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Vertical Relationships and Safety Standards in the Food Marketing Chain

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Abstract: In recent years it has become more common that downstream firms implement joint or collective private standards in order to improve the safety of final products. In this paper, we present a model of vertical relationships in which a group of downstream firms impose more stringent specifications on upstream suppliers. The probability of failing to provide safe goods is endogenously determined by the investments made by upstream producers. Furthermore, a penalty cost in the event of a crisis, due to a rule of liability, is modeled as a decreasing function of the level of the standard. The influence of the rule of liability on the adoption of the joint standard and the size of the stable coalition are examined. The conditions under which the probability of a failure to provide safe goods decrease are examined and discussed.

Keywords: PRIVATE STANDARDS, SAFETY STANDARDS, VERTICAL RELATIONSHIPS, LIABILITY

JEL CODES: L11, L14, L15, L22

1. Introduction

As a result of the food safety crises in the 1990s public authorities have implemented national and international regulations in an attempt to lower the risks related to e.g. microbial pathogens and residues of pesticides. Minimum quality standards (MQS) has been widely used for example in order to regulate the maximum values of residues in different products. Another policy tool has been to establish rules of liability widening the responsibility of food companies for deficiencies in the final products. In the U.K., the liability of retailers was extended through the Food Safety Act of 1990 which required that retailers could prove “due diligence” rather than rely on warranties from suppliers.[5] More recently, the European Union has implemented legislation that increased the liability of the food industry.[6] In the US the legal responsibility includes both the possibility of a private lawsuit by any injured consumers and the possibility of regulatory actions.[7]

As a result of the increased emphasis on liability, along with increased consumer concerns, food companies have implemented various voluntary schemes. Although such schemes have been implemented by firms at different levels of the chain it has been most prominent at retail level. Among the options available to firms two main strategies can be distinguished, “purely” private and collective standards. First, firms can implement firm-specific private standards that are defined, controlled and used by an individual retailer (see e.g. Berdegué et al. (2005), Codron et al. (2005), and Giraud-Héraud et al. (2006a)). However, different types of collective standards, i.e. private standards that are characterized by open access, have become more and more important. The ISO – system is one example of such a system that is used in many industries. In recent years several collective standards have been introduced by the food retailing industry, e.g. the BRC Global Standards, IFS (International Food Standard), and GLOBALGAP. In the following these standards are referred to as *Joint Private Standards* (JPS) to distinguish them from third-party standards such as the ISO-systems.

The necessity to thoroughly understand private standards characterized by open access is further emphasized by the fact that collective standards may replace

[5] See www.opsi.gov.uk/Acts/acts1990/plain/ukpga_19900016_en.
[6] Relevant EU-legislation includes Regulation 178/2002, the liability laws as laid down in Directives 1985/374/EEC & 1999/34/EC, and the product safety law Directive 2001/95/EC.
[7] See http://www.foodsafety.gov/~fsg/fssyst4.html.

governmental regulations. An all-inclusive private standard, such as ISO-systems and GLOBALGAP, may in effect become the minimum quality standard which is not the case with firm-specific private standards. Note, however, that all standards are commonly based on metasystems, i.e. general collective protocols concerning the process of achieving a certain quality. Examples of such standards that are embedded in various private and public standards are HACCP, good management practices and good agricultural practices (GAP). (Henson and Reardon, 2005; Caswell et al., 1998)

In order to understand the increased use of *JPS* and the effects of such standards it is essential to keep in mind some important features of the food sector. First, product differentiation with respect to food safety characteristics is not straight forward. Second, the specific vertical structure of the food marketing has to be taken into account.

While many quality characteristics can easily be used by retailers to differentiate their products in the final market this is not straight forward with safety characteristics. Experimental studies have shown that consumers perceive “safe” food to be a basic characteristic that they expect from all products and, hence, may not willing to pay a premium for (see e.g. Rozan *et al*, 2004). Even if less safe food may decrease consumers WTP this may not be sufficient to induce food companies to adopt more stringent food safety standards. Furthermore, it is from a legal stand point not possible to claim that some products are safe as the probability of a food crisis can never be completely eliminated and claiming safer implies that some products are less safe which naturally needs a credible reference. As a consequence, although some products signals safety through specific characteristics such as no pesticides (in for example organic production), products are not marketed as safe. In the absence of product differentiation with respect to safety, a food crisis can affect an entire industry even if the source of the problem can be located as the industry fails to provide what from a consumer point of view is a basic characteristic. As shown in a survey of European retailers conducted by Fulponi (2006), many firms do recognize that if one firm fails to provide safe goods this may affect other firms as consumer trust for retailers in general decreases in such situations. Hence, there is a potential free-riding problem for all voluntary safety standards.

Food crises often originate from early stages of the marketing chain and, hence, it is crucial for retailers to control the quality upstream. Assuring that private standards set down by retailers are met can be achieved by establishing relatively formalized contractual relationships between retailers and suppliers. How the vertical relationship between retailers and upstream producers are formulated is naturally affected by the concentration at retail level and the atomistic structure at primary level that signifies the food marketing chain. Joint private standards enables a group of retailers to obtain goods that fulfill a more stringent standard than what is produced in existing spot markets by creating new intermediary markets rather than using supply contracts and potentially costly firm-specific private schemes.

GLOBALGAP is one example of a JPS in the food retailing sector. This scheme specifies rules for good agricultural practices (GAP) and the aim is to establish one single standard "with different product applications capable of fitting to the whole of global agriculture".[8] In 2007 there were approximately 80000 certified producers in 80 countries.[9] Suppliers can be certified according to GLOBALGAP if they fulfill certain requirements primarily related to safety and environmental issues. The standard involves requirements concerning e.g. storage capacities and record keeping for product traceability. Hence, it requires suppliers to have a certain level of equipment. Consequently, farmers adopting such a standard may have to invest. How substantial investment that is required naturally depends on the previous management practices and the initial level of equipment. The risk that a food crisis occurs depends on the level of equipment at the upstream level. GLOBALGAP is a business-to-business standard. As it is not communicated towards the final market retailers cannot obtain a higher price by implementing the standard. Retailers do, however, have other incentives to require the standard from their suppliers.

The main reasons for retailers to adopt a JPS such as GLOBALGAP are i) to lower costs of certification, transactions etc, ii) to pre-empt legislation of a minimum quality standard, and iii) to avoid negative consequences of food crises. The focus of the analysis will be on the third reason mentioned, i.e. to avoid negative consequences of food crises. These negative consequences may be due to both market effects and effects related to legislated liability rules.

Despite an extensive literature pertaining to food safety no formal analysis has, to the best of our knowledge, been conducted concerning joint private standards

[8] See http://www.globalgap.org/cms/front_content.php?idcat=2.
[9] In 1997 retailers in the "Euro-Retailer Produce Working Group" initiatied EUREPGAP which included major European retailers such as Tesco, Sainsbury and Ahold. Since the launch EUREPGAP has spread over the world and changed name to GLOBALGAP. More extensive information can be found at www.globalgap.org.

implemented by downstream firms where the standard involves imposing more stringent requirements on upstream producers.[10] Given the increased use of JPS in and the specific characteristics of the food sector the objectives are to examine:

i) Under what conditions do retailers choose to adopt a joint private standard?

ii) What is the relative power of a joint private standard and how does it affect the risk, i.e. the probability that food crises occur?

iii) Under what conditions can a joint private standard become a MQS?

In order to address these issues we present a model describing the vertical relationship between upstream producers and downstream retailers in which two intermediary spot markets with different standards may potentially to co-exist. Upstream producers are required to have a minimum level of equipment in order to supply goods to the more stringent intermediary markets. The probability of failure in the final market is endogenously determined, and a potential penalty cost related to a rule of liability is incorporated into the model. As opposed to Giraud-Héraud et al (2006b) this paper presents a more realistic model which takes the dynamic effects on the final market into account, i.e. consumers respond to a failure to provide safe goods in the first period by reducing their demand in the subsequent period.

It is shown that even if consumers respond to a food crisis and this result in a dramatic drop in demand this may not be sufficient to induce the industry to take pre-emptive measures by implementing private standards that improves food safety. Hence, legislated liability rules may be necessary in order for to emerge. The reason for this is that free-riding effects are present due to the problems of differentiating food with respect to safety characteristics. Furthermore, we show 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 and this is the case only if these producers can cover their costs. A JPS may nonetheless exist due to the heterogeneity of upstream producers.

Finally, the conditions under which a JPS becomes the MQS, i.e. the standard all upstream producers have to adhere to, are examined. This corresponds to the classical question pertaining to the existence of the integral cartel (D'Aspremont *et al.*, 1983). A

[10] Important issues concerning food safety analyzed in the literature include consumer perceptions (Loureiro et al., 2001), how markets are affected by food safety crises (Salin and Hooker, 2001; Thomsen and McKenzie, 2001; Lloyd et al., 2001), and firm strategies related to food safety regulation (Antle, 1995; Elbasha and Riggs, 2003; Hennessy et al., 2001; Henson and Holt, 2000; Crespi and Marette, 2001; Fox and Hennessy, 1999; Starbird, 1997).

potential effect of such a standard, as for any MQS, is that some upstream producers may be excluded from the market if the cost of obtaining the minimum equipment required is too costly. If, on the other hand, only a part of the retailers require a joint private standard then no upstream producers will be excluded from the market. In fact, retailers and upstream producers not requiring/adopting the standard will be able to free–ride on the efforts made by those that do require/adopt the standard. Due to these free–riding effects, a joint private standard 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.

The structure of the paper is as follows. In the next section the model is presented. In section 3 the equilibrium of the strategic game is derived and analyzed. In section 4, the effects of the level of the standard are examined and, finally, the main results are summarized and possible extensions are discussed in section 5.

2. Model

A large number of upstream producers supply a good to a small number of downstream retailers who sell the good to consumers in a final market where there is no product differentiation. [11] By assumption there exists a potential safety problem in this market, i.e. the supply chain may fail to provide final goods that are safe. If a failure occurs this is assumed to originate from the farm level. In case of a failure to provide safe products, the future profits of all firms are negatively affected. Furthermore, retailers have to pay a penalty cost based on a rule of liability in the case of a failure to provide safe food to consumers. Suppliers can then be more or less penalized depending on what kind of precautions they have undertaken. As demonstrated below this encourages the industry to make the investments necessary to develop and implement joint private standards. In order to provide some basic properties of the model we first examine the case without any JPS. The basic features of this section are then used in the subsequent more generalized model.

Consider first a vertical relationship as shown in figure 1 between J upstream producers, indexed by $j = 1, \ldots, J$, and R downstream retailers, indexed by $r = 1, \ldots, R$. All upstream producers supply one unit of the good to an intermediary spot market at

[11] Given the empirical example of GLOBALGAP, which concerns "good agricultural practices", the upstream firms are in this article considered to be farms and the downstream firms are considered to be retailers.

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 spot market, pays ω_s per unit of input and sells quantity x_r to the final consumers at price $P(X)$ where $X = \sum_{r=1}^{R} x_r$ is the total quantity supplied by all retailers. By assumption there is no product differentiation in the final market and all retailers face the inverse demand function,

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

If a failure to provide safe products in the final market occurs, this is assumed to exclusively be due to an insufficient level of equipment at an upstream producer. The upstream producers differ with respect to their level of equipment (capital). How safe their products are depends on this level of equipment which is represented by the one-dimensional parameter $e \in [0, 1]$. The probability of failure of an individual producer is then given by $\sigma(e)$ which is a decreasing function of e.

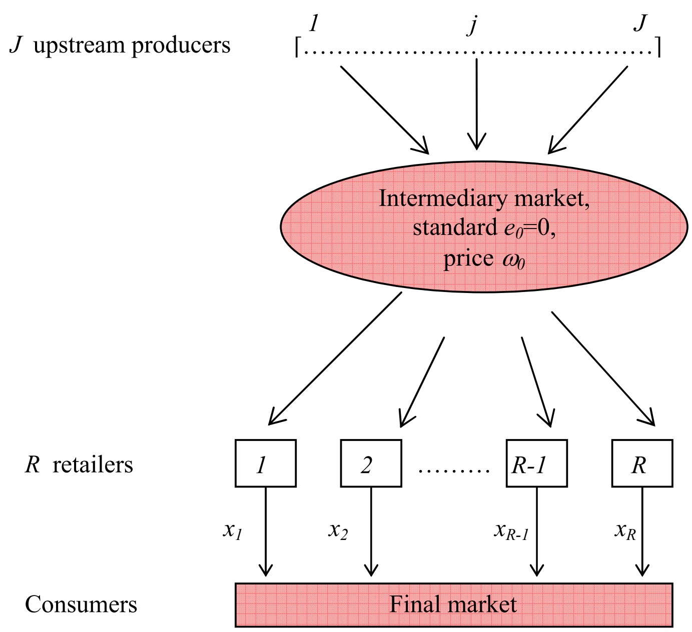

Figure 1. Vertical structure with one single standard.

Since all upstream producers supply the same quantity, the risk of a failure in the final market, $\bar{\sigma}$, depends exclusively on the density function $f(e)$, and on the probability of failure of each upstream producer, $\sigma(e)$. In the absence of a JPS all upstream producers supply one intermediary market and the standard on this market is the minimum level of equipment employed, i.e. $e_0 = 0$. Consequently, all upstream producers are initially in the market and the risk is given by,

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

Note that $\bar{\sigma}$ defines the market risk, i.e. the risk that the supply chain fails to provide safe products in the final market. There is no product differentiation in the final market so this market risk affects all retailers in the same manner. In the event of a failure in the final market retailers have to pay a penalty cost according to a legislated liability rule as discussed in the introduction. The penalty is a decreasing function of the minimum level of equipment employed by suppliers.

Suppose now that retailers have the possibility to adopt a more stringent joint private standard, $e_S > e_0$, than what is required by any existing legislated MQS, $e_0 \equiv 0$ at a negligible cost $\varepsilon > 0$.[12] The risk of failure is endogenously determined and a JPS changes the risk of failure in the final market if at least one upstream producer invests in additional equipment in order to comply with the higher standard. Consequently, retailers by adopting a JPS may reduce the cost of liability, $\Gamma(e_S)$, as well as the risk that a failure in the final market occurs. While the former is a firm-specific (private) benefit, all retailers benefit from a reduction in the market risk. As the market risk is negatively correlated with the proportion of retailers requiring a more stringent standards, a retailer that wants to reduce the market risk has an incentive to promote a JPS open to all retailers rather than a firm-specific private standard.[13] Note that the level of the standard, defined as the minimum level of equipment required of all upstream producers supplying the intermediary good, is decisive for the size of the potential penalty cost even if the level of equipment of individual producers may be higher. The risk that a failure in the final market occurs does, on the other hand, depend on the level of equipment of each individual upstream supplier.

Retailers buy inputs through the intermediary spot market. If some retailers require a JPS while others do not there will be two intermediary spot markets, a *stringent* spot market with $e_0 < e_s \leq 1$, and a *non-stringent* spot market with $e_0 = 0$. Such a situation where two intermediary markets co-exist is shown in Figure 2. A

[12] Introducing this negligible cost facilitates the subsequent analysis but does not change the main results.
[13] Other potential advantages of a joint private standard such as cost benefits are not considered in the model.

producer with equipment e has to invest $Max\{0, \mu(e_s - e)\}$ in order to enter the *stringent* intermediary market. Hence, all producers have access to the *non-stringent* spot market at no cost, all producers with $e \geq e_s$ can enter the *stringent* market at no cost while all producers with $e < e_s$ incurs a fixed cost to enter the *stringent* market. All the J upstream producers choose to supply one of the two intermediary markets.[14]

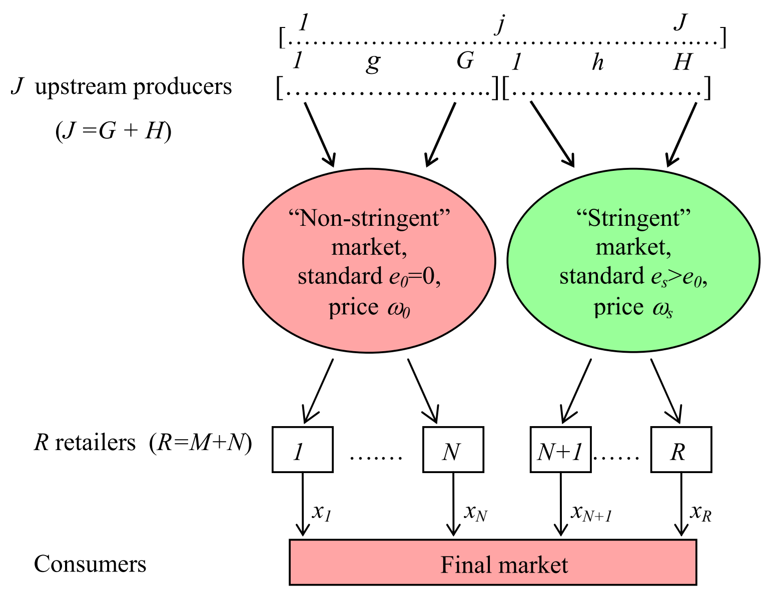

Figure 2. Vertical structure with two intermediary markets, standards e_0 and e_s

Formally, there are $R = N + M$ retailers of which N buys from the *non-stringent* spot market and M from the *stringent* spot market. There are $J = G + H$ upstream producers, G producers supply the *non-stringent* market and H producers supply the *stringent* market. The *non-stringent* market involves the first $j = 1,\ldots,G$ upstream producers and the first $r = 1,\ldots,N$ retailers. Consequently, the *stringent* market involves the $j = G+1, \ldots, J$ producers and the $r = N+1,\ldots, R$ retailers.

The model incorporates the three possible solutions, namely

i) *$M = 0$, i.e. no retailers demand a more stringent joint private standard.*

ii) *$0 < M < R$, i.e. some retailers require the standard while others do not.*

iii) *$M = R$, i.e. all retailers require the joint private standard.*

[14] In fact, while the producers supplying the *stringent* market have the option of supplying also the *non-stringent* market they will have no incentive in doing so as the profit supplying the *stringent* market will be at least as large as supplying the *non-stringent* market.

The first case is as shown in Figure 1 and the second in Figure 2. As subsequently demonstrated case $M = 0$ is equivalent to the case with a standard equal to the MQS, i.e. $e_s = e_0 = 0$. Hence, the main focus in the subsequent analysis will be on cases ii) and iii).

The joint private standards that have emerged in the food industry in recent years have been initiated by the retail industry. Upstream producers then have the choice to either adopt the JPS or to sell to the "non-stringent" market. Hence, the following sequence of events describes the game to be examined:

Stage 1*: Retailers simultaneously choose whether or not to require the JPS from suppliers.*

Stage 2*: Upstream producers simultaneously choose whether or not to adopt the JPS.*

Stage 3*: Retailers play a simultaneous two-period Cournot subgame in the final market taking into account that they are price takers in the intermediary market.*

The game is solved by backward induction. Who initiates the more stringent JPS is outside the scope of this paper. It suffices to say that prior to the game as outlined below the level of the joint standard e_s is determined by some initiator/s we do not need to identify at this point. Throughout this section, e_s is treated as exogenous and in section 4 we examine how the level of the *stringent* standard affects the results. In the first stage of the game retailers decide whether to require the JPS and, hence, buy intermediary goods from the "stringent" or the "non-stringent" intermediary market.

In the second stage of the game each upstream producer by anticipating the price obtained in the intermediary market decides whether or not to adopt the more stringent JPS. The alternative to implementing the JPS is in case (ii) to supply the "non-stringent" intermediary market and in case (iii) to exit the market. Given the heterogeneity of equipment among producers this game takes into account that at least some producers may have to make a decision of whether or not to invest. At the end of stage 2 the number of upstream producers in each of the intermediary markets is known.

In the final stage of the game retailers decide what quantity to market taking into account the probability of failure in the final market. Retailers maximize profits with respect to quantities taking into account that they are price-takers in the intermediary spot market and cannot discriminate among producers. As discussed in the introduction a failure will result in a decreased future demand. Hence, retailers maximize profits over two periods where a failure may occur during the first period thus affecting profits in the second period.[15]

3. Resulting equilibrium

In section 3.1 the Cournot-Nash equilibrium in the final stage of the game is derived. In section 3.2 the choice made by upstream producers concerning which intermediary market to supply is examined. In the subsequent section the retailer decision concerning whether or not to require the *stringent* JPS is analyzed.

3.1 Retailers choose what quantities to supply - The Cournot-Nash equilibrium

As consumers cannot distinguish between products originating from the *non-stringent* intermediary market and the *stringent* intermediary market the demand for the final product is given by equation (1).[16] Retailers maximize profits over two periods. If a failure occurs in the first period the profit is negatively affected in the subsequent period and by assumption drops to zero. Furthermore, retailers in the second period have to pay a penalty cost as previously discussed.

In the following subscript h is used to distinguish between the two intermediary markets with h = 0 referring to the *non-stringent* and $h = s$ referring to the *stringent* market. Let e_h denote the level of the standard and ω_h the intermediary price in each of the intermediary markets. The quantity demanded by retailer r in intermediary market h is denoted $x_{r,h}$. The profit of retailer r requiring standard e_h is given by,

$$\pi_{r,h} = (2-\bar{\sigma})(P(X)-\omega_h)x_{r,h} - \bar{\sigma}\,\Gamma(e_h) - \varepsilon_h \tag{3}$$

[15] Naturally, the effects on demand will depend on the type of failure, product, market etc. For example, food safety failures in the supply of green onions had a negative impact on demand for approximately 4 months before returning to previous levels according to a survey among US farmers while the impacts of the BSE crises have been considerably longer (USDA). For simplicity, only two periods are considered here and no discount factor is used. While simplified the present model set-up captures the key feature that a failure negatively affects future profits.

[16] The parameter a in the demand function is assumed to be sufficiently large for the upstream producers to cover any fixed cost required to enter the preferred intermediary market.

where ε_h denotes the cost required in order to enter intermediary market h with $\varepsilon_s > \varepsilon_0 = e_0 = 0$, $\Gamma(e_h)$ denotes the penalty cost in the case of failure and $\bar{\sigma}$ denotes the risk of failure in the final market which is fixed at this stage of the game.

Using the profits of the retailers as stated in (3) the reaction functions of the retailers can be derived noting that there are $r = 1, \ldots, N$ retailers in the *non-stringent* market and $r = 1, \ldots, M = N+1, \ldots, R$ retailers in the *stringent* market. In the following subscript r is dropped for brevity. Based on the symmetry of the model 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,

$$\left| \begin{array}{l} x_0(\omega_0, \omega_s) = \dfrac{a - (M+1)\omega_0 + M\omega_s}{b(R+1)} \\[2ex] x_s(\omega_0, \omega_s) = \dfrac{a + N\omega_0 - (N+1)\omega_s}{b(R+1)} \end{array} \right. \tag{4}$$

Hence, the intermediary prices are increasing in ω_s and decreasing ω_0.

Let $\hat{e}_S$ define the level of equipment of the producer indifferent between the *non-stringent* and the *stringent* market. Let $\hat{e}_0$ define the level of equipment of the producer indifferent between the *non-stringent* market and exiting the market. All upstream producers supply the same quantities and in each of the markets all retailers demand the same quantity. Hence, the equilibrium prices in the intermediary markets are found by equating supply and demand in each of the markets, i.e. by setting $Nx_0 = J(\hat{e}_S - \hat{e}_0)$ and $Mx_s = J(1 - \hat{e}_S)$. Given these market clearing condition the intermediary equilibrium prices are defined as

$$\left| \begin{array}{l} \omega_0 = a - \dfrac{bJ[N(1-\hat{e}_0) + (\hat{e}_S - \hat{e}_0)]}{N} \\[2ex] \omega_S = a - \dfrac{bJ[(M+1) - \hat{e}_S - M\hat{e}_0]}{M} \end{array} \right. \tag{5}$$

Note that if all retailers require the standard, i.e. $M = R$ corresponding to case (iii), then ω_0 does not exist and $\omega_S = [a - bJ((R+1)(1-\hat{e}_S)] / R$ as $\hat{e}_0 = \hat{e}_S$. If no retailer requires the standard, i.e. $M = 0$ corresponding to case (i), then ω_S does not exist and $\omega_0 = [a - bJ((R+1)] / R$ as $\hat{e}_0 = 0$ and $\hat{e}_S = 1$.

In order to take into account that the intermediary prices cannot be negative we in the following make use of the following thresholds,[17]

$$\omega_0 \geq 0 \quad iff \quad \hat{e}_0 \geq \overline{e}_0 \equiv \frac{(N+\hat{e}_S)}{(N+1)} - \frac{aN}{bJ(N+1)} \tag{6a}$$

$$\omega_S \geq 0 \quad iff \quad \hat{e}_S \geq \overline{e}_S \equiv 1 - \frac{aM}{bJ} + (1-\hat{e}_0)M \tag{6b}$$

It follows that if all retailers require the standard, i.e. $M = R$, then $\overline{e}_0 = \hat{e}_S$ and $\overline{e}_S = \left[R+1-aR/bJ\right]$. If no retailers require the standard $\overline{e}_0 = \left[1-aR/(bJ(R+1))\right]$ and $\overline{e}_S = 1$. Using these thresholds the intermediary prices can be stated as[18]

$$\omega_0 = \begin{cases} 0 & if \ \hat{e}_0 \leq \overline{e}_0 \\ a - \dfrac{bJ[N(1-\hat{e}_0)+(\hat{e}_S-\hat{e}_0)]}{N} & if \ \hat{e}_0 > \overline{e}_0 \end{cases} \tag{7a}$$

$$\omega_s = \begin{cases} \omega_0 & if \ \hat{e}_S \leq \overline{e}_S \\ a - \dfrac{bJ[(M+1)-\hat{e}_S - M\hat{e}_0]}{M} & if \ \hat{e}_S > \overline{e}_S \end{cases} \tag{7b}$$

Note that $\omega_S \geq \omega_0$ if and only if $\dfrac{(1-\hat{e}_S)}{(1-\hat{e}_0)} \leq \dfrac{M}{R}$, i.e. only if the proportion of retailers requiring the standard is at least as large as the proportion of the upstream producers adopting the standard.

Substituting the equilibrium prices back into (4) the equilibrium quantities are obtained as functions of the endogenous variables *M,* i.e. the retailers' choice of intermediary market, and $\hat{e}_s$, i.e. the equipment level of the upstream producer indifferent between the two markets.

$$\begin{aligned} x_0(\omega_0,\omega_s) &= \frac{a-(M+1)\omega_0 + M\omega_s}{b(R+1)} = \frac{J(\hat{e}_S - \hat{e}_0)}{(R-M)} \\ x_s(\omega_0,\omega_s) &= \frac{a+N\omega_0-(N+1)\omega_S}{b(R+1)} = \frac{J(1-\hat{e}_S)}{M} \end{aligned} \tag{8}$$

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[17] Note that $\omega_S = 0$ implies that $\hat{e} = \overline{e}_S$ and, hence $\omega_S \geq 0$ requires that $\hat{e} \geq \overline{e}_S$. Combining this condition with the condition that $\omega_0 \geq 0$ gives $\overline{e}_0$.

[18] In the case $0 < M < R$ combining (6a) and (6b) yields (7a).

It follows that if $M = 0$, then $x_0 = [J(1–\hat{e}_0)/R]$ and x_S is non-existing. If, on the other hand, $M = R$ then x_0 is non-existing and $x_S = [J(1–\hat{e}_S)/R]$. Note that the quantities marketed by the different types of retailers depend on the level of equipment of the marginal producer, $\hat{e}$, and the number of retailers in each market, M and N, respectively. If $\omega_0 \leq \omega_s$ it follows that $x_0 \geq x_s$, i.e. there will never be an excess supply of the more stringent standard in the intermediary market as long as the intermediary price in the *stringent* market is at least as large as the price in the *non-stringent* market.[19] 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 intermediary price and market the same quantity. Substituting the intermediary price and quantities given by (7)-(8) the equilibrium profits are obtained.

3.2. Upstream producers choose which standard to implement

In the second stage of the game, the upstream producers decide whether or not to supply the *stringent* intermediary market. The profit of producer j supplying intermediary goods with standard e_h, is given by,

$$B_{j,h} = (2-\bar{\sigma})\omega_h - Max\{0, \mu(e_h - e)\} \tag{9}$$

Upstream producers exit the market only if the payoff supplying the intermediary market with the lowest standard is smaller than exiting the market, i.e. if the intermediary price of goods with the lowest standard is negative. If $M \neq R$, i.e. not all retailers require a more stringent *JPS*, upstream producers can supply the *non-stringent* market without having to invest. The marginal producer indifferent between adopting – and potentially investing in – the level of equipment required to fulfill the JPS and not adopt is then found by solving (9) for the marginal producer. As previously noted, it is assumed that demand in the case without any JPS is sufficiently high to ensure positive prices given that $M = 0$.

Lemma 1*: If demand is sufficiently large to accommodate the supply of all upstream producers in the absence of a JPS, then*

i) there is no exclusion if some retailers require the standard while others do not,

ii) there may be exclusion if all retailers require the standard

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[19] If $x_s > x_0$ then $(1-\hat{e}_S)/(1-\hat{e}_0) > M/R$ which implies $\omega_S < \omega_0$.

Proof: It follows from (9) that the necessary condition for all upstream producers to stay in the market is given by $(2-\bar{\sigma})\omega_0 \geq 0$ for $0 \leq M < R$ and by $(2-\bar{\sigma})\omega_S \geq e_S$ for $M = R$. Hence, the intermediary price in the absence of a JPS is sufficient to avoid exclusion in the case of a partial cartel while an integral cartel requires a higher price.

It follows from Lemma 1 that upstream producers may be excluded only if the JPS becomes a minimum quality standard. Exclusion of upstream producers directly affects the probability of failure in the final market as producers with the least equipment, who would have to make the largest investment in order to adopt the JPS, exit the market. A JPS may, however, still reduce the risk of failure in the final market. The probability of failure is only affected if at least one producer with an insufficient level of equipment decides to sell to the *stringent* market. Consequently, the distribution of the upstream producers' equipment changes, the initial density shifts and the probability of failure in the final market decreases.

The level of equipment of the marginal upstream producer(s) indifferent between the alternatives is decisive for the outcome.[20] 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 analysis a "neutral equilibrium" refers to the case in which no upstream producer invests and a "non-neutral equilibrium" to the case in which at least one upstream producer invests. In the following these different equilibriums are discussed in turn.

A *"neutral equilibrium"* implies that all producers that prefer to enter the *stringent* market have a sufficiently high level of equipment to satisfy the JPS imposed by the retailers, i.e. $\hat{e} \geq e_s$. Hence, no upstream producer invests in additional equipment and the probability of failure is not affected by a JPS. This kind of equilibrium refers to a case where only some of the retailers require the standard (or $e_s = 0$ if all retailers require the standard). A producer decides to enter the *stringent* market if the expected profit is at least as large supplying the *non-stringent* market. Equating the profits of the upstream producers in the two markets, as given by (9), it follows that the marginal producer is indifferent between the two intermediary markets

[20] The level of equipment of the marginal upstream producer (MUP) of interest varies depending on the size of M. If M=0, the MUP indifferent between the *non-stringent* and exiting, $\hat{e}_0$, is relevant. If 0<M<R, the MUP indifferent between the *non-stringent* and exiting, $\hat{e}_0$, as well as the MUP indifferent between the *non-stringent* and the *stringent* market, $\hat{e}_s$, are relevant. If M=R, the MUP indifferent between the *non-stringent* and *stringent* market, $\hat{e}_s$, is relevant.

if and only if $\omega = \omega_0 = \omega_s$. Equating the intermediary prices as given by (5) and solving for $\hat{e}_S \geq e_s$ it follows that $\hat{e}_S = 1–M/R$. It follows that the intermediary prices in a neutral equilibrium are given by $\omega = a - bJ(R+1)/R$, the quantity marketed by each retailer is given by $x_0 = x_s = (a-\omega)/(b(R+1)) = J/R$ and the profit of each retailer adopting the standard *h* is given by,

$$\pi_h = \frac{3}{2}\left(\frac{bJ^2}{R^2}\right) - \frac{1}{2}\Gamma(e_h) - \varepsilon_h \tag{10}$$

Since the intermediary prices are the same in the two intermediary markets, the profits of the two types of retailers differ only because of the difference in the small fixed cost, ε_h, and in the penalty cost, $\Gamma(e_h)$. Note that the risk of failure does not depend on the number of retailers in the *stringent* market as no investments are made by the upstream producers.

In a "non-neutral equilibrium" producers initially located between $\hat{e}_S$ and e_S invest in order to enter the *stringent* market, i.e. $\hat{e}_S < e_S$. The investments made by these producers change the distribution of equipment and, hence, changes the risk of failure in the final market. Instead of being uniformly distributed on the interval [0, 1], the equipment level of the producers are now distributed on [0, $\hat{e}$] and [e_S, 1] and the density function shifts to $f'(e)$. For brevity these are given in the appendix. Consequently, the risk of failure in the final market is given by,

$$\bar{\sigma}' = \int_0^1 \sigma(e) f'(e) de = \frac{(1-\hat{e}_0)^2 - (e_S - \hat{e}_S)^2}{2} \tag{11}$$

The probability that an upstream producer fails to deliver safe products is given by $\sigma(e)$ which is a decreasing function of the level of equipment, *e*. In the following it is for simplicity assumed that $\sigma(e) = 1 - e$. It then follows that (11) reduces to 0.5 if $M = 0$, to [$0.5(1-(e_S - \hat{e}_S)^2)$] if $0 < M < R$, and to [$0.5(1-e_S)(1+e_S-2\hat{e}_S)$] if $M = R$.

There are potentially four types of upstream producers: *(i)* producers that exits the market, which requires that $M = R$ according to Lemma 1, *(ii)* producers that supply the *non-stringent* market, which requires that $0 < M < R$, (*iii)* producers that enter the *stringent* market and have to invest in order to do so, i.e. producers with equipment $\hat{e}_S \leq e < e_s$, and (*iv)* producers that enter the *stringent* market that do not need to invest, i.e.

producers with equipment $e \geq e_s$. The profits of the upstream producers are directly deduced from (9) given (11).

Equating the profits obtained by the marginal upstream producer in each of the markets as given by (9) and taking into account that this producer has to invest $\mu(e_S-\hat{e}_S)$ > 0 in order to enter the *stringent* market the following equation is obtained,

$$\mu(e_s-\hat{e}_s)-[2-\bar{\sigma}'](\omega_s-\omega_0)=0 \qquad (12)$$

Note that (12) requires that $\omega_s > \omega_0$. As previously emphasized a necessary condition for $\omega_s > \omega_0$ is that $M / R > (1-\hat{e}_s)/ (1-\hat{e}_0)$.

Substituting for the prices as given by (5) and solving for $\hat{e}_s$, the initial level of equipment of the marginal producer is obtained. The switching value, $\hat{e}_s$, is a function of the level of the JPS and the number of retailers in each market. Formally, the solution of (12) is quite complex and is given in the appendix. The profits of each retailer in the fringe, π_0, and each retailer in the coalition, π_s, are given by,

$$\left|\begin{array}{l}\pi_0=(2-\bar{\sigma}')\left(\dfrac{bJ^2(\hat{e}_S-\hat{e}_0)^2}{N^2}\right)-\bar{\sigma}'\Gamma(e_0)\\[2ex] \pi_s=(2-\bar{\sigma}')\left(\dfrac{bJ^2(1-\hat{e}_S)^2}{M^2}\right)-\bar{\sigma}'\,\Gamma(e_S)-\varepsilon_S\end{array}\right. \qquad (13)$$

3.3. 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 suppliers to adopt the *stringent* 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, the *coalition* is used to refer to the group of retailers requiring suppliers to fulfill the *stringent* JPS while the *fringe* is used to refer to the group of retailers not requiring this standard.

The size and the stability of the coalition are crucial for the profitability of retailers and their decision concerning which standard to require from suppliers. The coalition has to be stable in the sense that no agent in the coalition has an incentive to leave the coalition, "internal stability", and no agent outside the coalition has an incentive to join the coalition, "external stability" as shown by D'Aspremont *et al.* (1983). Let $\pi_s(M)$ denote the profit of a retailer inside the coalition of size M and let $\pi_0(M)$ denote the profit of a retailer outside the coalition. A stable coalition of size $0 < M^* \leq R$ exist if and only if $\pi_s(M^*) \geq \pi_0(M^*-1)$ and $\pi_s(M^*+1) \leq \pi_0(M^*)$.

The profits of the retailers, and thereby their decision of whether or not to join the coalition, are determined by the demand, the intermediary prices as determined by the equilibrium in the respective intermediary markets, and the penalty cost the retailer has to pay in the event of a crisis. Note that the overall risk of failure in the final market directly affects both demand and the probability of having to pay a penalty cost. The penalty cost *per se* does, however, depend on the minimum standard in the group the retailer belongs to (coalition or fringe).

The size of the coalition directly affects the overall risk of failure in the final market as well as the intermediary prices if at least one upstream producer invests in order to join the coalition. Unfortunately, it is not possible to solve for the optimal coalition size using (13). Instead we examine how the profits of retailers in the fringe and retailers in the coalition are affected by the size of the coalition. In order to do so take the derivative of the profits as given by equation (3) with respect to the coalition size, M, to obtain,

$$\frac{\partial \pi_h^r}{\partial M} = -\frac{\partial \bar{\sigma}'}{\partial M}[(P(X)-\omega_h)x_h^r + \Gamma(e_h)] - \frac{\partial \omega_h}{\partial M}(2-\bar{\sigma}')x_h^r + \frac{\partial x_h^r}{\partial M}(2-\bar{\sigma}')(P(X)-\omega_h) \qquad (14)$$

In the following we refer to the three right-hand terms as the "risk-effect", the "intermediary price effect" and the "quantity effect". As previously pointed out, an increase in the coalition size decreases the risk of failure in the final market, for retailers in the coalition as well as for retailers in the fringe, if at least one upstream producer invests.[21] Hence, the "risk-effect" is non-negative and positive if any upstream producer invests. Note that the "risk effect" consists of two parts, one related to the price-cost margin and the other related to the penalty cost. A free-riding effect is present in both these terms. However, while the positive effect of an increased coalition size with respect to the price-cost margin is at least as large for the retailers in the fringe as those in the coalition, the opposite is true for the penalty cost.

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[21] Specifically, $\partial \bar{\sigma}'/\partial M = 0$ if $e_s \leq \hat{e}$ and $\partial \bar{\sigma}'/\partial M < 0$ if $e_s > \hat{e}$.

"The intermediary price effect" is non-negative for retailers in the fringe. For retailers in the coalition this price effect is non-positive as long as it is profitable for one additional retailer to join the coalition. If no investments are made then $M \leq$ R$(1 - e_s)$ and the intermediary price in the *non-stringent* market equals the price in the *stringent* market. If, on the other hand, some upstream producers invest in order to enter the *stringent* market then $M >$ R$(1 - e_s)$. The investment the upstream producer has to make is increasing in M which implies that ω_0 is decreasing in M and that the difference in the intermediary prices, $(\omega_S - \omega_0)$, is increasing in M. If a retailer can earn a larger profit by joining the coalition the intermediary price in the *stringent* market is increasing in M stimulating more upstream producers to invest.[22] If investments are made, the risk of a failure in the final market decreases which affects the profits of all retailers positively. Hence, there is a free-riding problem as 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 and *ii)* a decrease in the intermediary price in the *non-stringent* market. Retailers respond to a decrease (increase) in the intermediary price by marketing a larger (smaller) volume. The relation between the "intermediary 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 positive for retailers in the fringe while it for retailers in the coalition is negative as long as it is profitable for one additional retailer to join the coalition.[23]

In figure 3, the profits of the retailers are shown with and without a penalty cost. In the absence of a penalty cost, the profit of the retailers in the fringe is at least as large as the profit of retailers in the coalition.[24] Hence, retailers have no incentive to invest in additional equipment and the coalition will not exist. In order to simplify, M is in Figure 3 presented as a continuous rather than a discrete variable.

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22 $\frac{\partial \omega_0}{\partial M} = \frac{-bJ}{(R-M)} \left[\frac{\partial \hat{e}_S}{\partial M} + \frac{\hat{e}_S}{(R-M)} \right] < (=) \, 0$ and $\frac{\partial x_0}{\partial M} = \frac{J}{(R-M)} \left[\frac{\partial \hat{e}_S}{\partial M} + \frac{\hat{e}_S}{(R-M)} \right] > (=) \, 0$ if $e_s > \hat{e}_s$ $(e_s \leq \hat{e}_s)$.

23 $\frac{\partial \omega_s}{\partial M} = -b \frac{\partial x_s}{\partial M}$ and $\frac{\partial x_s}{\partial M} = \frac{-J}{M} \left[\frac{\partial \hat{e}_S}{\partial M} + \frac{(1-\hat{e}_S)}{M} \right]$.

24 $\frac{\partial \omega_s}{\partial M} = \frac{\partial \omega_0}{\partial M} = \frac{\partial x_s}{\partial M} = \frac{\partial x_0}{\partial M} = \frac{\partial \bar{\sigma}'}{\partial M} = 0$ if $e_s \leq \hat{e}$ and $\frac{\partial \omega_s}{\partial M} = \frac{\partial x_s}{\partial M} > \frac{\partial \omega_0}{\partial M} = \frac{\partial x_0}{\partial M}$ and $\frac{\partial \bar{\sigma}'}{\partial M} = 0$ if $e_s > \hat{e}$

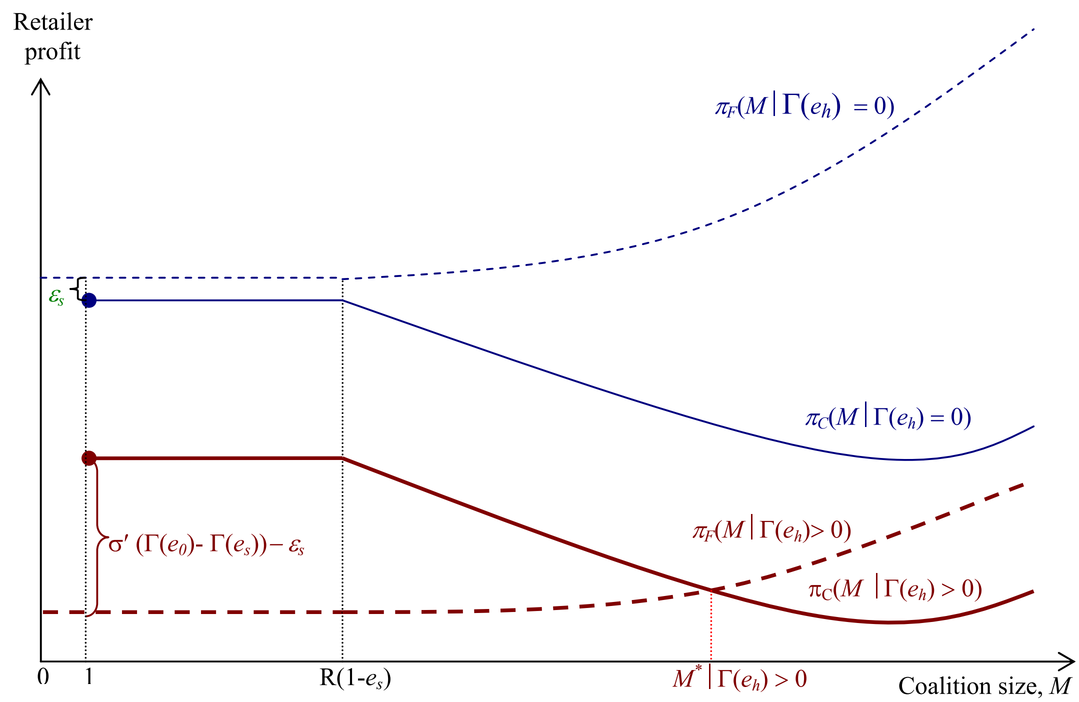

Figure 3. Profit of retailers as a function of the coalition size

Note that if retailers can require the standard without incurring any cost, some retailers can earn the same, but never a larger, profit by joining the coalition rather than be part of the fringe as shown in figure 3. Furthermore, $M \leq R(1{-}e_s)$ implies that the prices in the two intermediary markets are the same, and that the demand and the probability of failure in the final market do not change. As no upstream producer invests in additional equipment, a more stringent standard applied to part of the market does not affect the probability of failure in the market.

Proposition 1. *In the absence of a non-negligible penalty cost associated with failure to provide safe goods in the final market, then no investments are made, the probability of failure in the final market does not change, and the stable coalition will not exist but. Hence, M = 0 in a "neutral" equilibrium.*

Proof: See appendix.

In a "neutral equilibrium" no upstream producer invests in additional equipment. Hence, the prices are the same in the two intermediary markets and all retailers supply the same quantity. The intermediary prices and the quantities are in this case the same as in the case where no retailers require the *stringent* standard, i.e. $M = 0$.[25] The two types of retailers earn profits as given by equation (10). Hence, the coalition always earns a larger profit than the fringe and the fringe earns the same profit as in the case no retailer requires the standard.[26]

If there is a penalty cost for retailers associated with a failure in the final market then retailers have an incentive to require a *stringent* JPS as they can earn a larger profit by lowering the penalty cost without increasing production costs.

Proposition 2. *If there is a non-negligible penalty cost for retailers associated with failure in the final market then investments are made, the probability of failure in the final market decreases, and a stable coalition of size* $M^* > R(1-e_s) > 0$ exist.

Proof: See appendix.

In a "non-neutral equilibrium" an increase in the coalition size increases the profit of retailers in the fringe (as all terms in (*14*) are non-negative). For retailers in the coalition an increase in the coalition size has a positive impact on profits through a decrease in the risk, i.e. the "risk-effect" is positive, while it has a negative impact through a higher intermediary price as well as through a smaller volume. The negative effects dominate when the coalition size is small while the positive effect dominates when the coalition size is larger. Hence, the profit of retailers in the coalition initially decreases but eventually increases as *M* increases.

Proposition 3. *With a high enough penalty cost the integral cartel is a stable coalition and the JPS will become a MQS.*

The condition for when an integral cartel is stable is shown in the appendix. Intuitively, there exists a penalty cost high enough to ensure that the profit of retailers in the coalition is larger than the profit of the fringe regardless of the size of the coalition, i.e. $\pi_S > \pi_0 \ \forall \ M$.

The profit of retailers in the coalition is initially decreasing beyond the minimum coalition size $M = R(1-e_s)$ where investments are made as the "intermediary price

[25] Substituting $\omega = \omega_0 = \omega_s$ into (8) it follows that all upstream producers supply the same quantity, i.e. $x_0 = x_s$.

[26] The only difference is that in the latter, retailers incur the additional negligible cost $\varepsilon_h > 0$.

effect" and the "quantity effect" are negative. Eventually as M increases, the profit increases. The profit of retailers in the coalition will, however, always be larger than the profit in the absence of a JPS as the profit of retailers in the fringe, due to the free-riding effects, increases as the size of the coalition increases.

Corollary 1. *All retailers earn larger profits if a JPS exists then if it does not.*

As shown in Figure 3, a larger penalty cost implies lower profits for all retailers. Naturally, the effect of a penalty cost is greater for retailers in the fringe than for those in the coalition regardless the size of the coalition. The larger the penalty cost, the larger is the difference between the profits of retailers in the coalition and retailers in the fringe in the case no investments are made, i.e. for $M \leq R(1-e_s)$. Hence, a higher penalty cost provides retailers with a stronger incentive to join the coalition. The greater the penalty cost the greater is the size of the stable coalition, M^*, and the smaller is the risk of failure in the final market. As the size of the coalition increases, so do the investments made by upstream producers and consequently the risk of failure decreases.

Corollary 2. *For any given level of the standard, the risk of failure in the final market decreases as the size of the stable coalition increases.*

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

4. Effects of the level of the joint private standard

Although the level of the standard is exogenous to the game it naturally affects the equilibrium outcome. Hence, we in this section briefly discuss how the level of the standard affects the size of the stable coalition and the risk of a failure in the final market. As it is not possible to find the implicit function of the optimal coalition size we in the following resort to numerical simulations.

Proposition 4. *The stable coalition decreases as the level of the standard increases.*

For any given level of coalition size that requires that some upstream producers invests, 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 decreased risk of failure in the final market. The profits are, however, negatively affected by a higher intermediary price as producers with a level of equipment $e < e_s$ are required to invest more. Retailers in the fringe, on the other hand, experience only positive effects of an increase in the level of the standard. Specifically, a higher standard implies that the market risk decreases, the intermediary price decreases and the quantity increases. Due to the free-riding effects of the fringe, the optimal coalition size decreases as the level of the standard increases. In figure 4 the size of the stable coalition is depicted as a function of the level of the standard taking into account the discrete nature of M^*.

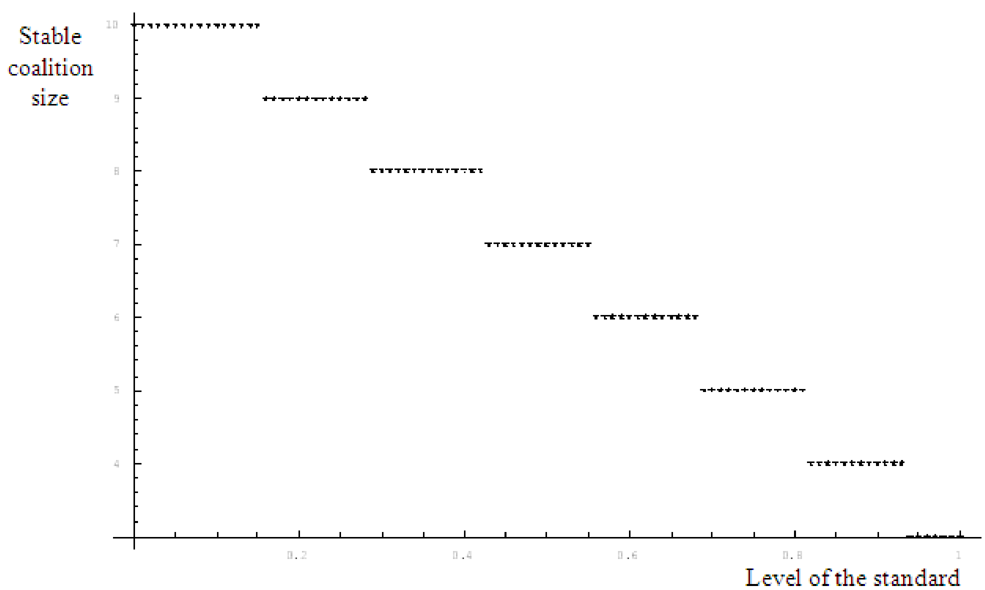

Figure 4. Size of stable coalition, M^*, as a function of the level of the standard, e_s.[27]

A consequence of proposition 4 is that a higher level of the joint private standard does not necessarily result in a decreased probability of failure in the final market. For

[27] The following parameter values were used: a = 2000, b = 1.4, J = 1000, R = 10, μ = 100; γ = 10000.

any given size of a coalition a more stringent standard implies a smaller risk of failure in the final market. However, as the optimal size of the coalition decreases with a higher standard, according to proposition 4, a higher level of the joint private standard does not necessarily result in a decreased probability of failure in the final market. A lower probability of failure in the final market can only be achieved if some upstream producers invest which would require a higher intermediary price in the *stringent* market, decreasing the price in the *non-stringent* market, thus potentially affecting the net profit of the coalition negatively and the profit of the fringe positively. Figure 5 shows the risk of failure in the final market, for the stable coalition sizes *M** (as shown in figure 4), as a function of the level of the standard.

Corollary 3. *A higher level of the standard does not necessarily reduce the risk of failure in the final market, even if* $\hat{e} < e_S$.

A consequence of Proposition 4 and Corollary 3 is that a joint private standard may be more successful in reducing the risk of failure in the final market by promoting a less restrictive standard which could include more retailers and producers than a more restrictive standard.

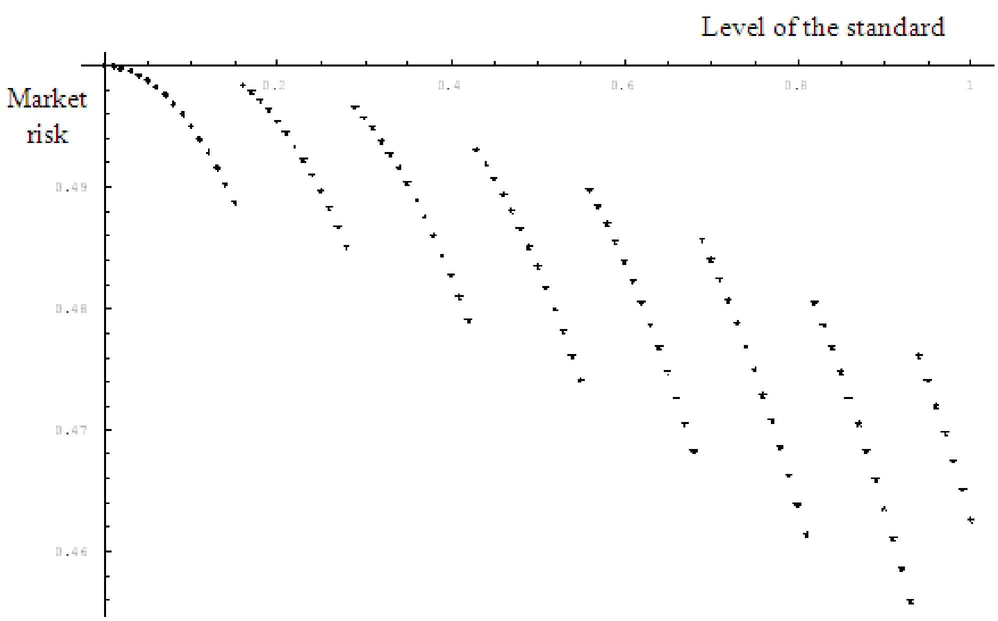

Figure 5. Probability of failure as a function of the level of the standard, e_S.[28]

[28] The following parameter values were used: a = 2000, b = 1.4, J = 1000, R = 10, μ = 100; γ = 10000.

5. Concluding remarks

In this paper we have examined the incentives for retailers to adopt a joint private safety standard. The model describes a vertical relationship between upstream producers and retailers in which at least some retailers require their suppliers to adopt a more stringent safety standard than what is required by law. The theory of cartel stability was used in order 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 shown that a private standard with open access may reduce the market risk as well as the penalty cost for retailers choosing to adopt a joint private standard. Unless all retailers require the *JPS* there are, however, potentially substantial free-riding effects as retailers not joining the coalition, due to the problems of differentiating food with respect to safety characteristics, may profit from a decreased probability of failure, lower intermediary price and a larger marketed volumes. At the same time retailers joining the coalition face the potential negative effects of a higher intermediary price and smaller quantity off-setting the benefits of a lower risk of failure and a lower penalty cost. Hence, it is shown that even dramatic effect on consumer demand is not sufficient to induce the industry to take pre-emptive measures by implementing private safety standards. Legislation with potential penalty costs associated with a failure is therefore necessary in order for JPS to emerge. Furthermore, it is shown 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, i.e. the standard 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 choose not to require the JPS. Due to these free–rider effects, a joint private standard 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. In this paper it has been assumed that a food safety crisis affects total demand, i.e. consumers do not distinguish between retailers buying from different intermediary markets. While this assumption may be relevant in some case, such as the BSE crisis, it may be less relevant in other cases where the cause of the failure can be more easily traced. Hence, it would be interesting to analyze the case of a joint private standard when consumers at least partially can discriminate between different retailers. Another issue that warrants further attention is the cost of upstream producers. The only cost considered in the present analysis is the fixed investments potentially required by producers that adopts 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 self-evident as retailers may want to encourage upstream producers to invest in the first place. Finally, it would be interesting to more thoroughly examine how the level of the standard is decided. A more stringent standard does not guarantee a decreased probability of failure in the final market. As this is the primary goal from the perspective of the policy maker, further research is needed concerning how to design the policy that best achieve such a goal.

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Appendix

Density functions when investments are made

$$f'(e)=\begin{cases} 1 & if \quad 0<e<\hat{e}_S \\ 0 & if \quad \hat{e}_S<e<e_S \\ e_S - \hat{e}_S & if \quad e=e_S \\ 1 & if \quad e_S<e\leq 1 \end{cases} \Bigg|_{0<M<R}$$

$$f'(e)=\begin{cases} 0 & if \quad 0<e<\hat{e}_S \\ 0 & if \quad \hat{e}_S<e<e_S \\ e_S - \hat{e}_S & if \quad e=e_S \\ 1 & if \quad e_S<e\leq 1 \end{cases} \Bigg|_{M=R}$$

Equilibrium with 0 < M < R

The equilibrium value of $\hat{e}$ is obtained by equalizing the expected profits of the upstream producer in the *non-stringent* and in the *stringent* market, i.e. $e_s-\hat{e}-[2-\bar{\sigma}(e_s)](\omega_s-\omega_0)=0$. Substituting for the prices as given by (5) and the risk as given by (11) the marginal upstream producer choosing to adopt the standard can be found using *Mathematica*,

$$\hat{e}=\frac{1}{3bJRC}\left(\left(bJ(N+2e_S R)+C\right)C+bJA\right)$$

where:

$$\begin{aligned} A &= bJ(N-e_S R)^2-3R(3bJR+2MN\mu); \\ B &= bJ(N-e_S R)^2+9R(3bJR-MN\mu) \\ C &= \left(b^2J^2(N-e_S R)B+\sqrt{b^3J^3(-A^3+bJ(N-e_S R)^2)B^2)}\right)^{1/3} \end{aligned}$$

Proof of Proposition 1

Assume a penalty cost decreasing in the level of the standard such that γ *(1-e_S)*. Equate the profits and solve for γ. If no investments are required for M = 1 then the stable coalition will not exist if $\gamma < \gamma_a \equiv \frac{bJ^2 (2-\bar{\sigma}|_{M=0})(1-(1-\hat{e}_S|_{M=1})R^2)}{R^2 \bar{\sigma}|_{M=0} \hat{e}_S|_{M=1}} - \varepsilon_S$. In order for the right-hand side to be positive $(1-(1-\hat{e}_S|_{M=1})R^2) > 0$ but we know that in the absence of investments $M = 1 \leq (1-e_S)R$ and as $(1-(1-e_S)R) \leq (1-(1-\hat{e}_S|_{M=1})R$ it follows that $\tilde{\gamma}_0 < 0$ and, hence, no stable coalition exists if $\gamma < \gamma_a$. If investments are required for M = 1, there will be no stable coalition if $\gamma < \gamma_b \equiv \frac{bJ^2 ((2-\bar{\sigma}_{0,M=0}) - (2-\bar{\sigma}_{S,M=1})(1-\hat{e}_{S,M=1})R^2)}{(\bar{\sigma}_{0,M=0} - (1-\hat{e}_{S,M=1})\bar{\sigma}_{S,M=1})R^2} - \varepsilon_S$. If investments are made it has to be $(1-(1-e_S)R) > (1-(1-\hat{e}_S|_{M=1})R$ and, hence, $\gamma_b < 0$ (as the denominator is negative) and no investments will be made.

Proof of Proposition 2:

As $\frac{\partial \pi_0^r}{\partial M} > 0$ and $\frac{\partial \pi_S^r}{\partial M}$ is first decreasing and then increasing it follows that either $\pi_S^r > \pi_0^r \ \forall\ M$ in which case a stable integral cartel will exist or there exist some 0 < *Z* < *R* for which $\pi_S^r > \pi_0^r \ \forall\ M < Z+1$ and $\pi_S^r < \pi_0^r$ for $M = Z+1$ in which case a stable partial coalition of size *Z e*xists.

Conditions for Proposition 3:

A stable integral coalition, $M^* = R$, exists if

$$\gamma|_{e_S} \geq \gamma_c|_{e_S} \equiv \frac{bJ^2 ((2-\bar{\sigma}|_{M=R-1})\hat{e}_S^2|_{M=R-1} R^2 - (2-\bar{\sigma}|_{M=R})(1-\hat{e}_S|_{M=R})^2)}{(\bar{\sigma}|_{M=R-1} - (1-e_S)\bar{\sigma}|_{M=R})R^2} - \varepsilon_S .$$

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Vertical Relationships and Safety Standards in the Food Marketing Chain

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Abstract: In recent years it has become more common that downstream firms implement joint or collective private standards in order to improve the safety of final products. In this paper, we present a model of vertical relationships in which a group of downstream firms impose more stringent specifications on upstream suppliers. The probability of failing to provide safe goods is endogenously determined by the investments made by upstream producers. Furthermore, a penalty cost in the event of a crisis, due to a rule of liability, is modeled as a decreasing function of the level of the standard. The influence of the rule of liability on the adoption of the joint standard and the size of the stable coalition are examined. The conditions under which the probability of a failure to provide safe goods decrease are examined and discussed.

Keywords: PRIVATE STANDARDS, SAFETY STANDARDS, VERTICAL RELATIONSHIPS, LIABILITY

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