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On the Use of Labels in Credence Goods Markets.

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Abstract

We analyze credence goods markets in the case of two firms. Consumers know that the quality of the good varies but do not know which firm is of high quality. First, we show that the high quality producer may be unable to monopolize the market, or even to survive in some cases, in situations where it is efficient and trusted by all consumers. Second, although a label restoring full information improves welfare, it may also reduce both firms' profits by intensifying competition. Since even the high quality producer may not wish to label its product, in such cases the label must be mandatory. Third, an imperfect label which moves everybody's beliefs closer to the truth without restoring full information may produce adverse results on market structure and welfare, either by increasing or by reducing the variance of beliefs.

JEL classification: D82, L15 ; Keywords: Credence goods, Incomplete information, Quality, Label, Differentiation.

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1 Introduction

In many instances consumers are aware of the existence of two firms producing goods of different qualities but do not know which firm sells the higher quality. Repeated purchases can in some cases reveal the good's quality (experience goods). In other cases, however, consumers cannot tell the quality of the good they have purchased even after consuming it (credence goods).[1] In many instances, a recognized authority can certify a product's quality after inspection and grant a recognizable label, thus helping consumers to make an informed choice. Common intuition suggests that a) a quality label that improves before-purchase information always increases welfare, and b) a high quality producing firm will always be willing to undergo the necessary inspection in order to reveal its product's quality to consumers, unless the verification cost is too high.[2] Hence, voluntary labelling schemes may be a viable alternative to mandatory labelling.

We show that in an oligopolistic market of credence goods where consumers cannot identify the high quality seller, both of the preceding conjectures may be incorrect. First, labels that do not restore full information but only partially improve consumers' perception on which firm sells the high quality product may reduce welfare by reducing the market share of the firm that sells the high quality. Second, our analysis limits the scope of voluntary labels by showing situations where both firms wish to avoid labelling because it would result in more intense competition and lower profits.

Whether a good is a credence good is related, for example, to long run health effects that are invisible within a long period after consumption, or to direct pref-

[1] Examples of credence goods are organic products, fair trade products, types of goods claiming higher safety or better environmental performance, etc. The classification into experience and credence goods follows Nelson (1970), Darby and Karny (1973) and Roe and Sheldon (2007).

[2] Information improving labels also increase welfare in the case of experience goods. However, their use in the case of credence goods is considered more urgent, due to the intensity of the informational problem. See Crespi and Marette (2003) for a survey on the economic issues related to public labeling.

erence for the production process. Prime examples in the first category are organic produce and Genetically Modified Organisms (GMO's). Fertilizer-produced grain, fruit, or vegetables are alleged to have harmful long term health effects of which their organic counterparts are supposed to be free. Similar long term health considerations are raised against the consumption of GMO's. In both these cases consumers are aware of the existence of two product types, but they cannot distinguish their preferred type from the health damaging one even after consuming the good.

Preference for the production process may also arise independently of the product's physical properties when consumers take into consideration "ethical" issues. Many consumers accept to pay a higher price for "fair trade coffee" simply because it guarantees that coffee farmers receive adequate payment. Similarly, consumers are willing to pay a premium for the products of "ethically correct" firms over the price they pay for similar products from their pure-profit maximizing rivals. In other cases, goods may be preferred simply because their production is environmentally less harmful than that of otherwise similar substitutes.[3] Again, even repeated consumption cannot reveal quality.[4]

Credence goods markets differ significantly from experience goods markets because reputation and signalling can rarely be used to alleviate informational problems. When there is adverse selection in a credence goods market, consumers can only base their purchase decision on subjective beliefs about each available product's quality.[5] These beliefs are based on all available information, including press

[3]The case of "green electricity" is such an example. Despite the fact that green electricity is neither more efficient, nor does it represent a smaller hazard to its user in any way, some consumers have a taste for its production process (less polluting) and are willing to pay a premium for it.

[4]Health and ethical issues are two different quality attributes even if they refer to the same good. Thus, on the coffee package of a typical small coffee seller in Montreal (Santropol) one can find two different labels: the TRANSFAIR logo and the organic product certification by the Organic Crop Improvement Association (OCIA). TRANSFAIR claims to be a ... "symbol of "Fair Trade" partnership with cooperatives of coffee farmers around the world" and " [the] guarantee that these farmers have been paid a fair price for their labour [...]." The OCIA label certifies that all coffees sold at that place are "shade grown without artificial fertilizers, pesticides or herbicides [...]."

[5]For moral hazard in credence goods markets see Marette et al. (2000), Fulton and Giannakas

reports, word-of-mouth, labels, *etc.*, and may differ among consumers, due to differences in consumers' ability to absorb and/or treat information. Most important, each consumer's beliefs about a credence good's quality cannot be updated after consumption. Since the production of bad quality cannot be detected and punished, no producer can build reputation. Signalling is also very difficult since the delayed detection of bad quality allows its producer to imitate the strategy of their good quality rivals.[6]

In this paper we analyze market structure and the efficiency of labels in a credence goods market, using a duopoly model inspired by the work of Gabszewicz and Grilo (1992). Consumers are similar in their tastes but have differing beliefs on the trustworthiness of each firm. When *all* consumers attribute a probability higher than .5 to a single firm as being the high quality producer, we say that this firm is trusted. Contrary to Gabszewicz and Grilo (1992), we assume that production of the higher quality requires higher marginal costs and call "efficient" the firm whose product yields the higher net surplus (after subtracting marginal cost) under full information.

We know summarize our three main results. First, there are situations where, despite the fact that the high quality producer is both efficient and trusted, the low quality producer can find a price above marginal cost such that it shrinks the high quality firm's market share to zero. Whether the low quality producer will allow the survival of its high quality rival depends on the width of the beliefs distribution. When beliefs are highly dispersed, the dominant low quality firm prefers to enjoy a higher price while leaving a market share for its rival. With narrowly dispersed beliefs competition is stiff and equilibrium prices do not allow the high quality pro-

(2004), Lapan and Moschini (2007), Roe and Sheldon (2007) and Garella and Petrakis (2007).

[6]The most common signals are price distortion (Shapiro, 1983), advertising (Tirole, 1988), and warranties (Palfrey and Romer, 1983). The prospect of repeated purchases allows the high quality producer of an experience good to signal her quality by sacrificing present for future profits, a strategy that her low quality counterpart cannot imitate. While reputation and signalling may be helpful in experience goods markets, such strategies are generally impossible in credence goods markets, due to the slow revelation of product quality.

ducer to cover its marginal cost. Since welfare maximization under full information requires that all consumers purchase the high quality, the situation is inefficient independently of whether the low quality chooses to eliminate its rival from the market. Thus, the informational problems may prevent high quality credence goods from obtaining the efficient market share.[7]

Second, while perfect labels solve the problem, they also intensify competition and may reduce both firms' profits. While such outcome is desirable to the extent that it benefits consumers, it also implies that voluntary labelling may not be functional, since even the high quality producer may in some cases wish to avoid it. In those situations mandatory labelling may be the appropriate solution.

Imperfect labels are those that, while moving all or some consumers' beliefs towards the right direction, do not restore full information. Our third result is that such labels may affect welfare by not only affecting average beliefs, but also the beliefs' dispersion. We show cases where an imperfect label that moves everybody's beliefs closer to the truth ends up producing adverse results on market structure and welfare, by either increasing or reducing the variance of beliefs.

The paper is organized as follows: the next section presents the basic model and analyzes equilibrium without labels. Section 3 examines the issues of both perfect and imperfect labels. Concluding remarks are presented in Section 4.

2 Market equilibrium

Assume two versions of a product, a high quality type (type h) and a low quality type (type l), produced at constant marginal costs c_j, $j = h, l$, respectively, with $c_h > c_l$. All fixed costs are zero and, without loss of generality, we normalize $c_l = 0$. All consumers buy one unit of the product or none at all and derive utility $U_j > 0$,

[7] Even worse, under a narrow beliefs dispersion, efficiency and consumer trust may not be able to even save the high quality product from complete elimination! Note that in our model the small market share of credence goods and the resulting inefficiency are not due to the presence of externalities. Adding the latter onto the picture makes, of course, things worse.

$j = h, l$ with $U_h > U_l$. Each type of product is produced by a different firm i and sold at price p_i, $i = 1, 2$. We assume that the high quality is produced by firm 2, so $U_2 = U_h,\ c_2 = c_h$ and $U_1 = U_l,\ c_1 = c_l$. All consumers have identical tastes given by: $V = U_i - p_i,\ i = 1, 2$, if they purchase from firm i, $V = 0$, otherwise.

Prices are expressed in terms of a Hicksian numéraire. If both products are offered at equal prices, under full information all consumers buy from firm 2. If, on the other hand, both products are offered at prices reflecting marginal costs, consumers favor unanimously firm 2 (firm 1) when $r \equiv \Delta/(c_2 - c_1) > (<)1$, where $\Delta \equiv U_h - U_l$. The high (low) quality is then called efficient quality and its producer, firm 2 (firm 1), is called efficient firm, since it creates a higher amount of net social surplus. Firms set prices simultaneously (Bertrand competition).

We assume that consumers are a) aware of the existence of two qualities, b) aware of the exact product characteristics,[8] c) totally ignorant about production costs, d) able to identify whether a product is made by firm 1 or 2, and e) uncertain about which firm sells the high quality.[9] With respect to the latter, they form subjective probabilities based on all available information, including word-of-mouth.

Following Gabszewicz and Grilo (1992), we assume that a consumer is identified by a subjective probability $\alpha \in [0, 1]$ she assigns to event E: "firm 1 sells the high quality product and firm 2 sells the low quality one". Since firm 1 is by assumption the low quality producer, the lower the α of a specific consumer is, the closer that consumer's beliefs are to the truth. We say that a consumer with $\alpha > \frac{1}{2}$ "trusts" firm 1 since she attributes higher probability on firm 1 being the high quality producer; when $\alpha < \frac{1}{2}$ the consumer trusts firm 2. We assume the consumer population distributed over a set of probabilities $S = [\underline{\alpha}, \overline{\alpha}]$, with $0 \leq \underline{\alpha} < \overline{\alpha} \leq 1$, according to a uniform distribution with density $(\overline{\alpha} - \underline{\alpha})^{-1}$. We assume that firms know the

[8] I.e., they perfectly know the consequences of consuming the high or the low quality.

[9] In our analysis consumers are certain that both product types are available in the market. Allowing consumers to assess positive probabilities to the events that only one product type (high or low quality) is sold by both firms complicates the analysis without adding anything significant to the results.

beliefs distribution, while consumers do not.[10] When $1/2 > \overline{\alpha}$ ($< \underline{\alpha}$), all consumers trust firm 2 (firm 1), while for $1/2 \in S$ consumer trust is split between the two firms.

Trusting a firm does not necessarily mean buying from it, since the actual choice depends on relative prices, as well. The expected utility a consumer α derives from consuming a product is: $\alpha U_h + (1-\alpha)U_l - p_1$, for good 1, and $(1-\alpha)U_h + \alpha U_l - p_2$, for good 2.

At equal prices, all consumers buy from the firm they trust. When $1/2 \notin S$ the model is reminiscent of vertical differentiation since consumers rank products unanimously, while for $1/2 \in S$ the model resembles horizontal differentiation. Recall, though, that differentiation does not stem from product characteristics–which are unobservable–but from initial beliefs; hence, it may well be that for some set of initial beliefs all consumers favor (erroneously) firm 1. We do not formally investigate the formation of such beliefs. Instead, we perform comparative statics for different sets of beliefs.

At given prices, the consumer just indifferent between the two products is the one whose beliefs are

$$\alpha_m(p_1, p_2) = \frac{1}{2} - \frac{p_2 - p_1}{2\Delta}. \tag{1}$$

We assume that in equilibrium the market is fully covered, and therefore, sales are, $D_1 = \max\left\{\frac{\overline{\alpha}-\alpha_m}{(\overline{\alpha}-\underline{\alpha})}, 0\right\}$ and $D_2 = \max\left\{\frac{\alpha_m-\underline{\alpha}}{(\overline{\alpha}-\underline{\alpha})}, 0\right\}$. When $\alpha_m(.) \notin S$, one firm's sales vanish (monopoly). We define as *"dominant"* the firm that can find a price above marginal cost such that reduces its rival's market share to zero. In other words, the dominant firm has the possibility of monopolizing the market at a price that does not incur losses. Under full information, the efficient firm is also dominant since it creates higher net surplus. Under incomplete information, efficiency and dominance may not coincide since the latter involves also consumers beliefs. The lemma below describes when each firm is in the dominant position.

[10] This assumption excludes from the analysis any sort of price signaling.

Lemma 1 $\forall\overline{\alpha} < \frac{1}{2}\left(1-\frac{1}{r}\right)$ *firm* 2 *is the dominant firm,* $\forall\underline{\alpha} > \frac{1}{2}\left(1-\frac{1}{r}\right)$ *firm* 1 *is the dominant firm,* $\forall\overline{\alpha} > \frac{1}{2}\left(1-\frac{1}{r}\right)$ *and* $\forall\underline{\alpha} < \frac{1}{2}\left(1-\frac{1}{r}\right)$ *no firm is dominant.*

Proof. See Appendix 1. ■

The fact that a dominant firm can monopolize the market does not also mean that it wishes to do so in equilibrium. The necessary and sufficient condition for $D_1 > 0$ is that $\overline{\alpha} > \frac{1}{2}\left[\underline{\alpha} + \frac{1}{2}(1-\frac{1}{r})\right] \equiv f(\underline{\alpha})$, and similarly, $D_2 > 0$ if and only if $\overline{\alpha} > 2\underline{\alpha} - \frac{1}{2}(1-\frac{1}{r}) \equiv g(\underline{\alpha})$ (see Appendix 1). It is now easy to show that

Proposition 1 *A) When the low quality is efficient* ($r \in [0,1]$)*, then i) firm* 1 *is also dominant, and ii) firm* 2 *must be trusted at least by some consumers in order to survive. B) When the high quality is efficient* ($r \in [1,+\infty)$)*, then i) firm* 2 *may well not be the dominant firm; ii) there are cases where firm* 2 *can be eliminated from the market, even when all consumers trust it, i.e, they correctly believe it to be most likely the high quality producer.*

Proof. A) i) $\forall r \in [0,1]$ it is always true that $\underline{\alpha} > \frac{1}{2}\left(1-\frac{1}{r}\right)$; ii) let $r \in [0,1]$; then $\forall\underline{\alpha} \in \left(\frac{1}{2},1\right]$, $\overline{\alpha} < g(\underline{\alpha})$, thus $D_2 = 0$.

B) i) $\forall r \in [1,+\infty)$, $\overline{\alpha} < \frac{1}{2}\left(1-\frac{1}{r}\right)$ may or may not hold, depending on $\overline{\alpha}$. ii) A necessary and sufficient condition for $D_2 > 0$ is that $\overline{\alpha} > g(\underline{\alpha})$. This condition is not always respected for $r \geq 1$ and $\overline{\alpha} < 1/2$, therefore, $\forall r \in [1,+\infty)$ there exists a set $\overline{\Omega} = \{S : \overline{\alpha} < 1/2,\ D_1 > 0,\ D_2 = 0\} \neq \emptyset$. ■

When the low quality is efficient ($r < 1$) firm 1 maintains dominance under incomplete information, even if all consumers trust its rival. However, when beliefs differ widely across consumers entry deterrence may not be the most profitable strategy. The low quality producer may prefer to charge a higher price in order to "cream" consumers who trust it more, while leaving those who trust it less to the high quality producer. A necessary and sufficient condition for $D_2 > 0$ is that $\overline{\alpha} > g(\underline{\alpha})$, which implies sufficiently dispersed beliefs.

When the high quality is efficient ($r > 1$), the situation is not symmetric: in moving from a full to an incomplete information environment, dominance may change hands. Under incomplete information, relative efficiency does not suffice in order to guarantee the dominant position to the high quality, which also requires beliefs to be strongly biased in favor of firm 2. When only one firm survives due to the narrow width of the beliefs distribution, the (efficient) firm 2 may be the one that finds no market share in equilibrium; this is a totally inefficient outcome. While this can be expected when for some reason all (or most) consumers erroneously trust firm 1, it is rather surprising that it may also happen when everybody trusts firm 2! This result has a strong "lemons" flavor: the presence of the low quality, along with intense competition due to the relative homogeneity of beliefs, prevent firm 2 from raising its price sufficiently as to recover its cost. Sufficiently dispersed beliefs, on the other hand, may let the high quality survive, yet with a smaller market share than its rival, an outcome that is also inefficient.

Thus, in situations where the efficient firm is also dominant, the incomplete information market outcome is inefficient as long as the beliefs are widely dispersed, since this allows the inefficient firm to find a positive market share in equilibrium. However, when $r > 1$ and firm 1 is dominant, it is a narrow beliefs distribution that may lead to a very inefficient outcome: unless beliefs are strongly favorable for firm 2, the inefficient low quality monopolizes the market. Widely dispersed beliefs may be less harmful in this case. Since the survival–let alone the dominance–of the high quality credence good requires an eventually quite strong beliefs bias, the call for some regulatory intervention is urgent in credence goods markets.

3 The introduction of a label

Assume that there are some substantial fixed costs in verifying and certifying quality, such that no individual would undertake to research for herself. For instance, in order

to find out whether the "fair trade coffee" is indeed equitable and not just a seller's trick to increase price, one must conduct an expensive research in order to track down where the money goes. Since research is prohibitively expensive for most or all individuals, it can only be conducted by the government, or by some specialized organization.

Suppose at this point that some recognized authority certifies the high quality product with a label, for example "free of GMO" or "fair trade product." If after the label's introduction all consumers know that firm 2 sells the high quality, so that $\underline{\alpha} = \overline{\alpha} = 0$, we say that the label is *perfect*. In other instances, the label may improve consumers' beliefs only partially, insofar as some or all α's remain positive. This may happen because the label is either not properly perceived or not fully trusted by some or all consumers. We define such labels as *imperfect*.

3.1 Labels that establish full information (perfect labels)

The introduction of a perfect label restores full information, and since all consumers have identical tastes, only one firm, the most efficient, will survive in the market. In the absence of externalities, this is also the most efficient outcome.[11]

That a label must be granted by an authoritative third party does not also imply that it must be mandatory. The possibility of voluntary labelling has already been proposed in the literature.[12] Since the informational imperfection mainly hurts the high quality, it is natural to assume that (at least) the high quality producer would voluntarily subject its product to inspection and labelling, even at a cost. We investigate below both firms' willingness to subject their product to certification, and show that in oligopolistic markets voluntary labelling may be problematic, even when the firms bear no labelling cost.

[11] As long as the market is covered (demand is completely inelastic), any price change results to a transfer between consumers and producers. Hence, market monopolization has no negative impact *per se*.

[12] See, for instance, Segerson (1999), Crespi and Marette (2001) and Roe and Sheldon (2007).

Recall that in the absence of fixed cost the surviving quality cannot be priced above a certain limit, otherwise the eliminated firm can re-enter and capture the entire market. The following lemma is straightforward and needs no further proof. Let a superscript PL indicate equilibrium values in the presence of a perfect label.

Lemma 2 *After the introduction of a perfect label (full information), the Nash equilibrium of the price game becomes:*

a) for $r \in [1, +\infty)$, $p_1^{PL} = 0$, $p_2^{PL} = \Delta$ *with* $D_2^{PL} = 1$, $D_1^{PL} = 0$;

b) for $r \in [0, 1]$, $p_1^{PL} = c_2 - \Delta$, $p_2^{PL} = c_2$ *with* $D_1^{PL} = 1$, $D_2^{PL} = 0$.

The following lemmata investigate a perfect label's impact on the efficient firm's profit.

Lemma 3 *When the low quality is the efficient one* ($r \in [0, 1]$)*, the introduction of a perfect label always reduces firm* 1*'s profit.*

Proof. In an environment without label, $\forall r \in [0, 1]$ the profit of firm 1 is $(2(\overline{\alpha} - \underline{\alpha})\Delta)\left(\frac{(2(2\overline{\alpha}-\underline{\alpha})-1)\Delta+c_2}{6(\overline{\alpha}-\underline{\alpha})\Delta}\right)^2$ for $\overline{\alpha} > \max\{f(\underline{\alpha}), g(\underline{\alpha})\}$, and $(2\underline{\alpha} - 1)\Delta + c_2$ for $\overline{\alpha} \leq g(\underline{\alpha})$.[13] In either case the profit is always superior to $(c_2 - \Delta)$, which is the profit under full information. ■

Lemma 3 shows that the label is undesirable for the low quality producer, even when that firm is efficient, and thus, the one to monopolize the market after qualities have been revealed.[14] By revealing the identity of the high quality producer to all consumers, the label forces firm 1 to adopt a low-price entry deterring strategy when accommodation would have been more profitable.

[13] $\forall r \in [0, 1]$ the case where $\overline{\alpha} \leq f(\underline{\alpha})$ is impossible from proposition 1.

[14] Equally undesirable for firm 1 is, therefore, to reveal itself as low quality producer, even when it is efficient.

Lemma 4 *When the high quality is efficient ($r \in [1, +\infty)$), if in the absence of a label the market is monopolized by one or the other firm, then the introduction of a perfect label always increases the high quality producer's profit. If, on the other hand, in the absence of a label the resulting market structure is a duopoly, there are cases where the label may reduce firm 2's profit.*

Proof. In an environment without label, $\forall r \in [1, +\infty)$ the profit of firm 2 is $(2(\overline{\alpha} - \underline{\alpha})\Delta) \left(\frac{(2(\overline{\alpha}-2\underline{\alpha})+1)\Delta - c_2}{6(\overline{\alpha}-\underline{\alpha})\Delta} \right)^2$ for $\overline{\alpha} > \max\{f(\underline{\alpha}), g(\underline{\alpha})\}$, $(1 - 2\overline{\alpha})\Delta - c_2$ for $\overline{\alpha} \leq f(\underline{\alpha})$, and 0 for $\overline{\alpha} \leq g(\underline{\alpha})$. In the last two cases, the profit is always inferior to $(\Delta - c_2)$, the profit in an environment with label . In the first case, it is inferior or equal to $(\Delta - c_2)$ if $\overline{\alpha} \leq i(\underline{\alpha}) \equiv \frac{-7+7r+8r\underline{\alpha}+3\sqrt{-1+r}\sqrt{-5+5r+8r\underline{\alpha}}}{4r}$ and superior otherwise. We may note that $\overline{\alpha} > i(\underline{\alpha})$ is a restrictive condition for $i(\underline{\alpha} = 0) < 1$, *i.e.,* $r < \frac{1}{3}(2 + \sqrt{5}) \simeq 1.41$, so for $\forall r \in \left[\frac{1}{3}(2 + \sqrt{5}), +\infty\right)$, $\overline{\alpha} \leq i(\underline{\alpha})$ always holds. ■

To understand this result one must decompose the effect of the label to its three components. The label helps firm 2 i) to expand its market, and ii) to reap a larger part of the total quality premium consumers are willing to pay.[15] However, iii) by revealing firm 1's true quality, the label forces that firm to lower its price, thus making competition stiffer and creating pressure on firm 2's price.[16]

The most interesting case arises when initially the market is a duopoly, becoming a monopoly under the impact of the label, *i.e.,* when $\overline{\alpha} > \max\{f(\underline{\alpha}), g(\underline{\alpha})\}$. Due to iii) above, there are instances characterized by a sufficiently wide beliefs dispersion, where in the absence of a label, the duopoly profit of firm 2 is higher than its monopoly profit under full information. In the absence of a label, the spread of beliefs assures each firm a "niche market," and firm 2 prefers to cater to its niche market at a high price instead of vying for a larger market share.[17] By revealing the

[15] The quality premium earned by firm 2 is increased by increasing the willingness to pay of consumers who *a priori* put little trust to firm 2 as being the high quality producer. Under imperfect information, the total premium firm 2 can earn by producing the high quality is $(1 - 2\overline{\alpha})\Delta - c_2$, which becomes larger as $\overline{\alpha}$ shrinks.

[16] Even at zero market share, in the absence of fixed cost firm 1 remains a potential competitor.

[17] Heterogeneity in beliefs transforms firm 1 into a puppy-dog (see Fudenberg and Tirole (1984)).

low quality, a perfect label forces firm 1 to lower its price, thus inducing the high quality to deter entry when accommodation would have been more profitable.

Lemmata 3 and 4 state that there exist cases where the efficient firm does not wish the implementation of the label. While the efficient low quality's opposition to the introduction of a label must somehow be anticipated, such opposition from the efficient high quality is rather intriguing, for the label is considered to benefit primarily the high quality. Obviously, the inefficient firm (whether the high or the low quality) never wishes labelling, for the label always forces it out of the market: when the inefficient firm is firm 2, the label triggers intense price competition; when the inefficient firm is firm 1, the label prevents it from cheating some consumers who (erroneously) trust that firm. The following proposition is a corollary to lemmata 3 and 4:

Proposition 2 *Voluntary labelling may be ineffective, and mandatory labelling necessary, in the following situations: a) when the low quality is efficient ($r < 1$), b) when the high quality is efficient ($r > 1$), but its relative efficiency is not too high ($1 < r < 1.41$) and beliefs are sufficiently dispersed ($\overline{\alpha} \geq i(\underline{\alpha})$).*

The question of mandatory *versus* voluntary labelling has already received attention in the literature. Segerson (1999) and Crespi and Marette (2001) compare these types of certification and conclude that, while voluntary certification is generally sufficient, mandatory certification may be necessary when there is a single safe product seller who needs to bear high certification costs (Crespi and Marette, 2001) without receiving compensatory subsidies (Segerson, 1999).

Our analysis shows that, even if they pay no labelling costs, *both firms may wish to avoid labelling* because it reduces profits by intensifying competition. Hence, even if a mandatory labelling scheme may generally be more costly than a voluntary one, it may, in some circumstances, constitute the only available policy.[18]

[18]The case for mandatory labelling can be even stronger if both firms supply the same quality,

3.2 Imperfect labels

In many instances labels may not be able to restore full information. This may happen because consumers either do not make full use of the label, or they do not fully trust it. The former may occur when the label's signal is not clear, or sufficiently publicized. Less than full trust occurs when consumers know (or simply believe) that there is a probability of erroneous labelling, due to either imperfections in verifying and labeling quality, or moral hazard on behalf of the authority that grants the label.

Concerning moral hazard, we note that the distinction between experience and credence goods also carries on to the corresponding labels. While the entity that labels experience goods can build a reputation for the accuracy of its labels, such reputation is generally impossible for organizations that label credence goods, due to the non verifiable nature of the quality of those goods after consumption. This implies that credence goods labels must be granted by organizations with already established prestige.[19] Even then, consumers may not be entirely certain about the information conveyed by the label.

The introduction of a label, whether perfect or imperfect, corresponds to a modification of consumer beliefs. We assume that the label's introduction increases no consumer's α, while it reduces α for at least some consumers. This assumption rules out misleading, totally ineffective, or confusing labels and also implies that the introduction of the label reduces the mean of the beliefs distribution.[20]

Recall that a key variable determining the aggressiveness in both firms' pricing behavior is the width of the beliefs distribution. Hence, the impact of the label on

since incomplete information creates differentiation, which in turn helps firms avoid the Bertrand paradox.

[19] For instance, while the quality and prestige of a scientific journal constitutes a label for a published article, readership and citations of the article influence in turn the prestige of the journal. Such a process is impossible for a label such as "fair trade coffee" for obvious reasons. Lizerri (1999) and Emons (1997, 2001) focus on certification performed by private organizations.

[20] A misleading label would increase all or some α's while a confusing label would increase α for some consumers and reduce it for others.

the width of the beliefs distribution is crucial in evaluating the welfare effects of the label. In order to keep things simple, in what follows we assume that only one end of the distribution is altered after the label's introduction. Which end is affected depends on the nature of the label. As it will be explained below, labels that are mostly perceived by the sophisticated consumers lower $\underline{\alpha}$, while those targeting the unsophisticated ones lower $\overline{\alpha}$. Despite the fact that we only deal with labels that improve information, it can be shown that:

Proposition 3 *In a duopoly market, the introduction of an imperfect label may reduce welfare even if it improves all or some consumers' information without misleading any consumer. More specifically, an imperfect label reduces welfare when i) the efficient firm is also dominant and the label reduces* $\underline{\alpha}$*, or ii) the inefficient low quality is dominant and the label reduces* $\overline{\alpha}$*.*

Proof. See Appendix 2. ■

Starting from cases where the label's introduction does not affect market structure, we observe that in monopoly markets, while the label affects the surviving product's price, it leaves the consumption pattern unaffected. Total welfare remains also unaffected, the price change representing only a transfer between consumers and producers.[21] In a duopoly market, when no firm is dominant, the label improves welfare by helping the efficient firm to gain a larger market share. When a dominant firm exists then, by affecting that firm's pricing behavior, the label may reduce welfare in two cases. First, when the efficient firm (whether high or low quality) is also dominant and the label is dispersion-increasing (*i.e.,* one that reduces $\underline{\alpha}$), since the label allows the efficient firm to cater to fewer consumers at a higher price. Second, when the inefficient low quality is dominant and the label is

[21] In all cases the price is set so as to extract the entire surplus of the least trusting consumer. When firm 2 monopolizes the market, a label that lowers $\overline{\alpha}$ allows it to charge a higher price and extract more consumer surplus. When firm 1 is the efficient monopolist, a label that lowers $\underline{\alpha}$ translates into a lower price.

dispersion-reducing (*i.e.,* one that reduces $\overline{\alpha}$), since by intensifying competition the label further reduces the market share of the efficient high quality.[22]

When the label alters market structure, once again its impact on the variance of beliefs cannot be neglected. Dispersion-increasing labels may transform a monopoly into a duopoly, while dispersion-reducing labels may have exactly the opposite effect. The welfare impact of the label obviously depends on which market form is more desirable. When the efficient firm is also dominant, dispersion-reducing labels are welfare enhancing. However, when the inefficient low quality is the dominant firm, dispersion-reducing labels may eliminate the already insufficient (from a social point of view) market share of the high quality and, thus, reduce welfare.

That an information improving label may end up being welfare reducing even in the absence of externalities is, to our knowledge, a result that has not been stressed in the literature. It calls for careful examination of the interaction between the initial market structure and the type of label, to the extend that this type determines whether beliefs dispersion will increase or decrease after the label.

Casual observation reveals the existence of substantial amounts of information–other than label related–concerning credence goods: television documentaries, magazine and newspaper articles, advertizing, etc. The problem is that, since experience cannot corroborate or refute that information in the absence of a perfect label initial beliefs about a product's quality remain "gut feelings." Nevertheless, one would expect to find more sophisticated consumers inhabiting the low end of the beliefs distribution (*i.e.,* being closer to the truth) since such consumers can better screen and process the available information than their unsophisticated counterparts.[23] Labels,

[22]If one allows for both ends of the distribution to be lowered, the same mechanisms are still at work but the final effect is hard to predict, since it depends on the relative magnitude of the changes.

[23]We do not imply that by screening and processing all available information one can identify the high quality with certainty, nor that a sophisticated consumer will *always* have more accurate beliefs than an unsophisticated one. We simply mean that a) among "junk" or misleading pieces of information there are also some useful ones that can help improve one's idea about who sells the high quality, and b) sophisticated consumers are more likely to take advantage of those pieces.

on the other hand, may differ by their nature: some contain hard technical information whereas others simply make already existing information easier to assimilate. While everybody can benefit from both kinds of labels, the former will most likely have a greater impact on the beliefs of the more sophisticated consumers, tending to lower $\underline{\alpha}$ more relatively to $\overline{\alpha}$, and *vice-versa* for the latter. For instance, the mandatory enumeration of a product's ingredients on its package may be considered as a label containing rather technical information, which can improve a sophisticated consumer's beliefs while being of little help to the unsophisticated one.[24] On the other hand, a sticker emphasizing some information that could also have been extracted otherwise clearly targets the latter category of consumers.[25]

Our analysis suggests that these two types of labels affect the pricing behavior of firms differently and have different consequences on welfare. The former, by increasing beliefs dispersion softens price competition while the latter does exactly the opposite. Proposition 3 describes the situations where each one of them can be welfare reducing. In most cases, labels targeting the unsophisticated consumers–hence, reducing beliefs dispersion–are better, since they cause no harm and most likely improve welfare. A notable exception is the (not unlikely) situation where, due to cost differences and belief distribution parameters, the inefficient low quality is dominant: a label that provides hard technical information targeting the sophisticated consumer softens competition through increasing beliefs dispersion, helping, thus, the high quality to acquire a larger market share.

Our analysis reveals that the difference between perfect and imperfect labels is not just quantitative, but also qualitative: perfect labels can never be welfare

[24] What we have in mind is chemical substances with exotic names or the infamous "e-'s" on European packages. An unsophisticated (and in most cases just average) consumer can at best rank products according to the (least) number of such ingredients they contain, without much idea about the seriousness of each ingredient's health consequences.

[25] For example, labelling a product as "juice," as opposed to "nectar" or "fruit drink," makes readily visible information that can also be extracted by reading the ingredients on the package. The "Blauer Engel" eco-label in Germany offers a credence good example of an easily understood label.

reducing, while imperfect labels can be so. Special care is, therefore, needed with the latter.[26] Our results also stress the need of improving on *all three* factors that may make a label imperfect: i) its accuracy, ii) the trust consumers place on the organization that grants the label, and iii) how easy it is for consumers to understand the label. Investments must, therefore, be also devoted to educating consumers about the label's meaning as well as to strengthening the label's reputation.

4 Conclusions

We show that when consumers are uncertain about the identity of the firm that produces the high quality, the high quality producer is at disadvantage, due to her higher cost. This disadvantage may not disappear even when the benefits from consuming the high quality are well worth the cost difference and all consumers' beliefs about the high quality producer are in the right direction. Our model partly explains the difficulty encountered by some high quality credence goods –environmentally friendly products, organic vegetables, fair trade products, *etc.*–to acquire the dominant market share they deserve from an efficiency point of view, or even any market share at all.

Depending on the distribution of consumer beliefs about the identity of the high quality producer, the market outcome may or may not be efficient. In the latter case, a perfect label is, as expected, welfare improving but it may need to be mandatory in order to have an impact. Voluntary labelling will, in many instances, be avoided by both firms–not just the low quality or the inefficient firm–since it reduces their profits. On the other hand, imperfect labels, *i.e.,* labels that just improve consumers' beliefs without restoring full information, may be welfare reducing. When the use of

[26] By stressing the qualitative importance of giving a label maximum accuracy, our model provides some support for the U.S. Food and Drug Administration's alleged tendency of not approving a new drug until being certain about its effects. While such policy must be primarily due to fear of health and legal consequences, it has the advantage of creating a sort of credible label: once a new drug is approved, consumers must be certain that it represents a superior product, even with respect to any long term health effects (we are grateful to a referee for pointing this out to us).

an imperfect label is unavoidable, it is important to know its relative impact on the sophisticated and the unsophisticated consumers. When the efficient quality is also dominant, it is best to reduce beliefs dispersion through labels that can be easily observed and understood by the unsophisticated consumer. When the inefficient low quality dominates the market, though, labels conveying hard information, mostly intended for sophisticated consumers, are preferable.

The analysis is quite robust if one allows some consumers to be fully informed.[27] Assume first that uninformed consumers cannot observe the informed ones. The presence of informed consumers helps the efficient high quality to survive: in situations where firm 2 would have found no market share, now it can at least cater to the informed consumers at the full information price. This relaxes competition and allows firm 1 to raise its own price, leaving also some uninformed consumers to firm 2.[28] Hence, the presence of informed consumers creates a positive externality, beneficial to some non-informed ones. When the high quality is dominant, however, this externality may well be negative, since the presence of informed consumers may induce cream-skimming by firm 2, thus leaving more consumers to purchase the low quality. While the presence of informed consumers may affect the magnitude of the welfare loss in the absence of a label, the policy prescription remains along the lines developed in this paper.

When the non-informed consumers can observe the informed ones, a new option is opened to them: waiting during a time period and observing the informed consumers' choice.[29] The discount factor (or, alternatively, the time lag) between the two periods becomes now a key variable. When the discount factor approaches 1 everybody waits and the informational problem disappears. For sufficiently low values of the discount factor, though, no consumer chooses to wait and observe, which

[27] The group of informed consumers may well be *the result* of a label that is perceived and/or understood by only a group of consumers.

[28] Competition is relaxed since in the absence of informed consumers the high quality would have been available at marginal cost, while now it is available at its full information price.

[29] We are grateful to a referee for pointing out this case.

takes us back to the situation described in this paper. For intermediate values of the discount factor, however, some consumers (most probably those around $\alpha = .5$) will choose to wait. Waiting most likely favors the efficient firm, but any further conclusion would be highly speculative.

How are these results affected by allowing free entry? In this model, dominance depends on both relative efficiency and beliefs. Hence, the market outcome strongly depends on how consumers' beliefs will be affected by entry, and no *a priori* prediction can be made. *Ex-post* welfare will also be affected by the true quality of the entrant's product. Since in almost all cases entry intensifies competition, the main mechanism identified in this paper must be present: by lowering prices, free entry squeezes the market share of the non-dominant firm.[30] When the efficient high quality is in the non-dominant position, entry can reduce welfare by reducing or eliminating its market share. One can, however, create many different alternative scenarios where entry is beneficial.

Appendix

Appendix 1: The Nash equilibrium of the price game whithout label.

From the definition of the consumer indifferent between the two products, we obtain the following demand functions : i) If $p_2 \leq p_1 - (2\overline{\alpha} - 1)\Delta \Longleftrightarrow \alpha_m \geq \overline{\alpha}$, then $D_1(p_1, p_2) = 0$ and $D_2(p_1, p_2) = 1$, ii) if $p_2 + (2\underline{\alpha} - 1)\Delta < p_1 < p_2 + (2\overline{\alpha} - 1)\Delta \Longleftrightarrow \underline{\alpha} < \alpha_m < \overline{\alpha}$, then $D_1 = (\overline{\alpha} - \alpha_m)\frac{1}{\overline{\alpha}-\underline{\alpha}} = \frac{\overline{\alpha}-\frac{1}{2}}{(\overline{\alpha}-\underline{\alpha})} + \frac{p_2-p_1}{2(\overline{\alpha}-\underline{\alpha})\Delta}$ and $D_2 = (\alpha_m - \underline{\alpha})\frac{1}{\overline{\alpha}-\underline{\alpha}} = \frac{\frac{1}{2}-\underline{\alpha}}{(\overline{\alpha}-\underline{\alpha})} - \frac{p_2-p_1}{2(\overline{\alpha}-\underline{\alpha})\Delta}$. iii) if $p_2 \geq p_1 - (2\underline{\alpha} - 1)\Delta \Longleftrightarrow \alpha_m \leq \underline{\alpha}$, then $D_1(p_1, p_2) = 1$ and $D_2(p_1, p_2) = 0$. Recall that the market is assumed to be fully covered, which implies $U_h + U_l \geq p_1 + p_2$.

[30] Consider, for instance, the special case where a potential entrant (say a foreign firm) does not gain market share in equilibrium, while . its presence (even at zero market share) reduces consumers' trust towards one or both incumbents. This reduces profit margins, thus inducing the dominant firm to seek a larger market share instead of creaming consumers. Although a very special case, this example illustrates the impact of new firms on the incumbents' behavior.

Maximizing firm 1's profit we get that firm's best reply function: i) if $p_2 > (2(\overline{\alpha} - 2\underline{\alpha}) + 1)\Delta$ the duopoly profit of firm 1 is inferior to its monopoly profit and firm 1 sets the highest price that keeps firm 2 out of the market : $p_1 = (2\underline{\alpha} - 1)\Delta + p_2$, ii) if $\Delta(1 - 2\overline{\alpha}) < p_2 < (2(\overline{\alpha} - 2\underline{\alpha}) + 1)\Delta$ the duopoly profit of firm 1 is superior to its monopoly profit and firm 1 sets its best reply to a value of p_2 that guarantees a duopoly competition: $p_1 = \left(\overline{\alpha} - \frac{1}{2}\right)\Delta + \frac{p_2}{2}$, iii) if $p_2 < \Delta(1 - 2\overline{\alpha})$ firm 1 can not have positive profits and drops out of the market setting $p_1 = c_1 = 0$. Hence, for $c_2 < \Delta(1 - 2\overline{\alpha})$, *i.e.,* $\overline{\alpha} < \frac{1}{2}\left(1 - \frac{1}{r}\right)$ with $r \equiv \Delta/c_2$, firm 2 is dominant.

Similarly, the best response function for firm 2 is: i) if $p_1 > (2(2\overline{\alpha} - \underline{\alpha}) - 1)\Delta + c_2$ then firm 2 sets $p_2 = (1 - 2\overline{\alpha})\Delta + p_1$, ii) if $\Delta(2\underline{\alpha} - 1) + c_2 < p_1 < (2(2\overline{\alpha} - \underline{\alpha}) - 1)\Delta + c_2$ then firm 2 sets $p_2 = \left(\frac{1}{2} - \underline{\alpha}\right)\Delta + \frac{p_1}{2} + \frac{c_2}{2}$, iii) if $p_1 < \Delta(2\underline{\alpha} - 1) + c_2$ then firm 2 sets: $p_2 = c_2$. Hence, for $c_1 < \Delta(2\underline{\alpha} - 1) + c_2$, *i.e.,* $\underline{\alpha} > \frac{1}{2}\left(1 - \frac{1}{r}\right)$, firm 1 is dominant.

Using both firms' best response functions we determine the Nash equilibrium of the game. When both firms have positive market shares in equibrium, equilibrium prices and quantities are:[31] $p_1 = \frac{(2(2\overline{\alpha} - \underline{\alpha}) - 1)\Delta + c_2}{3}$ with $D_1 = \frac{(2(2\overline{\alpha} - \underline{\alpha}) - 1)\Delta + c_2}{6(\overline{\alpha} - \underline{\alpha})\Delta}$, and $p_2 = \frac{(2(\overline{\alpha} - 2\underline{\alpha}) + 1)\Delta + 2c_2}{3}$ with $D_2 = \frac{(2(\overline{\alpha} - 2\underline{\alpha}) + 1)\Delta - c_2}{6(\overline{\alpha} - \underline{\alpha})\Delta}$. The equilibrium profits are: $\pi_1 = (2(\overline{\alpha} - \underline{\alpha})\Delta)(D_1)^2 > 0$ and $\pi_2 = (2(\overline{\alpha} - \underline{\alpha})\Delta)(D_2)^2 > 0$.

From the above expressions, a necessary and sufficient condition for $D_1 > 0$ is $\overline{\alpha} > f(\underline{\alpha}) \equiv \frac{1}{2}\left[\underline{\alpha} + \frac{1}{2}(1 - \frac{1}{r})\right]$ and for $D_2 > 0$ it is $\overline{\alpha} > g(\underline{\alpha}) \equiv 2\underline{\alpha} - \frac{1}{2}(1 - \frac{1}{r})$. When $\overline{\alpha} \leq f(\underline{\alpha})$, $D_1 = 0$ and firm 2 covers the entire market at price $p_2 = (1 - 2\overline{\alpha})\Delta > c_2$, according to its reaction function.[32] Similarly, when $\overline{\alpha} \leq g(\underline{\alpha})$, $D_2 = 0$ and firm 1 covers the entire market with $p_1 = (2\underline{\alpha} - 1)\Delta + c_2 > 0$.[33]

Appendix 2: Proof of Proposition 3.

[31] Global uniqueness and stability of the equilibrium are guaranteed by the following conditions: $\frac{\partial^2 \pi_1}{\partial p_1^2} = \frac{\partial^2 \pi_2}{\partial p_2^2} = -\frac{1}{\Delta(\overline{\alpha} - \underline{\alpha})} < 0$, $\frac{\partial^2 \pi_1}{\partial p_1^2}\frac{\partial^2 \pi_2}{\partial p_2^2} - \frac{\partial^2 \pi_1}{\partial p_2 \partial p_1}\frac{\partial^2 \pi_2}{\partial p_1 \partial p_2} = \frac{3}{(2\Delta(\overline{\alpha} - \underline{\alpha}))^2} > 0$

[32] The highest level of $\overline{\alpha}$ compatible with monopoly of firm 2 obtains from $\overline{\alpha} = \frac{1}{2}(\overline{\alpha} + \frac{1}{2} - \frac{c_2}{2\Delta})$ i.e. when $(1 - 2\overline{\alpha})\Delta = c_2$. As $\frac{\partial p_2}{\partial \overline{\alpha}} < 0$, then $p_2 > c_2$ for all $\overline{\alpha} < \frac{1}{2}(\underline{\alpha} + \frac{1}{2} - \frac{c_2}{2\Delta})$.

[33] The lowest level of $\underline{\alpha}$ compatible with monopoly of firm 1 is obtained from $\underline{\alpha} = \frac{1}{2}(\underline{\alpha} + \frac{1}{2} - \frac{c_2}{2\Delta})$, *i.e.,* when $(2\underline{\alpha} - 1)\Delta + c_2 = 0$. As $\frac{\partial p_1}{\partial \underline{\alpha}} > 0$, then $p_1 > 0$ for all $\underline{\alpha} > \frac{1}{2}(\overline{\alpha} + \frac{1}{2} - \frac{c_2}{2\Delta})$.

A label reduces welfare if and only if it increases the inefficient quality's sales. Hence:

i) When the high quality is efficient ($r \in [1, +\infty)$), a label that reduces $\underline{\alpha}$ reduces wefare if and only if $\frac{\partial D_1}{\partial \underline{\alpha}} < 0$, i.e if firm 2 is the dominant firm ($\overline{\alpha} < \frac{1}{2}\left(1 - \frac{1}{r}\right)$). Moreover, when the low quality is efficient ($r \in [0, 1]$), firm 1 is also the dominant firm (see Proposition 1). In this environment a label that reduces $\underline{\alpha}$ always reduces wefare: $\frac{\partial D_2}{\partial \underline{\alpha}} < 0$, if and only if $\overline{\alpha} > \frac{1}{2}\left(1 - \frac{1}{r}\right)$, which is always true.

ii) When the high quality is efficient ($r \in [1, +\infty)$), a label that reduces $\overline{\alpha}$ reduces welfare if and only if $\frac{\partial D_1}{\partial \overline{\alpha}} < 0$, *i.e.,* if firm 1 is the dominant firm ($\underline{\alpha} > \frac{1}{2}\left(1 - \frac{1}{r}\right)$). We may note that when the low quality is efficient ($r \in [0, 1]$), a label that reduces $\overline{\alpha}$ never reduces welfare ($\frac{\partial D_2}{\partial \overline{\alpha}} < 0$ is never true).

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