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Prominence and consumer search

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Prominence and Consumer Search*

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Abstract

This paper examines the implications of "prominence" in search markets. We model prominence by supposing that the prominent firm will be sampled first by all consumers. If there are no systematic quality differences among firms, we find that the prominent firm will charge a lower price than its non-prominent rivals. The impact of making a firm prominent is that it will typically lead to higher industry profit but lower consumer surplus and welfare. The model is extended by introducing heterogeneous product qualities, in which case the firm with the highest-quality product has the greatest incentive to become prominent, and making it prominent will boost industry profit, consumer surplus and welfare.

Keywords: consumer search, marketing, prominent display, product differentiation
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1 Introduction

In many markets consumers must search to find a satisfactory option. Without guidance, consumers may search randomly through the options, and sellers share the market equally if there are no systematic differences between them. However, if one option is somehow

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more prominent than others, consumers are likely to consider that option first. For example, when using a search engine online, people might first click on links displayed at the top of the page; when deciding what to watch on television, viewers may be biased towards the channels listed at the top of an electronic programme guide; when people visit a supermarket or bookstore, those products displayed in the entrance or other prominent positions might catch their attention first. In these examples, a consumer's search order is not random but influenced by the way the options are presented.

There is abundant evidence that the way options are presented can significantly influence people's choices, and more prominent options could be favored disproportionately. For example, Madrian and Shea (2001) identify a significant default effect with employee savings plans. They find that participation in such schemes is significantly higher under automatic enrolment, while a substantial fraction of participants hired under automatic enrolment "choose" both the default contribution rate and the default fund allocation. Ho and Imai (2006) and Meredith and Salant (2007) observe that being listed first on the ballot paper can significantly increase a candidate's vote share. Einav and Yariv (2006) present evidence that economists with surname initials earlier in the alphabet have more successful professional outcomes, and discuss various reasons why such researchers may be more "prominent". Lohse (1997) investigates experimentally the influence of yellow page advertisement characteristics on consumer information processing behaviour. By tracing subjects' eye movements, he finds that adverts which are larger, colorful, with graphics, or near the beginning of a heading, are more likely to catch a reader's attention.

Sellers are willing to pay for their products to be displayed in a prominent position. For example, internet search engines make money through selling sponsored links in response to search enquiries. Manufacturers pay supermarkets for access to prominent display positions (e.g., at eye level, or at the ends of aisles), publishers pay bookstores substantial fees for a book to be the "book of the week",[1] more prominent adverts are more expensive in yellow pages directories, and eBay offers sellers the option to list their products prominently in return for an extra fee. Moreover, when a product is made prominent—such as a book at the entrance to a bookshop—it is often sold at a discount. Indeed, the word "promote" can mean to make prominent *and* to offer at a discount.[2]

This discussion suggests that prominence plays an important role in affecting consumer choices and product prices, and its impact on market performance deserves investigation. In this paper, we examine the impact of prominence in a framework where consumers search sequentially through their available options. To model "prominence", we suppose that the prominent firm is the first firm to be sampled by consumers. If consumers are not satisfied

[1] Journalist Libby Purves, writing in *The Times* on 30 May 2006, says: "That WH Smith's "book of the week" title has been bought and paid for. The publisher handed over £50,000. Waterstone's Book of the Week accolade is £10,000 [...] Smaller sums buy other levels of prominence."

[2] According to the Oxford English Dictionary, one definition of "promote" is "to advance the interests of, move to a stronger or more prominent position." And "on promotion" is defined as "at a reduced price or on special offer as part of a campaign to promote sales."

with this initial offer, they will go on to search randomly among the remaining firms. We explore the following questions: Will a prominent firm charge a higher or lower price than its rivals? How does profit, consumer surplus and overall welfare change when a firm is made prominent?

In section 2 we present a benchmark model in which there are no systematic differences between firms or between consumers. In section 2.1, we consider the simplest setting where there is an infinite number of firms, where it turns out that prominence has no impact on price and welfare, and merely redistributes demand and profit towards the favoured firm. However, as we show in section 2.2, prominence does matter when there are finitely many suppliers. We find that the prominent firm will charge a *lower* price than its non-prominent rivals. Essentially, the prominent firm faces more elastic demand than its rivals. In addition, relative to the situation with random consumer search, the prominent firm's price falls while non-prominent firms' prices rise. We find that, after introducing a prominent firm, industry profit will typically increase. This means that, if a platform can extract industry profit, it will choose to make a firm prominent. However, introducing a prominent firm will lead to lower consumer surplus and lower total welfare. This is because, when a firm is made prominent, market prices are no longer uniform. Since the prominent firm charges a lower price than non-prominent firms, too many consumers are induced to buy from the prominent firm than is efficient. On top of this, we find that making a firm prominent will exclude more consumers from the market—that is to say, the price increase by non-prominent firms is more significant than the prominent firm's price reduction—and this is a second source of inefficiency.

The remainder of the paper deals with asymmetries, first on the supply side and then on the demand side. In section 3, we explore another effect of prominence in an extension where firms differ in their average quality. If the cost difference is small compared to the quality difference, we find that the firm with the highest quality is willing to pay the most to become prominent, and making it prominent will boost industry profit as before, but also boost consumer surplus and welfare. In effect, prominence now acts to guide consumers towards better products. The high-quality firm will set a high price, but consumers still benefit from encountering this firm first. In section 4, we briefly discuss the impact of prominence when consumers differ in their search costs. Here, we find that the prominent firm could offer a *higher* price than its rivals. The reason is that this firm may now face a less elastic demand than its rivals, since it holds a monopoly over those consumers with high search costs. Rational consumers should therefore avoid the prominent product if they have the ability to do so.

Our model assumes that all consumers sample the prominent option first. There are at least three ways to think about this assumption. First, consumers may be exposed to options in an exogenously restricted order, and they have no ability to avoid the prominent product. For instance, if we go to a travel agent to buy airline tickets or a financial advisor to buy a savings product, the advisor may tell us the options one by one. Second, consumers could suffer from bounded rationality of some form and be susceptible to manipulation by marketing ploys. In the psychological literature, it is well documented that a salient stimulus can more effectively catch people's attention, and this reaction, to some degree, is independent from the economic importance of the stimulus.[3] Third, consumers could be fully rational: they choose to visit the prominent firm first because they expect this firm to make the best offer, and this expectation is correct in equilibrium. While our approach is largely neutral with respect to these three possibilities, it is a bonus that most of our results admit the rational-consumer interpretation. In the models presented in sections 2 and 3, consumers are indeed better off if they choose to go first to the prominent firm, even when they have the ability to avoid it.

Our paper draws on the rich literature on consumer search. In particular, our model is related to the branch of the search literature concerned with product differentiation, where consumers must search both for price and product fitness. An early contribution to this literature is Weitzman (1979), and this was later developed and applied to a market context by Wolinsky (1986). We use Wolinsky's model as the starting point for our paper. Wolinsky's model is developed further by Anderson and Renault (1999), who, among other results, discuss how equilibrium prices are affected by changes in the degree of product differentiation.[4] Compared to the homogeneous product search model, models with product differentiation often better reflect consumer behavior in markets with nonstandardized products. Moreover, they avoid the well-known modeling difficulty suggested by Diamond (1971), who showed with homogeneous products and positive search costs that rivalry between firms had no impact on price. In search models with product differentiation, there are some consumers who are ill-matched with their initial choice of supplier and then search further, so that the pro-competitive benefit of actual search is present.[5]

While there is much evidence concerning the impact of prominence (generally conceived) on choice, not much of this work has examined market situations in which prominence affects subsequent competition between firms. In particular, there is little analysis of how prominence might affect a firm's pricing policy. Nevertheless, there is a small literature on this topic. For instance, Perry and Wigderson (1986) suppose consumers deal with a finite number of suppliers in a known, pre-determined order. (For instance, a driver may be looking for petrol along a road.) There is no scope for going back to a previous offer (unlike

[3]See, for instance, Fiske and Taylor (1991). If we adopt this bounded rationality interpretation, some readers may wonder why consumers are nevertheless able to calculate the optimal stopping rule (as assumed in this paper). However, we could think of the optimal stopping rule as being used for tractability rather than as a precise description of consumers' real behavior. In fact, our main results continue to hold qualitatively if we adopt an alternative behavioral stopping rule (e.g., consumers exhibit satisficing behavior and stop searching once their exogenous aspiration levels are met). The reason is that in our models in sections 2 and 3 the optimal stopping rule is stationary, regardless of the number of firms or whether one firm is prominent or not.

[4]Anderson and Renault (1999) assume that all consumers make a purchase. In our framework, this assumption would eliminate any impact of prominence on total output, which turns out to be an important ingredient in our welfare analysis.

[5]Another way to "get around" the Diamond Paradox is to stay with homogeneous products, but to allow some consumers to have zero search costs. We discuss this alternative framework briefly in section 4.

in our model), and so the final supplier holds a monopoly position over those consumers who wait that long. Their model assumes that consumers differ in their willingness-to-pay for the product, however, which implies that the final suppliers could be left with only the low-value consumers. The paper argues that in equilibrium the observed prices could be non-monotonic in the rank order of the supplier.

Arbatskaya (2007) also considers a completely ordered search model with a homogeneous product. Since consumers only care about price, in equilibrium the prices must decline with the order in which they are sampled, otherwise no rational consumer would have an incentive to sample products in unfavorable positions. This framework is briefly discussed in section 4 below.[6] Both Perry and Wigderson (1986) and Arbatskaya (2007) present a positive analysis of the impact of search order on equilibrium prices, and there is no discussion of how a non-random search order affects industry profit, consumer surplus or welfare compared with random searching.

Another strand of the literature to which our paper relates is advertising. Indeed, a major purpose of advertising is to make a product more "prominent". For instance, Robert and Stahl (1993) analyze a rich model where consumers search for a low price for a homogenous product, and firms can also advertise their price to a subset of consumers. They find that in equilibrium firms randomize between setting a high, unadvertised price and lower, advertised prices. Thus, the more prominent firms set lower prices, as in our model. A similar effect is found in Bagwell and Ramey (1994), although for very different reasons. In their paper, firms are identical *ex ante* and attract consumers by means of advertising (which is not directly informative). Firms have economies of scale, so that a firm facing greater demand has a lower marginal cost. Consumers follow the rule-of-thumb whereby they buy from the firm which advertises most heavily. Because of economies of scale, this firm will have a lower price than its rivals. Thus, the consumer response to advertising is indeed rational even though the advertising messages are not directly informative, and the more prominent firm sets a lower price. More recently, and closer in spirit to our approach, Haan and Moraga Gonzalez (2007) propose a model of search and advertising where the search model involves product differentiation as in Wolinsky (1986). A consumer's search order is potentially non-random, and a consumer's likelihood of sampling a firm is proportional to that firm's advertising intensity. (Adverts do not contain price information, and merely "persuade" consumers to sample that product first.) In symmetric equilibrium, all firms set the same (deterministic) prices and advertise with the same intensity, and so no firm is more prominent than any other. So consumers end up searching randomly and advertising is pure waste.

Finally, our work is related to the work on auctions for being listed prominently on online search engines. The two papers by Chen and He (2006) and Athey and Ellison (2007) are especially relevant since they include a model of the consumer side of the market,

[6] Hortaçsu and Syverson (2004) construct a related empirical search model, where investors sample different mutual funds with unequal probabilities, to explain the price dispersion in the market for mutual funds. But they did not explore theoretical predictions of their model, and there is also no empirical conclusion about the relationship between sampling probability and price.

and consumers search sequentially through the suggested links to find a good match for their needs. Links differ in "quality" in the sense that a high-quality link is more likely to generate a good match with any consumer. There is equilibrium behaviour on both sides: consumers optimally search for a good match by moving through the links in the order presented since they anticipate that high-quality links will be placed higher up the listing; higher-quality links have a greater incentive to be placed higher in the list than lower-quality links given the consumer search order, since a link's payoff is proportional to the number of good matches with consumers. In particular, the ordered search facilitated by position auctions is beneficial for overall efficiency. (We make a similar point in section 3.) However, in other respects our model is quite different. In particular, there is no price competition in Chen and He (2006) and Athey and Ellison (2007), and so no role for prominence to affect market prices.[7]

2 A Model of Prominence

Our underlying model of consumer choice is based on the framework developed by Wolinsky (1986). There are $n \geq 2$ firms, each of which supplies a single product at constant common unit cost, which we normalise to zero. There is no systematic quality difference among firms. Our aim is to extend this established framework to allow one product to be displayed more prominently than the others.

The number of consumers is normalized to one, and each consumer wishes to purchase one unit of one product from the market. The value of a firm's product is idiosyncratic to consumers. Specifically, $(u_1, u_2, \cdots, u_n)$ are the values attached by a consumer to each of the n products, and u_i is assumed to be independently drawn from a common distribution $F(u)$ on $[u_{\min}, u_{\max}]$ which has a positive density $f(u)$. We also assume that all match values are realised independently across consumers. The surplus from buying firm i's product is $u_i - p_i$, where p_i is this firm's price. If all match values and prices are known, a consumer will choose the product with the highest positive surplus $u_i - p_i$. If $u_i - p_i < 0$ for all i, she will leave the market without buying anything. In such a setting, making a firm more prominent has no impact.

Initially, however, we assume consumers have imperfect information about all prices and match values, and they must gather information through a sequential search process. By incurring a search cost $s > 0$, a consumer can discover any product's price and match value.[8]

[7] Chen and He (2006) do have prices charged by advertisers, but the structure of consumer demand in their model means that the Diamond Paradox is present, and all firms set monopoly prices.

[8] Note that we do not suppose that the prominent firm can be sampled at zero (or reduced) cost. In some situations—for instance, when a book is prominently displayed at the entrance to the store—it would be natural to assume that there was a reduced search cost to evaluate this option. However, in other situations—such as when the suggested links from a search engine are merely re-ordered—it is less natural to suppose that the prominent option has a lower search cost. All of our results concerning the impact of prominence on prices and profits would carry over to the case where the prominent firm has a smaller search cost. However, our results on consumer surplus and overall welfare would need to be adjusted, since when a

We assume that the search process is without replacement and there is costless recall (i.e., a consumer can return to any firm she has visited without extra cost).

If all firms are equally prominent, we have the Wolinsky model where consumers randomly sample from firms. When one firm is more prominent than its rivals, we assume that all consumers will sample this firm first and then, if unsatisfied with this prominent product offering, they will go on to search randomly among the other firms.[9] All firms maximize their profit, and they simultaneously set their prices p_i $(i = 1, 2, \cdots, n)$ conditional on whether they or their rivals (or neither) are prominent and their expectations of consumer behaviour.

2.1 An infinite number of suppliers

Consider first the relatively simple case with an infinite number of firms. Let p_∞ be the symmetric equilibrium price in the random search case. Expecting this uniform price, consumers will adopt a stationary stopping rule. They will stop searching when they find an offer where the net surplus $u-p$ is greater than a reservation utility $a-p_\infty$, where a satisfies

$$\int_a^{u_{\max}} (u-a)dF(u) = s \ , \tag{1}$$

so that the incremental benefit from one more search is equal to the search cost.[10] Therefore, in equilibrium a consumer will buy the first product which generates match utility of at least a. It is clear that a in (1) is decreasing in s, i.e., the higher the search cost, the sooner consumers will cease searching.

Now consider an individual firm's pricing decision. If a firm chooses price p instead of p_∞, a consumer who samples it will buy its product if

$$u - p > a - p_\infty \ ,$$

since she still expects that the other firms charge p_∞. Here, $a - p_\infty$ is the reservation surplus when a consumer deals with this firm. Thus, this firm will aim to maximize

$$p\left[1 - F(p + a - p_\infty)\right] .$$

Under regularity conditions (e.g., if the hazard rate $f(u)/(1-F(u))$ is increasing in u), the first-order condition determines the optimal price, so that[11]

$$p_\infty = \frac{1-F(a)}{f(a)} \ . \tag{2}$$

firm is made prominent this causes search costs to fall relative to the random search case.

[9]The assumption that all consumers sample the prominent firm first is for simplicity. Relaxing it by assuming that only a fraction (greater than $1/n$) of consumers do so will not change our results qualitatively.

[10]This optimal stopping rule is well-known in the search literature—for instance, see Weitzman (1979).

[11]As usual in search models, there also exists an uninteresting equilibrium where consumers expect all firms to set very high prices which leave them with no surplus, consumers do not participate in the market at all, and so firms have no incentive to reduce their prices. We do not consider this equilibrium further.

(This is expression (18) in Wolinsky (1986).) Provided the hazard rate is increasing, p_∞ in (2) decreases with a, and hence p_∞ increases with the search cost s. When s tends to zero (in which case a tends to $u_{\max}$), it follows that p_∞ also tends to zero. In particular, as emphasized in Wolinsky (1986), we do not see the "Diamond paradox" in this framework.

In equilibrium, $a - p_\infty$ is a consumer's expected surplus, including her search costs, from participating in the market.[12] Thus, a consumer finds it worthwhile to engage in search whenever $a - p_\infty \geq 0$, which requires that the search cost s not be too large. In equilibrium, industry profit is p_∞ (although each individual firm makes negligible profit) while total welfare—industry profit plus consumer surplus—is a.

Consider next the case where firm 1, say, is made prominent and so is sampled first by all consumers. Since all the non-prominent firms are symmetrically placed, we focus on equilibria where the prominent firm charges p_1 and all non-prominent firms charge the same price p_2. We are interested in an active search market where some consumers search beyond firm 1.[13] Once consumers have rejected the prominent firm's offering, they will behave as in the random search case just described. Hence, each non-prominent firm faces the same decision problem as in the random search case, and $p_2 = p_\infty$. Therefore, when a consumer considers the offer from the prominent firm, her reservation surplus is just $a - p_\infty$. This implies that the prominent firm will also charge $p_1 = p_\infty$. In sum, introducing prominence has no impact on market prices when there are infinitely many firms, and it merely redistributes consumer demand and profit between firms. Specifically, in equilibrium firm 1's demand is $1 - F(a)$ and its profit is

$$p_\infty(1 - F(a)) \ , \tag{3}$$

while each non-prominent firm again earns negligible profit. We observe that (given the increasing hazard rate condition) this profit (3) increases with the search cost, and so a firm is willing to pay more to become prominent in a market where consumers incur higher search costs. Since market prices are not affected by prominence, we deduce that prominence has no impact on industry profit, consumer surplus, or total welfare. In the next section we show that this "neutrality" fails with a finite number of suppliers.

Uniform example: To illustrate these results, consider the case where u_i is uniformly distributed on the interval $[0, 1]$ (so that $F(x) = x$). Then (1) and (2) imply

$$a = 1 - \sqrt{2s} \ ; \ p_\infty = \sqrt{2s} \tag{4}$$

[12] From (1), if all firms' prices are equal to p_∞, and if a consumer has found a product with match utility exactly equal to a, she is indifferent between consuming this product and searching further, and so $a - p_\infty$ is her expected surplus from participating in the market. Her expected surplus from the match achieved exceeds $a - p_\infty$ by an amount that equals her expected search costs.

[13] Similarly to footnote 11, there is another, less interesting equilibrium in which buyers expect that the price charged by non-prominent firms is very high so they never search beyond firm 1, and firm 1 sets the monopoly price. Since they do not expect consumers to visit them, the non-prominent firms have no incentive to deviate from this weakly dominated strategy. We do not consider such equilibria further.

and the value of prominence in (3) is $2s$. The market is active provided that $a - p_\infty$ is positive, i.e., if

$$s < \tfrac{1}{8}\ , \text{ or } a > \tfrac{1}{2}\ . \tag{5}$$

2.2 A finite number of suppliers

Having set out the benchmark case with an infinite number of firms, we now analyse the case where n is finite. First consider the random search case, i.e., where no firm is prominent. We focus on symmetric equilibria where each firm sets some price p_0. Given the finite options available, one might suppose that an optimal search strategy might exhibit features such as: (i) the consumer becomes less choosy as the number of remaining options shrinks; or (ii) when there are fewer suppliers, consumers are less choosy. However, when recall of previously rejected options is costless and when the agent can choose the order in which options are sampled, Weitzman (1979) reveals the remarkable property that (even with asymmetric offerings) an agent's optimal reservation utility from a given option takes the form (1), which does *not* depend on the number or the characteristics of the rival options. In the symmetric market competition context, Wolinsky (1986, page 499) shows that the optimal search rule when all firms are expected to offer the price p_0 reduces to (using our notation)[14]:

1. If $p_0 \geq a$, where a is given in (1), the consumer should not participate in the market;
2. If $p_0 \leq a$ the consumer should stop searching when she finds a product with $u_i \geq a$; if no such product is found among the n options, she buys the product with the highest u_i provided $u_i \geq p_0$. If all u_i are below p_0 then the consumer buys nothing.

For simplicity, from now on suppose that u follows the uniform distribution on $[0, 1]$. To guarantee an active search market, assume condition (5) holds. Given the stopping rule, we claim that if a firm deviates to a price p while other firms offer the equilibrium price p_0 its demand is

$$q_0(p) = \underbrace{h_0(1 - a + p_0 - p)}_{\text{fresh demand}} \quad + \quad \underbrace{r_0}_{\text{returning demand}} \quad , \tag{6}$$

where

$$h_0 = \frac{1}{n}\sum_{k=0}^{n-1} a^k = \frac{1}{n} \cdot \frac{1 - a^n}{1 - a} \tag{7}$$

[14] This strategy can also be understood by backward induction. When only one un-sampled firm remains, it is clear that the stated stopping rule is optimal. Now keep the inductive assumption and consider the situation with more than one un-sampled firm remaining. If the available net surplus so far is less than $a - p_0$, then searching one more firm is always desirable no matter what will happen after that. If the available net surplus so far is greater than $a - p_0$, expecting that she will stop searching whatever she will find in next firm (because of the inductive assumption), a consumer will actually stop searching now.

is the number of consumers who sample this firm's product, and

$$r_0 = \int_{p_0}^{a} u^{n-1} du \tag{8}$$

is the number of consumers who buy from this firm after sampling all firms.

To understand (6), consider the two sources of firm i's demand. First, a consumer may come to firm i after sampling k other firms but without finding a satisfactory product (i.e., their match values are less than a). The probability of this event is $\frac{1}{n}a^k$ since a consumer will choose any search order with equal probability. Summing up these probabilities over $k = 0, ..., n-1$ leads to h_0. As usual in search models, a firm cannot affect the number of consumers who choose to sample its product—consumer search decisions are based on their expectations of prices, not the actual prices—and so h_0 does not depend on the firm's price. After sampling the firm, a consumer will buy firm i's product immediately provided $u_i - p \geq a - p_0$, which occurs with probability $1 - a + p_0 - p$. This explains the first term in (6). We call this portion of a firm's demand the "fresh demand". Second, a consumer may find that the net surplus of all n products is less than $a - p_0$ (so she never stopped), and then returns to firm i if it provides the highest positive surplus. The probability of this event is

$$\Pr\left(\max_{j \neq i}\{0, u_j - p_0\} < u_i - p < a - p_0\right) = \int_{p}^{p+a-p_0} (u_i - p + p_0)^{n-1} du_i = r_0 \ ,$$

where the second equality follows from changing the integral variable from u_i to $u = u_i + p_0 - p$. We call this portion of a firm's demand the "returning demand".

It is perhaps surprising that a firm's returning demand in (8) is independent of its own price.[15] In general, reducing a firm's price has two effects on its returning demand: (i) more consumers are satisfied with this firm's offer and so fewer consumers sample all firms, and (ii) the firm's share of those consumers who sample all firms is increased. With a uniform distribution, these two effects exactly cancel out, and the returning demand is price-independent.[16] (This can be seen in Figure 1 below, where a decrease in firm 1's price simply shifts the set of consumers who buy its product after sampling all firms' offers to the left.) In particular, notice that a firm's returning demand is less price elastic than its fresh demand (which does depend on its price).

[15] Our demand function is legitimate only when the deviation price p is not too high. If $p > 1 - a + p_0$ then the fresh demand vanishes and the returning demand becomes $\int_p^1 (u - p + p_0)^{n-1} du = \int_{p_0}^{1+p_0-p} u^{n-1} du$, which is no longer independent of p. Therefore, a firm's profit function has a kink at $p = 1 - a + p_0$ and may fail to be globally concave. A similar issue exists in the prominence case. However, as we argue in footnote 18, this issue does not affect the equilibrium prices derived below.

[16] For other distributions, the net impact is not zero. Nevertheless, our main insights based on the uniform distribution will still apply provided that the returning demand is less price elastic than the fresh demand. One can check that this happens when the density function increases or does not decrease too fast.

When it charges price p a firm's profit is $pq_0(p)$. In symmetric equilibrium, each firm should have no incentive to deviate from p_0, which yields the first-order condition for p_0:

$$h_0(1-a-p_0)+r_0=0\ .$$

The first term is the marginal profit from fresh buyers, and the second term is the marginal profit from returning buyers. We rewrite this as

$$p_0=1-a+\frac{r_0}{h_0}\ . \tag{9}$$

Notice that, in equilibrium, each firm's fresh demand is $h_0(1-a)$, so r_0/h_0 is proportional to the ratio of returning demand to fresh demand. When the number of suppliers n becomes large, one can verify that r_0/h_0 tends to zero. As a result, when n tends to infinity p_0 converges to $p_\infty=1-a$ as in (4).

In equilibrium, each firm's demand is

$$q_0=h_0(1-a)+r_0=h_0p_0\ , \tag{10}$$

where the second equality follows from the first-order condition (9). Thus, total demand in the market is $Q_0=nh_0p_0$. On the other hand, total demand must also equal $1-p_0^n$, since p_0^n is the fraction of consumers who find each product's utility is lower than its price and who eventually leave the market without purchase. Hence, we have the following formula for the equilibrium price p_0:

$$\frac{1-a^n}{1-a}=\frac{1-p_0^n}{p_0}\ . \tag{11}$$

(One can check that (11) and (9) are indeed equivalent.) One can see there is a unique solution to (11) with $p_0\in(1-a,1/2)$, given assumption (5).[17,18] Thus, $p_0<a$ and the

[17] The right-hand side of (11) is a decreasing function of p_0 when p_0 is positive. If $p_0=1-a$, the right-hand side is greater the left-hand side given that $a>1/2$. If $p_0=1/2$, the right-hand side is $(1+\cdots+(1/2)^{n-1})$ which is less than the left-hand side $(1+a+\cdots+a^{n-1})$. Thus, there is a unique solution to (11), where $p_0\in(1-a,1/2)$.

[18] For p_0 to be the equilibrium price, we need to ensure that each firm has no profitable deviation. The difficult issue is that, as mentioned in footnote 15, the demand function needs to be modified if a firm deviates to a too high price, and the profit function may be no longer globally concave. Nevertheless, the price defined in the first-order condition is the equilibrium price even if we take this issue into account. In the random search case, a firm's profit function is $\pi(p)\equiv p\int_{p_0}^{1+p_0-p}u^{n-1}du$ for a high deviation price $p\in[1-a+p_0,1]$. If we can show that profit is decreasing on this price interval, then we are done. First, since u^{n-1} is logconcave, the integration term is logconcave in p. So $\pi(p)$ is logconcave (so quasi-concave). Second, we claim $\pi'(p_0)=\int_{p_0}^1u^{n-1}du-p_0<0$ (i.e., $(1-p_0^n)/p_0<n$). This is true because, from (11), $(1-p_0^n)/p_0=(1-a^n)/(1-a)<n$. Finally, since $\pi(p)$ is quasi-concave and $\pi'(p_0)<0$, $\pi'(p)<0$ for any $p\geq p_0$. Thus, $\pi(p)$ decreases with p on $[1-a+p_0,1]$. The prominence case, though more complicated, can be treated similarly.

market is indeed active. Since the left-hand side of (11) increases with a while the right-hand side decreases with p_0, it follows that the equilibrium price falls with a, i.e., it is increasing with the search cost s.

We now turn to the case where firm 1 is made prominent. Since all the non-prominent firms are symmetric, suppose the prominent firm charges p_1 and all non-prominent firms charge the same price p_2. Define $\Delta = p_2 - p_1$ to be the price difference (if any) between the two kinds of supplier. If a consumer has seen firm 1's offer, her optimal stopping rule is similar to that in the random search case since she expects all non-prominent firms to charge the same price p_2. That is to say, a consumer will stop searching when she finds a product which yields net surplus greater than $a - p_2$.

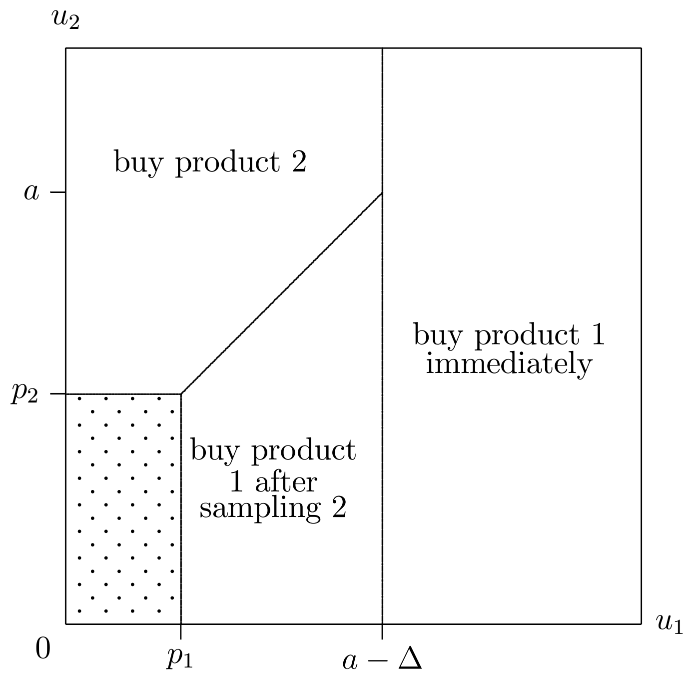

Figure 1: Consumer Demand When Firm 1 is Prominent

The pattern of consumer demand when there are just two firms is depicted in Figure 1. Here, consumers accurately predict that the second firm will be charging price p_2. If the net surplus from the first product, $u_1 - p_1$, is greater than $a - p_2$ (where $a = 1 - \sqrt{2s}$) the consumer buys this product immediately. (This is firm 1's "fresh demand".) If the net surplus is below this threshold level, the consumer samples the second firm, and then picks the option from the two with the greater net surplus (if one is positive). This generates firm 1's "returning demand". If neither option yields a positive surplus, the consumer does not buy at all (the shaded region in the figure).

The prominent firm's demand when it charges p and all non-prominent firms charge p_2 is

$$q_1(p) = (1 - a + p_2 - p) + r_1 \ , \tag{12}$$

where

$$r_1 = \int_{p_2}^{a} u^{n-1} du$$

is its returning demand. A non-prominent firm's demand when it charges p (and all other non-prominent firms choose p_2 and the prominent firm chooses p_1) is

$$q_2(p) = h_2 \left(1 - a + p_2 - p\right) + r_2 \ , \tag{13}$$

where

$$h_2 = \frac{a - \Delta}{n-1} \sum_{k=0}^{n-2} a^k = \frac{a - \Delta}{n-1} \cdot \frac{1 - a^{n-1}}{1 - a}$$

is the number of consumers who sample this firm and

$$r_2 = \int_{p_2}^{a} u^{n-2}(u - \Delta) du$$

is its returning demand. Note that each firm's returning demand is independent of its own price p, as is the number of consumers who choose to sample its product. In addition, we see that $r_1 \geq r_2$ if and only if $\Delta = p_2 - p_1 \geq 0$.

By definition, all consumers sample the prominent product. They will buy this product immediately if $u_1 - p \geq a - p_2$, which has probability $1 - a + p_2 - p$, and this explains the first term in (12). Its returning buyers are those who find that the net surplus of all products is lower than $a - p_2$, but firm 1 provides the highest positive net surplus. The number of these consumers is

$$\Pr\left(\max_{j\geq 2}\{0, u_j - p_2\} < u_1 - p < a - p_2\right) = \int_{p}^{p+a-p_2} (u_1 - p + p_2)^{n-1} du_1 = r_1 \ .$$

For a non-prominent firm i charging p, a consumer will sample it if she initially rejects the prominent firm, which has probability $\Pr(u_1 - p_1 \leq a - p_2) = a - \Delta$, and has visited other $k \leq n-2$ unsatisfactory firms, which has probability $\frac{1}{n-1}a^k$. Summing these probabilities over $k = 0, \cdots, n-2$ yields h_2. She will buy immediately at this firm if its net surplus is greater than $a - p_2$. This explains the first term in (13). Its returning buyers number

$$\Pr\left(\max_{j\neq i,1}\{0, u_1 - p_1, u_j - p_2\} < u_i - p < a - p_2\right) = \int_{p}^{p+a-p_2} (u_i - p + p_2)^{n-2}(u_i - p + p_1) du_i = r_2 \ .$$

The prominent firm's profit when it deviates to p is $pq_1(p)$, and each non-prominent firm's profit when it deviates to p is $pq_2(p)$. In equilibrium, no firm should want to deviate from the equilibrium price, so we get two first-order conditions for p_1 and p_2:

$$1 - a + p_2 - 2p_1 + r_1 = 0 \ , \tag{14}$$

$$h_2(1 - a - p_2) + r_2 = 0 \ .$$

We can solve this pair of simultaneous equations to give

$$p_1 = 1 - a + \frac{1}{2}\left(r_1 + \frac{r_2}{h_2}\right) \tag{15}$$

$$p_2 = 1 - a + \frac{r_2}{h_2} \ . \tag{16}$$

Given assumption (5), within the square $[0, a]^2$, the pair of equations (15)–(16) has a unique solution within the region $(p_1, p_2) \in (1 - a, 1/2)^2$. This is proved in Appendix A.1. When n tends to infinity, both p_1 and p_2 converge to $p_\infty = 1 - a$.

Using the first-order conditions, the prominent firm's equilibrium demand is

$$q_1 = 1 - a + \Delta + r_1 = p_1 \ , \tag{17}$$

while each non-prominent firm's demand is

$$q_2 = h_2(1 - a) + r_2 = h_2 p_2 \ . \tag{18}$$

Thus, total demand in the market is $Q_1 = p_1 + (n-1)h_2 p_2$. On the other hand, total demand must equal $1 - p_1 p_2^{n-1}$, since $p_1 p_2^{n-1}$ is the fraction of consumers excluded from the market (see Figure 1 for an illustration of the two-firm case). Therefore, we have the following equation relating p_1 and p_2 to a:

$$p_1 + \frac{1 - a^{n-1}}{1 - a}(a - \Delta)p_2 = 1 - p_1 p_2^{n-1} \ . \tag{19}$$

2.3 The Impact of Prominence

In this section we present five results describing the impact of making a firm prominent on market outcomes. (The proofs of each result are presented in the Appendix.) The first question is how making a firm prominent influences the equilibrium prices:

Proposition 1 *(i) The prominent firm charges a lower price than non-prominent firms. (ii) The prominent firm's price is lower than with random search while the prices of non-prominent firms are higher. In sum:*

$$p_1 < p_0 < p_2 \ . \tag{20}$$

The intuition for this result is as follows. If p_0, p_1, and p_2 are not too far apart from each other, then, compared to the random search case, the prominent firm's demand consists of proportionally more fresh demand while each non-prominent firm's demand consists of proportionally more returning demand.[19] Since fresh demand is more price sensitive than returning demand, a prominent firm faces more elastic demand than a firm in the random-search environment, which in turn faces more elastic demand than a non-prominent firm.

It is useful to consider two polar cases. When $a \approx 1$ (i.e., $s \approx 0$), consumers sample all firms before they purchase, and so prominence has no impact and all prices converge to the full-information price $\bar{p}$, say, which satisfies $n\bar{p} = 1 - \bar{p}^n$. (This formula for $\bar{p}$ is obtained from (11) by letting $a \to 1$.) At the other extreme, when $a \approx 1/2$, all prices converge to the same price 1/2, the monopoly price. Here, the high search cost makes a consumer willing to buy whenever she finds a product with positive surplus, and so each firm (prominent or not) acts as a monopolist. Thus, the price difference Δ caused by prominence will vanish when the search cost is too high or too low, and it is most pronounced when the search cost is at an intermediate level.

The next result describes the impact of prominence on total demand and on the search intensity:

Proposition 2 *(i) Total output is lower when a firm is made prominent, and (ii) the average number of searches made by consumers is smaller when a firm is made prominent.*

Proposition 1 showed that the impact of making one firm prominent was to make that firm's price fall and to raise the price offered by non-prominent firms. As such, the impact on overall demand is not clear *a priori*. However, the first part of Proposition 2 shows that the effect of the higher prices from the non-prominent firms is more marked than the impact of the price reduction by the prominent firm, and overall output falls with prominence.

Proposition 2 demonstrates two contrasting effects of prominence: output falls and the total occurrence of search costs also falls. While the second factor has benefits in terms of reducing search costs, it also means that the average match utility is reduced. In fact, as explained in the next result, with prominence there is too little search relative to the efficient benchmark.

Proposition 3 *Welfare is reduced when a firm is made prominent.*

The intuition behind this result goes as follows. For a *given* level of total demand, welfare is maximized if each product has the same price. If the market has a uniform price, the consumer's stopping rule is independent of the price and this is socially efficient because the consumer and the social planner face the same trade off between search costs and match utility. However, when a firm is made prominent, this induces non-uniform prices in the market. Therefore, keeping total demand constant, prominence induces sub-optimal search behaviour. To be precise, when $\Delta = p_2 - p_1 > 0$, those consumers with $u_1 \in [a - \Delta, a]$

[19] In equilibrium, the prominent firm's ratio of fresh to returning demand is $(1-a+\Delta)/r_1$, a non-prominent firm's ratio of fresh to returning demand is $(1-a)h_2/r_2$, while each firm's ratio of fresh to returning demand when no firm is prominent is $(1-a)h_0/r_0$. When all prices are similar, r_0, r_1 and r_2 are also similar. Therefore, since $1 > h_0 = \frac{1}{n}(1 + ... + a^{n-1}) > \frac{1}{n-1}(a + ... + a^{n-1}) \approx h_2$, the claim in the text is valid.

will not search beyond firm 1 even though it would be socially efficient for them to do so. Moreover, when $\Delta > 0$ too many of the returning buyers end up buying from firm 1. A second, reinforcing reason why welfare falls with prominence is that total output falls (see Proposition 2). In sum, making a firm prominent means that output is reduced *and* this output is poorly distributed across consumers.[20]

We next investigate how this welfare loss is distributed across consumers and industry. It turns out that consumers in aggregate are always made worse off with prominence:

Proposition 4 *Consumer surplus is reduced when a firm is made prominent.*

Finally, we turn to the impact of prominence on profit:

Proposition 5 *(i) The prominent firm earns more than a non-prominent firm, and it also earns more than it would with random search, and (ii) industry profit is higher if one firm is made prominent except when $n = 2$ and a is relatively small.*

Part (i) of this result is not surprising. For instance, the prominent firm *could* choose to set the non-prominent firms' equilibrium price, in which case it still makes more profit than its rivals since it has greater demand. But it can do still better than this by choosing a lower price than its rivals. Part (ii) requires a more delicate analysis, since the impact of the price cut by the prominent firm must be weighed against the price rise by the non-prominent firms. In effect, part (ii) shows that the price cut usually has less of an impact on industry profit than the price rise. This is not surprising in the light of our earlier result that total demand falls when a firm is made prominent.

Proposition 5 is silent about the impact of prominence on the non-prominent firms' profit. In fact, this impact is ambiguous due to three effects: (i) a non-prominent firm suffers from being pushed further back in each consumer's search order and (ii) from the lower price offered by the prominent firm, but (iii) it benefits from the fact that its other non-prominent rivals raise their price. Let π_2 denote a non-prominent firm's profit when one firm has been made prominent and let π_0 denote a firm's profit in the case of random search. First, when $n = 2$, it is clear that $\pi_2 < \pi_0$ since there is no countervailing benefit (iii). Moreover, for fixed $a < 1$, $\pi_2 < \pi_0$ always holds for sufficiently large n because $\lim_{n\to\infty} \frac{\pi_2}{\pi_0} = \lim_{n\to\infty} \frac{h_2}{h_0} = a < 1$. Thus, with either two firms or with many firms a non-prominent firm earns less than it would in a random search environment. By contrast, though, for fixed $n \geq 3$, one can show that

[20] There is a clear parallel with the welfare effects of price discrimination. If a firm sets different prices for units which cost the same to produce, then total output is sub-optimally distributed across consumers. Therefore, price discrimination can only improve welfare if it induces total output to rise. (See Varian (1985), for instance.) One difference with the (monopoly) price discrimination setting is that monopoly profit is sure to rise with non-uniform pricing allowed (since the firm could set uniform prices if it wishes), whereas in the prominence model prices are determined at equilibrium, and it is not obvious that industry profit rises with prominence. Indeed, as we show in Proposition 5, the impact of prominence on industry profit is ambiguous.

$\pi_2 > \pi_0$ whenever a is sufficiently close to 1.[21] Therefore, when the search cost is very low *all* firms are better off when one is made prominent.

One question we have not yet discussed is how the impact of prominence is affected by the search cost and the number of firms in the market. A complete investigation of this issue would be lengthy, and here we merely present some numerical examples. Figure 2 reports how the impact varies with a when $n = 5$, where the upper (thin) line is the difference in industry profit, the bottom (thick) line is difference in consumer surplus, and the central (medium) line is difference in welfare, all calculated as we move from the random search case to the case with prominence. All variables vary non-monotonically with a. In fact, this pattern holds quite generally. As we have pointed out, p_1 and p_2 coincide with p_0 when a tends to 1/2 or 1, so the impact of prominence vanishes at the extremes of a. Figure 3 reports how the impact on profit, consumer surplus and welfare varies with n when $a = 0.7$ (i.e., when $s = 0.045$). The non-monotonic pattern for industry profit and consumer surplus seen in Figure 3 seems quite widespread according to further numerical simulations. It is natural that the impact of prominence becomes less pronounced as the number of firms becomes large, since we are converging to the infinite firm case where prominence has no impact on industry profit, consumer surplus or welfare. However, it is less clear why it is common for industry profit to rise (and consumer surplus to fall) with n when the number of suppliers is relatively small. In both figures, it appears that the impact of prominence on overall welfare is small relative to the distributional impact on profit and consumer surplus separately.

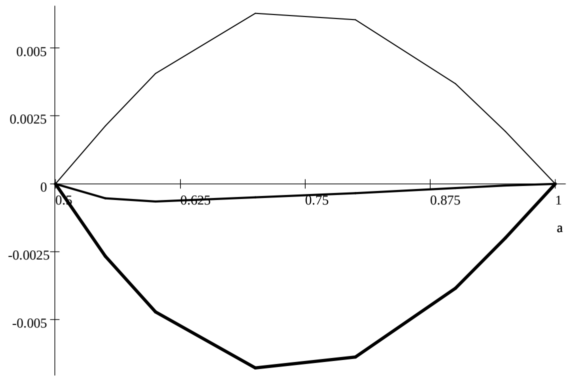

Figure 2: Impact with a ($n = 5$)

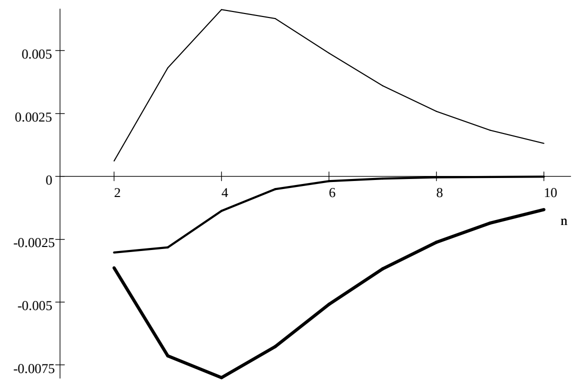

Figure 3: Impact with n ($a = 0.7$)

We end this section by pointing out the implications of these results in situations where there is a profit-maximizing platform through which firms sell their products to consumers. If the platform can extract the whole industry profit by, for example, charging each firm a fixed fee for access to its consumers, Proposition 5 tells us that it (usually) has an incentive to make one supplier more prominent than the others. However, if the platform can extract total welfare by charging both firms and consumers, Proposition 3 tells us that it has no incentive to do so.

[21] The argument is lengthy, and the details are available from the authors.

3 Asymmetric Firms

Until now, our analysis leads to a somewhat pessimistic view of the benefits of prominence, at least from the viewpoint of consumers and overall welfare. This assessment might change in a setting in which firms have differing product qualities, for then prominence could be used to guide consumer search towards better products.[22,23] In this section we investigate this possibility, assuming that consumers cannot discern a firm's average quality directly.[24] Since this analysis is considerably more involved than with the benchmark symmetric case, for simplicity we suppose there are infinitely many suppliers. As in the symmetric firm case, this assumption implies that prominence has no impact on equilibrium prices. However, in contrast to the symmetric case, this "pricing neutrality" nevertheless allows for a significant impact of prominence on industry profit, consumer surplus and welfare.[25]

Suppose that firms are distinguished by the parameter α, where a higher α represents a higher-quality firm (on average). Suppose that a consumer's match utility u from a type-α firm is uniformly distributed on the interval $[0, \alpha]$. For simplicity, suppose that firms have the same marginal cost of supply even though they differ in quality.[26] (This situation might apply to novels, where the marginal cost of production need not be strongly related to quality.) Suppose that α is itself uniformly distributed, on the interval $[1 - \frac{\varepsilon}{2}, 1 + \frac{\varepsilon}{2}]$.[27] Thus, ε measures the degree of firm heterogeneity present in the market, and the symmetric firm model corresponds to the degenerate case $\varepsilon = 0$.

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[22] This point is emphasized in Chen and He (2006) and Athey and Ellison (2007). As in the model we present in this section, the highest quality firm in their models (i.e., the firm with the highest probability of making a good match with each consumer) is willing to bid the most to be listed first, and so consumers have an incentive to click on the sponsored links in the order they appear. As with our model, this means the resulting order search is efficient.

[23] The analysis in this section can simply be adapted to allow firms to offer symmetric products but to have different unit costs. In this case the firm with the lowest cost will have the most to gain from becoming prominent.

[24] This assumption contrasts with Weitzman (1979), who assumes that consumers know the distribution of payoffs for each option in advance.

[25] With a finite number of firms, the "search-guidance" effect will interact with the price effect analyzed in section 2.2 which also influences welfare. The results in this section apply at least to the case with large but finite n since the price effect there is weak. In addition, with a finite number of firms a major complicating factor is that, when the highest-quality firm is made prominent (which we argue below will be the case), consumers will be able to infer something about the distribution of quality of the remaining firms after they sample the prominent product. (For instance, if the first product yields a low match utility, they may infer the prominent firm is more likely to have a low α, and hence that the remaining firms have still lower quality.) This updating will cause consumers to revise their stopping rule. This effect is analyzed in Athey and Ellison (2007). With an infinite number of suppliers, no such updating takes place.

[26] This analysis can easily be adapted to handle situations where the cost depends on α. The results reported below remain valid provided that cost does not vary by "too much". In other cases, however, it might happen that prominence harms market efficiency by inducing inefficient search. That is because the firm having the greatest incentive to become prominent may not be the highest gross surplus provider.

[27] It is not difficult to extend the following analysis to other distributions for α.

Let p_α denote the equilibrium price of the type-α firm. Consumers are assumed to know the distribution of α in the population of firms, as well as the equilibrium (but not actual) prices p_α. If there is no prominent firm, they will search among firms randomly; if one firm is made prominent, they are assumed to consider its offer first. In either case, they will use a stationary stopping rule, and they will buy a product if and only if the net surplus, $u - p$, is greater than some threshold y. Given the equilibrium prices p_a, y satisfies the indifference condition

$$\frac{1}{\varepsilon}\int_{1-\frac{\varepsilon}{2}}^{1+\frac{\varepsilon}{2}}\left(\frac{1}{\alpha}\int_{p_\alpha+y}^{\alpha}(u-p_\alpha-y)\ du\right)\ d\alpha = s\ . \tag{21}$$

Here, the left-hand side of (21) is the expected benefit from one more search. For this expression to be valid, we must have all types of firm be active in equilibrium (i.e., $\alpha - p_\alpha > y$ for all α). This requires there not be too much quality variation, and we derive an explicit ceiling on ε below. In addition, we continue to assume (5), so that $s < \frac{1}{8}$. As usual, y is also each consumer's expected net surplus from following the optimal stopping rule described above.

3.1 Equilibrium prices and the value of being prominent

We first characterize the equilibrium prices given a candidate stopping rule y. Regardless of whether there is prominence for one firm or not, given the reservation surplus y, a type-α firm's profit is proportional to $p\left(1 - \frac{y+p}{\alpha}\right)$ when it sets price p. The equilibrium price is chosen to maximize this profit, and so

$$p_\alpha = \tfrac{1}{2}(\alpha - y)\ . \tag{22}$$

In particular, a higher-quality firm will set a higher price in equilibrium.

Substituting the prices (22) into (21) shows that y satisfies

$$E_\alpha\left[\frac{(\alpha-y)^2}{8\alpha}\right] = s\ , \tag{23}$$

where E_α is the expectation operator using the distribution for α. Given the uniform distribution for α, expression (23) becomes

$$\eta_\varepsilon y^2 - 2y + 1 - 8s = 0\ ,$$

where $\eta_\varepsilon \equiv E_\alpha\left[\frac{1}{\alpha}\right] = \frac{1}{\varepsilon}\ln\frac{1+\varepsilon/2}{1-\varepsilon/2}$. Here, η_ε increases with ε and $\eta_\varepsilon \to 1$ as $\varepsilon \to 0$. The relevant root of the above quadratic is

$$y = \frac{1-\sqrt{1-\eta_\varepsilon(1-8s)}}{\eta_\varepsilon}\ . \tag{24}$$

When ε becomes small y tends to $1-\sqrt{8s}$, which is the reservation net surplus $(a-p^{\infty})$ in the case with symmetric firms in (4). The stopping rule in (24) has intuitive properties. First, as usual, y is decreasing in s. In particular, as $s \to \frac{1}{8}$, $y \to 0$ and consumers will choose the first product which gives them a positive net surplus. Second, y is increasing in η_{ε} and therefore increasing in ε. That is, the greater the degree of firm heterogeneity, the more choosy consumers will be. From (22), these two properties imply that equilibrium prices will increase with s but decrease with ε.

We need to verify that all types of firm are active in the market, since these calculations were predicated on that being so. This requires $\alpha - p_{\alpha} > y$ for all α, and from (22) this is equivalent to $y < 1-\frac{\varepsilon}{2}$.[28] This requirement determines a maximum feasible level for ε, say $\hat{\varepsilon}$, where

$$\frac{\hat{\varepsilon}}{2}+\frac{1-\sqrt{1-\eta_{\hat{\varepsilon}}(1-8s)}}{\eta_{\hat{\varepsilon}}}=1 \ .$$

For example, when $s=\frac{1}{32}$, one can check that $\hat{\varepsilon}\approx 0.95$. Therefore, as long as the quality variation among firms is not too great, so $\varepsilon < \hat{\varepsilon}$, all firms will be active in equilibrium and (21) is justified. When the search cost is very low ($s \approx 0$), one can check that there can be very little heterogeneity if our analysis is to be valid, so that $\varepsilon \approx 0$ in that case.

Within this framework, if a firm is not prominent its profit is zero; if it is prominent, its profit is

$$p_{\alpha}\left(1-\frac{y+p_{\alpha}}{\alpha}\right)=\frac{(\alpha-y)^2}{4\alpha}$$

which increases with α. We deduce that the highest-quality firm has the most to gain from becoming prominent. If there is a procedure to endogenize prominence, the highest-quality firm is therefore likely to become the prominent seller. For example, if a platform is selling (or auctioning) the prominent position, the highest-quality firm is willing to pay the most. In this case, prominence becomes a signal of high quality (and high price).

3.2 The impact of prominence

One issue is whether it is in a consumer's interest to sample the prominent firm first in those situations in which consumers are not *forced* to do so. As just mentioned, the prominent firm is predicted to offer a high-quality product (on average), but also to set a high price. To understand a consumer's incentives, suppose hypothetically a consumer can *choose* the type α of the first firm sampled, and denote by $v(\alpha)$ the payoff to her if she chooses to go first to a type-α firm. Then

$$v(\alpha) \equiv \frac{1}{\alpha}\int_{y+p_{\alpha}}^{\alpha}(u-p_{\alpha})\ du+(1-\varphi_{\alpha})y-s \ , \tag{25}$$

[28] In addition, we require $\eta_{\varepsilon} < \frac{1}{1-8s}$ to guarantee that y in (24) is a real solution. It turns out that the requirement that $y < 1-\frac{1}{2}\varepsilon$ is the tighter constraint. If $\eta_{\varepsilon}=1/(1-8s)$ then $y=1/\eta_{\varepsilon}$ in (24), and $1/\eta_{\varepsilon} > 1-\frac{\varepsilon}{2}$ for all $\varepsilon > 0$.

where

$$\varphi_\alpha \equiv 1 - \frac{y + p_\alpha}{\alpha}$$

denotes the probability that a consumer buys the type-α firm's product when she samples it. To understand expression (25), note that the first term represents net surplus in the event the match value is above the threshold $y + p_\alpha$, while if the match value is below the threshold (which occurs with probability $1 - \varphi_\alpha$), the consumer starts from scratch with random search, which we know yields her the expected payoff y. Finally, the consumer must pay the search cost s to sample the first product.

After substituting the price (22) into (25), this formula simplifies to

$$v(\alpha) = \frac{y^2 + \alpha^2 + 6\alpha y}{8\alpha} - s \ .$$

(As required, one can verify using expression (23) that the expected value of $v(\alpha)$ over all α just equals y.) Since $v(\alpha)$ increases with α, it follows that if a consumer could choose the type of the firm first sampled, she would choose the highest-quality firm. Since the prominent firm is the highest-quality firm, we deduce that a consumer has a strict incentive to visit that firm first, even if she has a choice to ignore the prominent firm. This argument also shows that consumers are better off when there is a prominent firm compared to the case where search is random: the firm that is willing to pay most for the privilege of being prominent is also the firm that consumers most want to visit first. That contrasts with the symmetric firm case, where we showed that consumers were worse off when there was a prominent firm (Proposition 4).

Consider next the impact on industry profit. Let Π_0 denote equilibrium industry profit when consumers search randomly. Using a similar argument to that for consumer surplus just above, if all consumers sample a type-α firm first, industry profit, denoted $\Pi(\alpha)$, is

$$\Pi(\alpha) = \varphi_\alpha p_\alpha + (1 - \varphi_\alpha)\Pi_0 \ .$$

The value of Π_0 can be obtained by noting that $E_\alpha \Pi(\alpha) = \Pi_0$, so that

$$\Pi_0 = \frac{E_\alpha[\varphi_\alpha p_\alpha]}{E_\alpha[\varphi_\alpha]}$$

and industry profit with random search is just a weighted average of market prices. Incremental industry profit when the type-α firm is made prominent is $\Pi(\alpha) - \Pi_0 = \varphi_\alpha(p_\alpha - \Pi_0)$, which is positive whenever the type-α firm's price is above the market average price. In particular, since p_α increases with α, this is true if the highest-quality firm is made prominent. The intuition is simple: compared to random search, the prominence case distributes more demand to the firm with the highest profit margin. This result implies that, as in the symmetric-firm case, the platform wants to implement a prominent position if it can extract the whole industry profit.

We summarize these results in the following:

Proposition 6 *In the asymmetric environment with an infinite number of firms (and with symmetric costs), a firm with a higher average quality charges a higher price, and the highest-quality firm has the greatest incentive to become prominent. Making this firm prominent boosts industry profit and consumer surplus (and hence total welfare) relative to the situation in which no firm is prominent.*

4 Asymmetric Consumers

In this section we briefly discuss the impact of prominence when consumers differ in their cost of search. Here, a new role for prominence emerges, which is that the prominent firm can exploit the high search cost consumers by setting a *high* price.[29] We can understand this effect most easily in the context of a homogenous product market. Arbatskaya (2007) analyzes this situation in a fairly general framework with n completely ordered firms. However, for our purposes the basic point can be illustrated very simply.[30] A stark model in which consumers have different search costs is in Varian (1980), where n identical firms compete to offer a homogenous product to consumers. A fraction λ, say, of consumers do not have any search cost and know the prices of all firms, and so buy from the lowest-price supplier. The remaining consumers have an infinite cost of searching beyond their initial sample, and they buy from the first firm they encounter (provided that that firm's price is no higher than their reservation utility). In Varian's model, the first firm a consumer sees is random and firms compete by offering random prices. (A firm must trade off the need to compete for the informed consumers with the profit obtained by exploiting the uninformed consumers.) If the reservation utility for a unit of the homogenous product is v and production is costless, Varian shows that in symmetric equilibrium the expected price paid is $p_0 = (1 - \lambda)v$, which is the weighted average of the competitive price ($p = 0$) and the monopoly price ($p = v$).

Suppose now that one firm is made prominent in this market, in the sense that all consumers see its price first, and that there are at least two other firms. This firm therefore knows that it will serve the entire market of uninformed consumers, while the other firms know that they will not meet any of these consumers. So the non-prominent firms can compete only for the informed consumers, and so in Bertrand fashion they will offer the competitive price $p_2 = 0$. Thus, making a firm prominent exerts a competitive externality on the remaining firms, since they are left with only the fully-informed consumers. It is more profitable for the prominent firm to supply only the uninformed consumers, in which case it should charge the monopoly price $p_1 = v$. In sum, in this framework with heterogenous search costs, making a firm prominent causes that firm to raise its price, while non-prominent

[29] Athey and Ellison (2007) also have heterogeneous search costs. However, since there is no product-market competition in their model, there is no scope for exploiting the high search cost consumers.

[30] This simplified framework also avoids one awkward point in Arbatskaya (2007), which is that an inactive firm offering a particular price must be assumed in order to avoid the Diamond Paradox.

firms are forced to reduce their price relative to the random search case, so that

$$p_1 > p_0 > p_2 \ . \tag{26}$$

(Under our assumption that each consumer has unit demand there is no impact on industry profit, aggregate consumer surplus, or welfare.) Here, prominence has the opposite impact on prices compared to our earlier model when all consumers had the same search cost (see expression (20) above).

In a less extreme model where consumers have intermediate search costs, we still expect to see the same relative prices as in (26). In particular, Arbatskaya (2007) shows that equilibrium prices fall monotonically as consumers move along the list of firms. Intuitively, those consumers who immediately stop at the prominent firm are more likely to have a high search cost than other consumers, and so we expect that the prominent firm faces less elastic demand than its rivals. Of course, since consumers here get a worse deal when they buy from the prominent firm (unlike in our other models), in many situations we expect that consumers will learn this feature of the market, and perhaps start to *avoid* the prominently displayed products if they have a choice to do so.

This argument relies very much on assuming a homogeneous product in the market. As we have said, in many markets it is more natural to assume a degree of product differentiation. Presumably, in a richer model where (i) consumers have different search costs and (ii) there is product differentiation *a la* Wolinsky, the prominent firm's price could be higher or lower than its rival's prices, depending on the relative importance of (i) and (ii). In particular, we expect that our earlier prediction that the prominent firm will offer a lower price remains valid when search costs do not vary too much.

5 Conclusion

This paper has examined the implications of biasing each consumer's search order, so that consumers encounter some prominent firm first. In an environment without systematic quality differences, we find that the prominent firm will charge a lower price than non-prominent firms, and the prominent firm will set a lower price than if no firm is prominent while non-prominent firms will set higher prices. We also find that making a firm prominent will typically reduce average search intensity, increase industry profit, but lower consumer surplus and welfare. In a richer environment in which firms differ in quality, the firm with the highest average quality most wants to become prominent if the cost variation among firms is insignificant, and making it prominent can increase industry profit, consumer surplus and welfare. In this situation, prominence acts to guide consumers efficiently towards better products.

A feature of these models—with the exception of the model with heterogenous search costs in section 4—is that rational consumers will prefer to sample the prominent product first, even when they need not do so. In the benchmark model of section 2.2, consumers expect the prominent firm to charge a lower price than others so they sample it first; predicting this consumer behaviour, the prominent firm does indeed have an incentive to charge a lower price. In theory, even without exogenous prominence, this kind of asymmetric equilibrium might occur. However, there are many such equilibria, and without guidance it will be hard for consumers to coordinate their expectations on one favoured firm. In this sense prominence functions as a coordination device.[31] In models in which the prominent firm offers a worse deal to consumers (as in the heterogeneous search cost model), by contrast, for the model to be convincing consumers must either have some form of bounded rationality or they must be exogenously compelled to sample this firm first.

The topic of prominence deserves further research. For instance, making a firm prominent will have an impact on product variety in a free-entry market. In situations where non-prominent firms enjoy lower profit compared to the random search case, we expect that prominence will reduce the free-entry number of firms. But this will not necessarily harm efficiency since free entry may result in excess entry in the random search case.[32] It would also be useful to study the impact of prominence on a firm's choice of product quality.

The fact that prominence as well as pricing can affect consumer behaviour is important for business strategy and public policy in settings ranging from the presentation of choices about savings plans to those concerning healthy eating, promotional marketing and its regulation, the operation of commission schemes for sales agents, and so on. Our analysis has used a consumer search framework with product differentiation and imperfect competition to examine interactions between prominence and pricing, and some implications for profits and welfare. With suitable adaptation, such a framework might have application to a variety of circumstances where market participants or public authorities seek to influence consumer choice by framing the ways that choices are presented.

A Appendix

A.1 Existence of Equilibrium with Prominence

Claim 1 *Under assumption (5), within the square* $[0,a]^2$*, (15) and (16) have a unique solution, and this solution satisfies* $(p_1,p_2)\in(1-a,1/2)^2$*.*

Proof: By assumption, $a>1/2$. Fix $p_1\in[0,a]$, and consider (16). Here, $p_2=1-a+t_2$, where

$$t_2=\frac{r_2}{h_2}=\frac{1}{\frac{1}{n-1}\sum_{k=0}^{n-2}a^k}\int_{p_2}^{a}\frac{u-\Delta}{a-\Delta}u^{n-2}du\ .$$

[31] A similar feature is seen in Bagwell and Ramey (1994). However, in the earlier paper, this coordination is good for consumers, since they obtain a lower price. In our model, prominence is often bad for consumers in aggregate.

[32] See Proposition 3 in Anderson and Renault (1999).

Here, t_2 is a decreasing function of p_2 for $p_2 \in [0, a]$ since the integrand $\frac{u-\Delta}{a-\Delta}$ is positive and decreases with p_2 when $p_2 < u < a$. Moreover, since $\frac{1}{n-1}\sum_{k=0}^{n-2} a^k \geq u^{n-2}$ when $p_2 \leq u \leq a$, we have $t_2 < a - p_2$. We then have: (i) If $p_2 = 1 - a$, then $p_2 < 1 - a + t_2$. This is because $t_2 > 0$ given that $p_2 < a$. (ii) If $p_2 = 1/2$, then $p_2 > 1 - a + t_2$. This is because $t_2 < a - p_2$. Therefore, for $p_1 \in [0, a]$ (16) has a unique solution for $p_2 \in [0, a]$, say $p_2 = b_2(p_1)$, and $b_2(p_1) \in (1 - a, 1/2)$.

Next, from (14) we have

$$p_1 = \frac{1}{2}\left[1 - a + p_2 + \frac{a^n - p_2^n}{n}\right] \equiv b_1(p_2).$$

One can check that $b_1'(p_2) \in (0, \frac{1}{2})$. One can also check that $b_1(p_2) \in (1 - a, 1/2)$ when $p_2 \in (1 - a, 1/2)$. A solution to the pair of equations (15)—(16) involves $p_1 = b_1(b_2(p_1))$, and by a fixed point argument there exists such a $p_1 \in (1-a, 1/2)$. Since $p_2 = b_2(p_1) \in (1-a, 1/2)$, the pair of first-order conditions has at least one solution $(p_1, p_2) \in (1 - a, 1/2)^2$.

Finally, consider uniqueness. Substituting $b_1(p_2)$ into (16), we have

$$p_2 = 1 - a + \frac{1}{\frac{1}{n-1}\sum_{k=0}^{n-2} a^k} \int_{p_2}^{a} \frac{u - p_2 + b_1(p_2)}{a - p_2 + b_1(p_2)} u^{n-2} du.$$

Since $b_1'(p_2) \in (0, \frac{1}{2})$, $b_1(p_2) - p_2$ decreases with p_2. This implies that the right-hand side of the above decreases with p_2. Therefore, the solution is unique.

A.2 Proof of Proposition 1

(i) Since $h_2 < 1$, (15)-(16) imply that

$$p_2 - p_1 = \frac{1}{2}\left(\frac{r_2}{h_2} - r_1\right) > \frac{1}{2}(r_2 - r_1) \ .$$

However, since $r_2 - r_1$ has the same sign as $p_1 - p_2$, the latter must be positive.

(ii) Define

$$A = \frac{1 - a^n}{1 - a} \ ; \ B = \frac{1 - a^{n-1}}{1 - a} \ . \tag{27}$$

Since $p_1 < p_2$, the left-hand side of (19) is less than

$$p_2 + aBp_2 = Ap_2 \ ,$$

but the right-hand side is greater than $1 - p_2^n$. So we have

$$A > \frac{1 - p_2^n}{p_2} \ .$$

Comparing this to (11), we deduce $p_2 > p_0$.

Finally, since $\Delta > 0$ and $a > p_2$, it follows that $(a-\Delta)p_2 > ap_1$. Then the left-hand side of (19) is greater than Ap_1 but the right-hand side of (19) is less than $1-p_1^n$. So

$$A < \frac{1-p_1^n}{p_1}.$$

Comparing this with (11) implies $p_1 < p_0$.

A.3 Proof of Proposition 2

It is useful first to establish two preliminary results:

Claim 2 $p_0 > ap_2 + (1-a)^2$

Proof: For simplicity, write $K_n = \frac{1}{n}\sum_{k=0}^{n-1} a^k$ (so $h_0 = K_n$ and $h_2 = (a-\Delta)K_{n-1}$). Since $p_2 > p_0$, we have

$$r_2 = \int_{p_2}^{a} u^{n-1}(1-\frac{\Delta}{u})du < (1-\frac{\Delta}{a})r_0 \ ,$$

so

$$\frac{r_2}{h_2} < (1-\frac{\Delta}{a})\frac{r_0}{h_2} = \frac{r_0}{aK_{n-1}} \ .$$

Then,

$$p_0 = 1-a+\frac{r_0}{K_n} > 1-a+\frac{aK_{n-1}}{K_n}\cdot\frac{r_2}{h_2} > 1-a+a\frac{r_2}{h_2} = ap_2 + (1-a)^2 \ .$$

The second inequality follows since $K_{n-1} > K_n$ and the final equality follows from (16).

Claim 3 $\Delta < A\,(p_2 - p_0)$*, where* A *is given in (27)*

Proof: From (11) and (19), we have

$$p_1 p_2^{n-1} - p_0^n = p_0 - p_1 + B\left[\Delta p_2 - a(p_2 - p_0)\right] \ .$$

(Recall that B is defined in (27).) On the other hand, we can write the left-hand side of the above expression as

$$p_1 p_2^{n-1} - p_0^n = p_2^{n-1}\left[(p_2 - p_0)\,L - \Delta\right] \ , \tag{28}$$

where $L = \frac{1-\lambda^n}{1-\lambda}$ and $\lambda = \frac{p_0}{p_2} < 1$. These two equations imply

$$\frac{\Delta}{p_2 - p_0} = \frac{A + p_2^{n-1}L}{1 + Bp_2 + p_2^{n-1}} \ . \tag{29}$$

Therefore, from (29) $A - \frac{\Delta}{p_2 - p_0}$ has the same sign as

$$ABp_2 - (L - A)p_2^{n-1} > p_2 - (L - A)p_2^{n-1} > p_2 - (n-1)p_2^{n-1} > p_2(1 - \frac{n-1}{2^{n-2}}) \geq 0 \ .$$

The first inequality follows because $AB > 1$. The second inequality follows since $\lambda < 1$ implies that $L < n$, and so $L - A < n - A < n - 1$. The third inequality follows because $p_2 < 1/2$.

Proof of (i): From section 2.2, we know that output with random search, Q_0, is equal to $1 - p_0^n$, while output with a prominent firm, Q_1, is equal to $1 - p_1 p_2^{n-1}$. Therefore, expression (28) implies that

$$\begin{aligned} Q_0 - Q_1 &= p_1 p_2^{n-1} - p_0^n \\ &= p_2^{n-1} \left[(p_2 - p_0) L - \Delta \right] \\ &> p_2^{n-1} (p_2 - p_0)(L - A) \\ &> 0 \ . \end{aligned}$$

Here, the first inequality uses Claim 3. The second inequality follows from the observation from Claim 2 that $p_0 > ap_2$, so that $\lambda > a$ in the proof of Claim 3, and so $L > A$.

Proof of (ii): With random search, the probability that a consumer searches exactly k times, for $1 \leq k \leq n - 1$, is $a^{k-1}(1 - a)$. The probability that a consumers searches all products ($k = n$) is a^{n-1}. Using these probabilities to form the expected value of k shows that the expected number of searches with random search is

$$\frac{1 - a^n}{1 - a} \ .$$

On the other hand, with one firm prominent, the probability that a consumer searches just once is $1 - (a - \Delta)$, the probability that a consumer searches k times, where $2 \leq k \leq n - 1$, is $(a - \Delta)a^{k-2}(1 - a)$, while the probability that a consumers search all products is $(a - \Delta)a^{n-2}$. The expected number of searches in this case is therefore

$$\frac{1 - a^n - \Delta(1 - a^{n-1})}{1 - a} \ .$$

A.4 Proof of Proposition 3

Let $W(p_1, p_2)$ denote welfare when the prominent firm charges price p_1 and the non-prominent firms charge p_2 (and consumers foresee this will be the non-prominent price). Therefore, we wish to evaluate the sign of $W(p_1, p_2) - W(p_0, p_0)$.

Since total demand when all prices are p is $Q_0(p) = 1 - p^n$, it follows that[33]

$$\frac{dW(p,p)}{dp} = -np^n \ . \tag{30}$$

Second, consider the effect on $W(p, p_2)$ of a small increase in p of ε. First, more consumers are excluded altogether. (These consumers are depicted on the right-hand boundary of the shaded region in Figure 1.) Since total demand when the prices are (p, p_2) is $1 - pp_2^{n-1}$, this extra exclusion leads to a welfare fall of

$$-\varepsilon p \frac{d}{dp}[pp_2^{n-1}] = \varepsilon pp_2^{n-1}$$

since these marginal consumers were originally buying a product with social value p. Second, a fraction of consumers are shifted to non-prominent firms from the prominent one, either because they are more likely to search beyond the prominent firm at the start or because they are less likely to return to the prominent firm instead of others after sampling all firms. (These consumers are depicted on the diagonal boundary in Figure 1.) The number of these marginal consumers is just the increase in total non-prominent firm demand, which from (12) is

$$\varepsilon \frac{d}{dp}\left[1 - pp_2^{n-1} - (1 - a + p_2 - p + r_1)\right] = \varepsilon(1 - p_2^{n-1}) \ .$$

Since these consumers were indifferent between buying from the prominent and non-prominent firms (including the search cost), the impact on these consumers is negligible. On the other hand, industry profit is affected since profit increases by $p_2 - p$ for each consumer who switches. Therefore, industry profit rises by

$$\varepsilon(p_2 - p)(1 - p_2^{n-1}) \ .$$

Putting these two welfare effects together, we obtain

$$\frac{\partial W(p, p_2)}{\partial p} = p_2 - p - p_2^n \ . \tag{31}$$

Therefore, using (30) and (31), the welfare difference between the two regimes is

$$\begin{aligned} W(p_1, p_2) - W(p_0, p_0) &= [W(p_1, p_2) - W(p_2, p_2)] + [W(p_2, p_2) - W(p_0, p_0)] \\ &= \Delta(p_2^n - \frac{\Delta}{2}) - n \int_{p_0}^{p_2} p^n dp \ . \end{aligned}$$

Note that

$$n \int_{p_0}^{p_2} p^n dp > np_0 \int_{p_0}^{p_2} p^{n-1} dp = p_0(p_2^n - p_0^n) > p_0(p_2^n - p_1 p_2^{n-1}) = \Delta p_0 p_2^{n-1} \ .$$

[33] If the uniform price rises by ε, total demand falls by $\varepsilon Q_0' = \varepsilon np^{n-1}$. Since each of the marginal consumers was previously consuming a product with surplus p, it follows that total welfare falls by εnp^n.

The second inequality follows since the prominence case excludes more consumers (Proposition 2). Thus

$$W(p_1,p_2) - W(p_0,p_0) < \Delta(p_2^n - \frac{\Delta}{2}) - \Delta p_0 p_2^{n-1} = \frac{\Delta}{2}[2(p_2-p_0)p_2^{n-1} - \Delta] < 0 \ ,$$

where the final inequality follows since $p_2 - p_0 < \Delta$ and $p_2 < \frac{1}{2}$.

A.5 Proof of Proposition 4

We use a similar method as in the proof of Proposition 3. Let $V(p_1,p_2)$ denote consumer surplus when the prominent firm charges p_1 and the non-prominent firms all charge p_2. We wish to evaluate the sign of $V(p_1,p_2) - V(p_0,p_0)$.

Since total demand when all prices are p is $1-p^n$, it follows that

$$\frac{dV(p,p)}{dp} = -(1-p^n) \ .$$

Similarly, from (12)

$$\begin{aligned}\frac{\partial V(p,p_2)}{\partial p_1} &= -\{\text{demand for prominent firm's product}\} \\ &= -(1-a+p_2-p+r_1)\end{aligned}$$

and so

$$\begin{aligned}V(p_1,p_2) - V(p_2,p_2) &= \int_{p_1}^{p_2} (1-a+p_2-p+r_1)\ dp \\ &= \Delta(1-a+r_1+\tfrac{1}{2}\Delta) \\ &= \Delta(p_1 - \tfrac{1}{2}\Delta)\ ,\end{aligned}$$

where the final equality follows from the first-order condition (14). Therefore, we can deduce

$$\begin{aligned}V(p_1,p_2) - V(p_0,p_0) &= [V(p_1,p_2) - V(p_2,p_2)] + [V(p_2,p_2) - V(p_0,p_0)] \\ &= \Delta(p_1 - \frac{\Delta}{2}) - \int_{p_0}^{p_2} (1-p^n)dp \ . \qquad (32)\end{aligned}$$

Since $1-p^n > 1-p_2^n$ in the above integral, it follows that

$$V(p_1,p_2) - V(p_0,p_0) < \Delta(p_1 - \frac{\Delta}{2}) - (p_2-p_0)(1-p_2^n) \ .$$

Claim 3 tells us that $\Delta < A(p_2 - p_0)$, so if we can show

$$1 - p_2^n > A(p_1 - \frac{\Delta}{2})$$

we are done. First, it can be verified that

$$\frac{p_1 - \frac{1}{2}\Delta}{1 - p_2^n} < \frac{p_1}{1 - p_1 p_2^{n-1}} \Leftrightarrow 1 > 3p_1 p_2^{n-1} \ .$$

The latter inequality must be true since both prices are less than 1/2. Therefore, a sufficient condition for the result to hold is that

$$\frac{1 - p_1 p_2^{n-1}}{p_1} > A \ .$$

However, using (19) and the observation that $(a - \Delta)p_2 > ap_1$, we have

$$\frac{1 - p_1 p_2^{n-1}}{p_1} = \frac{1}{p_1}\left[p_1 + \frac{1 - a^{n-1}}{1 - a}(a - \Delta)p_2\right] > 1 + a\frac{1 - a^{n-1}}{1 - a} = A \ .$$

A.6 Proof of Proposition 5

(i) Write π_0, π_1 and π_2 for the respective equilibrium profit of each firm in the random search case, of the prominent firm in the prominence case, and of each non-prominent firm in the prominence case. Then

$$\pi_1 > p_2(1 - a + r_1) > p_2(h_2(1 - a) + r_2) = \pi_2 \ .$$

The first inequality holds since the prominent firm makes smaller profit if deviates from p_1 to the price p_2. (Recall that its demand is given by (12).) The second inequality holds since $h_2 < 1$ and $r_2 < r_1$. Similarly,

$$\pi_1 > p_0\left(1 - a + p_2 - p_0 + r_1\right) > p_2(h_0(1 - a) + r_0) = \pi_0 \ .$$

Here, the second inequality holds since $h_0 < 1$ and $p_2 - p_0 > \frac{1}{n}\left(p_2^n - p_0^n\right) = r_0 - r_1$.

(ii) Industry profit when one firm is prominent is $p_1 q_1 + (n-1)p_2 q_2$, which can be written as

$$\begin{aligned} p_2\left[q_1 + (n-1)q_2\right] - \Delta q_1 &= p_2\left[p_2 - \Delta + B(a - \Delta)p_2\right] - \Delta p_1 \\ &= p_2\left[Ap_2 - \Delta(Bp_2 + 1)\right] - \Delta p_1 \ . \end{aligned}$$

(Recall the definition of A and B in (27).) The first equality follows from (17)–(18), while the second follows after noting that $A + aB = 1$. From (10), industry profit in the random search case is

$$np_0 q_0 = Ap_0^2 \ .$$

Therefore, prominence increases industry profit if and only if

$$A(p_2^2 - p_0^2) > \Delta\left[(Bp_2 + 1)p_2 + p_1\right] \ .$$

From (29), this condition is equivalent to

$$\frac{A + p_2^{n-1} L}{1 + Bp_2 + p_2^{n-1}} < \frac{A(p_2 + p_0)}{(1 + Bp_2)p_2 + p_1} \ . \tag{33}$$

For $n = 2$ and $a = 1/2$ (so that $A = 3/2$, $B = 1$, $L = 2$ and all prices are $1/2$), one can check that the left-hand side of (33) is $5/4$ but the right-hand side is $6/5$, so that (33) fails to hold. Therefore, prominence causes industry profit to fall in a duopoly when search costs approach their maximum limit.

We next show that (33) holds for $n \geq 3$ or for $n = 2$ but a is relatively large. Inequality (33) is equivalent to

$$Lp_2^{n-1}\left[(1 + Bp_2)p_2 + p_1\right] < A\left[Bp_0p_2 + p_0 - p_1 + p_2^{n-1}(p_2 + p_0)\right] \ .$$

After dividing both sides of the above by p_2 and using $p_2 > p_0 > p_1$, a sufficient condition for this inequality is

$$Lp_2^{n-1}\left(2 + Bp_2\right) \leq A\left[Bp_0 + p_2^{n-2}(p_2 + p_0)\right] \ ,$$

which in turn is true if

$$\frac{Lp_2^{n-1}}{p_0}\left(2 + Bp_2\right) \leq A\left(B + 2p_2^{n-2}\right) \ .$$

Note that

$$\frac{Lp_2^{n-1}}{p_0} = \frac{p_0^{n-1} + p_0^{n-2}p_2 + \cdots + p_2^{n-1}}{p_0} < (n-1)p_2^{n-2} + \frac{p_2}{p_0}p_2^{n-2} < kp_2^{n-2} \ ,$$

where $k = n - 1 + \frac{1-2(1-a)^2}{a}$. The last inequality follows from Claim 2 which implies that $\frac{p_2}{p_0} < \frac{1-2(1-a)^2}{a}$ by noting $p_0 < \frac{1}{2}$. Therefore, a new sufficient condition for industry profit to rise with prominence is

$$k\frac{2 + Bp_2}{2 + B/p_2^{n-2}} < A \ .$$

Since $p_2 < 1/2$, the above inequality is true if

$$\frac{k}{4 + 2^{n-1}B} < \frac{A}{B + 4} \ .$$

When $n = 2$, we have $A = 1 + a$ and $B = 1$, and one can check that this inequality holds for about $a > 0.794$. For $n = 3$, it holds for all $\frac{1}{2} \leq a \leq 1$. For $n > 3$, it holds since the left-hand side decreases with n when $n \geq 3$ and the right-hand side increases with n (which can be seen by noting that $A = 1 + aB$ and B increases with n).

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