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Voluntary Approaches to Food Safety: A Unified Framework[1]

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Abstract:
The emergence and the multiplication of safety quality management system within the food supply chain were extensively analyzed in the food safety literature. Some papers deal more specifically with the voluntary implementation by firms of these systems (Segerson, 1999; Venturini, 2003; Noelke & Caswell, 2000). Our paper develops a unified analytical framework of this burgeoning literature. We show three original results: (i) when the mandatory threat is strong, the voluntary adoption of safety measures can be implemented without the need of a cost differential assumption (Segerson, 1999), or a reputation effect (Venturini, 2003); (ii) when the mandatory threat is weak, the reputation effect and the liability rule may induce the voluntary adoption only when there is a "hard" response from the consumers; (iii) when the response from consumers is "soft", a well designed contract offered by the retailer in the supply chain can induce the firm to implement voluntary safety measures.

Keywords: Voluntary approaches, Food safety, Supply chain.

Approches volontaires et qualité sanitaire des aliments : un cadre analytique unifié.

Résumé :
Ces dernières années en économie agro-alimentaire, la multiplication et le développement de systèmes de management de la qualité (SMQ) au sein de l'offre alimentaire ont fait l'objet un intérêt particulier. Cependant, seules quelques recherches traitent formellement de l'adoption volontaire de tels systèmes par les entreprises (Segerson, 1999; Venturini, 2003; Noelke & Caswell, 2000).
Dans cet article, nous proposons un cadre analytique unifié de cette littérature émergente. Premièrement, nous relâchons les hypothèses d'existence d'un différentiel de coût entre des SMQ volontaire et réglementaire (Sergerson, 1999) ou d'un stock de réputation (Venturini, 2003). Nous montrons ainsi qu'une menace réglementaire forte est une condition nécessaire et suffisante à l'adoption volontaire par les entreprises d'un SMQ. Deuxièmement, nous distinguons deux situations lorsque la menace réglementaire est faible. D'une part, suite à une contamination sanitaire quand la réponse des consommateurs ou du marché est « forte », les effets de réputation et le « design » de la règle de responsabilité jouent comme des incitations à l'adoption volontaire. D'autre part, quand la réponse des consommateurs (du marché) est « molle », seul le contrat qu'offre le distributeur à l'entreprise peut induire une adoption volontaire.

Mots Clés : Approche(s) volontaire(s), contrôle, qualité sanitaire, supply chain.

JEL : Q18, L51, L81.

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1 Introduction

In the nineties, the multiplication of food safety outbreaks has raised concerns about food safety both from governments and consumers. In this context, food safety regulation has evolved from performance process-related requirements to performance standard, granting more flexibility to firms (Segerson,1999). That is, firms can choose the least cost method to reach the performance standard (Caswell & Hooker, 1996; Unnevehr & Jensen, 1996). Consequently, in the food supply chain, “quality management metasystems” (Caswell et al., 1998) have emerged both to enhance food safety and to comply with new food safety regulation. However, if some papers analyze the firm’s incentives to adopt quality management systems (Henson & Holt, 2000; Holleran et al., 1999; Northen, 2001), there is little formal discussion putting the emphasis on the voluntary nature of the implementation of these systems[1]. A first strand of this literature studies a “market model” in which the firm only faces the regulator who can impose a (public) mandatory safety system (Segerson, 1999; Venturini, 2003). A second strand analyzes a “supply chain” model where a retailer (downstream firm) can impose its own (private) safety system. Noelke & Caswell (2000) explore the incentives to implement a voluntary system in a simplified supply chain.

Our paper aims at developing a unified analytical framework of these two strands. First, considering a ”market model” we analyze the making decision process of a firm marketing food products that will be consumed in their fresh form (e.g. meat, fish, fruit and vegetables). This allow us to divide the safety risk in two categories related to the consequences of a

[1]By voluntary, we mean that the firm designs itself its own QMS.

contamination on human health. First, situations of major safety risk where contaminations episodes lead to a hard response from the consumers, because this type of contamination have immediate and strong consequences on consumers' health. Thats is consumers rapidily react affecting both the profit and the reputation of the firm. Thus, safety risk is related to huge commercial stakes. We particularly point out the pathogenic or microbiological risk (e.g. in meat or fish industries) where products contamination could be lethal for consumers. Second, situations of minor safety risk with very low probabilities of contamination episode. In theses cases there are not strong and instant consequences for human health after consumption of altered products. Thus, consumer's response is soft in this situation and thus safety risk does not induce commercial stakes. An example of minor safety risk is the pesticide risk in the fresh fruits and vegetables industries. We mainly show two results: (i) when the regulator involvement in promoting food safety is strong, whatever the nature of consumer response, neither the cost differential assumption (Segerson, 1999) nor the reputation effect (Venturini, 2003) are needed to implement a voluntary safety system; (ii) when the regulator involvement is weak, two mechanisms may have some impact: the reputation effect and the rule of liability. However, when the consumer response is “soft” there is no reputation effect and only the rule of liability may induce the voluntary adoption of safety measures. However, this result raises issues on the effectiveness of civil litigations in this situation of "soft" response. Therefore, we explore the possibility that the addition of some “private” incentives may solve the problem. Introducing a retailer (namely, supermarkets) in a supply chain model, we show that a well designed contract offered by the retailer can induce firms to voluntarily implement safety measures. That is “private incentives” may be very powerful and can be used as the sole mechanism to implement the efficient choice.

The paper proceeds as follows. Section 2 presents the related litterature. Section 3 deals with our market model. Section 4 extends the framework to deal with the firm's decision to voluntarily adopt safety measures in a supply chain. We provide some conclusions on section 5.

2 Related Literature

In the food safety literature, papers have mainly focused on the impact of the new safety regulation. For example, Loader & Hobbs (1999) have shown that this legislation can provide incentives and opportunities for firms requiring very fast strategic actions. Similarly, Henson & Heasman (1998) have analyzed the firm's compliance process to food safety regulation and show that firms follow a common sequence of activities when they have decided to comply with a new safety regulation. Buzby and Frenzen (1999) have focused on the US product liability system for food contamination episode and its impact on the firm incentives to produce safer food. Others research analyzed what goes on inside the firm. For example, Unnevher & Jensen (1999) have scrutinized the role of the HACCP safety control system as a public standard of food safety, and Henson & Hooker (2001) have dealt with both private and public implications of a private management of safety controls. They both have documented the different strategies that a firm may face when it has to comply with new safety requirements. Caswell and al. (1998) show that the adoption of a quality management system affects both the firm's profit and competitiveness in the food supply chain.

However, there is some formal discussion putting the emphasis on the voluntary nature of the implementation of these systems. Following the large body of literature in environmental economics that deals with voluntary approaches (see Khanna, 2001 for a survey), Segerson (1999) develops a model to analyze the voluntary choice of firms assuming that a mandatory safety system is more costly than a voluntary one. She shows that the only credible mean to induce a firm to adopt voluntary preventive measures is a strong mandatory threat. Venturini (2003) relaxes her assumption and argues that a strong mandatory threat is a necessary but not a sufficient condition to induce voluntary implementation of safety measures by firms. That is, government intervention is needed to help firms signalling safer food products to consumers. Another paper analyzes a "supply chain" model where a retailer (downstream firm) can impose its own (private) safety system. Noelke & Caswell (2000) explore the incentives to implement a voluntary system in a simplified supply chain where three different quality management systems could be implemented under two different systems of rules of liability (rule of strict liability and rule of negligence). The authors show that the level of safety implemented through a voluntary quality management system is always higher than through a mandatory or a quasi-voluntary one (imposed by the downstream firm). However, this level depends on the safety level implemented by the upstream (supplier) and the downstream firm (retailer). They also show that under a rule of negligence, firms implement a higher level of quality management than under a rule of strict liability. Indeed, a rule of negligence system leads most of the time to over-compliance.

3 A market model

In this section, we develop a model that focuses on a firm face to the regulator and directly to “the market”’. The model does not deal with the regulator’s willingness to pay to induce firm to voluntarily implement measures to improve food safety (“carrot” approach). The firm will thus not receive subsidies for voluntarily implementing safety measures. Therefore, incentives to implement voluntary measures comes from: (i) the regulator ability to impose to the firm a mandatory system improving food safety (“stick” approach); (ii) the different types of sanctions (economic and legal) that the consumers (“the market”) can impose to the firm following a contamination episode.

3.1 Set up

We consider a two-stage game (see Figure 1). In the first stage, the firm has two courses of actions: (i) implementing a voluntary safety system to produce and market safer products; (ii) no any safety measures implementation. If the firm implements a voluntary safety system the game is over. If the firm decides not to implement voluntary safety measures, the game continues. Thus, in the second stage the regulator intervenes with a probability $r \in [0; 1]$. We assume that r is an exogenous probability which reflects the probability that the regulator imposes a mandatory safety system to the firm. When $r = 0$ there is no mandatory threat, and when $r = 1$ the imposition of a mandatory system is certain. Whatever the firm’s decision, a contamination episode may occur. If the firm does not adopt any voluntary safety measures and the regulator does not impose any mandatory safety measures, there is a probability $p \in [0;1]$ that a contamination episode occurs. When (voluntary or mandatory) safety measures are undertaken, there is a probability $q \in [0;1]$ of contamination. Since undertaking (voluntary or mandatory) safety measures can reduce contamination risks but does not allow to completely avoid it we assume that $0 \leq q \leq p$. We suppose that p and q are exogenous probabilities. When a contamination episode occurs, consumers may sue the firm for damages. Let L denote the positive amount to be paid related to the judicial proceedings following a contamination episode. This legal cost will depend on the rule of liability which is operative regarding the payment of damages for injured consumers.

Concerning the payoff function of the firm, consider first the cost of implementing safety measures. Let C_V and C_M be the costs that a firm bears when it reaches a given level of food safety through respectively a voluntary and a mandatory safety system. Following the voluntary approaches literature in the environmental economics, Segerson (1999) assumes that the compliance costs associated to the implementation of a mandatory safety system (training employees, record keeping equipment, etc.) are higher than those associated to the implementation of a voluntary one. In contrast, Venturini (2003) suggests that such a cost differential is not supported by empirical evidence on the implementation of safety system such as HACCP [2]. Therefore, in what follows we suppose as Venturini (2003) that $\Delta C \equiv C_M - C_V = 0$. Consider now the firm's benefit of implementing safety measures.

[2] See Colatore and Caswell, 1999; Zaibet and Bredhal, 1997. For example, Colatore and Caswell (1999) show that for eight breaded fish companies the costs adoption of a mandatory HACCP raises the annual total costs of only 0.25%.

Following Venturini (2003), and in contrast to Segerson (1999), we split the gross benefit of implementing voluntary measures in three components. That is $B_V = B_0 + B_D + B_R$, where B_0 reflects the net revenue from products sales, B_D the direct market benefit due to an increased demand for its product as a result of increased safety, and B_R the benefit due to the firm's stock of reputation. Similarly, when the regulator imposes a mandatory safety system to the firm, it will receive $B_M = B_D + B_0$. When no safety measures (voluntary or mandatory) are implemented, it only receives B_0. This implies that the minimum benefit the firm can get is B_0. Moreover, since the direct market benefit B_D is the same whether the firm implements a voluntary or a mandatory safety system, the "incentive" component for a firm to adopt voluntary safety measures is B_R, that is the benefit due to its stock of reputation. We assume that after a contamination episode B_R could be altered, even if B_R still remains nonnegative. Indeed, the firm may loose its "good reputation" (B_R can decrease to 0) depending on the magnitude of consumers' response following a contamination episode. We consider two situations. First, a contamination episode leads to a "hard" response from consumers because of strong or lethal consequences following a contamination episode (pathogenic risk in the fresh meat or fish industry). In that case, a contamination episode is followed by a dramatic fall of the firm's reputation. Second, a contamination episode leads to a "soft" response from consumers. This is the case with pesticides issues in the fruits and vegetables industry since most of the time consumers are not fully aware of health problems linked to consumption of contaminated fruit and vegetables which primarily have not instant but cumulative effects.

[INSERT FIGURE 1]

3.2 Case 1: Contamination involving a hard response from the consumer

In such cases, firms which have marketed altered products face to very high commercial stakes. When the firm has undertaken a voluntary safety system and there is no contamination episode, the firm gets all the net "full return" $(B_V - C_V)$ from voluntarily increasing products safety. In contrast, when a contamination episode occurs with a probability q, then the firm gets only $B_0 - C_V - L$. Indeed, in such a case the "hard" consumer's response has two consequences. First, the benefit decreases from B_V to B_0 since the reputation and increased demand components associated to the increased food safety measure disappear (i.e. $B_D = B_R = 0$). Second, the firm must pay an additional fee L due to legal proceedings. Therefore, the expected payoff that a firm gets when it voluntarily implements safety measures is $q\,[B_0 - C_V - L] + (1-q)\,[B_V - C_V]$. When the firm has undertaken no safety measures and the regulator imposes a mandatory safety system, the "reputation" component in the benefit disappears since the measures are mandatory. Therefore, the net return from increasing the safety is $B_M - C_M$. When no safety measure have been implemented (voluntary or mandatory), the gross benefit reduces to the minimum gross benefit B_0. In both situations, the occurence of a contamination episode implies only a reduction of the expected losses relative to the payments of damages L. Therefore, the expected payoff that a firm gets when no voluntary measures are undertaken is $r(q\,[B_0 - C_M - L] + (1-q)\,[B_M - C_M]) + (1-r)\,[B_0 - pL]$. Then implementing a voluntary safety system is an equilibrium if:

$$q\,[B_0 - C_V - L] + (1-q)\,[B_V - C_V] \geq r(q\,[B_0 - C_M - L] + (1-q)\,[B_M - C_M]) + (1-r)\,[B_0 - pL]$$

or equivalently

$$qB_0 - C_V - qL + (1-q)B_V \geq r\,[qB_0 - C_M - qL + (1-q)B_M] + (1-r)\,[B_0 - pL] \quad (1)$$

Following Segerson's suggestion (1999) we consider now two extreme cases depending on the magnitude of the regulator's involvement in promoting food safety.

3.2.1 Strong mandatory threat ($r = 1$)

The regulator imposes mandatory measures if the firm does not voluntarily adopt safety measures . Then (1) becomes

$$(1-q)(B_V - B_M) \geq (C_M - C_V)$$

or

$$(1-q)B_R \geq \Delta_C \quad (2)$$

Condition (2) implies that the reputation component of the benefit (B_R) must outweight the cost differential Δ_C. Since we assumed that $\Delta_C = 0$, condition (2) is then

$$(1-q)B_R \geq 0$$

which always holds because B_R is positive. This result implies first that, in contrast to Segerson (1999), a positive cost differential assumption is not necessary to sustain voluntary measures when there is a strong mandatory threat. Indeed, if having a good reputation generates some benefits, then the firm adopts voluntary safety measures. Moreover, it is easier for firms to implement voluntary safety measures when there is no cost differential than when such a differential exists. Second, contrarily to Venturini (2003) claim, there is no need of a governement intervention to implement reputation effect. Even if the firm has no reputation, that is $B_R = 0$, condition (2) is trivially satisfied.

3.2.2 "Laissez faire" policy ($r = 0$)

If the government does not impose a mandatory safety system, then (1) becomes

$$qB_0 - C_V - qL + (1-q)B_V \geq B_0 - pL$$

or, equivalently

$$(1-q)(B_D + B_R) + (p-q)L \geq C_V \tag{3}$$

This condition implies that in a "laissez-faire" policy, the adoption of a voluntary safety system depends on two mechanisms: a "carrot" and a "stick". The "carrot" corresponds to the components of the benefit (B_D+B_R) that can increase when voluntary safety measures are implemented. This potential increase can be quite weak since B_D can be very low because of difficulties in signalling food safety to consumers[3]. But, if a good reputation has a high return, then B_R can be high enough to induce a voluntary adoption of safety measures improving the safety of products it sells. Second, the "stick" corresponds to the reduction of expected losses related to judicial proceedings ($(p-q)L$) following a contamination episode occurence.

[3] For example in France, signaling food safety is indirectly prohibited by law (Codron et al.. 2006).

Therefore, designing an efficient legal rule is an issue. For example, the rule of negligence, which is operative in the United Kingdom, can be an efficient solution to implement voluntary safety measures. Indeed, under the rule of negligence, when a contamination episode occurs the firm is held liable if the level of the safety system it has implemented is equal or lower than what the court could expect. Therefore, this rule often leads firms to "overinvest" in safety measures to comply with the "standard" of the court (Noelke & Caswell, 2000).

3.3 Case 2: Contamination involving a soft response from the consumer

In this section we deal with situations where, following a contamination episode, unawareness about the safety risk leads to a weak response from the consumer. This statement is relevant in cases where the appraisal of safety risks and contamination occurrence are quite difficult and costly to monitor. Because the consequences of a contamination episode are not instant in such cases these risks can be assumed as cumulative and have long-term effects on human health. Moreover, because it is difficult and costly to detect and to monitor, the likelihood of a contamination is quite low. To take into account of the specificity of this safety risk we suppose here that p and q do not more reflect the likelihood of a contamination episode, but the probabilities for a firm to fail to a test aiming to monitor the safety. In the case of failure, the firm's benefit is supposed to be softly affected since consumers are unaware about the safety risk. That is, in contrast to the hard response situation, when the firm implements a voluntary system the firm gets all the net full return $(B_V - C_V)$ from increasing food safety, even when a contamination episode occurs. Given this slight modification in the firm's payoff, now a voluntary strategy is an equilibrium if

$$B_V - C_V - qL \geq r(B_M - C_M - qL) + (1-r)(B_0 - pL) \tag{4}$$

As previously, we consider two extreme cases.

3.3.1 Strong mandatory threat $(r = 1)$

Here, the mandatory threat to impose a safety measure is certain. In this case, the firm will adopt voluntary measures if and only if

$$B_V - C_V - qL \geq B_M - C_M - qL \tag{5}$$

or equivalently

$$B_R \geq 0$$

The condition (5) always holds because B_R is nonnegative. Even if B_R is equal to zero, i.e. there is no gain to have a good reputation, then condition (5) is trivially satisfied. Thus, no additional constraint is needed to induce the implementation of a voluntary safety system.

3.3.2 "Laissez faire" policy $(r = 0)$

The regulator does not impose a mandatory safety measure within the firm. Then, (4) becomes

$$B_V - C_V - qL \geq B_0 - pL$$

or,

$$(B_D + B_R) + (p - q)L \geq C_V \tag{6}$$

As in (3), the firm voluntary adoption of a safety system depends on the same both mechanisms ("stick" and "carrot") which have to outweigh C_V. However, if the "carrot" mechanism (firm's stock of reputation) is still effective, there is a need to discuss about the nature of "stick" mechanism (the legal issue). As in the "hard" response case, there is a need to a well-designed liability rule. Civil litigations can be efficient if the consequences of a contamination episode are instant and thus consumers can sue firms for not being enough preventive. In such cases, the rule of negligence may be considered as the best instrument since a firm can avoid judicial proceedings if it has implemented a level of safety higher than the court can expect. However, civil litigations cannot be efficient when consequences of a contamination episode are not instant and when it can take decades before people gets sick. Indeed, consumers may not sue a firm which failed to provide safe goods because it is both difficult and costly, and most of the time impossible, to prove the real nature of a contamination. In such a situation, the rule of liability must not be linked to the "outcome" (is there a contamination or not ?) but to the "process" (does the firm comply to the monitoring plan designed by the regulator ?). However, when the regulator cannot impose a mandatory safety measure, it is hard to see how the rule of liability can be linked to the "process". In such as case, only harsh legal sanctions may discipline firms. For example, in France importers or producers of fresh produce are held liable under criminal law if they fail to the pesticide testing designed by the government agency (Codron & al., 2006).

4 A supply chain model

In this section, we extend our previous market model by introducing a new player: a retailer. That is, we assume now that the firm does not take decisions only with regard to the regulator, but also to a retailer. Following Noelke & Caswell (2000), we thus consider a simplified supply chain where the previous firm (upstream firm) does not market directly its goods but sells them to a "large scale retailer" (downstream firm). We aim to determine on what extend private incentives from the retailer can overcome our previous problem, that is how the retailer can influence the decision of the firm to adopt voluntary measures when the consumer response is soft.

4.1 Set up

Now, our model is a four-stage game (see Figure 2). The structure of the game is the following. In the first stage, the retailer offers a take-it-or-leave-it contract. If the firm accepts such a contract, the game continues. In the second stage, the firm chooses to implement a voluntary safety system or not. If the firm adopts a voluntary safety system, the game is over. If the firm does not implement a voluntary safety system, then the regulator intervenes in the third stage with a probability $r \in (0, 1)$. If the regulator intervenes and imposes a mandatory safety system to the firm, then the game is over. If the regulator does not impose a mandatory safety system, the retailer intervenes in the fourth stage and imposes its own safety system at a probability $s \in (0, 1)$. The retailer is supposed to test only the compliance with the safety public standard, since we assume that the retailer does not aim to provide a stronger safety standard than the public one. That is, there is some kind of "task sharing" between the regulator and the retailer: the regulator designs the (public) safety standard and the retailer enforces (monitors the compliance with) the public standard. Thus, we assume that product fails to the retailer safety testing with a probability $q \in (0, 1)$ whatever the firm has implemented or not a safety system.

Following Noelke & Caswell (2000), we distinguish four types of safety systems: (i) voluntary safety system, where the firm voluntarily undertakes safety measures. The firm decides to implement a safety system improving the safety of products without any explicit prompting, neither by the retailer nor by the regulator; (ii) a quasi-voluntary safety system, where without any explicit prompting by the regulator to implement safety measures the firm could be forced to do so by the retailer. Then, the firm must implement the retailer's requirement and increase its safety level. This system is not really voluntary because firm if they want to keep their contract with the retailer are forced to implement these systems; (iii) mandatory safety system, where all the firm involved in one food industry are forced to implement a safety system imposed by the regulator. Note, that the mandatory system is compulsory, the public system is supposed to be prevalent. We assume that the retailer is supposed not to ask an additional safety measure to comply with its own requirements; (iv) no measures, where no safety measures are undertaken neither by the firm nor imposed by the regulator or the retailer.

The payoff functions are also slightly modified. Concerning the cost notations, let C_C be the cost associated to the retailer's system implementation. For example, C_C can be the certification costs that the firm must bear when the retailer required a third party private certification. There is no gain for voluntarily implementing safety system we assume that $C_C = C_V$. Similarly, let B_C represent the benefits a firm receives when it implements a quasi-voluntary safety system. We assume there is no beneficial advantage to implement a quasi-voluntary safety system rather than a voluntary one, that is $B_V = B_C$, more formally, $B_V = B_C = B_R + B_D + B_0$. Finally, the introduction of a retailer in our food safety game implies that it can design a menu of contracts , $(P_1,\ P_2, P_3, P_4)$, where P_i are the private penalties that the retailer applies to the firm when it fails to provide safe fresh produce. More precisely, P_1 is associated to a failure with a voluntary safety system, P_2 is associated to a failure with a quasi-voluntarily system, P_3 with a mandatory one, and P_4 is applied when the firm do not undertake safety measures. Below, we assume that $P_3 \leq P_4$. The sanction related to a firm's failure is higher when the firm has not implemented safety measures than when it has implemented the retailer' system.

[**INSERT FIGURE 2**]

4.2 Private incentives and voluntary adoption

As in the section 2, we consider two extreme cases depending on the regulator's involvement in the design of safety measures within the supply chain.

4.2.1 strong mandatory threat

If the mandatory threat is certain ($r = 1$), then we get

$$B_V - C_V - qP_1 - qL \geq B_M - C_M - qL - qP_2$$

or equivalently,

$$B_R + q(P_2 - P_1) \geq 0 \tag{7}$$

Since q is always nonnegative and $B_R = 0$, then condition (7) becomes

$$P_1 \leq P_2$$

$B_R = 0$ because there are no reputation effects when the consumer response is soft. We have shown in our "market model" that a strong mandatory threat is a sufficient condition to implement voluntary measure. In a "supply chain model", an additional constraint is needed: the penalty for failure from the retailer associated to the voluntary system must be lower than the penalty associated to its compulsory alternative, the mandatory one (quasi-voluntary system).

4.2.2 "Laissez faire" policy with private incentives

We consider the general case where the retailer imposes its own safety system with a probability $0 \leq s \leq 1$.In such a case, a voluntary strategy is an equilibrium if

$$B_V - C_V - qP_1 - qL \geq s(B_C - C_C - qP_3 - qL) + (1 - s)(B_0 - qP_4 - qL)$$

that is,

$$(1-s)(B_D+B_R)-q(P_1-P_4)+sq(P_3-P_4)\geq C_V-sC_C$$

Since the consumer response is soft, then $B_D + B_R$ are next to 0 and $C_C = C_V$ then we get

$$-q\Delta_P \geq C_V - sC_V \text{ or } -q\Delta_P \geq (1-s)C_V$$

where $\Delta_P = (P_1 - P_4) - s(P_3 - P_4)$. This implies that $\Delta_P \leq 0$ and , which holds if

$$P_1 \leq sP_3 + (1-s)P_4 \tag{8}$$

That is, the penalty associated to a failure with voluntary safety system (P_1) must be lower than the weighted mean of both penalties either when the firm undertakes no measures (P_4), or when quasy-voluntary measures are implemented (P_3 and P_4). According to condition (8), if the retailer imposes its own safety system with certainty, then

$$P_1 \leq P_3$$

in contrast if he does not impose its own safety system, then

$$P_1 \leq P_4$$

These results imply that a well-designed menu of penalties can induce voluntary safety measures adoption. Indeed, if the retailer chooses P_1 such that $P_1 = \min\{P_2, P_3, P_4\}$, then the firm will undertake a voluntary safety measure. This result holds whatever the mandatory threat or the probability that the retailer imposes its own safety system. That is, the private incentives provided by the contract with the retailer are very powerful and can be used as the sole mechanism to induce the voluntary adoption of safety measures by the firm.

5 Conclusion

This paper is an attempt to provide a unified analytical framework of the burgeoning literature on voluntary approaches applied to food safety. We mainly show two significant results. First, considering a "market" model we show that a strong mandatory threat from the regulator is a sufficient condition for a voluntary implementation of safety measures. In contrast to the literature, we show that neither a differential cost between voluntary and mandatory system (Segerson, 1999) nor the existence of reputation effects (Venturini, 2003) are needed to support such implementation. However, when the mandatory threat is weak, the voluntary adoption of safety measures depends on two complementary mechanisms, a "carrot" (reputation effects) and a "stick" (rule of liability and expected looses according to judicial proceedings). Because safety is a credence attribute of food products there are difficulties in signalling safety to consumers and thus the reputation effect can be very low. Thus, the sole mechanism that may induce a voluntary adoption of safety measures is the liability rule. However, in the case of soft response from consumers, civil litigations provide too weak incentives for voluntary safety measures implementation. Second, we analyse a "supply chain" model with soft response from consumer to see if private incentives from the retailer (downstream firm) can be used as the exclusive mechanism to induce voluntary adoption of safety measures. We show that a contract where the penalty imposed under a voluntary system is lower than penalties under alternative systems, can induce a voluntary system implementation.

Our results raise some interesting directions for further research. First, we could extend our model by exploring how our results evolve: i) when we introduce moral hazard in the relationship between the firm and the retailer. That is, we should consider that the detection probabilities are endogenous and determined by effort the firm makes in monitoring the safety products. ii) when the retailer imposes its own safety scheme in the presence of a the mandatory system. Second, our result suggesting that private incentives are the sole mechanism to induce voluntary adoption of safety measures, namely the efficient one, raises welfare issues on the enforcement of safety standard by private parties: What are retailers' incentives in implementing such systems to provide safer food ? Avoiding blame for consumers or capturing the law? What are the consequences and costs on the exclusion and/or the reorganization of suppliers in the food supply chain? Moreover, we assumed in our model that the retailer does not aim to provide a stronger safety standard than the public one. That is, there is some kind of "task sharing" between the regulator and the retailer: the regulator designs the (public) safety standard and the retailer enforces (monitors the compliance with) the standard. However, in contractual practices, the retailer can also design the safety standard (Soler et al., 2005). Therefore, how far must go private implication in the food safety regulation ? Can "private" standards become a ("public") standard enforced by the regulator ?

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Figure 1 The market model.

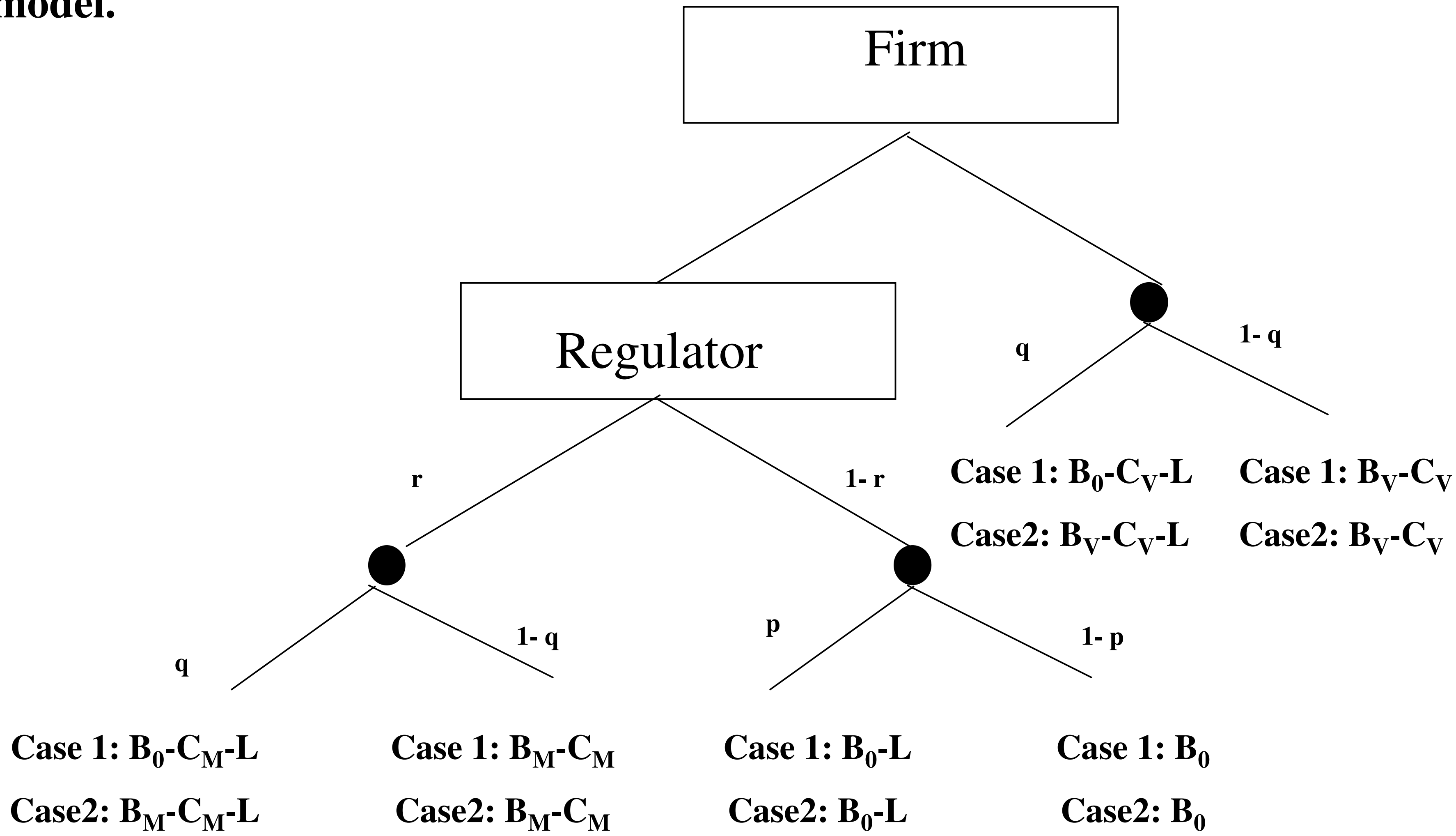

Figure 2. A Supply Chain Model.