A note on welfare-improving ignorance about quality[1]

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Consider a monopolist that is selling a high quality product when the quality is unknown to a fraction of the consumers. If the quality cannot be signaled and the fraction is sufficiently large, then the monopolist will offer a low price to induce uninformed consumers to buy. If the fraction is sufficiently small, then uninformed consumers are irrelevant to its optimal price. If the uninformed consumers are priced out of the market as a result, then welfare can decrease.

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1. Introduction

When product quality is unknown, a natural supposition is that informing consumers will always increase consumer surplus and welfare. Despite this, when a monopolist is selling a product of unknown and fixed quality and there is a pooling equilibrium, consumer surplus and welfare can be locally decreasing in the fraction of informed consumers. Thus, even a costless government program to inform consumers could reduce welfare as well as consumer surplus if the program does not result in a sufficiently large increase in the number of informed consumers.

The results here provide some contrast to the results of models in which there is signaling. For example, in Bagwell and Riordan (1991), high quality producers can separate with a sufficiently high price, i.e., at that price it is more profitable for low quality producers to set its profit maximizing complete information price than it is to mimic high quality producers. Bagwell and Riordan (1991) find that the high quality producer's price falls as more consumers are informed, while here the price rises as more consumers are informed. Hence, with the separating equilibrium welfare increases as more consumers are informed, while here it can decrease.

2 The Model

There is a monopolist. There is a single period of production. At the beginning of the period, the monopolist observes the quality of its product, but consumers do not. The product is one of two types of quality: high or low and the firm is referred to by its quality type. All market participants know that there is a probability $x \in (0,1)$ that the firm is of high quality. Both types have the same cost of production c and consumers have no value from a low quality product. These assumptions bias the model to make low quality production as welfare reducing as

reasonably possible: low quality production contributes nothing and is as costly as high quality production. The firm sets price, which all consumers observe.

A fraction $\alpha \in [0,1]$ of the consumers are informed as to the quality of the firm's product. A government could affect the level of α by testing the product's quality and then promulgating the test results through advertising, or by subsidizing private organizations such as Consumer Reports. While such costs are abstracted from the model here, the implications are straightforward. Given this faction α, consider the firms' optimal prices. As any deviation is equally costly to both types, for simplicity it is assumed that if consumers observe out-of-equilibrium prices that benefit both types equally, then they believe that the firm is of high quality with probability *x*. Likewise, if they observe prices that could only benefit a low quality type, then they believe the firm is of high quality with probability 0.

Lemma. *In equilibrium, both types set the same price; low quality mimics high quality.*

Proof. Assume not: each type sets a different price: p_L and p_H. Uninformed consumers would never buy from a firm setting price p_L and assign a probability one that the firm setting p_H is a high quality firm. Hence, a low quality firm would deviate and set p_H.//

2.1 Unit Demand

To provide some of the intuition behind the result, a simpler model is considered first: there is a mass 1 of identical consumers with unit demand and reservation price *v* for the high quality product and 0 for the low quality product. The next section will derive the result with the more general downward sloping demand.

The implication of the lemma is that the high quality firm will choose its price to

maximize profits knowing that the low quality firm will mimic its decision. Uninformed consumers, then, on observing the price will assign probability x that the product is of high quality, and their reservation price is $x \cdot v$. It is assumed that $c < x \cdot v$. There are two possible strategies for the high quality firm. One, it could capture uninformed consumers by setting a price $x \cdot v$ and earn profits $x \cdot v - c$.[2] Two, it could sell to only informed consumers and set a price v and earn $\alpha \cdot (v - c)$. At α=0, the high quality firm sets the price $x \cdot v$ and at α=1, the high quality firm sets the price v. As $\alpha \cdot (v - c)$ is continuous in α, there exists an α, α^{π}, such that the firm is just indifferent between the two strategies $\{\alpha: \alpha \cdot (v - c) = x \cdot \mathrm{v} - c\}$.

Proposition 1: *When there is production with incomplete information, then with unit demand expected welfare is decreasing in the fraction of uninformed consumers (α) on $[0,\alpha^{\pi})$ and $(\alpha^{\pi},1]$. However, at α^{π} expected welfare discretely increases.*

Proof: Between $[0,\alpha^{\pi})$ the price is $x \cdot v$ and expected welfare is $x \cdot [v - \mathrm{c}] + (1 - x) \cdot (1 - \alpha)(-\mathrm{c})$, which is increasing in α. At α^{π} the firm is indifferent between selling to informed or uninformed consumers. Expected welfare when the price is $x \cdot v$ is $x \cdot [v - \mathrm{c}] + (1 - x) \cdot (1 - \alpha^{\pi})(-\mathrm{c}) \geq x \cdot v - \mathrm{c}$. Expected welfare when the price is v is $x \cdot \alpha^{\pi} \cdot [v - \mathrm{c}] + (1 - x) \cdot 0 < \alpha^{\pi} \cdot (v - c) = x \cdot v - \mathrm{c}$. Hence, at α^{π} a small increase in α reduces welfare. Finally, between $(\alpha^{\pi},1]$ the price is v and expected welfare is $x \cdot \alpha \cdot [v - \mathrm{c}] + (1 - x) \cdot 0$, which is increasing in α. //

[2] Note that the assumption on consumers' beliefs regarding out-of-equilibrium prices allows the high quality firm to set the pooling equilibrium price that gives it the highest profits. That is, consider as a candidate equilibrium any p < $x \cdot v$. A high quality firm that deviated and set a price $x \cdot v$ would sell to uninformed consumers given the assumption. As this price is more profitable, the firm would set it. While this assumption on consumers' belief is natural, others could be used and then other pooling equilibria may exist, which would affect the results.

On the one hand, when a monopoly is of low quality and a consumer learns this at α^{π}, there is an efficiency gain as the consumer no longer buys the product, and so the production cost is saved. On the other hand, when the monopoly is of high quality, there is an efficiency loss as the uninformed consumers no longer buy the product because the monopolist has raised its price in response to enough consumers learning its quality. That is, the monopolist can be viewed as facing two markets: one with informed consumers ("high demand") and one with uninformed consumers, both with the same value for the product. If the fraction of uninformed consumers is sufficiently large, the monopoly price has both markets being served. However, when enough consumers become informed, it becomes optimal for the monopolist to set a price that maximizes profits for the high demand market only, which prices out low demand consumers. At that point efficiency decreases. While the inefficiency from a monopolist not serving low demand consumers is well known, what is surprising is that first, informing consumers has this effect, and that second, this efficiency loss can overwhelm the efficiency gain from informing consumers.

2.2 Downward Sloping Demand

Assume now that the identical consumers have a downward sloping demand for the high quality product with the demand being written Q(p). The demand is assumed to such that profits are concave in p. Otherwise the model is the same, specifically the demand for low quality is zero and the state of being informed or uninformed is independent of the consumer's preferences. Let $Q^u(p, b)$, $\partial Q^u(p, b)/\partial b > 0$ denote the demand for uninformed consumers given price p and belief b regarding quality, i.e., $Q^u(p, 1) = Q(p)$. Let p^I be the price that maximizes $\alpha(p - c)Q(p) \equiv \alpha \cdot \pi^I(p)$, profits when the high quality firm chooses to sell to the informed consumers only. Note

that p^I is independent of α. Let $p^U(\alpha)$ be the lowest price that maximizes $\alpha(p - c)Q(p) + (1 - \alpha)(p - c)Q^u(p, x) \equiv \alpha \cdot \pi^I(p) + (1 - \alpha) \cdot \pi^u(p, x)$. ($p^U(\alpha)$ is defined as the lowest price since for at least one α there may be two such prices, the other being p^I.) Analogous to the unit demand case, it is assumed that $Q^u(c, x) > 0$ and there exist a p', $p' < p^I$ such that $Q^u(p', x) = 0$ so that uninformed consumers are priced-out if the high quality sells to only informed consumers and that profits are concave in p given beliefs x. Note that since p^I maximizes π^I, $p^U(0) < p^I$, p^u is increasing in α and, since $p' < p^I$, there exist $\alpha < 1$ such that $p^U(\alpha) = p^I$. Let α^π be the greatest α such that the high quality firm is indifferent between p^I and $p^U(\alpha) < p^I$.

Proposition 2: *When there is production with incomplete information and uninformed consumers are priced-out at the complete information price, then with downward sloping demand, there exists a fraction of uninformed consumers such that a small decrease in this fraction reduces expected welfare.*

Proof: Consider first informed consumers at α^π. Since $p^I > p^u(\alpha^\pi) > c$, expected welfare decreases from an infinitesimal increase in α at α^π. Consider now the uninformed consumers at α^π. Note first that both types of firms sell the same amount to uninformed consumers. Thus, marginal and total cost of sales to uninformed consumers is identical for both types. Since $p^u(\alpha^\pi) \geq p^u(0)$, $p^u(\alpha^\pi) > c$ for both types. As the uninformed consumer's marginal expected value equals p^u, expected welfare for units sold to uninformed consumers is strictly positive at $p^u(\alpha^\pi)$. If the firm switches to p^I, this expected welfare decreases to zero.//

Recall that in the unit demand case informed consumers demanded the same amount under either

price strategy; the welfare loss in that case was from uninformed consumers only. Hence, with downward sloping demand there is now also a welfare loss from informed consumers. Finally, if linear demand is assumed, then it can be shown that there exist conditions such that for all α, expected welfare is greater under p^U.

3 Discussion

In a market with unknown quality in which low quality producers mimic high quality producers (i.e., a pooling equilibrium), a greater fraction of uninformed consumers can raise total welfare. In contrast, if there is a separating equilibrium (Bagwell and Riordan 1991), a greater fraction can have a negative effect. The difference is because here a greater fraction of uninformed consumers can lead the high quality producer to lower its price. This price decrease can increase welfare in two ways. First, if this lower price induces uninformed consumers to buy, then welfare increases because uninformed consumers' expected valuation is greater than the production cost. Second, if demand slopes downward, then informed consumers buy more. However, the first effect does not hold globally: when the high quality producer is already setting a price at which uninformed consumers buy, a greater fraction of uninformed consumers could reduce welfare because the inefficient production of the low quality producer increases. That is, wasteful production has increased.

That increasing the fraction of uninformed consumers can raise welfare, rather than being an exception, appears in other environments as well.[3] Most notably Meurer and Stahl (1994) examine a model with two horizontally differentiated products with unit demand (as in section 2.1), in which *both* consumers and firms do not know the consumers' match quality. Roughly,

[3] There is also work that examines the effect public information has on a firm's profits. See, e.g., Saak (2007) and citations therein.

instead of a firm being either a high or a low quality producer, it is both a high and a low quality producer. Firms, however, can truthfully advertise the products' characteristics. They examine both a duopoly with a symmetric pricing equilibrium and a monopoly that sells both products. With a monopoly, if there is very little advertising, the firm charges a different price for each product to discriminate between the informed and uninformed consumers. In this case, the fraction of uninformed consumers has no effect on total sales and so welfare is decreasing in this fraction because of the inferior matching instead of the wasteful production that was found here. As more consumers become informed, the products become more differentiated and the monopolist can raise the price of its lower priced good. As in the model here, this lowers welfare. Likewise, in a duopoly, the increased market power from the products becoming more differentiated can result in an increase in price that reduces welfare.

This second effect found here, the benefit uninformed consumers can impart on informed ones, has also appeared elsewhere. In particular, Anderson and Renault (2000) examine a horizontally-differentiated duopoly with consumers with downward-sloping demand (as in section 2.2) who do not know their match quality. In contrast to Meurer and Stahl (1994), consumers can incur a cost to learn their product match (rather than firms sending the information). They find that prices are decreasing in the fraction of uninformed consumers (and so consumer welfare increases). This cost to learn one's product match is assumed fixed and to vary continuously across consumers. Hence, for the marginal consumer that chooses to learn its product match, the benefit from learning just equals the cost. As this marginal consumer's learning imposes a negative externality on others through the higher price, the equilibrium number of consumers choosing to learn their product match exceeds the social optimum.

Another example is in Creane (1998) who finds that with perfect competition, consumer

welfare when all consumers are informed is less than consumer welfare when no consumers are informed. Creane (1998) also finds conditions for this outcome to hold in the circular city model. In either case, as in the model here, uninformed consumers allow low quality firms to compete with high quality ones, thereby reducing the equilibrium price. In addition – as in all of these models – since uninformed consumers' willingness-to-pay reflects expected quality (i.e., in equilibrium consumers are not fooled) the surplus from the marginal consumer is non-negative. Since the price is higher when all consumers are informed, this results in uninformed consumers who no longer buy, but who had had positive expected surplus before.

Finally, while the above papers focus on the price effects of uninformed consumers, Levin (2001) finds the possibility that consumers that acquire only partial information (specifically, they learn only some quality types) can reduce exchange, although only when there is unit demand (as in the model of section 2.1). Intuitively, what occurs with partial learning is that among the remaining unknown types the lemon's problem arises, while it did not when all types were unknown. Since by assumption any exchange is efficient in Levin (unlike here), reduced exchange reduces welfare.

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