American Economic Review 101 (June 2011): 1591–1600
http://www.aeaweb.org/articles.php?doi=10.1257/aer.101.4.1591

Information and Prices with Capacity Constraints

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Since George J. Stigler's (1961) seminal work, the literature on consumer search has attempted to understand the relationship between the prices that are set by sellers and the extent to which consumers can observe and compare these prices before purchasing a good. In the theoretical branch of this literature, one conclusion is almost universal: as buyers become better informed about prices ex-ante, sellers will set lower prices in equilibrium.[1] In fact, this relationship is so engrained in the theory of consumer search that it is often accepted as manifest, and applied to various markets and situations with little or no hesitation.[2] In this paper, I examine a completely standard consumer search model with one small—yet often relevant—additional restriction: I assume that sellers possess a limited number of goods, or can only serve a limited number of customers at once, so that a given seller may be unable to meet realized demand. In such an environment, I show that the conventional wisdom regarding information and prices does not necessarily hold: having more informed consumers can lead to either an increase or decrease in equilibrium prices, or have no effect at all. I characterize the regions of the parameter space where each is likely to occur.

The assumption that a seller's capacity may be fixed, and that this constraint may be binding, is a fairly important feature of many markets. In some markets *time* is the constraint: doctors and barbers and contractors can only serve a limited number of clients at once. In other markets *space* is an issue: private schools have a limited number of spots in each classroom, while restaurants have a limited number of tables. Perhaps most common is markets in which sellers' *inventory* is occasionally a limiting factor: landlords have a limited number of apartments for rent, and ticket agents have a limited number of concert tickets available. In markets such as these, consumers regularly trade off price and *availability*; they are willing to pay more for a greater chance of being able to purchase the good of their choice.

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[1] This result is true in all of the classic theoretical models of consumer search, such as Steven Salop and Joseph E. Stiglitz (1977), Hal R. Varian (1980), Kenneth Burdett and Kenneth L. Judd (1983), Dale O. Stahl II (1989), and many others.

[2] The idea that more informed consumers leads to more efficient (competitive) prices is the foundation for many empirical studies; for some recent examples, see Alan T. Sorensen (2000), Ali Hortaçsu and Chad Syverson (2004), and Jeffrey R. Brown and Austan Goolsbee (2002). This idea is taken as given in the popular press, as well. For example, *The Economist* predicted: "The explosive growth of the Internet promises a new age of perfectly competitive markets. With perfect information about prices and products at their fingertips, consumers can quickly and easily find the best deals. In this brave new world, retailers' profit margins will be competed away, as they are all forced to price at cost" (November 20, 1999, p. 112).

In such an environment, as more consumers become *informed* about prevailing prices—that is, as more consumers can observe and compare prices before choosing a seller—I show that there are two, opposing effects. On the one hand, a seller's optimal price-posting strategy depends on the ability of buyers to observe and compare other prices, as this determines the extent to which a seller is competing with other sellers. As more buyers become informed, competition amongst sellers increases, causing downward pressure on prices. This is the effect that has been identified in much of the traditional literature. However, when sellers are capacity constrained, there is a second effect: due to the limited availability of goods at each seller, buyers' strategies also depend on the ability of other buyers to observe prevailing prices, as this determines the extent to which buyers are competing with one another for low-priced goods. As more buyers become informed, congestion worsens at low-price sellers, and each informed buyer becomes more willing to pay a higher price in exchange for a lower probability of being rationed. Such willingness provides incentive for sellers to set higher prices. Therefore, from a theoretical point of view, it is not at all obvious how increased price transparency will affect markets in which capacity constraints are relevant.

In this paper, I consider one of the most basic models in Economics: sellers have a good, they set prices, and buyers choose a seller to visit in order to purchase this good. I add two ingredients, both of which have been used extensively in isolated literatures. First, I assume that sellers possess a limited number of indivisible goods, and that buyers cannot coordinate their search strategies. Thus, it is possible that there is excess demand at some sellers, and excess supply at others.[3] Second, buyers are heterogeneous with respect to their ex-ante information about prices: some buyers are perfectly informed and choose a seller strategically, while others are completely uninformed and choose a seller at random.[4] Within the context of this framework, I ask: What happens to prices when the fraction of informed buyers increases? I show that whether prices increase, decrease, or stay constant depends, broadly speaking, on three features of the environment: the overall ratio of buyers to sellers, the fraction of informed buyers, and market size. When the buyer-seller ratio and the fraction of informed buyers are relatively small, a marginal increase in the fraction of informed buyers typically leads to a decrease in prices. Alternatively, if these two values are sufficiently large, an increase in the fraction of informed buyers places no downward pressure on prices, and in small markets can even cause an increase in equilibrium prices.[5]

Ideally, one would like to test these predictions. Unfortunately, the majority of empirical studies in this area focus on markets where capacity constraints are largely irrelevant.[6] This is likely to change, however, as the information structure

[3] This follows the literature on directed search. See Burdett, Shouyong Shi, and Randall Wright (2001) and the references therein.

[4] This follows in the spirit of the references in Footnote 1.

[5] As I discuss at length in Section II, what is crucial about small markets is that a single agent's actions can affect equilibrium outcomes.

[6] An exception is Svend Albæk, Peter Møllgaard, and Per B. Overgaard (1997), who compare the price of concrete contracts before and after the Danish Competition Authority required prices be made public. They find that average prices rose 15–20 percent, despite no discernable changes in demand. Though this finding is potentially consistent with the theory developed here, clearly more empirical work needs to be done in markets with these types of frictions.

changes in several important markets in which availability (or waiting time) is a crucial component of consumers' decision-making. For example, the majority of states in the US have recently passed legislation to increase price transparency in health-care markets. A natural question would be: How will this affect doctors' fees? The contribution of the current paper is to provide a theoretical foundation for future empirical work in such markets, so that at the very least we know what we might *expect* to find when the information structure changes in markets with capacity-constrained sellers.

The paper proceeds as follows. Section I provides a complete characterization of equilibrium in *large* markets (i.e., a continuum of agents). This helps to isolate the importance of the buyer-seller ratio and the fraction of informed buyers. Section II then considers the case of *small* markets (i.e., a finite number of agents). Here I characterize a region of the parameter space where prices increase as agents become more informed, highlighting the importance of market size in determining the relationship between information and prices. Section III concludes.

I. Large Markets

There is a measure 1 of sellers and a measure b of buyers. Each seller possesses a single, indivisible, homogeneous good, and buyers receive one unit of utility per unit of consumption. The game proceeds in two stages. In stage one, sellers post and commit to a price p. In stage two, buyers choose a seller to visit. If multiple buyers arrive at a particular seller, a single buyer is chosen at random (each buyer with equal probability) to purchase the good at the posted price.

Buyers are heterogeneous with respect to ex-ante information about sellers. A fraction λ of buyers have perfect information (they are *informed*) about both the prices and locations of all sellers. In stage two, these buyers will choose the seller (or mix between sellers) promising the maximum expected utility, which is the product of the surplus he receives if he purchases the good, $1 - p$, and the probability that he will be selected to purchase the good. The remaining fraction $1 - \lambda$ of buyers cannot observe the prices posted by any particular seller (they are *uninformed*). Since all sellers appear ex-ante identical to an uninformed buyer, he picks a seller to visit at random (each seller with equal probability) in stage two.

Equilibria are constructed in two steps. Working backwards, I first characterize the symmetric equilibrium in the second stage sub-game associated with any distribution of prices, thus pinning down the expected number of buyers to arrive at each posted price.[7] Then I characterize the equilibrium distribution of prices at stage one, taking as given the equilibrium behavior of buyers in the stage two sub-game.

Consider the second stage game. Given any distribution $F(p)$, informed buyers observe all prices and forecast the probability of being served at each seller. Given buyers' strategies, the number of buyers to arrive at any particular seller (the *queue length*) is a random variable with expected value Q. As is standard in models of

[7] Restricting attention to symmetric strategies for buyers is standard in this literature, and crucial for generating a coordination friction. This restriction is generally justified by assuming that there is no channel for buyers to communicate and coordinate their actions. See both Burdett, Shi, and Wright (2001) and Robert Shimer (2005) for a more detailed discussion.

directed (or competitive) search, the expected queue length Q at a particular seller is assumed to be a sufficient statistic to determine the likelihood of a match. We follow Burdett, Shi, and Wright (2001), who characterize equilibrium with a finite number of agents and show that, as the number of agents tends to infinity, the probability that at least one buyer arrives at a particular seller is given by $\mu(Q) = 1 - e^{-Q}$, while the probability that each buyer is served at this seller is $\eta(Q) = \mu(Q)/Q$.[8] Uninformed buyers choose a seller at random, so that the expected number of uninformed buyers at each seller is $(1 - \lambda)b$. Informed buyers, on the other hand, are strategic: they visit a seller with price p' and expected queue length Q' only if the expected payoff, $\eta(Q')(1 - p')$, is at least as large as the maximal expected payoff from applying elsewhere, which we denote by V. Let $q(p; V) = \max\{0, \hat{q}\}$, where $\hat{q}$ satisfies $\eta[\hat{q} + (1 - \lambda)b]\,(1 - p) = V$.

DEFINITION 1: *Given any distribution of prices* $F(p)$, *a symmetric equilibrium of the second stage sub-game is an expected payoff* V^* *and an expected queue length at each price* $Q^*(p; V^*)$ *such that* $Q^*(p; V^*) = q(p; V^*) + (1 - \lambda)b$ *and* $\int Q^*(p; V^*)\,dF(p) = b$.

It is straightforward to show that for any $F(p)$ there exists a unique equilibrium V^*, which we refer to as the *market utility*. Note that, in any equilibrium of the second stage sub-game, there exists a critical price above which a seller only receives uninformed buyers. This critical price, $\overline{p}(V^*) = 1 - \{V^*/\eta[(1 - \lambda)b]\}$, is the price at which the queue length is $(1 - \lambda)b$ and the expected value of visiting this seller is exactly V^*. Thus, $Q^*(p; V^*)$ is strictly decreasing in p for $p \leq \overline{p}(V^*)$, and $Q^*(p; V^*) = (1 - \lambda)b$ for $p > \overline{p}(V^*)$.

Turning now to the first stage, each seller posts a price p that maximizes expected profits, taking as given the distribution of prices posted by other sellers. Given $F(p)$, each seller can forecast the market utility V^* in the corresponding second stage equilibrium, and thus the expected queue length given any posted price. Formally, each seller solves

$$\Pi(V^*) = \max_{p \in [0,1]} \{\pi(p; V^*) = \mu[Q^*(p; V^*)]p\}. \tag{1}$$

DEFINITION 2: *An equilibrium at stage one is a distribution of prices* $F^*(p)$, *a market utility* V^*, *and expected queue lengths* $Q^*(p; V^*)$ *such that* (*i*) $\pi(p; V^*) = \Pi(V^*)$ *for all p such that* $dF^*(p) > 0$ *and* $\pi(p; V^*) \leq \Pi(V^*)$ *for all p such that* $dF^*(p) = 0$*; and* (*ii*) V^* *and* $Q^*(p; V^*)$ *constitute a symmetric sub-game equilibrium given* $F^*(p)$.

Two features of the profit function $\pi(p; V)$ simplify the characterization of equilibrium. First, given any V, profits are strictly increasing on the domain $(\overline{p}(V), 1]$. Therefore, if it is optimal for an individual seller to set a price above $\overline{p}(V)$, it must

[8] All of the results in this section remain true under the alternative assumption that $\mu(Q)$ is an arbitrary matching technology, so long as it satisfies some concavity restrictions; this is the approach usually taken in *competitive* search, a la Espen R. Moen (1997).

be that the optimal price is $p_H = 1$, with corresponding queue length $Q_H = (1 - \lambda)b$ and profits $\pi_H = 1 - e^{-Q_H}$. Alternatively, if the optimal price is less than $\overline{p}(V)$, it must solve

$$\max_{p \in [0, \overline{p}(V)]} (1 - e^{-Q})p \tag{2}$$

$$\text{sub to} \left[(1 - e^{-Q})/Q\right](1 - p) = V. \tag{3}$$

Solving the constraint for p and substituting into the objective function reveals that this problem has a unique solution.[9] Taking first order conditions identifies the optimal queue length Q_L, price p_L, and resulting profits π_L:

$$e^{-Q_L} = V \tag{4}$$

$$1 - (Q_L e^{-Q_L})/(1 - e^{-Q_L}) = p_L \tag{5}$$

$$1 - e^{-Q_L}(1 + Q_L) = \pi_L. \tag{6}$$

Therefore, in any equilibrium with associated market utility V^*, a profit-maximizing seller will either post p_L and serve both informed and uninformed buyers, or post p_H and serve only uniformed buyers. Naturally, if $\lambda = 0$, all sellers post p_H; this is the result of Peter Diamond (1971). In Proposition 1, equilibrium is characterized for $\lambda > 0$. All proofs are in the online Appendix.

PROPOSITION 1: *An equilibrium exists and is unique. With* $\hat{\lambda} = \ln(1 + b)/b$*: (i)* $\lambda \in (0, \hat{\lambda})$ *implies a two price equilibrium in which* $\alpha^* \in (0,1)$ *sellers post* $p_L^* < 1$ *and* $1 - \alpha^*$ *sellers post* $p_H = 1$*. The equilibrium market utility, low price, and profits are given by* (4)–(6), *respectively, with* $Q_L^* = b[(\lambda/\alpha^*) + 1 - \lambda]$*. The fraction* α^* *is determined by the equilibrium condition* $\pi_L^* = \pi_H$*. (ii)* $\lambda \in [\hat{\lambda}, 1]$ *implies a one price equilibrium* $(\alpha^* = 1)$ *where* V^*, p_L^*, *and* π_L^* *are given by* (4)–(6) *with* $Q_L^* = b$.

Though there are many interesting features of the equilibria characterized above, I focus here on the relationship between the fraction of informed agents and prices. Most striking is the fact that, for $\lambda \geq \hat{\lambda}$, an increase in the fraction of informed agents has *no* effect whatsoever on equilibrium prices; $\alpha^* = 1$ and p_L^* is constant for $\lambda \geq \hat{\lambda}$.[10] To understand this, recall that equilibrium in the second stage sub-game requires that, at any seller attracting informed buyers, $\left[(1 - e^{-Q})/Q\right](1 - p) = V^*$. Thus $\partial Q/\partial p$—which determines the "elasticity of demand"—is independent of λ; it only depends on the market utility, which cannot be changed by a single seller's

[9] Substituting p into the objective function, so that it now a maximization problem over Q, and differentiating twice yields $\pi'' = -e^{-Q} < 0$. Since p is uniquely determined by Q through (3), there is a unique profit-maximizing price.

[10] An alternative interpretation of this result is that the standard model of directed search with fully informed agents, which is used in a variety of contexts, is robust to the introduction of buyers who search randomly; the equilibrium prices and allocations are identical for all $\lambda \geq \hat{\lambda}$. Daron Acemoglu and Shimer (2000) derive a similar result in a related model.

actions. Since the seller only adjusts his price in order to change his queue length, and this adjusts independently of λ, the trade-off he faces when setting prices is also independent of λ, so long as he wants to attract informed buyers. For $\lambda \in [\hat{\lambda}, 1]$, all sellers want to attract informed buyers, so the optimal price is constant in λ.

What is crucial is that, in the presence of capacity constraints, the informed buyers internalize congestion effects and change their behavior accordingly: in response to a price cut by a single seller, if the fraction of informed agents is small, then each informed buyer responds relatively strongly to this price cut (they visit with relatively high probability), while if the fraction of informed agents is large, then each informed buyer responds relatively weakly to this price cut. The key insight is that the elasticity of demand of informed buyers depends on whether *other* buyers observe the price deviation as well.

Only when there is a sufficiently large fraction of uninformed buyers do some sellers start offering the "rip-off" price $p_H = 1$. In this region, $\lambda < \hat{\lambda}$, a marginal increase in λ causes a decrease in the payoff from posting p_H, and thus sellers have a greater incentive to compete for informed buyers. In equilibrium, more sellers post a low price,

$$(7) \qquad \frac{\partial \alpha^*}{\partial \lambda} = \frac{\alpha^*}{\lambda}\left[1 - \alpha^* + \frac{\alpha^* e^{-Q_H}}{Q_L^* e^{-Q_L^*}}\right] > 0,$$

and this affects the buyer-seller ratio at low-price sellers. Congestion eases at these sellers,

$$(8) \qquad \frac{\partial Q_L^*}{\partial \lambda} = -\frac{b e^{-Q_H}}{Q_L^* e^{-Q_L^*}} < 0,$$

and the price falls, since clearly from (5) we have $\partial p_L / \partial Q_L \geq 0$.

Thus we see that there are really two potential effects from an increase in λ when firms are capacity constrained. There is the traditional effect: an increase in λ can decrease the incentive of sellers to target uninformed buyers, thus increasing the level of competition amongst sellers for informed buyers, which drives prices down. However, in the presence of capacity constraints, there is a second effect: the elasticity of demand for informed buyers is sensitive to the number of *other* informed buyers that observe price deviations. In particular, the elasticity of demand for informed buyers is greater when there are fewer other informed buyers. In the continuum, we have shown that the demand of informed buyers adjusts perfectly to offset any changes in λ. In the next section, we show that in a finite economy in which each agent has market power, in fact this second effect can lead to counterintuitive results: namely, that increasing the fraction of informed buyers can lead to *higher* prices.

II. Small Markets

Now suppose there are a finite number of informed buyers, uninformed buyers, and sellers, denoted by $\mathcal{N} = \{1, \ldots, N\}$, $\mathcal{U} = \{1, \ldots, U\}$, and $\mathcal{S} = \{1, \ldots, S\}$, respectively. The game proceeds as before: each seller $s \in \mathcal{S}$ posts a price p_s, and each informed buyer observes the vector of prices $(p_1, \ldots, p_S) \equiv \mathbf{p}$ and chooses to visit each seller with probability θ_s, where $\theta_s \in [0,1]$ for all s and $\sum_{s \in \mathcal{S}} \theta_s = 1$.[11] Uninformed buyers simply visit each seller with equal probability $1/S$.

Given $\mathbf{p}$ and the strategies of all other buyers $(\theta_1, \ldots, \theta_S) \equiv \boldsymbol{\theta}$, informed buyer $i \in \mathcal{N}$ chooses a strategy to maximize expected payoffs. At each location, the probability that buyer i will be served given all other buyers visit with probability θ_s can be defined[12]

$$(9) \quad \tilde{\eta}(\theta_s) = \sum_{i=0}^{N-1} \sum_{k=0}^{U} C_{N-1}^{i} \, \theta_s^i (1 - \theta_s)^{N-1-i} \, C_U^k \left(\frac{1}{S}\right)^k \left(1 - \frac{1}{S}\right)^{U-k} \frac{1}{i + k + 1},$$

where $C_X^j = X!/[j!(X-j!)]$. The expected payoff to a buyer visiting seller s is simply $\tilde{\eta}(\theta_s)(1-p_s)$. A symmetric equilibrium in the second stage sub-game is thus a $\boldsymbol{\theta}^*(\mathbf{p})$ with associated market utility V^* such that $\tilde{\eta}(\theta_s^*)(1-p_s) = V^*$ for all s such that $\theta_s^* > 0$, $\tilde{\eta}(\theta_s^*)(1-p_s) \leq V^*$ for all s such that $\theta_s^* = 0$, and $\sum_{s \in \mathcal{S}} \theta_s^* = 1$.[13] At the first stage, given the prices of all other sellers $\mathbf{p}_{-s}$, seller s chooses p_s to maximize expected profits given $\theta_s^*(p_s, \mathbf{p}_{-s})$. If informed buyers visit seller s with probability θ_s, the probability that at least one buyer arrives is

$$(10) \qquad \tilde{\mu}(\theta_s) = \left[1 - (1 - \theta_s)^N (1 - 1/S)^U\right].$$

Therefore, each seller solves the profit-maximization problem

$$(11) \qquad \max_{p_s \in [0,1]} \left\{\tilde{\pi}(p_s; \mathbf{p}_{-s}) = \tilde{\mu}[\theta_s^*(p_s, \mathbf{p}_{-s})] p_s\right\}.$$

As in the case with a continuum of agents, equilibrium involves sellers using mixed strategies when the fraction of informed buyers is sufficiently small, and all sellers setting the same price when this fraction is sufficiently large. Unlike the case with a continuum of agents, however, the market utility is *not* a sufficient statistic for sellers to forecast second stage behavior. Instead, each seller needs to know the vector of prices offered by other sellers; when sellers use mixed strategies, announced prices are stochastic, and a closed-form characterization of equilibria becomes intractable. Luckily, the most interesting comparative statics occur when all sellers set the same price, and this case allows for closed-form solutions.

To characterize this equilibrium, suppose that $S - 1$ sellers set price p, and consider the optimal price offered by a potential deviant seller, p_d. If informed buyers visit this seller with probability θ_d, the expected payoff is

$$(12) \qquad V = \tilde{\eta}(\theta_d)(1 - p_d).$$

[11] Note again that attention is restricted to symmetric strategies for informed buyers.

[12] To avoid confusion, for a variable or function x in the game with a continuum of agents, we will denote its analog in the game with a finite number of agents by $\tilde{x}$.

[13] The argument used by Michael Peters (1984) can be used to show that, for each $\mathbf{p}$, there exists a unique symmetric strategy equilibrium $\boldsymbol{\theta}^*(\mathbf{p})$. Note that, when possible, we will suppress the argument of $\boldsymbol{\theta}^*(\cdot)$.

Let $\theta^d(p_d,V)$ denote the implicit function in (12). Since we are looking for an equilibrium in which all sellers serve informed buyers, it must also be that

$$(13)\qquad V = \tilde{\eta}\left(\frac{1-\theta_d}{S-1}\right)(1-p).$$

Since $\theta_d = \theta^d(p_d,V)$, (13) defines an implicit function $V(p_d,p)$. Let the deviant seller's profits be denoted by $\tilde{\pi}^d(p_d;V) = \tilde{\mu}[\theta^d(p_d,V)]p_d$; this slight abuse of notation allows for an easy comparison with the analysis in the previous section. An equilibrium in which sellers use pure strategies is thus characterized by the first order condition

$$(14)\qquad \frac{\partial \tilde{\pi}^d}{\partial p_d} + \frac{\partial \tilde{\pi}^d}{\partial V}\frac{\partial V}{\partial p_d} = 0,$$

with $p_d = p \equiv \tilde{p}_L$ and $\theta_d = 1/S$, subject to the constraint that

$$(15)\qquad \tilde{\mu}\left(\frac{1}{S}\right)\tilde{p}_L = \left[1-\left(1-\frac{1}{S}\right)^{N+U}\right]\tilde{p}_L \geq \left[1-\left(1-\frac{1}{S}\right)^{U}\right] = \tilde{\mu}(0),$$

so that the deviation to setting price $p_d = 1$ is not profitable.

PROPOSITION 2: *For any $N \geq 2$, $S \geq 2$, $U \geq 0$, and $B = N + U$, let*

$$(16)\qquad \tilde{p}_L = \frac{\tilde{\mu}(1/S)[\tilde{\eta}(1/S) - (1-1/S)^{B-1}]}{\tilde{\mu}(1/S)[\tilde{\eta}(1/S) - (1-1/S)^{B-1}] + [1-\tilde{\mu}(1/S)]\tilde{\eta}(1/S)\{[N(B-1)]/[(N-1)S]\}}.$$

If N, S, and U are such that (15) is satisfied for $\tilde{p}_L$, then there exists a unique symmetric strategy equilibrium with $p_s^* = \tilde{p}_L$ and $\theta_s^* = 1/S\ \forall s \in \mathcal{S}$. Moreover, holding B and S constant, $\tilde{p}_L$ is a strictly increasing function of N.

Plugging in $\tilde{p}_L$, the condition in (15) is analogous to $\lambda \geq \hat{\lambda}_b$: the left hand side of the inequality is increasing in N, so the condition simply requires N to be sufficiently large for given values of U and S. Therefore, whereas prices in the one-price equilibrium with a continuum of agents were independent of λ, in a finite economy they are strictly increasing in the fraction of informed agents.[14] That is, having *more informed* consumers can lead to *higher prices*.[15]

[14] More generally, it is easy to see that this equilibrium converges to the analogous equilibrium with a continuum of agents. Setting $B = bS$, $\tilde{p}_L$ converges to p_L in (5) with $Q_L = b$ as $S \to \infty$.

[15] This has very interesting implications for information acquisition. Traditionally, one would think that a one-price equilibrium could not be supported if information were at all costly to acquire, and indeed this is true here in the case of a large economy. However, this is *not* true in the finite game, since the value of becoming informed is positive for values of N that result in a two-price equilibrium, and *negative* for values of N that result in a one-price equilibrium. In other words, letting $\hat{N}$ denote the minimum value of N such that (15) is satisfied, the marginal buyer would potentially be willing to acquire information up to $\hat{N}$, but it would never be optimal for $\hat{N}+1$ buyers to become informed; in fact, the $\hat{U} = B - \hat{N}$ buyers would pay to remain uninformed in order to keep prices down.

To understand this result, suppose that there are three buyers and two sellers, and consider two cases: case A, where $N = 3$ and $U = 0$, and case B, where $N = 2$ and $U = 1$. It can easily be verified that both cases satisfy (15), and that the equilibrium price set by both sellers in cases A and B are $\tilde{p}_L^A = 0.727$ and $\tilde{p}_L^B = 0.667$, respectively. As discussed earlier, in general there are two effects from replacing an uninformed buyer with an informed buyer. First, sellers have less incentive to set a high price targeting uninformed buyers, but this effect is shut down when (15) holds: in cases A and B, both sellers are targeting informed buyers with probability 1.[16] The second effect is that the demand of informed buyers becomes less sensitive to price changes when a larger fraction of other buyers observe these changes, too.

Using the notation defined in (12) and (13) with "d" representing firm 1, let us think about $\tilde{\mu}_j\{\theta_j^1[p_1, V(p_1,p_2)]\}$ as the *demand* for seller 1's good in case $j \in \{A,B\}$ given p_2. Then, looking at $d\tilde{\mu}_j/dp_1$, under the conditions $p_1 = p_2 \equiv p$ and $\theta_j^* = 1/2$ reveals

$$(17) \quad \frac{d\tilde{\mu}_A\{\theta_A^1[p, V(p,p)]\}}{dp} = \frac{3}{4}\left[\frac{-7}{16(1 - p)}\right] > \left[\frac{-7}{16(1 - p)}\right] = \frac{d\tilde{\mu}_B\{\theta_B^1[p, V(p,p)]\}}{dp},$$

so that for any p the elasticity of demand is greater in case B. Intuitively, consider the payoffs to seller 1 from deviating to $p - \epsilon$. In case B, informed buyers visit this seller with greater probability because there are fewer buyers who observe this deviation, and thus less competition from other buyers for the good at this seller. In case A, on the other hand, all buyers observe this deviation, and therefore each informed buyer is less willing to visit this seller because of the congestion caused by other informed buyers. Since the elasticity of demand is greater in case B than in case A, there is greater incentive for sellers to decrease prices, and the equilibrium price level is lower.[17]

Why are prices increasing in this region of the parameter space in the finite economy, and constant in the analogous region when there is a continuum of agents? The difference is that, in the finite economy, each agent can affect the market utility by changing his strategy. Fixing p, we can decompose the change in demand:

$$(18) \quad \frac{d\tilde{\mu}\{\theta^d[p_d, V(p_d,p)]\}}{dp_d} = \frac{\partial\tilde{\mu}}{\partial\theta^d}\left[\frac{\partial\theta^d}{\partial p_d} + \frac{\partial\theta^d}{\partial V}\frac{\partial V}{\partial p_d}\right].$$

In markets where strategic considerations are important, what is crucial is that the second term within the brackets is both relevant and sensitive to changes in the fraction of

[16] Consistent with equilibrium with a continuum of agents, sellers start deviating to prices aimed at ripping off uninformed buyers if (15) is not satisfied. For example, if $N = 1$ and $U = 2$ (say, case C), equilibrium is a mixed strategy for sellers and the mean price posted is $p_C^* = 0.863 > p_A^* > p_B^*$ where p_j^* denotes the mean price posted in equilibrium for case $j \in \{A, B, C\}$. Not only is the average posted price $p_C^* > p_A^*$, but the average price *paid by informed buyers* is also strictly greater than p_A^*. We derive this equilibrium in the online Appendix.

[17] To understand this point further, consider the extreme case when there is only one informed buyer, who will visit the lowest-priced seller with probability one. In this case, if both sellers set the same price, a marginal decrease by either seller will result in a discrete jump in the probability of making a sale (to one); at this point, the selling probability is *infinitely* elastic.

informed buyers. In particular, what is driving the comparative static in Proposition 2 is that $\partial\theta^d/\partial V$ is decreasing as N increases. Of course, as the economy gets large this second term vanishes, and $d\tilde{\mu}/dp_d$ becomes insensitive to changes in the fraction of informed buyers.

Finally, are small markets really relevant? I argue that they are, for at least two reasons.[18] First, although e.g., the market that exists between doctors and patients is large, the number of patients in a particular location that require a particular procedure, and the number of doctors that can perform this procedure, can actually be quite small. Secondly, what is important here is not that the market is small, necessarily, but rather that each agent's decisions can affect market outcomes. Naturally, this implies that the analysis here applies to a wide array of markets of all sizes that happen to have a few, big players.

III. Conclusion

In this paper, I examine a standard model of consumer search with one additional restriction: sellers are capacity-constrained. In such an environment, I illustrate that increasing the fraction of informed buyers in a market may lead to higher or lower prices, or have no effect at all. In addition to providing a theoretical insight, this result may prove useful in understanding the behavior of prices as the process of price discovery continues to rapidly change.

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[18] Similar arguments have been made by Philipp Kircher and Manolis Galenianos in a variety of contexts.

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