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"Distributional Implications of the Internet: Can Price Discrimination Improve Farmers' Welfare?"

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Distributional Implications of the Internet: Can Price Discrimination Improve Farmers' Welfare?

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Abstract

A price discrimination model is proposed to explain extraneous information provided by internet sales sites for agricultural inputs. Whether an informative site is offered depends on price discrimination potential, which depends on how much farmers reveal heterogeneity by internet behavior. Price discrimination is greater if information benefits are negatively correlated with farm-size, explaining why extraneous (not product-related) information is offered on internet sales sights. Price discrimination adversely affects some farmers but may be beneficial on average because it generates free information. Outcomes depend on whether internet users are aware of price differentials generated by the reverse flow of clickstream information.

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Since 1997, use of the internet in agriculture has accelerated rapidly (Wolf, Just, Wu, and Zilberman; Just and Just), although greater use has occurred by agribusiness and larger farms than small farms. Several websites now offer on-line sales of agricultural inputs ranging from fertilizer to large equipment. As more agricultural transactions take place on the internet, understanding is needed about the distributional effects of the internet.

Many have focused on the benefits of the internet including the broad range of general information freely available at internet marketing sites. We call this *extraneous information*, differentiating it from information directly related to promotion and use of products offered for sale. But the internet also generates a reverse flow of information from registration data and clickstream choices of users that can be used for third-degree price discrimination or targeted direct marketing (Just and Just). We call this *personal information*.

The reason internet sites to provide extraneous information is obscure because providing it is presumably costly but seemingly gains no benefit for the input supplier if users can surf the web, collect information, and then buy elsewhere at the lowest price. Initially, many agricultural internet sites provided an inexplicable array of extraneous information. Then many successful internet sites were purchased by major agricultural marketing firms or merged with other sites allowing an unprecedented sharing of farmers' personal information. As a result, the potential use of market power by agricultural suppliers remaining in the virtual world has increased. While market power is partially limited by off-line supplier competition, patent-protected monopolies exist for many inputs. Personal information permits price discrimination because the firm can offer different internet choices, including different email offers, and different prices depending on a farmer's clickstream choices. More recently, the provision of extraneous information for agriculture has been specialized in sites that provide links to numerous marketing sites, such as AgWeb.com, Agriculture.com, or DirectAg.com. Although the structure is different, these sites retain the right to pass clickstream information to agricultural marketers as their links are selected (see the privacy policies), thus enabling the same use of personal information while achieving economies of providing information.

This article explores the related implications for agriculture of information exchange via the internet. While some means of distinguishing customer traits may exist for storefront sales (such as face-to-face negotiation), these methods tend to be costly to implement, require skilled salesmen rather than automated software, and generate data that is hard to record or recall as needed. Alternatively, the majority of inputs sold in storefronts are sold at a single posted (though possibly non-linear) price, as assumed herein. The next section discusses the internet as a two-way information exchange focusing on the capabilities of internet site providers to infer preferences from individual choices, and on individuals' abilities to protect themselves from monitoring. Building on Maskin and Riley, a model is proposed where firms bundle extraneous information with products. For sharp results, price discrimination is considered only where one price is offered on the internet and another is offered in storefronts. The input supplier sets prices to maximize profit given internet choices of farmers where the benefits of extraneous information depend on farmsize and willingness to pay (WTP) for the product. Such third-degree price discrimination can, in some cases, increase welfare because some farmers receive lower prices and others receive free information without buying. However, both competition (which limits price discrimination) and free access to information can limit suppliers' abilities to recoup the cost of providing information, while lack of competition can lead to excessive price discrimination through use of personal information. Thus, market failures can occur where agricultural suppliers either under- (or over-) supply extraneous information compared to the social optimum.

The Internet as an Information Exchange

The internet differs from other forms of sales not only by distance and speed but because personal information transmitted by farmers can be used cheaply by internet site providers. Because information can be both sent and received, suppliers can bait farmers with links to extraneous information in order to classify them. While brick and mortar storefronts can also offer extraneous information, they cannot offer the same convenience or flexibility. Rather, storefronts tend to offer only information related to the product offered for sale, while internet marketing sites typically offer extraneous information not directly related to the product, such as crop news, scouting reports, or weather information. Furthermore, farmers can access updated information instantaneously on the internet without leaving their farms. Such behavior can be used to target advertising and price offers based on internet choices.

Shapiro and Varian have demonstrated in a nonagricultural context how personal clickstream information enables price discrimination. While privacy software has been developed, it is detectable by internet site providers, which in itself facilitates discrimination because it limits access to both extraneous information and transactions. Moreover, the analysis of massive internet customer data sets has motivated a new field of study called data mining.

While many studies focus on the potential for product customization and reduced search costs, the marketing literature has focused on internet price discrimination using personal information (see the review by Koch and Cebula). Daripa and Kapur find that the internet encourages market concentration and that third-degree price discrimination is rampant on the internet. Findings refute the idea that abundant price and quality information on the internet leads to rapid price discovery. Brynjolfsson and Smith find that price dispersion is greater on the internet and that firms change prices more often on the internet. They find as much as 33 percent differences in prices and that one firm with a 60 percent market share charged 10 percent more than other internet marketers for identical products. Bakos finds that prices diverge rather than converge on the internet and gives evidence that this is due to tailoring prices to individuals. Streitfeld documents price setting based on personal information including behavior by zip code and employer (based on IP addresses).

With growing evidence on internet price discrimination, the potential effects of internet marketing on agriculture deserve consideration. Because of the highly heterogeneous nature of farming (e.g., farmsize, location, and product mix), extraneous information choices may make discrimination by agricultural internet sites relatively easy. For example, larger farms may be able to use information on a larger scale and thus gain greater benefits. On the other hand, smaller farmers have less ability to process and utilize complex or raw technical information (see Just, Wolf, Wu and Zilberman) and may thus find convenient access to processed information more attractive.

An Explicit Stylized Model

Consider two sets of agents: farmers and agricultural input suppliers. Under constant returns to scale (CRTS), production on a single farm follows $aY(x)$ where a is acreage, x is the per acre application rate of an input such as a particular pesticide, and $Y(x)$ is yield per acre. (Profit-maximizing use of other inputs at given prices is implicit in $Y(x)$ as a function of x). Suppose p is a competitive output price faced by all farms, w is the input price, and a quasi-fixed setup cost π_* is incurred if the input is used. Set-up costs are due to additional machinery requirements, search costs for custom applicators, and cleaning and maintenance of required equipment.

Incremental profit from using the input is $\pi \equiv a[py(x) - wx] - \pi_*$ if the input is used, and zero otherwise, where $y(x) \equiv Y(x) - Y(0)$, $y'(x) > 0$ and $y''(x) \leq 0$. Under CRTS, each farmer either applies the input to the entire farm or acreage of a relevant crop or does not use the input. With positive use of the input, short-run profit maximization (given farmsize) yields first-order condition $y'(x) = w/p$ solved by $x^* = x(w) > 0$ with $x'(w) \leq 0$. The short-run incremental profit function is $\pi = \pi(a,w) \equiv \max\{a\bar{\pi}(w) - \pi_*, 0\}$ where $\bar{\pi}(w) \equiv py(x^*) - wx^*$ and $\bar{\pi}'(w) = -x(w) < 0$ by the envelope theorem. Thus, among all farms facing the same input price, the application rate is constant and profit varies linearly with farmsize. Farms facing a lower input price have higher per acre profit and higher yield due to a higher application rate.

Suppose the distribution of farmsize a (which may represent acreage of the relevant crop) is exogenous and continuous such that $\int_{a_1}^{a_2} dF(a)$ gives the total number of farms and $\int_{a_1}^{a_2} a\, dF(a)$ gives the total acreage in farms with $0 \leq a_1 < a < a_2 \leq \bar{a}$ where $\bar{a}$ is the maximum farmsize. Suppose the agricultural input is produced and supplied by a profit maximizing industry in storefronts, but that each input supplier can also sell on the internet by providing an internet site. Suppliers set storefront price w_0 if no internet site is offered, or storefront price w_1 and internet price w_2 if an internet site is offered ($w_i > 0$). For notational efficiency, let $x_i \equiv x(w_i)$, $x_i' \equiv x'(w_i)$, $x_i'' \equiv x''(w_i)$, and $\pi_i \equiv \bar{\pi}(w_i)$ so farm profit is $\pi_i a - \pi_*$, $i = 0,1,2$.

With an internet site, a farmer who chooses to not surf and buy necessarily pays price w_1 because buying on the internet is precluded by the choice to not surf. Koch and Cebula, Brynjolfsson and Smith, and Bailey have shown that prices per physical unit are not always lower on the internet than in storefronts. Thus, we consider two types of equilibrium. First, we consider an informed Nash equilibrium where surfing farmers observe both storefront and internet prices and maximize profits by choosing the lower of the two prices. Thus, the internet price cannot be higher than in storefronts, $w_2 \leq w_1$. Second, we consider a myopic or uninformed equilibrium where the price difference is not perceived, so the internet price may be higher.

The benefit from extraneous information is assumed separable from WTP for the physical input, but correlated with characteristics of farmers, represented here by farmsize. Let the monetary value of benefits received by a farmer with acreage a from extraneous information be given by $\phi(a)$ if the farmer chooses to surf and 0 if not. Two stylized cases of this relationship are considered. A unique feature of information (e.g., technical know-how) is that, once acquired by a farmer, the information may be utilized on the entire farm or acreage of a crop with no additional information cost. Accordingly, one stylized case reflects "increasing scale benefits" where farmers with larger scale reap greater extraneous information benefits.

However, some extraneous information benefits are not positively related to scale (e.g., information extraneous to the crop on which the input is used or information about how to lower a fixed cost). Also, the opportunity cost of acquiring or processing information may differ among farms. For example, (i) operators of larger farms may have higher opportunity costs because of binding family labor constraints that are exacerbated by junk email and other transactions costs imposed by internet transactions, (ii) farms with larger acreages using the input in question may have smaller acreages of other crops for which the extraneous information is useful, (iii) weather information that permits optimal timing of operations may be less useful on large farms that require more time for coverage, (iv) older farmers who have acquired more land may have less knowledge of how to use the internet, and/or (v) large (industrial) farms may have their own information processing capabilities and thus benefit less than small farms from highly processed information typically provided by broad-based agricultural internet sites. For simplicity of terminology, we refer to all these possibilities as "increasing opportunity costs."

Depending on which effect dominates, the two stylized cases are defined as follows:

Increasing Scale Benefits (*ISB*). If the increase in scale benefits dominates the increase in opportunity cost, then $\phi' > 0$ and $\phi_* \equiv \phi(0) < 0$ where $\phi(\hat{a}) = 0$ for some $\hat{a} \in (0, \overline{a})$.

Increasing Opportunity Costs (IOC). If the increase in opportunity costs dominates the increase in scale benefits, then $\phi' < 0$ and $\phi_* > 0$ where $\phi(\hat{a}) = 0$ for some $\hat{a} \in (0, \overline{a})$.

Alternative cases where $(\phi' > 0, \phi_* > 0)$, $(\phi' < 0, \phi_* < 0)$, or $\phi' \equiv 0$, or where $\phi(\hat{a}) = 0$ does not occur for $\hat{a} \in (0, \overline{a})$ are uninteresting because they do not generate mixed internet behavior where some farmers surf and some do not (see below). To avoid tedious discussion, we assume that ϕ is linear ($\phi'' = 0$), although extension to nonlinearity is straightforward, and that $|\phi'| < \pi_1$, which implies that the primary market is for the physical input rather than the extraneous information offered on internet sites that sell the input.

If an internet site is provided, a farmer with acreage a maximizes profit including the benefit of extraneous information $\phi(a)$ by choosing the largest net incremental benefit among four options (consistent with individual rationality and incentive compatibility):

- *SB*: "Surf" the internet for extraneous information and "Buy" the physical good, receiving net incremental benefit $SB(a) \equiv \pi_2 a - \pi_* + \phi(a)$.
- *SNB*: "Surf" the internet for extraneous information and "Not Buy" the physical good, receiving net incremental benefit $SNB(a) \equiv \phi(a)$.
- *NSB*: "Not Surf" the internet for extraneous information and "Buy" the physical good,

receiving net incremental benefit $NSB(a) \equiv \pi_1 a - \pi_*$.

- *NSNB*: "Not Surf" the internet for extraneous information and "Not Buy" the physical good, receiving net incremental benefit $NSNB(a) \equiv 0$.

The agricultural supplier's collection of personal information about farmers is reflected by farmers' choices among these four internet behaviors.

Useful notation for indifference points between behavioral alternatives is given by:

$a_1 \equiv \pi_*/\pi_1$ where $NSNB(a_1) = NSB(a_1)$,

$a_2 \equiv \pi_*/\pi_2$ where $SNB(a_2) = SB(a_2)$,

$\hat{a} \equiv -\phi_*/\phi'$ where $NSNB(\hat{a}) = SNB(\hat{a})$,

$a_* = \phi_*/(\pi_1 - \pi_2 - \phi')$ where $NSB(a_*) = SB(a_*)$,

$a_+ = (\pi_* - \phi_*)/(\pi_2 + \phi')$ where $NSNB(a_+) = SB(a_+)$.

To examine input supplier behavior, suppose manufacturing and selling has constant marginal cost function c'.[1] If internet sites are provided, the maximum aggregate short-run profit of input suppliers is

(1) $$\max_{w_1, w_2} \Pi^I = R_1 A^{NSB} + R_2 A^{SB} - nK,$$

subject to $w_2 \leq w_1$ where $R_i \equiv (w_i - c')x_i$ is per acre supplier profit at price w_i, assumed to be concave in w_i, total acreage in each regime is $A^{NSB} = \int_{NSB} a \, dF(a)$ and $A^{SB} = \int_{SB} a \, dF(a)$, n is the number of suppliers that provide internet sites, K is the cost of setting up an internet site (assumed to be independent of sales volume), and integration over *NSB* applies where $NSB(a) >$ $\max\{SB(a), SNB(a), NSNB(a)\}$ and *SB* applies where $SB(a) > \max\{NSB(a), SNB(a), NSNB(a)\}$.

If no internet site is provided, then farmers' choices are limited to "Buy" (denoted by *B*), which is chosen if $\pi_0 a - \pi_* > 0$, or "Not Buy" (denoted by *NB*) otherwise. Thus, the maximum aggregate short-run profit for input suppliers when no internet sales sites are provided is

(2) $$\max_{w_0} \Pi^{NI} = R_0 A^B$$

where $A^B = \int_{a_0}^{\bar{a}} a \, dF(a)$ and $a_0 \equiv \pi_*/\pi_0$.

Characterizing Equilibria and Welfare

This section examines how competitive profit-maximizing farms divide into behavioral regimes according to farmsize. Figures 1 and 2 illustrate how different groups of farmers may be attracted to different behaviors simultaneously in both *ISB* and *IOC* cases. The horizontal axis represents farmsize and the vertical axis measures incremental benefits associated with farmers' decisions to surf and/or buy. For *NSNB*, incremental benefits are zero along the horizontal axis. For *SNB*, incremental benefits follow $\phi(a)$, which is increasing from a negative intercept in the *ISB* case of Figure 1, and decreasing from a positive intercept in the *IOC* case of Figure 2. For *NSB*, incremental benefits follow $\pi_1 a - \pi_*$, and are increasing in acreage ($NSB' = \pi_1 > 0$ where primes on behavioral functions represent differentiation with respect to a) from a negative intercept, $-\pi_*$, assuming the storefront price is not so high that no farm would choose to buy. For *SB*, incremental benefits follow $\pi_2 a - \pi_* + \phi(a)$, which is increasing in acreage because $w_2 \leq w_1$ and $|\phi'| < \pi_1$. The *SB* intercept is negative in the *ISB* case (Figure 1) because $\pi_* > 0$ and $\phi_* < 0$.

Conceptually, market behavior of profit-maximizing farmers follows the upper envelope of these four incremental benefit functions (shown in bold in Figures 1 and 2). As in Figure 2, depending on parameters and prices, all four behaviors can occur simultaneously in an *IOC* equilibrium. Throughout this paper, we regard market equilibria that do not include both *NSB* and *SB* behavior as uninteresting because, as shown below, input suppliers find provision of informative internet marketing sites unprofitable unless both types of sales occur.

Proposition 1. Under *ISB* and informed Nash equilibrium, if prices induce both storefront and internet sales, then competitive profit-maximizing farms divide into behavioral regimes by farmsize with *NSNB* behavior for $0 < a < a_1$, *NSB* behavior for $a_1 < a < a_*$, and *SB* behavior for $a_* < a < \bar{a}$, in which case aggregate net benefits for farmers are

(3) $$S^I = \int_{a_1}^{a_*} (\pi_1 a - \pi_*) dF(a) + \int_{a_*}^{\bar{a}} [\pi_2 a - \pi_* + \phi(a)] dF(a).$$

Proof: Nonzero storefront (internet) sales implies $a_1 \leq \bar{a}$ ($a_2 \leq \bar{a}$), while $a_i > 0$ follows from $\pi_* > 0$ and $\pi_i > 0$, $i = 1, 2$. Also, $\pi_2 \geq \pi_1 > 0$ and $\phi' > 0$ (under *ISB*) implies both $SB' > NSB' >$

NSNB′ and *SB′* > *SNB′* > *NSNB′*. With *ISB*, both *NSB* and *SNB* cannot exist in the same equilibrium. That is, if *NSNB*(a) < *SNB*(a), i.e., $\phi(a) > 0$, for some acreage a, then *SB*(a) > *NSB*(a), i.e., $\pi_2 a - \pi_* + \phi(a) > \pi_1 a - \pi_*$, because $\pi_2 \geq \pi_1$. Thus, because *SNB′* > *NSNB′*, *NSB* cannot be the dominant behavior if *SNB* is the dominant behavior for some smaller farm size. Similarly, if *NSNB*(a) < *NSB*(a), i.e., $\pi_1 a - \pi_* > 0$, for some acreage a, then $\pi_2 a - \pi_* + \phi(a) > \phi(a)$ so *SB*(a) > *SNB*(a). Thus, because *SB′* > *SNB′*, *SNB* cannot be the dominant behavior if *NSB* is the dominant behavior for a smaller farm size. If both *SB* and *NSB* behavior occurs (as required by the proposition), then *SNB* does not occur, *NSNB* occurs because $0 < a_1 \leq \bar{a}$, and the ordering of behavior by farmsize must be as in the proposition because *SB′* > *NSB′* > *NSNB′*.

Excluding the uninteresting case where w_1 is so high that no farmer chooses to buy at storefronts, market equilibrium must appear as in Figure 1. The equilibrium including *SNB* (where *NSNB* dominates for $0 < a < \hat{a}$, *SNB* dominates for $\hat{a} < a < a_2$, and *SB* dominates for $a_2 < a < \bar{a}$) has w_1 too high for storefront sales to occur. Likewise, the case where *SB* dominates *NSB* for farmsizes with *NSB* > 0 and dominates *SNB* for farmsizes with *SNB* > 0 is uninteresting.

Proposition 2. Under *IOC* and informed Nash equilibrium, if prices induce both storefront and internet sales, then competitive profit-maximizing farms divide into behavioral regimes by farmsize with either (a) *SNB* behavior for $0 < a < \hat{a}$, *NSNB* behavior for $\hat{a} < a < a_+$, *SB* behavior for $a_+ < a < a_*$, and *NSB* behavior for $a_* < a < \bar{a}$ if $a_+ > a_2$; or (b) with *SNB* behavior for $0 < a < a_2$, *SB* behavior for $a_2 < a < a_*$, and *NSB* behavior for $a_* < a < \bar{a}$ if $a_+ < a_2$. Thus, aggregate net benefits for farmers are

$$(1) \qquad S^I = \int_0^{\min(\hat{a},a_2)} \phi(a)dF(a) + \int_{\max(a_+,a_2)}^{a_*} [\pi_2 a - \pi_* + \phi(a)]dF(a) + \int_{a_*}^{\bar{a}} (\pi_1 a - \pi_*)dF(a)\,.$$

Proof: For the *IOC* case, $\phi' < 0$ and $\pi_1 > 0$ implies *SNB′* < *NSNB′* < *NSB′*. Also, *SNB′* < *SB′* because $\pi_2 > 0$, and *NSNB′* < *SB′* follows from $|\phi'| < \pi_1$ because $w_2 \leq w_1$ implies $\pi_1 \leq \pi_2$, i.e., $\pi_2 + \phi' > 0$. Thus, (i) *SNB′* < *NSNB′* < *SB′* < *NSB′* if $\pi_1 > \pi_2 + \phi'$ (the case of Figure 2), or (ii) *SNB′* < *NSNB′* < *NSB′* < *SB′* if $\pi_1 \leq \pi_2 + \phi'$ (not shown). Under the latter condition, storefront sales do not occur (with linear ϕ) because *SB* dominates *NSB* for all farm sizes if *SB*(0) > *NSB*(0).[2] The proposition follows depending on whether *NSNB* behavior occurs.

Comparable to (3) or (4), aggregate farmer net benefits with no internet site are

$$(5) \qquad S^{NI} = \int_{a_0}^{\bar{a}} (\pi_0 a - \pi_*) dF(a).$$

Comparison of (5) to (3) or (4) requires solving for endogenous prices, w_0, w_1, and w_2.

Market Failure with Competition

Before considering possible price discrimination, examination of a benchmark case with many (competitive) input suppliers is useful. Comparison to this case makes clear that the profit motive for provision of extraneous information is internet price discrimination, which eliminates some cases of market failure associated with information that occur under competition.

Proposition 3. Input suppliers cannot recover the fixed cost of providing extraneous information on internet sales sites under competitive input pricing. Thus, such sites are not provided in the long run under competition if the fixed cost is positive. Market failure occurs depending on whether the incremental benefits for farmers exceed the fixed cost of providing a single site.

Proof: In the many-input-supplier case, competitive pricing causes input supply prices to be bid down to the point of marginal cost pricing, $w_1 = w_2 = c'$ if an internet site is provided and $w_0 = c'$ if not. Aggregate sales and short-run profit are thus the same whether or not internet sites are offered while costs are higher by nK (by K for each supplier) when internet sites are provided. Thus, input suppliers maximize long-run profits by not providing such sites, even if $S^{ISB} - S^{NI}$ (or $S^{IOC} - S^{NI}$) is greater than the cost of providing a site at $w_1 = w_2 = c'$.

As is typical considering the public good nature of information, competitive input suppliers have no incentive to provide information because sales and price are the same either way. A farmer can gain extraneous information by surfing available internet sites and then buying at the lowest internet or storefront price regardless of whether extraneous information is provided there. Unless some alternative source offers the same extraneous information (and ease of access), a market failure occurs suggesting the need for public intervention.

This market failure result depends on uniqueness and convenience of the information offered by internet marketing sites. While public (e.g., USDA and EPA) internet sites offer information useful for assessing program participation requirements and benefits, their price and market information tends to be historical or updated infrequently (not sufficiently processed or updated to support daily production and marketing decisions). By comparison, sites such as DirectAg.com and PowerFarm.com offer readily accessible links to timely commodity price and weather information of general interest for farmers. Such information may fill a unique role.

These results suggest a possible prisoner's dilemma whereby a firm not offering an internet site may lose sales during a transition to the internet but yet, after prices adjust, no firm may be able to recover the cost of providing an internet site. This may explain, in part, the dot.com bust where internet businesses with less product differentiation failed.[3]

Potential Welfare Gains with Monopoly

Consider alternatively the case of a single input supplier as a polar example of concentrated input supply. Concentration has greatly increased in agricultural input supply through mergers and bankruptcies nationally, and through declining farm population and rural commerce at the local level. For example, through concentration of agricultural machinery manufacturing, only one or two machinery companies may compete in many localities. Similarly, the pesticide industry that had 60-70 well-known manufacturers in the 1960s has been concentrated into fewer than ten major worldwide pesticide manufacturers. Furthermore, most individual pesticide markets, e.g., for post-emergent grass control in corn, involve no more than a few of these. Additionally, patents allow legal monopolization of specific agricultural input markets (e.g., brand name pesticides) and the adoption of herbicide-ready plants has increased pesticide specialization.

Consider first as a benchmark the behavior of a single input supplier when no internet site is provided. For the interesting case of an internal solution with $0 < a_0 < \bar{a},$ the no-internet input supplier problem in (2) has first-order condition[4]

(6) $$\Pi_0^{NI} = R_0' A^B + R_0 A_0^B = 0,$$

where subscript i of Π, R, and A denotes differentiation with respect to w_i, e.g., $R_i' = x_i + (w_i - c')x_i'$ and $A_0^B = -x_0 Z_0 < 0$ where $Z_i = dF(a_i)a_i^3 / \pi_* > 0,\ i = 0,1,2.$ Equation (6) is the classical monopoly condition that equates marginal revenue and marginal cost. The first right-hand term can be written as $R_0' A^B = x_0 A^B + (w_0 - c')x_0' A^B$ where $x_0 A^B$ is the marginal profit on existing sales, $(w_0 - c')x_0' A^B$ is the profit reduction from a reduction in application rate, and the remaining term, $R_0 A_0^B$, is the profit reduction from a reduction in acreage on which the input is used, each associated with a small unit increase in price w_0. Monopolistic pricing with downward sloping aggregate demand is caused by the $x_0 A^B$ term. In its absence, (6) is satisfied by competitive pricing at $w_0 = c'$. The latter term of (6) must be negative because $A_0^B < 0$ (the supplier is better off shutting down than choosing a price less than marginal cost).

Viewing as uninteresting the cases where price is set so high that the market disappears $(a_0 \geq \bar{a})$ or so low that all farms use the input $(a_0 \leq 0)$, we consider only an internal solution where $0 < a_0 < \bar{a}.$ The second-order condition, $\Pi_{00}^{NI} = R_0'' A^B + 2R_0' A_0^B + R_0 A_{00}^B < 0,$ can conceivably fail, but failure corresponds to uninteresting cases without an internal solution. Failure cannot occur if A^B is concave in w_0 (because $R_0 A^B$ is concave if R_0 and A^B are concave).

Pricing Behavior and Supplier Profits with Increasing Scale Benefits. If an internet site is provided in the *ISB* case, the single-supplier problem is given by (1) subject to $w_2 \leq w_1$ and $0 < a_1 \leq a_* < \bar{a}$ (where $n = 1$). The latter constraint limits consideration to the interesting case of observed mixed behavior. Any w_1 such that $a_1 > a_*$ is too high for *NSB* to occur, any w_2 such that $a_* \geq \bar{a}$ is too high for *SB* to occur, and any w_1 such that $a_1 \leq 0$ is too low for *NSNB* to occur.

First-order conditions for an internal solution are

(8) $\Pi_1^I = R_1' A^{NSB} + R_1 A_1^{NSB} + R_2 A_1^{SB} = 0,$

(9) $\Pi_2^I = R_2' A^{SB} + R_1 A_2^{NSB} + R_2 A_2^{SB} = 0,$

where $A^{NSB} = \int_{a_1}^{a_*} a\ dF(a),\ A^{SB} = \int_{a_*}^{\bar{a}} a\ dF(a),\quad A_1^{NSB} = -Z_1 x_1 + Z_* x_1 < 0,\ A_1^{SB} = -Z_* x_1 > 0,$ $A_2^{SB} = -A_2^{NSB} = Z_* x_2 < 0,$ and $Z_* = dF(a_*)a_*^3/\phi_* < 0.$ The first two terms in (8) have an interpretation similar to (6) while the latter term represents the increase in profit as upper marginal acreage moves from *NSB* to *SB* behavior with an increase in w_1. This term does not occur in (6) because farmsize is bounded by $\bar{a}$. The interpretation of (9) is symmetric to (8) and similar to (6) except that a_* replaces a_1 as the lower bound of the relevant behavioral regime, and the latter term is modified because the marginal acreage that exits the *SB* regime does not cease to use the input but rather earns alternative per acre profit R_1. As in the no-internet problem, second-order conditions can fail but only in uninteresting cases where an internal solution does not apply. Failure cannot occur if both A^{NSB} and A^{SB} are concave in w_1 and w_2.[5]

Proposition 4. Under *ISB* and informed Nash equilibrium, a monopolistic input supplier will choose not to offer an internet sales site with extraneous information because it offers no possibilities for price discrimination.

Proof: Consider the Lagrangian,

(10) $$L = R_1 A^{NSB} + R_2 A^{SB} - nK + \lambda(w_1 - w_2 - \Delta),$$

which has first-order conditions $\Pi_1^I + \lambda = 0$ and $\Pi_2^I - \lambda = 0$. Let bars denote evaluation at $w_1 = w_2 = \bar{w}_0$ where $\bar{w}_0$ solves (6), and let tildes denote evaluation at prices $w_1 = \tilde{w}_1$ and $w_2 = \tilde{w}_2$ that solve (8) and (9), e.g., $\bar{\Pi}_0^{NI} = 0$ and $\tilde{\Pi}_1^I = \tilde{\Pi}_2^I = 0$. Then the solution of (10) at $\bar{\Delta} = 0$ satisfies $\bar{\Pi}_1^I + \bar{\Pi}_2^I = \bar{\Pi}_0^{NI} = 0$. The relationship of the no-internet and internet cases can thus be examined by imposing the constraint $w_1 - w_2 = \Delta$ and varying Δ from $\bar{\Delta} = 0$ to $\tilde{\Delta} = \tilde{w}_1 - \tilde{w}_2$. Differentiating the constraint implies $dw_1^* / d\Delta - dw_2^* / d\Delta = 1$ where asterisks denote the optimum of (10). Thus, $d\Pi^* / d\Delta = \Pi_1^* dw_1^* / d\Delta + \Pi_2^* dw_2^* / d\Delta = -\lambda^* dw_1^* / d\Delta + \lambda^* (dw_2^* / d\Delta - 1) = -\lambda^*$. By LeChatelier's Principle, λ^* is a monotonic function of Δ such that $\lambda^* \to 0$ as $\Delta \to \tilde{\Delta}$ because $\tilde{\Delta}$ is the point where the constraint coincides with the unconstrained optimum. Thus, if $\Pi_1^I = -\Pi_2^I = -\lambda < (>)\ 0$ at Δ = 0 (the no-internet optimum) then Π^* is decreasing (increasing) in Δ, so the unconstrained optimum must satisfy $\Delta = \tilde{w}_1 - \tilde{w}_2 < (>)\ 0$. Thus, imposing $w_1 - w_2 = \Delta \geq 0$ (Nash equilibrium) in maximizing (1), Kuhn-Tucker conditions imply that prices will be set at optimal unconstrained prices such that $\tilde{w}_1 - \tilde{w}_2 > 0$ if $\bar{\Pi}_1^I = -\bar{\Pi}_2^I > 0$, and otherwise at $w_1 = w_2 = \bar{w}_0$ if $\tilde{w}_1 - \tilde{w}_2 \leq 0$ or, equivalently, if $\bar{\Pi}_1^I = -\bar{\Pi}_2^I < 0$. Evaluating (8) at $w_1 = w_2 = \bar{w}_0$ where $R_1 = R_2 = \bar{R}_0$ yields

$\overline{\Pi}_1^I = \overline{R}_0'\overline{A}^{NSB} + \overline{R}_0\overline{A}_0^B$, which by comparison to (6) at the no-internet optimum, $\overline{\Pi}_0^{NI} = \overline{R}_0'\overline{A}^B + \overline{R}_0\overline{A}_0^B = 0$, implies that $\overline{\Pi}_1^I < 0$ because $\overline{A}^{NSB} < \overline{A}^B = \overline{A}^{NSB} + \overline{A}^{SB}$ and $\overline{A}_0^B = \overline{A}_1^{NSB} + \overline{A}_1^{SB}$. Thus, the constraint $w_1 - w_2 = \Delta \geq 0$ is binding so both prices are set at the optimal no-internet price under *ISB*. Because $\overline{\Pi}^I = \overline{\Pi}^{NI} - K$, the supplier is better off avoiding fixed cost *K* and not offering an internet sales site (sales and other costs are the same either way).

Proposition 4 implies that either the input supplier must undertake some action that requires users of its extraneous information to make purchases at a higher internet price, or price discrimination does not increase profit. Without price discrimination, the input supplier has no way to recover the fixed cost of providing an informative site (excluding the case of product promotion information). In Figure 1, the higher benefits for farmers with an informative internet site are represented by the cross-hatched area. If $w_1 = w_2 = \overline{w}_0$ then $a_* = \hat{a}$ so the cross-hatched area is simply the shaded area below *SNB*. Farmers following *SB* behavior receive benefits from an internet site while farmers who follow *NSB* behavior either way are unaffected. Failure to provide the internet site is a market failure if the incremental farmer benefits exceed the cost *K* of providing the site (assuming the information is not available elsewhere with the same convenience—a necessary condition for the site to be preferred in the first place).

To consider briefly the case where an input supplier tries to charge a higher price for internet sales than storefront sales, if internet sales are limited to those who pay a fixed membership fee, then the effect is equivalent to increasing the negativity of ϕ_* by the amount of the membership fee. Thus, farmers may surf to receive the extraneous information but they would buy the input at the lower storefront price if $w_1 < w_2$. Selling information by membership fee on the internet would then operate as a profit making activity independent of input sales. If a minimum sales quantity were required to access the internet information, the price increment for internet sales multiplied by the minimum sale quantity would be equivalent to a membership fee so that all other purchases would occur at storefronts. The only way the input supplier can charge a higher price on the internet in an informed Nash equilibrium is by offering information that has a value proportional to the amount of sales, which is the case of product promotion information.

Pricing Behavior and Supplier Profits with Increasing Opportunity Cost. For the *IOC* case, the single-supplier problem is given by (1) subject to $w_2 \leq w_1$ and $0 < \max(a_+, a_2) \leq a_* < \bar{a}$ (where $n = 1$). The latter constraint limits consideration to the interesting *IOC* case where both storefront and internet sales occur. Any w_2 such that $\max(a_+, a_2) > a_*$ implies that w_2 is so high that *SB* cannot occur, and any w_1 such that $a_* \geq \bar{a}$ implies that w_1 is so high that *NSB* cannot occur. First-order conditions for an internal solution are again given by (8) and (9) where now $A^{NSB} = \int_{a_*}^{\bar{a}} a\ dF(a)$, $A^{SB} = \int_{\max(a_+, a_2)}^{a_*} a\ dF(a)$, $A_1^{NSB} = -A_1^{SB} = -x_1 Z_* < 0$, and $A_2^{SB} < -A_2^{NSB} = -x_2 Z_*$ < 0, because now $Z_* > 0$. Interpretations of (8) and (9) are similar although the roles reverse as large farms now buy from storefronts and small farms buy on the internet.

Proposition 5. Under *IOC* and informed Nash equilibrium, a monopolistic input supplier will offer an internet sales site with extraneous information and set the internet price lower than the storefront price if the incremental profits from price discrimination more than cover the fixed cost of providing the site.

Proof: The proof follows that of Proposition 4 except that evaluating (8) at $w_1 = w_2 = \bar{w}_0$ yields $\bar{\Pi}_1^I = \bar{R}_0' \bar{A}^{NSB}$ because $A_1^{NSB} = -A_1^{SB}$ and $R_1 = R_2 = \bar{R}_0$, which by comparison to (6) at the no-internet optimum, $\bar{\Pi}_0^{NI} = \bar{R}_0' \bar{A}^B + \bar{R}_0 \bar{A}_0^B = 0$, implies $\bar{\Pi}_1^I > 0$. That is, $\bar{A}_0^B < 0$ in $\bar{\Pi}_0^{NI}$ implies $\bar{R}_0' > 0$, which implies $\bar{\Pi}_1^I > 0$. Thus, the Nash equilibrium constraint, $w_1 - w_2 = \Delta \geq 0$, is not binding in the *IOC* case.

Proposition 6. Suppose per acre input demand generates concave per acre supplier profit under the conditions of Proposition 5. Then (a) the internet price will be lower than the no-internet storefront price and (b) the storefront price will be higher with an internet site than the no-internet storefront price if the farmsize distribution is such that the density function is not declining sharply at acreage levels below that which use the input at the high price.

Proof: (a) Let the arguments of A^B, A^{NSB}, and A^{SB} be given explicitly following $A^B(w_0) = \int_{a_0}^{\bar{a}} a\ dF(a)$, $A^{NSB}(w_1, w_2) = \int_{a_1}^{a_*} a\ dF(a)$, and $A^{SB}(w_1, w_2) = \int_{a_*}^{\bar{a}} a\ dF(a)$. Evaluating the no-internet acreage function at w_2 instead of w_0 given that $w_1 \geq w_2$ in the *IOC* case reveals $A^B(w_2) = A^{NSB}(w_1,w_2) + A^{SB}(w_1,w_2)$ and $A_0^B(w_2) = A_2^{NSB}(w_1,w_2) + A_2^{SB}(w_1,w_2)$ because all acreage for which input use is profitable at internet price w_2 will use the input for $w_1 \geq w_2$ when an internet site is provided. The no-internet first-order condition in (6) can thus be written as

(11) $$\Pi_0^{NI} = R_0'[A^{NSB}(w_1,w_0) + A^{SB}(w_1,w_0)] + R_0[A_2^{NSB}(w_1,w_0) + A_2^{SB}(w_1,w_0)] = 0$$

for any $w_1 \geq w_0$. By comparison, the first-order conditions in (8) and (9) can be rewritten as

(12) $$\Pi_1^I = R_1' A^{NSB}(w_1,w_2) + (R_1 - R_2)A_1^{NSB}(w_1,w_2) = 0,$$

(13) $$\Pi_2^I = R_2' A^{SB}(w_1,w_2) + R_1 A_2^{NSB}(w_1,w_2) + R_2 A_2^{SB}(w_1,w_2) = 0.$$

The difference between (11) and (13) where $w_0 = w_2$ is

$$\Pi_0^{NI} - \Pi_2^I = R_2' A^{NSB}(w_1,w_2) + (R_2 - R_1)A_2^{NSB}(w_1,w_2)$$

$$= [R_2'/x_2 - R_1'/x_1]x_2 A^{NSB}(w_1,w_2) > 0$$

where the latter equality follows by substituting the implication of (12) because $A_2^{NSB}(w_1,w_2)/A_1^{NSB}(w_1,w_2) = -x_2/x_1$. The sign follows because concavity of R implies $R_2'/x_2 - R_1'/x_1 > 0$ if $w_1 > w_2$. Positivity of $\Pi_0^{NI} - \Pi_2^I$ at the optimal $w_1 = \tilde{w}_1$ implies that the optimal no-internet price $\bar{w}_0$ must be greater than the $w_2 = \tilde{w}_2$ that solves the internet problem because $\Pi_0^{NI} > 0$ at $w_0 = \tilde{w}_2$ where $\Pi_2^I = 0$. Thus, by second-order conditions of the no-internet problem, $\Pi_0^{NI} = 0$ must occur at $w_0 > \tilde{w}_2$. (b) To see that $\tilde{w}_1 > \bar{w}_0$, note that (8) and (9) imply

(14) $$\frac{R_1'}{R_1} = -\frac{A_1^{NSB}}{A^{NSB}} - \frac{R_2}{R_1}\frac{A_1^{SB}}{A^{NSB}} > -\frac{A_0^B(w_1)}{A^B(w_1)}$$

(15) $$\frac{R_2'}{R_2} = -\frac{A_2^{SB}}{A^{SB}} - \frac{R_1}{R_2}\frac{A_2^{NSB}}{A^{SB}} > -\frac{A_0^B(w_2)}{A^B(w_2)}$$

respectively, where the latter inequalities follow from (6), which implies $R_0'/R_0 = -A_0^B/A^B$ at $\bar{w}_0$, and, hence, $R_i' A^B(w_i) + R_i A_0^B(w_i) > 0$ or, equivalently, $R_i'/R_i > -A_0^B(w_i)/A^B(w_i)$ at $w_i < \bar{w}_0$ by the associated second-order condition. Equations (14) and (15) can be expressed as

(16) $$\frac{R_1'}{R_1} = \frac{x_1 Z_*}{A^{NSB}} - \frac{R_2}{R_1}\frac{x_1 Z_*}{A^{NSB}} > \frac{x_1 Z_1}{A^{NSB} + A^{SB}}$$

(17) $$\frac{R_2'}{R_2} = \frac{x_2 Z_* + x_2 Z_2}{A^{SB}} - \frac{R_1}{R_2}\frac{x_2 Z_*}{A^{SB}} > \frac{x_2 Z_2}{A^{NSB} + A^{SB}},$$

respectively, where the latter inequality follows from $A^B(w_2) = A^{NSB} + A^{SB} > A^B(w_1)$. Thus, where $\theta = A^{NSB}/(A^{NSB} + A^{SB})$, equations (16) and (17) imply $Z_1R_1 < Z_*(R_1 - R_2)/\theta < Z_2R_2$. Because $R_1 > R_2$ if $w_2 < w_1 < \overline{w}_0$, which follows because concavity of R implies $R_2' > R_1' > \overline{R}_0'$ and (6) implies $\overline{R}_0' > 0$, this condition cannot hold if $Z_1 > Z_2$. Where $Z(w) = dF(a(w))a^3(w)/\pi_*$ and $a(w) = \pi_*/\pi(w)$,

$$(18) \qquad \text{sign}\, Z'(w) = \text{sign}\left[\frac{dF'(a(w))}{dF(a(w))}a(w) + 3\right].$$

Thus, $Z'(w) > 0$ for $w_2 < w < w_1$ and $Z_1 = Z(w_1) > Z_2 = Z(w_2)$ as long as $w_2 < w_1$ and the density function is not declining so sharply at acreages $a(w)$ for $w \leq w_1$ that (18) becomes negative.

The density condition in (18) is typical of the mechanism design literature because erratic distribution functions can cause almost any qualitative result. Intuitively, price discrimination benefits for input suppliers are possible for two reasons. First, the higher storefront price applies to farmers unwilling to bear the opportunity costs of the internet who would buy the input either way. Profits earned from this group increase because the price increases without reducing the acreage on which the input is applied (although the application rate decreases marginally). Second, the lower internet price permits additional sales to farmers willing to bear the opportunity costs of the internet who would not otherwise find use of the input profitable.

Comparing to the case of no internet in Figure 2, the return to input use with no internet follows a broken line with the same intercept as *NSB* but rotated counter-clockwise to $NSB(\overline{w}_0)$ because the storefront price is higher with an internet site. Compared to the case with no internet site, (i) farms with the largest farmsizes, $a_* < a < \overline{a}$, are worse off because they pay a higher price w_1 than $\overline{w}_0$ while applying the input to the same acreage, (ii) farms with intermediate farmsizes, $\overline{a}_0 < a < a_*$, are better off because they receive a lower internet price w_2 than $\overline{w}_0$ while applying the input on the same acreage, in addition to receiving benefits from information, (iii) farms with smaller farmsizes, $a_+ < a < \overline{a}_0$, gain byusing the input on acreage where it would not otherwise be profitable, in addition to receiving benefits from information, and (iv) farms with the smallest farmsizes, $0 < a < \hat{a}$, reap a windfall gain from free information on the internet without buying the input. The windfall gain of the smallest farms is represented by the cross-hatched area below *SNB*. The shaded area represents the loss to farmers who would buy the input in absence of the internet site. The cross-hatched area under *SB*, which partially overlaps the shaded area, represents the additional gains from offering the lower internet price plus the value of information received by those who use the input.

Market failure can also occur in the *IOC* case. The supplier receives incremental price discrimination profits from farms with sizes $a_+ < a < \overline{a}_0$ that would not otherwise be customers, as well as from farms with sizes $a_* < a < \overline{a}$ that pay a higher price than without an internet. However, the input supplier receives no return from the smallest farms who receive the windfall gain, and less profit than without an internet from farms with sizes $\overline{a}_0 < a < a_*$. Thus, private profits from providing an internet site may not be sufficient to offset the fixed cost of providing it even though aggregate social welfare is improved thereby. Further, provision of the internet site is not necessarily preferred if an input supplier chooses to provide it. Because the input supplier charges a higher price to large farms, their per acre use of the input declines (a standard monopoly pricing result). The deadweight loss of this higher price to large farms may or may not be made up by the additional social benefits to those groups who gain when an internet is provided. Social preferences depend on the farmsize distribution and magnitude of fixed costs. These results extend those found elsewhere whereby the internet may or may not increase aggregate economic surplus. For example, third-degree price discrimination has been shown to increase welfare if total output increases (Hausman and MacKie-Mason) or if transactions take place that would not otherwise occur (Deneckere and McAfee).

For the case where $\overline{a}_0 < \hat{a}$ (not shown in Figure 2), the distributional implications are mathematically the same where both $\hat{a}$ and a_* are replaced by a_2. Thus, the largest farms are worse off, small farms receive a windfall gain, and some midsize farms are able to afford use of the input at a profit that would not otherwise be possible. In both cases, the ability to achieve price discrimination through internet sales has nontrivial distributional implications.

Characteristics of Information Provided by Internet Marketing Sites. The informed Nash equilibrium results show that provision of extraneous information on internet sales sites depends on whether the associated fixed costs can be recovered through price discrimination. The results thus determine what types of extraneous information will be provided by internet marketing.

Proposition 7. With informed Nash equilibrium, internet marketing sites will not provide information that has benefits positively correlated with the WTP of farmers for the product offered for sale, nor will they provide extraneous information that benefits all farms.

Proof: Propositions 4 and 5 shows that the correlation of extraneous information benefits with farmers' WTP for the physical input must be negative to facilitate effective price discrimination. Extraneous information with either positive benefits for all customers $(\phi' > 0, \phi_* > 0)$ or negative benefits for all customers $(\phi' < 0, \phi_* < 0)$ does not facilitate price discrimination (thus ruling out cases with $\hat{a} < 0$). Similarly, price discrimination incentives vanish when $\hat{a} > \overline{a}$, because all sales occur on the internet (at storefronts) if $\phi_* > 0$ $(\phi_* < 0)$.

Proposition 7 explains why internet marketing sites choose to offer extraneous information that does not have a direct relationship with the products offered for sale. The optimal degree of price discrimination (the difference in w_1 and w_2) and the ability to recover fixed costs depends on the strength of negativity of the correlation of information benefits with WTP. For example, in both Figures 1 and 2, if *SNB* is relatively flat and thus near the horizontal axis, then $SB \doteq NSB$. Therefore, the incremental profits from price discrimination will be small and less likely to cover the fixed cost of providing an informative internet site.

While market failure is typical for dissemination of information because of its public good nature, a significant contribution of the internet implied by these results is that private provision of information is induced by price discrimination possibilities. But this is true for only for a very specific type of information. Failure to provide information that has positive benefits for all farmers is a market failure that is not resolved by the internet.

Privacy and Naivety on the Internet

While early users tended to be naive about how personal information could be collected and used by internet sites, privacy concerns have been increasing. As users have become less myopic, many businesses have posted policies about sharing personal information. But few individuals read such policies, the policies are often vague and difficult to enforce, and firms often retain the option of sharing data with firms within a corporate structure that do not have the same policies, or of sharing data with firms for which links are provided on the site. Further, when faced with failure, many firms have cut losses by selling customer data (Rosencrance).

Due to privacy concerns, some internet users are increasingly reluctant to provide personal information, e.g., through registration, and expend more effort to investigate alternative prices.[6] To understand the implications of increasing awareness of this reverse information flow, this section examines myopic or uninformed equilibrium, which might represent internet marketing prior to Nash equilibrium. Suppose myopic farmers are unaware of the reverse flow of personal information and the associated price differences associated with surfing behavior. That is, suppose farmers buy or not buy based only on the price revealed by the choice to surf or not. Thus, in the *ISB* (*IOC*) case, farmers with farmsizes larger (smaller) than $\hat{a}$ surf the web and others do not. The supplier can thus monopolize the two groups independently.

Benefits with Increasing Scale Benefits. Aggregate farmer benefits under *ISB* are

$$S^I = \int_{a_1}^{\hat{a}} (\pi_1 a - \pi_*) dF(a) + \int_{\hat{a}}^{\max(a_2,\hat{a})} \phi(a) dF(a) + \int_{\max(a_2,\hat{a})}^{\bar{a}} \left[\pi_2 a - \pi_* + \phi(a)\right] dF(a).$$

Substituting limits of integration into (1), the constraints for an internal solution involving both internet and storefront sales are $0 < a_1 < \hat{a}$ and $a_2 < \bar{a}$. No farm would buy at the storefront (internet) price if $a_1 \geq \hat{a}$ $(a_2 \geq \bar{a})$. Neither constraint is binding unless costs are so high that $c' > w_1, w_2$ for all $a_1 < \hat{a}$ and $a_2 < \bar{a}$. The first-order conditions in (8) and (9) become

(19) $\Pi_1^I = R_1' A^{NSB} + R_1 A_1^{NSB} = 0,$

(20) $\Pi_2^I = R_2' A^{SB} + R_2 A_2^{SB} = 0,$

where now $A^{NSB} = \int_{a_1}^{\hat{a}} a \; dF(a),$ $A^{SB} = \int_{\max(a_2,\hat{a})}^{\bar{a}} a \; dF(a),$ $A_1^{NSB} = -x_1 Z_1 < 0$ $A_1^{SB} = A_2^{NSB} = 0,$ and

$A_2^{SB} = -x_2 Z_2 < 0$ if $a_2 > \hat{a}$ and $A_2^{SB} = 0$ if $a_2 < \hat{a}$. Conditions (19) and (20) are identical in form to the no-internet case of (6) where the upper limit of farmsize distribution is $\hat{a}$ for (19) and $\overline{a}$ for (20). Second-order conditions hold in similar circumstances.

Proposition 8. Under *ISB* and myopic behavior: (a) If all farms that buy the input in absence of an internet site prefer surfing, then a monopolistic input supplier who offers an internet sales site with extraneous information will set the internet price the same as would exist in storefronts in absence of the internet, and set a lower storefront price. The site will be offered if profit from selling in storefronts at the lower price is sufficient to cover the fixed cost of providing the site. (b) Otherwise, a monopolist input supplier who offers such an internet site will charge a higher internet price and a lower storefront price than the storefront price in absence of an internet. (c) In either case, the incentive from price discrimination can be insufficient to offer the site even when provision of the site is socially preferred.

Proof: Consider the two alternatives, $\overline{a}_0 > \hat{a}$ and $\overline{a}_0 < \hat{a}$, to compare pricing behavior with and without an internet site. (a) If $\overline{a}_0 > \hat{a}$, then (20) is an identical condition on w_2 as (6) is on w_0 and yields the same price, $w_2 = \overline{w}_0$. So profit on sales to large farms (with $\overline{a}_0 < a < \overline{a}$) is identical to profit from all farms in the no-internet case. But the input supplier can make additional profit by selling to small farms (with $a_1 < a < \hat{a}$) if a lower storefront price, w_1, satisfies $\overline{w}_0 > w_1 > c$ and $a_1 < \hat{a}$. If this additional profit is more than the fixed cost of providing the internet site, then the input supplier will provide the site. (b) If $\overline{a}_0 < \hat{a}$, then midsize farms that buy at storefronts without an internet site (with $\overline{a}_0 < a < \hat{a}$) will choose not to surf. Evaluating (20) at $w_2 = \overline{w}_0$ yields $\overline{\Pi}_2^I = \overline{R}_2' \overline{A}^{SB}$, which by comparison to (6) at the no-internet optimum, $\overline{\Pi}_0^{NI} = \overline{R}_0' \overline{A}^B - \overline{x}_0^2 \overline{Z}_0 = 0$, implies that $\overline{\Pi}_2^I > 0$ because $\overline{x}_0^2 \overline{Z}_0 > 0$. Positivity and negative monotonicity (by second-order conditions) of (20) at $w_2 = \overline{w}_0$ imply that w_2 must be increased from $\overline{w}_0$ to satisfy (20). Evaluating (19) at $w_1 = \overline{w}_0$ yields $\overline{\Pi}_1^{NI} = \overline{R}_1' \overline{A}^{NSB} - \overline{x}_1^2 \overline{Z}_1 = 0$ compared to (6) at the no-internet optimum. At $w_1 = \overline{w}_0$, the second term is identical to (6) while the first term is proportionally less (because $\overline{A}^{NSB} < \overline{A}^B$), implying negativity of (19). Negativity and negative monotonicity (by second-order conditions) of (19) imply that w_1 must be reduced from $\overline{w}_0$ to satisfy (19). (c) In either case, the internet site will provide a windfall gain to those who follow *SNB* behavior (farmsizes $\hat{a} < a < a_2$) but do not add profit opportunities for the input supplier. Thus, depending on the farmsize distribution, the input supplier may not have a sufficient profit incentive even though provision of the internet site is socially preferable.

Likely, w_2 will be increased at least to the point where $a_2 \geq \hat{a}$ because choosing a lower w_2 would not increase the acreage on which the input is used. If so, farmers with farmsizes at $\hat{a}$ (or slightly larger) will receive zero (or near zero) incremental profits compared to substantially positive profits in the case without an internet site (where all farms with sizes above $\overline{a}_0$ receive positive incremental profits that increase in *a*). So at least the smallest farms that choose to surf (with $a > \hat{a}$) are worse off when an internet site is provided under myopia. Midsize farms (with $\overline{a}_0 < a < \hat{a}$) that would buy at storefronts if an internet site were not provided are better off because they receive a lower storefront price. Smaller farms (with $a_1 < a < \overline{a}_0$) are better off both because they can profitably use the input only when the lower storefront price is provided (note that $a_1 < \overline{a}_0$ follows from $w_1 < \overline{w}_0$).

The interesting contrast in the *ISB* results between myopic and informed equilibria is that opportunities for price discrimination are eliminated by eliminating myopia. Thus, price discrimination may be possible and profitable during the infancy of the internet with both types of information. However, providing information with benefits that are positively correlated with farmsize becomes unprofitable as myopia decreases. These results suggest an interesting hypothesis about the transformation in types of information provided at internet marketing sites.

Benefits with Increasing Opportunity Cost. Aggregate farmer benefits with *IOC* are

$$S^I = \int_0^{\min(a_2,\hat{a})} \phi(a)dF(a) + \int_{\min(a_2,\hat{a})}^{\hat{a}} \left[\pi_2 a - \pi_* + \phi(a)\right] dF(a) + \int_{\max(\hat{a},a_1)}^{\overline{a}} (\pi_1 a - \pi_*) dF(a).$$

Substituting these limits of integration into (1), the relevant constraints for an internal solution that involves both internet and storefront sales are $0 < a_2 < \hat{a}$ and $a_1 < \overline{a}.$ No farm would buy at the internet price if $a_2 \geq \hat{a},$ and no farm would buy at the storefront price if $a_1 \geq \overline{a}.$ Neither constraint is binding unless costs are so high that $c' > w_1, w_2$ for all $a_1 < \bar{a}$ and $a_2 < \hat{a}$. The first-order conditions for an internal solution are given by (19) and (20) where now $A^{NSB} = \int_{\max(\hat{a},a_1)}^{\bar{a}} a\ dF(a)$, $A^{SB} = \int_{a_2}^{\hat{a}} a\ dF(a)$, $A_1^{NSB} = -x_1 Z_1 < 0$ if $a_1 > \hat{a}$ and $A_1^{NSB} = 0$ if $a_1 < \hat{a}$, $A_1^{SB} = A_2^{NSB} = 0$, and $A_2^{SB} = -x_2 Z_2 < 0$. These conditions are parallel to the *ISB* case under myopic behavior with the role of *NSB* and *SB* (and associated prices) reversed. Thus, analogous interpretations and results follow.

Proposition 9. Under *IOC* and myopic behavior: (a) If all firms that buy the input in absence of an internet prefer not surfing, then a monopolistic input supplier who offers an internet sales site with extraneous information will charge a lower internet price and the same storefront price as in the absence of an internet. The site will be offered if the profit from internet selling at a lower price is sufficient to cover the fixed cost of providing the site. (b) Otherwise, a monopolist input supplier who offers such an internet site will charge a lower internet price and a higher storefront price than the storefront price in absence of an internet. (c) In either case, the incentive from price discrimination can be insufficient even when provision of the site is socially preferred.

For the *IOC* case with $\bar{a}_0 < \hat{a}$, larger farms (with $\hat{a} < a < \bar{a}$) who choose not to surf are worse off when an internet site is provided because a higher price is charged at storefronts. But this group is larger than in the informed Nash equilibrium because farms with $\hat{a} < a < a_*$ enjoy a lower internet price and increased profit when informed (note that $\hat{a} < a_*$ follows in the *IOC* case from $w_2 < w_1$). Midsize farms (with $\bar{a}_0 < a < \hat{a}$) that would buy at storefronts if an internet site were not provided are better off because they receive the lower internet price plus information. Smaller farms (with $a_2 < a < \bar{a}_0$) are better off both by receiving information and because they can profitably use the input only at the lower internet price (note that $a_2 < \bar{a}_0$ follows from $w_2 < \bar{w}_0$). Finally, the smallest farms (with $0 < a < a_2$) reap a windfall gain from free information without buying the input, even though they generate no profit for the input supplier. As with *IOC* and informed Nash equilibrium, two offsetting distortions affect whether the input supplier offers an internet site. Monopoly pricing to large farmers may make the input supplier's incremental profits larger than social gains (a distortion that affects more farmers in the myopic case), but windfall gains of free information to the smallest farmers may make social gains larger than the supplier's incremental profit.

Some farmers can be better off and others worse off with myopic behavior. For example, farmers who pay a higher price on the internet because they fail to compare with the lower storefront price are worse off. But farmers with farmsizes below $\hat{a}$ are offered lower prices than with informed behavior. Interestingly, the additional profit for the supplier can also be less than when farmers are informed. For example, in Figure 2, myopia implies that no price discrimination among farmers with farmsizes greater than $\hat{a}$ is possible. They all choose not to surf and thus all face the same price w_1. If the input supplier's cost is such that $w_2 = c'$ yields $a_2 \geq \hat{a},$ then the input supplier cannot price discriminate and no internet site is offered.

Notably, this case where the supplier is worse off with myopic farmers than informed farmers because price discrimination possibilities vanish is also a case where farmers are worse off. With myopia, farmers lose virtually all of the gains that are possible with an internet site in the informed case. Of course, this result arises only under *IOC*. With *ISB*, profit-enhancing price discrimination is not feasible with informed farmers so no internet site is provided. And supplier profits with myopic equilibrium must be higher than in the case with no internet because that outcome is among the ones over which the supplier optimizes.

Conclusions

We have investigated why internet sites provided by agricultural input suppliers offer extraneous information (not directly related to their products) such as current commodity price and weather information. Results generate equilibria with a mixture of internet behavior and non-trivial distributional implications for farmers depending on heterogeneity. In most cases, the benefits are biased toward smaller farms because they benefit from lower prices under price discrimination or because they receive windfall gains from free information without buying. Larger farms in most cases pay higher prices than without an internet.

Input suppliers find providing extraneous information profitable only when it provides additional profits from third-degree price discrimination sufficient to cover the cost of providing an informative marketing site. When farmers are well informed about price differences between storefronts and the internet, only information that has benefits negatively correlated with WTP for the physical input among farmers permits such price discrimination. When farmers are uninformed about price differences (or choose to use or not use the internet based on its transactions costs, risk, and nuisance factors regardless of price), both positive and negative correlation of information benefits with farmers' WTP permit price discrimination. A casual review of agricultural marketing sites reveals a rough correspondence to the implications of the model and explains why informative marketing sites do not focus heavily on promotional information related to the product offered for sale.

The results suggest two contributing explanations for the dot.com bust of 2000 and 2001 in which internet site providers without a real-world presence failed, and why many successful sites have been acquired by established firms with differentiated products. First, competition bids down prices toward marginal cost, which leaves input suppliers without product differentiation unable to cover the fixed cost of an informative internet site. Second, the types of information that can be used profitably by suppliers narrows with decreasing myopia (internet experience). Another oft-cited reason is that consumers trust products of well-established firms, but trust and does not provide a reason why conventional goods are bundled with extraneous information.

Information generally has public good characteristics that lead to market failure. However, price discrimination made possible by informative internet marketing may provide sufficient profits to make its public provision privately profitable for input suppliers. A peculiar implication is that eliminating, say by legal means, the market failure associated with price discrimination can eliminate the possibility of private internet marketing to correct the public good market failure associated with information. But the profit incentive of suppliers may be either too strong (when price discrimination profits are primarily captured from farmers by raising prices, thus reducing application rates) or too weak (because windfall gains for farmers from free information do not add to supplier profitability) to achieve an optimal social welfare.

Several important qualifications must be borne in mind in application of these results. Other motivations for providing informative internet sites besides price discrimination include product promotion, which enhances farmers WTP for the supplier's products, and revenue from advertising products for other firms. Obviously, these explanations offer a viable explanation for providing information generally. But the product promotion explanation does not explain why suppliers provide extraneous information that is not positively related to customers' WTP for the products offered for sale.

The model developed here offers several opportunities for useful generalizations. First, while heterogeneity is measured by farmsize here, the results have implications for modeling other dimensions of heterogeneity. Second, although internet behavior is modeled crudely here by including only a choice to surf or not surf and to buy or not buy the input, the same principles can be generalized to consider other linking choices observed by suppliers in farmers' clickstream behavior. Expanding suppliers' data mining possibilities in this way would make discernment of farmers WTP more accurate and permit greater price discrimination. Third, the model can be generalized to the case of several suppliers by solving for the optimal or equilibrium number of suppliers and then examining the extent of price discrimination possibilities. Fourth, the supplier's choice of information characteristics can be endogenized so the supplier can choose a profit maximizing correlation of extraneous information benefits with WTP. Fifth, endogenizing both firm numbers and suppliers' extraneous information choice can lead to a model of niche internet marketing that can determine the equilibrium number of internet niches and associated extraneous information characteristics that would not be offered by the private sector. Finally, the model could be generalized for the case where some (small?) farmers are myopic but other (large?) farmers are well informed.

Footnotes

[1] Constant cost merely simplifies notation. All results hold under a typical cost function $c(\cdot)$ with standard properties, $c' > 0,\ c'' \geq 0.$

[2] Results thus far hold with nonlinear $\phi.$ With nonlinearity of $\phi,$ both cases (i) and (ii) can occur in the same equilibrium, although any switching must be from the second case to the first as farm size increases if $\phi'' \leq 0.$ Linearity of ϕ is assumed to avoid the tedium of such switching cases.

[3] Dewan, Jing and Seidmann (1999 and 2000) find a similar prisoner's dilemma for price discrimination facilitated by customizing products based on personal information.

[4] Because $\partial a_0 / \partial w_0 > 0,$ an internal solution for a_0 is highly likely. An input supplier cannot increase acreage that uses the input by reducing w_0 below the point where $a_0 = 0$, and input use and revenue would fall to zero by increasing w_0 to the point where $a_0 = \overline{a}.$ If a bounded solution with positive profit occurs, it is at $a_0 = 0$ where all farmers use the input and w_0 is chosen such that the per acre input demand elasticity is equal to the supplier's inverse profit rate, $-x_0' w_0 / x_0 = w_0 / (w_0 - c'),$ which is evident from evaluating (6) at $a_0 = 0$.

[5] To see that results hold with increasing marginal cost, note that (1) becomes $\max_{w_1, w_2} \Pi^I = w_1 x_1 A^{NSB} + w_2 x_2 A^{SB} - c(x_1 A^{NSB} + x_2 A^{SB}) - nK,$ for which first-order conditions are exactly as in (8) and (9), and (2) becomes $\max_{w_0} \Pi^{NI} = w_0 x_0 A^B - c(x_0 A^B),$ for which the first-order condition is exactly as in (6). The second-order conditions are modified only by subtracting additional c'' terms, which make second-order conditions more likely. For example, $c''(x_0 A^B)$ is subtracted from the right-hand side of Π_{00}^{NI} in the no-internet case. Thus, while constancy of marginal cost simplifies the notational presentation, it does not modify the results presented here.

[6] However, few users protect themselves from cookies (small files placed on a user's computer that allow internet sites to identify previous clickstream behavior). As of August 2000, the Pew Research Center reported that 86 percent of online users were concerned about privacy but only 10 percent had disabled cookies. Fifty-six percent did not know what cookies are.

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