Joint Private Safety Standards and Vertical Relationships in Food Retailing

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In recent years, it has become common for downstream firms to impose Joint Private Standards (JPSs) on upstream producers. In this paper, we present an original model of a vertical relationship, explaining the incentives for and the effects of such JPSs with an example concerning food safety. The risk of a food crisis is endogenously determined. Using the concept of cartel stability (d'Aspremont et al., 1983), it is shown that liability rules are crucial for JPSs to emerge, that a JPS can become a minimum quality standard, and that a more stringent JPS does not necessarily reduce the market risk.

1. Introduction

Food safety has received increasing attention in the Western hemisphere since the 1990s. The frequency of food-related illnesses in many countries and major food crises, such as the mad cow disease, has contributed to this attention. In the United States, it is estimated that 76 million

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people suffer from food-borne illnesses every year, resulting in 325,000 persons being hospitalized and more than 5,000 deaths (Mead et al., 1999). In total, 713 food recalls were made in 2002 and 2003. Of these, 313 recalls were due to pathogens, such as *Listeria*, *Salmonella*, *E. coli*, and *Campylobacter* (Salin et al., 2005). In Canada, between 11 and 13 million people suffer from food-related illnesses every year. In 2008, 150 recalls, advisories, and warnings were given.[1] In Europe, *salmonellosis* and *campylobacteriosis* are the most common causes of food-borne diseases, amounting to 400,000 reported cases per year. In 2008, 5,332 outbreaks of contaminated food were reported, resulting in 45,622 human cases, 6,230 hospitalizations, and 32 deaths.[2]

In order to reduce the risks of unsafe food reaching consumers and restore consumer trust, governments in many countries have increased the responsibility of firms in the food chain. Following the implementation of the "due diligence" principle in the U.K. Food Safety Act in 1990, the EU Food Law Regulation in 2006 imposed strict liability for food firms in the case that they fail to provide safe food and cannot prove that all "reasonable precautions" have been undertaken (Henson and Humphrey, 2009). Therefore, compliance with Good Food Safety Practices has become an important way for firms to defend themselves in potential future lawsuits. Even if a firm is found liable, such compliance can reduce the punitive damages, as the firm can show that it has taken "reasonable care" when producing, handling, and selling the product.

The implementation of private standards is one major tool to assure due diligence and signal that firms are taking all reasonable precautions to prevent incidents from occurring. Although all stakeholders in the food chain have been engaged in reinforcing food safety controls, the major retailer groups have played a prominent role since the 1990s. Indeed, the retailers' liability is directly involved for two types of products: processed foods sold under retailers' brands (private labels), which are getting increasing market share in many countries, and nonbranded/unprocessed foods, especially fruits, vegetables, and meat. In both cases, global retailers require their suppliers to adopt more stringent standards in order be able to show due diligence and to ensure the safety of the products for which they are more directly responsible.

An important initiative for processed foods produced under retailers' private labels is the British Retail Consortium (BRC) Global

1. Canadian Food Inspection Agency report, 2008: http://www.inspection.gc.ca/english/fssa/concen/causee.shtml.

2. EFSA, 2009: Report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in the European Union, http://www.efsa.europa.eu/en/scdocs/scdoc/1496.htm.

Standard—Food,[3] which was set up in 1998 in order to facilitate for retailers to comply with U.K. legislation. Dutch retailers rapidly joined the standard and started requiring that suppliers be certified according to the standard. In 2002, German retailers created the International Food Standard[4] (IFS), which, like the BRC Global Standard, was required to be adopted by suppliers of products sold under the retailers' private labels. Shortly after the launch of the standard, French retailers joined, followed by Italian and Polish retailers. In the United States, the Food Marketing Institute launched the Safe Quality Food[5] (SQF) program in 2002. Its origins as the first private standard date back to 1995, when it was originally developed in Western Australia.

This worldwide expansion of various standards created a need for harmonization. Consequently, the Global Food Safety Initiative[6] (GFSI) was launched to bring together food retailers in different parts of the world in an attempt to collectively address food safety. The GFSI is characterized by open access and based on mutual recognition of some major private standards used by global retailers. The GFSI requires food suppliers to be certified according to SQF, BRC, and/or IFS. In 2008, Wal-Mart became the first nationwide U.S. retailer to implement the GFSI and require all suppliers of products sold under the retailer's private label to be certified according to one of the standards recognized by the GFSI standard.[7]

Retailers have also implemented standards for unprocessed foods. Global GAP is an example of such a standard, imposing more stringent requirements on and control of products sold without strong brands (such as, fresh fruits and vegetables). Although this standard deals with a broad range of issues (including both environmental and social dimensions), food safety aspects are crucial to the standard. The standard, which was created in 1997 by retailers belonging to the Euro-Retailer Produce Working Group (EUREP), specifies rules for good agricultural practices (GAP). The aim was to establish one single standard "with different product applications capable of fitting to the whole of global agriculture."[8] Initially, British retailers and some retailers in continental Europe adopted the standard, but it has since spread to many retailers in different European countries and, more recently, to the United States, where Wal-Mart has joined. In 2010, there were approximately 100,000 certified producers in 100 countries.

3. See http://www.brcglobalstandards.com.
4. See http://www.ifs-certification.com.
5. See http://www.sqfi.com.
6. See http://www.mygfsi.com.
7. See http://walmartstores.com/pressroom/news/7918.aspx.
8. See http://www.globalgap.org/.

There are two major reasons for why the emergence of this kind of collective, private safety standard to a large extent has been driven by European retailers: (i) the changes in public regulation in the aftermath of the mad cow crisis and the pressure placed on the private sector in terms of due diligence; and (ii) the food retail structure and the large market shares of private labels in several countries in Europe. However, the recent spread of private labels in the United States means that retailers such as Wal-Mart[9] are becoming more responsible for a larger market share and now play a key role in the diffusion of standards aimed at certifying suppliers of products sold under their private label.

Several characteristics of the mentioned food safety standards deserve to be emphasized. The standards are collectively adopted by retailers for managing the relationships with the upstream suppliers. Although they were initially designed by a small group of retailers, they are all characterized by open access, and the aim is to include as many retailers as possible worldwide. With a larger proportion of the upstream market being certified, the possibility for retailers to obtain safe products increases and the competition between certified suppliers increases. Furthermore, these collective standards aim at imposing more stringent requirements than what is required by public regulations. In order to minimize the risks of delivering unsafe products in the final market, the standards are mainly related to the compliance of the equipment and the personal skills used in the manufacture, processing, transport, storage, and supply of raw materials and ingredients.[10] For instance, the premises, buildings, and equipment must be located, constructed, and designed to facilitate the proper manufacture, handling, storage, and delivery of safe food. New equipment and methods for sampling, inspecting, and analyzing raw materials and finished products must be installed and adopted. Personal training and new processing lines might be needed to avoid bacteriological or microbial contaminations. Finally, it is worthwhile to note that these standards are not meant to enhance the product or process characteristics communicated to consumers but to guarantee compliance with safety requirements imposed by public regulations and to avoid liability and negative demand effects in case a food crisis occurs. The motivation for implementing these standards is not to enable price differentiation but rather to protect retailer brands. As they are not communicated to the final consumer, retailers cannot obtain a higher price by implementing the standard. Hence, there are no price premiums and no added values based on consumer labels.[11]

9. See http://supermarketnews.com/news/walmart_pl_0108/.

10. See, for instance, BRC requirements: http://www.brcglobalstandards.com/standards/food/what-does-it-cover/.

11. Some private standards are aimed at differentiating and enhancing products in order to obtain a price premium in the final market. In general, they are individually

The features of these standards raise several important questions. Why do competitive retailers choose to cooperate in imposing more stringent requirements on suppliers? Under which conditions do retailers choose to implement the same food safety standard? How does the existence of such collective standards affect the market outcome? To what extent does it affect how safe the products of suppliers are, and how does it affect the risk of failure in the final market?

The aim of this paper is to present an analytical framework for addressing these issues and to discuss the potential consequences of retailers implementing such collective standards. We present an original model describing the vertical relationship between heterogeneous upstream producers and downstream retailers in which two intermediate markets with different standards may co-exist. In one of the intermediate markets, the safety standard corresponds to the Minimum Quality Standard (MQS) imposed by the public regulation. In the other intermediate market, upstream producers must comply with a more stringent private standard, henceforth, referred to as a Joint Private Standard (JPS), that is, collectively imposed by a subset of retailers. The JPS is defined as the minimum level of equipment (capital) of upstream producers that downstream retailers require. Due to the heterogeneity of suppliers, such a standard implies that some suppliers may have to invest (for instance, in production units, cooling facilities, management registration system, and tracking and tracing systems) in order to gain access to this intermediate market. A potential penalty cost related to a liability rule is also incorporated into the model.

Standards have been extensively studied in the literature. Besides the literature on MQS (see, e.g., Crampes and Hollander, 1995; Scarpa 1998; Garella and Petrakis, 2008), most of the existing economics literature on food safety is, however, of a descriptive and empirical nature. Examples of issues discussed in the literature include the reasons for adopting food safety standards (Jayasinghe-Mudalige and Henson, 2006; Henson and Hooker, 2001; Henson and Caswell, 1999), how standards affect the internal organization of firms (Holleran et al., 1999), the strategic behavior of firms and the organization of

implemented by large manufacturers and in some cases by retailers. Tesco's Nature's Choice or Carrefour Quality Chains are examples of such "standards for differentiation." In this case, the key points mentioned for justifying the price differentiation are related to taste, healthy eating, animal welfare, or environmental issues (Humphrey, 2008; Li and Hooker, 2009). On the contrary, collective standards implemented by retailers are focused on safety issues and not used by retailers to differentiate their products in the final market. Indeed, from a legal standpoint, it is not possible to claim that some products are safer than others, as (i) the probability of a food crisis can never be completely eliminated, (ii) claiming "safer" implies that other products are less safe, which naturally needs a credible reference and would mean that the public authorities failed to guarantee food safety for all consumers (see, e.g., Berdegué et al., 2005; Codron et al., 2005; Giraud-Héraud et al., 2006).

the supply chain (Hennessy et al., 2001; Charlier and Valceschini, 2008). While drawing on the literature on standards, which primarily focuses on firm-specific and public standards, in this paper we provide a theoretical framework that explains the emergence of the increasingly widespread collective standards.[12] An important feature of this paper is the vertical coordination between upstream and downstream firms.[13] In the literature, different aspects of such coordination have been discussed, for example, the reasons for it (Hobbs and Young, 2000) and the problems of asymmetric information between different stakeholders (Hennessy, 1996; Bogetoft and Olesen, 2003). As we focus on collective standards, the vertical coordination is realized through intermediate markets and third-party certification rather than individual contracts between upstream and downstream firms.[14] In addition to vertical coordination, this paper also takes into account the horizontal coordination characterizing the collective standards analyzed.

We analyze JPSs by using the theory of cartel stability, originally proposed by d'Aspremont et al. (1983). The cartel in d'Aspremont et al. corresponds in the present paper to the coalition of retailers requiring the JPS. Relating to the classical question of the existence of an integral cartel (i.e., when the cartel encompasses all firms), the links between a JPS and a MQS are examined. If the integral cartel is the only stable coalition within the industry, the JPS becomes the minimum standard required in the market and effectively replaces any regulated MQS. A potential effect of such a standard, as for any MQS, is that some upstream

12. Our paper also relates to the literature on Corporate Social Responsibility (CSR) in the sense given by Lyon and Maxwell (2008) in environmental economics. This literature studies the motivations for firms to engage in CSR and the welfare effects. It also studies the extent to which voluntary commitments can substitute for government mandates.

13. The analysis focuses on a "hybrid form" of vertical coordination that lies between the two polar cases, simple anonymous spot market transactions and internal organization of the supply chain (pure vertical integration). This "hybrid form" includes an implicit long term coordination in order to deal with problems that may arise when relying on repeated spot market transactions between upstream and downstream firms (see, e.g., Joskow, 2005). In our context we show that retailers may require suppliers of raw materials to provide goods adhering to a certain (non-firm specific) standard, involving additional food safety characteristics, in order to strengthen the long-term vertical coordination between the upstream and downstream levels of the supply chain. Note, however, that we do not examine the effect of "pure" vertical integration where upstream and downstream firms merge and we do not analyze the use of firm-specific standards (for a discussion on these cases, see, e.g., Giraud-Héraud et al., 2006).

14. Optimal contracting with asymmetric information has been analyzed in the theoretical principal-agent literature (Starbird 2005, Baiman et al., 2000; Chalfant et al., 2002). Some studies (see, e.g., Starbird and Amanor-Boadu, 2007) have shown how the incentives for suppliers to invest in food safety may depend on various characteristics of the inspection system and the different costs associated with failing to provide safe products.

producers may be excluded from the market if the cost of obtaining the minimum equipment required is too high. If, on the other hand, only a subset of the retailers requires a JPS, then no upstream producers will be excluded from the market. In fact, retailers that do not require the JPS will be able to free-ride on the efforts made by those that do require the standard.

We show that due to these free-riding effects, a JPS will only be established if there is a regulated rule of liability, such as a due diligence principle, related to the efforts made by the private firms. Consequently, even if consumers respond to a food crisis in such a way that demand drops drastically, this may not be sufficient to induce the industry to take preventive measures by implementing private standards that improve food safety. The reason for this is the free-riding effects that arise due to the difficulty of differentiating food with respect to safety characteristics in the communication to consumers. As in the classical lemons case (Akerlof, 1970) there is therefore a risk that high quality goods, that is, goods with a lower risk of causing a food crisis, are not being marketed. Hence, legislated liability rules may be necessary in order for a JPS to emerge.

Furthermore, we show that a more stringent JPS does not necessarily reduce the risk of a failure in the final market. The reason for this is that the risk of failure depends not only on the level of the JPS but also on the size of the coalition implementing the JPS that may be negatively correlated with the level of the standard. Finally, using simulations, we examine how the level of the JPS and the size of the penalty affect the outcome. If the penalty cost in case of market failure is sufficiently high, retailers maximize their profits by adopting a sufficiently low level of the JPS to achieve an integral, stable coalition.

The structure of the paper is as follows. In Section 2, we present the model. In Section 3, we present some general results, taking into account the endogenous risk and the evolution of the size of the coalition. In Section 4, we derive the size of the stable coalition and discuss how the stringency level of the JPS affects the size of the stable coalition and the risk of a failure in the final market. The main results are summarized and possible extensions are discussed in Section 5.

2. The Model

To provide the key properties of the model we first examine the case without a JPS. The basic features presented in this section are then used in the subsequent, more generalized model. Consider a vertical relationship, as shown in Figure 1, between J upstream producers, indexed by $j = 1, \ldots, J$, and R downstream retailers, indexed by $r = 1, \ldots, R$.

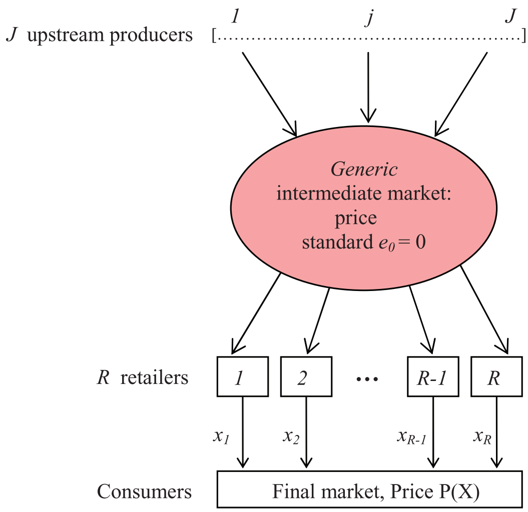

FIGURE 1. VERTICAL STRUCTURE WITHOUT A JPS

All upstream producers supply one unit of a good to an intermediate (spot) market at zero marginal cost.

A fixed-proportion technology between the upstream and the downstream level is assumed. Each downstream retailer r buys quantity x_r from the intermediate market, pays the intermediate price ω per unit of input and sells quantity x_r to the final consumers at price $P(X)$, where the total quantity supplied by all retailers is given by $X = \sum_{r=1}^{R} x_r$.

$$P(X) = a - bX = a - b\sum_{r=1}^{R} x_r \quad (a,\ b,\ >0). \tag{1}$$

The parameter a in the demand function is assumed to be sufficiently large to ensure nonnegative profits for retailers and upstream producers. By assumption, there is no product differentiation in the final market, and all retailers face the inverse demand function described by (1). However, there exists a potential safety problem in this market, that is, the supply chain may fail to provide final goods that are safe. If a food crisis occurs, it is assumed that demand ultimately drops to zero.[15]

The probability that a food crisis occurs is assumed to exclusively depend on the level of equipment (capital) of the upstream produc-

15. In the absence of product differentiation with respect to safety in the final market, a food crisis can affect an entire industry even if the source of the problem can be identified. As shown in a survey of European retailers conducted by Fulponi (2006), many firms do recognize that the failure of one firm to provide safe goods may affect other firms as consumer trust for retailers in general decreases in such situations.

ers. These upstream producers differ with respect to their level of equipment, which is represented by the one-dimensional parameter e, uniformly distributed over an interval [0, 1] (i.e., with a density function $f(e) \equiv 1$). In the case without a JPS, it is assumed that the minimum level of equipment required in the intermediate market (i.e., the MQS) is fixed at $e_0 = 0$. This ensures that all upstream producers are initially in the intermediate market (no exclusion) as long as the price ω is nonnegative.

The probability that an individual producer with equipment level e fails to provide safe goods is given by $\sigma(e)$, which is a decreasing function of e, such that $\sigma(0) = 1$ and $\sigma(1) = 0$. Because all upstream producers supply the same quantity, the risk of a failure in the final market, $\bar{\sigma}_0$, depends exclusively on the density function, $f(e)$, and on the probability of failure of each upstream producer, $\sigma(e)$. Hence, the market risk, that is, the average risk that the supply chain fails to provide safe products in the final market, is given by

$$\bar{\sigma}_0 = \int_0^1 \sigma(e) f(e)\, de. \tag{2}$$

As there is no product differentiation in the final market, the market risk affects all retailers and all upstream producers in the same manner.

Suppose now that retailers, at a small cost $\varepsilon > 0$, have the possibility to require that suppliers adopt a JPS, which is more stringent than the MQS. Let e_S ($e_0 = 0 < e_S \leq 1$) denote the level of equipment required by the JPS. If some but not all retailers require a JPS, there will be two intermediate markets: a "generic intermediate market," with standard e_0 and price ω_0, and a "certified intermediate market," with standard e_S and price ω_s. Such a situation, in which two intermediate markets co-exist, is illustrated in Figure 2. Each of the J upstream producers chooses to supply one of the two intermediate markets or to exit the market. In Figure 2, the generic intermediate market involves the $j = 1, \ldots, G$ upstream producers with the least equipment, and the certified intermediate market involves the $j = G + 1, \ldots, J$ producers. Each retailer chooses to buy from one of the two intermediate markets. N retailers buy from the generic intermediate market, and M retailers buy from the certified intermediate market (with $N + M = R$).

The difference between the standard e_S and the level of equipment e of a producer is given by $d(e, e_S) = e_S - e$. We define an "efficient producer" as an upstream producer that initially has a sufficient level of equipment to adopt the standard, that is, a producer with $e \geq e_S$. This efficient producer can enter the certified market at no cost, while an "inefficient producer," that is, a producer with equipment $e < e_S$, has

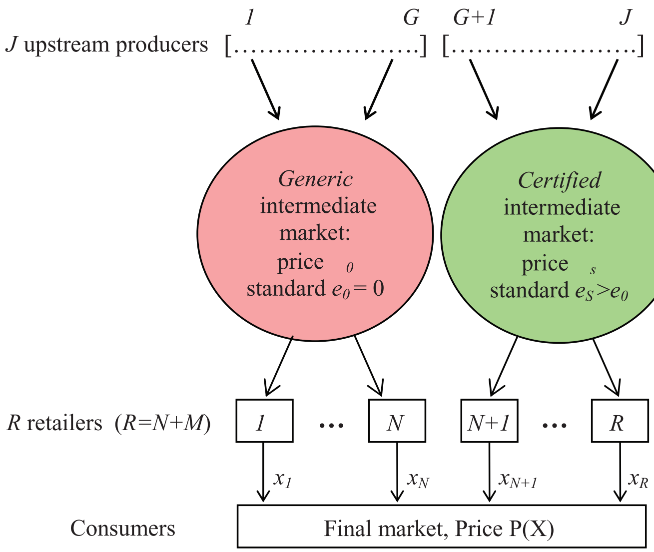

FIGURE 2. VERTICAL STRUCTURE WITH TWO CO-EXISTING INTERMEDIATE SPOT MARKETS

to invest $C(d(e, e_S))$ in order to enter the certified intermediate market. $C(.)$ is assumed to be a strictly increasing function of d if $d > 0$ (i.e., if $e < e_S$), and $C(d) = 0$ if $d \leq 0$ (i.e., if $e \geq e_S$).

Hence, all upstream producers can supply the generic intermediate market at no cost, and all producers with $e \geq e_S$ can enter the certified intermediate market at no cost, while all producers with $e < e_S$ incur a fixed cost to enter this market. Depending on the level of the prices in the two intermediate markets, there exists a threshold of equipment, $\hat{e}$, such that producers with $0 \leq e < \hat{e}$ will choose to supply the generic intermediate market, and producers with $\hat{e} \leq e \leq 1$ will choose to supply the certified intermediate market.[16] Note that if $M = 0$, no retailers require the JPS, all producers supply the generic market, and $\hat{e} = 1$. Inversely, if $M = R$, all retailers require the JPS. In this case, the threshold equipment $\hat{e}$ corresponds to a producer who is indifferent between supplying the certified intermediate market and exiting the market.

16. While the producers supplying the certified market have the option of supplying the generic market, they will have no incentive to do so, as the profit earned supplying the former will be at least as large as the profit earned supplying the latter. It is assumed that if a producer is indifferent between supplying either of the two intermediary markets, he will choose the certified market.

The existence of the certified intermediate market based on the JPS will change the market risk if at least one upstream producer invests in order to comply with the more stringent standard, $e_S > e_0$. Investments that are made will change the distribution of equipment and, hence, change the risk of failure in the final market. If investments are made, $\hat{e} < e_{S,}$ and the equipment of producers will be distributed on $[0, \hat{e}]$ and $[e_S, 1]$ with a Dirac mass at e_S (i.e., all producers initially located between $\hat{e}$ and e_S have the same level of equipment, e_S, after investing).

Market Risk

The probability that an individual retailer supplies a deficient product depends on the average risk in the intermediate market that the retailer buys from, which, in turn, depends on the level of equipment of all the producers supplying this market. The probability of supplying a deficient product if two intermediate markets co-exist, that is, if $0 < M < R$, is given by equations (3) and (4), where $\tilde{\sigma}_0$ defines this probability for retailers not requiring the JPS and $\tilde{\sigma}_S$ defines the probability for retailers requiring the JPS.

$$\tilde{\sigma}_0 = \frac{1}{\hat{e}} \int_0^{\hat{e}} \sigma(e) f(e)\, de. \tag{3}$$

$$\tilde{\sigma}_S = \frac{1}{(1-\hat{e})} \begin{cases} \displaystyle\int_{e_S}^{1} \sigma(e) f(e)\, de + (e_S - \hat{e})\sigma(e_s) & \text{if } \hat{e} < e_S \\ \displaystyle\int_{\hat{e}}^{1} \sigma(e) f(e)\, de & \text{if } \hat{e} \geq e_S \end{cases}. \tag{4}$$

If $M = 0$, then $\hat{e} = 1$, and only equation (3) is relevant. If $M = R$, only equation (4) is relevant. Note that if the two intermediate markets co-exist, the average risk in the generic market is greater than the risk in the certified market, that is, $\tilde{\sigma}_0 > \tilde{\sigma}_S$. Note, however, that the market risk affects all retailers in the same manner, as there is no product differentiation in the final market.

The market risk $\bar{\sigma}$, that is, the risk that a food crisis occurs in the final market, depends proportionally on the risk in the two intermediate markets and is given by

$$\bar{\sigma} = \hat{e}\,\tilde{\sigma}_0 + (1-\hat{e})\tilde{\sigma}_S. \tag{5}$$

It follows from equation (5) that the risk of failure in the final market is endogenously determined in the model. If $\hat{e} \geq e_S$, the market risk reduces to $\bar{\sigma}_0$, as defined by (2), because no upstream producer invests in additional equipment. However, if $\hat{e} < e_S$, then at least one producer invests in additional equipment and, hence, the market risk decreases. The change in risk is given by $\delta(\hat{e}) = (e_S - \hat{e})\sigma(e_S) - \int_{\hat{e}}^{e_S} \sigma(e) f(e)\, de$, which is a decreasing function of $\hat{e}$, that is, the market risk decreases as the number of certified producers, $(1-\hat{e})$, increases.

Liability Rule

As previously discussed, retailers have to pay a penalty cost in the event of a failure in the final market (according to a legislated rule of liability). The penalty cost is assumed to be a decreasing function of the minimum level of equipment required by the retailers. In the absence of a JPS, all retailers use inputs from the same generic intermediate market and, hence, face the same risk of having to pay a penalty cost, Γ_0. For retailers requiring suppliers to adopt the JPS, the cost of liability is reduced to $\Gamma(e_S)$, where $\Gamma(.)$ is a decreasing function of e_S, and $\Gamma(e_S = e_0) = \Gamma_0$. Note that the level of the standard is decisive for the magnitude of the penalty cost even though the level of equipment of individual producers may be higher. The market risk and the probability that a retailer fails to provide safe products do, however, depend on the level of equipment of the individual upstream producers.

Structure of the Game

As explained in the introduction of the paper, the JPSs that have emerged in the food industry in recent years have, to a large extent, been initiated by the retail industry. These standards are frequently imposed on upstream producers as a minimum requirement if they want to sell to the retailer. The upstream producers that do not adopt the standard are left with the option of either supplying retailers that do not require the standard or exiting the market. In order to capture this situation, the following sequence of events describes the game to be examined:

Stage 1: Retailers simultaneously choose whether or not to require the JPS from producers.
Stage 2: Upstream producers simultaneously choose whether to exit the market, to supply the generic market, or to supply the certified intermediate market.
Stage 3: Retailers play a simultaneous two-period Cournot subgame in the final market, taking into account that they are price-takers in the intermediate markets.

In the first stage of the game, retailers decide whether or not to require the JPS and, hence, whether to buy goods from the certified intermediate market or from the generic intermediate market. The model incorporates all possible solutions:

(i) $M = 0$, that is, no retailer requires the JPS,
(ii) $0 < M < R$, that is, some but not all retailers require the JPS, and
(iii) $M = R$, that is, all retailers require the JPS.

Figures 1 and 2 correspond to cases (i) and (ii), respectively. Case (i) corresponds to the case with a JPS equal to the legislated MQS, that is, $e_S = e_0 = 0$. Hence, the main focus in the subsequent analysis will be on (ii) and (iii). The latter of these corresponds to a situation in which the JPS becomes the minimum standard required in the market, a standard that is, more stringent than the legislated MQS, that is, $e_S > e_0$.

In the second stage of the game, each upstream producer decides whether or not to adopt the JPS, anticipating the price obtained in the intermediate market. The alternative to implementing the JPS is, in case *(ii)*, to supply the generic intermediate market, and in case *(iii)*, to exit the market. An upstream producer enters the certified intermediate market if and only if his expected profit is greater or equal to these alternative actions. Given the heterogeneity of equipment among producers, this game takes into account that at least some producers may have to decide whether or not to invest. At the end of stage 2, the number of upstream producers in each of the intermediate markets is known.

The third stage of the game corresponds to a classic repeated subgame with two periods (denoted by $t = 1$ and $t = 2$) without discounting. At each period t, the retailers simultaneously buy quantity x_r^t ($r = 1, \ldots, R$) on the chosen intermediate market, acting as price-takers in this market and facing the inverse demand function $P(X)$ described by (1). Retailers instantaneously market these quantities in the final market. However, if a food crisis occurs in the first period, then consumer demand in the subsequent period is assumed to drop to zero.

3. Resulting Equilibrium

The game described in the previous section is solved by backward induction. Throughout this section, the level of the standard, e_S, is treated as exogenous. The resulting equilibrium is general in the sense that it does not depend on specific functional forms of $\sigma(.)$, $C(.)$, and $\Gamma(.)$, although these functions have the properties previously discussed. In the following, subscript h is used to distinguish between the two intermediate markets, with $h = 0$ referring to the generic and $h = S$

referring to the certified market. It is assumed that of the $r = 1, \ldots, R$ retailers, $r = 1, \ldots, N$ retailers buy from the generic market ($h = 0$), and $r = N + 1, \ldots, R$ buy from the certified market ($h = s$).

3.1 Stage 3: Retailers Choose what Quantities to Supply

As consumers cannot distinguish between products originating from the different intermediate markets, the demand for all final products is given by equation (1). If the supply chain fails to provide safe goods in the final market, the demand in the subsequent period will be affected and by assumption drops to zero.[17] If there is no sanitary crisis during the first period, the quantity supplied by each upstream producer and marketed by each retailer will be the same in the two periods. Retailers maximize profits in each period t of the subgame ($t = 1, 2$).

The profit of retailer r requiring standard e_h, and buying x_r^t on the intermediate market h, at period t is given by,

$$\pi_r^t = \left(P(X^t) - \omega_h^t\right)x_r^t \tag{6}$$

where $X^t = \sum_{r=1}^{R} x_r^t$ and $P(X^t)$ denote, respectively, the total quantity marketed and the final price at period t, and ω_h^t denotes the price in intermediate market h at period t. Using the profits of the retailers, as stated in (6), the reaction functions of the retailers can be derived. Based on the symmetry of the model, all retailers requiring the same standard ($h = 0$ or $h = S$) market the same quantity. Consequently, superscript t and subscript r are for brevity henceforth dropped, and index h is used to distinguish between the types of retailers when necessary (profits and quantities).

At $t = 1$ (and at $t = 2$ if no sanitary crisis occurs during the first period), we show in the appendix that the quantity marketed by each retailer not requiring the standard, $x_0(\omega_0, \omega_S)$, and by each retailer requiring the standard, $x_S(\omega_0, \omega_S)$, are given by

$$\left|\begin{aligned} x_0(\omega_0, \omega_S) &= \frac{a - (M+1)\omega_0 + M\omega_S}{b(R+1)} \\ x_s(\omega_0, \omega_S) &= \frac{a + (R-M)\omega_0 - (R-M+1)\omega_S}{b(R+1)}. \end{aligned}\right. \tag{7}$$

If all retailers buy from the same intermediate market h (i.e., if $M = 0$ or $M = R$), then $x_h(\omega_0, \omega_S) = \frac{a-\omega_h}{b(R+1)}$.

17. Note that this assumption is equivalent to assuming that a retailer exits the market if it fails to provide safe goods in the final market, but retailers do not anticipate the potential reduction in the number of competitors in the second period.

All upstream producers supply the same quantity, and all retailers requiring the same standard demand the same quantity. Hence, the equilibrium prices in the intermediate markets are found by equating supply and demand in each of the intermediate markets, that is, by setting $(R - M)x_0 = J\hat{e}$ and $Mx_s = J(1 - \hat{e})$. Given these market-clearing conditions, the equilibrium intermediate prices are given by

$$\left| \begin{array}{l} \omega_0 = \text{Max}\left\{0, a - \dfrac{bJ\,(R - M + \hat{e})}{R - M}\right\} \\ \omega_S = \text{Max}\left\{0, a - \dfrac{bJ\,(M + 1 - \hat{e})}{M}\right\} \end{array} \right. . \tag{8}$$

If all retailers adopt the same intermediate market h, then $\omega_h = a - \frac{bJ\,(R+1)(1-\underline{e})}{R}$, with $\underline{e} = 0$ if $M = 0$ and $\underline{e} = \hat{e}$ if $M = R$. It can easily be verified that $\omega_S \geq \omega_0$ if and only if $\frac{M}{R} \geq (1 - \hat{e})$, that is, the proportion of retailers requiring the standard is at least as large as the proportion of the upstream producers not adopting the standard.

Substituting the equilibrium prices back into (7), the equilibrium quantities are obtained as functions of the endogenous variables M (the number of retailers requiring suppliers to adopt the JPS) and $\hat{e}$ (the initial level of equipment of the upstream producer indifferent between adopting and not adopting the JPS). If the two intermediate markets coexist (in which case ω_0 and ω_S are nonnegative), the quantities marketed by the retailers are given by

$$\left| \begin{array}{l} x_0 = \dfrac{J\hat{e}}{R - M} \\ x_S = \dfrac{J\,(1 - \hat{e})}{M} \end{array} \right. . \tag{9}$$

The main results of Section 4.1 are summarized in Proposition 1.

Proposition 1: *Let $\hat{e}$ denote the equipment of the upstream producer indifferent between supplying either of the two markets. In the case that two intermediate markets coexist, the intermediate prices are given by $\omega_0 = a - \frac{bJ\,(R-M+\hat{e})}{R-M}$ and $\omega_S = a - \frac{bJ\,(M+1-\hat{e})}{M}$, and the quantities marketed by the retailers are given by $x_0 = \frac{J\hat{e}}{R-M}$ and $x_S = \frac{J\,(1-\hat{e})}{M}$. If there is only one intermediate market h, then $\omega_h = a - \frac{bJ\,(R+1)(1-\underline{e})}{R}$ and $x_h = J\,(1 - \underline{e})/R$, where $\underline{e} = 0$ if $M = 0$ and $\underline{e} = \hat{e}$ if $M = R$. If no upstream producer exits the market, the total quantity in the market is $X = J$, and the price in the final market is $P(X) = a–bJ$.*

The long-run profits of the retailers (i.e., the profit over the two periods) can be stated as

$$\begin{aligned}\Pi_h &= \left[\pi_r^1 + (1-\bar{\sigma})\pi_r^2\right] - \tilde{\sigma}_h\Gamma(e_h) - \varepsilon_h \\ &= (2-\bar{\sigma})(P(X)-\omega_h)x_h - \tilde{\sigma}_h\Gamma(e_h) - \varepsilon_h. \end{aligned} \tag{10}$$

The first term of the profit corresponds to the expected revenues over the two periods. The second term corresponds to the expected penalty for a retailer buying from intermediate market h ($\tilde{\sigma}_h$ corresponds to the average risk in this market), and the third term defines the cost of requiring the standard e_h with $\varepsilon_S > \varepsilon_0 = 0$.

Substituting the intermediate prices and quantities given by (8) and (9) into (10), we obtain the long-run profits for the two types of retailers,

$$\left|\begin{aligned}\Pi_0 &= b(2-\bar{\sigma})\left(\frac{J\hat{e}}{R-M}\right)^2 - \tilde{\sigma}_0\Gamma(e_0) \\ \Pi_S &= b(2-\bar{\sigma})\left(\frac{J(1-\hat{e})}{M}\right)^2 - \tilde{\sigma}_S\Gamma(e_S) - \varepsilon_S\end{aligned}\right. \tag{11}$$

where $\bar{\sigma}$ is the market risk and, $\tilde{\sigma}_0$ and $\tilde{\sigma}_S$ are the average risks in the intermediate markets, as given by equations (3) and (4).

3.2 Stage 2: Upstream Producers Choose which Standard to Adopt

The profit of producer j, with equipment e and supplying intermediate market h, is given by

$$B_{j,h} = (2-\bar{\sigma})\omega_h - C(d(e,e_h)), \tag{12}$$

where ω_h is given by (8) and $\bar{\sigma}$ by (5). Upstream producers will exit the market only if staying in the market results in a negative payoff. As previously noted, it is assumed that demand in the absence of a JPS is sufficient to ensure positive prices. Consequently, upstream producers may be excluded only if the JPS becomes an MQS. Due to the heterogeneity of upstream producers, exclusion directly affects the probability of failure in the final market. The market risk is also affected if at least one producer that chooses to supply the certified intermediate market has to invest in order to do so. In the case of exclusion and/or investments at the upstream level, the distribution of equipment changes, the initial density shifts, and the probability of failure in the final market decreases.

In the second stage of the game, an equilibrium is defined by two thresholds, $\underline{e}$ and $\hat{e}$. Producers with equipment $e < \underline{e}$ exit the market, producers with equipment $\underline{e} \leq e < \hat{e}$ supply the generic market, and producers with equipment $\hat{e} \leq e \leq 1$ supply the certified intermediate market. Note that $\underline{e} = 0$ if $M \neq R$ and that no producer decides to enter the certified intermediate market if $\omega_S < \omega_0$. We then have the following proposition.

Proposition 2: *In the case that two intermediate markets coexist, there exists a unique equilibrium at stage 2 of the game in which $\omega_S \geq \omega_0$ and $1 - \frac{M}{R} \leq \hat{e} \leq 1$.*

It follows from Propositions 1 and 2 that $x_S \leq x_0$ and that there will never be an excess supply in the certified intermediate market as long as the price in this market is at least as large as the price in the generic intermediate market. Note that if the proportion of retailers requiring the standard is equal to the proportion of upstream producers adopting the standard, all retailers, whether they require the standard or not, will pay the same intermediate price and market the same quantity.

The level of equipment of the marginal upstream producer indifferent between the available alternatives is decisive for the outcome. Specifically, it is necessary to distinguish between the case in which the marginal producer invests in equipment and the case in which he does not. In the following, a "neutral equilibrium" refers to the case in which no upstream producer invests and a "nonneutral equilibrium" refers to the case in which at least one upstream producer invests. In the following, these alternative equilibriums are discussed in turn.

A "neutral equilibrium" implies that all producers that prefer to enter the certified market have sufficient equipment to satisfy the JPS required by (at least some) retailers, that is, $\hat{e} \geq e_S$. Hence, no upstream producer invests in additional equipment, and the probability of failure in the final market is not affected by a JPS.[18] In this kind of equilibrium, only some of the retailers require the standard (or $e_S = 0$ if all retailers require the standard). A producer decides to enter the certified market if the expected profit is at least as large that obtained when supplying the generic market. Equating the profits of the upstream producers in the two markets, as given by (12), it follows that a producer is indifferent between supplying either of the two intermediate markets if and only if there exists an intermediate price, ω, such that $\omega = \omega_0 = \omega_S$. Equating the intermediate prices as given by (8) and solving for $\hat{e} \geq e_S$, it follows that $\hat{e} = 1$–M/R. Consequently, the intermediate prices in a neutral equilibrium are $\omega = a - bJ(R+1)/R$, the quantity marketed by each retailer is $x_0 = x_S = J/R$, the market risk is $\bar{\sigma}_0$, the profit of the upstream

18. Hence, this type of equilibrium is analogous to what in environmental economics is referred to as "greenwashing."

producer is $B_{j,h} = (2 - \bar{\sigma})\omega = (2 - \bar{\sigma}_0)J/R$, and the profit of each retailer requiring standard h is $\Pi_h = b(2 - \bar{\sigma})(\frac{J}{R})^2 - \tilde{\sigma}_h \Gamma(e_h) - \varepsilon_h$. Although the intermediate prices are the same in the two intermediate markets, the profits of the two types of retailers differ because of differences in the small fixed cost, ε_h, in the magnitude of the penalty cost, $\Gamma(e_h)$, and in the risk of having to pay a penalty cost, $\tilde{\sigma}_h$.

In a *"nonneutral equilibrium,"* $\hat{e} < e_S$, and producers initially located between $\hat{e}$ and e_S invest in order to enter the certified market. The investments made by these producers change the distribution of equipment and, hence, change the risk of failure in the final market. As previously mentioned, the equipment of the producers in this case is distributed on $[0, \hat{e}]$ and $[e_S, 1]$ with a Dirac mass at e_S instead of being uniformly distributed on the interval [0,1].

There are potentially four types of upstream producers: *(i)* producers that exit the market, that is, producers with equipment $e < \underline{e} = \hat{e}$, which requires that $M = R$, *(ii)* producers that supply the generic market, that is, producers with equipment $\underline{e} = 0 \leq e < \hat{e}$,[19] which requires that $0 \leq M < R$, *(iii)* producers that enter the certified market and have to invest in order to do so, that is, producers with equipment $\underline{e} \leq \hat{e} \leq e < e_S$, and *(iv)* producers that enter the certified market and do not need to invest, that is, producers with equipment $e_S \leq e$. The profits of the upstream producers can be deduced from (12) given (8).

The initial level of equipment of the upstream producer indifferent between adopting and not adopting the JPS, $\hat{e}$, is found by equating the profits that can be obtained in each of the markets as given by (12) and substituting for prices, as given by (8), and market risk, as given by (5). In order to obtain the threshold value, however, it is necessary to specify specific functional forms of $C(d(e, e_s))$ and $\sigma(e)$. Once $\hat{e}$ is obtained, it can be substituted back to obtain the risks in each of the intermediate markets (equations 3–4), the market risk (eq. 5), the intermediate prices and quantities (equations 8–9), the profits of the upstream producers (eq. 12), and, once the functional form of $\Gamma(e_h)$ is specified, the profit of the retailers (eq. 11). Note that the threshold value will be a function of the number of retailers in each intermediate market and, hence, the retailers' choice of which standard to require is decisive for the resulting equilibrium outcome.[20]

19. With $\hat{e} = 1$ if $M = 0$.

20. In Section 5, an example assuming certain specific functional forms of C(.), σ(.), and Γ(.) is provided.

3.3 Stage 1: Retailers Choose Which Standard to Require

In the first stage of the game, retailers choose whether or not to join the coalition of retailers that require producers to adopt the JPS. Each of the R retailers decides whether or not to join the coalition by anticipating how their action affects the final outcome. All retailers have perfect information about the possible payoffs. Given the level of the standard, the Nash equilibrium is a vector of the strategic choice {*Enter, Not enter*} made by the R retailers. Henceforth, *coalition* is used to refer to the group of retailers requiring their suppliers to adopt the JPS, while *fringe* is used to refer to the group of retailers not requiring this standard.

As shown by d'Aspremont et al. (1983), a game with free and simultaneous entry into a coalition leads to a "stable cartel" if no agent in the cartel has an incentive to leave the coalition (internal stability) and if no agent outside the coalition has an incentive to join the coalition (external stability). Let $\Pi_S(M)$ denote the profit of a retailer inside a coalition of size M, and let $\Pi_0(M)$ denote the profit of a retailer outside the coalition. A stable coalition of size $0 < M^* < R$ exists if and only if $\Pi_S(M^*) \geq \Pi_0(M^*-1)$ (internal stability) and $\Pi_S(M^* + 1) \leq \Pi_0(M^*)$ (external stability). A stable, integral coalition (encompassing all firms), can exist if and only if $\Pi_S(R) \geq \Pi_0(R-1)$. Thus, the normative approach to the stability of cartels (definition of a stable cartel) is equivalent to the positive approach of endogenous formation of cartels (entry game into the cartel as described above).

The size of the stable cartel and the conditions for a stable, integral cartel to exist are fundamental issues analyzed in the theoretical literature on cartel stability. In our context, these issues are highly relevant, especially because an integral coalition corresponds to the formation of a private standard imposed on suppliers that may have the same effect as a public MQS. Furthermore, the size of the coalition directly affects the overall risk of failure in the final market as well as the intermediate prices if at least one upstream producer invests in order to adopt the JPS.

According to Proposition 2, $\omega_S \geq \omega_0$, and hence, $\hat{e} \geq 1 - \frac{M}{R}$ in an equilibrium where the two intermediate markets coexist. Investments are made if and only if $\hat{e} < e_S$, that is, if $M > \bar{M} \equiv R(1 - e_S)$. Consequently, if $M \leq \bar{M}$, the equilibrium in stage 2 of the game will correspond to a neutral equilibrium, where no producers invest, the intermediate prices are such that $\omega_0 = \omega_S = a - bJ(R+1)/R$ and the market risk $\bar{\sigma}$ is constant and equal to $\bar{\sigma}_0$, as defined by (2). If, on the other hand, $M > \bar{M}$, the equilibrium in stage 2 of the game will correspond to a nonneutral equilibrium. If an additional retailer decides to join the coalition and this implies that $M > \bar{M}$, then retailer profits in the coalition (fringe) will decrease (increase) because of a higher (lower) intermediate price and a smaller (larger) quantity marketed. Furthermore, all retailers will benefit from a reduced market risk, while the average risk in each of the intermediate markets will increase. The resulting alternative equilibria are summarized in the proposition below.

Proposition 3: *If $M \leq \bar{M} \equiv R(1 - e_S)$, the intermediate prices ($\omega_0 = \omega_S = a - bJ(R+1)/R$), retailer quantities ($x_0 = x_S = J/R$), and the market risk ($\bar{\sigma}_0$) do not change as the size of the coalition increases. If there is a penalty associated with failing to provide safe products in the final market, an increase in the coalition size will increase the average risk of facing a penalty, which will have a negative impact on retailer profits.*

If $M > \bar{M} \equiv R(1 - e_S)$, the intermediate price in the certified market will increase, while the quantity marketed by a retailer in the coalition will decrease; the intermediate price in the generic market will decrease, while the quantity marketed by a retailer in the coalition will decrease; and the market risk $\bar{\sigma}$ will decrease as the size of the coalition increases. If there is a penalty associated with failing to provide safe products in the final market, an increase in the coalition size will increase the average risk of facing a penalty, which will have a negative impact on retailer profits.

The proof of Proposition 3 is given in the Appendix. In order to illustrate how retailer profits are affected by an increase in the coalition size, M is in the following treated as continuous. Taking the derivative of the profits as given by equation (10) with respect to the coalition size, M, we obtain

$$\begin{aligned} \frac{\partial \Pi_h}{\partial M} &= -\frac{\partial \bar{\sigma}}{\partial M}[(P(X) - \omega_h)x_h] - \frac{\partial \omega_h}{\partial M}(2 - \bar{\sigma})x_h \\ &\quad + \frac{\partial x_h}{\partial M}(2 - \bar{\sigma})(P(X) - \omega_h) - \frac{\partial \tilde{\sigma}_h}{\partial M}\Gamma(e_h). \end{aligned} \tag{13}$$

In the following discussion, we refer to the four right-hand terms as the "market risk effect," the "intermediate price effect," the "quantity effect," and the "penalty effect."

As previously pointed out, the market risk is a decreasing function of $\hat{e}$, that is, the market risk decreases as the number of certified producers, $(1 - \hat{e})$, increases. The "market risk effect" is nonnegative and positive if at least one upstream producer invests, that is, if $M > \bar{M}$. Note that this effect is at least as large for retailers in the fringe as for retailers in the coalition (as $\omega_S > \omega_0$ and $x_S < x_0$ according to Proposition 2). Consequently, there is a free-riding effect with respect to the market risk unless $M \leq \bar{M}$, in which case the market risk does not change.

If $M > \bar{M}$, some upstream suppliers invest in order to enter the certified market. The investment these upstream producers have to make is increasing in M, which implies that ω_S is increasing in M. Thus, a retailer that can earn a larger profit by joining the coalition has to stimulate upstream producers to invest by paying a higher intermediate price in the *certified* market. On the contrary, the "intermediate price effect" is nonnegative for retailers in the fringe.[21] Consequently, there is a free-riding effect unless $M \leq \bar{M}$, in which case these prices are the same and do not change.

Retailers respond to a decrease (increase) in the intermediate price by marketing a larger (smaller) volume. The relationship between the "intermediate price effect" and the "quantity effect" is given by $\frac{\partial \omega_h}{\partial M} = -b\frac{\partial x_h}{\partial M}$. Hence, the "quantity effect" is nonnegative for retailers in the fringe and nonpositive for retailers in the coalition. Consequently, there is a free-riding effect with respect to the quantity marketed unless $M \leq \bar{M}$, in which case these quantities are the same and do not change.

The "penalty effect" corresponding to the fourth term of equation (13) is negative for the coalition as well as for the fringe. As M increases, additional upstream producers that previously supplied the generic market choose to supply the certified market. The producers that do so are the ones that have the best equipment (and, hence, if $M > \bar{M}$, they have to make the smallest investment in order to comply with the standard), that is, the producers with the lowest risk. This implies that as M increases, $\tilde{\sigma}_0$ increases (the generic market loses the producers with the lowest risk), as does $\tilde{\sigma}_S$ (additional producers invest no more than what is required to enter the certified market). In the event of a failure to provide safe food in the final market, the retailers in the coalition pay a smaller penalty than the retailers in the fringe.

The "market risk effect," the "intermediate price effect," and the "quantity effect" imply that whenever $M > \bar{M}$, retailers in the fringe benefit from the efforts made by the coalition in terms of (i) a lower risk of failure in the final market, (ii) a decrease in the intermediate price in the generic intermediate market, and (iii) an increase in the quantity supplied by each of the retailers not requiring the JPS. The profit of retailers in the fringe is only negatively affected by the "penalty effect." For retailers in the coalition, on the other hand, the "intermediate price effect" and the "quantity effect" are negative. As for retailers in the fringe, the "penalty effect" is negative and the "market risk effect" is

21. $\frac{\partial \omega_0}{\partial M} = \frac{-bJ}{(R-M)}\left[\frac{\partial \hat{e}}{\partial M} + \frac{\hat{e}}{(R-M)}\right] < (=)\ 0$ and $\frac{\partial \omega_S}{\partial M} = \frac{bJ}{M}[\frac{\partial \hat{e}}{\partial M} + \frac{(1-\hat{e})}{M}] > (=)\ 0$ if $e_S > \hat{e}$ ($e_S \leq \hat{e}$).

positive. The latter is, however, smaller than for the fringe. For $M < \bar{M}$, an increase in the coalition size only affects retailer profits through a negative "penalty effect." Consequently, in the absence of a penalty cost associated with failure to provide safe goods in the final market, retailers in the fringe always earn a larger profit than retailers in the coalition.[22]

4. Illustration of the Effects of a Joint Private Standard

In this section, we discuss the existence and effects of a stable coalition of retailers requiring the JPS (Nash equilibrium of stage 1 of the game) and how the level of the standard affects the size of a stable coalition. The resulting equilibrium depends on the functional forms of the probability that an upstream producer fails to provide safe goods, $\sigma(e)$, the investment cost of upstream producers, $C(d)$, and the penalty that retailers face in case of a failure to provide safe food, $\Gamma(e_S)$. Throughout this section, the following linear functional forms are assumed:

(A1) $\sigma(e) = 1 - e$

(A2) $C(d) = \mu\, d \qquad (\mu \geq 0)$

(A3) $\Gamma(e_s) = \gamma(1 - e_s) \qquad (\gamma \geq 0)$

These assumptions allow us, in a simple manner, to illustrate the effects of the JPS discussed in the previous section and explain the formation of a stable cartel. On the basis of these assumptions, we in Section 5.2 also discuss how the level of the JPS may change the equilibrium.

4.1 Existence and Effects of a Stable Coalition

The profits of the retailers in the fringe and in the coalition are presented in Figure 3 with and without a penalty cost. In order to simplify, M is in the figure presented as a continuous rather than as a discrete variable.

As discussed in Section 4.3, the profit of the retailers in the fringe is at least as large as the profit of retailers in the coalition in the absence of

22. For a non-negligible cost, $> \varepsilon$, $\Pi_0 > \Pi_S$ can be verified by noting that $\frac{\partial \omega_S}{\partial M} = \frac{\partial \omega_0}{\partial M} = \frac{\partial x_S}{\partial M} = \frac{\partial x_0}{\partial M} = \frac{\partial \bar{\sigma}}{\partial M} = 0$ if $e_S \leq \hat{e}$ and $\frac{\partial \omega_S}{\partial M} = \frac{-1}{b}\frac{\partial x_S}{\partial M} > \frac{\partial \omega_0}{\partial M} = \frac{-1}{b}\frac{\partial x_0}{\partial M}$ and $-\frac{\partial \bar{\sigma}}{\partial M}\Pi_0 > -\frac{\partial \bar{\sigma}}{\partial M}\Pi_S$ if $e_S > \hat{e}$.

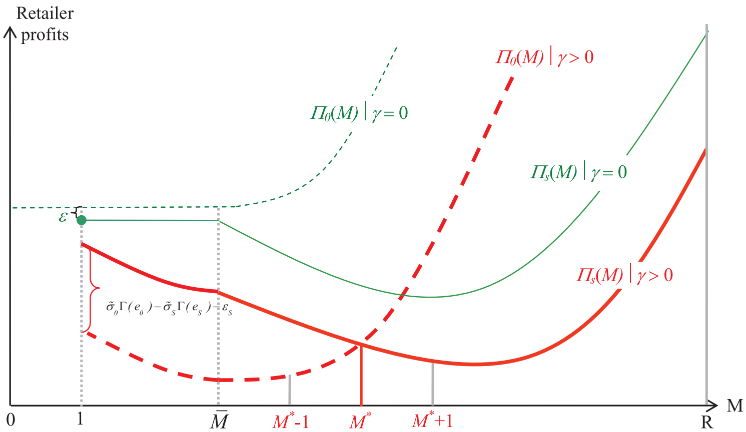

FIGURE 3. PROFIT OF RETAILERS AS A FUNCTION OF THE COALITION SIZE

a nonnegligible penalty cost. According to Proposition 3, for all $M \leq \bar{M}$, the intermediate prices are the same in the two intermediate markets, the retailers in the fringe and in the coalition market the same quantities, and the market risk is equal to $\bar{\sigma}_0$. Consequently, the profits of retailers in the fringe and retailers in the coalition only differ because of the fixed cost ε incurred by retailers requiring the JPS.

As the coalition size increases beyond $\bar{M}$, the profit of retailers in the fringe increases due to a lower market risk, a lower intermediate price, and a larger quantity (Proposition 3). The profit of the retailers in the coalition is negatively affected by an increase in the intermediate price and a decrease in the quantity marketed, while it is positively affected by a decrease in the market risk. Recall that the positive effect of the market risk is smaller for the coalition than for the fringe. Hence, a retailer in the fringe always earns a larger profit than a member of the coalition, even if the coalition size differs (for every M and M', $\Pi_0(M) \geq \Pi_S(M')$). Consequently, a stable coalition will not exist (for every M, $\Pi_0(M) \geq \Pi_S(M+1)$ and the coalition is not internally stable).

As shown in Figure 3, a penalty cost implies that all retailers earn lower profits. Naturally, the effect of a penalty cost is greater for the fringe than for the coalition. A larger penalty cost is associated with a larger difference between the profits of retailers in the coalition and retailers in the fringe when no investments are made, that is, for $M \leq \bar{M}$. In this case, the profits of a member of the coalition and a member of the fringe differ due to the difference in the size of the penalty in case of a failure and the difference in the average risk in the two intermediate markets. An increase in the coalition size beyond $\bar{M}$ increases the profits of retailers in the fringe. A reduced market risk, a lower intermediate price and a larger quantity supplied outweigh the negative effect of an increase in risk of failure in the generic market. While $M \leq \bar{M}$ implies that the prices in the two intermediate markets are the same, the intermediate price in the certified market will increase and the price in the generic market will decrease as M increases beyond $\bar{M}$. The increased relative price in the intermediate market induces additional upstream producers to invest in order to adhere to the JPS. It follows that if a penalty cost exists, then at least some upstream producers will invest, and the market risk will decrease.

For retailers in the coalition, an increase in M beyond $\bar{M}$ has a positive impact on profits through a decrease in the market risk, which, however, is smaller than for the fringe. Furthermore, an increase in M beyond $\bar{M}$ has a negative impact through a higher intermediate price, a smaller volume, and a larger penalty. The negative "penalty effect" is smaller than for the fringe. The negative effects dominate when the coalition size is small, while the positive effect dominates when the coalition size is larger. Hence, as M increases, the profit of retailers in the coalition initially decreases and then increases.

If there is a nonnegligible penalty cost associated with failure in the final market, retailers have an incentive to join the coalition, as they can earn a larger profit by reducing the penalty cost. In Figure 3, the size of the stable coalition is thus represented by M^* such that $\Pi_S(M^*) \geq \Pi_0(M^* - 1)$ and $\Pi_S(M^* + 1) \leq \Pi_0(M^*)$.[23]

Note that a drop in profits resulting from a food safety crisis is not sufficient to prompt retailers to require that producers adopt the JPS. The reasons for this are the free-riding effects, that is, (i) all retailers benefit from a reduced risk of failure in the final market, (ii) the intermediate price increases for the coalition, while it decreases for the fringe, and (iii) the quantity marketed by retailers in the coalition decreases, while the quantity marketed by retailers in the fringe increases. Public intervention via legislated costs of liability is thus necessary in order to penalize free-riders and encourage behavior that decreases the probability of failure in the final market.

23. Because profits are normally discrete and not continuous, the size of the stable coalition, M^*, may be close to the intersection of the profit of a member of the fringe and the profit of a member of the coalition. In Figure 3, we make the simplifying assumption that M^* corresponds exactly to where the two curves intersect.

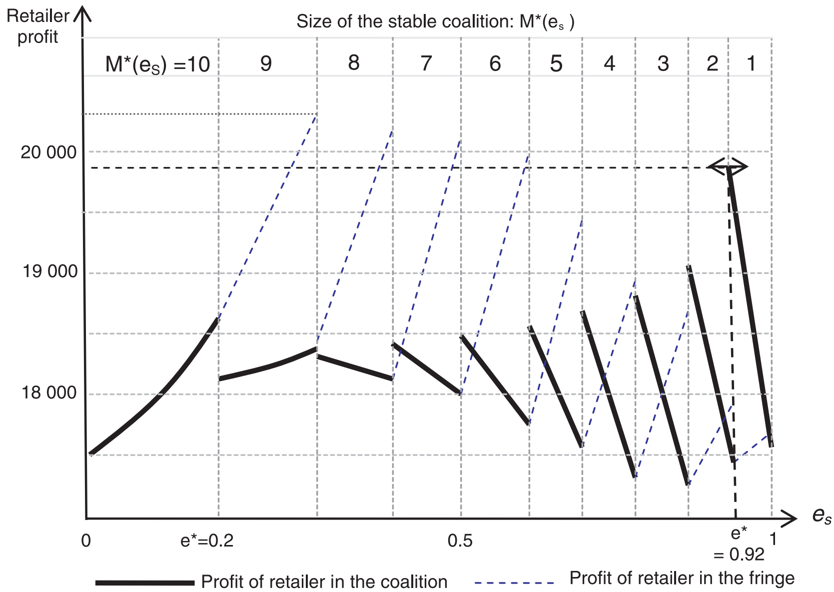

FIGURE 4. RETAILER PROFIT AND SIZE OF THE STABLE COALITION AS FUNCTIONS OF THE LEVEL OF THE STANDARD GIVEN A SMALL PENALTY ASSOCIATED WITH FAILURE IN THE FINAL MARKET (PARAMETER VALUES : $R = 10$; $J = 1000$; $a = 2000$; $b = 1.4$; $\mu = 240$; $\gamma = 7000$)

4.2 Effects of the Level of the JPS and the Size of the Penalty

For any given size of the coalition $M > \bar{M}$, an increase in the level of the standard implies that the profit of retailers in the coalition is positively affected by a lower penalty cost and a decrease in the market risk. The profits are, however, negatively affected by a higher intermediate price (and by a smaller marketed quantity), as the investment a producer has to make is increasing in e_S. Retailers in the fringe, on the other hand, experience only positive effects of an increase in the level of the standard. Specifically, a more stringent standard implies that the market risk decreases, the intermediate price decreases, and the quantity increases.

Consequently, the level of the JPS influences the equilibrium of the three-stage game presented in this paper. Taking into account the discrete nature of the endogenous size M^*, Figures 4–7 demonstrate how the profits of retailers and the market risk are affected by changes in the level of the JPS, given some specific parameter values. The difference

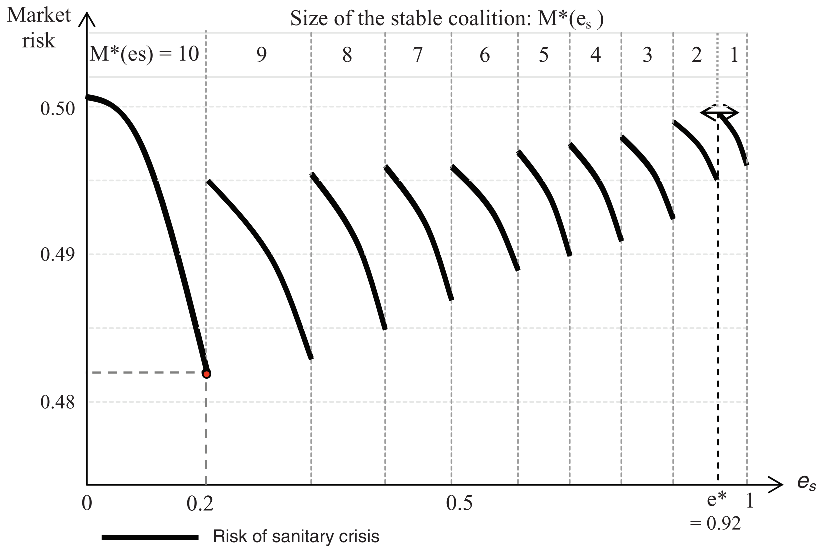

FIGURE 5. MARKET RISK AND SIZE OF THE STABLE COALITION AS FUNCTIONS OF THE LEVEL OF THE STANDARD GIVEN A SMALL PENALTY ASSOCIATED WITH FAILURE IN THE FINAL MARKET (PARAMETER VALUES : $R = 10$; $J = 1000$; $a = 2000$; $b = 1.4$; $\mu = 240$; $\gamma = 7000$)

between Figures 4–5 and Figures 6–7 is that the penalty cost is larger in the latter. It is clear from these figures that changes in the level of the standard can alter the size of the stable coalition and substantially affect retailer profits and the market risk. Specifically, when the standard increases beyond certain threshold values, the stable coalition consists of one less retailer, resulting in an upward shift of the market risk. If the standard increases further, the market risk gradually decreases until another threshold value evokes another upward shift. We then have the following result.

Due to the free-riding effect, the size of the stable coalition decreases as the level of the standard increases. Thus, a more stringent standard does not necessarily reduce the risk of failure in the final market.

A consequence of this result is that a JPS may be more successful at reducing the risk of failure in the final market by promoting a less restrictive standard that includes more retailers and producers, compared to a more restrictive standard. In Figure 4 we can see that with a low-penalty cost, the maximum profit of a retailer in the coalition is obtained when the standard is high enough ($e^* = 0.92$) to ensure that there is only one retailer in the coalition ($M^*(e_S) = 1$). As can be seen

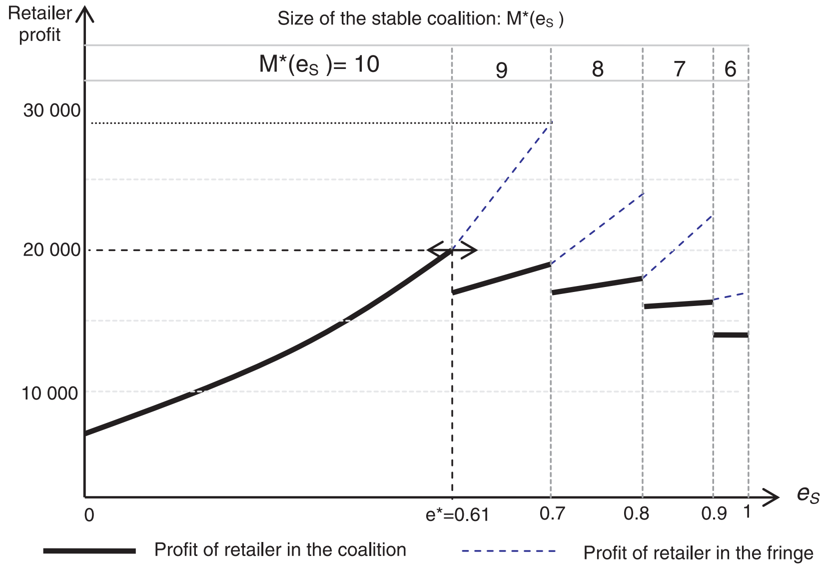

FIGURE 6. RETAILER PROFIT AND SIZE OF THE STABLE COALITION AS FUNCTIONS OF THE LEVEL OF THE STANDARD GIVEN A SMALL PENALTY ASSOCIATED WITH FAILURE IN THE FINAL MARKET (PARAMETER VALUES : $R = 10$; $J = 1000$; $a = 2000$; $b = 1.4$; $\mu = 240$; $\gamma = 28000$)

in Figure 5, the market risk in this case ($e^* = 0.92$) approaches the risk in the case when no retailer requires the standard (if $e^* = 0.92$ then $\bar{\sigma} \approx 0.5$).[24] Instead, the market risk is minimized at the highest standard that ensures that all retailers require the standard, corresponding to the case where $e^* = 0.2$. With a high-penalty cost, on the other hand, the maximum profit of retailers in the coalition coincides with the smallest market risk. As shown in Figure 6, the maximum profit of a retailer in the coalition is achieved with the highest standard that ensures that all retailers require the standard, corresponding to a lower level of the JPS ($e^* = 0.61$) than with a low-penalty cost, which leads to an integral coalition and corresponds to the lowest market risk, $\bar{\sigma} \approx 0.32$.

Considering that the JPS can be initiated by a subset of the retailers,[25] these retailers will choose a level of the standard that maximizes their own profits, anticipating the number of partners who would choose to join the coalition. In the case that the cost of failing to

24. $\bar{\sigma} = 0.5$ corresponds to the maximum level of the risk, that is, when there is no JPS set-up in the market ($M = 0$) or when the standard e_s equals the MQS.

25. That one or a few retailers decide the level of the standard is a realistic assumption. GlobalGAP, for example, was created on the initiative of some retailers in Northern Europe.

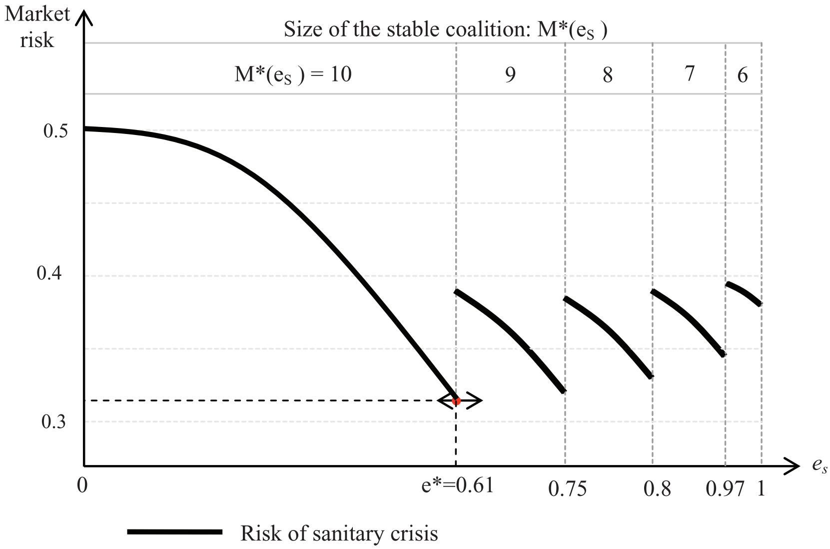

FIGURE 7. MARKET RISK AND SIZE OF THE STABLE COALITION AS FUNCTIONS OF THE LEVEL OF THE STANDARD GIVEN A HIGH PENALTY ASSOCIATED WITH FAILURE IN THE FINAL MARKET (PARAMETER VALUES : $R = 10$; $J = 1000$; $a = 2000$; $b = 1.4$; $\mu = 240$; $\gamma = 28000$)

produce safe goods in the final market is low, due to weak enforcement and/or low penalties, these retailers would be inclined to set a high level of the standard, which would not substantially reduce the market risk. Conversely, a higher penalty would encourage the initiators to set a lower level of the standard in order to encourage as many retailers as possible to join the coalition, thus reducing the market risk, which would be in the interest of consumers.[26]

5. Concluding Remarks

In this paper, we have examined the incentives for retailers to adopt a

26. Note, however, that while these results demonstrate that the magnitude of the penalty is negatively correlated with the market risk, they do not imply that an infinitely high-penalty cost is preferable (as this may result in negative profits and firms exiting the market, depending on the size of investment cost and demand). The optimal size of the penalty is outside the scope of this paper and would require a number of additional assumptions concerning, for example, the social costs and benefits related to the market risk. As opposed to the literature on optimal penalties (e.g., Saha and Poole, 2000), risk in this paper concerns the probability of a food crisis occurring (in which case there are no information asymmetries between firms and governmental agencies) and is not related to the probability of being monitored or of not adhering to legislation.

joint private safety standard. The model describes a vertical relationship between upstream producers and retailers, in which at least some retailers require their producers to adopt a more stringent safety standard than what is required by law. The theory of cartel stability was used to examine the effects of introducing a JPS.

The risk that the supply chain fails to provide safe goods in the final market is endogenously determined in the model. It is demonstrated that a private standard with open access may reduce the market risk and the penalty cost for retailers choosing to adopt a JPS. However, unless all retailers require the JPS, potentially substantial free-riding effects exist, as retailers not joining the coalition due to the problems of differentiating food with respect to safety characteristics may profit from a decreased market risk, lower intermediate price, and a larger marketed volume. At the same time, retailers joining the coalition face the potential negative effects of a higher intermediate price and smaller quantity, at least partially off-setting the benefits of a lower risk of failure and a lower penalty cost. Hence, it is demonstrated that even dramatic effects on consumer demand may not be sufficient to induce the industry to take preemptive measures by implementing private safety standards. Legislated penalty costs associated with a failure to provide safe food in the final market are therefore necessary in order for JPSs to emerge. Furthermore, it is demonstrated that a more stringent JPS does not necessarily reduce the probability that a food crisis occurs. The risk in the market is only affected if at least one upstream producer invests or exits the market. The conditions under which a JPS becomes a MQS, that is, the standard that all upstream producers have to adhere to, are examined. A potential effect of such a standard, as for any MQS, is that some upstream producers may be excluded from the market, a situation that will not occur if at least one retailer chooses not to require the JPS. Due to these free-riding effects, a JPS will only be established if there is a regulated rule of liability, such as a due diligence principle associated with the efforts made by the private firms.

Several interesting extensions of the presented model can be identified. From our point of view, the most important ones are the following. It would be interesting to more thoroughly examine how the level of the standard is decided. We have demonstrated that if the penalty is high enough, then the standard level chosen by the retailers of the coalition will be low enough to ensure the creation of the integral cartel. It is likely that once the integral cartel is reached, the market risk could be reduced by increasing the penalty cost. However, in this case, it is likely that the level of the JPS would increase, resulting in a progressive exclusion of producers, an increase in the final prices, and a reduced social welfare. How the level of the JPS is decided is hence an important issue that warrants further research.

Another issue that warrants further attention is the cost of upstream producers. The only cost considered in the present analysis is that of the fixed investments potentially required by producers that adopt the standard. It may be argued that a variable cost of adopting the JPS should be taken into account to more accurately resemble many real-world situations. Furthermore, the penalty cost in the present model only concerns retailers. In an extended model, it would be desirable to examine the effects if retailers can transfer parts of this cost to upstream producers. How such a transfer should be designed is not obvious, as retailers initially may want to encourage upstream producers to invest in the first place. Furthermore, it might be useful to consider more general (or different) functional forms of the cost structure, the penalty cost, and the probability that an upstream producer fails to provide safe goods. The assumption related to the risk of a food crisis is especially interesting. While we do not examine the case of nonlinearity, it seems intuitive to us that, for example, a quadratic function of the probability that an upstream producer fails to provide safe goods would not qualitatively alter the results as a larger probability that a food crisis occurs would only reduce the penalty cost required for a stable coalition to exist.

Appendix

Equilibrium of Stage 3

According to (6), the first-order condition for maximization of a retailer's profit z ($z = 1, \ldots, R$) is given by, $\frac{\partial \pi_z^t}{\partial x_z^t} = (P(X^t) - \omega_h^t) + \frac{\partial P(X^t)}{\partial x_z^t} x_z^t = 0$ with $P(X^t) = a - bX = a - b \sum_{r=1}^{R} x_r^t$. We then have, $\frac{\partial \pi_r^t}{\partial x_z^t} = a - 2bx_z^t - b \sum_{r \neq z} x_r^t - \omega_h^t = 0$. Knowing that each retailer adopts the same strategy at each period of the subgame ($t = 1$ and $t = 2$), and knowing that in one hand, each retailer within the fringe ($z = 1, \ldots, R - M$) markets the same quantity x_0, and in the other hand each retailer within the cartel ($z = R - M + 1, \ldots, R$) markets the same quantity with x_s, we obtain the following system,

$$\begin{cases} a - 2bx_0 - b\left[(R - M - 1)x_0 + Mx_s\right] = \omega_0 \\ a - 2bx_s - b\left[(R - M)x_0 + (M - 1)x_s\right] = \omega_s \end{cases}$$

Taking the difference between the two equations, we obtain $b(x_0 - x_s) = \omega_s - \omega_0$ and then equation (7).

Proof of Proposition 3. The first part of the proposition concerns the case when no investments are made, that is, when $M \leq \bar{M} \equiv R(1 - e_S)$. As no investments are made and no upstream producers are excluded, the market risk does not change. Equating the profits of the upstream producers in the two markets, as given by (12), it follows that there exists an intermediate price, ω, such that $\omega = \omega_0 = \omega_S$, which given (8) is the case when $\hat{e} = 1 - M/R$. Hence, the intermediate price is $\omega = a - bJ(R+1)/R$, the quantity marketed by each retailer is $x_0 = x_S = J/R$ and the market risk is given by $\bar{\sigma}_0$. As M increases, some upstream producers will switch from the generic to the certified market. The ones that do so are the best equipped of all producers in the generic market that are less equipped than the producers already supplying the certified market. Hence, the average risk in both the generic and the certified market increases as the coalition size increases.

The second part of the proposition concerns the case when investments are made, that is, when $M > \bar{M} \equiv R(1 - e_S)$. We start by showing that ω_S increasing in M. If M retailers join the coalition, the profit of the upstream producer indifferent between adopting and not adopting the *JPS* is, based on equation (12), given by

$$(2 - \bar{\sigma}(M))\omega_S(M) - C(d(\hat{e}(M), e_S)) = (2 - \bar{\sigma}(M))\omega_0(M). \quad \text{(A1)}$$

Similarly, the profit of the marginal producer if $M + 1$ retailers join the coalition is given by

$$(2 - \bar{\sigma}(M+1))\omega_S(M+1) - C(d(\hat{e}(M+1), e_S)) = (2 - \bar{\sigma}(M+1))\omega_0(M+1). \quad \text{(A2)}$$

In order for (A1) to be an equilibrium at stage 2 of the game, no producer supplying the generic market should have an incentive to supply the certified market at the current prices, that is, the RHS of (A1) should be at least as large as the LHS of A2 given the market prices $\omega_S(M)$ and $\omega_0(M)$. Consequently, we have

$$\begin{aligned}(2 - \bar{\sigma}(M))\omega_0(M) &= (2 - \bar{\sigma}(M))\omega_S(M) - C(d(\hat{e}(M), e_S)) \\ &\geq (2 - \bar{\sigma}(M+1))\omega_S(M) - C(d(\hat{e}(M+1), e_S)) \\ &\Rightarrow \Delta C \geq \Delta\bar{\sigma}\omega_S(M)\end{aligned} \quad \text{(A3)}$$

where $\Delta C \equiv C(d(\hat{e}(M+1), e_S)) - C(d(\hat{e}(M), e_S))$ and $\Delta\bar{\sigma} \equiv -(\bar{\sigma}(M+1) - \bar{\sigma}(M))$.

Assume that ω_S is nonincreasing in M. Given equation (8), $\omega_S(M) \geq \omega_S(M+1)$ implies that $(\hat{e}(M) - \hat{e}(M+1)) \geq (1 - \hat{e}(M))/M > 0$, which in turn implies that investments are made (because the LHS is positive). According to (A3) the additional cost of investment, ΔC, is at least as large as the benefit of a reduced market risk, $\Delta\bar{\sigma}$, given $\omega_S(M)$ and, if $\omega_S(M) \geq \omega_S(M+1)$, the same result hold for $\omega_S(M+1)$. However, in order to attract additional upstream producers to adopt the standard the benefits have to be larger than the costs. Consequently, ω_S increasing in M.

That ω_S is increasing in M implies that $(\hat{e}(M) - \hat{e}(M+1)) < (1 - \hat{e}(M))/M$ (condition C1). Now let us assume that ω_0 is nondecreasing in M. This implies that $(\hat{e}(M) - \hat{e}(M+1)) \geq \hat{e}(M)/(R - M)$ (condition C2). Combining condition C1 and C2, simplifying and rearranging, we have that $\hat{e}(M) < (R - M)/R$, which contradicts *Lemma 2*. Hence, we can conclude that as ω_S is increasing, ω_0 is decreasing in M.

That the quantity marketed by retailers in the coalition decreases as the coalition size increases can be shown by assuming the opposite, that is, $x_S(M) \geq x_S(M+1)$, which given (9) can only be the case if $(1 - \hat{e}(M))/M \geq \hat{e}(M) - \hat{e}(M+1)$. This, however, contradicts condition C1, that is, that $\omega_S(M) \geq \omega_S(M+1)$. Hence, we can conclude that as ω_S is increasing, x_S is decreasing in M. Similarly, it can be shown that as ω_0 is decreasing, x_0 is increasing in M.

The market risk is a decreasing function of the level of equipment. That $\hat{e}$ is nonincreasing in M thus ensures that the market risk is a nonincreasing function of M. If $\hat{e}$ was increasing in M, no additional investments would be made and the market risk would not change as an additional retailer required the standard. Hence, in order for an upstream producer to have an incentive to switch from the certified to the generic intermediate market as an additional retailer require the *JPS*, the intermediate price in the generic market with M+1 retailers has to be greater than the intermediate price in the certified market with M retailers. This can, however, not be that case as *Lemma* 2 and that ω_S is increasing and ω_0 is decreasing in M ensures that $\omega_S(M+1) > \omega_S(M) \geq \omega_0(M) > \omega_0(M+1)$. Hence, $\hat{e}$ is nonincreasing in M.

As M increases, some upstream producers will switch from the supplying the generic to supplying the certified market. The ones that do so are the ones that have to make the smallest investment. The generic market, thus, loses the producers supplying products with the lowest risk that results in the average risk in the generic market increases. The producers that switch to the certified market make the necessary investments (and no more) to enter this market and then have equipment e_S. These producers are now among the producers in the certified market with the lowest equipment and, thus, the highest risk. Consequently, the average risk in the certified market increases as the coalition size increases. □

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