) = m_H(x)\pi(H;x) + m_L(x)\pi(L). \tag{22}$$

*Then,*

$$\overline{W}_2'(x) = \alpha_n(\pi(H;x) - \pi(L;x)) + m_H(x)\frac{d\pi(q;x)}{dx}. \tag{23}$$

*By envelop condition,*

$$\frac{d\pi(q;x)}{dx} = \mu(\Lambda(H;x))V_H'(x). \tag{24}$$

*From (15),*

$$V_H'(x) = -\frac{\alpha_g\alpha_n}{m_H(x)^2}(v_h - v_\ell). \tag{25}$$

*By substituting (24) and (25) into (26) and doing some algebra, we get*

$$\overline{W}_2'(x) = \alpha_n\left[\mu(\Lambda(H;x))v_\ell - \mu(\Lambda(L))v_\ell - k(\Lambda(H;x)) - \Lambda(L))\right]. \tag{26}$$

*The claim is shown once it is shown that for any* $\lambda > \Lambda(L)$,

$$\Delta(\lambda) \equiv \mu(\lambda)v_\ell - \mu(\Lambda(L))v_\ell - k(\lambda - \Lambda(L)) < 0. \tag{27}$$

*Now, since* $\mu'(\lambda)$ *is decreasing in* $\lambda$,

$$\Delta'(\lambda) = \mu'(\lambda)v_\ell - k < \mu'(\Lambda(L))v_\ell - k = 0. \tag{28}$$

*Combining this with*

$$\Delta(\Lambda(L)) = \mu(\Lambda(L))v_\ell - \mu(\Lambda(L))v_\ell - k(\Lambda(L) - \Lambda(L)) = 0, \tag{29}$$

*we get the claim.* □

This proposition is a direct consequence of competitive search market where reputation has a function to allocate buyers across sellers. The intuition behind the proposition is as follows. The higher $x$ implies that the submarket with good history is consisted by more of normal sellers. Buyers as well as planner cannot distinguish types, so they have to assign the same probability of matching to a good and normal sellers. However, since normal sellers produce low quality goods in the second period, planner wants to decrease the matching probability of normal seller. This result is in contrast to the many of literature on reputation where reputation in the second period only affects transfer.

Notice, the proposition compares among different $x$ unlike the first proposition. One implication of this proposition is that a planner who can choose $x$ faces a non-trivial dynamic consistency problem. In the first period, high $x$ is good because there are more of high quality goods. However, this hurts total production in the second period.

Finally, we have the following lemma.

**Lemma 1.** $\overline{W}_2(x)$ *is a convex function,* i.e.

$$\overline{W}''_2(x) > 0. \tag{30}$$

**Proof.**

$$\begin{aligned}
\overline{W}''_2(x) &= \alpha_n[\mu'(\Lambda(H;x))\Lambda'(H;x)v_\ell - k\Lambda'(H;x)] \\
&= \alpha_n\left[\mu'(\Lambda(H;x))V_H(x)\frac{v_\ell}{V_H(x)} - k\right]\Lambda'(H;x) \\
&= \alpha_n k\left[\frac{v_\ell}{V_H(x)} - 1\right]\Lambda'(H;x) \\
&> 0
\end{aligned} \tag{31}$$

*as* $\Lambda'(H;x) < 0$. □

# 4 The First Period

The above section defines and characterizes equilibrium in the second period. Now we have to define equilibrium in the first period. In the first period, only normal sellers make a nontrivial decision.

## 4.1 Equilibrium

Each normal seller chooses quality of goods, given the expected payoff in the second stage and others' strategy $x$. Let $\pi^*(q;x)$ be the equilibrium payoff of a seller in the second period if the seller has produced a good with quality $q \in \{H, L\}$ and other normal sellers choose strategy $x$. If a normal seller produces a high quality good, then she gets $p_1 - c + \pi^*(H;x)$ and a low quality $p_1 + \pi^*(L;x)$. Hence, the expected payoff to a normal seller $i$ who chooses strategy $x^i$ is

$$x^i(p_1 - c + \pi^*(H;x)) + (1 - x^i)(p_1 + \pi^*(L;x)), \tag{32}$$

given that other sellers choose $x$.

**Definition 3.** *An equilibrium consists of* $x^*$ *that satisfies*

$$x^* \in \arg\max_{x^i\in[0,1]} x^i(p_1 - c + \pi^*(H;x^*)) + (1 - x^i)(p_1 + \pi^*(L;x^*)), \tag{33}$$

*i.e.* $x^*$ *is a best response to* $x^*$ *itself.*

In the first period, only normal sellers make non-trivial decision. For $x$ to be positive, normal sellers must be indifferent between to produce a high or low quality good. If a seller produces a high quality good, then she gets $\pi_H(x)$ in the second period. If she produces a low quality good, then she gets $\pi_L$ in the second period.

Hence, for some sellers to produce high quality goods, *i.e.* $x > 0$, it must be the case that

$$c \geq \pi_H(x) - \pi_L. \tag{34}$$

$\pi_H(x)$ is decreasing in $x$, so there is at most one intersection.

## 4.2 Planner's Problem

Here, planner's problem is considered. The objective of the planner is to maximize total production $W(x)$, where

$$W(x) \equiv \alpha_g v_h + \alpha_n[x(v_h - c) + (1-x)v_\ell] + \overline{W}_2(x). \tag{35}$$

**Proposition 4.** *Planner chooses either $x = 0$ or $x = 1$.*

**Proof.** *Follows from*

$$W''(x) = \overline{W}_2''(x) > 0. \tag{36}$$

□

# 5 Conclusion

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