DISCUSSION PAPERS IN ECONOMICS

Working Paper No. 09-08

Price-Directed Consumer Search

Tianle Zhang

University of Colorado

November 2009

Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

Price-Directed Consumer Search

Tianle Zhang[†]
University of Colorado at Boulder

November 2009

Abstract

This paper presents an oligopoly model in which consumers conduct sequential costly search for a desired product. In contrast to the specification of random or pre-determined search order in most current studies, I allow the order of consumer search to be endogenously determined. In the model, consumers observe product prices before searching among firms. Thus, price additionally affects profit by influencing the order in which consumers search. I find that the pattern of equilibrium price distribution depends on the size of search cost. In particular, for a medium search cost, a mixture price distribution prevails: firms randomly play two separate price distributions with a gap in between. Firms either price high, following a high price distribution, or price low, following a low price distribution, but always avoid prices at the intermediate interval. For low or high search costs, equilibrium price distribution is continuous with positive density on the entire support. Comparative statics show that equilibrium price is non-monotonic in search cost and firm profit can be higher when consumers have lower search costs.

[*] I thank Mark Armstrong and Yongmin Chen for helpful comments and suggestions. All remaining errors are my own.

[†] Department of Economics, University of Colorado at Boulder, 256 UCB, CO 80309, E-mail: tianle@colorado.edu

1 Introduction

An extensive literature has examined how consumers' costly sequential for information a¤ects market performance. These models typically assume that consumers search randomly among …rms. Stahl (1989) analyzes a model where …rms sell homogenous goods, and consumers with positive search costs visit …rms in a random order and buy from the …rst …rm that o¤ers a price below their reservation price. Wonlinsky (1986) and Anderson and Renault (1999) consider di¤erentiated product markets in which consumers incur costs to obtain price as well as product information. Consumers examine each product with an equal probability and purchase if a product yields a su¢ cient match to their preference. In these modelstpn2ltpn2ltpn2it2eron.t2erœle6(n) instance, with price search engines, consumers may easily obtain a list of prices of products by different sellers. However, the costs of time and effort for consumers to find out if a product matches their preferences remain significant. With observable prices, an interesting twist occurs. Prices, in addition to entering into firms' profit function directly, it may also influence the order in which consumers search, thus, indirectly affect firms' profits. By charging a relatively low price, a firm may become more "prominent" and increase sales. Surprisingly, the latter strategic consideration has not been explored in the literature. This paper attempts to fill in this gap.

Equilibrium analysis is conducted in section 3. Section 4 shows comparative statics on search cost. Section 5 concludes.

2 The model

There is a continuum of consumers, each with a "need." A consumer derives utility V if her need is met and 0 otherwise. N 2 …rms exist in the market, each of which carries a product that meets a consumer's need with a certain probability.[1] The probability is assumed independent and identical for all …rms and is denoted as 2 [0; 1]. The marginal cost is assumed constant and normalized to zero.

There are two types of consumers: informed and uninformed. In particular, 2 [0; 1] of consumers are informed knowing if products meet their needs (without search). The remaining 1 of consumers are uninformed. An uninformed consumer initially does not know if a product meets her need but can learn it by incurring a search cost scdupcngductmee1910Td[(o)11(ua.10Tf[(o)11408)-237(a)11(l)6(m9(H99Tf[(o11(o)119v1(k)

Since an informed consumer observes all prices and knows if a product matches her preference she will purchase from the matched firm (if any) with the lowest price in the market. An uninformed consumer has to decide a search strategy to maximize her expected payoff. Given that a firm charges price p; an uninformed consumer will search the firm only if the expected payoff is non-negative, that is,

$$(V \quad p) \quad s \quad 0$$

or

$$p \quad V \quad \frac{s}{\ }:$$

Define

$$r = V \quad \frac{s}{\ }: \qquad (1)$$

We shall call r as reservation price. Thus, an uninformed consumer will only search a firm if the firm charges a price that is equal to or below the reservation price, that is, $p \quad r$: Next, we consider the order by which uninformed consumers search among firms charging prices below the reservation price. Given that each firm has a same probability to match a consumer's preference, uninformed consumers get

$$G_l = \frac{1}{1} \left[\frac{1}{(1 \quad)} \left(\frac{V}{p} \right)^{\frac{1}{N-1}} \quad 1 \right] \qquad (4)$$

$$= \frac{1}{\quad} \left[\left(\frac{V}{r} \right)^{\frac{1}{N-1}} \quad 1 \right] \qquad (5)$$

and r is de…ned as in (1).

Proof. We …rst verify that $G(p)$ is a c.d.f. Since $G(V) = 1$; $G \quad (1 \quad)^{N-1} \; V \quad = 0$, $G \; V \quad \frac{s}{} \; = G \; \frac{V-s}{} \; = 1 \quad \frac{1-}{} \quad \left(\frac{V}{V-s} \right)^{\frac{1}{N-1}} \quad 1$ and $G(p)$ weakly increases in p; it follows that $G(p)$ is a continuous c.d.f.

We next show that each …rm is optimizing following $G(p)$, given that other …rms choose prices according to $G(p)$ and uninformed consumers' reservation price is r: Note that a …rm can only sell to an (informed and uninformed) consumer if its price is the lowest among the matched …rms. In addition, selling to a uninformed consumers requires the price is lower than r to induce a search. The expected pro…t when a …rm chooses p is:

(i) If $p = V$;

$$= V \quad (1 \quad)^{N-1} \qquad (6)$$

because the …rm only sells to the informed consumers who …nd the …rm is the only match.

(ii) If $p = r$ a …rm sell to matched consumers (informed or uninformed) who …nd that the …rm has the lowest price. That is, …rms with lower prices do not match. Thus, the pro…t is

$$= \; r \; [(1 \quad)^{N-1} + \binom{N-1}{1} \quad (1 \quad)^{N-2} \quad + \binom{N-1}{2} \; ^2 (1 \quad)^{N-3} \; ^2$$

$$+ ::: + \binom{N-1}{i} \; ^i (1 \quad)^{N-1-i} \; ^i + ::: + \; ^{N-1} \; ^{N-1}]$$

Y255 1 1 1 9 5 5 Tf 1 3.062 0 Td [(F

$$= \; r$$

(iii) if $p \ 2 \ G_h(p)$ or $p > r$;

$$= p \sum_{i=0}^{N-1} \binom{N}{i} \quad {}^{i} (1 \quad)^{N-1-i} \quad {}^{i} (1 \quad G_h(p))^{i}$$

$$= p \quad [\quad (1 \quad G_h(p)) + 1 \quad]^{N-1} \tag{8}$$

because the …rm only sells to the informed consumers who …nd its price is lowest among the matched …rms.

(iv) If $p \ 2 \ G_l(p)$ or $p < r$;

$$= p \sum_{i=0}^{N-1} \binom{N}{i} \quad {}^{i} (1 \quad)^{N-1-i} [\quad + (1 \quad) (1 \quad G_l(p))]^{i}$$

$$= p \quad f \quad [\quad + (1 \quad) (1 \quad G_l(p))] + 1 \quad g^{N-1} \tag{9}$$

because the …rm can sell to both informed and uninformed consumers when the its price is lowest among the matched …rms.

Equal pro…t from (i) and (ii) yield (5), Equal pro…t from (i) and (iii) yield (3). Equal pro…t from (i) and (iv) yield (4). Therefore, the …rm optimizes choosing prices according to $G(p)$:

Finally, note that when $\overset{h}{1} \quad (1 \quad)^{N-1} \overset{i}{} \ V > s > (1 \quad (1 \quad (1$

probability and 1

Substituting (3), (4) and (5) into (2), the price distribution can be rewritten as

$$G(p) = \begin{cases} 1 \quad \frac{1-}{} \quad \left(\frac{V}{p}\right)^{\frac{1}{N-1}} \quad 1 & \text{if } V \quad \underline{s} > p > (1 \quad)^{N-1} \ V \\ 1 \quad \frac{1-}{} & \text{if } V \end{cases}$$

As shown in Figure 1a, the equilibrium price distribution function stays constant over some intermediate prices. This implies zero probability placed on these prices.

We next discuss the case where s is small.

Proposition 2 When $s < (1 \quad) V$ there exists a symmetric equilibrium, in which each ...rm prices according to mixed strategy

$$F(p) = 1 \quad \frac{1}{\quad} \left[\left(\frac{r}{p}\right)^{\frac{1}{N-1}} \quad 1 \right] \quad \text{if} \quad r \quad p \quad (1 \quad)^{N-1} r: \qquad (12)$$

Proof. Given F (p), the uninformed consumers search optimally. To show that the proposed is an equilibrium, we thus only need to show that given r and other ...rms choose F (p), each ...rm optimizes choosing any $p \, 2 \, [(1 \quad)^{N-1} r; r]$: For any such price, the ...rm's expected pro...t is

$$
\begin{aligned}
& p \sum_{i=0}^{N-1} \binom{N}{i} \quad {}^{i} (1 \quad)^{N-1-i} (1 \quad G_I (p))^{i} \\
= \; & p \, [\quad (1 \quad F (p)) + 1 \quad]^{N-1} \\
= \; & p \left[1 \quad \frac{1}{\quad} \left(\left(\frac{r}{p}\right)^{\frac{1}{N-1}} \quad 1 \right) + 1 \quad \right]^{N-1} \\
= \; & r \, (1 \quad)^{N-1}
\end{aligned}
$$

Note that p > r would lead to zero sale and any

4 Comparative Statics on Search Cost

Our previous analysis shows how the equilibrium price strategies depend on if the

the equilibrium price stochastically; (ii) increases …rms' pro…ts; and (iii) increases total welfare.

When s is small, …rms choose a price strategy with all prices below the uninformed consumers reservation price, r. By (1), as s decreases, r increases. This allows …rms charge higher prices resulting in a higher pro…t. Note that there is no welfare loss as long as consumers with at least one match will …nd her matched products and purchase. This is true in this equilibrium. Moreover, there is a reduction in search cost. Therefore, total welfare increases. Note that the change of consumer welfare is not clear. On one hand, the lower search cost bene…ts consumers. On the other, equilibrium prices increase which lowers consumer welfare.

When s is medium, by (10), G (p) is weakly increasing in s. Moreover, the limits of upper bound, $\frac{V - s}{\;}$ and lower bound, $V \quad \frac{s}{\;}$, increase in as s decreases. Therefore, the price distribution G (p) stochastically increases, thus, the equilibrium prices are stochastically lower as s decreases. Figure 2b illustrates the change of G (p) for a decrease in search cost.

Proposition 5 When s is medium, that is $\left[1 \quad (1 \quad)^{N-1}\right] V > s > (1 \quad) V$, a decrease in s (i) decreases the equilibrium prices stochastically; (ii) increases consumer surplus; (iii) does not a¤ect …rms' pro…ts; and (iv) increases total welfare.

When s is medium, …rms adopt a clustered price distribution: randomly playing a high price distribution with prices above r and a low price distribution with price below r. As before, r. Ar

Several points that are worth to notice. First, equilibrium prices are non-monotonic in search cost and reach their minimum at some intermediate search costs. Second, since the welfare of informed consumers is positively correlated with the expected minimum market price it follows that a decrease in uninformed consumers' search cost may exert positive, negative or none externality to informed consumers. Third, firms earn more profit with a lower consumer search cost. In fact, maximum profit is obtained when uninformed consumers have zero search cost. Equivalently, profit maximizes when consumers are all informed.

5 Conclusion

In many situations, consumers need to search costly for goods or services to meet their needs. The search often is conducted in a non-random order. This paper presents a model with endogenous consumer search order. The rapid development of Internet allows consumers to have easy access of price information before searching for the desired product. In the model, prices affect firms' profits directly and indirectly via influencing the order in which consumers search. Firms charging lower prices appear on the top of the consumers' search order, and thus, make more sales. We show that the pattern of equilibrium price distribution depends on the size of search cost. In particular, mixture price distribution occurs when the search cost is medium while standard continuous price distribution appears when the search costs are high or low. We find that a decrease in search cost may increase, decrease or have no impact on equilibrium prices depending on the initial size of search cost; and market price minimizes at some medium size of search cost. Moreover, a decrease in search cost weakly increases firms' profits.

For future research, it would be interesting to compare a price-directed search model as in this paper to a random search model where consumers search costly for both price and product information. In the comparison, one could examine how price patterns and the impact of search costs on welfare differ in these models.

References

[1] Anderson, S. and Renault, R., 1999, “Pricing, Product Diversity, and Search Costs: A Bertrand-Chamberlin-Diamond Model.” RAND Journal of Economics, Vol. 30 , pp. 719–735

[2] Arbatskaya, M., 2007 “Ordered Search.” RAND Journal of Economics, Vol. 38, pp. 119–126.

[3] Armstrong, M. and Chen, Y., 2009 "Inattentive Consumers and Product Quality.” Journal of the European Economic Association, 7, 411-422.

[4] Armstrong, M., Vickers, J., and Zhou, J. "Prominence and consumer search" RAND Journal of Economics, Vol. 40, No. 2, Summer 2009, pp. 209–233

[5] Athey, S. and Ellision, G., 2009 “Position Auctions with Consumer Search.” Mimeo, Harvard University and Massachusetts Institute of Technology,

[11] Burdett, K. and Judd, K., 1983. "Equilibrium Price Dispersion." Econometrica, 51, 955-969.

[12] Diamond, P. 1971. "A Model of Price Adjustment." Journal of Economic Theory, 3, 156-168.

[13] Ellison, G. 2005. "A Model of Add-on Pricing." Quarterly Journal of Economics, 120, 585-637.

[14] Ellison, G. 2006. "Bounded Rationality in Industrial Organization," in Richard Blundell, Whitney Newey, and Torsten Persson (eds.) Advances in Economics and Econometrics: Theory and Applications, Ninth World Congress, Cambridge University Press, Cambridge.

[15] Ellison, G and Ellison, S. 2005. "Lessons About Markets from the Internet." Journal of Economic Perspectives, 19, 139-158.

[16] Ellison, G and Ellison, S. 2008. "Search, Obfuscation, and Price Elasticities on the Internet." Econometrica, forthcoming.

[17] Gabaix, X and Laibson, D. 2006. "Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets." Quarterly Journal of Economics, 121, 505-540.

[18] Janssen, M. and Moraga-Gonzalez, J. 2004. "Strategic Pricing, Consumer Search and the Number of Firms." Review of Economics Studies, 71, 1089-1118.

[19] Reinganum, J. 1979. "A simple Model of Equilibrium Price Distribution." Journal of Political Economy, 87, 851-858.

[20] Rosenthal, R. 1980. "A Model in which an Increase in the Number of Sellers Leads to a Higher Price." Econometrica, 48, 1575-1579.

[21] Stahl, D. 1989. "Oligopolistic Pricing with Sequential Consumer Search." American Economic Review, 79, 700-712.

[22] Stahl, D. 1996. "Oligopolistic Pricing with Heterogeneous Consumer Search." International Journal of Industrial Organization, 14, 243-268.

[23] Varian, H. 1980. "A Model of Sales." American Economic Review, 70, 651-659.

[24] Wolinsky, A., 1986 "True Monopolistic Competition as a Result of Imperfect Information." Quarterly Journal of Economics, Vol. 101, pp. 493–511.