Agrifood safety standards, market power and consumer misperceptions

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Summary

This paper analyzes how the implementation of a food safety standard affects firms' strategic behaviour within the context of a food chain. We provide a formal analysis, which considers that the sanitary risk results from a strong heterogeneity of upstream production conditions and the final demand depends on consumers' risk estimations (given that consumers may underestimate or, conversely, overestimate the sanitary risk).

We show how downstream (processing or retailing) firms may be prompted to play a positive role with respect to food safety, either by selecting only the safest upstream producers or by encouraging the improvement of suppliers' production conditions.

When the degree of consumers' risk misperception is relatively low, then a downstream firm may adopt the latter strategy and increase the marketed quantities as the food safety standard is improved. However, we show that the actual contamination risk is not necessarily decreasing in the level of the food safety standard.

KEYWORDS: food safety standards, market power, risk misperception

Introduction

Over the last decade, public concern over the safety of food has increased as a result of sanitary crisis (Mead et al., 1999, Roe et al., 2000). As a consequence, increasing food safety regulation has arised, which covers a broad range of regulatory techniques, from public to private and from low interventionist to highly prescriptive obligations.

On the one hand, public authorities have tightened food safety legislations and created new control procedures. The classical rationale for government regulation in the risk and environmental area is the presence of externalities. Indeed, the operation of business often generates health pollution, water pollution and toxic waste. Health, safety and environmental regulations thus specify the technological requirements that must be met or the pollution standards that cannot be exceeded. Thus, it is well known that the main feature of regulation is that it directly controls economic agent's behaviour and affects an activity before the externality is generated (see for example Viscusi, Harrington and Vernon, 2005).

On the other hand, private systems and certification programs have been implemented by processors or distributors, aimed at meeting customer expectations in terms of food safety. These "strategies" are often implemented to respond to higher consumer requirements and are attempt to achieve improved both product safety and quality characteristics (Bazoche et al., 2005, Havinga, 2006, Fulponi, 2006).

As it was noticed by Henson and Caswell (1999), there are a lot of arguments for co-ordinating the incentives of public with those of private systems. Moreover, these authors point out that private systems may act as a mechanism to increase market share by delivering higher or more dependable quality, but they may act also to protect current market share from erosion. In both cases, there are incentives for the adoption of private controls by individual operators in the food supply chain and it is well obvious that

standard requirements affect the strategic behaviours within the vertical relationships, between producers and retailers.
Given these premises, the objective of this paper is to evaluate the impact of safety standards on the strategic behaviour of economic agents in the context of agri-food chains. We develop our analysis in the framework of the theory of industrial organization and examine a vertical relationship, where upstream producers (farmers) have do adopt a process standard. This process standard requires a minimum level of equipment which could lead to high investments by certain producers. We show how the compliance with this standard depends also on the strategic behaviour of the downstream firm, who processes and distributes the product. Then, with respect to the strategic interactions among the supply chain participants, we highlight some unexpected effects of these standards, namely a positive effect on the number of producers who accept to adapt their equipments to the standard. We also show some possible perverse effects, namely we point out that the actual contamination risk is not necessarily decreasing in the level of standard.
Two main hypothesis delimit our framework. At first, we suppose that a downstream firm does not have any possibility to fix its own private norm to reinforce the standard defined by the public authority, but, conversely, completely maintains its strategic flexibility to select the best equipped up-stream producers. Secondly, we assume that consumers are informed about the efforts that firms exert along the production-commercialization process, but they may underestimate or, conversely, overestimate the sanitary risk arising from economic activities[1]. The firms thus have to adapt their strategic behaviour by taking into account the foreseeable distorsions on the final market.

Background

There exists a large swathe of the literature concerning the process of compliance of firms to the food safety regulation and the effects of food safey standards on firms' strategic behaviour.
With respect to the first issue, Henson and Heasman (1998) focuse on the process by which firms comply with food safety regulations and illustrate a model of compliance process. The authors show that firms decide to comply if the perceived marginal benefit of compliance is equal to, or exceeds, the perceived marginal cost. However, the decision whether to commit depends on adaptation costs and represents a long-term decision. These authors also argue that the compliance decision is affected by the extent to which firms are aware of cost-benefit relationships associated with regulations.
Loader and Hobbs (1999) adresse the question of firms' responses to changes in food safety legislation and suggest the necessity for firms to respond rapidly to food safety issues – as they directly affect the marketability of products – to assure consumers that their products meet safety requirements. Moreover, these authors point out the necessity to take into account the role of vertical relationships. In fact, they argue that food safety regulation encourages firms to follow an organisational strategy aimed at building closer supply chain relationships. In this spirit, Unnevehr and Jensen (1999) show that the use of mandating HACCP may create incentives for vertical coordination to control food safety throughout

[1] The issue of consumers perception of sanitary risk has been examined by several contributions. See for example, McCarthy and Henson (2005), for an analysis of the major facets of perceived risk for beef among Irish consumers. Yeung and Yee (2002), show that health loss is the most important component of perceived risk, followed by psycological, financial, time and taste losses. Lobb, Mazzocchi and Traill (2007) suggest a statistical strategy for explaining how food purchasing intentions are influenced by different levels of risk perception and trust in food safety information. Costa-Font and Mossialos (2007) focus on how individuals learn about the risks and benefits of genetically modified (GM) food, along with the influence of information sources on the formation of both risk and benefits perceptions. See also Krystallis and Arvanitoyannis (2005) for the analysis of Greek consumers' beliefs, attitudes and intentions towards GM food products and Rosati and Saba (2004) for an analysis of public perception of risks associated with different food-related hazards and perception of reliability of various sources providing information on food-related risks.

the production process. Moreover, it may pose a greater burden on small firms, due to the large investments needed, and thus result in concentration processes (see also Henson and Caswell, 1999).

Following a quantitative approach, Antle (1999) provides an analytical framework for the measurement of the costs of regulations and discusses the use and limitations of currently available benefit and cost information for quantitative regulatory impact assessment. Indeed, several contributions examine the economic implications of food safety regulatory standards using a cost and benefit analysis (see for example Caswell and Kleinschmit, 1997; Viscusi, 2006). This cost-benefit research attempts to measure the cost for firms of implementing food safety regulations and compare it to the benefits in terms of the reduced societal costs of consumers mortality and foodborne illness.

With respect to the effects of food safey standards on firms' strategic behaviour, some contributions have taken into account the dimension of firms' behaviour in the context of vertical relationships. These studies often refer to a context of moral hazard. Thus, they take into account the opportunistic behaviour of upstream sellers, who exploit the fact that many food products characteristics remain uncertain to downstream buyers in the course of market transactions. Hence, buyers run the risk to pay a premium price for inferior products or to use, or consume, substances which are harmful (health risk). Incentive systems must thus be designed to induce compliance with specified regulations and standards. For an example of this type of models in the context of food chains, see Hirschauer (2004), who specifies the conditions at which optimal control intensity and price can be determined. In this line of research, Starbird and Amanor-Boadu (2007) use a monopsonistic pricipal-agent model in the context of adverse selection to examine how contracts that include traceability can be used to deter unsafe producers, within the context of a food chain. They show that the motivation for the processor to select against unsafe producers depends on the magnitude of the failure costs and the proportion of them allocated to producers.

Furthermore, it is well known – in the literature concerning the analysis of safety regulation – that as firms engage in externality-creating activities, then they may derive a profit (or private benefit) from it. They also may reduce the risk, by exerting precaution efforts and supporting the related costs. Thus, the implementation of safety standards, as a means of controlling risky activities, affects firms' strategic choices. Nevertheless, to our knowledge, a few papers analyze the effects of standards on firms' strategic behaviour. For example, in a recent theoretical paper, Shavell (2007) analyzes the effects of the level of legal standards on the parties' level of activity, this latter representing whether or how much a potential injurer engages in a particular (risky) activity. It is shown that overly strict legal standards may discourage parties from engaging in socially desiderable activities, when standards are required by the regulatory system.

Nevertheless, the market dimension (that is, the effects of food safety regulation on firms' strategic behaviour in terms of quantity and price) is often neglected by this kind of models. Therefore, the effects of consumers' attitudes towards a risky product are not taken into account and furthermore, the willingness to pay of consumers for food safety is often ignored.[2]

However, in a seminal paper, Polinsky and Rogerson (1983) have studied this issue by fixing, from a theoretical point of view, the basis of the formalization that we propose at the beginning of our paper. Indeed, these authors argue that introducing the market dimension requires to take into account consumers' risk misperceptions (several analysis of consumers' risk perception within the food sector are provided in the literature; see for example McCarthy and Henson, 2005, Yeung and Yee, 2002, Lobb, Mazzocchi and Traill,

[2] Some models have been used in order to derive expressions for willingness to pay (WTP) for reduced risk (Harrington, Portney, 1987, Cropper, Freeman, 1991, Berger et al. 1997). Several studies have shown an increase of consumers' WTP for products characterized by a lower risk of contamination (Buzby, Read, Skees, 1995, Fox et al., 1995).

2007, Costa-Font and Mossialos, 2007, Krystallis and Arvanitoyannis, 2005, Rosati and Saba, 2004).

As far as markets react to the perceived and not to the actual risk, then consumers' risk misperceptions may affect the strategic behaviour of economic agents and thus the design of the regulation. In this paper, we show how both the strategic behaviour of firms within the context of vertical relationships and the consumers' risk misperception may influence the effectiveness of the food safety regulation.

Objectives

The objective of this paper is to evaluate the impact of safety standards on the strategic behaviour of economic agents in agri-food chains. We develop our analysis in the framework of the theory of industrial organization and study the strategic interactions among food chain participants (upstream producers, downstream processing or retailing firm, final consumers), when the sanitary risk results from the upstream production conditions.

For this purpose, we study a vertical relationship where upstream producers (farmers) have do adopt a process standard. This standard requires a minimum level of equipment which could lead to high investments by certain producers. We consider that the downstream firm does not have any possibility to fix its own private norm to reinforce the standard defined by the public authority, but, conversely, completely maintains its strategic flexibility to select the best equipped upstream producers. Moreover, consumers are supposed to be informed about the efforts that firms exert along the production-commercialization process, but they may underestimate or, conversely, overestimate the sanitary risk arising from the economic activities. Thus, the final demand depends on consumers' risk estimations.

Methodology

Statements of the formalization

We consider a vertical relationship between J upstream producers and one downstream retailer. Following Giraud-Héraud, Hammoudi and Soler (2006), the upstream producers are differentiated according to their equipment level, which is represented by a one-dimensional parameter e, assumed to be uniformly distributed within the interval $[0,1]$, according to the density function $f(e) \equiv 1$. Each of the upstream producers can offer one unit of the good in the intermediary market. However, this unit is more or less risky, according to the equipment level of the producer. Thus, the contamination risk results from upstream production conditions.

The contamination risk arising from each individual producer, whose equipment level is e, is given by $\sigma(e)$, where $\sigma(.)$ is a decreasing function of e. For the sake of simplicity, we consider that $\sigma(e) = 1 - e$. We then have $\sigma(0) = 1$ and $\sigma(1) = 0$. Hence, the risk is certain with a producer characterized by the minimum level of equipment and null with a producer characterized by the maximum level of equipment. As we consider that each producer always supplies the same quantity of product (non-elastic individual supply), the contamination risk is given by:

$$\sigma = \int_0^1 \sigma(e) f(e) de = \frac{1}{2} \qquad (1)$$

We consider that σ defines the probability of crisis in the end market. This initial probability can be modified if at least one of the producers changes his equipment over the course of time. Then, the density *f(e)* will shift to a density *f'(e)* and change the level of σ given by (1). We will refer to σ as the contamination risk in the rest of this paper.

We suppose that, in order to enter the intermediary market, an upstream producer must, at least, reach a certain level of equipment e^S, which corresponds to the food safety standard implemented in the selected market. We assume that the fixed cost for each producer of type e, who wants to participate in the intermediary market with a level of standard e^S, takes a linear form $Max\{0, e^S - e\}$. Then, each producer is assumed to be price taker in his decision to enter or not the intermediary market.

In the end market, consumers are identical and risk neutral. Let σ be the true probability of crisis in the end market. Following Polinsky and Rogerson (1983), we define by $(1-\lambda)\sigma$ each consumer's perception of σ, where $\lambda \leq 1$. Since larger values of λ correspond to lower estimates of the contamination risk, λ may be interpreted as a measure of the extent of the consumers' risk misperception. Three representative degrees of consumers' risk misperception are identified: $\lambda = +1$ (maximal underestimation[3]), $\lambda = 0$ (no misperception) or $\lambda = -1$ (overestimation)[4]. Then, the aggregate inverse demand for the product, when the risk perception is $(1-\lambda)\sigma$ is given by:

$$\begin{cases} p = \beta(\alpha, \lambda, \sigma) - x \\ with \\ \beta(\alpha, \lambda, \sigma) = \alpha - (1-\lambda)\sigma l \end{cases} \qquad (2)$$

Equation (2) considers that the maximum level of price $\beta(\alpha, \lambda, \sigma)$ which consumers are willing to pay, that we denote "consumers's reservation price", depends both on the actual level of risk and on the degree of consumers' risk misperception. The parameter l represents the monetary loss for consumers for each unit of the product which is contaminated.

The quantity x is bought by the monopsonist in the intermediary market and supplied to the end market. We suppose that the monopsonist can always select the producers in order to obtain the quantity x with the best levels of equipment within the interval $[0,1]$. Thus, we denote by $\tilde{e}$ the threshold of equipment starting from which the producers are selected by the monopsonist:

$$\tilde{e} = 1 - \frac{x}{J} \qquad (3)$$

The risk assessment on the market corresponds to the knowledge of the relative position of $\tilde{e}$ and e^S. As a result, the level of risk depends on the level of quantity x demanded by the monopsonist on the intermediary market.

Let us denote by $\hat{x} = J(1-e^S)$, the quantity asked by the monopsonist, such that all the initially well-equipped producers are selected (that is $\tilde{e} = e^S$). Using (3), we verify that $\tilde{e} \geq e^S$ if and only if $x \leq \hat{x}$.

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[3] This case represents the particular case in which consumers treat the good as if it were perfectly safe.

[4] Consumers' purchase decision is affected both by the degree of risk's misperception and by the trust in food safety information (Lobb, Mazzocchi, Traill, 2007). Consumers' risk misperception can be interpreted as a psychological trait of consumers. They may under- or overestimate the contamination risk according to several determinants; namely perceived product's consistency, interest in cooking, interest in the product, experience and confidence in purchase location (McCarthy and Henson, 2005), health loss, followed by psychological, financial, time and taste losses (Yeung and Yee, 2002). Moreover, advertisement and communication campaigns potentially influence risk perceptions (Costa-Font and Mossialos, 2007).

Therefore, if $x \le \hat{x}$ (that is $\tilde{e} \ge e^S$), no selected producer has to modify his equipment in order to supply the intermediary market. The statistical distribution of producers' equipments on the support $[\tilde{e},1]$ is then unchanged (with $f(e) \equiv 1$).

If $x > \hat{x}$ (that is $\tilde{e} < e^S$), the producers which are initially located between $\tilde{e}$ and e^S have to modify their equipment in order to supply the intermediary market. As a result of the equipment's upgrading for producers such that $\tilde{e} \le e \le e^S$, the statistical distribution of the producers' equipment on the support $[\tilde{e},1]$ changes and is given by:

$$f'(e) = \begin{cases} 0 & \text{if } \tilde{e} \le e < e^S \\ e^S - \tilde{e} & \text{if } e = e^S \\ 1 & \text{if } e^S < e \le 1 \end{cases} \quad (4)$$

Definition 1. A strategic choice of quantity x is denoted *"Equipments non-affecting"* (*ENA*) *strategy* if x is such that no selected producer modifies his equipment, that is $x \le \hat{x}$, or "*Equipments affecting*" (*EA*) *strategy* if x is such that some producers modify their equipments, that is $x > \hat{x}$.

Let us denote by $\bar{\sigma}(x,e^S) = \int_{\tilde{e}}^{1} \sigma(e) f(e) de$ the contamination risk for a given level of food safety standard e^S and for a quantity x demanded by the monopsonist on the intermediary market. Using (3) and (4), we then obtain :

$$\bar{\sigma}(x,e^S) = \int_{\tilde{e}}^{1} \sigma(e) f(e) de = \begin{cases} \frac{1}{2}\left(\frac{x}{J}\right)^2 & \text{if } x \le \hat{x} \\ (1-e^S)\left[\frac{x}{J} - \frac{1}{2}(1-e^S)\right] & \text{if } x > \hat{x} \end{cases} \quad (5)$$

Using (5), we verify that the risk is an increasing function of the supplied quantity.

When the *ENA strategy* is implemented, the contamination risk $\bar{\sigma}(x,e^S)$ does not depend on the level of the food safety standard e^S, as the monopsonist only selects producers with a level of equipment higher than e^S.

Conversely, when the *EA strategy* is implemented, the great quantity demanded by the monopsonist implies that also initially not well-equipped producers are selected (that is producers with a level of equipment lower than the standard e^S). These producers have to upgrade their equipment levels in order to comply with the food safety standard e^S. As a result, the contamination risk depends on the standard e^S. In any case, for a given level of e^S, the contamination risk $\bar{\sigma}(x,e^S)$ is an increasing function of the quantity x demanded by the monopsonist, as an increase of the quantity demanded on the intermediary market implicitly leads to an increase of the number of producers involved.

The contamination risk affects the monopsonist's profit. Namely, it affects the reservation price and thus, the level of demand. Let us denote by ω the price paid by the monopsonist on the intermediary market. The monopsonist's expected profit $\pi_\lambda(x,e^S,\omega)$, when the consumers' risk misperception is λ, the demanded quantity is x, the intermediary price paid for that quantity is ω and the food safety standard on the intermediary market is e^S, is thus given by :

$$\pi_{\lambda}(x,e^S,\omega) = [\alpha - (1-\lambda)\bar{\sigma}(x,e^S)l - x - \omega]\,x \qquad (6)$$

The quantity choice affects the monopsonist's expected profit by different ways. On the one hand, the quantity directly affects the inverse demand function. On the other hand, the quantity affects the contamination risk on the final market. As a result, the quantity has an indirect effect on the inverse demand function (by affecting the reservation price), whose magnitude depends both on the level of risk and on the consumers' risk misperception.

Monopsonist's optimal procurement strategy

We assume that the monopsonist has complete negociation power towards upstream producers in the definition of the intermediary price ω. In other words, if the monopsonist chooses to buy the quantity x on the intermediary market and sell it to the end market, then he optimally determines a level of the intermediary price $\omega(x)$, so as to involve the number of producers required to get and sell the quantity x.

The monopsonist selects the producers characterized by equipments between $\tilde{e}$ and 1. However, when the *ENA strategy* is chosen, there is no producer which modifies his equipment ($\tilde{e} \geq e^S$), thus producers can accept a null intermediary price in order to supply the intermediary market. If the *EA strategy* is chosen, the producers which are initially located between $\tilde{e}$ and e^S have to invest in a higher equipment ($\tilde{e} < e^S$). In particular, the producer located in $\tilde{e}$ is the last (less equipped) producer which upgrades his equipment by investing $e^S - \tilde{e}$. Hence, he does not participate in the market if the intermediary price is lower than $e^S - \tilde{e}$. Then, we have $\omega = e^S - \tilde{e}$ and the intermediary price is given by $\omega(x,e^S) = e^S - \tilde{e}$. Using (3) we then obtain:

$$\omega(x,e^S) = \begin{cases} 0 & if\ x \leq \hat{x} \\ \frac{x}{J} - (1-e^S) & if\ x > \hat{x} \end{cases} \qquad (7)$$

Let us underline that if an *ENA strategy* is implemented, then all the producers located within the interval $[e^S, 1]$ agree to enter the intermediary market. Hence, the monopsonist has to select only the highest equipments in order to get the quantity x. If an *EA strategy* is implemented, then the monopsonist chooses an intermediary price $\omega(x,e^S)$ such that only the producers between $\tilde{e}$ and 1 accept to join the intermediary market.

Using (5), (6) and (7), we then determine the optimal quantity chosen by the monopsonist as a function of the level of the standard e^S.

For every degree of consumer's risk misperception λ, there exist two levels, $\underline{e}_{\lambda}$ and $\overline{e}_{\lambda}$, of the food safety standard such that the optimal quantity $x^*_{\lambda}(e^S)$ chosen by the monopsonist, when the food safety norm is e^S, is given by:

$$x^*_{\lambda}(e^S) = \begin{cases} J[1-\underline{e}_{\lambda}] & if\ e^S \leq \underline{e}_{\lambda} \\ J[1-e^S] & if\ \underline{e}_{\lambda} \leq e^S \leq \overline{e}_{\lambda} \\ J\Psi_{\lambda}(e^S) & if\ e^S \geq \overline{e}_{\lambda} \end{cases} \qquad (8)$$

setting :

$$\Psi_{\lambda}(e^{s}) = \frac{1}{4}\left[\frac{(1-\lambda)l(1-e^{s})^{2} + 2(\alpha + 1 - e^{s})}{(1-\lambda)l(1-e^{s}) + (J+1)}\right] \tag{9}$$

The property $\Psi_{\lambda}(\bar{e}_{\lambda}) = 1 - \bar{e}_{\lambda}$ is verified.[5]

Results

Using (8), we can easily determine the expressions of the other variables:

the threshold equipment $\tilde{e}_{\lambda}(e^{s})$, obtained by (3)

the contamination risk $\sigma_{\lambda}(e^{s})$, obtained by (5)

the intermediary price $\omega_{\lambda}(e^{s})$, obtained by (7)

the total upstream producers' profit $B(e^{s},\tilde{e},\omega)$, given by[6]:

$$B(e^{s},\tilde{e},\omega) = J\{\int_{\tilde{e}}^{e^{s}} [\omega - (e^{s} - e)]de + \omega(1-e^{s})\} = J\left[\omega(1-\tilde{e}) - \frac{(e^{s}-\tilde{e})^{2}}{2}\right] \tag{10}$$

- and the consumers' surplus $S_{\lambda}(e^{s})$, given by :

$$S_{\lambda}(e^{s}) = \begin{cases} \frac{J^{2}}{2}[1-\underline{e}_{\lambda}]^{2} & \text{if } e^{s} \le \underline{e}_{\lambda} \\ \frac{J^{2}}{2}(1-e^{s})^{2} & \text{if } \underline{e}_{\lambda} \le e^{s} \le \bar{e}_{\lambda} \\ \frac{J^{2}}{2}\Psi^{2}_{\lambda}(e^{s}) & \text{if } e^{s} \ge \bar{e}_{\lambda} \end{cases} \tag{11}$$

Using the expression of the optimal quantity $x^{*}_{\lambda}(e^{s})$, given by (8), we then define the following three types of food safety regulation, which can be implemented by the public authority.

Definition 2. A regulation whose level of food safety standard is given by e^{s}, is denoted "*weak*" if $e^{s} \le \underline{e}_{\lambda}$, "*moderate*" if $\underline{e}_{\lambda} \le e^{s} \le \bar{e}_{\lambda}$ and "*strong*" if $e^{s} > \bar{e}_{\lambda}$.

The expressions (8) and (9) characterize the monopsonist's optimal strategy, given the type of regulation chosen by the public authority. Using this terminology, we provide in the next sections, an analysis of the effects of each type of regulation in terms of both food safety and surplus of the different agents.

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[5] This property allows to verify that the optimal quantity choice of the monopsonist is continuous in e^{s}.

[6] By substituting (3) and (7) into (10), we easily obtain the expression of the total upstream producers' profit $B(e^{s})$ as a function of the food safety standard.

Food safety regulation, monopsonist's selecting strategy and the level of contamination risk

Starting from the monopsonist' optimal quantity choice associated with each type of food safety regulation and by comparing it to the quantity $\hat{x} = J(1-e^S)$, we obtain the following results.

> **Result 1.** *If a weak regulation is implemented, then the monopsonist chooses an ENA strategy. Neither the optimal quantity nor the contamination risk are affected by the food safety standard.*

Weak regulations do not affect the upstream equipments levels. Thus, as only the initially best equipped producers are selected by the monopsonist, then no equipments' upgrading is required for producers to participate in the market. Furthermore, if no specific production conditions are required to access the market (that is, if the food safety standard is fixed at zero), then the exceeding supply reinforces the monopsonist's negociation power. Hence, the intermediary price equals zero (see Figure 1 below[7]).

Moreover, if this type of regulation is implemented, an improvement of the food safety standard does not affect either the monopsonist's optimal quantity choice or the contamination risk, regardless of the degree of consumers' risk misperception. From this point of view, weak regulations result in the same effects which would arise from a passive attitude of the public authorities towards food safety (that is, in the benchmark situation $e^S = 0$).

[insert Figure 1]

> **Result 2**. *If a moderate regulation is implemented, then the monopsonist chooses an ENA strategy. However, the contamination risk is lower than in the context of a weak regulation and decreasing in the food safety standard.*

As the weak regulations, the moderate ones do not affect the upstream equipments levels. Indeed, the monopsonist selects all the initially well-equipped producers and does not pay them any remuneration. However, the level of food safety is improved with respect to the context of weak regulations. Moreover, an increase of the food safety standard – within the context of moderate regulations ($\underline{e}_\lambda \le e^S \le \bar{e}_\lambda$) – affects the monopsonist's strategic behaviour, which in turn determines a food safety improvement. Indeed, if the food safety standard is reinforced, the contamination risk decreases.

This result can be explained as follows. As the food safety standard increases, the monopsonist anticipates that by implementing an *EA strategy* he could have an action on the reservation price (through an action on the contamination risk), but he would have to pay a positive remuneration to the upstream producers. Moreover, this remuneration would increase in the level of the food safety standard (see Figure 1). The monopsonist thus prefers to improve demand by reducing the supplied quantity, rather than by implementing an *EA strategy* and paying the producers a positive remuneration.

> **Result 3.** *If a strong regulation is implemented, then the monopsonist chooses an EA strategy. The contamination risk is not necessarily lower than in the context of weak regulations and is not necessarily decreasing in the food safety standard.*

[7] Figures 1-5 are created according to values of the parameters which are consistent with the basic model's assumptions; namely, they have been chosen within consistent ranges of each variable, that is quantity, price and probability of crisis ($J = 100$, $\alpha = 200$, $l = 50$). The following representative degrees of misperception have been represented : overestimation ($\lambda = -1$), perfect estimation ($\lambda = 0$), and maximal underestimation ($\lambda = +1$).

If a strong regulation is implemented, the monopsonist selects also initially not well-equipped producers and pay them a positive remuneration, in order to support their equipments' upgrading. As a result, the strategic behaviour of the monopsonist affects the contamination risk and thus the reservation price. We show that, if this type of regulation is implemented, the food safety is not necessarily improved with respect to the context of weak regulations.

Figures 2-3 and 4 below illustrate the effects of the food safety regulation on the monopsonist's strategic choice of quantity, on the contamination risk and on the final price.

[insert Figures 2-3-4]

The monopsonist's reaction to a reinforcement of a strong regulation and the consequences on the contamination risk are affected by the degree of consumers' risk misperception. Namely, the improvement of the food safety standard implies a decrease of quantity when risk's misperception is relatively high and an increase of quantity conversely. Figure 3 shows that in latter case, the contamination risk is not necessarily decreasing in the food safety standard.

In the context of strong regulations, the effect of a reinforcement of the food safety standard on the optimal quantity depends on two key-factors. One the one hand, as the intermediary price is increasing in the food safety standard (Figure 1), then the monopsonist has an incentive to decrease the quantity if the food safety standard becomes more demanding. On the other hand, as the reservation price increases in the standard (through the reduction of the contamination risk), the monopsonist has an incentive to increase the quantity if the standard increases.

The degree of consumers' risk misperception affects this monopsonist's trade-off. Namely, the lower is the degree of misperception, the higher is the increase of reservation price which can be obtained through a reduction of the contamination risk. As a result, when misperception is relatively low, the second effect dominates the first one. Thus, the monopsonist's may have a strategic behaviour, such that he takes advantage of a relatively low degree of consumers' risk misperception (and of the related marginal effect on the reservation price) and increases the demanded quantity in response to a food safety standard improvement (see Figure 2). Conversely, as the degree of consumers' risk misperception is relatively high, then the second effect does no longer dominate the first one and quantity decreases in the food safety standard, even if the action of the monopsonist on the contamination risk may improve reservation price.

Moreover, in the particular case such that consumers completely underestimate the risk ($\lambda = +1$) – that is they treat the good as if it were perfectly safe – then the second effect completely disappears. That is, the monopsonist has no longer the possibility to improve demand by having an action on the contamination risk. Hence, the monoposonist's quantity choice is only affected by the evolution of the intermediary price according to the level of the food safety standard (see Figures 1 and 2).

Then, the monopsonist's response to a food safety improvement – in terms of quantity – affects the level of contamination risk. The effect of a reinforcement of the food safety standard on the contamination risk is thus strictly arising from the monopsonist's quantity choice. Moreover, the contamination risk is a function of the food safety standard. As a result, the effect of the food safety standard on the contamination risk depends on two key-factors. One the one hand, the contamination risk increases in quantity, as an increase of the quantity demanded on the intermediary market implicitly leads to an increase of the number of producers involved. One the other hand, as an *EA strategy* is implemented, the contamination risk is a decreasing function of the food safety standard. Thus, the contamination risk may increase in the food safety standard, namely as far as the first effect dominates the second one. We verify that the first effect is greater, the lower is the degree of misperception (see Figure 3). Thus, food safety regulation may have a contradictory effect with respect to the objective of a food safety's improvement; namely when the degree of risk's misperception is relatively low.

In addition, Figure 4 shows that – for a given type of regulation and level of food safety standard – relatively low degrees of misperception imply higher levels of final price. However, when the degree of misperception is relatively low, a strong regulation does not necessarily imply a higher price, with respect to a weak regulation. Moreover, a strong regulation may determine a food safety improvement and – at the same time – a lower final price (with respect to the weak regulation).

If underestimation is maximal ($\lambda = +1$), then the implementation of a food safety standard implies a greater quantity restriction on the end market with respect to the absence of standard (Figure 2). Moreover, as the quantity restriction increases in the food safety standard, then the final price increases if the standard becomes more demanding (Figures 2-4). As a result, when consumers treat the good as if it were perfeclty safe, a food safety standard improvement determines a decrease of consumers' surplus[8] and an increase of final price.

Food safety regulation, monopsonist's strategic behaviour and participation of upstream producers

Given the food safety standard e^s , the monopsonist optimally defines the quantity $x^*_\lambda(e^s)$, which in turn determines *de facto* the number of upstream producers, which are excluded from the market. Let us thus denote by $\tilde{e}_\lambda(e^s)$ the threshold equipment starting from which upstream producers are involved in the market (participating producers), when the level of misperception is λ and the food safety standard is e^s .

> **Result 4.** *The number of producers selected by the monopsonist is not affected by the food safety standard if a weak regulation is implemented but decreases in the food safety standard if a moderate regulation is implemented.*

Figure 5 below shows the effects of the food safety regulation on the number of producers selected by the monopsonist. A relatively great reinforcement of the food safety standard (switching from weak to moderate regulations) implies a decrease of the number of upstream producers participating in the market, regardless of the degree of consumers' risk misperception.

[insert Figure 5]

A switch from weak to moderate regulations, does not affect the monopsonist's selecting strategy: the monopsonist continues to exert his negociation power towards upstream producers and pay them a null remuneration, even if the food safety standard increases. As the monopsonist decreases quantity in order to improve demand (see Result 2), then the number of producers participating in the market decreases.

> **Result 5**. *If a strong regulation is implemented, then the number of upstream producers involved increases (decreases) in the food safety standard when the degree of misperception is relatively low (high).*

If the Government is supposed to minimize the threshold equipment, in order to minimize upstream producers' exclusion, then the analysis of the threshold equipment as a function of the food safety standard points out an important policy implication, which is illustrated by the following result.

[8] Using (8), (9) and (11), we easily verify that consumers' surplus varies according to the quantity chosen by the monopsonist.

Result 6. *An exclusion-minimizing Government chooses a weak regulation (or* $e^S = 0$*), when the degree of consumers' risk misperception is relatively high and the strongest regulation (*$e^S = 1$*) when the degree of consumers' risk misperception is relatively low.*

If the Government is supposed to minimize the threshold equipment, in order to minimize upstream producers' exclusion, then he has two opposite strategies. He chooses either a null or a maximal standard, according to the degree of consumers' risk misperception. Namely, if misperception is sufficiently low, then paradoxically producers' exclusion is minimized by imposing the most demanding standard (Figure 5).

Let us detail the link between consumers' risk misperception and upstream producers' exclusion. The consumers' risk misperception affects the monopsonist's strategic behaviour, which in turn affects the exclusion of upstream producers.

On the one hand, it is shown that – for a given type of regulation and a given level of standard – relatively low degrees of misperception favour the choice of a food safety standard such that producers' exclusion is relatively high (Figure 5). In fact, the exclusion is decreasing in the degree of consumers' risk misperception, for a given type of regulation and level of standard. On the other hand, when the degree of misperception is relatively low, strong regulations do not necessarily imply a higher exclusion with respect to weak regulations. Indeed, we verify that for a relatively high level of standard, within the context of strong regulations, the participation of upstream producers is higher than in the case of weak regulations (Figure 5).

Moreover, when the degree of misperception is relatively low, we show that two different levels of food safety standard may exist (in the context of strong regulations) such that the same contamination risk arises and the more demanding standard corresponds to a lower upstream producers' exclusion (Figures 3 and 5). That is, paradoxically, a lower upstream producers' exclusion may be achieved by choosing the more demanding standard as a condition to access the market. As a result, the monopsonist's strategic behaviour, such that the quantity increases in the standard, may generate a positive effect in terms of upstream producers' market access.

Moreover, we show that the upstream producers' exclusion may be minimized by choosing the most demanding standard, that is $e^S = 1$, which in turn determines the choice of an *EA strategy* by the monopsonist. As a result, relatively low degrees of consumers' misperception favour the participation of initially not well-equipped producers (as the monopsonist has interest in paying them a positive remuneration in order to have an action on the reservation price).

In addition, we show that, paradoxically, a strong regulation may determine a food safety improvement and – at the same time – a decrease of producers' exclusion (with respect to the absence of regulation).

Final remarks

In this paper, we have provided a normative analysis of the effects of food safety regulation within food chains, when the sanitary risk results from the upstream production conditions. Our formal analysis has allowed to illustrate the complex strategic interactions among food chain participants (upstream producers, downstream processing or retailing firm, final consumers). We have shown why the effectiveness of food safety regulation, in terms of contamination risk's reduction, results from a good anticipation of firms' strategic behaviour. A downstream firm may adopt different procurement and commercialization strategies (consisting of upstream producers' selection and remuneration, choice of quantity and final price), according to the level of the food safety standard fixed by the public authority. These choices affect not only the level of contamination risk, but also the allocation of value among supply chain participants.

The firms' reaction to the level of food safety standard is also affected by market's response to the firms' efforts aimed at improving food safety; namely by the consumers' risk misperception. Hence, with respect to upstream producers' participation in the market, downstream firms react positively to highly demanding food safety standards, when the degree of consumers' risk misperception is relatively low. Moreover, we have shown the economic conditions such that a food safety improvement is consistent with the economic interests of the other supply chain participants (upstream producers and consumers).

Furthermore, our paper provides an original contribution in the sense that it explicitly takes into account the heterogeneity of upstream producers' capacities to comply with the food safety standard. If a food safety improvement is intended to be achieved, this heterogeneity may result in two possible scenarios. The first one consists of strongly selecting upstream producers, without encouraging an improvement of production conditions. The second one consists of driving an improvement of initial production conditions. The first scenario – which results in a great upstream producers' exclusion from the market – is no longer encouraged by the public authority when social reasons or agriculture multifunctionality issues are put forward. Nevertheless, the second scenario may be highly costly and require overly high public funding. However, we have shown how a highly demanding regulatory standard may allow to partially transfer these costs to firms.

The selecting strategy which we have examined (corresponding to the *ENA strategy*) is frequently observed within vertical relationships in food chains. This strategy allows the downstream firm to access to the safest quantity procurement. When it is possible (from a technical, legal and economic point of view), the same quantity may be obtained by implementing a private food safety standard, more demanding than the legislation (indeed a development of private food safety standards from processing and retailing firm has been observed). Taking into account this type of strategy in our model, would allow to analyze the complementarity and substitutability of these two types of strategies and provide a further element to the analysis of firms' strategic behaviour.

Moreover, public authorities often implement other types of regulatory tools, which consist of making firms liable for food safety damages, by imposing them penalties if a sanitary crisis occurs. The main idea behind this kind of regulation consists of making firms liable and thus encouraging them to exert precautionary efforts aimed at minimizing the risk of contamination damages. This is the reason why a large swathe of the literature aims at comparing this "ex-post regulation" to the "ex-ante regulation", which we have examined in this paper by considering that a minimum level of equipement is required for upstream producers to access the market[9].

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[9] Several contributions analyze the substitutabiliy and complementarity of these two regulatory tools as means of controlling externality-creating activities (see for example, Shavell, 1984, Kolstad et al., 1990, Schmitz, 2000, Innes, 2004). Nevertheless, except for a few contributions (see for example, Hiriart, Martimort and Pouyet, 2004, Boyer and Porrini, 2004), the market dimension and the role of vertical relationships are often neglected.

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Figures

Figure 1 - Effects of the food safety standard on the intermediary price

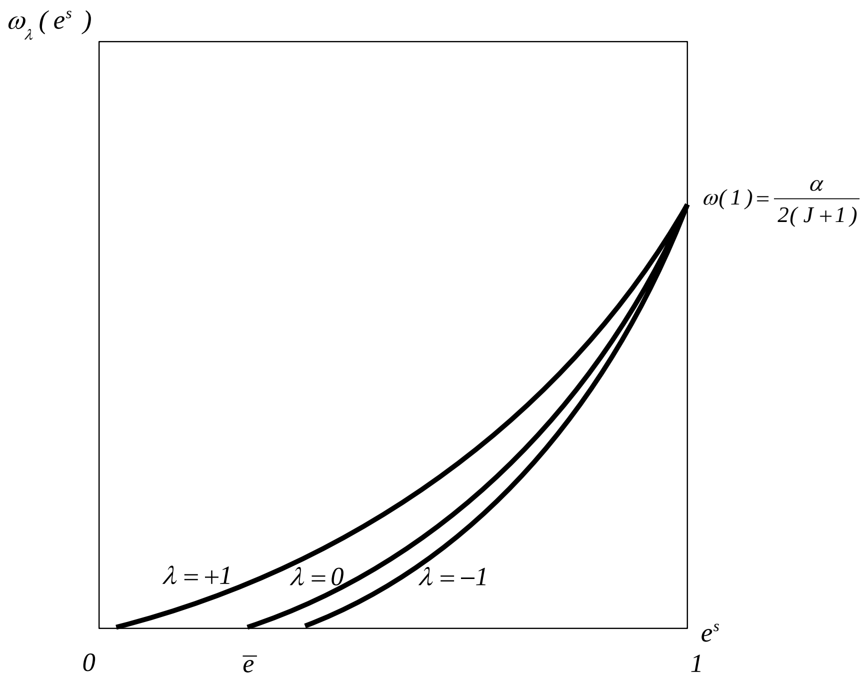


Figure 2 - Effects of the food safety standard on the monopsonist's quantity choice

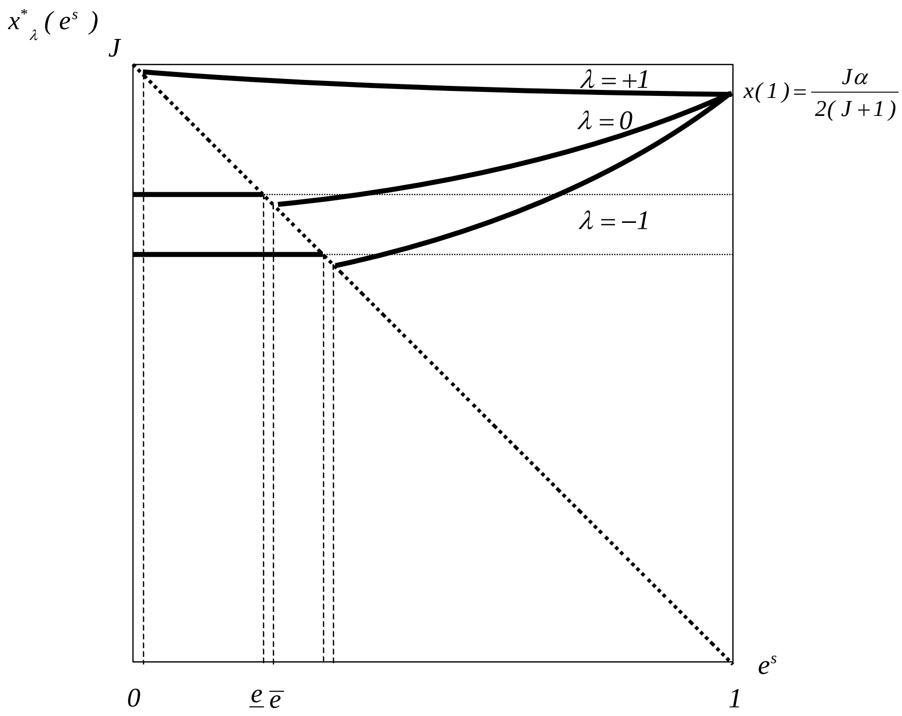


Figure 3 - Effects of the food safety standard on the contamination risk

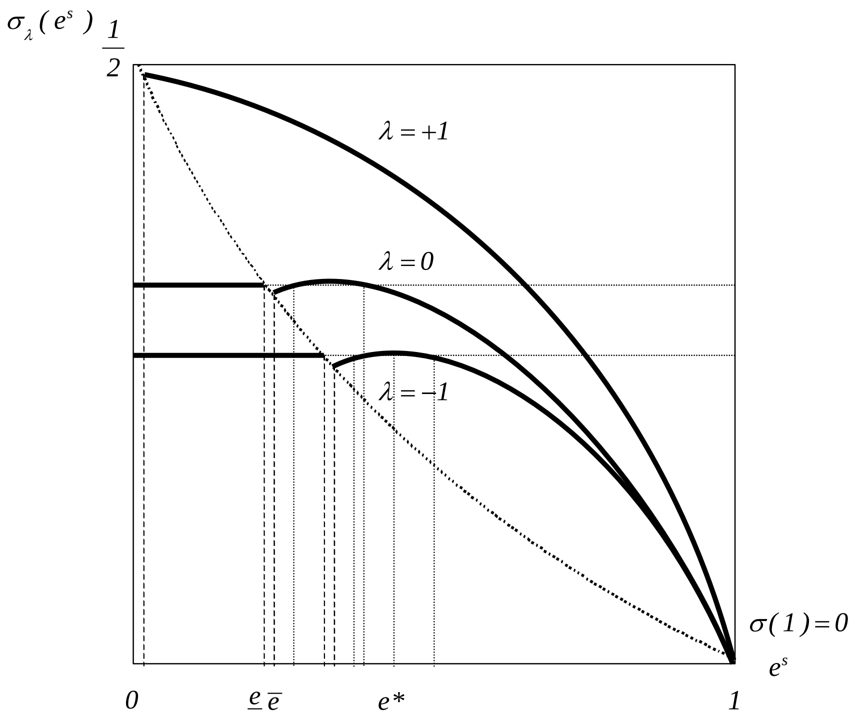


Figure 4 - Effects of the food safety standard on the final price

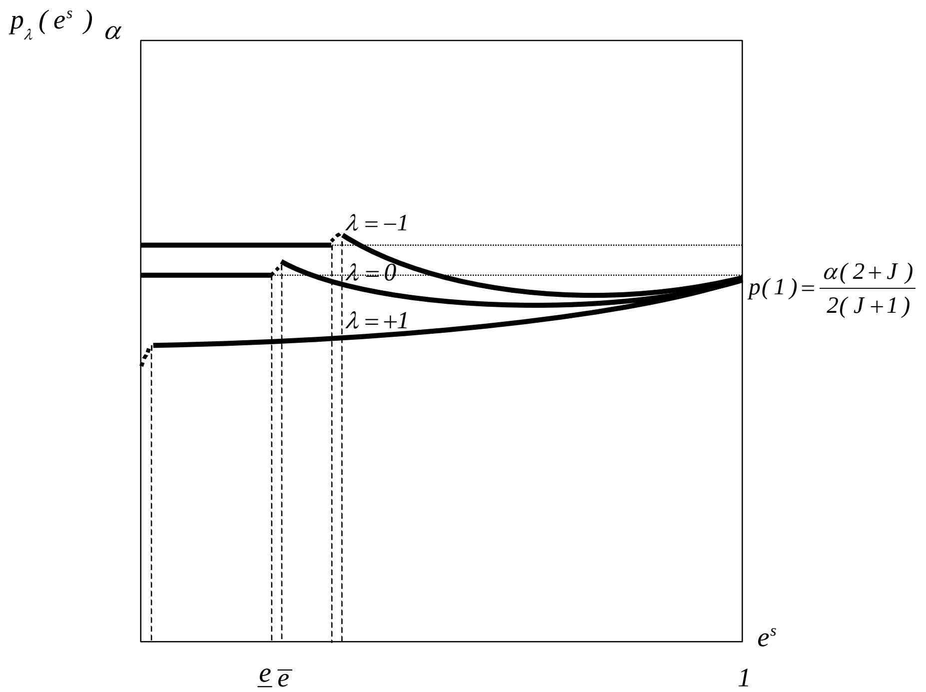
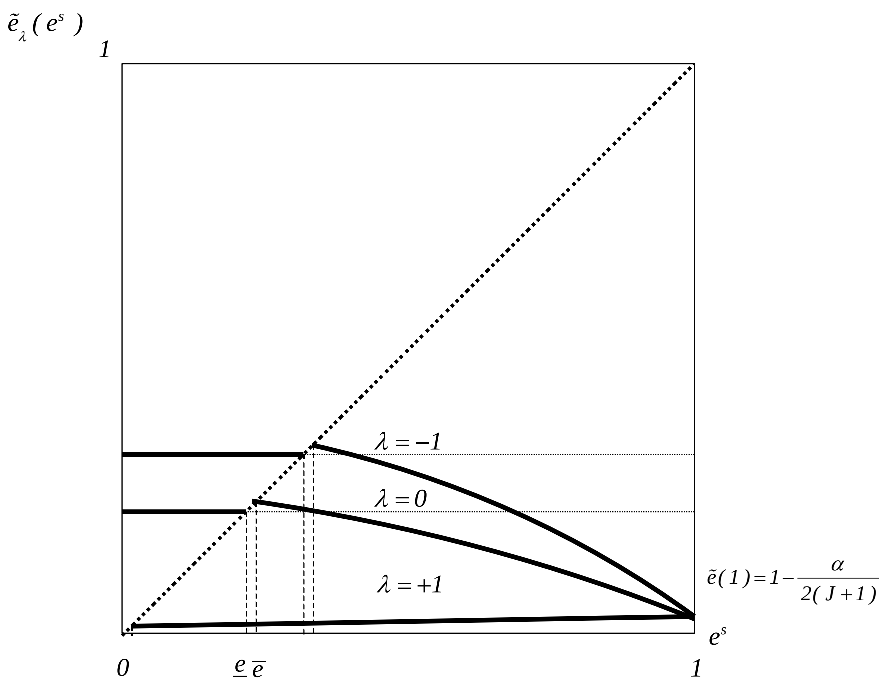


Figure 5 - Effects of the food safety standard on the upstream producers' exclusion



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