UNIVERSITY OF MANNHEIM

University of Mannheim / Department of Economics

Working Paper Series

Information Disclosure and Consumer Awareness

Sanxi Li Martin Peitz Xiaojian Zhao

Working Paper 14-28

December 2014

Information Disclosure and Consumer Awareness*

Sanxi Li† Martin Peitz‡ Xiaojian Zhao§

December 14, 2014

Abstract

Whether consumers are aware of potentially adverse product effects is key to private and social incentives to disclose information about undesirable product characteristics. In a monopoly model with a mix of aware and unaware consumers, a larger share of unaware consumers makes information disclosure less likely to occur. Since the firm is not interested in releasing information to unaware consumers, a more precise targeting technology that allows the firm to better keep unaware consumers in the dark leads to more disclosure. A regulator may want to intervene in this market and impose mandatory disclosure rules.

Keywords: Information disclosure, informative advertising, targeted advertising, consumer awareness, behavioral bias, non-common prior, consumer protection, behavioral industrial organization

JEL Classification: L51, M38

---

*A previous version of this paper was circulated under the title "Worried about adverse product effects? Information disclosure and consumer awareness." Peitz gratefully acknowledges financial support from the German Science Foundation (SFB TR 15). Li gratefully acknowledges financial support from National Natural Science Foundation of China (Grant No. 71303245), and MOE (Ministry of Education in China) Project of Humanities and Social Sciences (13YJC790077).

†School of Economics, Renmin University of China, Beijing 100872, China. Email: lisanxi@gmail.com.

‡Department of Economics, University of Mannheim, D-68131 Mannheim, Germany. Email: martin.peitz@googlemail.com. Also affiliated with CEPR, CESifo, MaCCI, and ZEW.

§Department of Economics, Hong Kong University of Science and Technology, Hong Kong. Email: xjzhao@ust.hk.

1 Introduction

Adverse product effects are a serious economic problem. As a result of information disadvantages, consumers may be unaware of some low-quality aspects of products, such as harmful radiation from computer monitors or cell-phones, health risks due to nanoparticles or artificial sweeteners in food, and side effects of medicines. A profit-seeking firm may use many ingredients to different degrees to produce its products. Such ingredients are supposed to improve the product's performance or reduce the cost of production. However, these substances may have adverse effects on a consumer's well-being. Not only may such adverse effects be uncertain and of an unknown degree, but the consumer may initially be unaware that, by consuming, she exposes herself to such a risk. Additional examples are asbestos, nicotine, transgenic fats, and flavor enhancers, whose health risks were and, for some consumers, still are largely unknown. The recent debate on genetically modified agricultural products has a similar flavor: Firms use products with certain genetic modifications; consumers are imperfectly informed about the degree of such modifications and whether they are harmful. Other specific examples include Taiwan's plasticizer food scandal, pork containing ractopamine in the U.S., and breast implants made of a suspect silicone gel by the French company PIP.

In many of these examples, the consumer side is characterized by both, uncertainty and unawareness. To capture this, we develop a simple and unified monopoly model in which the consumer side is composed of a mix of aware and unaware consumers. In the model, with some probability, an ingredient of a product leads to a utility loss, e.g., due to health problems for consumers. Some of the consumers are aware of the ingredient but uncertain of its level and whether it is harmful. By contrast, unaware consumers are not aware of the ingredient's existence at all. Thus, unaware consumers suffer from a biased prior. The monopolist firm knows whether or not the ingredient is harmful, as well as the level contained in its product. It then decides about its disclosure policy: It may fully, partially, or not at all disclose information through advertising. Partial disclosure takes the form of awareness-enhancing disclosure: The firm informs potential consumers that the product contains an ingredient that may carry some health risk, and a fraction of initially unaware consumers this information. Under full disclosure, the level of the ingredient (and the exact health risk) is disclosed. However, even under full disclosure, some consumers may remain unaware.

Our results are as follows. First, in the positive analysis, we find that the firm will be more likely to advertise if its product is of higher quality, if it has a higher share of initially aware consumers and if it has a lower

incremental share of aware consumers after advertising.[1] A lower incremental share of aware consumers after advertising is, from the firm's viewpoint, due to a better targeting technology, as a larger fraction of unaware consumers will remain in the dark after advertising. If the firm has a high product quality, and the incremental share of aware consumers after advertising is large but the initial share of aware consumers is either small or large, then the firm will sell to both aware and unaware consumers whether or not the firm advertises or not. Otherwise, the firm will sell only to unaware consumers if and only if it does not advertise. The firm's expected profit decreases with the consumer's initial awareness, whereas the consumer surplus increases. The increase of initially aware consumers benefits all consumers, as the price is weakly decreasing in the share of initially aware consumers. The effect of an increase in initial awareness on total welfare is ambiguous.

Second, from a public policy perspective, for a given entry decision, mandatory disclosure policies make unaware consumers better off. In a market with unaware consumers, we distinguish between awareness-enhancing and full-disclosure policies. Awareness-enhancing disclosure refers to informing consumers that a particular ingredient is harmful, while full disclosure refers to also disclosing the amount of the harmful ingredient that the product contains. Awareness-enhancing disclosure can be enforced by the courts if they punish the non-disclosure of the adverse effect of a particular substance (as, e.g., was an issue in various class action suits against tobacco firms in the U.S.). Alternatively, consumers may know about the health risk of particular ingredients, but be unaware that a product uses such ingredients; awareness-enhancing disclosure policies then require firms to explicitly declare all ingredients used. Awareness-enhancing disclosure makes consumers better off if they are initially unaware of the potentially adverse effect. It also makes initially aware consumers better off as long as they purchase some units of the product after disclosure. In general, for given entry, more information is better for consumers, but may not be in the interest of the firm. Thus, under a consumer surplus standard, mandatory disclosure rules may be chosen.

Results are more nuanced when endogenizing the firm entry decision. We show that *consumers are not necessarily better off when full rather than awareness-enhancing disclosure is mandated*. The reason is that imposing full

[1] A similar effect is also present in the work by Gabaix and Laibson (2006), who consider a competitive market in which some consumers are unaware of add-ons. They show that firms are more likely to disclose the add-on if the fraction of aware consumers in the population is higher. Relatedly, von Thadden and Zhao (2012) show in a principal-agent model that the principal will make all agents aware if the fraction of initially aware agents is sufficiently high.

disclosure may cause the monopolist not to enter, which may be consumer-surplus reducing. Since awareness-enhancing disclosure is never privately optimal for the firm, we show that the publicly chosen disclosure rule may be qualitatively different from any potentially optimal disclosure strategy by the firm.

If a firm can invest in reducing the level of the adverse effect, then mandatory disclosure rules affect the firm's incentive to invest. We show that the mandatory full-disclosure rule provides the firm with the strongest incentive to reduce the adverse effect.

Related Literature: In uncertainty problems with information disclosure, it is typically assumed that consumers know the distribution of the relevant unknown attribute, although they do not know the exact value that the attribute takes. The underlying adverse-selection problem can be solved through voluntary information disclosure by the firm. It is well known that, if such disclosure is costless, full unravelling results and the adverse-selection problem is fully solved – see, e.g., Grossman and Hart (1980), Grossman (1981), Milgrom (1981), Milgrom and Roberts (1986), and the generalized model by Okuno-Fujiwara, Postlewaite, and Suzumura (1990). However, if disclosure is costly, no or only partial unravelling will occur (see, e.g., Shavell, 1994).[2] After disclosure, consumers update their beliefs in a Bayesian fashion upon observing firms' disclosure actions. In our setting, an opportunity cost of disclosure arises endogenously since the information provided to aware consumers spills over to some initially unaware consumers. Thus, our result that there is no full unravelling is due to the fact that some consumers are initially unaware of a variable that affects their willingness-to-pay function.

The law and economics literature has used the above approach to address consumer protection issues.[3] In the legal literature, Korobkin (2003) recommends ex ante intervention by legislatures; this corresponds to imposing a mandatory disclosure rule. However, this ex ante mechanism sometimes inefficiently prevents firms from entering, as we show in this paper. Polinsky and Shavell (2006) compare mandatory to voluntary disclosure rules in a setting in which two firms decide whether to acquire information. They show that firms may have less incentive to acquire information under mandatory disclosure. We note that if the legislator can require the seller to disclose

[2]With respect to the contracting literature on information disclosure, we refer to the overview provided in Chapter 5 in Bolton and Dewatripont (2005).

[3]See, e.g., Shavell (2004) for extensive discussions of the law and economics literature on this issue. A different remedy with respect to adverse effects is to define minimum-quality standards that refer to product safety or product quality (see, e.g., Leland, 1979, and Shapiro, 1983).

all the possibly harmful substances, it matters how the seller discloses the eye-opening information. If the seller puts the information only in the fine print, the seller's action constitutes mis-selling if the information does not reach the consumers.

Other work has considered ex post judicial mechanisms. In the economics literature, Daughety and Reinganum (1995, 2008) examine the firm's behavior when it is liable to make a payment in the event of harm. However, in our context, harm is often not contractible. Thus, this judicial mechanism has limited applicability.[4]

According to a different class of informational problems, unaware consumers do not know the attribute and do not know that they do not know it and so on. For instance, Milgrom (2008) remarks that consumers often do not know which characteristics of a given product are relevant or even that such characteristics exist. To analyze this class of information problems, one has to give up common knowledge of the game (and rationality), and assume a non-common prior between firm and consumers. From a normative viewpoint, the consumers' prior is biased, unless they are made aware. This non-common prior approach has been used in a number of recent behavioral-IO models – see, e.g., present-biased consumers (Della Vigna and Malmendier, 2004) and the extension to diversely naive consumers (Eliaz and Spiegler, 2006), consumers who are unaware of some options (Eliaz and Spiegler, 2011); consumers who are unaware of some add-ons (Gabaix and Laibson, 2006) or unaware of contingencies (Filiz-Ozbay, 2012; Auster, 2013); consumers with limited attention to a complex multi-attribute product (Zhou, 2008); analogy-based-reasoning consumers (Mullainathan et al., 2008); limited-recall consumers (Shapiro, 2006); consumers who are susceptible to the law of small numbers (Spiegler, 2006).[5] Our paper adds to this literature by taking a closer look at disclosure rules. It highlights the role of two dimensions: first, the role of the initial composition of the demand

[4]It is worth mentioning that some legal scholars suggest another ex-post judicial mechanism (see Korobkin, 2003; and Becher, 2008): By using the unconscionability doctrine to interpret contracts, contracts with unconscionable terms (which, thus, put one party at the mercy of the other) are not enforced. Unfortunately, this mechanism appears to be of little help in our context because its implementation is difficult in the presence of adverse effects.

[5]In the psychology literature, the related concept of awareness is availability (see Kahneman and Tversky, 1973). For a different, Bayesian approach of modeling contracting with unawareness, see, e.g., Tirole (2009). Zhao (2014) extends Tirole (2009) to a model with asymmetric awareness between a seller and a buyer and focuses on the transaction cost of pre-contractual cognition of the buyer. By contrast, in this paper, unaware consumers are biased in the sense that they are naive; thus, there is no pre-contractual cognition involved.

side, consisting of consumers who lack information but do not have biased beliefs and others who do have biased beliefs; and second, the role of the composition of the demand side after the disclosure that the product contains a harmful substance. In a related paper (Li, Peitz, and Zhao, 2014), we consider a vertically differentiated duopoly with unaware consumers. In contrast to that paper, the present paper explores the importance of the mix between aware and unaware consumers before and after disclosure and the public policy on information disclosure.

More broadly, our paper connects to the literature on informative advertising (e.g., to Grossman and Shapiro, 1984, and more closely to the advertising of product characteristics, as in Anderson and Renault, 2009). Our contribution to that literature is to identify whether a monopolist has an incentive to advertise and how public policy can address market failure resulting from some consumers being unaware of certain product characteristics. In particular, we address this issue in the context of targeted informative advertising (in particular, Esteban, Gil, and Hernandez, 2001 and 2004).[6] This literature addresses targeting to consumers who differ in their willingness-to-pay and the way in which advertising can guide consumers to particular products. By contrast, in our setting, from the firm's viewpoint, better targeting technology allows the firm to keep more unaware consumers in the dark about a negative product characteristic, thus inflating their willingness-to-pay.[7]

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 provides the analysis. Section 4 analyzes the public policy of information disclosure. Section 5 augments the analysis to include an investment decision by the firm to reduce the level of the adverse effect – a decision taken prior to observing the actual level of the adverse effect. Section 6 briefly discusses the effects of competition and taxation (excise tax on the product). Section 7 concludes.

[6]Additional contributions in oligopoly contexts include Galeoti and Moraga (2008), Iyer, Soberman, and Villas-Boas (2005), and Roy (2008).

[7]Another link is to the literature on persuasive advertising because advertising "changes" preferences; see Footnote 10 below. However, in that literature, advertising increases the willingness-to-pay of consumers, while, in our model, advertising to unaware consumers reduces their willingness to pay as the result of bad news, which they otherwise do not anticipate.

2 The Model

A firm can incur an entry cost, which generates a new and untested product with potential adverse effect and gives the firm monopoly rights over its product (e.g., because of IP protection). To enter the market, the monopolist has to incur an entry cost K. The firm sells a single product to a unit mass of consumers. Consumers are aware of the existence of the product and know the utility from its intended use. However, the firm's product contains a potentially harmful ingredient (e.g., asbestos, nicotine, artificial sweeteners, etc.). The monopolist incurs constant marginal costs of production that are normalized to zero. It sets its price (or, equivalently, quantity) and its information-disclosure policy, as will be specified below. We assume that the firm learns the quality of the product (i.e., the exact level of the product's adverse effect) only *after* investing.[8]

We introduce the possibility of unawareness about adverse effects into a linear-quadratic representative-consumer model. In the context of information disclosure policies, this model has also been used by Daughety and Reinganum (2005).[9] Aware consumers are aware of the potentially adverse effect; however, absent information disclosure, they lack information about whether such adverse effects are present and about the magnitude of these effects. Unaware consumers are not aware that there are potentially adverse effects, unless such information is disclosed. In effect, they have a biased prior.

We develop a simple framework to analyze how awareness in the population affects market outcomes. We then derive the welfare implications of different mandatory disclosure rules when there are both aware and unaware consumers in the market. To do so, we need some notations. We denote

- ρ_0 as the initial share of aware consumers;
- u as a demand shifter that reflects the consumer's willingness to pay for the first unit when abstracting from possible adverse effects – it is, thus, a measure of product quality for unaware consumers;
- θ as the amount of the adverse effect, uniformly drawn from $\left[0, \overline{\theta}\right]$;
- $a \equiv u - \theta$ as the true quality measure (net of any adverse effects) of the product;

[8] Thus, we abstract from the issue of quality tests (see, e.g., Matthews and Postlewaite, 1985).

[9] We have checked that our results also hold in a heterogeneous consumer model with unit demand and a uniform distribution of the willingness-to-pay.

- $\widetilde{a}$ as the expected quality measure according to consumer beliefs; and
- p as the per-unit price of the product and q as the quantity sold by the monopolist.

We postulate that the utility function of the representative consumer takes the standard linear-quadratic form

$$U = (u - \theta)q - \frac{1}{2}q^2 - pq.$$

The firm may disclose the adverse effect of its product through advertising; for simplicity, we assume that information disclosure is costless. In addition, we assume that advertising is truthful.[10] Advertising increases the share of aware consumers to $\rho_1 = \rho_0 + \Delta\rho \leq 1$ with $\Delta\rho \geq 0$. A firm may want to target this advertising to aware consumers. In one polar case, advertising is perfectly targeted to aware consumers, i.e., $\Delta\rho = 0$. In the other polar case, advertising is non-targeted and reaches aware and unaware consumers alike, i.e., $\rho_1 = 1$. The precision of the targeting technology is defined as $\Delta\rho/(1 - \rho_0)$.

Note that targeting has become very prominent in the context of internet advertising (see Evans, 2008; Goldfarb, 2014; and Peitz and Reisinger, 2014). In our context, targeting may be based on observable consumer characteristics that correlate with consumer awareness. A better targeting technology is based on consumer characteristics that are more strongly correlated to consumer awareness. Alternatively, targeting may be based on observed consumer behavior. Here, the advertising firm may show ads only to consumers who consume certain content (e.g., by placing the ad on media with a narrow audience) or who have a certain history of behavior (based on information collected through cookies). Again, observed consumer behavior must correlate with the awareness of consumers to be harnessed by the advertising firm.

We will consider comparative statics in the share of initially aware consumers ρ_0. In the analysis, we vary ρ_0 while keeping $\Delta\rho$ constant. The following interpretation motivates this modeling choice.

[10] This can be motivated by measures taken against misleading or false advertising. Such advertising about product characteristics is, thus, within the domain of informative advertising. However, since unaware consumers have biased beliefs, advertising changes consumer preferences for the product at the moment of purchase – this is a feature of persuasive advertising. In contrast to work on persuasive advertising, in our setting, advertising "corrects" consumer preferences – i.e., ex post preferences are the true preferences. For a monopoly model of persuasive advertising that allows for distorted preferences ex ante or ex post, see Dixit and Normann (1978); for a survey on the economics of advertising, see Bagwell (2007).

Suppose that the firm sells its product through two distribution channels A and B, but has to set a uniform price across channels. It caters to aware consumers (experts), as well as to some unaware consumers (naives) through channel A. The remaining unaware are served through distribution channel B. If the firm discloses the level of the adverse effect of its product in channel A, all consumers using this channel ($\rho_0 + \Delta\rho$) will become aware of the adverse effect and learn its level (i.e., the value of θ). Comparative statics in ρ_0 then refers to some naive consumers in channel B listening to what expert consumers have to say; experts may simply warn about the adverse effect if they lack further information or, if they got the information about its level, also communicate this piece of information. The more consumers in B that listen to experts in A, the larger is ρ_0.[11]

The timing of the game played by the monopolist firm and consumers evolves as follows:

1. The firm decides whether to enter with a new product.
2. If the firm has entered, it observes the adverse effect θ as *private* information.
3. The firm chooses whether to disclose information on θ through advertising and sets its price p.
4. Consumers observe the price and, if applicable, the advertisement and then make their purchasing decision.

At stage 4, consumers form beliefs about θ and face a decision problem that yields demand functions. We solve for perfect Bayesian equilibria where aware consumers are Bayesian and unaware consumers have constant biased beliefs.

3 Analysis

In the first subsection, we focus on a monopolist who is already active in the market and, thus, has sunk the entry cost. Here, we characterize the profit-maximizing advertising (i.e., disclosure) and pricing decision and its impact on profits and consumer surplus. In the second subsection, we then endogenize entry.

[11] In general, $\Delta\rho$ might depend on ρ_0. For example, if the imperfect targeting technology delivers the information to half of all unaware consumers, then $\Delta\rho = (1 - \rho_0)/2$.

3.1 Private Disclosure for Given Entry

Suppose that the firm has entered and learned its type θ. We first determine the firm's profit-maximizing price given the share of aware consumers ρ. The remaining share $1-\rho$ of consumers are unaware. Their expected product quality measure is u and, hence, their demand is $u-p$. The share ρ of consumers are aware. Their expected product quality measure is $\widetilde{a}$ and, hence, their demand is $\widetilde{a}-p$. Consumers do not condition their quality expectations on price.

The firm's expected demand function is, therefore,

$$Q(p)=\begin{cases}(1-\rho)(u-p)+\rho(\widetilde{a}-p) & \text{if } p\leq\widetilde{a},\\ (1-\rho)(u-p) & \text{if } p>\widetilde{a}.\end{cases}$$

The expected demand function has a kink at the point $p=\widetilde{a}$. The firm's problem is $\max_p pQ(p)$. Solving the firm's profit maximization problem at stage 3, we obtain the firm's pricing strategy as

$$p=\begin{cases}\frac{(1-\rho)u+\rho\widetilde{a}}{2} & \text{if } \widetilde{a}\geq\overline{a},\\ \frac{u}{2} & \text{if } \widetilde{a}<\overline{a},\end{cases}$$

where

$$\overline{a}=\frac{\sqrt{1-\rho}\left(1-\sqrt{1-\rho}\right)}{\rho}u.$$

If the belief of aware consumers is above the threshold, the firm chooses a price that generates positive demand from all consumers. If this belief is below, the firm sets the monopoly price to unaware consumers – a price at which demand from aware consumers is zero.

The corresponding profit (gross of entry costs) is

$$\pi=\begin{cases}\frac{[(1-\rho)u+\rho\widetilde{a}]^2}{4} & \text{if } \widetilde{a}\geq\overline{a},\\ \frac{(1-\rho)u^2}{4} & \text{if } \widetilde{a}<\overline{a}.\end{cases}\tag{1}$$

In words, if $\widetilde{a}$ is large enough, then the firm will sell its product to both aware and unaware consumers, and it will determine the profit-maximizing price as if it were facing only consumers with expected quality equal to the average quality measure $(1-\rho)u+\rho\widetilde{a}$. However, if $\widetilde{a}$ is small, the firm will sell its product only to unaware consumers and will set its price as if it were facing only consumers with quality measure u.

Observation 1 *The threshold value $\overline{a}$ is decreasing in ρ.*

Observation 1 implies that if the firm chooses to serve both types of consumers in the case of no advertising, it does so also in the case of advertising, as this leads to a larger share of aware consumers. It is worth mentioning that the firm will lower its price for a larger share of aware consumers since it prefers to serve both types of consumers.

Observation 2 *The profit-maximizing price is decreasing in ρ if the firm decides to sell to all consumers and is constant otherwise.*

This benefits all consumers, including those who remain unaware. We return to this observation when considering consumer surplus implications (see Proposition 2 below).

We consider the following intuitive solution: If $a > \widehat{a}$, (i.e., θ sufficiently small), the firm discloses θ, and all those consumers who are aware after the disclosure decision learn a; if $a < \widehat{a}$, the firm does not advertise, where the threshold value $\widehat{a}$ is to be determined later. The expected quality measure of the aware consumers is then

$$\widetilde{a} = \begin{cases} \frac{\widehat{a}+u-\overline{\theta}}{2} & \text{if } a < \widehat{a}, \\ a & \text{if } a > \widehat{a}. \end{cases}$$

The firm advertises if and only if its profit is higher with advertising than without advertising, which gives a cutoff value $\widehat{a}$ such that the firm advertises if and only if $a \geq \widehat{a}$. Note that in the extreme case with only aware consumers, there would be full unravelling since we consider the special case of zero exogenous disclosure costs. But this does not hold with a mixed population, as information disclosure takes place only for a low level of the harmful substance.

We distinguish two cases: In case 1, the firm sells to both types of consumers if it chooses not to advertise. In case 2, the firm sells only to unaware consumers if it chooses not to advertise. Note that if the firm chooses to advertise, it will necessarily serve both types of consumers because it cannot be profitable for the firm to engage in advertising and sell at the same price as with no advertising to a smaller number of consumers (namely, the remaining unaware consumers).

Case 1 – i.e., the firm sells to both types if it chooses not to advertise.

In this case, the firm with product quality $\widehat{a}$ would choose to sell to both types of consumers whether or not it advertises. According to equation (1), the threshold value $\widehat{a}$ is determined as follows:

$$\frac{\left((1-\rho_0)\,u + \rho_0 \frac{\widehat{a}+u-\overline{\theta}}{2}\right)^2}{4} = \frac{\left((1-\rho_1)\,u + \rho_1 \widehat{a}\right)^2}{4}.$$

In the equation, the left-hand side is the firm's profit with no advertising, while the right-hand side is its profit with advertising. The firm with quality $\widehat{a}$ is indifferent between advertising and not advertising. We obtain

$$\widehat{a} = u - \frac{\rho_0 \overline{\theta}}{\rho_0 + 2\Delta\rho}. \tag{2}$$

The upside of advertising is that it enables the firm to distinguish its product from those with higher levels of the harmful substance and, thereby, obtain a higher profit, paying attention to aware consumers. The downside of advertising from the firm's point of view is that some initially unaware consumers become aware of the adverse effect. We observe that $\widehat{a}$ is increasing in $\Delta\rho$ and decreasing in ρ_0: The firm's benefit from advertising increases with the fraction of initially aware consumers, while the opportunity cost increases with the additional share of consumers who become aware as the result of the advertising.

We observe that $\widehat{a} > u - \overline{\theta}$ if $\Delta\rho > 0$. This means that, as long as advertising makes some consumers aware of the harmful substance, there will not be full unravelling, even though the exogenous disclosure cost is zero.

Case 1 applies if the condition $\widetilde{a}_N = \left(\widehat{a} + u - \overline{\theta}\right)/2 \geq \overline{a}$ holds, where the subscript N stands for no advertising. This condition is equivalent to

$$u \geq A \equiv \frac{\rho_0 \left(\rho_0 + \Delta\rho\right) \overline{\theta}}{\left(1 - \sqrt{1 - \rho_0}\right) \left(\rho_0 + 2\Delta\rho\right)}. \tag{3}$$

We observe that the critical value A that separates case 1 from case 2 is first increasing and then decreasing in ρ_0, while it is strictly decreasing in $\Delta\rho$.

In case 2, the firm sells only to unaware consumers if it chooses not to advertise. In this case, according to equation (1), the threshold value $\widehat{a}$ above is given by

$$\frac{\left(1 - \rho_0\right) u^2}{4} = \frac{\left(\left(1 - \rho_1\right) u + \rho_1 \widehat{a}\right)^2}{4},$$

where the left-hand side is the firm's profit with no advertising, and the right-hand side is its profit with advertising. The above equation gives

$$\widehat{a} = u - \frac{1 - \sqrt{1 - \rho_0}}{\rho_0 + \Delta\rho} u. \tag{4}$$

Equation (4) implies that $\widehat{a}$ is increasing in $\Delta\rho$ and decreasing in ρ_0 in case

2 since[12]

$$\frac{d\widehat{a}}{d\rho_0} = \frac{2\left(\sqrt{1-\rho_0} - (1-\rho_0)\right) - (\rho_0 + \Delta\rho)}{2\left(\rho_0 + \Delta\rho\right)^2\sqrt{1-\rho_0}} < 0$$

and

$$\frac{d\widehat{a}}{d\Delta\rho} = \frac{\left(1 - \sqrt{1-\rho_0}\right)}{\left(\rho_0 + \Delta\rho\right)^2} > 0.$$

The condition of serving only unaware consumers requires $\widetilde{a}_N = \left(\widehat{a} + u - \overline{\theta}\right)/2 < \overline{a}$, which, by using (4) and simplifying, can be rewritten as $u < A$, where A is as defined above.

From (4), we know that

$$\begin{aligned}\widehat{a} &= u - \frac{1-\sqrt{1-\rho_0}}{\rho_0 + \Delta\rho}u \\ &> u - \frac{1-\sqrt{1-\rho_0}}{\rho_0 + \Delta\rho}A \\ &= u - \frac{\rho_0\overline{\theta}}{\rho_0 + 2\Delta\rho} > u - \overline{\theta},\end{aligned}$$

which means that there will not be full unravelling for any $\overline{\theta} > 0$, $\rho_0 > 0$, and $\Delta\rho > 0$.

Observation 3 *A firm with high product quality measure a (and, thus, low value of θ) will advertise, whereas a firm with low product quality a (and, thus, high value of θ) will not, even though the exogenous disclosure cost is zero.*

This observation is due to an endogenous opportunity cost of disclosure when targeting is imperfect. As a result, there is only partial unravelling.

The following proposition provides comparative statics results on the firm's profit-maximizing disclosure and selling decision.

Proposition 1 *Suppose that a share ρ_0 of consumers is initially aware, and advertising informs not only aware consumers but also a share of unaware consumers – namely, $\Delta\rho \geq 0$ of the population.*

a) *The set of parameters such that the firm advertises increases in ρ_0 and decreases in $\Delta\rho$.*

[12]The following inequality holds if $2\left(\sqrt{1-\rho_0} - (1-\rho_0)\right) < \rho_0$, which, after simplification, is equivalent to $\rho_0 > 0$.

b) *If u and $\Delta\rho$ are large and ρ_0 is either small or large, the firm will sell to both aware and unaware consumers* ***whether or not the firm advertises****. For small values of u and $\Delta\rho$ and intermediate values of ρ_0, the firm will sell only to unaware consumers if and only if it does not advertise.*

Part (a) of the proposition says that a larger share of initially aware consumers is more likely to lead to the firm disclosing information.[13] However, a larger additional share of aware consumers after advertising, $\Delta\rho$, reduces the firm's incentive to advertise. This suggests a complementarity between ex-ante information that may stem from an awareness-improving media campaign and the firm's information-disclosure behavior. A case in point is the outbreak of the Chinese milk scandal in 2008. Media coverage and information dissemination among consumers increased consumers' awareness of the health risks of melamine in milk powder. In response to the scandal, firms in the milk powder industry advertised that their product contained no melamine.

According to part (b) of the proposition, case 1 – i.e., the firm will serve both aware and unaware consumers even if it does not advertise – is more "likely" to occur when (1) the product's highest quality u is large; (2) advertising significantly increases the share of aware consumers; and (3) the fraction of initially aware consumers is either very small or very large.

Recall that case 1 applies if the aware consumers' expected quality in the absence of advertisement, $\widetilde{a}_N$, exceeds the threshold value $\overline{a}$. Increasing the willingness-to-pay parameter u has two effects. First, it increases the aware consumers' expected quality in the absence of advertising $\widetilde{a}_N$. Second, it also increases the threshold value $\overline{a}$. The first effect, however, dominates the second one. As a result, case 1 is more likely to occur as u increases. Figure 1 illustrates this finding with the help of a numerical example in which $\rho_0 = 0.4$, $\Delta\rho = 0.2$, and $\overline{\theta} = 1$. In this example, case 1 applies if $u \geq 1.33$ and case 2 applies if $u \leq 1.33$. Consistent with part (b) of Proposition 1, in case 1, the firm advertises if and only if $\theta \leq 0.5$, whereas, in case 2, the firm advertises if and only if $\theta \leq \left(1 - \sqrt{1 - 0.4}\right) u / (0.4 + 0.2) = \left(1 - \sqrt{0.6}\right) u / 0.6$. Considering the adverse effect θ as initially uncertain, the figure also illustrates that the monopolist is more likely to advertise as the willingness-to-pay parameter u initially increases and that his incentives to advertise remain unaffected, when this parameter is increased starting from a larger value.

[13] Relatedly, Gabaix and Laibson (2006) and von Thadden and Zhao (2012) also derive the self-reinforcing pattern of unawareness, meaning that population with a high extent of unawareness will preserve unawareness.

Next consider an increase in $\Delta\rho$ – i.e., a reduction in the precision of the targeting technology. Because advertising makes more consumers aware, firms with a high product quality are also rather reluctant to advertise. Taking this into account, aware consumers have a higher expectation about product quality in the absence of advertising. On the other hand, an increase in $\Delta\rho$ has no effect on the threshold value $\overline{a}$. Consequently, increasing $\Delta\rho$ makes case 1 more "likely" to occur. Figure 2 illustrates this finding with the help of a numerical example, where $u = 1.33$, $\rho_0 = 0.4$, and $\overline{\theta} = 1$. In this example, case 1 applies if $\Delta\rho \geq 0.2$ and case 2 applies if $\Delta\rho \leq 0.2$. The firm advertises if and only if $\theta \leq 0.4/(0.4 + 2\Delta\rho)$, whereas, in case 2, the firm advertises if and only if $\theta \leq 1.33\left(1 - \sqrt{1 - 0.4}\right)/(0.4 + \Delta\rho)$. Figure 2 also illustrates part (a) of Proposition 1 (where it refers to $\Delta\rho$), as the boundary for advertising is decreasing in $\Delta\rho$. Considering the adverse effect θ as initially uncertain, this result says that the less precise the targeting technology, the less likely is the monopolist to advertise.

The effect of an increase in the share of initially informed consumers ρ_0 is less obvious. Both $\widetilde{a}_N$ and $\overline{a}$ are decreasing in ρ_0. The decreasing rate of $\widetilde{a}_N$ is larger (smaller) than that of $\overline{a}$ when ρ_0 is small (large). Thus, case 1 is more "likely" to apply to small and large ρ_0, but less so for intermediate values. Figure 3 illustrates this finding with the help of a numerical example, where $u = 1.33$, $\Delta\rho = 0.2$, and $\overline{\theta} = 1$. In this example, case 1 applies if $\rho_0 \leq 0.4$ and $\rho_0 \geq 0.47$; case 2 applies if $0.4 \leq \rho_0 \leq 0.47$. In case 1, the firm advertises if and only if $\theta \leq \rho_0/(\rho_0 + 0.4)$. In case 2, the firm advertises if and only if $\theta \leq 1.33\left(1 - \sqrt{1 - \rho_0}\right)/(\rho_0 + 0.2)$. Moreover, the boundary that separates advertising from not advertising is increasing in ρ_0. Thus, Figure 3 also illustrates part (a) of Proposition 1 (concerning ρ_0).

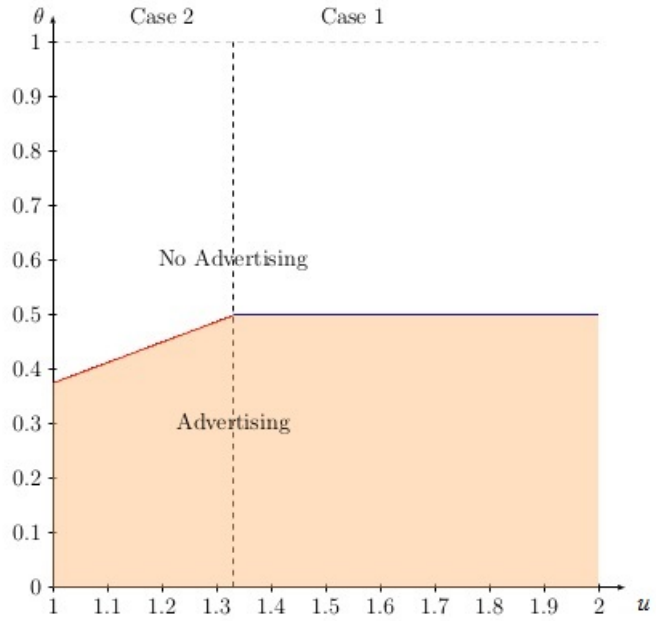

Figure 1: $\rho_0 = 0.4$, $\Delta\rho = 0.2$, $\overline{\theta} = 1$.

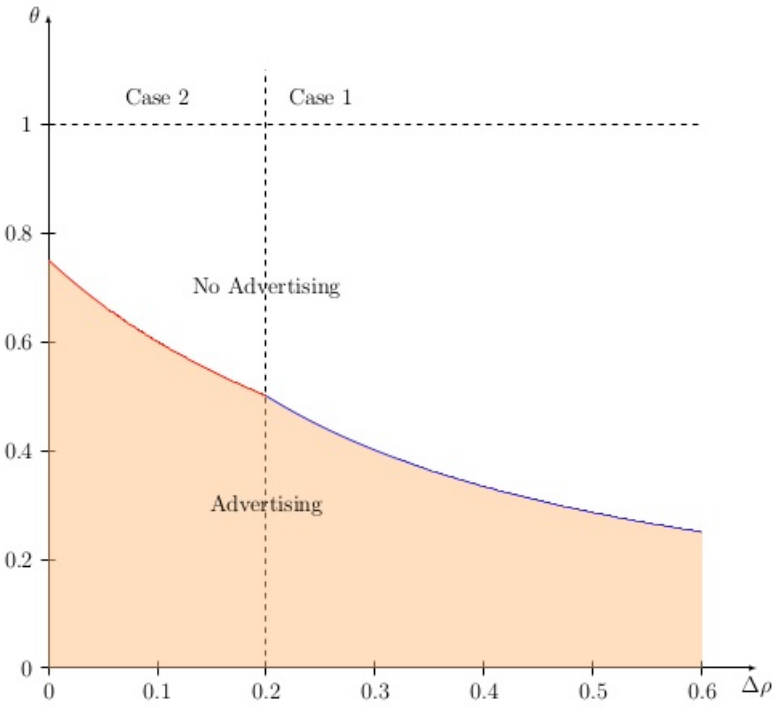

Figure 2: $u = 1.33$, $\rho_0 = 0.4$, $\overline{\theta} = 1$.

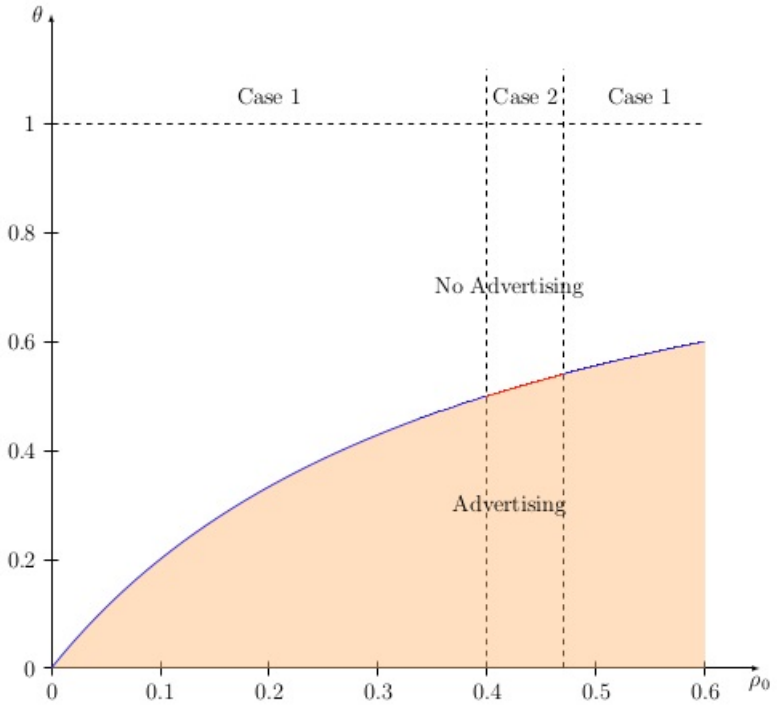

Figure 3: $u = 1.33$, $\Delta\rho = 0.2$, $\overline{\theta} = 1$.

One further result in the positive analysis is worth pointing out. Consider the effect of the availability of information disclosure on the monopolist's optimal selling strategy. If the firm cannot disclose any information to consumers, it is more likely for the firm to sell to unaware consumers only. In other words, if the instrument of information disclosure is available to the firm, it is more likely to sell to both types of consumers than in its absence. To show this, consider the alternative case in which the firm cannot disclose any information. The firm will sell to both types if the aware consumer's expected quality $\widetilde{a} \geq \overline{a}$, in which case we have $\widetilde{a} = u - \overline{\theta}/2$, which is equivalent to

$$u \geq B \equiv \frac{\rho_0 \overline{\theta}}{2\left(1 - \sqrt{1 - \rho_0}\right)}.$$

It is straightforward to see that $B < A$. Even if the additional share $\Delta\rho$ of aware consumers makes the firm more likely to sell to both types, the likelihood of selling to both types is necessarily smaller than in the absence of the instrument of information disclosure, when aware consumers cannot draw any inferences from the firm's non-disclosure decision.

Surplus measures and awareness. In the following, we focus on the effect of the initial share of aware consumers on profits, consumer surplus and total surplus. The initial share is a key characteristic of the composition

of consumers. For simplicity, we restrict our attention to case 1, in which the firm serves both aware and unaware consumers whether or not it advertises. (Some of the results will be helpful is our subsequent analysis of mandatory disclosure policies in Section 4.)

The expression of A, defined by (3), cannot exceed the value $2\overline{\theta}$.[14] Hence, only case 1 is relevant as long as $u \geq 2\overline{\theta}$, which is assumed to hold in the remainder of the paper.

We derive the firm's profit, consumer's surplus and the total surplus as a function of aware consumers' quality measure a. Ex post, without advertising, the quantity sold to the unaware consumer is $Q_u = u - p_N$, while the quantity sold to the aware consumer is $Q_a = \widetilde{a}_N - p_N$, where $p_N = \left(\left(1-\rho_0\right)u + \rho_0 \widetilde{a}_N\right)/2$.

With advertisement, the quantity sold to unaware consumers is $Q_u\left(a\right) = u - p\left(a\right)$, while the quantity sold to aware consumers is $Q_a\left(a\right) = a - p\left(a\right)$, where $p\left(a\right) = \left(\left(1-\rho_0-\Delta\rho\right)u + \left(\rho_0+\Delta\rho\right)a\right)/2$.

The firm will advertise when the quality of its product is high, $a > \widehat{a}$; and it will remain silent when the quality of its product is low, $a < \widehat{a}$. Given the product's quality a, the aware consumer's utility is

$$U_a\left(a\right) = \begin{cases} \left(a - p\left(a\right)\right)Q_a\left(a\right) - \frac{1}{2}Q_a^2\left(a\right), & \text{if } a > \widehat{a} \\ \left(a - p_N\right)Q_a - \frac{1}{2}Q_a^2, & \text{if } a \leq \widehat{a} \end{cases}; \tag{5}$$

the unaware consumers' utility is

$$U_u\left(a\right) = \begin{cases} \left(a - p\left(a\right)\right)Q_u\left(a\right) - \frac{1}{2}Q_u^2\left(a\right), & \text{if } a > \widehat{a} \\ \left(a - p_N\right)Q_u - \frac{1}{2}Q_u^2, & \text{if } a \leq \widehat{a} \end{cases}; \tag{6}$$

the firm's profit, by equation (1), is

$$\pi\left(a\right) = \begin{cases} \frac{1}{4}\left[\left(1-\left(\rho_0+\Delta\rho\right)\right)u + \left(\rho_0+\Delta\rho\right)a\right]^2, & \text{if } a > \widehat{a} \\ \frac{1}{4}\left[\left(1-\rho_0\right)u + \rho_0\widetilde{a}_N\right]^2, & \text{if } a \leq \widehat{a} \end{cases};$$

the total surplus from aware consumers' consumption is

$$TS_a\left(a\right) = \begin{cases} aQ_a\left(a\right) - \frac{1}{2}Q_a^2\left(a\right), & \text{if } a > \widehat{a} \\ aQ_a - Q_a^2/2, & \text{if } a \leq \widehat{a} \end{cases};$$

and the total surplus from unaware consumers' consumption is

$$TS_u\left(a\right) = \begin{cases} aQ_u\left(a\right) - \frac{1}{2}Q_u^2\left(a\right), & \text{if } a > \widehat{a} \\ aQ_u - Q_u^2/2, & \text{if } a \leq \widehat{a} \end{cases}.$$

[14] This is seen as follows: $A = \rho_0\left(\rho_0+\Delta\rho\right)\overline{\theta}/\left(\left(1-\sqrt{1-\rho_0}\right)\left(\rho_0+2\Delta\rho\right)\right) \leq \rho_0\overline{\theta}/\left(1-\sqrt{1-\rho_0}\right) \leq 2\overline{\theta}$, where the last inequality holds as long as $\rho_0 > 0$.

The firm's expected profit is given by

$$E\pi = \int_{u-\overline{\theta}}^{\widehat{a}} \frac{\left[(1-\rho_0)\,u + \rho_0 \widetilde{a}_N\right]^2}{4\overline{\theta}} da + \int_{\widehat{a}}^{u} \frac{\left[(1-(\rho_0+\Delta\rho))\,u + (\rho_0+\Delta\rho)\,a\right]^2}{4\overline{\theta}} da. \tag{7}$$

The expected consumer surplus is given by

$$ECS = \int_{u-\overline{\theta}}^{\widehat{a}} \frac{1}{\overline{\theta}} \{\rho_0 U_a(a) + (1-\rho_0)\,U_u(a)\} da + \int_{\widehat{a}}^{u} \frac{1}{\overline{\theta}} \{(\rho_0+\Delta\rho)\,U_a(a) + (1-(\rho_0+\Delta\rho))\,U_u(a)\} da, \tag{8}$$

and the total surplus is given by

$$ETS = \int_{u-\overline{\theta}}^{\widehat{a}} \frac{1}{\overline{\theta}} \{\rho_0 TS_a(a) + (1-\rho_0)\,TS_u(a)\} da + \int_{\widehat{a}}^{u} \frac{1}{\overline{\theta}} \{(\rho_0+\Delta\rho)\,TS_a(a) + (1-(\rho_0+\Delta\rho))\,TS_u(a)\} da. \tag{9}$$

The following proposition establishes how the consumers' initial awareness ρ_0 affects surplus measures.

Proposition 2 *Conditional on the firm having entered the market, the following holds:*

a) *The firm's expected profit decreases with the consumer's initial awareness ρ_0;*

b) *The consumer's surplus increases with the his initial awareness ρ_0;*

c) *The effect of an increase in ρ_0 on the total welfare is ambiguous.*

Proof. See Appendix. ■

In part (a) of the proposition, intuitively, a firm can charge a higher price to the unaware consumers, who are incorrectly "optimistic" about the firm's product. Thus, its profit decreases as awareness increases in the population.

With respect to part (b) of Proposition 2, as awareness increases in the population, consumers face a lower price (see Observation 2), and their probability of making a correct decision increases. This leads to an increase in consumer surplus. As pointed out above, due to the price effect, an awareness-increasing shock also positively affects those consumers whose awareness is not affected by the shock.

The following describes the intuition for part (c) of Proposition 2 that social welfare may be higher with unaware consumers than with aware consumers. Note that a monopoly seller always sets a price higher than the socially optimal level. This leads to too little consumption in the market with complete information. If consumers are unaware of the potentially adverse effect, they consume a larger quantity; if the firm hides the information, the consumer's demand is larger since the adverse effect shifts the consumers' willingness-to-pay upwards. Thus, the distortions created by monopoly and unawareness go in opposite directions. Consequently, in the presence of market power, consumer unawareness is not necessarily detrimental to social welfare measured as total surplus. Whether total surplus is larger with aware consumers than with unaware consumers depends on the values the parameters take. If the quality u is large relative to the potential size of the harmful substance, then total surplus is decreasing with consumer awareness.

3.2 Entry Decision

In this subsection, we turn to the firm's entry decision at stage 1 and its consumer surplus implication. The firm will enter the market and introduce a new product if and only if the expected gross profit exceeds the entry cost K; i.e., $E\pi \geq K$. With endogenous entry, depending on parameter values, the firm optimally chooses one of the three options: (1) the firm does not enter; (2) the firm enters and does not disclose; or (3) the firm enters and (partially) discloses. Clearly, with entry, there are also no parameters such that the firm optimally chooses awareness-enhancing disclosure. The reason is that a firm of type θ' such that all types $\theta \leq \theta'$ disclose has a strict incentive to disclose its type, as well.

From Proposition 2, we know that increasing the consumers' initial awareness ρ_0 reduces the firm's profit and, hence, may make entry unprofitable for the firm. The decision of the firm not to enter harms those consumers who would receive a strictly positive surplus in the case of entry. The next corollary, which follows our Proposition 2, shows that the consumer surplus is non-monotone in the consumer's initial awareness ρ_0.

Corollary 1 a) *If $K < E\pi|_{\rho_0=1-\Delta\rho}$ then the consumer surplus is strictly increasing in ρ_0;*

b) *If $E\pi|_{\rho_0=1-\Delta\rho} < K < E\pi|_{\rho_0=0}$ then there exists $\widehat{\rho}_0 \in (0, 1-\Delta\rho)$ such that the consumer surplus is increasing on the interval $(0, \widehat{\rho}_0)$ and decreasing discontinuously at $\widehat{\rho}_0$ and remains zero on the interval $(\widehat{\rho}_0, \Delta\rho)$.*

c) *If $K > E\pi|_{\rho_0=0}$ then the consumer surplus is zero for any ρ_0.*

Proof. See Appendix. ■

Increasing consumer awareness raises the consumer surplus, as long as it does not impede the firm's entry. But it is possible that consumer awareness is increased by a sufficiently large extent such that the firm does not want to enter in the first place, and, hence, reduces the consumer surplus to zero. This corollary has important implications for the evaluation of different mandatory disclosure rules, which will be discussed in the next section.

4 Mandatory Disclosure Rules

In this section, we turn to consumer protection policies that may be introduced by the regulator, the consumer protection authority, or the legislator. The party introducing such a policy commits itself to applying the rule unconditionally. In our model, this means that the rule is implemented at some prior stage, which can be called stage 0. We explore the implications of two simple information-disclosure policies.

One policy is *mandatory awareness-enhancing disclosure*, according to which the firm is forced to reveal only the existence of θ (or, equivalently, the public authority performs an awareness-improving campaign itself). As mentioned before, in the alternative setting – in which consumers know the negative effect of an ingredient, but unaware consumers do not suspect that the product contains the ingredient – the firm is forced to disclose that this ingredient is contained in the product, a possibility that unaware consumers ignored. It is then up to the firm to decide whether to disclose the exact amount of θ. The awareness-enhancing disclosure raises the proportion of initially aware consumers from ρ_0 to ρ_0'.

The other policy is *mandatory full disclosure,* according to which the firm must reveal all the information that it has – that is, the existence and the exact amount of θ. We assume that revealing the exact amount of θ may increase consumer awareness from ρ_0 to $\rho_0''(\geq \rho_0')$ with $\rho_0'' - \rho_0 \equiv \Delta\rho$, as consumers may pay more attention to the information.

An extreme case is that mandatory awareness-enhancing disclosure makes all the consumers aware; i.e., $\rho_0' = 1$. If so, after the awareness-improving campaign, the model turns out to be one in which all consumers are uncertain but aware of the amount of θ. Because we assume that it is costless to disclose information, the unravelling logic tell us that there is full information disclosure. Thus, mandatory partial information disclosure and mandatory full information disclosure are equivalent in this case. If $\rho_0'' > \rho_0'$, the full-disclosure rule leads to more aware consumers than the awareness-enhancing disclosure rule.

No mandatory disclosure rule. If there is no mandatory disclosure rule, the proportion of initially aware consumers is ρ_0. According to our previous analysis, the firm will advertise if $a > \widehat{a}$, with $\widehat{a}$ given by (2). The firm's profit and the consumer surplus are given by (1) and (8) and are denoted by $E\pi_n$ and ECS_n, where n represents no mandatory disclosure rule.

Mandatory awareness-enhancing disclosure. With the mandatory awareness-enhancing disclosure rule, the firm's behavior and, hence, the consumer surplus, the firm's profit and the total surplus are exactly the same as in the case of no mandatory disclosure rule, except that now the proportion of initially aware consumers is ρ_0' instead of ρ_0 with $\rho_0' \geq \rho_0$. We denote the firm's profit and the consumer surplus by $E\pi_a$ and ECS_a, where a represents mandatory awareness-enhancing disclosure rule. As we noted in the previous subsection, the monopolist would never choose an advertising strategy featuring this type of disclosure. However, for some parameters, the regulator optimally imposes such a rule ex ante.

Mandatory full disclosure. With the mandatory full information disclosure rule, the proportion of aware consumers is $\rho_0'' = \rho_0' + \Delta\rho$, where $\Delta\rho \geq 0$. Moreover, aware consumers are fully informed about the product's adverse effect. Consequently, the firm's profit and the consumer surplus are given by (1) and (8), by replacing $\widehat{a}$ with $u - 1$, ρ_0 with ρ_0'', and are denoted by $E\pi_f$ and ECS_f, where f represents the mandatory full information disclosure rule.

After careful calculation and comparison, we have the following lemma:

Lemma 1 *Conditional on the firm having entered the market, profits and consumer surplus under the different mandatory disclosure rules are* $E\pi_f < E\pi_a < E\pi_n$ *and* $ECS_f > ECS_a > ECS_n$.

Proof. See Appendix. ■

The above lemma suggests that the mandatory disclosure rule protects consumers. The stronger the requirement, the more protective the law is. A mandatory partial information disclosure rule increases the proportion of aware consumers compared to no disclosure, which directly increases consumer surplus, because fewer consumers make biased purchase decisions. Furthermore, the increased consumer awareness provides the firm with a stronger incentive to disclose information, which increases the consumer surplus further. A mandatory full information disclosure not only weakly increases consumer awareness, but also provides consumers who, after disclosure, are aware of the presence of an adverse effect with the full information about the

level of that effect, which makes it possible for consumers to make better-informed decisions. Thus, it leads to the largest consumer surplus among the three regimes.

In many real-world situations, laws oblige sellers to disclose their private information about the quality of their products. However, the theoretical justification is not obvious. The well-known unravelling reasoning tells us that a seller will voluntarily disclose all the quality information, as long as the information-disclosure cost is zero. Unawareness, however, undermines this full disclosure result, and explains why it is possible that only high-quality firms choose to disclose. Mandatory disclosure rules increase awareness and, hence, raise consumer surplus at the expense of firm profits. Given the mix of aware and unaware consumers, even if the cost of information disclosure is zero for the firm, imposing mandatory disclosure is in the consumers' interest, as it protects them.

Taking the firm's entry decision at stage 1 into account, leads to a more nuanced result captured by the following proposition, which directly follows from the above:

Proposition 3 **a)** *If $K < E\pi_f$ then the consumer surplus is highest under the mandatory full information disclosure rule.*

b) *If $E\pi_f < K < E\pi_a$ then the consumer surplus is highest under the mandatory awareness-enhancing information disclosure rule.*

c) *If $E\pi_a < K < E\pi_n$ then the consumer surplus is highest without a mandatory information disclosure rule.*

d) *If $K > E\pi_n$ then the consumer surplus is zero in all regimes.*

Although a stronger information disclosure rule provides better protection for consumers, it may discourage the firm's investment and, hence, hurt consumers from an ex ante perspective. The optimal information disclosure rule responds to the tradeoff between the benefit of providing information to consumers and the cost of impeding the firm's entry. The smaller the entry cost, the more demanding the optimal information disclosure rule. If the cost is small, even the strongest mandatory information disclosure rule will not impede the investment. Hence, consumers are best off if the mandatory full information disclosure rule is in place. As the investment cost increases, when the investment becomes unprofitable with the mandatory full disclosure rule, but not with the mandatory awareness-enhancing disclosure rule, the latter rule is the best consumer-protection policy in this case. As pointed out in the previous section, the firm would never choose such a rule. Thus, the regulator

may want to require the firm to disclose qualitatively different information than what the firm would consider. As mentioned above, if unaware consumers know that a certain ingredient has adverse effects but are unaware that the product may contain this ingredient, the awareness-enhancing disclosure rule requires the firms to list all ingredients of the product (but not their amounts). We currently observe this policy applied to food products in a number of countries. Those consumers who would be unaware absent this mandatory disclosure, but who receive the information that the firm has been required to post, increase the overall fraction of aware consumers. This increases consumer surplus relative to a no-disclosure rule, but still allows the firm to make an expected (gross) profit larger than the investment cost. As the investment cost continues to increase, even awareness-enhancing disclosure will deter the firm's investment. In this case, no mandatory information disclosure rule should be imposed.

5 Investment in Reducing the Adverse Effect

In many real-world situations, firms are aware as early as at the product design stage that a particular ingredient is potentially harmful. They may take steps to limit the required level of that ingredient; in the extreme, they may design the product so as to avoid the use of the ingredient altogether. Our analysis is easily extended to allow for (observable or unobservable) effort in the reduction of the amount of the ingredient θ prior to stage 1, but after the regulator has chosen its mandatory disclosure rule. How do investment costs affect the optimal mandatory disclosure policy? To address this question, suppose, for simplicity, that the firm can completely avoid or remove the adverse effect of its product by exerting a costly effort, with associated cost C. In this special case, it is immaterial whether or not effort is observable.[15] The firm's gross profit then becomes $\overline{\pi} = u^2/4$.

Under the mandatory full disclosure rule, the firm exerts such an effort to remove the adverse effect if $C \leq C_f = \overline{\pi} - E\pi_f$. Under the mandatory awareness-enhancing disclosure rule, the firm will exert such an effort if $C \leq C_a = \overline{\pi} - E\pi_a$. If there is no mandatory disclosure rule, the firm will exert effort if $C \leq C_n = \overline{\pi} - E\pi_n$. It follows from Lemma 1 that $C_f > C_a > C_n$. This shows that the mandatory disclosure rule gives a firm incentives to remove the adverse effect from its product. The more demanding the disclosure rule, the stronger the incentives for the firm to exert the effort. The fact that $C_a > C_n$ indicates that a firm's incentive to reduce the adverse effect increases with consumer awareness.

[15] Since disclosure is costless, a firm will always disclose if it has exerted effort.

Mandatory disclosure positively affects consumers. It benefits consumers by not only providing them with more information to make correct purchasing decisions, but also gives the firm incentives to reduce its product's adverse effect.

The possibility of eliminating the adverse effect by exerting a fixed cost C increases the set of parameters such that the mandatory full disclosure rule is the optimal disclosure rule from the consumers' point of view. Indeed, consider the case in which $E\pi_f < K < E\pi_a$ and $C_a < C < C_f$. In our previous setting, from proposition 3, the mandatory full disclosure rule was not optimal for consumers because it impeded the firm's investment K. In our current setting, however, when $E\pi_f < K < \overline{\pi} - C$, the mandatory full disclosure rule does not impede the firm's investment K. Indeed, the firm can obtain strictly positive profit by investing K and then exerting effort C. Consequently, the mandatory full disclosure rule is optimal for consumers. Note further that the mandatory awareness-enhancing disclosure rule is still the optimal rule for consumers when $\overline{\pi} - C < K < E\pi_a$, since the mandatory full disclosure rule impedes the firm's investment K. We summarize our results in the following proposition.

Proposition 4 a) *The mandatory full disclosure rule provides the firm with the strongest incentive to reduce the adverse effect of its product, while no mandatory disclosure rule provides the weakest incentives.*

b) *There exist parameters for each rule to be optimal for consumers. The possibility of exerting an effort to remove the adverse effect enlarges the set of parameters such that the mandatory full disclosure rule is optimal for consumers, and reduces the set of parameters such that the no-disclosure rule is optimal for consumers.*

To make as transparent as possible our result on the firm's effort to reduce the adverse effect, we proposed a particular setting with binary actions and the possibility to completely remove it. Is is straightforward to extend the analysis in these two respects.

First, with binary effort choice and the possibility to only partly remove the adverse effect to $\overline{\theta} - \Delta\theta$, the equilibrium effort, entry, disclosure and price decision will depend on whether or not effort is observable, as it affects the updating of aware consumers. If it is not observable, we can truly speak of moral hazard, as consumers may not be able to infer the firm's effort decision when making their purchasing decision. We do not formally analyze this setting as the content of the qualitative findings about the desirability of mandatory disclosure rules remains unchanged irrespective of the size of $\Delta\theta$ and the observability of the effort decision.

The observability of the investment, however, does affect the strength of the firm's investment incentive whenever $\overline{\theta} - \Delta\theta > 0$. Unobservability of corresponding effort weakens the firm's incentive to reduce the adverse effect of its product under the no information disclosure rule or the mandatory awareness-enhancing disclosure rule.[16] Hence, the mandatory full disclosure rule is more likely to be socially beneficial when effort is unobservable than when it is observable.

Second, the firm may choose $\overline{\theta}$ from the positive real numbers with the associated cost being infinite for $\overline{\theta} = 0$ and zero for $\overline{\theta}$ turning to infinity. Assuming that this cost function is continuously differentiable and convex, provides a unique $\overline{\theta}$ for the three mandatory disclosure rules under consideration. In this setting, mandatory disclosure leads to more effort (i.e., lower value of $\overline{\theta}$) than awareness-enhancing disclosure, which, in turn, leads to more effort than in the absence of mandatory disclosure. This ranking holds whether or not the investment is observed by aware consumers.

6 Discussion

Competition: We have restricted our analysis to a monopoly, but it is straightforward to set up an oligopoly model with linear demand. While we do not pursue a formal analysis here, a few points are worth making. In the case of competition, a firm (which has information about its own and its competitors' level of the adverse effect) may have an incentive to reveal information about adverse product effects if this makes its competitors appear sufficiently worse than itself. Therefore, there may be information disclosure by some firm even if its adverse effect is large in absolute terms. The result is akin to the one with respect to revealing attribute information in comparative advertising (see Anderson and Renault, 2009).

[16]The reasoning is as follows. Suppose that the effort is observable; then, aware consumers hold the correct belief that the adverse effect is uniformly distributed on $\left[0, \overline{\theta}\right]$ if a firm shirks. Conditional on shirking, the quality of a product with no advertising will be regarded as $\widetilde{a}_N = u - \overline{\theta}$. Suppose, instead, that the effort is unobservable. Consider an equilibrium in which the firm exerts effort. If the firm adopts the equilibrium strategy and aware consumers form the correct belief, then the quality of a product with no advertising will be regarded as $\widetilde{a}'_N = u - \left[\overline{\theta} - \Delta\theta\right]$. Notice that $\widetilde{a}'_N > \widetilde{a}_N$. After shirking, a firm has two options: disclosing information or hiding information. If the firm discloses information, its profit is the same as in the case of observable effort. If the firm hides information, then the quality of its product will be regarded as $\widetilde{a}'_N$, since consumers can not observe the shirking behavior and, therefore, still hold the equilibrium belief. In this case, the firm earns a higher profit than in the case of unobservable effort. To sum up, unobservability of effort makes shirking more profitable and, therefore, weakens the firm's incentive to reduce the adverse effect.

Within the corresponding duopoly model extended by the inclusion of two potentially harmful ingredients, firms may end up in a prisoner's dilemma, with both of them disclosing information on the ingredient in which they have a comparative advantage. In fact, both of them would be better off if they could jointly agree not to disclose information. However, given its rival's strategy of information disclosure, it is optimal for a firm to disclose information in the dimension in which it performs better than its competitor. Thus, the message is that competition renders the problem that a firm may refrain from information disclosure less severe.

We conjecture that our insight – that the awareness-enhancing disclosure rule may be better than the mandatory full disclosure rule – also applies to imperfect competition. Indeed, for a range of investment costs, the awareness-enhancing disclosure rule will keep both firms active in the market, while mandatory full disclosure may lead to market exit by some firms and, thus, to a monopoly position for the remaining firm. The resulting pricing inefficiency tends to reduce consumer surplus. Future work may want to take a systematic look at imperfectly competitive markets beyond what has been done in Li, Peitz, and Zhao (2014) in a simple vertical differentiation duopoly.

Taxation: Suppose that, for each unit of the product that the firm sells, the firm (or the consumer) has to pay an excise tax $\tau > 0$. Our qualitative finding continues to hold true for $\tau > 0$.[17] Since equilibrium demand decreases in τ, the firm's profit and consumer surplus are decreasing in τ.

Increasing the tax rate is formally equivalent to reducing u. Thus, when the tax rate τ is marginally increased, starting from a low level, the firm's inclination to advertise remains unchanged; in such a situation, the firm optimally sells to both types of consumers when not advertising (case 1). Starting from a high level of τ, when not advertising, the firm optimally sells to unaware consumers only, and the firm becomes less inclined to advertise as the tax rate is marginally increased. This was illustrated in Figure 1.

Moreover, with a higher tax, the firm has now a lesser incentive to enter the market due to lower expected profits. Compared to the case with zero tax, this suggests that entry costs must be rather low for a mandatory disclosure rule to be socially desirable. While a formal analysis is beyond the scope of this paper, our discussion hints at an interesting interaction between tax policy and public policy as regards mandatory disclosure rules.

[17] In our specification, the pass-through rate is one half.

7 Conclusion

This paper presents a simple monopoly product model to capture the effect of a potentially harmful substance contained in the product. The firm operates in a market with a population mix of aware and unaware consumers. The firm may want to hide the fact that its product contains a harmful substance, as well as the level of it. As a result, a firm discloses all its information if the level of the harmful substance is low, while it does not disclose if the level is high. Consumers always benefit from more information; thus, they will benefit from learning that the substance is indeed harmful and from knowing how much of the substance the product contains. When endogenizing the firm's entry decision, the issue arises that a firm may not find it profitable to offer the product. This holds if the expected gross profits are below the entry cost. This makes well-meaning mandatory disclosure rules a double-edged sword. Given the firm's entry, more-stringent disclosure rules are consumer-surplus increasing. However, implementing a strict rule carries the risk that the firm will not enter. Thus, full mandatory disclosure may be harmful, and, under some circumstances, awareness-enhancing disclosure that does not contain information about the level of the potentially harmful substance may be consumer-surplus superior. Absent regulation, the firm will never choose such a disclosure rule, while the rule may well be optimal for the regulator trying to strike a balance between reducing consumer biases and allowing a firm to extract rents.

We motivated our analysis by referring to potentially harmful substances. More generally, our analysis applies to products that affect consumers' utilities, although they may not be aware of this at the moment of purchase. In particular, it applies to complex products about which information is, in principle, available, but about which consumers may suffer from biased beliefs at the moment of purchase.[18]

Selling to consumers who hold biased beliefs because they are kept in the dark, can be called mis-selling. Whether a certain action should be considered mis-selling depends on consumer behavior. In a Bayesian world, consumers may lack information, but they use correct beliefs given their information. Therefore, they cannot be systematically misled. This also means that non-disclosure and other attempts to hide unfavorable information, do not lead to systematically wrong purchase decision. By contrast, if consumers are unaware of certain product characteristics, the possibility of mis-selling arises. Here, firms may systematically suppress information. In this context,

[18]Our analysis can also be seen as a reduced-form model of add-on pricing, where consumers may be adversely surprised by the add-on costs—e.g., of cartridges after buying a printer or of watching in-room movies in a hotel.

mandatory testing and disclosure rules are an important policy instrument to protect consumers. In the case of non-compliance, harsh punishments may be the only means to deter a firm from ignoring such consumer-protection policies. Attempts to encourage information gathering by consumers have little relevance if consumers are completely naive, in the sense that they are over-confident about their knowledge of the products and believe that adverse effects cannot materialize.

Empirical evidence by Jin and Leslie (2003) is in line with our argument. They consider the effect of a mandatory disclosure rule that, starting in 1998, applied to restaurants in parts of Los Angeles: Restaurants were forced to display the results of hygiene inspections on a grade card placed in their front restaurant window. They found that average hygiene scores improved, the number of hospitalizations due to food poisoning went down and consumer demand became more sensitive to changes in hygiene. In particular, the third finding is consistent with consumers initially not being aware of the health risks involved. Thus, the key impact of the mandatory disclosure rule may have been direct and indirect effects of increased consumer awareness of the health risks.[19]

Our theory applies not only to how a product directly affects consumers, but also to the type of production processes that is used and the type of labor contracting within the firm and in vertical supply relationships. To be applicable, the utility that a consumer derives must depend on the use of inputs and contracts that the firm uses. This is the case if the utility function reflects ethical and environmental concerns. Cases in point are the failure to uphold standards in labor contracts, such as the use of child labor or forced labor (as exemplified by hand-woven carpets and textiles—recall, for instance, past media coverage on sweatshops for products by Nike); the health and safety risks for workers (this applies, e.g., to mining products and textiles – recent concrete examples are jeans dying in Turkey and textile manufacturing in Bangladesh), disrespect of environmental standards (e.g., in case of textiles and cleaning products); disrespect of indigenous rights (as happened in case of oil extraction); and animal experiments (e.g., for cos-

[19]Two caveats are in order: First, we do not claim that the findings in Jin and Leslie (2003) contradict the Bayesian model. However, the fact that the policy intervention was triggered by a hidden-camera exposé done by a local television news channel indicates that initial consumer unawareness has contributed to the observed effects of the policy intervention. Second, we admit that our model includes neither the incentive aspect of mandatory disclosure nor the analysis of reputation effect absent disclosure through the display of grade cards. As indicated in the modified simple model that includes moral hazard, the distribution of restaurant types endogenously changes due to the policy intervention, which then leads to an improved average record of restaurant hygiene.

metics).[20] Under mandatory partial information disclosure, the government (or NGOs) makes consumers aware of the possible disrespect of certain standards. Such awareness campaigns make consumers aware of the relevance of a certain product characteristic that enters the consumer's utility function (directly or through peer effects). It is up to the firms to certify that they follow certain business practices and comply with standards. Such processes are often certified by third parties. This hints at a potential complementarity between mandatory information disclosure and private certification efforts: Partial public information disclosure may be necessary to make private certification efforts viable in market equilibrium.[21]

We note that an increase in the share of initially aware consumers may come from public awareness campaigns. Such campaigns can affect the incentives of firms to reveal private information. In particular, if the share of aware consumers is large, private information disclosure through advertising is more pronounced. Thus, some initially unaware consumers also become informed. This suggests that public awareness campaigns can have a multiplier effect through private (albeit only partial) information disclosure about the level of the adverse effect.

[20]The "war diamonds" from Congo are a concrete example. Here, consumers were concerned about the effect of upstream profits on the suffering of people, as a consequence of war that was financed through these profits. In this context, NGOs play an important role in raising awareness; a firm's response consists in certifying the origin of inputs: De Beers' certification efforts of the origin of its diamonds can be seen as a response to the consumers being aware that they may be buying war diamonds (which do not make a nice wedding gift).

[21]Whether private certification is fully revealing is a different issue. See Biglaiser (1993) and Lizzeri (1999) on this issue.

References

[1] Anderson, S. and R. Renault (2009): "Comparative Advertising: Disclosing Horizontal Match Information," *Rand Journal of Economics,* 40(3), 558-581.

[2] Auster, S. (2013): "Asymmetric Awareness and Moral Hazard," *Games and Economic Behavior*, 82, 503-521.

[3] Bagwell, K. (2007): "The Economic Analysis of Advertising," in: M. Armstrong and R. Porter, *Handbook of Industrial Organization*, vol. 3, North Holland.

[4] Becher, S. (2008): "Asymmetric Information in Consumer Contracts: The Challenge that is yet to be Met," *American Business Law Journal*, 45(4), 723-774.

[5] Biglaiser, G. (1993): "Middlemen as Expert," *Rand Journal of Economics*, 24, 212-223.

[6] Daughety, A. and J. Reinganum (1995): "Product Safety: Liability, R&D, and Signaling," *American Economic Review*, 85(5), 1187-1206.

[7] Daughety, A. and J. Reinganum (2008): "Products Liability, Signaling and Disclosure," *Journal of Institutional and Theoretical Economics*, 164(1), 106-126.

[8] Della Vigna S. and U. Malmendier (2004): "Contract Design and Self-Control: Theory and Evidence," *Quarterly Journal of Economics,* 119, 353-402.

[9] Dixit, A and V. Norman (1978): "Advertising and Welfare," *Bell Journal of Economics*, 9(1), 1-17.

[10] Eliaz, K. and R. Spiegler (2006): "Contracting with Diversely Naive Agents," *Review of Economic Studies*, 73, 689-714.

[11] Eliaz, K. and R. Spiegler (2011): "Consideration Sets and Competitive Marketing," *Review of Economic Studies,* 78, 235-262.

[12] Esteban, L., Gil, A., and J. Hernandez (2001): "Informative Advertising and Optimal Targeting in a Monopoly," *Journal of Industrial Economics*, 49, 161-180.

[13] Esteban, L., Gil, A., and J. Hernandez (2004): "Pricing with Endogenous Direct Advertising in a Monopoly," *Review of Industrial Organization*, 49, 161-180.

[14] Evans, D. (2008): "The Economic of the Online Advertising Industry," *Review of Network Economic*s, 7, 359-391.

[15] Filiz-Ozbay, E. (2012): "Incorporating Unawareness into Contract Theory," *Games and Economic Behavior*, 76, 181-194.

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

[17] Galeotti, A., and J. L. Moraga-Gonzalez (2008). "Segmentation, Advertising, and Prices," *International Journal of Industrial Organization* 26, 1106-1119.

[18] Goldfarb, A. (2014): "What is different about online advertising?" *Review of Industrial Organization*, 44, 115-129.

[19] Grossman, M. (1981): "The Informational Role of Warranties and Private Disclosure about Product Quality," *Journal of Law and Economics*, 24, 461-483.

[20] Grossman, M. and O. Hart (1980): "Disclosure Laws and Takeover Bids," *Journal of Finance*, 35, 323-24.

[21] Iyer, G., Soberman, D., and J.M. Villas-Boas (2005): "The Targeting of Advertising," *Marketing Science*, 24, 461-476.

[22] Jin, G. and P. Leslie (2003): "The Effect of Information on Product Quality: Evidence From Restaurant Hygiene Grade Cards," *Quarterly Journal of Economics,* 118, 409-51.

[23] Jovanovic, B. (1982): "Truthful Disclosure of Information," *Bell Journal of Economics,* 13, 36-44.

[24] Kahneman, D. and A. Tversky (1973): "Availability: A Heuristic for Judging Frequency and Probability," *Cognitive Psychology*, 5, 207-232.

[25] Korobkin, R. (2003): "Bounded Rationality, Standard Form Contracts, and Unconscionability," *University of Chicago Law Review*, 70, 1203-95.

[26] Leland, E. (1979): "Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards," *Journal of Political Economy*, 87, 1328-46.

[27] Li, S., M. Peitz and X. Zhao (2014): "Vertically Differentiated Duopoly with Unaware Consumers," *Mathematical Social Sciences* (Special Issue: Unawareness), 70, 59-67.

[28] Lizzeri, A. (1999): "Information Revelation and Certification Intermediaries," *Rand Journal of Economics*, 30(2), 214-231.

[29] Matthews, S. and A. Postlewaite (1985): "Quality Testing and Disclosure," *Rand Journal of Economics*, 16, 328-340.

[30] Milgrom, P. (1981): "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics*, 12, 380-391.

[31] Milgrom, P. (2008): "What the Seller Won't Tell You: Persuasion and Disclosure in Markets," *Journal of Economic Perspectives*, 22, 115-131.

[32] Milgrom, P. and J. Roberts (1986): "Relying on the Information of Interested Parties," *Rand Journal of Economics*, 17, 18-32.

[33] Mullainathan, S., J. Schwartzstein and A. Shleifer (2008): "Coarse Thinking and Persuasion," *Quarterly Journal of Economics*, 123, 577-619.

[34] Okuno-Fujiwara, M., A. Postlewaite and K. Suzumura (1990): "Strategic Information Revelation," *Review of Economic Studies*, 57, 25-47.

[35] Peitz, M. and M. Reisinger (2014): "The Economics of Internet Media," in: Anderson, S. and J. Waldfogel (eds.): Handbook of Media Economics, Elsevier, forthcoming.

[36] Polinsky, A. M. and S. Shavell (2006): "Mandatory versus Voluntary Disclosure of Product Risks," Mimeo, Stanford Law School and Harvard Law School.

[37] Roy, S. (2000): "Strategic Segmentation of a Market," *International Journal of Industrial Organization*, 18, 1279-1290.

[38] Shapiro, C. (1983): "Premiums for High Quality Products as Returns to Reputations," *Quarterly Journal of Economics*, 98(4), 659-79.

[39] Shapiro, J. (2006): "A "Memory-Jamming" Theory of Advertising," mimeo, University of Chicago.

[40] Shavell, S. (1994): "Acquisition and Disclosure of Information Prior to Sale," *Rand Journal of Economics*, 25, 20-36.

[41] Shavell, S. (2004): *Foundations of Economic Analysis of Law*, Harvard University Press, 2004.

[42] Spiegler, R. (2006): "The Market for Quacks," *Review of Economic Studies*, 73, 1113-1131.

[43] Tirole, J. (2009): "Cognition and Incomplete Contracts," *American Economic Review*, 99, 265-94.

[44] von Thadden, E. L. and X. Zhao (2012): "Incentives for Unaware Agents," *Review of Economic Studies*, 79, 1151-1174.

[45] Zhao, X. (2014): "Strategic Mis-selling and Pre-Contractual Cognition," mimeo, Hong Kong University of Science and Technology.

[46] Zhou, J. (2008): "Advertising, Misperceived Preferences, and Product Design," mimeo, NYU Stern School of Business.

8 Appendix

8.1 Proof of Proposition 2

Part a) Since we restrict attention to case 1, from (7), (8), and (9), we have that

$$\begin{aligned}\frac{\partial E\pi}{\partial \rho_0} &= \int_{u-\overline{\theta}}^{\widehat{a}} \left(\widetilde{a}_N - u + \rho_0 \frac{\partial \widetilde{a}_N}{\partial \rho_0}\right) \frac{\left[\left(1-\rho_0\right) u + \rho_0 \widetilde{a}_N\right]}{2\overline{\theta}} da \\ &\quad - \int_{\widehat{a}}^{u} \left(u-a\right) \frac{\left[\left(1-\left(\rho_0+\Delta\rho\right)\right) u + \left(\rho_0+\Delta\rho\right) a\right]}{2\overline{\theta}} da \\ &< 0,\end{aligned}$$

where the last inequality holds taking note that

$$\frac{\partial \widetilde{a}_N}{\partial \rho_0} = -\frac{\Delta\rho\overline{\theta}}{\left(\rho_0+2\Delta\rho\right)^2} < 0.$$

Part b)

$$\begin{aligned}\frac{\partial ECS}{\partial \rho_0} &= \frac{1}{\overline{\theta}} \int_{u-\overline{\theta}}^{\widehat{a}} \left(U_a\left(a\right) - U_u\left(a\right)\right) + \rho_0 \frac{\partial U_a\left(a\right)}{\partial \rho_0} + \left(1-\rho_0\right) \frac{\partial U_u\left(a\right)}{\partial \rho_0} da \\ &\quad + \frac{1}{\overline{\theta}} \int_{\widehat{a}}^{u} U_a\left(a\right) - U_u\left(a\right) + \left(\rho_0+\Delta\rho\right) \frac{\partial U_a\left(a\right)}{\partial \rho_0} + \left(1-\left(\rho_0+\Delta\rho\right)\right) \frac{\partial U_u\left(a\right)}{\partial \rho_0} da \\ &\quad + \frac{1}{\overline{\theta}} \{\left[\rho_0 U_a\left(a\right) + \left(1-\rho_0\right) U_u\left(a\right)\right] |_{a\to\widehat{a}-} \\ &\quad - \left[\left(\rho_0+\Delta\rho\right) U_a\left(a\right) + \left(1-\left(\rho_0+\Delta\rho\right)\right) U_u\left(a\right)\right] |_{a\to\widehat{a}+}\} \frac{\partial \widehat{a}}{\partial \rho_0} \\ &\quad > 0.\end{aligned}$$

The inequality above holds since

$$\begin{aligned}\frac{\partial}{\partial \rho_0} U_a\left(a\right) &= \frac{\partial}{\partial \rho_0} \left(\frac{1}{2} Q_a\left(a\right)^2\right) \\ &= Q_a\left(a\right) \frac{\partial Q_a\left(a\right)}{\partial \rho_0} \\ &= -Q_a\left(a\right) \frac{\partial p\left(a\right)}{\partial \rho_0} > 0, \text{ for } a > \widehat{a}, \text{ as}\end{aligned}$$

$$\begin{aligned}\frac{\partial}{\partial\rho_0}U_u(a) &= \frac{\partial}{\partial\rho_0}\left((a-p(a))\,Q_u(a)-\frac{1}{2}Q_u^2(a)\right)\\ &= (a-p(a))\,\frac{\partial Q_u(a)}{\partial\rho_0}\\ &= -Q_a(a)\,\frac{\partial p(a)}{\partial\rho_0} > 0, \text{ where } \frac{\partial p(a)}{\partial\rho_0} = -\frac{u-a}{2} < 0\ ,\end{aligned}$$

$$\frac{\partial\widehat{a}}{\partial\rho_0} < 0$$

and the fact that $U_a(a) \geq U_u(a)$, as

$$\begin{aligned}U_a(a) &= \begin{cases}\max_Q (a-p(a))\,Q-\frac{1}{2}Q^2, \text{ if } a>\widehat{a}\\ \max_Q (a-p_N)\,Q-\frac{1}{2}Q^2, \text{ if } a<\widehat{a}\end{cases}\\ &\geq U_u(a) = \begin{cases}(a-p(a))\,Q_u(a)-\frac{1}{2}Q_u^2(a), \text{ if } a>\widehat{a}\\ (a-p_N)\,Q_u-\frac{1}{2}Q_u^2, \text{ if } a<\widehat{a}\end{cases},\end{aligned}$$

where $Q_u(a)$ and Q_u are unaware consumers' optimal quantities under the wrong prior that the product has quality u.

Part c) To prove that $\partial ETS/\partial\rho_0$ can be positive or negative, it suffices to illustrate that this can happen when $\rho_0 \to 1$ and $\Delta\rho \to 0$. In this case, notice that $\partial\widehat{a}/\partial\rho_0 \to 0$, $\widehat{a} \to u-\overline{\theta}$, and $p(a) = ((1-\rho_0-\Delta\rho)\,u+(\rho_0+\Delta\rho)\,a)/2 \to a/2$.Hence, we have

$$\begin{aligned}\lim_{\rho_0\to1,\Delta\rho\to0}\frac{\partial ETS}{\partial\rho_0} &= \lim_{\rho_0\to1,\Delta\rho\to0}\frac{1}{\overline{\theta}}\int_{u-\overline{\theta}}^{u} TS_a(a)-TS_u(a)+\frac{\partial TS_a(a)}{\partial\rho_0}da\\ &= \lim_{\rho_0\to1,\Delta\rho\to0}\frac{1}{\overline{\theta}}\int_{u-\overline{\theta}}^{u}\left[(Q_a(a)-Q_u(a))\left(a-\frac{Q_u(a)+Q_a(a)}{2}\right)\right.\\ &\qquad\left.+(a-Q_a(a))\,\frac{\partial Q_a(a)}{\partial\rho_0}\right]da\\ &= \lim_{\rho_0\to1,\Delta\rho\to0}\frac{1}{\overline{\theta}}\int_{u-\overline{\theta}}^{u}\left[(a-u)\left(a-\frac{Q_u(a)+Q_a(a)}{2}\right)\right.\\ &\qquad\left.-(a-Q_a(a))\,\frac{\partial p(a)}{\partial\rho_0}\right]da\\ &= \frac{1}{\overline{\theta}}\int_{u-\overline{\theta}}^{u}(a-u)\left(a-\frac{u}{2}\right)-\frac{a}{2}\frac{u-a}{2}da\\ &= -\frac{1}{4}\overline{\theta}\left(u-3\overline{\theta}\right),\end{aligned}$$

which is positive if $u < 3\overline{\theta}$ and positive if the reverse inequality holds. The equalities are results of tedious calculation, by noticing also that $TS_a(a) = aQ_a(a) - 1/2Q_a^2(a)$ and $TS_u(a) = aQ_u(a) - 1/2Q_u^2(a)$ and that $Q_a(a) = a - p(a)$ and $Q_u(a) = u - p(a)$.

8.2 Proof of Corollary 1

If $K < E\pi|_{\rho_0=1-\Delta\rho}$, the firm will enter for any ρ_0, and, hence, the result follows immediately from Proposition 2.

Suppose that $E\pi|_{\rho_0=1-\Delta\rho} < K < E\pi|_{\rho_0=0}$. When $\widehat{\rho}_0 \in (0, \Delta\rho)$, a marginal increase in in ρ_0 does not change the firm's entry decision. From Proposition 2, we know that consumer surplus is decreasing. At point $\widehat{\rho}_0$, a marginal increase in ρ_0 makes it unprofitable for the firm to enter and, hence, reduces consumer surplus to zero.

If $K > E\pi|_{\rho_0=0}$, the firm will not enter for any ρ_0. Hence, the consumer surplus is zero.

8.3 Proof of Lemma 1

The ordering $E\pi_a < E\pi_n$ and $ECS_a > ECS_n$ follows directly from Proposition 2. Hence, we need only prove that $E\pi_f < E\pi_a$ and $ECS_f > ECS_a$. From equations (1), (8) and our analysis in Section 3, we have

$$\begin{aligned} E\pi_f - E\pi_a &= \frac{1}{\overline{\theta}} \int_{u-\overline{\theta}}^{\widehat{a}} \frac{\left[(1-\rho_0'')\,u + \rho_0'' a\right]^2}{4} - \frac{\left[(1-\rho_0')\,u + \rho_0' \widetilde{a}_N\right]^2}{4} da \\ &< 0. \end{aligned}$$

The inequality is due to the fact that $\left[(1-\rho_0'')\,u + \rho_0'' a\right]^2/4$ is decreasing in a and that $\left[(1-\rho_0'')\,u + \rho_0''\widehat{a}\right]^2 = \left[(1-\rho_0')\,u + \rho_0'\widetilde{a}_N\right]^2$. Denote $U_a^*(a)$ (resp. $U_u^*(a)$) as the aware (resp. unaware) consumers utility when the firm faces mandatory full information disclosure and its product has quality a. Notice that $U_a^*(a)$ (resp. $U_u^*(a)$) and $U_a(a)$ (resp. $U_u(a)$) coincide at $(\widehat{a}, u]$. (Here, we use the notations $U_a(a)$, $p(a)$, $p_N, \widehat{a}, \widetilde{a}_N$ etc. to denote the corresponding

variables when the awareness-enhancing disclosure rule is imposed.)

$$
\begin{aligned}
&ECS_f - ECS_a \\
&= \frac{1}{\overline{\theta}} \int_{u-\overline{\theta}}^{\widehat{a}} \rho_0'' U_a^*(a) + (1-\rho_0'') U_u^*(a) - (\rho_0' U_a(a) + (1-\rho_0') U_u(a))\, da \\
&\quad + \frac{1}{\overline{\theta}} \int_{\widehat{a}}^{u} \rho_0'' U_a^*(a) + (1-\rho_0'') U_u^*(a) - (\rho_0' U_a(a) + (1-\rho_0') U_u(a)) \\
&> \frac{1}{\overline{\theta}} \int_{u-\overline{\theta}}^{\widehat{a}} \rho_0' U_a^*(a) + (1-\rho_0') U_u^*(a) - (\rho_0' U_a(a) + (1-\rho_0') U_u(a))\, da \\
&> 0.
\end{aligned}
$$

The first inequality is due to $U_a^*(a) > U_u^*(a)$ and that $U_a^*(a) > U_a(a)$ and $U_u^*(a) > U_u(a)$ for $a \in (\widehat{a}, u]$. To prove the second inequality, we will show, first, that $\int_{u-\overline{\theta}}^{\widehat{a}} U_a^*(a) - U_a(a)\, da > 0$ and, second, that $\int_{u-\overline{\theta}}^{\widehat{a}} U_u^*(a) - U_u(a)\, da > 0$. It is useful to note that $p^*(\widehat{a}) = p_N$, where $p^*(\widehat{a})$ is the firm's optimal price when the firm faces the mandatory full information disclosure and its product has quality a.

$$
\begin{aligned}
\int_{u-\overline{\theta}}^{\widehat{a}} U_a^*(a) - U_a(a)\, da &= \int_{u-\overline{\theta}}^{\widehat{a}} \max_Q \{(a - p^*(a))\, Q - \frac{1}{2}Q^2\} - U_a(a)\, da \\
&> \int_{u-\overline{\theta}}^{\widehat{a}} \max_Q \{(a - p^*(\widehat{a}))\, Q - \frac{1}{2}Q^2\} - U_a(a)\, da \\
&= \int_{u-\overline{\theta}}^{\widehat{a}} \max_Q \{(a - p_N)\, Q - \frac{1}{2}Q^2\} - U_a(a)\, da \\
&> \int_{u-\overline{\theta}}^{\widehat{a}} \max_Q \{(\widetilde{a}_N - p_N)\, Q - \frac{1}{2}Q^2\} - U_a(a)\, da \\
&= 0,
\end{aligned}
$$

The first inequality is due to $p^*(a) < p^*(\widehat{a})$ and that $\max_Q\{(a-p)\,Q - \frac{1}{2}Q^2\}$ is decreasing in p. The second inequality is due to the fact that $\max_Q\{(a-p_N)\,Q - \frac{1}{2}Q^2\}$ is convex in a. The proof that $\int_{u-1}^{\widehat{a}} U_u^*(a) - U_u(a)\, da > 0$ is similar. The basic logic is that, by $p^*(a) < p^*(\widehat{a}) = p_N$ for $a < \widehat{a}$, mandatory full information disclosure reduces the price of the product and, hence, benefits unaware consumers.