Shrouded Attributes and Information Suppression in Competitive Markets

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Abstract

Following Becker (1957) we ask whether competition will eliminate the effects of behavioral biases. We study the case of shrouded product attributes, such as maintenance costs, expensive add-ons, and hidden fees. In standard competitive models with costless advertising all firms choose to reveal all product information. We show that information revelation breaks down when some naive consumers do not anticipate shrouded attributes. Firms will not compete by publicly undercutting their competitors' add-on prices if (i) add-ons have close substitutes that are only exploited by sophisticated consumers, or (ii) many consumers drop out of the market altogether when the add-on market is made salient. We show that informational shrouding flourishes even in highly competitive markets, even in markets with costless advertising and

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even when the shrouding generates allocational inefficiencies. In equilibrium, two kinds of exploitation coexist. Optimizing firms exploit naïve consumers through marketing schemes that shroud negative product information. In turn, sophisticated consumers exploit these marketing schemes. It is not profitable to try and lure either of them to non-exploitative firms. As a result, the distortions due to consumer biases persist across a wide range of markets.

JEL classification: D00, D60, D80, L00.

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1 Introduction

Research in psychology and economics argues that consumers sometimes make suboptimal decisions. Rational firms will optimally exploit such consumers and the resulting equilibria often generate deadweight losses. We would like to know whether these deadweight losses are robust. For example, market inefficiencies give an entering firm the incentive to educate other firms' customers, debias them, offer them efficient pricing schemes, and consequently win their business. Advertising like this helps to protect consumers from their own biases. We want to determine when such debiasing will endogenously arise.

Our analysis begins with the observation that consumers sometimes fail to anticipate contingencies. When consumers pick among a set of goods, some consumers do not take full account of *shrouded product attributes,* including maintenance costs, prices for necessary add-ons, or hidden fees.[1] Bank accounts, for example, have many shrouded attributes like fees and surcharges. A bank may prominently advertise "free checking," but the advertising won't highlight the $30 fee for a bounced check, the $15 surcharge for a checkbook, or the $2 penalty per check for writing more than five checks in a month. Many consumers do not know the details of this fee structure until after they open their account.

Bank accounts are not uniquely opaque. Many products have shrouded attributes that some customers fail to observe when they *initially* choose a product (Ellison 2003).[2] Hotels do not reveal their long distance phone fees when a potential customer asks about the price of a room.[3] Video stores do not remind customers about late fees when a movie is rented.[4] Mail-order retailers hide shipping and handling charges. Rental car companies do not announce their gas refill charges when a car reservation is made. Most mutual funds do not advertise management fees and most individual investors report that they do not know the fees that they are paying (Alexander et al. 1998, Barber et al. 2002). Printer manufacturers almost never advertise operating costs, and only 3% of printer buyers report that they knew

[1] See Caplin and Leahy (2003) for a discussion of the economics of situations where consumers are not aware of some future events.

[2] Ellison (2003) discusses myriad examples of this phenomenon and shows that firms will exploit add-ons to raise profits when consumers have heterogeneous demands.

[3] There are exceptions to this observation. At one point, the discount hotel chain Motel 6 advertised free local phone calls. This suggest that the size of the subsidy (the left-hand side of Eq. 19) is less than the size of the distortion (the right-hand side of Eq. 19). This could be due to the fact that Motel 6 consumers are low income, and very price sensitive. We thank Chad Syverson for drawing this example to our attention.

[4] We thank Joseph Farrell for pointing this example out to us.

the ink price per page when they bought their printer (Hall 2003).

Even when consumers understand that shrouded costs exist, they may not observe these costs before deciding what good to buy. It is well known that firms will exploit aftermarket prices that consumers do not observe at the time the base good is sold (Holton 1957, Lal and Matutes 1994 and Borenstein *et al.* 1995). Complementary add-ons — like printer cartridges — will be priced far above marginal cost.

Cartridge prices that exceed marginal cost create an inefficiency. An economist might conjecture that competition should eliminate the inefficiency: a firm could *cut* its cartridge price and then *advertise* the gap between its own low price and the high cartridge prices of its competitors: "When you choose a printer, remember to take into account the aftermarket for printer cartridges. Our cartridges cost less."

In the current paper, we derive conditions under which this competitive price cutting and educational advertising will actually *not* arise in equilibrium. Educational advertising will not arise when either (i) sophisticated consumers have inexpensive substitutes for overpriced add-ons (Propositions 2 and 11) or (ii) naive consumers drop out of the market altogether when the true cost, inclusive of add-ons, is revealed to them (Proposition 3). When these conditions apply, firms will *not* able to profitably attract naive consumers by teaching them about shrouded high-priced attributes. Since, the second reason is straightforward, we focus most of our analysis on the first one.

We show that when inexpensive add-on substitutes exist, "educated" consumers paradoxically prefer to give their business to firms with *high* add-on prices because these consumers end up with an implicit cross-subsidy from the naive customers at those firms (cf Della Vigna and Malmendier 2003, 2004).[5] Educating consumers won't be a profitable competitive strategy. Advertising (efficient) marginal cost pricing won't attract consumers.

To develop intuition for these results, consider a hotel room that costs the hotel $100 to supply. Once a typical (naive) guest checks in, the guest purchases extra services (parking, meals, minibar, phone, gift shop items, etc.) that cost the hotel $10 to supply. Suppose that those services have a 200% markup, so the hotel charges $30 for the services and makes a $20 service profit. In a competitive market, the hotel will then rent the room for $80; in

[5] DellaVigna and Malmendier (2003, 2004) study cross-subsidies that arise from self-control problems. Naive consumers who don't recognize their self-control problems cross-subsidize sophisticated consumers who do.

equilibrium, total cost (\$100+\$10) equals total revenue (\$80+\$30).

Now consider a nearly identical "educated" customer, who is only different because she anticipates all of the marked up add-ons and finds inexpensive ways to avoid buying them (e.g., she eats before arriving at the hotel, she brings a cell phone instead of relying on the hotel phone, etc.). The educated consumer substitutes away from the add-ons while reaping the benefits of the loss-leader room charge. The key point of our paper is to identify conditions under which educated consumers won't want to leave the firm with high markups, even when competitors are offering marginal-cost pricing. It's often better to pay \$80 for a hotel room and skip a few overpriced add-ons, then to pay \$100 for the same hotel room and get add-ons priced at marginal cost.

In essence, we show that there are two kinds of exploitation. Sophisticated firms exploit naive consumers. In turn, the sophisticated consumers take advantage of these exploitative firms. In equilibrium, nobody has an incentive to deviate, except the naive consumers. But the naive consumers don't know any better and often nobody has an incentive show them the error in their ways. Educating a naive consumer turns him into a (less profitable) sophisticated consumer who still doesn't want to leave the firm.

These findings apply to a wide range of markets. An educated banking customer gets the benefit of a \$25 gift for opening an account and avoids paying the fees that snare naive consumers. An educated credit card holder gets convenience, float, and miles and avoids paying interest charges and late payment fees. An educated home printer buyer gets a loss-leader price and avoids paying for frequent cartridge replacements (by printing in black and white instead of color, printing in draft mode, or printing fewer large jobs at home). In such markets educated consumers prefer to stick with the firms that feature high add-on prices, since these firms have loss-leader base-good prices, and the educated consumer can partially substitute away from the overpriced add-ons.

Our analysis shows why high add-on markups will persist in markets with numerous competitors and *free* advertising. This prediction distinguishes our model from standard search models, which imply that firms have an incentive to disseminate information about their products and choose not to do so only if such dissemination is costly (e.g., Butters 1977, Salop and Stiglitz 1977, Stahl 1989).[6] We identify conditions under which firms will choose

[6]This can be viewed as the key difference between modelling bounded rationality as search costs (e.g., Salop and Stiglitz 1977) and modelling it directly as failure to anticipate an attribute as in our model. In

not to advertise and hence *not* compete by lowering add-on prices, even when advertising is free. This explains why industries with nearly costless marginal information dissemination still shroud their add-on prices.[7] In a search model with only rational consumers, firms will choose to disclose all of their information if they can do so costlessly. In our model, with some naive consumers, shrouding is the more profitable strategy.

The rest of this paper formalizes our claims. Section 2 defines a shrouded attribute and presents a simple equilibrium analysis of a market with discrete demand for add-ons. Section 3 discusses the general case with continuous demand. Section 4 concludes.

Literature Review A recent literature argues that consumers' psychological biases explain a variety of puzzling marketing strategies. DellaVigna and Malmendier (2003), Oster and Morton (2004), and Shui and Ausubel (2004) apply quasi-hyperbolic discounting to respectively study gym contracts, magazine subscriptions, and credit card accounts. Heidhues and Koszegi (2004) and Koszegi and Rabin (2004) apply loss aversion to study bait and switch marketing. Gabaix and Laibson (2004), Jin and Leslie (2003) and Spiegler (2003) apply boundedly rational heuristics to study how market equilibria exploit noise in consumer product evaluations. Finally, the marketing literature (e.g., Bertrand et al. 2004, Wertenbroch 1998) shows how frame manipulations can have dramatic effects on consumer demand.

As a complement to this literature, one might ask why consumer biases persist. Indeed, a long intellectual tradition argues that competition will prevent behavioral biases from having any effects. For instance, Becker (1957) reasons that competition will drive out employment discrimination by firms.[8] Our paper asks whether competitive pressure will drive out consumer biases in the market for add-ons. Although our context is specific, our conclusions apply to many of the biases studied in the literature. In general, firms will not find it profitable to educate consumers if (i) sophisticated consumers are subsidized sufficiently by the mistakes of naives (ii) enough naive consumers will drop out of the market

the search cost approach, if firms can costlessly educate the consumers, they will do so because consumers are Bayesian. If a firm goes out of its way to sustain high search costs, Salop and Stiglitz consumers will rationally infer that it has something to hide. So if advertising costs are low all firms reveal information to the consumers. Crucially, this is not the case in our model with boundedly rational consumers.

[7] Finding the operating cost of a printer (e.g., price of ink per page) on the web site of a printer manufacturer is like looking for a needle in a haystack (cf Hall 2003).

[8] Cf. Laibson and Yariv (2004).

altogether when they become sophisticated.

Many authors have developed rational actor models that explain why add-ons have relatively high markups.[9] Three types of explanations figure prominently in the literature:[10] search costs, commitment, and price discrimination. Our explanation is consumer naiveté, and we work out the difference between this model and the other three.

Search-cost models imply that firms choose high add-on prices because consumers find it too costly to observe add-on prices before the consumers buy the base good (Diamond 1971, Lal and Matutes 1994, Stahl 1979). Like search models, our model predicts that consumers will not always purchase the most competitively priced good. However, our model also generates some contrasts with the predictions of traditional search models. For example, in a search model, easy dissemination of information — e.g., free advertising — eliminates equilibrium market power and markups.[11] However, in our model, the existence of free advertising does not diminish market power since firms individually prefer to shroud information about the add-on market. Similarly, competitive pressure does not generate an incentive to eliminate the shrouding. Our model generates *voluntary* information suppression in equilibrium, a result that won't arise in search equilibria.

Commitment models imply that firms choose high add-on prices when firms can't commit to add-on prices at the time the base good is sold. This theory was introduced in Klemperer's (1987) work on switching costs (see also the survey by Farrell and Klemperer 2004) and extended by Borenstein *et al.* (1995). When firms can't commit to add-on prices, producers will set add-on prices above marginal cost (and rational consumers will anticipate this). In our analysis, we consider the polar case in which firms *can* commit to an add-on price (e.g., in our setting, printer manufacturers can freely and credibly preannounce the price of their printer cartridges).

Price-discrimination models imply that add-on pricing enables firms to charge high demand consumers relatively more than low demand consumers (Ellison 2003). In Ellison's model, search costs make it costly for consumers to observe add-on prices. Add-on pricing

[9] Ayres and Nalebuff (2003) propose that high add-on prices are partially due to *suboptimal* choices on the part of firms. In their view firms would make more profits if they had low add-on prices and consequently developed a good corporate reputation.

[10] Ellison (2003) identifies Holton (1957) as the seminal paper in this literature.

[11] If firms can costlessly unshroud their attributes and consumers are Bayesian, then firms will be forced to eliminate gratuitous search costs in equilibrium. A rational consumer would expect the worst of a firm that engages in gratuitous shrouding.

raises profits because add-on pricing generates a technology for price discrimination. Ellison points out that add-on pricing will not raise profits when advertising is costless (i.e., when search costs vanish). Ellison's analysis motivated our own study, particularly his concluding conjecture that the persistence of shrouding could be explained by some form of costly advertising and/or by bounded rationality. We develop a model with the latter microfoundation.

2 Shrouded Attributes: Definitions and an Example of a Market Equilibrium

We analyze consumers who sometimes make purchase decisions without incorporating the effects of future contingencies, like the need to pay an overdraft fee at a bank. A shrouded attribute is any contingency that is not fully incorporated into the initial purchase decision. We introduce a formal framework below. At this stage we present some examples for motivation.

Shrouded attributes may include surcharges, fees, penalties, accessories, options, or any other hard-to-anticipate feature of the ongoing relationship between a consumer and a firm. We simplify this list by dividing it into two mutually exclusive categories: (unavoidable) surcharges and (avoidable) add-ons.

Surcharges are shrouded attributes that a consumer cannot avoid (or can only probabilistically avoid) once she buys a product. Surcharges are quite common in the rental car industry. Rental car companies typically charge "airport fees," "concession recoupment fees," and "vehicle license fees." These fees are paid to the rental car company and then remitted to third parties. Rental car companies could incorporate these charges into their base prices, but instead they choose to isolate these costs and include them as surcharges tacked on at the end of the transaction. Hidden surcharges are also common in financial contracts where they are tied to particular states of nature that one party probabilistically underweighs.[12]

[12] Landier and Thesmar (2003) study banking contracts. They show that entrepreneurs underestimate the probability of a bad state – the estimated probability is less than the true probability, $\pi^S < \pi^T$. As expected, a well-calibrated bank will distort a debt contract by loading penalties/fees onto the underweighted state. This is isomorphic to a "hidden" surcharge, with probability $\pi^T - \pi^S$. See Appendix 7.3 for a discussion of

While unavoidable surcharges are quite common, most shrouded attributes are complementary goods that consumers have the option to avoid. For example, hotel guests can avoid paying telephone charges if they instead use a public phone or a cell phone. Likewise, hotel guests can avoid paying for a room service meal by finding a local restaurant. Both hotel phone use and hotel room service complement a hotel stay. Such complementary (voluntary) goods are often referred to as *add-ons*.

This paper discusses both unavoidable surcharges and avoidable add-ons, though we will focus most of our analysis on the latter category. In our modeling, we distinguish between a "base good" and the shrouded attribute. In the preceding examples, the base goods are rental cars and hotel rooms and the shrouded attributes are surcharges and hotel services.

We assume that consumers may pick a base good — e.g., hotel — without observing shrouded attributes. For example, a consumer could simply compare prices of closely located four star hotels on a web travel site (e.g., Orbitz), without observing the hotels' telephone pricing schedule[13]. Indeed, we suspect that few people bother to inquire about a hotel's phone charges when reserving a room. Such shrouding is not restricted to the hotel industry. Consumers routinely conduct transactions without complete knowledge of product attributes.

2.1 A Simple Example with Discrete Demand

The body of this paper presents a general model of shrouded attribute pricing and advertising in competitive markets. To develop intuition, we first analyze a stripped down example that illustrates many of the key points. To motivate this example, consider a bank that sells two kinds of services. For a price p a consumer can open an account. If the account holder later violates the minimum balance of the account, she pays a fee $\widehat{p}$. In our language, being "allowed" to violate the minimum balance is an "add-on" service with price $\widehat{p}$. Without loss of generality, we assume that the cost to the bank of having the consumer violate the minimum balance is zero.

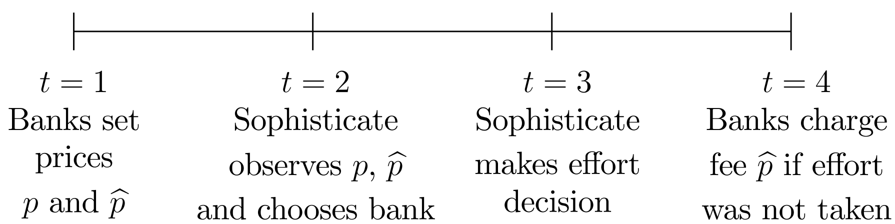
We assume that consumers can avoid violating the minimum balance requirement by exerting effort $e > 0$. For example, the consumer could transfer balances or cut back

a model of partial attention, $A = \pi^S/\pi^T$, that encompasses this case.

[13] Ayres and Nalebuff (2003).

expenditure, etc. We also assume that fee $\widehat{p}$ is effectively bounded above by $\overline{p} > e$. This bound could be generated in many different ways. For example, if a customer is forced to pay a high fee, the customer might terminate her relationship with the bank or lodge a complaint that will waste teller or call-center time. Legal and regulatory constraints also limit the penalties/"fees" that banks can charge.

We assume that sophisticated consumers are aware of and observe the fee $\widehat{p}$. Sophisticated consumers will either exert effort e or pay fee $\widehat{p}$. Assuming that e is measured in a money-metric, the sophisticated consumer violates the minimum balance if and only if $\widehat{p} < e$. The time-line for the sophisticate is given below.



Time-line for Sophisticates

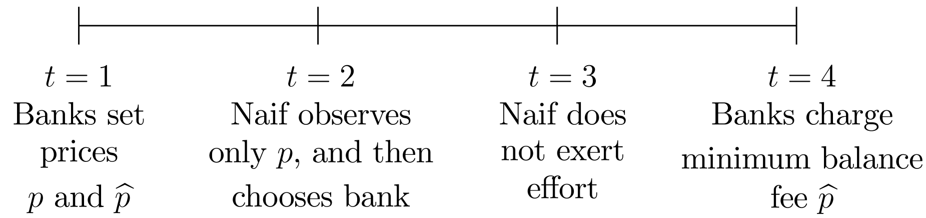
We assume that naive consumers do not consider exerting effort e and do not think about the add-on price $\widehat{p}$. Naive consumers mistakenly believe that $\widehat{p} = 0 < e$.[14] So the naive consumer ends up violating the minimum balance threshold and paying the minimum balance fee $\widehat{p}$.

And here's the second time-line (Naives):

We can now characterize the symmetric equilibrium in this market.[15] Let $D(x_i)$ represent the probability that a consumer opens an account at bank i, assuming that x_i is the *average* anticipated net surplus from opening an account at bank i less the *average* anticipated net

[14] We can relax this assumption by assuming instead that naive consumers simply believe that $\widehat{p} < e$. For example, naive consumers may believe that add-ons are (counterfactually) priced at a low price, say marginal cost.

[15] See Appendix B for a discussion of the existence of a symmetric equilibrium.



Time-line for Naives

surplus from opening an account at the best alternative bank.[16] Variable x_i incorporates anticipated surplus from *both* the base good and the add-on.

For a sophisticated (perfectly rational) consumer,

$$x_i = \left[-p_i - \min\left\{\widehat{p}, e\right\}\right] - \left[-p^* - \min\left\{\widehat{p}^*, e\right\}\right].$$

Throughout the paper we use starred variables to represent the (uniform) prices set by other firms.[17] For a naive consumer,

$$x_i = -p_i + p^*,$$

since the naive consumer neglects the aftermarket when deciding where to open her bank account. D is strictly increasing, bounded below by zero, and bounded above by one.

Let α represent the share of sophisticated consumers in the marketplace. The following proposition shows that firms will choose high markups in the add-on market. Indeed, when the share of sophisticated consumers is small ($\alpha < 1 - e/\overline{p}$), firms will choose markups that are so high that the sophisticated consumers substitute out of the add-on market.

Proposition 1 *Call*

$$\alpha^\dagger = 1 - e/\overline{p}. \tag{1}$$

and

$$\mu = D(0)/D'(0). \tag{2}$$

[16] See Appendix A for a microfoundation of the demand function.
[17] We analyze symmetric equilibria. We give sufficient conditions for the existence of such equilibria in Appendix B.

If $\alpha < \alpha^{\dagger}$*, equilibrium prices are*

$$\begin{aligned} p &= -(1-\alpha)\overline{p}+\mu && (3) \\ \widehat{p} &= \overline{p} && (4) \end{aligned}$$

and only naive agents consume the add-on.
If $\alpha \geq \alpha^{\dagger}$*, equilibrium prices are*

$$\begin{aligned} p &= -e+\mu && (5) \\ \widehat{p} &= e && (6) \end{aligned}$$

and all agents consume the add-on.

Proof. *Step 1.* We observe that if $(p, \widehat{p})$ is a best response, then $\widehat{p} \in \{e, \overline{p}\}$. To see this, consider first the case $\widehat{p} < e$. A firm can increase $\widehat{p}$ by a small positive increment δ, decrease p by the same δ, and not change the demand of sophisticated consumers (the total price they face does not change), but increase strictly the demand of naive consumers.

Consider next the case $e < \widehat{p} < \overline{p}$. The firm can earn more by charging $\widehat{p} = \overline{p}$, as this will not change the demand of naive consumers (which is 1), nor of the sophisticated consumers (which is 0, as sophisticated consumers would rather substitute away from the add-on). Finally, consider the case $\widehat{p} > \overline{p} > e$. The firm can earn more by charging $\widehat{p} = \overline{p}$, as this will increase the demand from naive consumers (form 0 to 1), and will not change the demand of sophisticated consumers (which stays at 0).

Step 2. For $\widehat{p} \in \{e, \overline{p}\}$, the profit function reduces to

$$\begin{aligned} \Pi(p, \widehat{p} = e) &= (p+e)\, D(p^{*}-p) && (7) \\ \Pi(p, \widehat{p} = \overline{p}) &= (p+(1-\alpha)\overline{p})\, D(p^{*}-p). && (8) \end{aligned}$$

Demand is independent of the aftermarket since sophisticates get no utility from it and naives do not anticipate it.

Comparing (7) and (8), we see that the firm picks the maximum of e and $(1-\alpha)\overline{p}$. It will pick $\widehat{p} = \overline{p}$ iff $e < (1-\alpha)\overline{p}$, i.e., iff $\alpha < \alpha^{\dagger}$.

As a result, to pick p the firm solves

$$\max_p \left(p + \max\left\{e, (1-\alpha)\,\overline{p}\right\}\right) D\left(p^* - p\right).$$

The first order condition is

$$D\left(p^* - p\right) - \left(p + \max\left\{e, (1-\alpha)\,\overline{p}\right\}\right) D'\left(p^* - p\right) = 0$$

and in the equilibrium $p = p^*$, so

$$p + \max\left\{e, (1-\alpha)\,\overline{p}\right\} = \frac{D(0)}{D'(0)} = \mu.$$

■

The proposition shows that in equilibrium firms will choose high markups in the add-on market.[18] Firms set $\widehat{p}^* \geq e$, though the marginal cost of producing the add-on is 0. These markups are particularly high when the fraction of sophisticated consumers is small. When $\alpha < 1 - \frac{e}{\overline{p}}$, the markup is $\overline{p}$. High markups for the add-on are offset by low or negative markups on the base good. This is easiest to see when the market is approximately competitive (i.e., the demand curve is highly elastic, and hence μ is close to zero). In a relatively competitive market with small μ, the base good is always a loss leader with a negative markup: $p^* \approx -(1-\alpha)\,\overline{p} < 0$ or $p^* \approx -e < 0$. This explains why in a host of seemingly competitive markets the price of the base good is typically set below its marginal cost (e.g., printer, hotel, car rental), while the price of the shrouded add-on is set well above its marginal cost (printer cartridge, hotel phone call, gas charge[19]).

The model implies that the shrouded attribute will be the "profit-center" and the base good will be the "loss leader." The shrouded attribute market becomes the profit-center because some consumers don't anticipate the shrouded add-on market and won't respond to a price cut in the shrouded attribute market.

We now evaluate the robustness of this result. Previous authors have conjectured that advertising would drive down after-market prices. Shapiro (1995) describes the inefficiency

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[18] For empirical applications,we reexpress Proposition 1 in the case where the marginal costs c and $\widehat{c} \leq e$ are not zero. In this case, if $\alpha < \alpha^\dagger$, $p = c - (1-\alpha)\left(\overline{p} - \widehat{c}\right) + \mu$, and if $\alpha \geq \alpha^\dagger$, $p = c + \widehat{c} - e + \mu$. The value of $\widehat{p}$ does not change.

[19] See Ellison (2003) for more examples.

caused by high markups in the aftermarket and then observes that competition and advertising should drive them away.

> Furthermore, manufacturers in a competitive equipment market have incentives to avoid even this inefficiency by providing information to consumers. A manufacturer could capture profits by raising its [base-good] prices above market levels (i.e., closer to cost), lowering its aftermarket prices below market levels (i.e., closer to cost), and informing buyers that its overall systems price is at or below market. In this fashion, the manufacturer could eliminate some or all of the deadweight loss, attract consumers by offering a lower total cost of ownership, and still capture as profits some of the eliminated deadweight loss. In other words, and unlike traditional monopoly power, the manufacturers have a direct incentive to eliminate even the small inefficiency caused by poor consumer information (Shapiro 1995, p. 495).

We will show that this intuition sometimes fails to apply. In general, high markups in the aftermarket will *not* go away as a result of competition or advertising. We will also describe cases in which advertising does eliminate high markups in the add-on market.

2.2 The Curse of Education: The No-Advertising Result

In this subsection, we show that firms will *not* cut prices in the aftermarket, even if the firms can freely advertise the resulting efficiency gains to consumers. Naturally, our findings also extend to the case in which advertising is costly.[20]

We assume that advertising makes more consumers anticipate the aftermarket, which will lead these previously naive consumers to care about inefficiencies in aftermarket prices. For example, such advertising might report, "When you choose a printer, remember to take into account the aftermarket for printer cartridges. Our cartridge prices are low relative to our competitors." More formally, advertising increases the proportion of sophisticated

[20] See Anderson and Renault (2003) for a complementary analysis of the information revealed by advertising, and Bagwell (2002) for a review of the literature on advertising.

consumers from α to $\alpha' \in (\alpha, 1]$. We assume that all sophisticated consumers anticipate the aftermarket and take into account all aftermarket prices.

We look for a Nash equilibrium, defined as a set of prices and advertising decisions that are all simultaneously chosen. If no firm advertises, then α is low. If at least one firm advertises, then α rises to α'. We take the prices from the previous proposition and call them the *Shrouded Market Prices.*

Proposition 2 *If $\alpha < \alpha^{\dagger}$, the Shrouded Market Prices support an equilibrium in which firms choose not to advertise.*

Proof. If the firm advertises (and thereby deviates from the no-advertising equilibrium), the firm's optimal value $\widehat{p}$ must still be in $\{e, \overline{p}\}$. Its profit, as in (7) and (8), will be

$$\Pi\left(\widehat{p} = e\right) = \max_{p}\left(p + e\right) D\left(p^{*} - p\right) \tag{9}$$

$$\Pi\left(\widehat{p} = \overline{p}\right) = \max_{p}\left(p + \left(1 - \alpha'\right)\overline{p}\right) D\left(p^{*} - p\right). \tag{10}$$

If the firm does not advertise, its profit will be

$$\Pi = \max_{p}\left(p + \left(1 - \alpha\right)\overline{p}\right) D\left(p^{*} - p\right), \tag{11}$$

as implied by the conjectured no-advertising equilibrium. Given that e and $\left(1 - \alpha'\right)\overline{p}$ are each less than $\left(1 - \alpha\right)\overline{p}$, the deviation is not profitable and the no-advertising equilibrium survives. ■

At first glance these results seem highly counter-intuitive. Why doesn't Shapiro's argument about advertising apply? Shapiro conjectured that firms will compete by advertising low add-on prices, thereby making naive consumers more sophisticated and attracting consumers who as a result of the advertising appreciate the benefit of being able to buy efficiently priced add-ons. However, the current proposition shows that this competitive effect is offset by a "pooling" effect. In equilibrium, sophisticated consumers would rather pool with the naive consumers at firms with high add-on prices than defect to firms with marginal cost pricing of both the base good and the add-on.

To gain intuition for this effect consider the case in which the firm has no market power, so $\mu = 0$. If a sophisticated consumer gives her business to a firm with *Shrouded Market*

Prices, the sophisticated consumer's surplus will be,

$$\begin{aligned}\text{sophisticated surplus} &= -p - e \\ &= (1-\alpha)\,\overline{p} - e \\ &> (1-\alpha)\,\overline{p} - (1-\alpha)\,\overline{p} = 0.\end{aligned}$$

By contrast, if the sophisticated consumer gives her business to a firm with zero markups on both the base good and the add-on, the sophisticated consumers surplus will only be 0.[21] So the sophisticated consumer is strictly better off pooling at the firm with *Shrouded Market Prices* (and high aftermarket markups), then deviating to the firm with marginal cost pricing.

This preference for pooling reflects the fact that the sophisticated consumers are being cross-subsidized by the naive consumers. The sophisticated consumers benefit from the "free gifts" and can avoid the high fees.

Because of this effect, no firm has an incentive to cut their add-on prices, raise their base-good prices, and advertise these efficiency-enhancing changes. Making naive consumers sophisticated — i.e., advertising information about add-ons — won't enable the firm to profitably attract those consumers. Hence, monopoly pricing of the add-on will persist in markets with high levels of competition and *free* advertising.

Another of way of seeing this effect is to note that educating naive consumers only enables those consumers to get more value out of their relationships with high markup suppliers. After education, naive consumers see the high add-on prices, and hence know to substitute away from add-ons while still enjoying loss leader prices on the base good.

Note that the current proposition characterizes equilibrium for the case $\alpha \leq \alpha^{\dagger}$. Our no-advertising result will not change if we consider the case $\alpha > \alpha^{\dagger}$. Recall that this latter case generates no inefficiency, since all consumers purchase the add-on in equilibrium. Without inefficiency, no firm will strictly benefit from advertising.

These "no-advertising" results characterize games in which all actions are chosen simultaneously, including advertising. We can change the timing of the advertising decision without affecting the "no-advertising" results. Assume that advertising is chosen first and that all

[21] The particular value of a 0 surplus depends on the choice of normalization. If we shift all utilities by a factor V, the surplus will be V.

firms pick their prices *after* observing the advertising decision. To eliminate indeterminacy, also assume that advertising has a vanishingly small cost. Then we find that advertising will not arise in equilibrium, since the firms that advertise make lower profits then the firms that don't. Advertising won't change the market-wide level of profits (once all firms adjust their prices in response to the advertising), and it won't change the gross profit per firm. Advertising will only reduce the profits of the firms that choose to advertise.

This section's toy model is non-generic in one important sense. In this illustrative model, the sophisticated agents can "easily" substitute away from the add-on. Specifically, welfare losses for sophisticates are bounded even when add-on prices are large. We relax this assumption in the general model of continuous add-on consumption in Section 3.

2.2.1 Another Impediment to Unshrouding

Until now we have ignored the consumer entry decision, since we have assumed that all consumers must buy a base good. We now endogenize the consumer entry decision and find that this reinforces our no-advertising result.

When some consumers naively believe that aftermarket expenses are minimal, these consumers may buy the base good when they should *avoid* the market altogether. Think of a consumer who buys a $50 deskjet printer without realizing that the lifetime operation costs of such a printer typically add up to hundreds of dollars of ink cartridges[22]. Firms that compete by unshrouding high aftermarket prices will drive some of these naive consumers out of the base-good market. Hence, naive consumer entry decisions are another force that discourages firms from using advertising to unshroud the aftermarket.[23]

To illustrate these effects, we adopt a special case of the model we have been using above; specifically, we microfound the demand function with a random utility model (see Appendix B). The perceived value of the good sold by firm i to sophisticated consumer a is

$$v_{ai} = -p - \min(e, \widehat{p}) + \sigma\varepsilon_{ai},$$

with ε_{ai} a random variable with values in $[-1, 1]$. The perceived value of the good sold by

[22] At the moment, black and white text costs between 2 cents and 15 cents per page, depending on the deskjet printer. Color text costs a bit more than black and white text A photographic image costs an order of magnitude more. Printing 10 pages per day at 10 cents a page costs $1460 over four years.

[23] Ellison (2003) anticipates this effect in the discussion of his model with sophisticated consumers.

firm i to naive consumer a is

$$v_{ai} = -p + \sigma \varepsilon_{ai}.$$

Note that naive consumers overlook the add-on market, implying that their perceptions omit the term $\min(e, \widehat{p})$.

We call R the reservation value. A consumer first picks the good i with the highest v_{ai}, and buys that good iff $v_{ai} \geq R$. The following illustrative proposition shows that introducing a binding reservation value reinforces our earlier "no-advertising" prediction.

Suppose that a fraction γ of naive consumers have a finite reservation value R, while the other naive consumers will always want to buy the good.[24] Given our assumptions, it will turn out that the consumer with reservation value R will want to buy the good when they are naive, but will not want to buy the good when they become sophisticated and realize that the full price of the good is quite high. To illustrate this effect, we assume a simple sufficient condition.

$$\sigma < R < -\mu + \max\left[(1-\alpha)\,\overline{p}, e\right] - \sigma. \tag{12}$$

Proposition 3 *Assume that some naive consumers exist — i.e., the fraction of sophisticates, α, is strictly less than one. Assume that a fraction $\gamma > 0$ of naive consumers have a finite reservation utility R, satisfying equation 12. Then if costless advertising becomes possible, firms still choose not to advertise in equilibrium. The market keeps the Shrouded Market Prices of Proposition 1.*

The proof is in Appendix C. Condition $R > \sigma$ implies that, even if the price of the base good and the add-ons were 0, the consumer would still prefer not to consume the good.[25]

2.3 Welfare

In this subsection we consider the welfare consequences of naiveté.

Proposition 4 *Suppose that the reservation utility is such that all consumers would buy the good, even if they were aware of the cost of the add-on ($\gamma = 0$). The equilibrium social*

[24] They have a $-\infty$ reservation utility.

[25] With marginal costs c and $\widehat{c}$, this condition would become: $R > \sigma - c - \min(e, \widehat{c})$.

welfare loss is

$$\begin{aligned}\Lambda &= \alpha e \text{ for } \alpha \in \left[0, \alpha^{\dagger}\right] \\ &= 0 \text{ for } \alpha \in (\alpha^{\dagger}, 1)\end{aligned}$$

where the loss is calculated relative to the case in which all consumers are sophisticated ($\alpha = 1$). For $\alpha \leq \alpha^{\dagger}$, sophisticated consumers are $\overline{p} - e$ units better off than naive consumers. For $\alpha > \alpha^{\dagger}$, all consumers are equally well.

Proof. The social welfare loss is proportional (with factor e) to the fraction of agents who exert costly effort when a socially costless substitute is available. When $\alpha \in \left[0, \alpha^{\dagger}\right]$, all of the sophisticated agents exert effort e, so the deadweight loss is αe. When $\alpha > \alpha^{\dagger}$, no agents exert costly effort, since the firms price the add-on at $p = e$. ■

Consumption of the add-on is socially efficient since the add-on is produced at zero *social* cost.[26] In the case with inefficiency ($\alpha < \alpha^{\dagger}$), the welfare losses increase as the fraction of sophisticates increase, since sophisticates are the source of socially inefficient underconsumption of the add-on. In equilibrium, all naive consumers purchase the add-on, hence there are no social deadweight losses when there are only naive consumers (i.e., $\alpha = 0$).[27]

However, social losses will arise *if* shrouded attributes generate distorted consumer decisions to buy the base good. Assume that a fraction $\gamma(1 - \alpha)$ of consumers shouldn't buy the good. This corresponds to a social loss of R, where R is the consumer's reservation utility, and 0 is the consumer's actual utility. The welfare accounting is given by the following corollary.

Corollary 5 *Suppose that a fraction γ of naive consumers satisfy $R > 0$ (with $\sigma = 0$). Those consumers would not buy the good if they were aware of the cost of the add-on. Then, the equilibrium social welfare loss is*

$$\begin{aligned}\Lambda &= \alpha e + (1 - \alpha)\gamma R \text{ for } \alpha \in \left[0, \alpha^{\dagger}\right] \\ &= (1 - \alpha)\gamma R \text{ for } \alpha \in (\alpha^{\dagger}, 1).\end{aligned}$$

[26] This assumption is made without loss of generality.

[27] This conclusion is a special property of the toy model and does not generalize to the continuous demand model of the next section.

The total deadweight loss is decomposed into losses arising from price distortions, αe, plus losses arising from purchases of goods that are not socially beneficial, $(1-\alpha)\gamma R$. The second term falls linearly with fraction of sophisticated consumers, α.

3 General case of Shrouded Attributes with Continuous Demand

In this section, we generalize the arguments above to the case of continuous demand for the add-on. We show that the no-advertising result applies when sophisticates have relatively inexpensive substitutes for the add-ons. For example, a sophisticated hotel visitor will bring her cell phone, providing a low-cost substitute for hotel phone service. When sophisticates do *not* have a relatively inexpensive substitute technology, firms will choose to advertise low add-on prices.[28]

As before, each firm sells a base good with a single shrouded attribute. Each firm sets a price p_i for the base good. Each firm also sets a price $\widehat{p}_i$ for the shrouded attribute. If the shrouded attribute is a surcharge, then $\widehat{p}_i$ is the value of the surcharge. If the shrouded attribute is an add-on, then $\widehat{p}_i$ is the per-unit price of the add-on.

Total utility is decomposed into two parts: the value of owning the base good assuming that the shrouded attribute did not exist and the incremental value of the shrouded attribute. Let u_{ai} represent agent a's gross value of firm i's *base good*, not including the value associated with the shrouded attribute. Let $\widehat{u}(\widehat{e}_{ai}, \widehat{q}_{ai})$ represent the gross utility flow associated with the *after-market*, reflecting both the quantity of the add-on that is consumed, $\widehat{q}_{ai}$, and any costly efforts, $\widehat{e}_{ai}$, to substitute away from the add-on. So $\partial\widehat{u}(\widehat{e}_{ai}, \widehat{q}_{ai})/\partial\widehat{e}_{ai} \leq 0$, $\partial\widehat{u}(\widehat{e}_{ai}, \widehat{q}_{ai})/\partial\widehat{q}_{ai} \geq 0$, and $\partial^2\widehat{u}(\widehat{e}_{ai}, \widehat{q}_{ai})/\partial\widehat{e}_{ai}\partial\widehat{q}_{ai} \leq 0$. Note that substitution is only possible when the shrouded attribute is at least partially avoidable. In the surcharge case, $\widehat{e}_{ai} = 0$ and $\widehat{q}_{ai} = 1$.

[28] In some ways, these results reflect our early findings. Recall that inefficient add-on pricing only arises in the toy model when the fraction of sophisticated consumers is less than $1 - e/\overline{p}$. Here e represents the cost of substituting away from the add-on. As e rises, inefficient add-on pricing is less likely.

Summing up all of the terms, the net value of buying the base good can be written

$$\underbrace{u_{ai} - p_i}_{\text{base good}} + \underbrace{\widehat{u}\left(\widehat{e}_{ai}, \widehat{q}_{ai}\right) - \widehat{p}_i \widehat{q}_{ai}}_{\text{shrouded attribute}} .$$

3.1 Sophisticated Consumers

Sophisticated consumers take into account the existence of the add-on, so they choose $\widehat{e}$ optimally. For example, a sophisticated consumer will avoid hotel phone charges by bringing a cell phone. A sophisticated bank customer will avoid late payment fees by mailing mortgage payments early. A sophisticated printer owner will avoid buying expensive ink cartridges by printing large jobs on the office machine (instead of printing at home).[29]

We adopt the following timing assumptions for the sophisticated consumer. The sophisticated consumer first observes all prices at all firms, then picks a base good i, then picks a level of substitution effort $\widehat{e}_{ai}$, and finally picks a quantity of add-ons $\widehat{q}_{ai}$. Formally, the complete maximization problem for the sophisticated consumer can be written,

$$\max_i \left\{ \max_{\widehat{e}_{ai}, \widehat{q}_{ai}} u_{ai} - p_i + \widehat{u}\left(\widehat{e}_{ai}, \widehat{q}_{ai}\right) - \widehat{p}_i \widehat{q}_{ai} \right\} .$$

We introduce notation that enables us to compactly summarize the choices of the sophisticated consumer. Let $\widehat{e}^S_{ai}(\widehat{p})$ and $\widehat{q}^S_{ai}(\widehat{p})$ represent the equilibrium choices of the sophisticated consumer who buys good i,

$$u_{ai} - p_i + \widehat{u}\left(\widehat{e}^S_{ai}(\widehat{p}), \widehat{q}^S_{ai}(\widehat{p})\right) - \widehat{p}_i \widehat{q}^S_{ai}(\widehat{p}) = \max_{\widehat{e}_{ai}, \widehat{q}_{ai}} u_{ai} - p_i + \widehat{u}\left(\widehat{e}_{ai}, \widehat{q}_{ai}\right) - \widehat{p}_i \widehat{q}_{ai}.$$

Without loss of generality, we assume that $E_a u_{ai} = 0$. Then the average utility of sophisticated consumers at firm i is

$$u^S(p_i, \widehat{p}_i) \equiv -p_i + \widehat{u}\left(\widehat{e}^S_{ai}, \widehat{q}^S_{ai}\right) - \widehat{p}_i \widehat{q}^S_{ai}.$$

[29] A sophisticated consumer could also purchase the add-on from a third party, at some transaction cost. This is why base-good firms often hinder such third party transactions. See Salop (1993) and Hall (2003) for examples.

3.2 Naive Consumers

Naive consumers do not (fully) take account of the effect of the shrouded attribute,[30] and they may choose $\widehat{e}$ suboptimally. For example, a naive consumer will not recognize the true (high) price of printing on her inkjet printer and will therefore fail to appropriately reduce her use of the printer. Eventually, the naive consumer may learn the true costs of the add-on, but these learning effects are not modeled in this paper to preserve tractability.[31]

We make the following timing assumptions. The naive consumer first observes only *base-good* prices, then picks a base good i, and then picks some *default* level of substitution effort $\widehat{e}_{ai}$. Later, the add-on price $\widehat{p}_i$ is revealed to the naive consumer and she finally picks an add-on quantity $\widehat{q}_{ai}$.[32]

The complete maximization problem for the naive consumer can be decomposed into three parts. First the naive consumer picks a base good:

$$\max_i \{u_{ai} - p_i + \text{constant}\}.$$

The constant in this equation captures the naive consumer's expectations about the aftermarket. Note that this constant does not depend on the true value of $\widehat{p}_i$. This last assumption could be relaxed as we discuss below.

The naive consumer now chooses a substitution level that we denote $\widehat{e}_{ai}^N$. We assume $\widehat{e}_{ai}^N$ does not depend on $\widehat{p}_i$ and that $\widehat{e}_{ai}^N \leq \widehat{e}_{ai}^S$. To motivate this setup, we assume that naive agents choose their substitution level under the false belief that the add-on price is low (e.g., the marginal cost of producing the add-on[33]). We could weaken this assumption by making $\widehat{e}_{ai}^N$ depend on $\widehat{p}_i$ with some sensitivity, but with insufficient sensitivity relative to the

[30] See Stahl and Wilson (1995) for a model of myopic decision-making.

[31] As the industry matures, more and more consumers become sophisticated. This generates interesting industry dynamics. At the beginning, most consumers are naive (α is low). They get burned and progressively become more sophisticated. At some point, there are enough sophisticated consumers to make the pooling equilibrium break down ($\alpha \geq \alpha^{\dagger}$). Pricing is now closer to marginal cost. This may be the time when a new innovation is introduced, with new shrouded attributes, and a new cycle starts again. We thank Douglas Bernheim for this observation.

[32] Here consumers are locked in after they buy the base good. In a repeated game model, consumers could switch. In the pooling equilibrium of our model, though, this will not happen. After a consumer becomes sophisticated, she will enjoy the subsidy from the naive consumers, and will stay with the initial firm she chose. Concretely she was burned by a surprise charge at her bank, but all other banks have similar fees. So she does not switch, and just makes sure to avoid the fees next time.

[33] This heuristic is appealing because it is approximately true in most market settings.

optimal level of responsiveness.[34] It is notationally easier to consider the extreme case of no dependence between $\widehat{e}_{ai}^{N}$ and $\widehat{p}_i$, which is the approach we take in this paper. Alternatively, we could assume that naive agents underestimate how much of the add-on they will end up consuming. As an example of the last mechanism, consider a consumer who knows the true price of hotel phone calls, but mistakenly believes that she will not need to use the hotel phone.

Finally, the naive consumer chooses $\widehat{q}_{ai}$, the continuous quantity of add-on consumption. We assume that this choice is made after the substitution effort level $\widehat{e}_{ai}^{N}$ has already been fixed and after the add-on price $\widehat{p}_i$ is eventually revealed:

$$\max_{\widehat{q}_{ai}} \ \widehat{u}\left(\widehat{e}_{ai}^{N}, \widehat{q}_{ai}\right) - \widehat{p}_i \widehat{q}_{ai} \ .$$

We introduce notation that enables us to summarize the choices of the naive consumer. Let $\widehat{q}_{ai}^{N}\left(\widehat{p}\right)$ represent the equilibrium choices of the naive consumer who buys good i.

$$\widehat{q}_{ai}^{N}\left(\widehat{p}\right) \equiv \arg\max_{\widehat{q}_{ai}} \ \widehat{u}\left(\widehat{e}_{ai}^{N}, \widehat{q}_{ai}\right) - \widehat{p}_i \widehat{q}_{ai}$$

3.3 The Firm's Problem

To analyze the firm's optimization problem, we need to know how firm level demand responds to the average perceived value of buying the firm's base good. Let $D(x)$ represent the demand of a firm that offers an average perceived surplus x units greater than the average perceived surplus provided by its competitors (Appendix A presents a standard microfoundation for D). We assume that a fraction α of consumers are sophisticated and a fraction $1-\alpha$ of consumers are naive, and that they share the same demand curve $D(.)$, though they will have different perceived surpluses. Finally, we assume that the marginal cost of manufacturing the base good (e.g., printer) is c, and the marginal cost of manufacturing the add-on (printer cartridge) is $\widehat{c}$.

[34] For example, the naive consumer could simply underestimate the true price of the add-on by a factor θ.

Drawing all of our assumptions together, the firm's profits will be,

$$\Pi = \alpha \left(p - c + (\widehat{p} - \widehat{c})\, \widehat{q}^S(\widehat{p})\right) D\left(u^S(p, \widehat{p}) - u^S(p^*, \widehat{p}^*)\right) \\ + (1-\alpha)\left(p - c + (\widehat{p} - \widehat{c})\, \widehat{q}^N(\widehat{p})\right) D(-p + p^*)\,. \tag{13}$$

The first line represents profit derived from sophisticated consumers and the second line represents profit derived from naive consumers.

3.4 Characterization of Equilibrium

We characterize equilibria when a symmetric equilibrium exists. Existence is guaranteed for sufficiently high levels of idiosyncratic variation in consumer preferences (see Appendix B).

Proposition 6 *Define the weighted demand for the add-on:*

$$\widehat{\overline{q}}(\widehat{p}) := \alpha \widehat{q}^S(\widehat{p}) + (1-\alpha)\, \widehat{q}^N(\widehat{p})\,. \tag{14}$$

If a symmetric equilibrium exists, it satisfies:

$$\frac{d}{d\widehat{p}}\left[(\widehat{p} - \widehat{c})\, \widehat{\overline{q}}(\widehat{p})\right] = \frac{\alpha \widehat{q}^S(\widehat{p})}{\mu}\left[p - c + (\widehat{p} - \widehat{c})\, \widehat{q}^S(\widehat{p})\right] \tag{15}$$

$$p - c + (\widehat{p} - \widehat{c})\, \widehat{\overline{q}}(\widehat{p}) = \mu, \tag{16}$$

where μ is the inverse quasi-elasticity of the demand for the good,

$$\mu = D(0)/D'(0). \tag{17}$$

Corollary 7 *If all consumers are naive ($\alpha = 0$), the add-on has a price corresponding to the case of full monopoly:*

$$\frac{\widehat{p} - \widehat{c}}{\widehat{p}} = \frac{1}{\eta},$$

where $\eta = -\widehat{p}\widehat{q}^{N\prime}(\widehat{p}) / \widehat{q}^N(\widehat{p})$ is the price elasticity of the naive demand for the shrouded attribute.

Corollary 8 *If all consumers are sophisticated ($\alpha = 1$), the add-on is priced at marginal* *cost:*

$$\widehat{p} - \widehat{c} = 0$$
$$p - c = \mu.$$

Corollary 9 *If the sophisticated and naive consumers have the same demand function* $\widehat{q}(\widehat{p})$ *for the add-on, then:*

$$\frac{\widehat{p} - \widehat{c}}{\widehat{p}} = \frac{1 - \alpha}{\eta}, \tag{18}$$

where $\eta = -\widehat{p}\widehat{q}'(\widehat{p}) / \widehat{q}(\widehat{p})$ *is the price elasticity of the demand for the shrouded attribute.*

Corollary 10 *In the case of (unavoidable) surcharges, the surcharge* $\widehat{p}$ *is set to its upper bound and*

$$p - c = \mu - (\widehat{p} - \widehat{c}).$$

The proofs are in Appendix C.

If all consumers are sophisticated ($\alpha = 1$), the market equilibrium reflects marginal cost pricing of the add-on $\widehat{p} - \widehat{c} = 0$ (Corollary 8), replicating standard economic efficiency results. By contrast, if no consumers are sophisticated ($\alpha = 0$), we get monopoly pricing of the add-on (Corollary 7). Firms exploit the invisibility of the add-on market and charge their captured customers full monopoly prices for add-ons.

In the intermediate cases ($0 < \alpha < 1$), the add-on will have supra-competitive markups and these markups are offset by low or negative markups on the base good. This is easiest to see when the market is approximately competitive (i.e., the demand curve is highly elastic, and hence μ is close to zero). Equation (16) decomposes profits per customer into two terms: profits on the base good and profits on the add-on. Equation (16) implies that in a relatively competitive market (i.e., μ small), the base good is always a loss leader with a negative markup: $p - c \approx -(\widehat{p} - \widehat{c})\,\widehat{\overline{q}}(\widehat{p}) < 0$.

Equation (18) enables an analyst to use data on markups and demand elasticities to impute the fraction of sophisticated consumers, α

$$\alpha = 1 - \eta(\widehat{p} - \widehat{c}) / \widehat{p}.$$

Markets with high markups and high add-on elasticities are likely to have a low level of consumer sophistication. Intuitively, competitive pressure would normally push down add-on prices in markets with elastic demand curves, unless some consumers do not anticipate the aftermarket when they pick their base good.

In practice a good is likely to have many aftermarket components with different degrees of shroudedness. In Appendix C we present the generalization of our results to this multi-attribute case. Once again, high add-on markups are generated by high levels of shroudedness.

3.5 The Curse of Education: The No-Advertising Result

In this subsection, we show that firms may *not* cut prices in the aftermarket (raising prices in the base-good market), even if the firms can advertise the resulting efficiency gains to *naive* consumers. As before, we assume that advertising is free and that advertising leads previously naive consumers to become aware of inefficiencies in aftermarket prices. In the current subsection, we assume that advertising increases the proportion of sophisticated consumers from α to 1. We assume that sophisticated consumers observe all aftermarket prices.

We look for a Nash equilibrium, defined as a set of prices and advertising decisions that are all simultaneously chosen. If no firm advertises, then α is unchanged. If at least one firm advertises, then α rises to 1. We take the prices from the previous proposition (6) and call them the *Shrouded Market Prices*. Let $\widehat{u}^S(\widehat{p})$ represent aftermarket utility, so $\widehat{u}^S(\widehat{p}) \equiv \widehat{u}\left(\widehat{e}^S(\widehat{p}), \widehat{q}^S(\widehat{p})\right)$.

Proposition 11 *The Shrouded Market Prices support an equilibrium in which firms choose not to advertise if and only if:*

$$(1-\alpha)(\widehat{p}-\widehat{c})\left(\widehat{q}^N(\widehat{p})-\widehat{q}^S(\widehat{p})\right) > \left[\widehat{u}^S(\widehat{c})-\widehat{c}\widehat{q}^S(\widehat{c})\right]-\left[\widehat{u}^S(\widehat{p})-\widehat{c}\widehat{q}^S(\widehat{p})\right]. \tag{19}$$

The proof is in Appendix C.

This no-advertising result contains a boundary condition that determines when advertising will appear. Intuitively, advertising — and resulting segmentation — does not arise when the distortion from the monopoly pricing in the add-on market is less costly to sophisticates than the benefits of loss leader pricing in the base good market. Hence, advertising does not appear because there are no profitable prices that will enable the firm to educate *naive* consumers — thereby making them *sophisticated* — and lure them away from firms with high add-on markups. Educating naive consumers only enables those consumers to get more value out of their relationships with high markup suppliers. After education, naive consumers see the high add-on prices, and hence know to substitute away from add-ons while still enjoying loss leader prices on the base good.

Formally, advertising does not arise when the cross-subsidies to sophisticates are larger than the distortions arising from pricing that deviates from marginal cost. To see this worked out in a transparent example, consider the case in which $\mu = 0$, so firms have no market power. Now consider the equilibrium payoff of a sophisticated consumer in the no-advertising equilibrium:

$$-p + \widehat{u}^S(\widehat{p}) - \widehat{p}\widehat{q}^S(\widehat{p}).$$

Compare this to the equilibrium payoff of a sophisticated consumer if the consumer has access to a firm with marginal cost pricing:

$$-c + \widehat{u}^S(\widehat{c}) - \widehat{c}\widehat{q}^S(\widehat{c}).$$

To further simplify exposition assume (without loss of generality) that $c = \widehat{c} = 0$. Then the sophisticated payoff with marginal cost pricing reduces to $\widehat{u}^S(0)$. The no-advertising equilibrium is robust if the payoff with marginal cost pricing is less than the payoff in the no-advertising equilibrium:

$$\widehat{u}^S(0) < -p + \widehat{u}^S(\widehat{p}) - \widehat{p}\widehat{q}^S(\widehat{p}).$$

Substituting equation (16) implies that this inequality can be reexpressed

$$\widehat{u}^S(0) < \widehat{p}\widehat{\overline{q}}(\widehat{p}) + \widehat{u}^S(\widehat{p}) - \widehat{p}\widehat{q}^S(\widehat{p}),$$

recalling that $\widehat{\overline{q}}(\widehat{p}) = \alpha\widehat{q}^S(\widehat{p}) + (1-\alpha)\widehat{q}^N(\widehat{p})$. Rearranging yields

$$(1-\alpha)\widehat{p}\left(\widehat{q}^N(\widehat{p}) - \widehat{q}^S(\widehat{p})\right) > \widehat{u}^S(0) - \widehat{u}^S(\widehat{p}),$$

which is equivalent to the condition in Proposition 11 when $c = \widehat{c} = 0$. Formally, firms choose to advertise when the *cross-subsidies* to sophisticates (the left hand side of the inequality) are smaller than the *distortions* arising from pricing that deviates from marginal cost (the right hand side).

Until now, this subsection has focused on the case of shrouded add-ons. When the shrouded attribute is instead a *surcharge*, two types of equilibria exist: one with advertising and indeterminate use of surcharges (holding the "total" price fixed) and one with maximal surcharges and no advertising. If advertising has a vanishingly small cost then the second type of equilibrium is selected. Hence, the model predicts that maximal surcharges will always arise when advertising is nearly costless.

Finally, our earlier conclusions about the effects of endogenous entry (subsection 2.2.1) apply to the general model discussed in this section. Again endogenizing the consumer's entry decision reinforces our no-advertising results. The benefits to producers of advertising the aftermarket are further reduced when advertising reveals aftermarket costs that drive some consumers out of the base-good market altogether.

3.6 Welfare Losses from Shrouded Attributes

We have already seen that if all consumers are sophisticated ($\alpha = 1$), then add-ons are priced at marginal cost. When some consumers are naive, add-ons are priced above marginal cost, producing classic welfare losses associated with underconsumption of the add-on. We call this loss Λ_H (H for "Harberger's triangle").

Deadweight losses may also arise from excess consumer purchases in the *base-good* market. Some naive consumers buy the base good because they have not thought about the (high) price of the add-on. Had they considered the add-on price, they might not have purchased anything at all. In the worst case, the welfare loss is the full marginal cost of the base good and the (purchased) add-on. We call this loss Λ_{FP} (for False Positive) as it arises from consumers who shouldn't have entered the base-good market in the first place.

It is well known that Harberger's triangles Λ_H are of second order magnitude when price distortions are small.[35] The losses Λ_{FP} are always first order and are likely to be big in practice. For instance, if some consumers in the printer market should not have bought their

[35] In our case, the price distortions may not be local, since large mark ups in the aftermarket will translate into large subsidies in base-good pricing.

$50 printer, then the social welfare loss may be as high as the full printer price. Such results are an additional reason why naiveté is very important for welfare. The first-order entry loss, Λ_{FP}, is more important than classical second-order losses, Λ_H. Appendix D develops these points and shows that Λ_{FP} can attain its upper bound: the sum of the marginal costs of the base good and the add-ons.[36]

4 Conclusion

Following Becker (1957) we ask whether competition will correct behavioral biases. A monopolist can exploit consumers' biases. Sometimes competition will protect naive consumers. Our main contribution is to identify conditions under which competition fails to be protective. We show that competition will not induce firms to reveal information that would improve market efficiency.

We analyze an environment in which consumers fail to anticipate "shrouded attributes" of goods, like the high cost of replacement printer cartridges. We identify conditions under which competition and advertising fail to fix these distortions. Even when advertising is free, firms will not use it, thereby suppressing the competitive pressure that advertising normally produces.

In equilibrium, educated consumers buy the loss-leader base good and partially substitute away from add-on consumption. Educated consumers take advantage of subsidized hotel room prices and avoid high hotel service charges (e.g., phone, food, mini-bar, etc). So educated consumers end up with a cross-subsidy from their naive counterparts. Advertising low markups and educating consumers about the aftermarket won't attract new customers. Educated consumers would rather pool with naive consumers than defect to firms with marginal cost pricing.

Our analysis implies that improvements in information technology won't necessarily make markets more competitive. This finding stands in contrast to many economic intuitions. In classical discrete choice models with commodity products and nearly homogeneous consumers (e.g., Anderson et al. 1992) markups vanish as search costs go to zero. In such settings, falling search costs force all producers to unshroud aftermarket prices and set markups close

[36] See Caplin and Leahy (2003) for a related discussion of welfare economics with naive agents.

to zero. By contrast, we study markets in which firms suppress information even when information dissemination costs are minimal.

We chose to study a particular market structure – add-ons – but the issues raised here apply quite generally. Whenever naive consumers make mistakes, firms will exploit those mistakes. Other sophisticated consumers will see through the firm's strategy and take advantage of it. For example, a firm offers a $50 rebate, anticipating that most consumers will forget about the rebate and fail to turn it in. But sophisticated consumers know that they are likely to make this mistake and turn in the rebate the day they make their purchase.

As another example, consider a bank that offers borrowers a low interest rate coupled with a penalty for missing an interest payment. Naive borrowers will overoptimistically fail to anticipate how likely they are to be hit by this penalty (cf Landier and Thesmar 2003). Sophisticated borrowers get the benefit of the low interest rate and discipline themselves to diligently make their interest payments thereby avoiding the penalty.

In almost every market there are two kinds of exploitation. Rational firms exploit naive consumers. In turn, sophisticated consumers take advantage of these exploitative firms. In equilibrium, nobody has an incentive to deviate, except the naive consumers. But the naive consumers don't know any better and often nobody has an incentive show them the error of their ways.

5 Appendix A: The Demand Function $D(x)$

We define $D(x)$ as the demand of a firm that offers an average perceived surplus x units greater than the average perceived surplus provided by its competitors. We develop the microfoundations for $D(x)$ using random utility theory (see Anderson *et al.* 1992 for an excellent review). We assume that good i gives agent a decision utility equal to $U_{ai} = v_i - p_i + \sigma_i \varepsilon_{ai}$, where ε_{ai} is i.i.d. across firms i and agents a. We interpret ε_{ia} as a tremble or an idiosyncratic consumer preference (McFadden 1981). We normalize the mass of consumers to 1. To keep the exposition simple, we assume here that agents do not have a reservation utility. The case with the reservation utility R is identical, but more cumbersome[37]. The demand for firm i is thus:

$$D_i = P\left(U_{ai} \geq \max_{j \neq i} U_{aj}\right).$$

We will be looking for symmetrical equilibria where a firm posts quality v and prices p, while the other firms post the same quality v^* and price p^*, and all firms have the same σ. In those cases, one can set $S = v - p$ and $S^* = v^* - p^*$ the net average surplus from the good, and the demand for firm 1 is:

$$D_1 = P\left(S + \sigma\varepsilon_1 \geq S^* + \sigma \max_{j=2\ldots n} \varepsilon_j\right).$$

So $D_1 = D(S - S^*)$, where we define:

$$D(x) = P\left(x + \sigma\varepsilon_1 \geq \sigma \max_{j=2\ldots n} \varepsilon_j\right) \tag{20}$$

which can be expressed (Perloff and Salop 1985, Anderson et al. 1992)

$$D(x) = \int_{-\infty}^{\infty} f(\varepsilon) F^{n-1}\left(\frac{x}{\sigma} + \varepsilon\right) d\varepsilon.$$

The demand depends only on the difference $S - S^*$ between the surplus S offered by the firms, and the surplus S^* offered by its competitors.

The following Proposition characterizes the symmetrical equilibrium. Numerical explo-

[37] Proposition 12 if $v - c - \mu + \sigma\underline{\varepsilon} \geq R$, where $\underline{\varepsilon}$ is the lower bound of the support of ε, which can be infinite.

rations suggest that a symmetrical equilibrium exists in many cases of interest, even if $\ln f$ is not concave (Gabaix and Laibson 2004).

Proposition 12 *Suppose that firms compete in prices, and have identical costs* c *and values* v*. Then there is a symmetrical equilibrium with* $p - c = D(0) / D'(0)$ *if* $\ln f$ *is concave.*

Proof. If marginal costs are c and profits $(p-c) D(p^* - p)$, a symmetrical equilibrium will satisfy:

$$p^* = \arg\max_p (p-c) D(p^* - p)$$

which implies $D(p^* - p) - (p-c) D'(p^* - p) = 0$. If the symmetrical equilibrium exists, $p = p^*$ and

$$p - c = \frac{D(p^* - p)}{D'(p^* - p)} = \frac{D(0)}{D'(0)} = \mu. \tag{21}$$

The existence of the equilibrium is guarantied by Caplin and Nalebuff (1991), Theorem 2 and Proposition 7. ■

6 Appendix B: Existence of the Symmetric Equilibrium

We now provide sufficient conditions for existence of a symmetric equilibrium. First, we need the following Assumption, which ensures that the value $\widehat{p}_1$ that satisfies the f.o.c. is indeed locally a profit maximizing price, rather than a profit minimizing one.

Assumption 1 *The function* $\phi(\widehat{p}) = \frac{d}{d\widehat{p}}\left(\widehat{\widehat{p}\widehat{q}}(\widehat{p})\right) - \alpha\widehat{q}^S(\widehat{p})$ *has a unique root* $\widehat{p}_0$ *and* $\phi'(\widehat{p}_0) < 0$.

Proposition 13 *If Assumption 1 holds, and* $\alpha = 0$*, then a symmetric equilibrium exists.*

Proof. We set: $\Pi = \left(p + \widehat{p}\widehat{q}^N(\widehat{p})\right) D(-p + p^*)$. By Assumption 1, there is a unique maximum $\arg\max \widehat{p}\widehat{q}^N(\widehat{p})$. This determines the value of $\widehat{p}$. As detailed in Appendix A, the price is unique and satisfies $p = \mu - \widehat{p}\widehat{q}^N(\widehat{p})$. ■

We now show for $\alpha \in [0,1]$, that there is a unique symmetrical equilibrium if σ is large enough (or, equivalently, if μ is large enough). Intuitively, a firm might want to deviate from the conjectured symmetric equilibrium (with high price in the aftermarket) and instead charge efficient add-on prices so it would attract the rational consumers, and capture their associated surplus. But such a firm would lose the market of naive consumers. This creates a drop in profit proportional to $(1-\alpha)\mu$. So if μ is large enough, a firm will not want to deviate from the symmetric equilibrium.

Proposition 14 *Parametrize the demand function by $D_\sigma(x) = D_1(x/\sigma)$. There is a σ^* such that for all $\sigma \geq \sigma^*$ there exists a unique symmetrical equilibrium $(p, \widehat{p})$ of the game maximizing profit (13). It is described by Proposition 6.*

We will need a purely mathematical Lemma. The Implicit Function Theorem guaranties that if $\varepsilon \geq 0$ is small enough, there is *a* solution $X(\varepsilon)$ of $H(X, \varepsilon)$. This Lemma gives conditions for this solution to be *unique*.

Lemma 15 *Suppose that n is a non-zero integer, I is a compact subset of $\mathbb{R}^n$, $a > 0$, and H is a continuous function $H : I \times [0, a] \to \mathbb{R}^n$. Suppose that there is a unique X_0 in the interior of I such that $H(X_0, 0) = 0$, that H and $\partial_X H$ are continuous in a neighborhood of $(X_0, 0)$, and that $\partial_X H(X_0, 0)$ is invertible. Then, there is an $\varepsilon^* > 0$ such that for all $\varepsilon \in [0, \varepsilon^*]$, there is a unique solution $X(\varepsilon)$ of $H(X(\varepsilon), \varepsilon) = 0$.*

Proof. The Implicit Function Theorem guaranties the existence of a set of solutions $X(\varepsilon)$ such that $H(X(\varepsilon), \varepsilon) = 0$. We just have to show that when ε is small enough, there is indeed just *one* solution to $H(\cdot, \varepsilon) = 0$. Suppose the opposite. We would have a series $\varepsilon_n \to 0$ and $X_n \neq X_n'$ such that $H(X_n, \varepsilon_n) = H(X_n', \varepsilon_n) = 0$.

As each X_n is contained in the compact set I, $X_n \to X_0$. Otherwise, one would be able to extract a subseries X_{n_k} converging to some $Y \neq X_0$, and one would have $H(Y, 0) = \lim_k H(X_{n_k}, \varepsilon_{n_k}) = 0$, contradicting the hypothesis that X_0 is the unique zero of $H(\cdot, 0)$. So $X_n \to X_0$, and likewise $X_n' \to X_0$.

We observe that $u_n = (X_n - X_n') / \|X_n - X_n'\|$ is in the compact $\{w \mid \|w\| = 1\}$, so one can extract a subseries m_i such that $u_{m_i} \to v$ for some v. As $\|v\| = 1$, we have $v \neq 0$. Because:

$$0 = \frac{H(X_{m_i}, \varepsilon_{m_i}) - H(X_{m_i}', \varepsilon_{m_i})}{\|X_{m_i} - X_{m_i}'\|} \to \partial_X H(X_0, 0) \cdot v$$

we have $\partial_X H(X_0, 0) \cdot v = 0$, which contradicts the fact that $\partial_X H(X_0, 0)$ is invertible. This concludes the proof of the Lemma. ■

We are now ready to prove the Proposition. We call p_1 and p_1^* the candidate values for the price, and set $\varepsilon = 1/\sigma$ and $p' = p/\sigma$, $\Pi' = \Pi/\sigma$, and without loss of generality $c = \widehat{c} = 0$. We call $D_1 = D$ to simplify notations. With those notations, the profit function (13) is written:

$$\begin{aligned}\Pi'\left(p, \widehat{p}, p^*, \widehat{p}^*, \varepsilon\right) &= \alpha\left(p + \varepsilon \widehat{p}\widehat{q}^S\left(\widehat{p}\right)\right) D\left(-p + \varepsilon \widehat{u}^S\left(\widehat{p}\right) + p^* - \varepsilon \widehat{u}^S\left(\widehat{p}^*\right)\right) \\ &\quad + (1-\alpha)\left(p + \varepsilon \widehat{p}\widehat{q}^N\left(\widehat{p}\right)\right) D\left(-p + p^*\right). \end{aligned} \tag{22}$$

Eq. (22) gives the intuition for the proof. A small ε means that the add-on is "small" for the determination of the overall demands and profits. The strategy of the proof is to show that for ε close to 0, there is a unique equilibrium value of p, and $\widehat{p}$.

The rest of the proof is a bit intricate. The key difficulty is that $\Pi'\left(p, \widehat{p}, p^*, \widehat{p}^*, \varepsilon = 0\right) = pD\left(-p + p^*\right)$, so that at $\varepsilon = 0$, Π' is independent of $\widehat{p}$. To circumvent this difficulty, we define the function $F : \mathbb{R}^3 \to \mathbb{R}^2$:

$$F\left(p^*, \widehat{p}^*, \varepsilon\right) = \begin{pmatrix} \partial_1 \Pi'\left(p^*, \widehat{p}^*, p^*, \widehat{p}^*, \varepsilon\right) \\ \partial_2 \Pi'\left(p^*, \widehat{p}^*, p^*, \widehat{p}^*, \varepsilon\right)/\varepsilon \end{pmatrix}$$

and F is defined by continuity at $\varepsilon = 0$. We take F because the f.o.c. for $\left(p^*, \widehat{p}^*\right)$ to be an equilibrium is $F\left(p^*, \widehat{p}^*, \varepsilon\right) = 0$, and the division by ε in the second component of F removes the degeneracy at $\varepsilon = 0$.

The next step of the proof is to calculate $F\left(p^*, \widehat{p}^*, 0\right)$. The first component is straightforward. The second component requires some care. We observe that as $\partial_2 \Pi'\left(p^*, \widehat{p}^*, p^*, \widehat{p}^*, \varepsilon = 0\right) = 0$:

$$\lim_{\varepsilon \to 0} \partial_2 \Pi'\left(p^*, \widehat{p}^*, p^*, \widehat{p}^*, \varepsilon\right)/\varepsilon = \partial_2\left(\partial_5 \Pi'\left(p^*, \widehat{p}^*, p^*, \widehat{p}^*, 0\right)\right).$$

We calculate:

$$\partial_5 \Pi'\left(p, \widehat{p}, p^*, \widehat{p}^*, 0\right) = \widehat{p\widehat{q}}\left(\widehat{p}\right) D\left(-p + p^*\right) + \alpha D'\left(-p + p^*\right)\left[\widehat{u}^S\left(\widehat{p}\right) - \widehat{u}^S\left(\widehat{p}^*\right)\right].$$

As the envelope theorem gives $\partial_{\widehat{p}} \widehat{u}^S\left(\widehat{p}\right) = -\widehat{q}^S\left(\widehat{p}\right)$, we finally get:

$$F\left(p^*, \widehat{p}^*, \varepsilon = 0\right) = \begin{pmatrix} -\widehat{p}^* D'(0) + D(0) \\ \frac{d}{d\widehat{p}^*}\left(\widehat{p}^* \widehat{q}\left(\widehat{p}^*\right)\right) D(0) - \alpha p^* \widehat{q}^S\left(\widehat{p}^*\right) D'(0) \end{pmatrix}.$$

As anticipated, $F\left(p^*, \widehat{p}^*, \varepsilon=0\right)=0$ iff:

$$\begin{aligned}
p^* &= D(0)/D'(0) \\
\frac{d}{d\widehat{p}^*}\left(\widehat{p}^*\widehat{\overline{q}}\left(\widehat{p}^*\right)\right) &= \alpha\widehat{q}^S\left(\widehat{p}^*\right).
\end{aligned}$$

Assumption 1 ensures a unique zero $P^*(0)=\left(p^*, \widehat{p}^*\right)$ for $\varepsilon=0$. By continuity, there is also a unique zero $P^*(\varepsilon)$ of $F\left(P^*, \varepsilon\right)$ for ε close enough to 0.

We have now constructed our local equilibria $P^*(\varepsilon)$. We want to show that they are global equilibria, at least for ε close enough to 0. For $X=(x, \widehat{x}) \in \mathbb{R}^2$, we define the following function:

$$G(X, \varepsilon)=\begin{pmatrix} \partial_1\Pi'\left(x+p^*(\varepsilon), \widehat{x}+\widehat{p}^*(\varepsilon), p^*(\varepsilon), \widehat{p}^*(\varepsilon), \varepsilon\right) \\ \partial_2\Pi'\left(x+p^*(\varepsilon), \widehat{x}+\widehat{p}^*(\varepsilon), p^*(\varepsilon), \widehat{p}^*(\varepsilon), \varepsilon\right)/\varepsilon \end{pmatrix}.$$

G gives a condition for $P(\varepsilon)$ to be a global equilibrium, as follows:

$$\Pi'\left(p, \widehat{p}, p^*(\varepsilon), \widehat{p}^*(\varepsilon), \varepsilon\right) \text{ has a unique maximum for } \left(p^*, \widehat{p}\right)=\left(p^*(\varepsilon), \widehat{p}^*(\varepsilon)\right) \tag{23}$$

$$\Leftrightarrow \text{The only solution of } G(X, \varepsilon)=0 \text{ is } X=(0,0).$$

In other terms, we have a global equilibrium iff the only zero of $G(X, \varepsilon)$ is $X=(0,0)$. As $G(0, \varepsilon)=0$ by construction of G, Lemma 15 shows that this is true for ε small enough if $G_X(X=0,0)$, a 2×2 matrix, is invertible.

We just have to calculate that quantity. We observe that:

$$G(X, 0)=\begin{pmatrix} \frac{d}{dp}\left(pD\left(p-p^*\right)\right) \\ \frac{d}{d\widehat{p}}\left(\widehat{p}\widehat{\overline{q}}(\widehat{p})\right) D\left(p-p^*\right)-\alpha p\widehat{q}^S(\widehat{p}) D'\left(p-p^*\right) \end{pmatrix}$$

evaluated at $\left(p^*, \widehat{p}^*\right)=\left(p^*(0), \widehat{p}^*(0)\right)$ and $(p, \widehat{p})=\left(p^*(0)+x, \widehat{p}^*(0)+\widehat{x}\right)$. Thus

$$G_X(X=0,0)=\begin{pmatrix} \frac{d^2}{dp^2}\left(pD\left(p^*-p\right)\right)_{|p=p^*} & 0 \\ B & D(0)\frac{d}{d\widehat{p}^*}\left[\frac{d}{d\widehat{p}^*}\left(\widehat{p}^*\widehat{\overline{q}}\left(\widehat{p}^*\right)\right)-\alpha\widehat{q}^S\left(\widehat{p}^*\right)\right] \end{pmatrix}$$

where the specific value of B does not matter. As $G_{11}<0$, $G_{22}<0$ and $G_{21}=0$,

$G_X(X=0,0)$ is invertible. By applying Lemma 15, we conclude that there is an ε^* such that for $\varepsilon \in [0,\varepsilon^*]$, (23) holds. Given $\sigma = 1/\varepsilon$, our Proposition holds for $\sigma^* = 1/\varepsilon^*$.□

7 Appendix C: Longer Derivations

7.1 Proof of Proposition 3

First, we give some intuition for our sufficient condition 12. To simplify the algebra, we assume that our consumers want to buy the good when they are naive. This is expressed $-p-\sigma > R$ for all equilibrium prices in Proposition 1, i.e.:

$$-\mu + \max\left[(1-\alpha)\,\overline{p}, e\right] - \sigma > R.$$

However, as they become sophisticated, they do not want to buy the good when they see that its full price is quite high. This is expressed: $-p - \min(\widehat{p}, e) + \sigma < R$ for all prices p 1 and $\widehat{p}$ that support a non-negative profit for the deviating firm, i.e. $\sigma < R$.

We now analyze the market structure after a firm educates the consumers. A quantity $\alpha' - \alpha$ of naive consumers become sophisticated. But a fraction γ of those newly sophisticated drop out of the market, because their reservation value is too high. So the mass of remaining consumers is:

$$M = 1 - (\alpha' - \alpha)\,\gamma < 1.$$

The sophisticated population is made of the old sophisticates, in quantity α, and the new sophisticates who did not drop out of the market, in quantity $(\alpha' - \alpha)(1-\gamma)$. So the new fraction of sophisticates is: $\alpha'' = \left[\alpha + (\alpha' - \alpha)(1-\gamma)\right]/M$. One can readily show that $\alpha'' > \alpha$: the new fraction of sophisticates is higher after the advertising.

We now examine the deviating firms's profit, and will show that, for any price the firm chooses, its profit is less than before it educated the consumers. That will prove the proposition. The proof is close to the one of Proposition 2. Consider a firm that charges prices p and $\widehat{p}$ and educates the consumers. The other firms are still charging the pre-deviation prices, p^* and $\widehat{p}^*$. We first derive the optimal prices p and $\widehat{p}$ of the advertising firm. By the same reasoning as in the proof of Proposition 1, the optimal $\widehat{p}$ belongs to $\{e, \overline{p}\}$, and:

$$\begin{aligned}\Pi\left(p, \widehat{p}=e\right) &= M\left(p+e\right) D\left(p^{*}-p\right) && (24)\\ \Pi\left(p, \widehat{p}=\overline{p}\right) &= M\left(p+\left(1-\alpha''\right)\overline{p}\right) D\left(p^{*}-p\right). && (25)\end{aligned}$$

So the profit is:

$$\begin{aligned}\Pi &= \max_{p} M\left(p+\max\left(e,\left(1-\alpha''\right)\overline{p}\right)\right) D\left(p^{*}-p\right)\\ &< \max_{p}\left(p+\max\left(e,\left(1-\alpha''\right)\overline{p}\right)\right) D\left(p^{*}-p\right) \text{ because } M<1\\ &\leq \max_{p}\left(p+\max\left(e,\left(1-\alpha\right)\overline{p}\right)\right) D\left(p^{*}-p\right) \text{ because } \alpha''>\alpha.\end{aligned}$$

But the last expression was realizable before the deviation, and is equal to the pre-deviation profit, $\mu D(0)$. So the post-deviation profit is less than the pre-deviation profit, $\mu D(0)$. The deviation is not profitable.

7.2 Proof of Proposition 6

We observe $\frac{\partial}{\partial p} u^{S}(p, \widehat{p}) = -1$, and the envelope theorem gives $\frac{\partial}{\partial \widehat{p}} u^{S}(p, \widehat{p}) = -\widehat{q}^{S}(\widehat{p})$. We take the first order condition in (13) at $(p, \widehat{p}) = (p^{*}, \widehat{p}^{*})$.

$$\begin{aligned}0 &= \frac{\partial \Pi}{\partial p} = \alpha D\left(u^{S}(p,\widehat{p}) - u^{S}(p^{*},\widehat{p}^{*})\right) - \alpha\left(p-c+(\widehat{p}-\widehat{c})\,\widehat{q}^{S}(\widehat{p})\right) D'\left(u^{S}(p,\widehat{p}) - u^{S}(p^{*},\widehat{p}^{*})\right)\\ &\quad + (1-\alpha) D(-p+p^{*}) - (1-\alpha)\left(p-c+(\widehat{p}-\widehat{c})\,\widehat{q}^{N}(\widehat{p})\right) D'(-p+p^{*})\\ &= \alpha D(0) - \alpha\left(p-c+(\widehat{p}-\widehat{c})\,\widehat{q}^{S}(\widehat{p})\right) D'(0)\\ &\quad + (1-\alpha) D(0) - (1-\alpha)\left(p-c+(\widehat{p}-\widehat{c})\,\widehat{q}^{N}(\widehat{p})\right) D'(0)\\ &= D(0) - \left(p-c+(\widehat{p}-\widehat{c})\,\widehat{\overline{q}}(\widehat{p})\right) D'(0).\end{aligned}$$

Rearranging this equation yields an expression for unit profit (equation 16):

$$p-c+(\widehat{p}-\widehat{c})\,\widehat{\overline{q}}(\widehat{p}) = \frac{D(0)}{D'(0)} = \mu.$$

Optimization of the add-on's price gives:

$$
\begin{aligned}
0 &= \frac{\partial \Pi}{\partial \widehat{p}} = \alpha \frac{d}{d\widehat{p}} \left[(\widehat{p} - \widehat{c}) \, \widehat{q}^S (\widehat{p}) \right] D \left(u^S (p, \widehat{p}) - u^S (p^*, \widehat{p}^*) \right) \\
&\quad + \alpha \left[p - c + (\widehat{p} - \widehat{c}) \, \widehat{q}^S (\widehat{p}) \right] \frac{\partial u^S (p, \widehat{p})}{\partial \widehat{p}} D' \left(u^S (p, \widehat{p}) - u^S (p^*, \widehat{p}^*) \right) \\
&\quad + (1 - \alpha) \frac{d}{d\widehat{p}} \left[(\widehat{p} - \widehat{c}) \, \widehat{q}^N (\widehat{p}) \right] D (-p + p^*) \\
&= \alpha \frac{d}{d\widehat{p}} \left[(\widehat{p} - \widehat{c}) \, \widehat{q}^S (\widehat{p}) \right] D(0) - \alpha \left[p - c + (\widehat{p} - \widehat{c}) \, \widehat{q}^S (\widehat{p}) \right] \widehat{q}^S (\widehat{p}) \, D'(0) \\
&\quad + (1 - \alpha) \frac{d}{d\widehat{p}} \left[(\widehat{p} - \widehat{c}) \, \widehat{q}^N (\widehat{p}) \right] D(0) \\
&= \frac{d}{d\widehat{p}} \left[(\widehat{p} - \widehat{c}) \, \widehat{\widehat{q}} (\widehat{p}) \right] D(0) - \alpha \left[p - c + (\widehat{p} - \widehat{c}) \, \widehat{q}^S (\widehat{p}) \right] \widehat{q}^S (\widehat{p}) \, D'(0),
\end{aligned}
$$

which gives (15). For sufficient conditions on D, see Appendix A. The proofs of the corollaries are immediate.

7.3 Extension of Proposition 6 to Partial Attention and Several Shrouded Attributes

We generalize the case of K shrouded attributes, indexed by $k = 1...K$. We suppose that the decision utility that consumer a has for good i is

$$
u_{ai} = -p_i + \sum_k A_{ak} \left[\widehat{u}_k \left(\widehat{e}_{aik}, \widehat{q}_{aik} \right) - \widehat{p}_{ik} \widehat{q}_{aik} \right]
$$

where u_{ai} is a random utility shock and $A_{ak} \in [0, 1]$ is the amount of attention that consumer a devotes to the attribute k. If $A_{ak} = 1$, the consumer pays full attention to the attribute. If $A_{ak} = 0$, the consumer pays no attention to the attribute. Intermediate values of A_{ak} mean that the consumer pays partial attention to attribute, or that he underestimates the probability that the attribute will be used. $\widehat{e}_{aik}$ is the amount of preventive action for the consumption of add-on k.

Call $P_i = (p_i, p_{i1}, ..., p_{ik})$ firm i's $(K + 1)-$ dimensional vector made of its prices for the base good and the K add-ons. After maximization on the preventive action $\widehat{e}_{aik}$, the average indirect utility from the good is:

$$U_a(P_i) = -p + \max_{(\widehat{q}_{aik})_{k=1\ldots K}} \sum_k A_{ak}\left[\widehat{u}_k(\widehat{e}_{aik}, \widehat{q}_{aik}) - \widehat{p}_{ik}\widehat{q}_{aik}\right].$$

If the other firms post prices P^*, a firm that posts prices P will have profit:

$$\Pi = E\left[\left(p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)\right) \cdot D\left(U_a(P) - U_a(P^*)\right)\right]. \tag{26}$$

We take the expectation on the various types of attentions A_k. For instance,[38] in the case $K = 1$, we get expression (13).

In this setup with many attributes, we can generalize Proposition 6.

Proposition 16 *If a symmetric equilibrium exists, it satisfies, for all k:*

$$\mu = E\left[p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)\right] \tag{27}$$

$$\frac{d}{d\widehat{p}_k}\left[(\widehat{p}_k - \widehat{c}_k)\,E\left[\widehat{q}_k(a, \widehat{p}_k)\right]\right] = \frac{1}{\mu}E\left[A_{ka}\widehat{q}_k(a)\left(p - c + \sum_{k'} (\widehat{p}_{k'} - \widehat{c}_{k'})\,\widehat{q}_{k'}(a)\right)\right]. \tag{28}$$

Corollary 17 *If all consumers have identical demand for add-on k, and the attention A_{ka} paid to add-on k is independent of the attention $A_{k'a}$ paid to the other add-ons, then:*

$$\frac{\widehat{p}_k - \widehat{c}_k}{\widehat{p}_k} = \frac{1 - E[A_k]}{\eta_k} \tag{29}$$

where $\eta_k = -\widehat{p}_k\widehat{q}'_k(\widehat{p}_k)/\widehat{q}_k(\widehat{p}_k)$ is the price elasticity of the demand for the add-on, and $E[A_k]$ is the average amount of attention paid to it. In particular, if consumers all overlook the add-on ($A_k = 0$), it is priced at monopoly pricing, and if all consumers pay full attention to the add-on ($A_k = 1$), then it is priced at marginal cost.

[38] If the distribution of types is that $A_k = 1$ with probability α_k, and $A_k = 0$ with probability $1 - \alpha_k$, and the draws are independent, the profit function is:

$$\Pi = \sum_{(A_1, \ldots A_k) \in \{0,1\}^K} \left[\prod_k \alpha_k^{Ak}(1 - \alpha_k)^{1 - A_k}\right]\left(p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(A_k)\right) \cdot D\left(U_a(P) - U_a(P^*)\right)$$

Corollary 18 *In the case of (unavoidable) surcharges, the surcharge $\widehat{p}_k$ is set to its upper bound.*

Condition (16) means that the overall profit remains μ, independently of the structure of the add-ons. Hence add-ons do not create additional unit profits, they just reallocate the profit centers $(\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)$. We have fixed the market size at 1. If add-ons can change the market size, as is likely in practice, then they would increase total profits, if not the profit on each unit.

Condition (15) is easiest to interpret in the special cases of Corollary 17. Corollary 17 predicts that, for the same good, the markup (actually, the Lerner index) $(\widehat{p}_k - \widehat{c}_k)/\widehat{p}_k$ of the add-ons could vary from add-on to add-on. In theory, one can infer the attention paid by consumers for the add-on by simply observing the markup and the elasticity. This gives the scope for a market-based inference of the amount of attention $E[A_{ka}]$.

Proof. As before, we have $\frac{\partial}{\partial p}u(P) = -1$, and $\frac{\partial}{\partial \widehat{p}_k}u(P) = -A_{ka}\widehat{p}_k$. We take the $(K+1)$ first order conditions in (26) at $P = P^*$. We start with the first component, the price of the base good p.

$$
\begin{aligned}
0 &= \frac{\partial \Pi}{\partial p} = E[D(u_a(P) - u_a(P^*)) + \left(p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)\right) D'(u_a(P) - u_a(P^*))] \\
&= E\left[D(0) + \left(p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)\right) D'(0)\right]
\end{aligned}
$$

so the average unit profit is:

$$
E\left[p - c + \sum_k (\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)\right] = \frac{D(0)}{D'(0)} = \mu,
$$

which proves (27).

Optimization of the k-th add-on's price gives:

$$
0 = \frac{\partial \Pi}{\partial \widehat{p}_k} = E[\frac{d}{d\widehat{p}_k}[(\widehat{p}_k - \widehat{c}_k)\,\widehat{q}_k(a)]\,D(0) - \left(p - c + \sum_{k'} (\widehat{p}_{k'} - \widehat{c}_{k'})\,\widehat{q}_{k'}(a)\right) A_{ka}\widehat{q}_k(a)\,D'(0)]
$$

which gives:

$$E\left[\frac{d}{d\widehat{p}_k}\left[\left(\widehat{p}_k-\widehat{c}_k\right)\widehat{q}_k\left(a\right)\right]\right]=\frac{D'\left(0\right)}{D\left(0\right)}E\left[A_{ka}\widehat{q}_k\left(a\right)\left(p-c+\sum_{k'}\left(\widehat{p}_{k'}-\widehat{c}_{k'}\right)\widehat{q}_{k'}\left(a\right)\right)\right]$$

which proves (28).

We now prove Corollary 17. Under its assumptions, $\widehat{q}_k\left(a\right)$ is independent of a, and we just call it $\widehat{q}_k$. Eq. (28) now reads:

$$\frac{d}{d\widehat{p}_k}\left[\left(\widehat{p}_k-\widehat{c}_k\right)E\left[\widehat{q}_k\left(\widehat{p}_k\right)\right]\right]=\frac{1}{\mu}E\left[A_{ka}\right]\widehat{q}_kE\left[p-c+\sum_{k}\left(\widehat{p}_k-\widehat{c}_k\right)\widehat{q}_k\left(a\right)\right]=E\left[A_{ka}\right]\widehat{q}_k$$

by (27). This gives (29). Finally, the proof of Corrolary 18 is immediate. ■

7.4 Proof of Proposition 11

Without loss of generality, we take $\widehat{c}=c=0$ to simplify exposition.[39] In this proof, we call $p^*$and $\widehat{p}^*$ the equilibrium values from Proposition 6. We start from the situation where no firm advertises. Suppose that a firm advertises, and sets new prices p and $\widehat{p}$. Its profit is

$$\Pi=\left(p+\widehat{pq}\right)D\left(u^S\left(p,\widehat{p}\right)-u^S\left(p^*,\widehat{p}^*\right)\right)=xD\left(\widehat{u}^S\left(\widehat{p}\right)-x-u^S\left(p^*,\widehat{p}^*\right)\right),$$

where $x=p+\widehat{pq}$ is the total profit per customer. Maximizing $\Pi\left(x,\widehat{p}\right)$ over $\widehat{p}$ we get $\widehat{p}=0$, so the highest profit the firm can get after deviating is:

$$\Pi=\max_x xD\left(-x+x^*\right) \tag{30}$$

with $x^*=\widehat{u}^S\left(0\right)-u^S\left(p^*,\widehat{p}^*\right)$.

As the pre-deviation profit is μ, the firm doesn't want to deviate iff

$$\Pi<\mu. \tag{31}$$

Given $\mu=\max_y yD\left(-y+\mu\right)$ and Eq. (30), and the fact that $\max_y yD\left(-y+z\right)$ is increasing

[39] To go back to the general case, replace $\widehat{p}$ by $\widehat{p}-\widehat{c}$, p by $p-c$, and $\widehat{u}^\theta\left(\widehat{p}\right)$ by $\widehat{u}^\theta\left(\widehat{p}\right)-\widehat{c}\widehat{q}^\theta\left(\widehat{p}\right)$ for both $\theta=N$aive and $\theta=S$ophisticate.

in z, (31) is equivalent to $x^* < \mu$. In other terms, x^* is the price offered by the competitor firms to sophisticates after the deviation. The deviation is unprofitable iff this price is less than μ, which is the pre-deviation, or "normal," level of profits. To find the sign of $x^* - \mu$, we calculate:

$$\begin{aligned} x^* - \mu &= \widehat{u}^S(0) - u^S(p^*, \widehat{p}^*) - \mu = \widehat{u}^S(0) - \widehat{u}^S(\widehat{p}^*) + p^* + \widehat{p}^* \widehat{q}^S(\widehat{p}^*) - \mu \\ &= \widehat{u}^S(0) - \widehat{u}^S(\widehat{p}^*) + p^* + \widehat{p}^* \widehat{q}^S(\widehat{p}^*) - \left[p^* + \widehat{p}^* \widehat{\overline{q}}(\widehat{p}^*)\right] \text{ by(16)} \\ &= \widehat{u}^S(0) - \widehat{u}^S(\widehat{p}^*) + \widehat{p}^* \widehat{q}^S(\widehat{p}^*) - \widehat{p}^* \left[\alpha \widehat{q}^S(\widehat{p}^*) + (1-\alpha)\widehat{q}^N(\widehat{p}^*)\right] \text{ by (14)} \\ &= \widehat{u}^S(0) - \widehat{u}^S(\widehat{p}^*) - (1-\alpha)\widehat{p}^* \left(\widehat{q}^N(\widehat{p}^*) - \widehat{q}^S(\widehat{p}^*)\right). \end{aligned}$$

As the firm doesn't want to deviate iff $x^* - \mu < 0$, the Proposition is proven.

8 Appendix D: Some Welfare Analysis

This Appendix proves the results announced in section 3.6. If consumer a buys the good in a symmetric equilibrium, he will get surplus:

$$S_a(p, \widehat{p}) = u_a - p + \widehat{u}(\widehat{e}_a, \widehat{q}_a) - \widehat{p}\widehat{q}_a$$

where $u_a = \max_i u_{ai}$. Call $S_a^E(p, \widehat{p})$ the surplus he expects, perhaps naively, if he faces prices $(p, \widehat{p})$. The consumers buys the good iff $S_a^E(p, \widehat{p}) \geq 0$.

In equilibrium, each firm has profits equal to $p - c + (\widehat{p} - \widehat{c})\widehat{q}_a$. So, if consumer a buys the good, the transaction yields a total social surplus equal to the consumer's surplus and the firms's profit

$$V_a(p, \widehat{p}) = u_a - c + \widehat{u}(\widehat{e}_a, \widehat{q}_a) - \widehat{c}\widehat{q}_a. \tag{32}$$

If the equilibrium prices are $(p, \widehat{p})$, the social welfare is $E\left[1_{S_a^E(p,\widehat{p})>0} V_a(p, \widehat{p})\right]$ – one counts only consumers who buy the product. The social loss Λ is the the difference between that expression under marginal cost pricing $(c, \widehat{c})$ and the actual pricing $(p, \widehat{p})$:

$$\Lambda = E\left[1_{S_a^E(c,\widehat{c})>0} V_a(c, \widehat{c}) - 1_{S_a^E(p,\widehat{p})>0} V_a(p, \widehat{p})\right].$$

It is useful to express the total welfare loss as

$$\Lambda = \Lambda_H + \Lambda_{FN} + \Lambda_{FP}$$

where

$$\Lambda_H = E\left[1_{S_a^E(p,\widehat{p})\geq 0,\ S_a^E(c,\widehat{c})\geq 0}\left(V_a\left(c,\widehat{c}\right) - V_a\left(p,\widehat{p}\right)\right)\right]$$

is the "Harberger's triangle" loss due to marginal consumption distortions of the add-on;

$$\Lambda_{FN} = E\left[1_{S_a^E(p,\widehat{p})<0,\ S_a^E(c,\widehat{c})\geq 0} V_a\left(c,\widehat{c}\right)\right]$$

(FN stands for False Negative) is the loss due to consumers that did not buy the good at prices $(p,\widehat{p})$, but would have bought the good if it had been priced at marginal cost $(c,\widehat{c})$; and

$$\Lambda_{FP} = -E\left[1_{S_a^E(p,\widehat{p})\geq 0,\ S_a^E(c,\widehat{c})<0} V_a\left(p,\widehat{p}\right)\right]$$

(FP stands for False Positive) is the welfare loss due to naive consumers who bought the good but shouldn't have done so. They bought it because they mistakenly expected a high surplus, whereas the true surplus is less than 0, even under marginal cost pricing.

The following bound gives us a rough quantification of Λ_{FP}.

Proposition 19 *Assume free disposal, i.e.* $u_a + \widehat{u}\left(\widehat{e}_a, \widehat{q}_a\right) \geq 0$. *Then*

$$0 \leq \Lambda_{FP} \leq E\left[1_{S_a^E(p,\widehat{p})\geq 0,\ S_a^E(c,\widehat{c})<0}\left(c + \widehat{c}\widehat{q}_a\left(\widehat{p}\right)\right)\right] \tag{33}$$

i.e. the loss due to naive consumers buying a good they shouldn't have bought, Λ_{FP}, *is bounded above by the amount of their purchase, valued at marginal cost, multiplied by the mass of those naive consumers who shouldn't have purchased the good.*

Proof. Immediate as $-V_a\left(p,\widehat{p}\right) = c + \widehat{c}\widehat{q}_a - \left(u_a + \widehat{u}\left(\widehat{e}_a, \widehat{q}_a\right)\right)$. ■

It is easy to get conditions under which bound (33) is reached,[40] so it is the least upper bound for Λ_{FP}.

[40]For instance, take a competitive market, with $u = 0$, $\widehat{u} = 1$, $\widehat{c} = 0$, $c = 1$, $\widehat{p} = 1$, $p = 1$, and assume further it is entirely populated by naive consumers, with mass 1. The naive consumer expects a price $\widehat{p} = 0$, so she makes the purchase iff her valuation for the whole experience is $V \geq 1$. However, her true surplus is $V - 2$, so the loss is $\Lambda_{FP} = 2 - V$. One has $\Lambda_{FP} = c + \widehat{c}\widehat{q} = 1$ if $V = 1$.

As sketched above, one expects Λ_H and Λ_{FN} to be second order losses, while Λ_{FP} is first order. We illustrate this tendency in the following proposition.

Proposition 20 *Consider the case $\eta = \max\left((\widehat{p} - \widehat{c})\,\widehat{\overline{q}}\,(\widehat{c})\,, \mu\right) > 0$. Let $\eta \to 0^+$. We have $\Lambda_H = O(\eta^2)$ and $\Lambda_{FN} = O(\eta^2)$ if (i) at marginal cost pricing, we have a non-zero density of naive consumers just indifferent between buying or not buying, and (ii) η tends to 0 in such a way that $\widehat{\overline{q}}\,(\widehat{c})\,(\widehat{p} - \widehat{c}) - \mu \sim k'\mu$, for a positive constant k', then there is a constant k such that $\Lambda_{FP} = k\eta$. In particular, $\Lambda_{FP} \gg \max(\Lambda_H, \Lambda_{FN})$.*

Proof. The first two statements are classic results. They derive from the fact that the welfare optimum is reached for $\eta = 0$, and the fact that the welfare function is C^2. To prove the last statement, recall that naive consumers have a subjective surplus $S_a^E(p) = u_a - p + \widehat{u}^E$, where u_a is a random variable with density $f(u_a)$. Pivotal naive consumers are those such that $S_a^E(c) = 0$, i.e. $u_a = c - \widehat{u}^E$. For them, Eq. (32) shows that the loss is

$$-V_a(c, \widehat{c}) = L := \widehat{u}^E - \left(\widehat{u}\left(\widehat{e}^N, \widehat{q}^N\right) - \widehat{c}\widehat{q}^N\right),$$

which is the gap between the expected and realized surplus from the add-on. So as $\eta \to 0$

$$\begin{aligned}
\Lambda_{FP} &= -E\left[1_{S_a^E(p,\widehat{p})\geq 0,\ S_a^E(c,\widehat{c})<0} V_a(p,\widehat{p})\right] \sim LE\left[1_{S_a^E(p,\widehat{p})\geq 0,\ S_a^E(c,\widehat{c})<0}\right] \\
&= L\Pr\left(p - \widehat{u}^E \leq u_a < c - \widehat{u}^E\right) = L\int_{p-\widehat{u}^E}^{c-\widehat{u}^E} f(x)\,dx \\
&\sim Lf\left(c - \widehat{u}^E\right)(c - p) \text{ as } p - c \to 0 \text{ when } \eta \to 0 \\
&= Lf\left(c - \widehat{u}^E\right)k'\mu
\end{aligned}$$

and the result holds with $k = Lf(c - \widehat{u}^e)\,k'$. ■

So the largest deadweight losses come from naive consumers who are lured into the market because they see the low price for the base good but not the high price of the add-ons. This is an additional reason why naiveté matters for welfare analysis.

9 References

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