The Regulatory Choice between a Label and a Minimum-Quality Standard

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Abstract

This paper revisits the issue of the regulatory choice between a mandatory label and a minimum-quality standard. When the cost of regulation is relatively low, we show that the socially optimal choice depends on the producers' cost structure for complying with regulation and improving quality. Under a marginal cost for improving quality, the mandatory labeling is sufficient for reaching the socially optimal level of quality. Under a fixed cost for improving quality, we show that each instrument or the combination of both instruments may emerge at the equilibrium.

Keywords: cost of regulation, information, standard.

1. Introduction

Safety and quality are major policy issues in most developed countries. Consumers are more demanding as to safety of buildings (asbestos), cars, aircrafts, drugs (…), and a variety of products, particularly those designed to be used by children. Empirical evidence shows that markets do not always provide an adequate level of safety and that there may be a role for government intervention (Viscusi *et al.*, 1995).

As demands for more regulation have gained momentum in recent years, governments have responded by setting stricter regulations and by expanding the role of agencies enforcing existing regulations. As government regulation is obviously costly, many economists have argued for careful assessment of the usefulness, costs, and benefits of regulations on product safety. In particular, there is broad consensus that regulations involving large compliance costs should be restricted to cases where market-based mechanisms lead to an insufficient provision of product safety. This raises the question of the best policy response through alternative instruments such as minimum-quality standards, information campaigns (health-warnings), labelling, taxation, liability, and so forth.

This article analyzes the complex interaction between information about quality and/or minimum-quality standards. Specifically, we seek to answer the question: should regulators rely on a mandatory labelling or a minimum-quality standard or both for regulating and limiting "dangerous consumption"?

An analytical framework where a representative consumer is imperfectly informed about product content is used to investigate the welfare effects of a public labeling system and/or minimum-quality standard. These two instruments perfectly signal (for the label) and control (for the minimum-quality standard) the level of quality selected by the firm(s). We abstract from the consumers' heterogeneity regarding the quality preferences, since the representative consumer prefers only one level of quality that maximizes his utility. We consider various combinations of producers' cost for complying with regulation and improving quality, namely, either a marginal cost or a fixed cost. Producers decide whether or not to enter the market.

We show that a policy-improving quality is selected when the cost of regulation is relatively low. The selected tools depend on the producers' cost structure for satisfying regulation and improving quality. Under a marginal cost for improving quality, mandatory labeling is sufficient for reaching the socially optimal level of safety. The competition among numerous producers leads to a satisfying level of quality for the representative consumer who is perfectly informed by the label. Under a fixed cost for improving quality, we show that each instrument or the combination of both instruments may emerge at the equilibrium. In a context of imperfect competition (because of the fixed cost), the minimum-quality standard helps correct an insufficient quality choice with or without the mandatory label. The extension section of this paper focuses on the potential flaws linked to these two instruments.

The present paper is linked to the strand of literature focusing on regulatory choices under vertical-product differentiation. The literature includes numerous papers on minimum-quality standards (Marino, 1998), while some other studies focus on labels (Crampes and Hollander, 1995). These studies usually abstract from (*i*) the complex interaction among different regulatory tools and (*ii*) the difference in the cost structure for improving quality. Most of these papers use the Mussa and Rosen (1978) framework with heterogeneous consumers, so that product diversity and quality differences are the main concerns regarding the regulatory choice (Beales *et al.*, 1981). Our framework differs since we explicitly abstract from heterogeneous consumers by focusing on the quantity-quality trade-off for a representative consumer preferring one type of quality/safety level. In our context, the benefits of regulatory tools are not weighed against the costs of product variety, but the regulatory benefit is measured by the ability to cap the consumers' risks. This paper adds to this literature by showing that the combination of regulatory instruments crucially depends on the producers' cost structure for improving quality.

The next section provides regulatory examples linked to the food industry. The third section introduces the model. The main results are presented in the fourth section, while the fifth provides some extensions, and the final section concludes.

2. Some Examples in the Food Industry

In the food sector, safety and nutrition have become an increasing concern in recent years, mainly because of highly publicized outbreaks of foodborne diseases (*E. Coli*, *Salmonella, etc.*), worries about transmission of animal diseases to humans (the "mad cow" crisis in Europe or the recent outbreaks of avian flu in Asia) and health concerns linked to obesity (WHO, 2003). The following three examples are illustrative of current debates relating to regulation for improving nutrition and food safety.

The first example concerns fish consumption by pregnant women. Methylmercury is a toxin that alters fetal brain development when there is significant prenatal exposure. Children of women who consume large amounts of fish during pregnancy are particularly vulnerable to the adverse neurological effects of methylmercury (Budtz-Jorgensen *et al.*, 2002). A high level of methylmercury is concentrated in long-lived, predatory fishes, such as tuna, shark, and swordfish (Mahaffey *et al.*, 2004). The regulatory choice is complex since the nutrients in fish are also essential to the health of a developing fetus. More precisely, the omega 3 polyunsaturated fatty acids, along with iodine or phosphorus, confer benefits to the fetus such as infant cognition and improvement of cardiovascular health. There is still a lot of uncertainty about whether these benefits may outweigh the harm from mercury exposure.

This health problem raises the issue of the optimal policy for limiting the risks of exposure. Regulatory agencies favored an information policy. The US in 2001, Canada in 2002 and the UK in 2003 broadcast specific messages asking pregnant women to forego consumption of predatory fish with a high content of methylmercury during their pregnancies.In the US, the messages were found to have their intended effect, as pregnant women reduced their consumption of fish (Oken *et al.*, 2003). Without massive informational campaigns, there would be very few chances for a pregnant woman to be informed regarding the risks of methylmercury.

The alternative to a health warning is a product performance standard, where in this case fish with too much mercury would be withdrawn from the market. Sophisticated testing procedures have recently emerged that allow agencies to recognize mercury, which opens opportunities for more stringent regulations such as product performance standards.[1] The choice of a standard raises the issue of the cost bearing of eradication of dangerous fish by fisheries, supermarkets, and so forth in a context where the resources are scarce and fisheries relatively fragile.

The second example concerns the regulation of genetically modified organisms (GMOs). Despite pre-market testing (necessary for satisfying the safety standards), some buyers are reluctant to use GMO-derived products because of either perceived residual contamination (e.g., via antibiotic resistant genes or allergic reactions) or concern over environmental safety (e.g., with the emergence of resistance in or unintentional harm to other species), regardless of whether

[1] Micro Analytical Systems Inc. is developing a testing procedure to detect the level of mercury in fish (Adamy, 2005.

such perceptions are valid. Numerous countries, including the European Union, Mexico, and Japan, require the labeling of GMOs. In the United States, the US Food and Drug Administration (FDA) decided against mandatory labeling, proposing instead to help producers who voluntarily wish to label their goods that are free of GMOs (Caswell, 2000).

The US position is that foods with GMOs pose no more food-safety risk than conventional foods. As a consequence, there is no rationale for the labeling. The safety standards via pre-market testing and the liability system are enough for insuring consumers' safety. However, other countries, including many in Europe, counter the US argument by saying that countries may take precautionary measures against risk and guarantee the right of consumers to choose among different products (Caswell, 2000; Sheldon, 2002). In other words, even if there is typically no distinction between final goods produced from GMO inputs and those created from conventional inputs (especially the more processed is the final good), standards are not enough and GMO labelling is useful for satisfying consumer preferences for information and product diversity.[2] Clearly, the regulatory choice for a mandatory label for informing consumers depends on (*i*) the cost imposed on producers and consumers and (*ii*) the risk of confusion or panic among consumers leading to a potential decrease in demand.

The third example is linked to mandatory food labelling on the packages of many foods. Modjuska and Caswell (2000) showed that the US nutrition labelling regulation from May 1994 requiring mandatory disclosure of information on the nutritional content of foods influenced

[2] These different views on GMO regulation have WTO (World Trade Organization) consequences. The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) provided a framework for solving disputes, through the WTO's Dispute Settlement Body; it tackles the problem of non-tariff trade barriers through the Sanitary and Phytosanitary (SPS) Agreement and a strengthened Technical Barriers to Trade (TBT) Agreement. The US is arguing about the prohibitive cost of labeling based on the conventions of the SPS agreement, while Europe focuses on the right to choose for consumers based on the TBT agreement (Crespi and Marette, 2003).

market mechanisms and consumers' behavior. An important issue linked to the nutrition labelling is the number of ingredients to report on packages. Beyond the Nutrion Labeling and Education Act of 1990, the new food labelling law set to take effect January 1, 2006, will require the amount of transfats to be listed on all food nutrition labels. Transfats have been linked to raised levels of bad cholesterol and risk of heart disease and cause 2100 to 5600 deaths in the US each year (FDA, 2002).

The new law will also require signalling allergy-triggering substances like peanuts, soy, almonds, and walnuts. Zhang (2005, page D1) mentions that "the new law is causing confusion, too. It requires allergens to be identified even if they are present only in a tiny amount as ingredients — an issue the federal Food and Drug Administration hasn't clarified." The number of allergens and the threshold above which one ingredient should be indicated on packages make this a tricky task for the regulator in a context where responses to potential allergens vary widely from person to person. Moreover, the label system may cause consumers to worry needlessly about a heath problem. The alternative regulatory choice is to offer products without some ingredients via the imposition of a product standard, which is costly for firms.

These previous examples are intended to be illustrative rather than exhaustive, yet they do suggest that how any public regulator chooses its instruments is an important question, yet one for which the correct answer is not so obvious. Because of the potential costs to society from inefficient regulations, the optimal choice should be determined, and the following model tries to give some clues regarding this choice.

3. The Model

The objective of this paper is to produce the simplest possible model (various extensions will be discussed in section 5). Using a very simple framework, we assume that the utility function of a representative consumer is

$$U(x,\mu,q,v) = ax - x^2/2 - \mu(\alpha - q)hx + v\,, \tag{1}$$

where v is the numeraire and $ax{-}x^2/2$ is the immediate satisfaction from consuming an amount x of the product. The perceived risk (or benefit) associated with the consumption of the product is denoted $-\mu(\alpha{-}q)hx$, where the consumer perception of risk (or benefit) is captured by the parameter μ (see Polinsky and Rogerson, 1983). When $\mu{=}1$, the perception of the risk is perfect, while the absence of perception is equivalent to $\mu = 0$. α is a measure of the maximum per-unit damage that the consumer may suffer in the absence of any quality effort ($q{=}0$) and q is the quality of the product that reduces the damage. When the quality q is lower than the maximum per-unit damage, α, the consumption of x units of the good implies a negative effect for the consumer's utility. Conversely, when the quality q is higher than the maximum per-unit damage, α, the consumption of x units of the good leads to a positive effect for the consumer's utility.[3] The parameter h is a measure of the consumer's sensitivity to the damage. A large h means that a consumer may suffer a lot in terms of health problems.[4] The maximization of (1)

[3] A good such as Dupont's high-oleic soybean, yielding an oil lower in artery-clogging saturated fats, is an example of goods that are produced for quality improvements at the consumer level, corresponding to a quality q higher than a damage α.

[4] For instance, the variable h also captures the difference of responses to potential allergens that vary widely from person to person (see the previous section).

under budget constraint $px+v=y$, where y denotes consumer income and p the price of the good leads to the following demand function:

$$x(p) = a - p - \mu(\alpha - q)h. \qquad (2)$$

The unperceived damage (or benefit) associated with the consumption of the product is equal to $-(1-\mu)(\alpha - q)hx$, and it is not taken into account in the demand defined by (2). This unperceived risk by the consumer is taken into account in the welfare by the regulator. Whatever the consumer's perception, the overall damage, $-(\alpha - q)hx$, depends on the products' quality q, the consumers' sensitivity h, and the consumed quantity x.

We consider a market with numerous potential producers able to enter the market. The entry decision is public information for all producers and the regulator, while the quality choice q is private information for each producer. The quality q comes about through a fixed expenditure $Cq^2/2$ or through a marginal cost $cq^2/2$. Although many situations might include a combination of these different types of costs, we separate them in the analysis for the sake of simplicity. There is no other cost of production, for simplicity.

The regulator selects its policy, namely, a minimum-quality standard and/or a label for the consumer. It is assumed that only a public regulator is able (*i*) to perfectly monitor the firms' level of quality when a standard is selected and/or (*ii*) to provide credible and perfect information about the level of risk (μ=1) and the producers' quality choice q via the public label. Consumer's perception is assumed to be solely influenced by the public label policy leading to μ=1. Conversely, when no public message is disclosed, the consumer is completely unaware of the risks with μ=0. When a minimum-quality standard, q_S, is selected, the producers' quality choice q satisfies the condition $q \geq q_S$. While the label perfectly reveals the extent of the damage to consumers, the standard modifies the extent of the unperceived damage via a quality improvement of the product. The cost of each instrument is denoted *R*. When both instruments are selected, the cost is *2R*.[5] For simplicity, we assume that regulatory instruments are affordable in terms of social choice, which means that the welfare when both instruments are selected (with a cost *2R*) is greater than zero. This assumption corresponds to a case where the per-instrument cost *R* is not too high.

The game proceeds in four stages. In stage 1, the regulator announces its policy, namely, whether or not to propose a minimum-quality standard and/or an information policy for the consumer. The regulator seeks to maximize welfare (defined as the sum of producers' profits, consumers' surplus, the unperceived damage and the cost of regulation). In stage 2, producers simultaneously choose whether or not to enter. In stage 3, the active producer(s) chooses their level of quality q in order to comply with the regulation or to satisfy consumers' demand. In the case of a fixed expenditure, $Cq^2/2$, for improving quality, this cost is sunk before stage 4. In stage 4, producers simultaneously set prices (Bertrand competition).

4. The Policy

The characterization of the subgame perfect Nash equilibrium of this four-stage game (solved by backward induction) with producers' choices (in stages 2, 3, 4) is detailed in the appendix.

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[5] The cost of regulation includes the cost linked to the control policy that consists in a probability of random inspection and a sanction/fine mechanism on discovered cheaters. These parameters are selected such that cheating is deterred at the equilibrium. No producer cheats, so that the fine/sanction mechanisms will never be applied in the equilibrium (see also Daughety and Reinganum, 1997, for a similar case under punitive damage). In this paper, the cost of regulation is financed by taxpayers. Alternatively, it could be financed by per-unit or fixed fees imposed on producers or by penalties (Marette and Crespi, 2005). The greatest deterrent to cheating, however, may simply be the loss of a firm's reputation if caught (not detailed in this paper).

We now detail the regulator's decision that maximizes welfare (defined as the sum of producer's profit, consumer's surplus, consumer's losses/gains coming from unawareness for $\mu=0$ and the cost of regulation). The two cases (namely, the fixed costs and the marginal costs for improving quality) are successively considered. This allows us to derive figures 1 and 2 showing the regulatory cost, *R*, located along the vertical axis, and the consumer's sensitivity, *h*, located along the horizontal axis.

Figure 1 illustrates proposition 1 for the case with a marginal cost incurred by the producer for improving quality (denoted $cq^2/2$). The relative values of *R* and *h* determine the regulator's optimal strategy and define the limit of areas 1 and 2 (the frontiers for these regions are detailed in the appendix). Below, we present the proposition and provide an intuitive interpretation, leaving the mathematical proofs in the appendix.

PROPOSITION 1. *Under a marginal cost for improving quality, the regulatory choice is*

(i) the absence of policy in area 1,

(ii) the selection of a mandatory label in area 2.

Proof: see the appendix.

Whatever the regulatory choice, the entry is not restricted because of the absence of any fixed cost for producers, and the equilibrium price is equal to the marginal cost. Under the absence of regulatory controls in region 1, producers in competition have no incentive to invest in quality (with a quality *q=0*), since consumers are unaware of the damage. The welfare is improved by ignoring even a medium amount of damage because the regulatory cost is relatively high compared to the consumers' sensitivity: the costs of regulation in region 1 exceed the benefits.

In region 2, the label policy is selected since the benefits of informing consumers (with $\mu=1$) exceed the cost. This policy means that the damage is fully internalized by the consumer who adjusts his consumption regarding his sensitivity, *h*, and the quality. The producers propose the level of quality $q^*(1)$ (defined by (A2)) that the consumer prefers. Indeed, the competition leads producers to produce the best quality at the marginal cost (coming from the Bertrand competition). The producers can simply pass on the marginal cost, $c\left(q^*(1)\right)^2/2$, to consumers. As the marginal cost is internalized by market prices with fully aware consumers, the quality choice provided by producers is socially optimal. Note that the regulatory policy in area 2 is the same if the optimal quality $q^*(1)$ is lower or higher than the maximum per-unit damage, α (namely, $-(\alpha-q^*(1))hx\left(p(q^*(1))\right)$ negative or positive). Indeed, the internalization of both overall risk and marginal cost is essential for reaching the efficient allocation. When the per-unit damage, α, is relatively large, the choice of a label in area 2, may lead to the absence of exchange since consumers refuse to buy because of a too-low quality-price ratio.

We now turn to the case with a fixed cost incurred by producer(s) for improving quality (denoted $Cq^2/2$).

The relative values of *R* and *h* determine the regulator's optimal strategy and define the limits of areas 1 to 4' in figure 2 (the frontiers of these regions are detailed in the appendix).

PROPOSITION 2. *Under a fixed cost for improving quality, the regulatory choice is*

(i) the absence of policy in area 1',

(ii) the selection of a mandatory label in area 2’,

(iii) the selection of a minimum-quality standard in area 3,

(iv) the selection of a mandatory label and a minimum-quality standard in areas 4 and 4’.

Proof: see the appendix.

Under the absence of regulatory controls in region 1’, producers have no incentive to invest in quality (with a quality $q=0$) because of the absence of awareness by consumers. The welfare is improved by ignoring even a medium level of consumers’ sensitivity, *h*, because the regulatory cost is also relatively high: the costs of regulation in region 1’ exceed the benefits. Since no cost is incurred, the producer entry is not restricted, which leads to a price equal to zero under the Bertrand competitive pressure.

Unlike region 1’, in regions 2’, 3, 4 and 4’, as the consumers’ sensitivity, *h*, increases, a regulatory policy is imposed because the relative cost of the regulation, *R*, is now affordable. In these regions, regulation is useful in order to prod a producer into improving its product’s quality. As the cost for improving quality is fixed, only one producer is able to enter in the second period, which leads to a monopoly price in period 4 (under Bertrand competition). In regions 2’, 3, 4 and 4’, the social benefit of a quality improvement under monopoly and regulation outweighs the social benefit of competition without any quality effort because of the absence of regulation.

The regulatory choice in figure 2 with a fixed cost for improving quality is more complex than the regulatory choice with a marginal cost for improving quality in figure 1. Under a fixed cost for improving quality, the monopoly price does not internalize this fixed cost, so that the producer’s incentive to improve quality does not correspond anymore to the best level of quality expected by the consumer. The complementary or the substitution of both tools is used for influencing the quality choice selected by the producer in regions 2', 3, 4 and 4'.

In regions 4 and 4', both instruments are used since the overall cost equal to *2R* is not too costly. The label leads to the consumer's awareness that entails incentives for the producer to improve quality because of the demand shift integrating the quality. However, this producer's incentive is not enough for reaching a satisfying level of quality since the consumer does not pay for the fixed cost linked to the quality improvement. In other words, the monopolist does not sufficiently improve the product's quality, even though it is socially optimal for the society to do so (the monopolist only considers its profit, not social welfare). In this case, the minimum-quality standard completes the mandatory label in order to provide a satisfying level of quality for consumers.

The difference between regions 4 and 4' only comes from different levels of quality imposed by the standard policy. In area 4, the selected standard $q_S^{**}(1)$ (defined by (A12)) that maximizes the welfare is affordable for the producer. The regulator cannot implement this level $q_S^{**}(1)$ in area 4', because the seller's profit is then negative. Total welfare in area 4' could increase with $q_S^{**}(1)$, but it is not viable for the producer. In this case the regulator imposes a label and a standard $q_S^{***}(1) < q_S^{**}(1)$ in area 4' (see equation (A15)), such that the producer's profit is equal to zero. In other words, $q_S^{***}(1)$ is selected at the producer's breakeven point. Thus, we see that in the case of fixed cost where a producer wields market power, the use of both tools is necessary in areas 4 and 4', by taking into account the producer's incentive and its breakeven point.

When the per-instrument cost *R* increases, the use of both instruments is too costly, and the regulator chooses either the standard (area 3) or the label (area 2’). In area 3, the selected standard $q_S^{**}(0)$ (defined by (A12)) is lower than the maximum per-unit damage, α (namely, for $-(\alpha - q_S^{**}(0))hx\left(p(q_S^{**}(0))\right)$<0), so that not informing the consumer avoids a demand decrease. The standard is sufficient for reducing the unperceived damage to an acceptable level for the society. In area 2’, the label leads to a positive-quality level $q^{**}(1)$ selected by the producer (and defined by (A10) with μ=1). This level $q^{**}(1)$ is higher than the maximum per-unit damage, α (namely, for $-(\alpha - q^{**}(1))hx\left(p(q^{**}(1))\right)$>0), so that informing the consumer leads to a demand increase that is profitable for the producer. The label is sufficient for changing the unperceived damage into a perceived benefit for the consumer because of a relatively large quality, $q^{**}(0)$, that replies to the relatively large consumers’ sensitivity *h*. Thus, regions 2’ and 3 in figure 2 mark a difference with figure 1, where only the label was selected. In region 3, when the effect of the product on the consumer’s utility is negative, the standard is the best instrument from a social point of view. Conversely, the information emerges for signalling a positive effect of the products on the consumer’s utility in region 2.

5. Extensions

Our analytical framework is admittedly simple. The following extensions could be easily integrated into the previous model. The link between the cost structure and the choice of instruments is robust under alternative assumptions.[6] In order to fit different problems coming

[6] A Cournot competition could be considered. Under a marginal cost for improving quality, the result would be equivalent to the result of proposition 1, since the absence of fixed cost would not impede entry. Under a fixed cost for improving quality, the results would be equivalent to the results of proposition 2 regarding the choice of instruments but different regarding the number of firms able to enter the market. One or several firms may enter the market depending on the value of the fixed cost.

from various contexts, some extensions could be easily integrated into the model presented here.

(1) We abstracted from heterogeneity among consumers. In our context, the consideration of sensitivity differences among consumers could be introduced. In order to capture preferences heterogeneity, it would be possible to consider other types of buyers who have differing attitudes toward the risk or the quality.[7] The label could be favored, since it allows product diversity satisfying the heterogeneous preferences. However, different levels of information could also create risks of confusion among different consumers. In this case, the benefits of standardization must be weighed against the costs of lower product variety.

(2) We assume perfect information about the risk and the quality for the consumer (μ=1) when the mandatory label was selected. One extension could be to allow misleading messages or confusion coming from the label (Sloan *et al.*, 2002). This would reduce the attractiveness of the labeling policy. In addition, consumers' behavior can be affected by what they imagine to be a risk, even if it is not backed up by scientific evidence, resulting in costs to society.[8] Consumers could have an inappropriate evaluation of the risk level, raising some very difficult questions for economists. Pollak (1995, 1998) shows that the way imagined risks should be accounted for by economists, in particular in cost-benefit

[7] Considering a continuum of preferences might be interesting, though obviously less tractable.

[8] Magat and Viscusi (1993) have observed many cases where consumers seem to deviate from "rational" behavior, inasmuch as their behavior was inconsistent with the predictions of the anticipated subjective utility model. According to the authors, individuals accord excessive importance to low probabilities of risk. The questions raised by risk misperception are complex. Even when the public fears are not shared by the experts, these fears affect their economic behavior and therefore the state of an economy (Viscusi, 1997). Governmental regulations should therefore account for unjustified public fears to a certain extent. In addition, in a democratic society, the government ought to respond to consumers' worries, however remote and conservatively estimated the risk is (Margolis, 1996). However, spending money on expensive treatment of (clean) water, just because "people feel worried about some risk" would be clearly economically inefficient (Pollak, 1998).

analysis, is still unclear. In this context, the quality of information/messages revealed to consumers in the recommendations is a crucial issue to consider for avoiding confusion, misinterpretation or risks of panic by consumers.

(3) Throughout the model, we abstract from other regulatory tools, namely, taxation or liability. Taxation or liability could be used for limiting the overall damage (namely, when $-(\alpha - q)hx$ is negative) because of a low level of consumption x linked to these instruments. For instance, a tax may complete a label that imperfectly informs about the risk ($\mu < 1$). However, such a tax could be perceived as a regressive tax because it hurts people with a low sensitivity (if the parameter *h* is low).

(4) Throughout the model, we assumed that the regulator was acting in the public's best interest. One stumbling block for such regulatory "fairness" is the efficiency of the public regulatory authority itself. Public agencies may be doomed to failure (*i*) if their mandate is not clearly defined, (*ii*) if they suffer from excessive bureaucracy, or (*ii*) if the industrial lobby's influence creates lax regulation. A regulator may sometimes choose more than the necessary amount of regulation with very large standards, depending on the incumbent's influences upon the agency. Kim (1997) underscores how regulation is sub-optimal when an incumbent behaves strategically against the government (the regulator, as a follower, deters entry by newcomers, protecting the incumbent's oligopoly situation), an aspect we do not consider here. Further, the restriction in the number of firms leading to a monopoly in figure 2 needs to be mitigated with respect to the government's ability to collect information regarding parameters such as firms' fixed costs and market demand.

(5) Government regulation is not the only approach deserving consideration, with measures ranging from voluntary practice, codes of good conduct, private standards and

market incentives as reputation mechanisms. One extension that is of interest concerns that of a voluntary labeling system where each producer decides whether or not to label its products. The private label may partially replace the mandatory label, when there is a lack of public money. This is for instance the case in areas 2' and 4 in figure 2, where the producer could incur one part of the label cost because of positive profit. A voluntary label could emerge since the consumers' demand would increase in areas 2' and 4.

6. Conclusion

Imposing regulatory requirements is always a thorny task for the regulator. Using a very stylized framework, we illustrated various mechanisms by which the structure of producers' cost may influence the provision of product quality/safety. Because the effect of cost structure and imperfect competition are intermingled, the examination of the cost structure is crucial for implementing a policy. We showed that the various policy instruments have different effects on the safety of products supplied on the market and on the overall welfare, depending on the cost structure.

Key factors in the choice of the optimal regulation are the market context, the number of firms that are likely to comply with the regulation, and especially firms' incentives. The simple model presented here underscores the importance in choosing appropriate regulatory tools. Thus, this paper suggests that it is especially imperative for governments to examine not only the types of regulations imposed upon an industry but also the industry structure.

Even when it is desirable, regulation is sometimes too costly for an economy. To some extent, our model paves the way to a cost-benefit analysis that can be used to identify when labeling and/or minimum-quality standards are useful, thus reinforcing the credibility of the public regulation.

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APPENDIX:

Proof of proposition 1.

We detail different stages corresponding to a subgame perfect Nash equilibrium. In stage 4, the price competition with at least two producers leads to a price $p^*(q)$ equal to the marginal cost $cq^2/2$. The profits for producers are zero. By using $U(x,\mu,q,v)$ given by (1), *x(p)* defined by (2), the budget constraint *v=y-px(p)* and $p^*(q)=cq^2/2$, the consumer's surplus is

$$\widehat{U}(\mu,q)=U\left(x(p^*(q)),\mu,q,y-p^*(q)x(p^*(q))\right)=\frac{\left(a-cq^2/2-\mu(\alpha-q)h\right)^2}{2}+y\,. \quad \text{(A1)}$$

In stage 3, the quality is selected (*i*) to maximize the consumers' utility $\widehat{U}(\mu,q)$ given by (A1) because of competition and /or (*ii*) to satisfy the standard q_S with $q\geq q_S$. The choice of quality by producers in competition is such that $\frac{d\widehat{U}(\mu,q^*)}{dq}=0$ and $\frac{d^2\widehat{U}(\mu,q^*)}{dq^2}<0$. Figure 1 is built when the second-order condition is satisfied, namely, for *h* and α relatively low, since $\frac{d^2\widehat{U}(\mu,q^*)}{dq^2}=-ac+\alpha ch\mu+h^2\mu^2-3c\mu hq+3c^2q^2/2<0$. The first-order condition leads to the quality

$$q^*(\mu)=\frac{\mu h}{c}\,. \quad \text{(A2)}$$

There is no other quality choice for the producers. Because of the competitive pressure, the consumer always finds producers proposing the optimal quality $q^*(\mu)$ at a price equal to the marginal cost, $c(q^*(\mu))^2/2$. When a standard is proposed, the producers select a quality level equal to max[q_S, $q^*(\mu)$].

In stage 2, two or more producers enter because of the absence of fixed cost. A producer that has chosen to enter does at least as well by doing so (with zero profits), as it would do if it were to change its decision to stay out the market, given the anticipated result of choices in periods 3 and 4. The case with one producer making positive profit is not a market equilibrium since at least one inactive producer would enter the market.

In stage 1, the regulator decides its policy. As the welfare depends on the policy, let I_S and I_L represent the decision regarding the standard and the label. A value I_S=1 and/or I_L=1 means that a standard q_S and/or the label (leading to μ=1) are selected by the regulator. Otherwise, a value I_S=0 and/or I_L=0 (leading to $\mu = 0$) means that the standard and/or the label are not selected by the regulator. By using the previous expression given by (A1) and the unperceived damage, defined as $-(1-\mu)\left(\alpha - q\right)hx(p^*(q))$ in section 2, the welfare is

$$\begin{aligned} W(I_L, I_S q_S) &= \widehat{U}\left(I_L, \max[I_S q_S, q^*(I_L)]\right) \\ &-(1-I_L)\left(\alpha - \max[I_S q_S, q^*(I_L)]\right)hx\left(p^*\left(\max[I_S q_S, q^*(I_L)]\right)\right) - (I_S + I_L)R \end{aligned} \quad \text{(A3)}$$

The welfare comparison allows the regulator to determine its choices.

First, under the absence of regulation (I_S=0 and/or I_L=0), no quality improvement is made ($q^*(0) = 0$) and the welfare is

$$W(0,0) = \frac{a(a - 2\alpha h)}{2} + y\,. \quad \text{(A4)}$$

This welfare is positive for $h \le h_1$ with

$$h_1 = \frac{a^2 - 2y}{2a\alpha}\,. \quad \text{(A5)}$$

The absence of regulation is viable only for $W(0,0) > 0$. Otherwise the regulation is selected since it is assumed in section 2 that R is not too large, which leads to positive welfare.

Second, the following inequalities $W(1,0) > W(0,q)$ and $W(1,0) > W(1,q)$ are always satisfied whatever the value of q (except for $q = \alpha$, where $W(1,0) = W(0,\alpha)$). It means that the mandatory label leading to the first-best welfare, $W(1,0) = \frac{\left(2ac + h(h-2\alpha c)\right)^2}{8c^2} + y - R$, dominates the other regulatory choices.

Third, the equality, $W(1,0) = W(0,0)$, leads to

$$R_1 = \frac{\left(2ac + h(h-2\alpha c)\right)^2}{8c^2} - \frac{a(a-2\alpha h)}{2}. \qquad \text{(A6)}$$

It easy to check that $W(1,0) > Max[0, W(0,0)]$ for $R \le R_1$ and $h > h_1$, which corresponds to the region 2 in figure 1.

□

Proof of proposition 2.

As demonstrated in the proof of proposition 1, under the absence of regulation (corresponding to area 1' in figure 2), no quality improvement is made ($q^*(0) = 0$), two or more producers enter the market because of the absence of fixed cost. The welfare $W(0,0)$ is defined by (A4) and is positive for $h \le h_1$ defined by (A5).

As soon as a positive level of quality q>0 in stage 3 is selected because of one or two regulatory tools, the number of firms entering in stage 2 is equal to one if the monopoly gross profits cover the fixed cost $Cq^2/2$. If two or more firms enter, the Bertrand competition in stage 4 leads to negative profit, and one producer leaves the market in stage 2 given this anticipated result of competition leading to negative profit. Conversely, if no producer enters, one producer could always gain by entering and improving quality. Thus, only the situation of a single producer can be a subgame perfect equilibrium when there exists a fixed cost for improving quality.

In stage 4, the single producer sets a monopoly price. The profit of the single producer can be written as $px(p)-Cq^2/2$ with $x(p)$ defined by (2). From the first-order condition, $p^{**}x'(p^{**})+x(p^{**})=0$, the equilibrium price determined in stage 4 is $p^{**}=(a-\mu(\alpha-q)h)/2$. The substitution of this value in the profit leads to the producer profit:

$$\pi(\mu,q)=\frac{(a-\mu(\alpha-q)h)^2}{4}-\frac{Cq^2}{2}. \qquad \text{(A7)}$$

By using $U(x,\mu,q,v)$ given by (1), *x(p)* defined by (2), the budget constraint *v=y-px(p)* and p^{**}, the consumer's surplus is

$$\tilde{U}(\mu,q)=U\left(x(p^{**}),\mu,q,y-p^{**}x(p^{**})\right)=\frac{\left(a-\mu(\alpha-q)h\right)^2}{8}+y\,. \qquad \text{(A8)}$$

The unperceived damage is $-(1-\mu)\left(\alpha-q\right)hx(p^{**})$. As the welfare depends on the policy, let I_S and I_L represent the decision regarding the standard and the label. A value I_S=1 and/or I_L=1 means that a standard q_S and/or the label (leading to μ=1) are selected by the regulator. Otherwise, a value I_S=0 and/or I_L=0 (leading to $\mu=0$) means that the standard and/or the label are not selected by the regulator. When a standard is proposed, the producers select a quality level equal to max[q_S, q]. The welfare is

$$\begin{aligned}&\tilde{W}(I_L,I_Sq_S)=\pi(I_L,\max[I_Sq_S,q])+\tilde{U}\left(I_L,\max[I_Sq_S,q]\right)\\&-(1-I_L)\left(\alpha-\max[I_Sq_S,q]\right)hx\left(p^{**}\right)-(I_S+I_L)R\end{aligned}. \qquad \text{(A9)}$$

We now turn to the quality choice in stage 3 and the regulatory choice in stage 1.

In stage 3, the quality is selected (*i*) to maximize the producer's profit $\pi(\mu,q)$ given by (A7) and /or (*ii*) to satisfy the standard q_S with $q \geq q_S$.

First consider the case without a standard, namely, I_S=q_S=0. The choice of quality by the producer (for maximizing profit) is such that $\frac{d\pi(\mu,q^{**})}{dq}=0$ and $\frac{d^2\pi(\mu,q^{**})}{dq^2}<0$. Figure 2 is built when the second-order condition is satisfied, namely, for C relatively large, for $h<\sqrt{2C}/\mu$. The first-order condition leads to the quality

$$q^{**}(\mu)=\frac{\mu h(a-\alpha\mu h)}{2C-\mu^2h^2}. \tag{A10}$$

When no standard is selected (I_S=q_S=0), the previous quality choice is positive only under the label policy, namely, for I_L= μ=1. In this case, the quality choice is $q^{**}(1)$ and the welfare is

$$\tilde{W}(1,0)=\frac{C(a-\alpha h)^2(3C-h^2)}{2\left(2C-h^2\right)^2}+y-R. \tag{A11}$$

For I_L=0, the quality choice is $q^{**}(0)=0$, and the monopoly situation is not viable because of the absence of fixed cost. Two or more producers enter the market because of the absence of fixed cost, and the welfare $W(0,0)$ is defined by (A4).

This level of quality $q^{**}(\mu)$ has to be compared with the level of standard q_S for characterizing the level of quality on the market. For a given level of information, the regulator chooses the standard q_S by maximizing the welfare $\tilde{W}(I_L,q_S)$, subject to a positive profit (defined by (A7)) for the producer. The choice of quality by the producer is such that $\frac{d\tilde{W}(I_L,q_S^{**})}{dq}=0$ and $\frac{d^2\tilde{W}(I_L,q_S^{**})}{dq^2}<0$. The second-order condition is satisfied for C relatively large, namely, for $h<\sqrt{4C/\left[\mu(4-\mu)\right]}$. The first-order condition leads to

$$q_S^{**}(\mu)=\frac{h\left(a(2+\mu)-\alpha h\mu(4-\mu)\right)}{4C-h^2\mu(4-\mu)}. \tag{A12}$$

With such a level of quality, the welfare is

$$\tilde{W}(I_L,q_S^{**}(\mu))=\frac{a^2\left(3C+h^2(1-\mu)^2\right)-Ch\alpha\left(2a(2+\mu)-\alpha h\mu(4-\mu)\mu\right)}{8C-2h^2\mu(4-\mu)} \\ +y-R+I_LR. \tag{A13}$$

The producer's profit is $\pi(I_L,q_S^{**}(\mu))$.

For $\mu=0$ or $\mu=1$, the inequality, $q^{**}(\mu)<q_S^{**}(\mu)$, is always satisfied. It means that the producer complies with the standard by increasing the quality of its product to a level $q_S^{**}(\mu)$, compared to its choice, $q^{**}(\mu)$.

When $I_L=\mu=0$ and $I_S=1$, only the standard $q_S^{**}(0)$ is selected. In this case, the profit $\pi(0,q_S^{**}(0))$ is positive for C relatively large, namely, for $h<\sqrt{2C}$. The welfare is $\tilde{W}(0,q_S^{**}(0))$.

Both instruments are selected ($I_L=\mu=1$ and $I_S=1$) with a level $q_S^{**}(1)$ leading to a welfare $\tilde{W}(1,q_S^{**}(1))$, if the producer's profit $\pi(1,q_S^{**}(1))=\frac{C\left(a-\alpha h\right)^2(8C-9h^2)}{2\left(4C-3h^2\right)^2}$ is positive, which is the case if $h<h_3$ with

$$h_3=\sqrt{\frac{8}{9}C}. \tag{A14}$$

For $h>h_3$, the regulator may reduce the standard to a viable level for the monopoly. In this case, the regulator chooses a standard level $q_S^{***}(1)$ such that the profit given by (A7) is equal to zero (the breakeven point), namely, $\pi(1,q_S^{***}(1))=0$. Thus

$$q_S^{***}(1) = \frac{h\left(a-\alpha h\right)+\sqrt{2C\left(a-\alpha h\right)^2}}{2C-h^2} \quad \text{(A15)}$$

The welfare is $\tilde{W}(1, q_S^{***}(1))$ by using (A9).

In stage 1, the regulator decides its policy. The welfare comparison allows the regulator to determine its choices.

The welfare comparison between the label only ($I_L=\mu=1$ and $I_S=q_S=0$) and the standard only ($I_L=0$ and $I_S=1$ with $q_S^{**}(0)$), is given by the comparison between $\tilde{W}(1,0)$ and $\tilde{W}(0, q_S^{**}(0))$. The equality $\tilde{W}(1,0)=\tilde{W}(0, q_S^{**}(0))$ leads to the frontier

$$h_2 = \frac{2\alpha C}{a}. \quad \text{(A16)}$$

The welfare comparison between the standard only ($I_L=0$ and $I_S=1$ with $q_S^{**}(0)$) and the absence of regulation is given by the comparison between $\tilde{W}(0, q_S^{**}(0))$ and $W(0,0)$. The equality $W(0,0)=\tilde{W}(0, q_S^{**}(0))$ leads to the frontier

$$R_2 = \frac{a^2\left(3C+h^2\right)-4aCh\alpha}{8C} - \frac{a(a-2\alpha h)}{2}. \quad \text{(A17)}$$

The welfare comparison between the standard only ($I_L=0$ and $I_S=1$ with $q_S^{**}(0)$) and the standard and the label ($I_L=1$ and $I_S=1$ with $q_S^{**}(1)$) is given by the comparison between $\tilde{W}(0, q_S^{**}(0))$ and $\tilde{W}(1, q_S^{**}(1))$. The equality $\tilde{W}(0, q_S^{**}(0))=\tilde{W}(1, q_S^{**}(1))$ leads to the frontier

$$R_3 = \frac{3C\left(a-\alpha h\right)^2}{8C-6h^2} - \frac{a^2\left(3C+h^2\right)-4aCh\alpha}{8C}. \quad \text{(A18)}$$

The welfare comparison between the label only (I_L=1 and I_S=0) and the standard and the label (I_L=1 and I_S=1 with $q_S^{**}(1)$) is given by the comparison between $\tilde{W}(1,0)$ and $\tilde{W}(1,q_S^{**}(1))$. The equality $\tilde{W}(1,0)=\tilde{W}(1,q_S^{**}(1))$ leads to the frontier

$$R_4 = \frac{3C\left(a-\alpha h\right)^2}{8C-6h^2} - \frac{C(a-\alpha h)^2(3C-h^2)}{2\left(2C-h^2\right)^2}. \tag{A19}$$

The welfare comparison between the label only (I_L=1 and I_S=0) and the absence of regulation is given by the comparison between $\tilde{W}(1,0)$ and $W(0,0)$. The equality $\tilde{W}(1,0)=W(0,0)$ leads to the frontier

$$R_5 = \frac{C(a-\alpha h)^2(3C-h^2)}{2\left(2C-h^2\right)^2} - \frac{a(a-2\alpha h)}{2}. \tag{A20}$$

The welfare comparison between the label only (I_L=1 and I_S=0) and the label and the standard $q_S^{***}(1)$ is given by the comparison between $\tilde{W}(1,0)$ and $\tilde{W}(1,q_S^{***}(1))$. The equality $\tilde{W}(1,0)=\tilde{W}(1,q_S^{***}(1))$ leads to the frontier

$$\begin{aligned} R_6 = {} & \frac{3\left(2aC-2\alpha Ch+h\sqrt{2C\left(a-\alpha h\right)^2}\right)^2}{8\left(2C-h^2\right)^2} - \frac{c\left(h\left(a-\alpha h\right)+\sqrt{2C\left(a-\alpha h\right)^2}\right)^2}{\left(2C-h^2\right)^2} \\ & -\frac{C(a-\alpha h)^2(3C-h^2)}{2\left(2C-h^2\right)^2}. \end{aligned} \tag{A21}$$

The welfare comparison between the label and the standard $q_S^{***}(1)$ and the absence of regulation is given by the comparison between $\tilde{W}(1,q_S^{***}(1))$ and $W(0,0)$. The equality $\tilde{W}(1,q_S^{***}(1))=W(0,0)$ leads to the frontier

$$R_7 = \frac{3\left(2aC - 2\alpha Ch + h\sqrt{2C\left(a-\alpha h\right)^2}\right)^2}{8\left(2C-h^2\right)^2} - \frac{c\left(h\left(a-\alpha h\right)+\sqrt{2C\left(a-\alpha h\right)^2}\right)^2}{\left(2C-h^2\right)^2} - \frac{a(a-2\alpha h)}{2}. \qquad \text{(A22)}$$

The policy selected in each area corresponds to the choice of instrument(s) leading to the best welfare, according to the frontiers defined above.

Figure 1

The regulatory choice under a marginal cost for improving quality

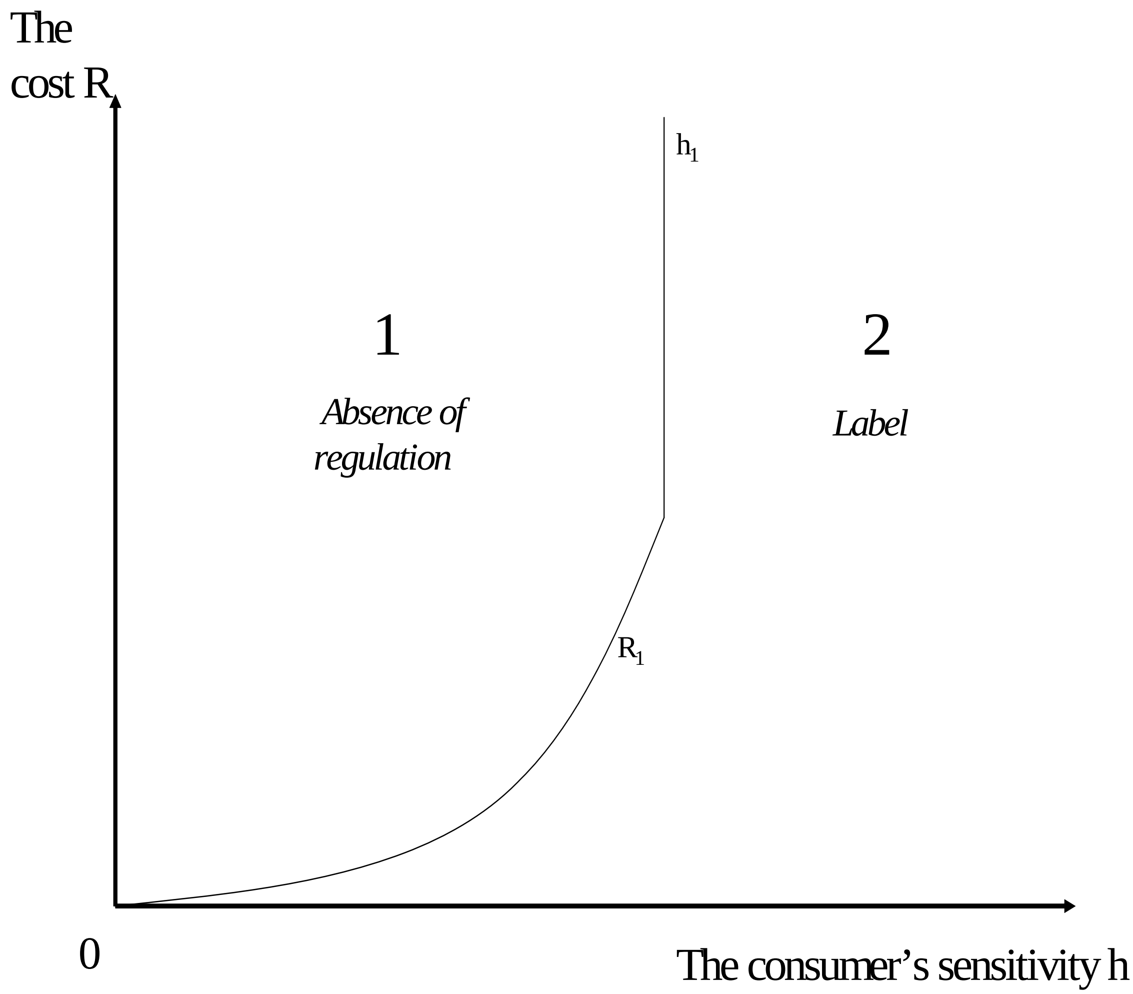

Figure 2

The regulatory choice under a fixed cost for improving quality