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Explaining the Emergence of Private Standards in Food Supply Chains

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Abstract

This paper provides an original theoretical framework to better understand the raise of private standards in agrifood chains. Reasons for the emergence and conditions for the effectiveness of private standards are identified, by investigating retailers' strategic behaviour and, more precisely, both interactions among retailers and upstream producers and the role of consumer behaviour vis-à-vis the food safety risk. We show that a relatively strict Minimum Quality Standard (MQS) may incentive the retailer to develop an even more demanding private standard, when market-driven incentive is relatively high; this result crucially depends on consumer risk misperception. Setting a private standard may improve market access for upstream producers. In addition, it may reduce food safety risk and, at the same time, improve consumer surplus.

Keywords: Private standards, vertical relationships, risk misperception.

JEL codes: L1, L15, Q13, Q18

Introduction

Contemporary agrifood systems are increasingly pervaded by a plethora of private quality standards that have emerged in a context of increasing consumer concerns about the sustainability of food (including environmental and safety considerations, nutritional aspects, product authenticity, equity within the supply chain, etc.). The implementation of these standards has been especially prominent among large food retailers, food manufacturers and food service operators, reflecting both their considerable market power and competitive strategies based around 'own' or private brands that tie a retailer's reputation and performance to product's quality.

Here, the communication on product quality, which often bundles a variety of attributes, such as food safety, environmental, ethical or social aspects, may be more or less direct, and realized through sub-brands on retailer private label (identified by a specific logo or a symbol), e.g. Field-to-Fork (Marks and Spencer, UK), Nature's Choice/Nurture (Tesco, UK), "EQC-Engagement Qualité Carrefour" (Carrefour, France), "Gold Star" (BI-LO, US), "Sheffield & Sons" or "Nature's Place" chicken[1] (Delhaize Group-owned US grocer Bloom), or "Nature's Pride" (PM Beef Holdings LLC, US)[2], and, more in general, through *retailer claims* on the quality of own-brand products. Own-brand reputation *may* also rely on most often "invisible" standards such as the McDonald's Supplier Quality Management System (SQMS)[3] or Nestlé Quality System (NQS).

These private voluntary standards (in the terminology of Henson and Humphrey, 2010) often rely on direct relationships with upstream suppliers. Hence, vertical coordination is needed to build consumer confidence through consistency in standards implementation (Henson and Reardon, 2005); since these standards are individual in nature, vertical coordination is realized through more or less contractualized buyer-supplier relationships. In this framework, suppliers are required specifications that are often more restrictive than public regulations[4] and may require considerable investments to upgrade agricultural production practices[5] (e.g. handling and hygiene practices, equipment and buildings for chemical storage, hygiene and temperature controlled facilities, pesticide storage units, pesticides disposal pits, technical skills, etc.). The further the farm is from meeting the requirement, the more costly to upgrade (OECD, 2007)[6]. However, the issue is not the

[1] "Sheffield & Sons" offers only USDA Choice Angus beef that only comes from south-western Minnesota. Growers are committed to producing superior-quality beef following exacting production specifications. "Nature's Place" chicken has no additives, no enhancements and is antibiotic free; poultry is raised with no chemical medicines, no growth stimulants or hormones and receives an all-vegetable diet. Nature's Place chicken suppliers are industry leaders in the quality of their products and operations (Source: http://www.shopbloom.com/Explore/Meat).

[2] PM Beef Holdings is a leading processor and supplier of meat products to consumers, retailers, and foodservice operators. PM Beef quality management system either meets or exceeds regulatory standards for humane treatment of animals, quality and food safety (http://pmbeef.com/assets/HACCP-Letter-1QTR-2012.pdf).

[3] McDonald's SQMS includes food safety/quality system expectations for suppliers globally, e.g. an "Antibiotics Use Policy" (www.aboutmcdonalds.com).

[4] As highlighted by Henson and Humphrey (2010), private standards "go beyond" public regulations in two ways: either they take the form of more stringent standards, or they implement controls on issues that are not covered by public regulations.

[5] Hence, whilst public regulations most often concern *what* outcomes are to be achieved, private standards mainly focus on *how* such outcomes are to be achieved (Henson and Humphrey, 2010; Hammoudi et al. 2009) or how to operationalise process-based requirement. Hence, they may be considered as an 'input normalization' strategy.

[6] Several studies analyze the process of compliance with private standards (and the related costs) in an open Economy by focusing on the impact of GlobalGap on developing countries. Not only are individual private standards such as Tesco Nature's Choice (TNC) or Marks and Spencer Field to Fork more stringent, but there is

compliance cost itself, but rather the cost *in relation to* the profitability of the business that also depends on market opportunities. Hence, these strategies may also influence retailers' quantity/price decisions to adapt *in fine* to demand and competitive environment dynamics.

A wide literature aims at explaining the emergence of private standards in agrifood chains. First, private standards perform a function of "procurement regulation" in intermediary markets (Giraud-Héraud et al. 2012). Hence, procurement becomes progressively broader in geographical scope: concentration within food retailing is driving a shift towards buyer-driven supply chains that are extending beyond regional and national boundaries with the emergence of multinational retailers, food service operators and manufacturers. In this context, private standards allows to standardize over suppliers, and reduce procurement transaction costs, e.g. suppliers identification and approval audits, routine supplier site visits, routing end-product laboratory, chemical, biochemical or microbial testing, etc. (Holleran et al. 1999); for example, third party certification transfers auditing costs from retailers onto suppliers, while enhancing the credibility of production practices (Hatanaka, 2005; Henson and Northen, 1998).

Second, private standards provide additional security for firms against the risk of food safety failures and the consequent strategic costs (e.g. loss of market share, loss of market revenue, erosion of brand capital, etc.) and operational costs (e.g. product recall, customer complaints, and penalties from enforcement authorities, these latter depending on the extent of liability rules[7]). Private standards thus afford "domain defense" (Caswell and Johnson, 1991) thus protecting market share and reputation (Fulponi, 2006).

Third, private standards allow firms to take advantage of market opportunities through product differentiation ("domain offence"). Trends in consumer demand have put greater focus on product quality. Food scares in a number of industrialised countries have raised consumer concerns about the safety of food and eroded confidence in prevailing mechanisms of food safety control; at the same time, consumers have increasingly focused on a broader array of food attributes when assessing product quality, many of which are experience or credence ones. In this context, the possibility to capture a premium price based on consumers' willingness to pay (WTP) for quality improvements may drive retailers to move beyond public regulations towards adopting more demanding private standards (Garella and Petrakis, 2008; Giraud-Héraud et al., 2006)[8].

Given these premises, it is an accepted idea that retailers will arguably have the greatest incentive to implement private standards when there are *missing or inadequate* public institutions (Henson and Reardon, 2005). When the MQS do not preexist, private standards allow to replace "missing" institutions, and protect the reputation of retailers (Reardon and

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a significant overlap between these standards and GlobalGap, so much that third party audits of suppliers are often undertaken simultaneously. These studies show that compliance costs may be appreciable (Graffham et al. 2007) and highlight the role of *non-recurring costs* associated with buildings and facilities that farmers must establish as a precondition to implement the standard (Asfaw et al. 2008). While one-time investments represent "entry costs" for producers, the issue of *recurring costs* (such as recurrent audit and certification, record keeping on chemical use, protecting clothing, variable inputs such are safer pesticides, training, soil analysis, etc) is at the heart of the issue of the *long-term viability* of the compliance system (PIP, 2009).

[7] Private standards perform a "liability function" in the sense they provide additional security *vis-à-vis* the threat of civil legal actions against a firm producing unsafe food (and the resulting financial damages) (Hobbs, 2004). Liability rules are thus crucial for private standards to emerge (Giraud-Héraud et al. 2012). For example, the 1990 Food Safety Act (FSA) in the UK has significantly affected quality management practices within the food sector. The FSA requires retailers to be proactive regarding the safety of food in their possession, assigning retailers responsibility for both the safety of the supplies retailers procure as well as the food they handle. The increased buyer/seller interaction forced retailers to closely monitor suppliers because retailers needed to verify and monitor the safety of supplier production processes, in addition to their own internal processes.

[8]Moreover, private standards on own-branded products increase retailers' differentiation in the product range (increasing variety proposed to consumers) and consequently lessen retailing competition.

Farina, 2002), or to pre-empt future regulations (Lutz et al., 2000; Segerson, 1999). In addition, MQS may be "inadequate" in the sense that they do not provide sufficient scope for a quality-based product differentiation and to reward firms for investments in quality management systems (Reardon et al. 2001); here, private standards allow retailers to differentiate on a quality basis and gain market share[9].

Nevertheless, a direct relationship between the laxity of public regulation and the raise of private standards is not necessarily confirmed by facts. Even if some private initiatives had preceded the establishment of a regulatory framework, e.g. under the pressure of increasing liability rules at national level, it appears that the landscape of private standard is highly dynamic and continuously evolves towards more restrictive requirements despite the progressive strengthening of market access conditions set by public authorities. In this paper, we investigate the mechanisms driving the emergence of private standards by developing an original model of Industrial Organization and we show that even when the minimum quality standard (MQS) is relatively high, firms may have incentive to move beyond it. Namely, the decision to set a private standard is shown to depend on the complex interaction among market-driven incentives (quantity/price strategy according to consumer behaviour toward the risk[10]) and the level of effort (or cost) required to ensure the quality of procurement (selection and remuneration of upstream suppliers). Furthermore we analyse the conditions for private standard effectiveness for the supply chain stakeholders (notably upstream suppliers and consumers).

More specifically, our model considers both (i) consumer reaction to the level of risk, this latter being interpreted as the probability that the product does not meet consumer expectations about product quality and (ii) the role of vertical relationships and the heterogeneity of suppliers in terms of food safety characteristics.

On the demand side, following the seminal paper by Polinsky and Rogerson (1983), we consider that consumers react to the perceived rather than to the actual level of risk. Hence, even if consumers receive more or less precise information about product attributes, they may misperceive product quality (respectively, risk), with important consequences on firms' strategic behaviour (e.g. Yeung and Yee, 2002, McCarthy and Henson, 2005). First, consumers are *imperfect problem solvers*, who collect limited information upon which to base their choices (Henson and Traill, 1993)[11]. Second, the information set available to consumers is itself imperfect[12]. Finally, individual consumers are less informed than firms about the nature of products. In this context, especially when credence attributes are concerned, consumers rely upon "external risk indicators" or "risk relievers" to infer product quality (e.g. brands, product information, price, the nature of food packaging, the nature of

[9]Several studies in the literature on MQS show that MQS may reduce the average quality offered on the market and/or decrease variety (Scarpa, 1998; Cramps and Hollander, 1995; Ronnen, 1991). Firms may have thus strong incentive to differentiate themselves on a quality basis from those competitors that operate at or near the MQS.

[10] In this paper we use the term "risk" to specify the probability that the product does not meet consumers' expected quality. The concept of risk in the food sector thus concerns the chance that the product may not meet taste expectations, money is wasted, a poor meal is served to guest (Feng et al., 2010; McCarthy and Henson, 2005), and also the health (e.g. fat content) or safety (e.g. food poisoning) risks and, more in general, those risks related to characteristics that are not verifiable by consumers even after purchase, i.e. the so-called "credence qualities" (Darby and Karni, 1973).

[11] The result of these imperfections is biases in the subjective probabilities generated by consumers for different risky outcomes. For example, several studies show a systematic primary bias in probability estimation with high risks tending to be underestimated and low risk overestimated (Feng et al. 2010; Verbeke et al., 2007; Sparks and Shepherd, 1994).

[12] As regards to food safety, for example, all food-borne risks factors fall into the experience categories (e.g. acute food risk factors, *salmonellosis* and other food poisonings) and credence ones (e.g. chronic food risk factors, such as nutritional imbalance in the diet, food additives or pesticide residues).

the food store and its ability to handle produce, etc.), i.e. "a piece of information that increases the likelihood of product success" (Kornelis et al., 2007; McCarthy and Henson, 2005; Mitchell and McGoldrick, 1996). Indeed, several contributions show consumers' WTP for a quality/safety improvement, while this latter is not directly observable (Loureiro and Umberger, 2007; Grunert, 2005). Moreover, the higher the perceived risk, the more consumers tend to use risk relievers (and use them more frequently)[13] and are willing to pay for quality improvements (Angulo and Gil, 2007; Brown et al., 2005).

On the supply side, we take into account the specific features of agricultural markets (downstream concentration *vis-à-vis* an atomized upstream supply) and we consider a downstream retailer that has a monopolist position towards the final market and a monopsonist position towards upstream suppliers. Suppliers are differentiated according to their equipment levels, which in turn determine the risk associated with their supply. The risk of product failure is thus assumed to be endogenous and to result from upstream characteristics[14]. The compliance with a public MQS or a private standard might lead producers to undertake investments in order to access to the intermediary market.

In this context, the downstream retailer faces a quality-quantity trade-off in the following sense. Raising the standard lowers the risk associated with each unit of product sold on the market, while, for a given level of standard, an increase of the commercialized quantity increases the risk. Hence, reinforcing a relatively strict MQS with an even more demanding private standard by encouraging an upgrading of upstream production practices may be needed to avoid the risk-increasing effect of increasing volumes. Hence, this normalization strategy enables the retailer to benefit from an increased WTP (especially when consumers tend to overestimate the risk) and thus increase volumes. However, also the reinforcement of a relatively weak MQS may be optimal for the retailer since this strategy enables to reduce the risk by restricting volumes without encouraging any supplier equipments' upgrading.

Looking in more details into the retailer incentives, we show that the retailer's strategy depends both on the level of consumer risk misperception and on the level of the public MQS. On the one hand, when consumers underestimate (or correctly perceive) the risk, the retailer reinforces the MQS without encouraging an upgrading of upstream production practices (and only selects "the best producers"). On the other hand, when consumers highly overestimate the risk, the retailer always reinforces the MQS by encouraging an improvement of upstream production conditions. In the most interesting intermediate case (i.e. when consumers overestimate the risk, but overestimation is not too high), both strategies may be optimal, according to the level of MQS: the retailer may either reinforce the MQS by selecting the best equipped producers (if the MQS is relatively weak) or by encouraging an improvement of production practices (if the MQS is relatively strict).

Furthermore, we analyse the effectiveness of private standards for both consumers and upstream suppliers. On the consumers' side, we highlight the reasons why strengthening precautions on the criteria for market access is not always a synonym of risk reduction (raising the standard, even if it reassure consumers, may imply an increase of commercialized quantities and consequently of the average risk). However, it appears that when firms have interest in implementing a private standard, the risk is reduced and, at the same time, consumer surplus may be improved. Indeed, we show that consumer risk misperception

[13] For example, McCarthy and Henson (2005) show that "sceptic consumers", who have the lowest level of confidence in their ability to select beef and were least interested in beef, are the group that used the most risk reduction strategies. This lack of perceived ability manifested itself in both the intensive and wider use of risk relievers. Similarly, Kornelis et al. (2007) show that those who have a low perceived "health control" (that is they believe themselves to be personally powerless to influence their own health outcomes resulting from exposure to food safety hazards) indicate *the highest intended use for product label information.*

[14] This assumption is crucial since it makes it possible to isolate the influence of the retailer's strategic behaviour on the risk, regardless of the role that he may play from a technical point of view.

requires taking into account both criteria when assessing private standards' impact on consumers, i.e. the actual risk and the 'classical' surplus criterion (this latter based on the perceived risk and taking into account the perceived risk that the product does not correspond to consumers' expectation). This enables to highlight the possible contrasting effects (reduced risk but worst surplus).

On the suppliers' side, we show that reinforcing the MQS with a more demanding private standard may improve market access. The extent of this effect increases in the level of consumer risk overestimation. In this sense, we depart from the accepted idea that private standards act to exclude (notably smallholder) farmers. The exclusion effect is mainly explained in the literature by the fact that 'entry costs' in terms of farm upgrading may be prohibitively large for small scale growers thus excluding them from the more safety-discerning high-value supermarket global chains[15]. Products marketed through these chains have to be third-party certified as meeting standards such as GlobalGap, Tesco Nature's Choice (TNC), or Farm to Fork (Okello et al. 2011; Dolan and Humphrey, 2000). Nevertheless, the evidence on private standards' impact on farmers is mixed, with some studies showing smallholder 'inclusion effects', opportunities provided to smallholders by buyer-driven supply chains (Lee et al. 2010) and/or revenue/productivity gains for farmers having achieved compliance[16]. In this vein, we show that producers' exclusion does not only depend on the level of the compliance costs itself, but also on the supply chain structure and notably on the strategic behaviour of the downstream retailer, both towards the upstream and the downstream market.

The remainder of the paper is organized as follows. In section 1 we present the model. In section 2 the private standard setting game. The retailer procurement and normalization strategy is presented in sections 3. Private standard's effectiveness for producers and consumers is presented in section 4.

1. The basic model

We consider a vertical relationship between J heterogeneous upstream producers and a downstream retailing firm. This "retailer"[17] acts as a monopoly in the final market and has a monopsony power in purchasing the input from producers. Each producer can supply one unit of input, and the retailer is assumed to buy x units ($x \leq J$). The downstream stage may concern processing, preserving, conditioning or packing operations. For the sake of simplicity we suppose that the retailer converts the x units of inputs into y units of a finished product, according to the fixed proportion production function $y = T(x)$, where we simply set $T(x)=x$. As explained in the introduction of the paper, the retailer is assumed not to influence the risk of product failure and the risk is assumed to technically result from upstream production characteristics.

[15] A number of empirical studies have examined smallholders' adoption of private collective standards (e.g. GlobalGap, BRC, IFS, etc.) mainly focused on the impact of GlobalGap in developing countries. These studies mostly suggest that private standards act to generate small farmers' exclusion predominantly due to high compliance costs (Graffham et al., 2007; Jaffee, 2003; Dolan and Humphrey, 2000).

[16] Some studies provide evidence of smallholders maintaining or enhancing their role in export value chains (e.g. Gulati et al. 2007; Minten et al, 2006; Minot and Ngigi, 2004). As noted by Lee et al. (2010), despite the rise of industrialized farming, production in buyer-driven chains is often smallholder-based, partially attributable to the relatively greater efficiency of smallholders in land and labour use. In addition, some studies show appreciable gains for producers that have achieved compliance in terms of productivity, revenues, producer prices or reduced pesticide application, etc. (Kariuki et al. 2012; Henson et al. 2011; Maertens and Swinnen, 2009; Okello and Swinton, 2009; Asfaw et al. 2008).

[17] In the rest of the paper, we denote "retailer" the downstream firm. Of course, this "retailer" may also represent a large-sized processing firm and its strategy of product standardisation.

Consumers' risk perception and demand function

The demand function of the consumers is the result of the maximization of a utility function, taking into account that the risk is communicated on the market.[18] Considering that this communication is not perfect and not necessarily well done, or considering that the psychological behaviour of the consumers is unpredictable, we suppose that the risk may be overestimated or underestimated. In our model, the utility function for a representative consumer takes the form:

$$U(x) = (\alpha - s)x - \frac{x^2}{2} + M \qquad (\alpha \geq s \geq 0) \tag{1}$$

The formula (1) is a modified version of the standard quadratic utility function. Thus x represents the quantity of good bought by the representative consumer and $M=Y-px$ denotes the expenditure on outside goods. The parameter s is the perception of risk by the consumer, which may increase the utility according to food safety considerations. We suppose that this evaluation is a function of the actual risk σ of product failure and of a parameter $\xi \geq 0$ measuring the "consumers' misperception" of the risk (following the terminology used by Polinsky and Rogerson, 1983). When $\xi = 1$, consumers correctly perceive the actual level of risk. When $\xi < 1$ consumers underestimate the risk and when $\xi > 1$ consumers overestimate the risk. Thus we write $s = \xi\sigma$ the risk perceived by consumers. The utility maximization with respect to x gives the (inverse) demand function for the representative consumer,

$$p(\sigma, x) = \alpha - \xi\sigma - x \tag{2}$$

Equation (2) is similar to the linear demand function used by Polinsky and Rogerson[19]. This specification makes it possible to take into account two mechanisms: for a given quantity x, (i) the higher the level of ξ the higher the perceived risk $\xi\sigma$ and thus the lower consumer willingness to pay (WTP), which is measured by the expression $(\alpha - \xi\sigma)$; (ii) the higher the level of ξ the stronger the WTP-increasing effect of a risk reduction.

For the sake of simplicity and without loss of generality, we assume $J + \frac{\xi}{2} < \alpha < 2J$.[20]

Producers' equipment and risk

Upstream producers are differentiated according to their level of "equipment", which represents the value of the initial infrastructure of a producer. The equipments are measured by a one-dimensional parameter e, uniformly distributed on the interval $[0,1]$ according to the density function $f(e) \equiv 1$. The individual risk arising from each producer, whose level of equipment is e, is denoted by $\sigma(e) = 1 - e$. Hence, the risk is maximum with a producer

[18] Sanitary risk reduction may be in fact communicated either by the government through public certifications or by different firms' brands and logos. For example, in the case of pesticide reduction in agrifood products, there exist a wide number of certifications, from the "Integrated Pest Management" to organic certifications. US retailers have widely developed, since the beginning of the 90s, products with « certification for pesticide residue-free ». Note that several studies (see for example Ott, 1990; Misra et al, 1991, Eom, 1994) have attempted to assess the effect of these signals on consumer behaviour.

[19] In order to regain the demand function of Polinsky and Rogerson we have to pose $\xi = (1 - \lambda)l$, where the parameter λ is interpreted as a measure of the extent of consumer risk misperception and l represents the monetary loss for each unit of the product that fails.

[20] The condition $\alpha > J + \xi/2$ is necessary to always have $p(s,x) > 0$ and the condition $\alpha < 2J$ simplifies the presentation of all the results we can obtain with this model.

characterized by the minimum level of equipment ($\sigma(0)=1$) and zero with a producer characterized by the maximum level of equipment ($\sigma(1)=0$).

Since the retailer has to deal with different suppliers, some producers who are involved in the intermediary market may not supply inputs meeting the "ideal situation" of zero risk (*i.e.* if we do not consider the trade-off between risk and product prices). The heterogeneity of inputs will thus determine an average risk for the processed product. Since all upstream producers supply the same quantity, the risk of a failure in the final market exclusively depends on the density function $f(e)$, and on the probability of failure $\sigma(e)$ of each upstream producer involved in the intermediary market. This average risk is endogenous in the sense that it will depend on the investments of upstream producers to improve their initial equipments.

The benchmark with a Minimum Quality Standard

In the benchmark situation, upstream production characteristics can only be regulated by a public Minimum Quality Standard (MQS) $e_0 \geq 0$. Consequently, only producers with equipment such that $e \geq e_0$ can supply the intermediary market. Setting the MQS determines what we denote the "eligible supply" $\hat{x}_0 = J(1-e_0)$. Moreover we assume that the compliance with e_0, for a producer of type *e*, implies a fixed cost that takes the simple form $\text{Max}\{0; e_0 - e\}$.[21]

Given the MQS e_0, the retailer chooses the quantity *x* to market. Since we consider that the downstream retailer has a monopsonist position towards upstream producers, then he has complete negotiation power in the definition of the intermediary price ω. Following Xia and Sexton (2004), who model this kind of intermediary market, the retailer thus sets the quantity *x* by anticipating the necessary price in order to obtain this quantity *x* from the upstream producers. Hence, the intermediary price is strictly positive only if the quantity exceeds the eligible supply and remunerates the lowest initially non-eligible equipment that has to be upgraded to satisfy retailer's demand.[22]

We denote by $\omega_0(e_0, x)$ the intermediary price paid to producers in the benchmark situation. If $x \leq \hat{x}_0$ the retailer involves producers with equipment levels between e_0 and 1 and $\omega_0(e_0, x)=0$. If $x > \hat{x}_0$, the minimum price paid to producers should be such that $\omega_0(e_0, x) = e_0 - \tilde{e}(x)$ where $\tilde{e}(x)$ defines the threshold of equipment starting from which producers are involved in the intermediary market.

Given the initial uniform distribution of the *J* upstream producers, the total quantity supplied on the intermediary market is given by $J(1-\tilde{e})$. At these conditions, the

[21]Given the heterogeneity of upstream supply, this cost function allows to explicitly take into account the heterogeneity of the compliance costs. For an illustration of this heterogeneity in the empirical literature, see for example Kleinwechter and Grethe (2006).

[22] We assume that the downstream retailer does not have the possibility to discriminate between upstream producers. Hence the intermediary price is the same for all the suppliers, regardless of their initial level of equipment. This assumption is consistent with several buyer-supplier relationships observed in agrifood supply chains (see Giraud-Héraud et al., 2012) and with the fact that intermediate price is usually negotiated between the retailer and the Producers Organizations and/or the cooperatives, and rarely between the processing and/or retailing firm and each of the upstream farmers. Indeed, it is noteworthy that individual contracts rarely exist in the agrifood sector (see for example, Royer, 1998, Kleinwechter and Grethe, 2006, and Malorgio and Grazia, 2009, for an analysis of the role of Producers Organizations in the implementation of GlobalGAP by fruit and vegetables farmers). Note also that we have voluntarily left out the explicit formalization of the intermediation assured by the Producers Organization, with which the downstream retailer negotiates.

equalization of supply and demand on this market is such that $x = J(1-\tilde{e})$. This makes it possible to obtain the expression (3) below, which identifies the position of the initially less-equipped (i.e. the riskiest) supplier, as a function of the quantity x demanded by the retailer.

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

Thus, the intermediary price $\omega_0(e_0,x)$ is given by:

$$\omega_0(e_0,x) = \begin{cases} 0 & if\ x \le \hat{x}_0 \\ \dfrac{x}{J} - (1-e_0) & if\ x > \hat{x}_0 \end{cases} \tag{4}$$

Note that the position of the quantity x with respect to the eligible supply affects the average risk on the final market. If the quantity x does not exceed the eligible supply, we consider that the upstream producers involved in the intermediary market are randomly chosen between e_0 and 1.[23] Hence, the risk corresponds to the average risk of eligible equipments (located between e_0 and 1) and is not affected by the quantity x. If $x > \hat{x}_0$ the retailer also involves some initially not well-equipped producers (with equipments between $\tilde{e}$ and e_0) and an "additional" risk is associated to the eligible supply, i.e. the average risk associated with the initially non-eligible equipments. Indeed, suppliers' equipments will be distributed on $[e_0,1]$ with a Dirac mass at e_0 (i.e., all producers initially located between $\tilde{e}$ and e_0 invest in order to adopt the same level of equipment, e_0).For a given standard e_0 and a given quantity x, the average risk $\bar{\sigma}_0(e_0,x)$ is then given by:

$$\bar{\sigma}_0(e_0,x) = \begin{cases} \dfrac{1}{1-e_0}\displaystyle\int_{e_0}^{1} \sigma(e)f(e)de = \frac{1-e_0}{2} & if\ x \le \hat{x}_0 \\ \dfrac{1}{1-\tilde{e}}\left[\displaystyle\int_{e_0}^{1} \sigma(e)f(e)de + (e_0-\tilde{e})\sigma(e_0)\right] = (1-e_0)\left[1-\frac{J}{2x}(1-e_0)\right] & if\ x > \hat{x}_0 \end{cases} \tag{5}$$

For a given standard e_0 and a given quantity x, the retailer's expected profit $\pi_0(e_0,x)$ is the following,

$$\pi_0(e_0,x) = [\,p(\bar{\sigma}_0(e_0,x),x) - \omega_0(e_0,x)]\,x \tag{6}$$

Where the risk $\bar{\sigma}_0(e_0,x)$ is given by (5), the intermediary price $\omega_0(e_0,x)$ by (4), and the final price $p(\bar{\sigma}_0(e_0,x),x)$ is obtained by substituting (5) into (2).

We show in the Appendix that for every level of ξ and given the MQS e_0, there exist $e^-(\xi)$ and $\hat{e}(\xi)$ increasing in ξ with $e^-(\xi) < \hat{e}(\xi)$, whereby the optimal quantity $x_0^*(e_0)$ set by the retailer in the benchmark situation is given by:

[23] An alternative to this hypothesis would be to consider that producers involved in the relation with the retailer are selected from the right to the left on the segment $[e_0,1]$ in order to only hold the best producers. However, this strategy would assume the implementation of a selection by the retailer, which is comparable to the implementation of a private standard (see section 3 of the article).

$$x_0^*(e_0)=\begin{cases}\dfrac{1}{2}[\alpha-\xi\dfrac{(1-e_0)}{2}] & \text{if } e_0 \le e^-(\xi) \\ \hat{x}_0 = J[1-e_0] & \text{if } e^-(\xi) \le e_0 \le \hat{e}(\xi) \\ J\dfrac{[\alpha+(1-e_0)(1-\xi)]}{2(J+1)} & \text{if } e_0 \ge \hat{e}(\xi)\end{cases} \quad (7)$$

Setting:

$$\begin{cases} e^-(\xi)=1-\dfrac{2\alpha}{\xi+4J} \\ \hat{e}(\xi)=1-\dfrac{\alpha}{\xi+(2J+1)}\end{cases} \quad (8)$$

We easily verify that $x_0^*(e_0)$ is continuous in e_0. The thresholds $e^-(\xi)$ and $\hat{e}(\xi)$ identify the relative position of this optimal quantity, with respect to the eligible supply.

● When $e_0 \le \hat{e}(\xi)$, the MQS is relatively weak and the retailer does not exceed the eligible supply. In this context, raising the MQS below the level $e^-(\xi)$ generates the incentive for the retailer to increase quantity to benefit from the WTP improvement (for each positive level of ξ). Beyond $e^-(\xi)$, the retailer's quantity exactly matches the eligible supply and decreases in the MQS. In this case, the retailer prefers to reduce the commercialized quantity when the MQS increases, in order to maintain at zero the intermediate price for suppliers. The average risk thus decreases as a result of the decrease of quantity.

● When $e_0 > \hat{e}(\xi)$, the quantity exceeds the eligible supply and the intermediary price becomes strictly positive. When the MQS increases, a trade-off arises between (i) decreasing quantity to reduce the intermediary price and (ii) increasing quantity in order to benefit from the WTP improvement. Note that the effect (ii) is positively influenced by the level of ξ (the higher ξ, the higher the incentive for the retailer to increase quantity as the MQS increases).

As it will be detailed in section 3 below, the incentive for the retailer to increase quantity, when this latter exceeds the eligible supply, may generate an "unexpected" effect so that the average risk may increase in the MQS. Hence, the 'reassuring' effect that an increase of the MQS has on consumers may lead the retailer to increase quantities and procure from less safe suppliers.

2. Private Standard Setting

We suppose now that the retailer may require a more demanding (private) standard $e_1 > e_0$ for upstream suppliers to be selected, or not, and thus simply complies with the MQS ($e_1 = e_0$). In the same way as in the benchmark, we denote by $\hat{x}_1 = J(1-e_1)$ the eligible supply, which initially complies with the private standard and by $\omega_1(e_1,x)$ the intermediary price paid to producers.

The implementation of the private standard is set before the strategic choice of quantity, according to the following game,

Stage I. The retailer chooses the level of the private standard $e_1 \geq e_0$.

Stage II. The retailer decides the quantity $x \geq \hat{x}_1$ of inputs to purchase (stage II.1). The retailer then chooses *N* upstream producers ($N \leq J$) and proposes an intermediary unit price ω in order to obtain the quantity *x* (stage II.2). The *N* producers accept or reject this offer and upgrade their equipment if necessary (stage II.3).

Stage III. The retailer converts the obtained inputs into a finished product and sells it on the final market.

In stage I, we consider that the retailer sets-up the private standard, knowing the level of the MQS. The standard e_1 corresponds to the minimum level of equipment now required by the retailer for upstream producers to be selected. It affects the risk of product failure depending on whether the retailer's strategy has an influence on producers' equipments or not. As described previously in the benchmark, at the stage II of the game the retailer imposes to the upstream producers a "take it or leave it' contract, fixing a unit price in order to obtain the quantity that maximizes his expected profit on the final market. Note however that in the case of private standard, the retailer cannot choose a quantity that is lower than the "eligible" quantity with respect to the standard. This constraint does not have any consequence on the issue of the proposed game, since there is no fixed cost to set a private standard more demanding than the MQS at the first stage.[24] Then $\tilde{e}(x)=1-x/J$ defines the threshold of equipment starting from which producers are involved in the intermediary market ($x \geq \hat{x}_1$ i.e. $\tilde{e} \leq e_1$).

According to the relative position of the quantity set at stage II with respect to $\hat{x}_1$, we distinguish two different possibilities of standards,

(i) *Standard with a "pure selection strategy"*: the retailer selects only all the producers that are initially compliant with the standard set at stage I ($x = \hat{x}_1$ i.e. $\tilde{e} = e_1$), thus no equipment upgrading is required for selected producers to supply the intermediary market.

(ii) *Standard with a "proactive strategy"*: the retailer also involves some producers that are initially non-compliant with the standard set at stage I ($x > \hat{x}_1$ i.e. $\tilde{e} < e_1$), implying an equipments' upgrading.

This distinction will be useful in the rest of the paper, especially to discuss about the positive effects of standards with respect to upstream producers' market access and consumer interests.

In stage III, the retailer has a capacity constraint (given by *x*) in order to choose the quantity to market. The game is solved by backward induction.

Optimal procurement

Using the same arguments as in the benchmark situation, the intermediary price $\omega_1(e_1,x)$ is the following,

$$\omega_1(e_1,x) = \begin{cases} 0 & \text{if } x \leq \hat{x}_1 \\ \dfrac{x}{J} - (1-e_1) & \text{if } x > \hat{x}_1 \end{cases} \tag{9}$$

[24] Indeed, if the retailer wants to market a quantity $x < \hat{x}_1$, he could set-up without cost $e_1 = \tilde{e}(x)$ at stage I of the game.

For a given quantity, the intermediary price is an increasing function of the standard. Moreover, the existence of a unique intermediary price generates a positive externality for the producers, whose equipment is higher than the lowest equipment level $\tilde{e}$.

The average risk that the supply chain fails to provide safe products in the final market takes a different form with respect to that obtained in the benchmark[25]:

$$\bar{\sigma}_1(e_1,x)=\frac{1}{1-\tilde{e}}\begin{cases}\int_{\tilde{e}}^{1}\sigma(e)f(e)de & \text{if } e_1\le\tilde{e}\\ \int_{e_1}^{1}\sigma(e)f(e)de+\left[e_1-\tilde{e}\right]\sigma(e_1) & \text{if } e_1>\tilde{e}\end{cases} \tag{10}$$

If no investments are made, $\tilde{e}\ge e_1$, the risk simply corresponds to the average risk of suppliers located between $\tilde{e}$ and 1 (without change in the initial level of equipment). If investments are made, $\tilde{e}<e_1$, suppliers' equipments will be distributed on $[e_1,1]$ with a Dirac mass at e_1 (i.e., all producers initially located between $\tilde{e}$ and e_1 invest in order to adopt the same level of equipment, e_1).

Using (3) and (10), we then obtain:

$$\bar{\sigma}_1(e_1,x)=\begin{cases}\dfrac{x}{2J} & \text{if } x\le\hat{x}_1\\ (1-e_1)[1-\dfrac{J}{2x}(1-e_1)] & \text{if } x>\hat{x}_1\end{cases} \tag{11}$$

The expression (11) shows the existence of a quantity/quality trade-off for the retailer in the following sense. For a given standard e_1, the risk is an increasing function of the quantity because an increase of quantity implicitly implies the involvement of a higher number of under-equipped producers. Moreover, for a given quantity *x*, the risk decreases in e_1, as long as the retailer's strategy leads to an improvement of upstream supply characteristics, i.e. when $x>\hat{x}_1$.

For a given standard e_1 and a given quantity *x*, the retailer's expected profit $\pi_1(e_1,x)$ is the following,

$$\pi_1(e_1,x)=[\,p(\bar{\sigma}_1(e_1,x),x)-\omega_1(e_1,x)]x \tag{12}$$

Where the risk $\bar{\sigma}_1(e_1,x)$ is given by (11). The intermediary price $\omega_1(e_1,x)$ is given by (9) and the final price $p(\bar{\sigma}_1(e_1,x),x)$ is obtained by substituting (11) into (2).

For a given standard, the quantity choice affects the expected profit in two ways: (i) the lower the quantity, the lower the intermediary price; (ii) the lower the quantity, the higher the final price. This second effect is due to the direct "rarity effect" and to an indirect risk-reducing effect of a decrease of quantity. Note that consumer misperception affects the extent of the indirect effect.

Using (12), we then maximize the expected profit $\pi_1(e_1,x)$ with respect to the quantity *x*, given e_1. We show in the Appendix, that for any level of ξ and given the private standard e_1, the optimal quantity $x_1^*(e_1)$ chosen by the retailer is given by:

[25] Taking into account that in the case of private standard the selection of upstream producers is always done by selection the most effective ones (selection from the right to the left on the interval [0,1]).

$$x_1^*(e_1) = \begin{cases} \hat{x}_1 = J[1 - e_1] & \text{if } e_1 \le \hat{e}(\xi) \\ J\dfrac{[\alpha + (1 - e_1)(1 - \xi)]}{2(J+1)} & \text{if } e_1 \ge \hat{e}(\xi) \end{cases} \quad (13)$$

Where $\hat{e}(\xi)$ is given by (8).

We can easily verify that $x_1^*(e_1)$ is continuous in e_1. The threshold of equipment $\hat{e}(\xi)$ identifies the relative position of this optimal quantity with respect to $\hat{x}_1$. By comparing $x_1^*(e_1)$ to $\hat{x}_1$ we highlight in Proposition 1 the influence of the private standard e_1 on the retailer's procurement strategy.

Proposition 1

If $e_1 \le \hat{e}(\xi)$, the retailer selects all the initially well-equipped producers using a pure selection strategy, and quantity decreases in e_1. If $e_1 > \hat{e}(\xi)$, the retailer also involves some initially not well-equipped producers using a proactive strategy. Quantity decreases in e_1 when consumers underestimate the risk and increases in e_1 when consumers overestimate the risk. In the absence of consumer misperception the optimal procurement is constant in e_1.

***Proof** : see Appendix*

Let us consider in figure 1 the influence of the private standard on the retailer's quantity strategy and for different levels of risk misperceptions. When the private standard is relatively weak ($e_1 \le \hat{e}(\xi)$), the retailer adopts a pure selection strategy, selecting $x = \hat{x}_1$ at a zero intermediary price, regardless of the level of risk misperception. Hence, when e_1 increases in this context, the retailer prefers to reduce the quantity (and increase the final price via the rarity effect) rather than remunerating the equipments' upgrading of some initially not well-equipped producers. When the private standard is relatively strict ($e_1 > \hat{e}(\xi)$), the retailer also involves some initially not well-equipped producers in order to implement his optimal procurement strategy. For a given quantity *x*, a stricter standard implies an increased unitary procurement cost (intermediary price) for the retailer. If the standard increases in this context, the retailer could thus have interest in decreasing quantity. However, for a given quantity *x*, a stricter standard implies a reduced risk of product failure and thus an enhanced consumer demand. The retailer could then have interest in increasing quantity.

Consumer misperception plays a crucial role in the following sense. While it does not affect the intermediary price-increasing effect of the standard, it influences consumers' reaction (in terms of WTP) to the risk-reducing effect. More specifically, for a given quantity *x*, the higher consumer misperception the higher the perceived risk-reduction (and the WTP improvement) effect of the standard. Hence, if consumers underestimate the risk ($\xi < 1$), the retailer decreases quantity in order to reinforce the risk-reducing effect and mitigate the intermediary price-increasing effect. It is worthy to notice that if consumers correctly perceive the actual risk level ($\xi = 1$), the risk-reducing effect balances the intermediary price-increasing effect; as a consequence, the quantity is constant in the standard. Conversely, if consumers overestimate the risk ($\xi > 1$), the WTP improvement is more important than the increase of the intermediary price, for a given quantity. Since the increase in the marginal

benefit exceeds the increase in the marginal cost, the retailer responds to an increase of the standard with an increase of the supplied quantity, at a higher intermediary price.

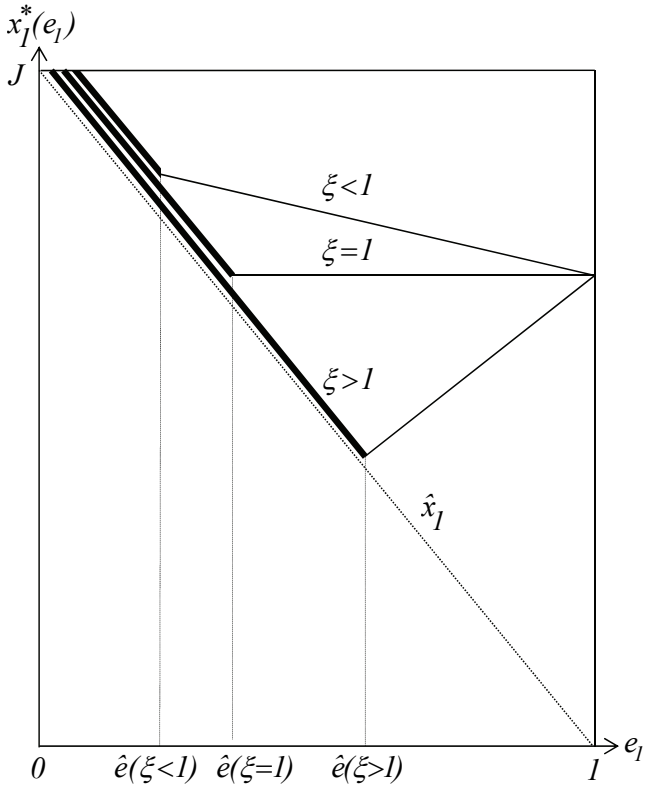

figure 1. *Retailer's quantity choice, according to the private standard level and for different levels of consumers' misperception.*

Effect of the standard level on the risk

An increase of the marketed quantity implies an increase of the sanitary risk, for a given level of standard (as it results in the involvement of an increasing number of underequipped producers). Nevertheless, as shown in the previous section, this increase of quantity may be related to a reinforcement of the standard and thus imply a trade-off in the assessment of the actual level of sanitary risk on the final market. In the following Proposition 2, we show that the consequences of the retailer's strategy on the risk are ambiguous.

Proposition 2

If $e_1 \le \hat{e}(\xi)$*, the risk decreases in* e_1*. If* $e_1 > \hat{e}(\xi)$*, the risk decreases in* e_1 *when consumers underestimate (or correctly perceive) the risk and may increase in* e_1 *when consumers overestimate the risk.*

Proof : see Appendix

The figure 2 shows the influence of the private standard e_1 on the risk $\sigma_1(e_1) = \sigma_1(e_1, x^*(e_1))$. As long as $e_1 \le \hat{e}(\xi)$, the risk decreases in e_1 through the decrease of quantity. It is worthy to notice that if $e_1 = 0$ the risk is given by $\sigma_1(0) = .5$, that

corresponds to the average risk when all upstream producers are selected with their initial equipments ($x = \hat{x} = J$ i.e. $\tilde{e} = 0$). If $e_1 > \hat{e}(\xi)$, the retailer's strategic behaviour affects the risk in the following sense. If consumers underestimate or correctly perceive the risk ($\xi \leq 1$), the risk decreases, as a result of the increase of the standard, while quantity decreases (if $\xi < 1$) or is constant (if $\xi = 1$) in e_1. Conversely, if consumers overestimate the risk ($\xi > 1$), quantity increases in the standard (Proposition 1). As long as the risk-increasing effect of the increase of quantity dominates the risk-reducing effect of the standard's reinforcement, the risk of product failure increases in the standard[26]. The risk has thus a local maximum on the interval $[\hat{e}(\xi),1]$, given by $\bar{e}(\xi)$ in figure 2 (see the Appendix for details) and two levels of standard could exist whereby the same risk arises, i.e. the same probability of product success may be achieved by implementing the higher of these two levels of standard (which corresponds to the highest level of quantity supplied on the market, e.g. $\bar{\sigma}_1^{\circ}$ in figure 2).

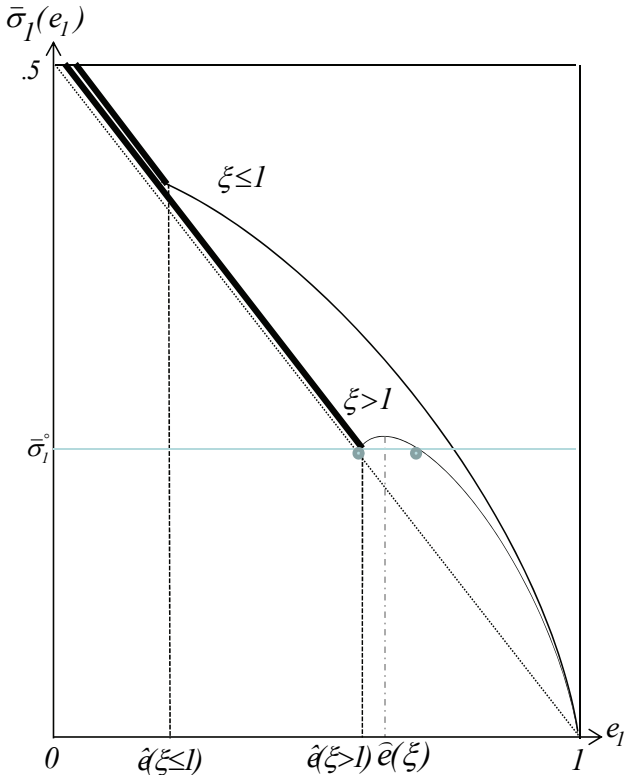

figure 2. *Risk of product failure according to the private standard level and for different levels of consumers' misperception.*

[26] The possible quality-reducing effect of a standard has been widely illustrated by the literature on MQS, but without vertical relationships considerations. See for example Scarpa (1998) who shows that if a MQS is introduced in a vertically differentiated market with three retailers, then the maximum quality level, the average quality consumed as well as the profit levels of all retailers decrease. In this spirit, Maxwell (1998) illustrates that a MQS may reduce retailer incentives to innovate – when the innovating retailer correctly anticipates that a regulator will raise the minimum standard once an innovation has been discovered – leading to a lower level of social welfare under regulation. Furthermore, the introduction of "innocuous" minimum quality standards, namely below the lowest quality level in a market, may reduce the incentive to invest in R&D by the quality-leading retailer (Garella, 2006).

3. Retailer's normalization strategy

We detail now at which conditions the retailer has interest in reinforcing the MQS with a more demanding private standard (stage I of the game). We denote by $e_1^*(e_0)$ the optimal decision of the retailer, when he chooses the level of the private standard, according to the level e_0 of the MQS. This decision is made by anticipating the optimal procurement strategy *vis-à-vis* upstream suppliers (described in the previous section).Since we assume no fixed cost for the implementation of a private standard more demanding than the MQS at stage I, the retailer's profit, when he chooses the level of the private standard, according to the level of the MQS, is higher than the retailer's profit in the benchmark ($\pi_1(e_1^*(e_0)) > \pi_0(e_0)$), when the retailer reinforces the MQS with a more demanding private standard ($e_1^*(e_0) > e_0$) and equal ($\pi(e_1^*(e_0)) = \pi(e_0)$) when the retailer simply complies with the MQS ($e_1^*(e_0) = e_0$), for each positive level of ξ; whilst for $\xi = 0$ we always have $\pi(e_1^*(e_0)) = \pi(e_0)$ (see Appendix for details).

Figure 3 illustrates the retailer's profit as a function of the private standard e_1 and for three situations of consumer misperception. For each of these situations, the first part of the curve (in bold characters) corresponds to the pure selection strategy, while the second one (in fine characters) corresponds to the proactive strategy.[27] Two possible optima are thus conceivable according to different configurations, on the one hand the implementation of the most demanding standard with a proactive strategy, on the other hand a less demanding standard with a simple selection of suppliers. We show in the Appendix that this latter case arises for the local maximum $\underline{e}(\xi)$ given by:

$$\underline{e}(\xi) = 1 - \frac{\alpha}{2J + \xi} \tag{14}$$

● In the situation (1) of figure 3, consumers underestimate (or correctly perceive) the risk ($\xi \leq 1$) and the retailer's profit has a unique maximum here illustrated by the value $\underline{e}_{(1)}$. In this case, the retailer prefers adopting a relatively weak level of standard by implementing the pure selection strategy. Consequently, if the public standard e_0 is lower than $\underline{e}_{(1)}$, then the retailer adopts this strategy by reinforcing the public standard, and chooses $e_1^*(e_0) = \underline{e}_{(1)}$. Inversely, if the public standard is such that $e_0 \geq \underline{e}_{(1)}$, then the retailer does not implement a more demanding private standard and chooses $e_1^*(e_0) = e_0$.

● In the situation (2) of figure 3, consumers do not overestimate too much the risk ($1 < \xi < 2$) and the pure selection strategy makes it again possible for the retailer to obtain the best profit for $e_1^*(e_0) = \underline{e}_{(2)}$. However, the proactive strategy admits a local minimum between $\underline{e}_{(2)}$ and $e_1 = 1$. Then, there exists a threshold $\bar{e}(\xi)$ such that the retailer's profit is the same for this level of standard and the level $e_1 = 1$.

[27] The proactive strategy is implemented starting from the threshold $\hat{e}(\xi)$ that we did not represent in order to assure a better readability of figure 3.

$$\bar{e}(\xi) = \begin{cases} 1 - \dfrac{2\alpha(\xi - 1)}{1 + \xi(2J + \xi)} & \text{if } 1 < \xi \le U \\ 1 - \alpha\left[\dfrac{4(J+1) - \sqrt{8(J+1)(2-\xi)}}{4(J+1)(2J+\xi)}\right] & \text{if } U \le \xi \le 2 \end{cases} \tag{15}$$

where $U = \sqrt{(J+1)(J+3)} - J$, with $1 < U < 2$.

In the figure 3, $\bar{e}(\xi)$ is represented by $\bar{e}_{(2)}$ in the situation (2). If the public standard e_0 is such that $e_0 < \underline{e}_{(2)}$, then the retailer adopts the pure selection strategy and reinforces the public standard by choosing $e_1^*(e_0) = \underline{e}_{(2)}$ (situation (2a)). If the public standard is such that $\underline{e}_{(2)} \le e_0 \le \bar{e}_{(2)}$, then the retailer does not implement a more demanding private standard and chooses $e_1^*(e_0) = e_0$. If the public standard is such that $\bar{e}_{(2)} < e_0 < 1$, then the retailer reinforces the MQS, by choosing $e_1^*(e_0) = 1$ (situation (2b)). Highly constrained by the MQS in his procurement strategy, the retailer implements the risk-minimizing private standard in order to increase quantity.

● In the situation (3) of figure 3, consumers overestimate the risk even more ($\xi \ge 2$). The profit curve is similar to that of the previous situation, but the maximum profit is achieved for the standard $e_1 = 1$. Consequently, for every $0 \le e_0 < 1$, the retailer reinforces the public standard, choosing $e_1^*(e_0) = 1$.

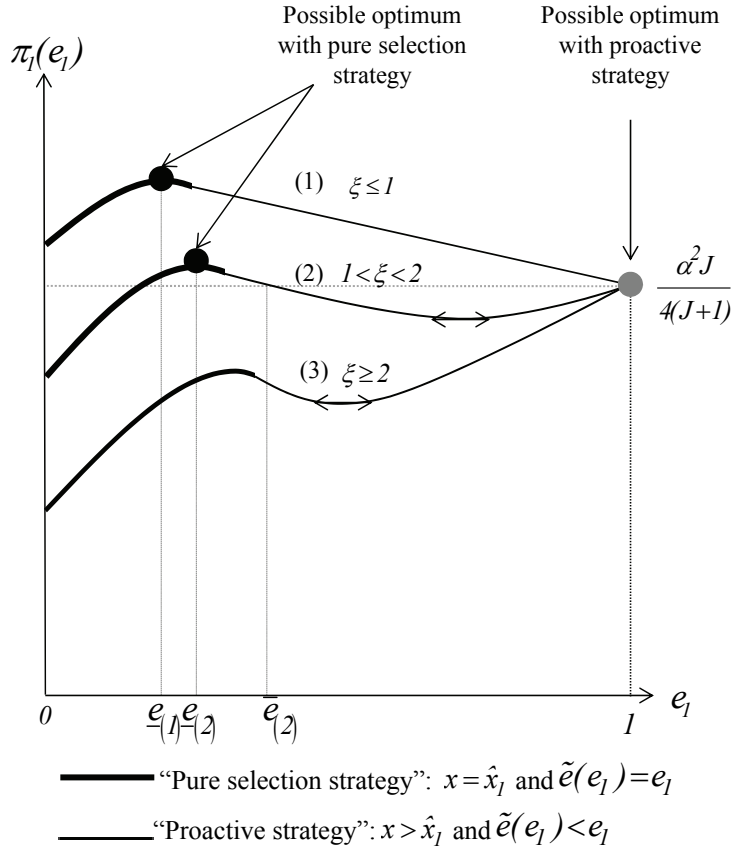

figure 3. *Retailers' profit according to the private standard and for different levels of consumers' misperception*

The following proposition 3 summarizes these results.

Proposition 3

When $\xi \leq 1$, the retailer *sets a private standard more demanding than the MQS iff* $e_0 < \underline{e}(\xi)$. *When* $1 < \xi < 2$, the retailer *sets a private standard more demanding than the MQS iff* $e_0 < \underline{e}(\xi)$ *or* $\overline{e}(\xi) < e_0 < 1$. *When* $\xi \geq 2$, the retailer *sets a private standard more demanding than the MQS for every* $0 \leq e_0 < 1$.

Proof *: see Appendix*

Hence, we have shown that the level of consumer misperception could explain the retailer's decision and that it is not necessarily when the MQS is relatively weak that the retailer has interest in implementing a more demanding private standard. Moreover, it appears (see appendix for details) that the normalization strategy may be developed in different ways according to whether it corresponds to a simply selection of suppliers or to a proactive role of the retailer in encouraging investments towards an improvement of food safety (such that the retailer supports the compliance of upstream suppliers to a more demanding private standard). The choice of the type of strategy depends on both the level of MQS and, above all, on the level of consumer misperception. When the consumers correctly perceive or underestimate the risk, the retailer never implements a more demanding standard than the MQS with a proactive strategy. This strategy is implemented only if consumers highly overestimate the risk, regardless of the level of MQS, or if consumers moderately overestimate the risk and the MQS is relatively strict.

4. Effectiveness for upstream producers and consumers

This section examines the positive and negative externalities of private standards for upstream producers and consumers. We first analyze the effects of raising the standard e_1 and then the effectiveness of the private standard, with respect to the benchmark, for both producers and consumers. For the sake of simplicity and without loss of generality, we restraint the analysis to the case in which consumer risk overestimation is not too high (i.e. to situations (1) and (2) previously identified in section 3), taking $\xi < 2$.

Effectiveness for producers

We first consider the effects of the standard on producer market access, this latter measured by *x/J*, i.e. the proportion of producers involved in the intermediary market. When $e_1 \leq \hat{e}(\xi)$, the retailer exactly selects all the initially well-equipped producers at a zero intermediary price. In this context, since quantity decreases in e_1 (as shown in figure 1), market access gets worse. When $e_1 > \hat{e}(\xi)$ and consumers underestimate the risk ($\xi < 1$) the same result holds. It is worthy to notice that when there is no risk misperception ($\xi = 1$), raising the standard does not affect market access. However, if consumers overestimate the risk ($\xi > 1$), raising the private standard improves market access (as a result of the incentive for the retailer to increase quantity). Moreover, producers are also better-off in terms of intermediary price, this latter increasing in e_1 .

The most interesting issue is to look at the optimum of the retailer's normalization strategy. We show in the appendix that when the retailer implements a private standard with

pure selection strategy ($e_1 = \underline{e}(\xi)$ when $e_0 < \underline{e}(\xi)$), the quantities commercialized by the retailer (and ordered from upstream producers) are lower than in the benchmark. An exclusion effect thus arises without an improved remuneration of producers who supply the intermediary market. Inversely, when the retailer implements a proactive strategy ($e_1 = 1$ when $e_0 > \overline{e}(\xi)$), in the presence of a risk overestimation by consumers, commercialized quantities are higher than in the benchmark with moreover a higher profit of upstream producers. Hence, the sanitary risk reduction at its minimum level, which leads consumers to increase the demand on the final market, may also be optimal for producers.

Effectiveness for consumers

From the point of view of consumers, we consider two criteria to characterize the effectiveness of the private standard. On the one hand, the actual sanitary risk (measured by $\overline{\sigma}_1$) and on the other hand, the surplus that makes it possible to measure consumer "satisfaction" toward product characteristics (by taking into account the perceived risk and the price of the final product).[28]The main results in the appendix are the following.Taking into account the role of risk misperception, we show that raising the standard may benefit consumers both in terms of actual risk reduction and surplus improvement. When $e_1 \leq \hat{e}(\xi)$, and regardless of the level of ξ, raising the standard reduces the risk but at the same time worsens consumer surplus. The reduction of consumer surplus is explained by the decrease of quantity and the increase of final price (this latter increasing through the rarity effect and the risk reduction), in a context where raising the standard has no WTP-effect (i.e., for a given quantity *x*, the risk is not affected by the level of standard). When $e_1 > \hat{e}(\xi)$ and consumers underestimate (or correctly perceive) the risk ($\xi \leq 1$), raising the standard reduces the risk and at the same time may improve consumers' surplus. More specifically, the surplus increases in this context when the WTP effect is non negligible ($\underline{\xi} \leq \xi \leq 1$ see appendix for details) and as long as it dominates the decrease of quantity (and the increase of final price), i.e. for relatively low levels of standard in this context. However, if consumers overestimate the risk ($\xi > 1$), raising the standard implies an increase of quantity (proposition 1) and improves WTP more than proportionally than the actual risk reduction); final price has an initially decreasing trait (when the standard is relatively low) and then increases in the standard (see appendix for details). In this context, the effect of the standard on consumer surplus thus results from the interaction between the negative effect of an increase of final price and the positive effect of both the quantity and the WTP-effect. Surplus thus increases when the increase of quantity and the WTP-effect dominates the price effect. The WTP-effect is shown to be amplified by the level of ξ so that, for a sufficiently high level of ξ, consumer surplus increases in the standard and achieves its maximum level $e_1 = 1$. It is worthy to notice that, if consumers overestimate the risk, the contrasting effect may arise whereby raising the standard improves consumer surplus, but increases the actual risk, notably when the standard increases but remains lower than the threshold $\widehat{e}$ (Proposition 2) so that the related risk-reducing effect is dominated by the risk-increasing effect of the increase of quantity.

We now analyze the effects of the private standard on consumer surplus with respect to the benchmark. This analysis is particularly tedious from the analytical point of view, given

[28]Using (2), (7) and (10), we obtain consumers' surplus $S(e_1)$, for a given standard e_1 (see Appendix for details).

the multiplicity of the above mentioned effects. We have to compare the levels of consumer surplus (in the private standard and in the benchmark situation) for each level of MQS e_0. We provide in the appendix the results of this analytical comparison. However, for the sake of reading simplicity, let us now focus on the most symptomatic result obtained in the situation (2), taking into account the particular case of risk misperception $\xi = 7/5$. Figure 4 represents the benchmark consumer surplus (dotted line) and the consumer surplus arising when the retailer may implement the private standard $e_1^*(e_0)$ (in bold line) as functions of the MQS e_0.

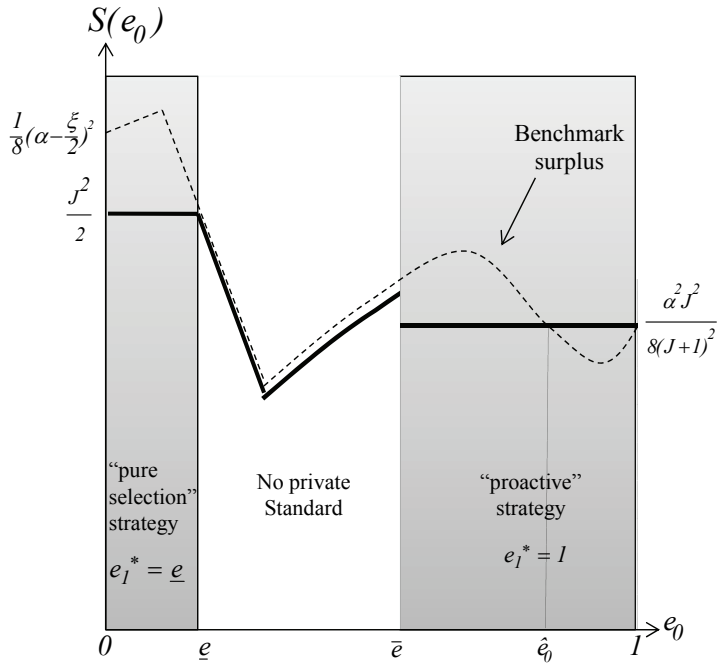

figure 4. *Effectiveness of the private standard for consumers, taking* $\xi = 7/5$

When the retailer implements a private standard with pure selection strategy ($e_1 = \underline{e}(\xi)$ when $e_0 < \underline{e}(\xi)$), consumer surplus is always worsen with respect to the benchmark as a result of the decrease of quantities (see proof in the appendix). Inversely, when the retailer implements a proactive strategy ($e_1 = 1$ when $e_0 > \overline{e}(\xi)$), consumer surplus may be higher than in the benchmark. In the particular case represented in Figure 4, and for the above mentioned contrasting effects of quantity, price and WTP-effect, the benchmark surplus adopts a sinusoidal shape for $e_0 > \hat{e}(\xi)$. In the case the retailer may set a private standard, the implementation of the maximum level of standard implies a discontinuity in $\overline{e}(\xi)$ whereby, in this particular case, we have $S_1(\overline{e}(\xi)) < S_0(\overline{e}(\xi))$. Hence, the private standard with proactive strategy improves consumer surplus with respect to the benchmark, when the MQS is higher than the level $\hat{e}_0$ (see the appendix for details).

The following proposition 4 summarizes the results illustrated in this section.

Proposition 4
Considering the cases where the retailer set-up a private standard more demanding than the MQS, we obtain the following results. If the private standard corresponds to a pure selection strategy ($e_1 = \underline{e}(\xi)$) then the private standard always reduces the market access for upstream producer and it also reduces consumer surplus. If the private standard corresponds to a proactive strategy ($e_1 = 1$) then the private standard always improve the market access for upstream producers and may also improve consumer surplus, while the risk is minimized.
Proof : see Appendix

Synthesizing the results, we have shown that a retail-led strengthening of market access conditions does not necessarily deteriorate the market access for upstream producers. This result notably arises, even if the MQS is relatively high, when the retailer implements a proactive strategy under the "market-incentive" of consumer risk overestimation. In addition, risk overestimation appears to be crucial in determining the private standard effectiveness for consumers: the more consumers overestimate the risk, the higher is the private standard effectiveness for consumers, even if the MQS is relatively high. The situation may thus arise whereby the private standard may be effective for both sides of the market, consumers and upstream producers.

Conclusion

Our paper provides an original contribution as we explicitly consider how both public and private policies are affected by consumers' information about the average quality provided on the market.

We have studied the incentive for the retailer to develop private standards, more constraining that the minimum quality standard set by the public authority, in a context where product's attributes are signalled to consumers (either by the retailer or by third parties) through a communication based on the product's average quality. We have shown that when consumer risk perception is sufficiently high, and even if the MQS is relatively severe, the retailer has interest in developing a more constraining private standard, in order to benefit from the improvement of willingness to pay and thus increase the supplied quantity. Further, we have analyzed the conditions for the effectiveness of private standards for producers and consumers. As for the impact of private standards on producers, we have shown that the retailers' normalization strategy may favour an upgrading of upstream production conditions and, at the same time, an improvement of upstream producers market access. As for the impact of private standards on consumers, we have shown that setting a private standard may, at the same time, improve food safety and consumer surplus.

Empirical evidence shows an increasing use of global business to business (B2B) standards, which are not communicated directly to consumers, in procurement from suppliers and as a governance tool in the food system. In general, investments in quality or quality control mechanisms are seen as a way to build consumer trust and increase the value of a retailer's reputation, once signalled to consumers. But why do retailers exceed the legal MQS, when quality signals are not transmitted to consumers, such as use of EurepGap, or GFSI standards? Some reasons may be put forward. At first, providing consumers with products that meet consistent quality and safety standards that go beyond the minimum requirements builds reputation, the key asset for current and future earnings flows (Fulponi, 2006). Secondly, major processors and retailers implement private standards as instruments for the coordination of supply chains by standardizing product requirements over suppliers (Henson and Reardon, 2005). This becomes of greater importance as supply chains become

more global and cut across differing regulatory, economic and regulatory environments. Private standards may thus be implemented in order to reduce the transaction costs and risks associated with procurement. Thirdly, retailers may be prompted to develop private standards in order to limit exposure to potential regulatory action and/or anticipate future regulatory developments (Lutz et al., 2000) and manage exposure to liability. Our analysis could thus be extended by considering that the public authority jointly uses ex-ante regulation (MQS) and ex-post liability rules. The existence of an expected sanction associated with product's failure and the consequently risk of market share erosion in the long term is thus likely to incentive retailers to implement private standards, even if they are not signalled to consumers (Fulponi, 2006, Henson, 2006).

Moreover, in this paper we explicitly takes into account the dimension of vertical relationships, by considering that the MQS is applied to the upstream retailers, whereas the downstream retailer maintains the strategic flexibility to choose both quantity and quality, given that the upstream supply complies with the MQS. Hence, empirical evidence shows that MQS often concern intermediate products29. In a context where the risk arises both from the upstream production conditions and from the strategic behaviour of the downstream retailer, the MQS may have different effects whether it is applied to the upstream suppliers or to the downstream retailer. This extends our analysis in the larger debate about the optimal public policy between "obligation of means" and "obligation of results". In the latter case, the MQS is applied to the downstream retailer, which is thus constrained in the quality-quantity choice by a level of average quality fixed by the public authority. The question raised is thus whether the retailer has interest in developing a private standard and which are the effects of the different policy instruments on social welfare.

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[29] To the best of our knowledge, the existing literature of minimum quality standards does not take into account the dimension of vertical relationships and almost uniquely deals with MQS concerning final products markets: obligation for a car producer to install airbags, safety standards for pharmaceutical products (Boom, 1995), service quality in the market of local cable television subscription (Besanko et al., 1987) or licensing standards for medical services (Leland, 1979).

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Appendix

Benchmark

By using (2)-(6) we determine the retailer's expected profit for a given standard e_0 and a given quantity x,

$$\pi_0(e_0,x)=\begin{cases}-x^2+[\alpha-\xi\frac{(1-e_0)}{2}]x & if\ x\le\hat{x}_0\\ -\frac{J+1}{J}x^2+[\alpha+(1-e_0)(1-\xi)]x+\frac{J}{2}\xi(1-e_0)^2 & if\ x>\hat{x}_0\end{cases} \quad (A1)$$

For $x\le\hat{x}_0$ the first order condition gives the expression $x(e_0)=\frac{1}{2}[\alpha-\xi\frac{(1-e_0)}{2}]$; we verify that $x(e_0)\le\hat{x}_0=J(1-e_0)$ iff $e_0\le e^-(\xi)$ with $e^-(\xi)$ given by (8). For $x>\hat{x}_0$ the first order condition gives the expression $x(e_0)=\frac{J}{J+1}\Phi(\xi,e_0)$ where $\Phi(.,.)$ is defined by the following,

$$\Phi(\xi,e_0)=\frac{1}{2}[\alpha+(1-e_0)(1-\xi)] \quad (A2)$$

In this case we verify ex-post that $x(e_0)\ge\hat{x}_0=J(1-e_0)$ iff $e_0\ge\hat{e}(\xi)$ with $\hat{e}(\xi)$ given by (8).

Using (8) we easily verify that $e^-(\xi)<\hat{e}(\xi)$ for each $\xi\ge0$. The optimal quantity $x_0^*(e_0)$ is then given by (7). The continuity of this optimal quantity (and of all benchmark expressions) in e_0 is demonstrated noting that $\frac{1}{2}[\alpha-\frac{\xi}{2}(1-e^-(\xi))]=J(1-e^-(\xi))$ and $\Phi(\xi,\hat{e}(\xi))=(J+1)(1-\hat{e}(\xi))$.

By using (3) we easily verify the following. When $e_0\le e^-(\xi)$ and $\xi=0$, $x_0^*(e_0)$ does not depend of e_0; when $e_0\le e^-(\xi)$ and $\xi>0$, $x_0^*(e_0)$ increases in e_0. When $e^-(\xi)\le e_0\le\hat{e}(\xi)$ $x_0^*(e_0)$ decreases in e_0. When $e_0\ge\hat{e}(\xi)$, (i) if $\xi<1$, $x_0^*(e_0)$ decreases in e_0; (ii) if $\xi=1$, $x_0^*(e_0)$ does not depend of e_0 and (iii) if $\xi>1$, $x_0^*(e_0)$ increases in e_0.

Optimal procurement and risk of product failure

By using (2), (9), (11) and (12), we determine the retailer's expected profit $\pi_1(e_1,x)$ as a function of the standard e_1 and for the quantity $x\ge\hat{x}_1$:

$$\pi_1(e_1,x)=-\frac{J+1}{J}x^2+[\alpha+(1-e_1)(1-\xi)]x+\frac{J}{2}\xi(1-e_1)^2 \quad (A3)$$

The first order condition gives the expression $x(e_1)=\frac{J}{J+1}\Phi(\xi,e_1)$ with $\Phi(\xi,e_1)$ defined by (A2). We then verify ex-post that $x(e_1)\ge\hat{x}_1=J(1-e_1)$ if and only if $e_1>\hat{e}(\xi)$ with $\hat{e}(\xi)$ given by (8).The optimal quantity $x_1^*(e_1)$ is then given by (13).We verify the continuity noting $\frac{1}{J+1}\Phi(\xi,\hat{e}(\xi))=1-\hat{e}(\xi)$.

By using (3) and (13) we determine $\tilde{e}(e_1)$:

$$\tilde{e}(e_1)=\tilde{e}(e_1,x^*(e_1))=\begin{cases} e_1 & \text{if } e_1\le\hat{e}(\xi) \\ 1-\dfrac{1}{J+1}\Phi(\xi,e_1) & \text{if } e_1\ge\hat{e}(\xi) \end{cases} \tag{A4}$$

By using (11) and (13) (knowing that we always have $x\ge\hat{x}_1$), we determine the risk $\bar{\sigma}_1(e_1)=\bar{\sigma}_1(e_1,x_1^*(e_1))$:

$$\bar{\sigma}_1(e_1)=\begin{cases} \dfrac{1}{2}(1-e_1) & \text{if } e_1\le\hat{e}(\xi) \\ (1-e_1)[1-\dfrac{J+1}{2\Phi(\xi,e_1)}(1-e_1)] & \text{if } e_1\ge\hat{e}(\xi) \end{cases} \tag{A5}$$

By using (9) and (13), we determine the intermediary price $\omega_1(e_1)=\omega_1(e_1,x^*(e_1))$:

$$\omega_1(e_1)=\begin{cases} 0 & \text{if } e_1\le\hat{e}(\xi) \\ \dfrac{1}{J+1}\Phi(\xi,e_1)-(1-e_1) & \text{if } e_1\ge\hat{e}(\xi) \end{cases} \tag{A6}$$

By using (2), (A5) and (13), we determine the final price $p(e_1)=p(e_1,x_1^*(e_1))$:

$$p(e_1)=\begin{cases} \alpha-\dfrac{1}{2}(1-e_1)(2J+\xi) & \text{if } e_1\le\hat{e}(\xi) \\ \alpha-\dfrac{\xi(1-e_1)(J+1)}{2\Phi(\xi,e_1)}[\dfrac{2}{J+1}\Phi(\xi,e_1)-(1-e_1)]-\dfrac{J}{J+1}\Phi(\xi,e_1) & \text{if } e_1\ge\hat{e}(\xi) \end{cases} \tag{A7}$$

When $e_1\le\hat{e}(\xi)$, the price $p(e_1)$ is an increasing function of e_1. Consequently, since $\alpha>J+\frac{\xi}{2}$, $p(e_1)$ is always positive. When $e_1\ge\hat{e}(\xi)$, then: (i) if $\xi\le 1$, the price $p(e_1)$ increases in e_1, (ii) if $\xi>1$, the price $p(e_1)$ has a local minimum on the interval $[\hat{e}(\xi),1]$, given by:

$$\breve{e}(\xi)=1-\frac{\alpha}{\xi-1}+\frac{\alpha\sqrt{2\xi}(J+1)}{(\xi-1)\sqrt{\xi(J+2)(2J+\xi)-J}} \tag{A8}$$

By substituting (A8) into (A7), we easily verify that $p(\breve{e}(\xi))>0$. We also verify that $p(e_1=1)>p(\hat{e}(\xi))$.

Proof of Proposition 1

By using (13), we easily verify the following. When $e_1\le\hat{e}(\xi)$, $\tilde{e}(e_1)=e_1$ and the optimal quantity $x_1^*(e_1)=J(1-e_1)$ decreases in e_1.When $e_1>\hat{e}(\xi)$, then: (i) if $\xi<1$, the optimal quantity $x_1^*(e_1)$ decreases in e_1, (ii) if $\xi=1$, the optimal quantity $x_1^*(e_1)\equiv\dfrac{\alpha J}{2(J+1)}$ does not depend of e_1, (iii) if $\xi>1$, the optimal quantity $x_1^*(e_1)$ increases in e_1.

Proof of Proposition 2

When $e_1 \le \hat{e}(\xi)$, by using (A5) we easily verify that the risk $\bar{\sigma}_1(e_1)$ decreases in e_1. When $e_1 > \hat{e}(\xi)$, by using (A5) we calculate $\partial\bar{\sigma}_1(e_1)/\partial e_1$ and we verify that: (i) if $\xi \le 1$, $\partial\bar{\sigma}_1(e_1)/\partial e_1 < 0$ on the interval $[\hat{e}(\xi),1]$, (ii) if $\xi > 1$, there exists a local maximum $\tilde{e}(\xi)$ on the interval $[\hat{e}(\xi),1]$, such that the risk increases from $\hat{e}(\xi)$ to $\tilde{e}(\xi)$ and decreases from $\tilde{e}(\xi)$ to 1 ($\partial\bar{\sigma}(e_1)/\partial e_1 \ge 0 \Leftrightarrow e_1 \le \tilde{e}(\xi)$), with $\tilde{e}(\xi)$ given by:

$$\tilde{e}(\xi) = 1 - \alpha\left[\frac{(J+\xi) - \sqrt{(J+1)(J+\xi)}}{(J+\xi)(\xi-1)}\right] \tag{A9}$$

Proof of Proposition 3

Using (12), (13) and (A5)-(A7), we determine the retailer's profit $\pi_1(e_1) = \pi_1(e_1, x_1^*(e_1))$ as a function of the standard e_1:

$$\pi_1(e_1) = \begin{cases} -\frac{J}{2}(2J+\xi)(1-e_1)^2 + \alpha J(1-e_1) & \text{if } e_1 \le \hat{e}(\xi) \\ \frac{J}{(J+1)}[\Phi(\xi,e_1)]^2 + \frac{J}{2}(1-e_1)^2\xi & \text{if } e_1 \ge \hat{e}(\xi) \end{cases} \tag{A10}$$

When $e_1 \le \hat{e}(\xi)$ the profit $\pi(e_s)$ has a local maximum on the interval $[0,\hat{e}(\xi)]$ given by $\underline{e}(\xi)$, such that $\partial\pi_1(e_1)/\partial e_1 \ge 0 \Leftrightarrow e_1 \le \underline{e}(\xi)$, with $\underline{e}(\xi)$ given by (14). We verify that we always have $\underline{e}(\xi) \le \hat{e}(\xi)$ and that $\underline{e}(\xi) \ge 0$ iff $\alpha \le 2J + \xi$. When $e_1 \ge \hat{e}(\xi)$, we verify that $\partial\pi_1(e_1)/\partial e_1 \ge 0 \Leftrightarrow e_1 \ge \breve{e}(\xi)$, with $\breve{e}(\xi)$ given by:

$$\breve{e}(\xi) = 1 - \frac{\alpha(\xi-1)}{(\xi-1)^2 + 2\xi(J+1)} \tag{A11}$$

We easily verify that $\breve{e}(\xi) > \hat{e}(\xi)$ and $\breve{e}(\xi) < 1$ iff $\xi > 1$. Hence, if $\xi \le 1$, the profit $\pi_1(e_1)$ decreases in e_1 on the interval $[\hat{e}(\xi),1]$, and if $\xi > 1$, the profit $\pi_1(e_1)$ has a local minimum $\breve{e}(\xi)$ on the interval $[\hat{e}(\xi),1]$, such that the profit decreases from $\hat{e}(\xi)$ to $\breve{e}(\xi)$ and increases from $\breve{e}(\xi)$ to 1. By using (A10) and (14) we verify that $\pi_1(e_1 = 1) \ge \pi(\underline{e}(\xi))$ iff $\xi \ge 2$. The result of these calculations allows us to distinguish the following cases according to the level of ξ:

(1) When $\xi \le 1$ the profit $\pi_1(e_1)$ has a local maximum on $[0,\hat{e}(\xi)]$ given by $\underline{e}(\xi)$ and decreases in e_1 on $[\hat{e}(\xi),1]$. The retailer's optimal standard's choice $e_1^*(e_0)$ is then given by:

$$e_1^*(e_0) = \begin{cases} \underline{e}(\xi) & \text{if} \quad e_0 < \underline{e}(\xi) \\ e_0 & \text{if} \quad e_0 \ge \underline{e}(\xi) \end{cases} \tag{A12}$$

(2) When $1 < \xi < 2$ the profit $\pi_1(e_1)$ has a local maximum on $[0,\hat{e}(\xi)]$ given by $\underline{e}(\xi)$ and a local minimum $\breve{e}(\xi)$ on the interval $[\hat{e}(\xi),1]$ given by (A11). In addition, we know that in this case $\pi_1(e_1 = 1) < \pi(\underline{e}(\xi))$. We have thus to compare $\pi_1(e_1 = 1)$ with $\pi(e_1)$ on the interval $[\underline{e}(\xi),1]$, by distinguishing according to the relative position of e_1 with respect

to $\hat{e}(\xi)$. We first verify that $\pi_1(e_1=1) \geq \pi(\hat{e}(\xi)) \Leftrightarrow \xi \geq U$, with $U=\sqrt{(J+1)(J+3)}-J$ (and $1<U<2$). Then, we verify that there exists $\overline{e}(\xi) \in [\underline{e}(\xi),1]$ given by:

$$\overline{e}(\xi)=\begin{cases} 1-\dfrac{2\alpha(\xi-1)}{1+\xi(2J+\xi)} & \text{if } 1<\xi\leq U \\ 1-\alpha\left[\dfrac{4(J+1)-\sqrt{8(J+1)(2-\xi)}}{4(J+1)(2J+\xi)}\right] & \text{if } U\leq\xi<2 \end{cases} \tag{A13}$$

whereby $\pi_1(e_1=1) \geq \pi_1(e_1)$ iff $e_1 \geq \overline{e}(\xi)$, with $\overline{e}(\xi)$ decreasing in ξ. More specifically, if $1<\xi\leq U$, then $\hat{e}(\xi) \leq \overline{e}(\xi) < 1$ and if $U\leq\xi<2$, then $\underline{e}(\xi) < \overline{e}(\xi) \leq \hat{e}(\xi)$. The retailer's optimal standard's choice $e_1^*(e_0)$ is given by:

$$e_1^*(e_0)=\begin{cases} \underline{e}(\xi) & \text{if} \quad e_0 < \underline{e}(\xi) \\ e_0 & \text{if} \quad \underline{e}(\xi) \leq e_0 \leq \overline{e}(\xi) \\ 1 & \text{if} \quad e_0 > \overline{e}(\xi) \end{cases} \tag{A14}$$

(3) When $\xi \geq 2$ the profit $\pi_1(e_1)$ has a local maximum on $[0,\hat{e}(\xi)]$ given by $\underline{e}(\xi)$ and is maximised with $e_1=1$.

Finally, we verify that $\pi_1(e_1^*(e_0)) \geq \pi_1(e_0)$.Using (A10) and according to the three cases detailed in Proposition 3, we easily calculate the profit $\pi_1(e_1^*(e_0))$.

Proof of Proposition 4

Given the conditions on ξ and e_0 whereby the retailer sets a private standard as detailed in Proposition 3, we now determine the effects on market access, consumer surplus, and risk.

Effect on market access

The benchmark quantity $x_0^*(e_0)$ is given by (7).

(i) *Private standard with pure selection strategy(when $e_0 < \underline{e}(\xi)$).*

By using (13), we verify that the quantity $x_1^*(e_1^*(e_0))$ is given by $x_1^*(e_1^*(e_0)) = J[1-\underline{e}(\xi)]$. Given that $x_1^*(e_1^*(e_0)) < x_0^*(e_0=0)$ (under hypothesis $\alpha > J+\xi/2$), we verify that $x_1^*(e_1^*(e_0)) < x_0^*(e_0)$ for each level of e_0 whereby $e_0 < \underline{e}(\xi)$.

(ii) *Private standard with proactive strategy(when $\overline{e}(\xi) < e_0 < 1$).*

By using (13), we verify that the quantity $x_1^*(e_1^*(e_0))$ is given by $x_1^*(e_1^*(e_0)) = \dfrac{\alpha J}{2(J+1)}$.

By using (7), we obtain $x_1^*(e_1^*(e_0)) > x_0^*(e_0)$ for each level of e_0 whereby $\overline{e}(\xi) < e_0 < 1$.

Effect on consumer surplus

For a given standard e_s, and a quantity x supplied by the retailer, the consumer surplus $S(e_s,x)$ is given by:

$$S(e_s,x)=\begin{cases} \int_0^x p(t)dt - p(x)x & \text{if } x \leq \hat{x} \\ \int_0^{\hat{x}} p(t)dt + \int_{\hat{x}}^x p(t)dt - p(x)x & \text{if } x \geq \hat{x} \end{cases} \tag{A15}$$

with $\hat{x} = J(1-e_s)$.

For the benchmark situation, $p(x)$ is obtained by substituting (5) into (2) according to the position of x with respect to $\hat{x}_0$. By using (A15), we then obtain $S(e_0,x) = x^2/2$ if $x \le \hat{x}_0$ and if $x \ge \hat{x}_0$ we find the following,

$$S(e_0,x) = \frac{x^2}{2} + \frac{\xi(1-e_0)\hat{x}_0}{2} ln(\frac{x}{\hat{x}_0}) \quad \text{(A16)}$$

By substituting (7)into (A16), we calculate the benchmark consumer surplus as a function of the standard e_0, $S_0(e_0) = S(e_0, x^*(e_0))$:

$$S_0(e_0) = \begin{cases} \frac{1}{8}[\alpha - \xi\frac{(1-e_0)}{2}]^2 & \text{if } e_0 \le e^-(\xi) \\ \frac{\hat{x}_0^2}{2} & \text{if } e^-(\xi) \le e_0 \le \hat{e}(\xi) \\ \frac{y(e_0)^2}{2} + \frac{\xi J}{2}(1-e_0)^2 ln(\frac{y(e_0)}{\hat{x}_0}) & \text{if } e_0 \ge \hat{e}(\xi) \end{cases} \quad \text{(A17)}$$

Where: $y(e_0) = \frac{J}{J+1}\Phi(\xi,e_0) = \frac{J}{2(J+1)}[\alpha + (1-e_0)(1-\xi)]$.

Hence, $S_0(e_0)$ is an increasing function of e_0 on $[0,e^-(\xi)]$ (for $\xi > 0$) and a decreasing function of e_0 on $[e^-(\xi),\hat{e}(\xi)]$.

The suite of the demonstration is analytically particularly complex and we have used simulations to verify the effects announced for specific values of the parameters. Posing $J = 100$ and $\alpha = 180$ (consistent with the frame of hypothesis $J + \xi/2 < \alpha < 2J$), it appears that as ξ is greater than $\hat{\xi} \approx 1.90$ (with $\hat{\xi} \approx 1.90 < U(J=100)$) then $S_0(e_0)$ is an increasing function of e_0 on $[\hat{e}(\xi),1]$. When ξ is less than $\hat{\xi}$ we distinguish the following cases:

- If $\tilde{\xi} \approx 1.60 < \xi \le \hat{\xi} \approx 1.90$ then $S_0(e_0)$ admits a local maximum and a local minimum on $]\hat{e}(\xi),1[$ with maximum surplus achieved for $e_0 = 1$.
- If $1 < \xi \le \tilde{\xi} \approx 1.60$ then $S_0(e_0)$ adopts a sinusoidal shapeon $]\hat{e}(\xi),1[$. Therefore $S_0(e_0)$ admits a local maximum and a local minimum along the interval $]\hat{e}(\xi),1[$ with maximum surplus achieved between $\hat{e}(\xi)$ and 1.
- If ξ $\underline{\xi} \approx 0.55 < \xi \le 1$ then $S_0(e_0)$ admits a local maximum along the interval $]\hat{e}(\xi),1[$ with maximum surplus achieved between $\hat{e}(\xi)$ and 1.
- If ξ is less than $\underline{\xi} \approx 0.55$ then $S_0(e_0)$ decreases on $[\hat{e}(\xi),1]$.

For the situation of private standard, $p(x)$ is obtained by substituting (11) into (2). Knowing that in this case we always have $x \ge \hat{x}_1$, we obtain an equation similar to (A16), only by substituting $\hat{x}_0$ by $\hat{x}_1$. We then write the consumer surplus as a function of the standard e_1, and using (A14), we obtain the expected consumer surplus in the case of private standard $S_1(e_0) = S_1(e_1^*(e_0), x_1^*(e_1^*(e_0)))$. We distinguish two cases according to the level of ξ with respect to U (i.e. to the relative position of $\bar{e}(\xi)$ with respect to $\hat{e}(\xi)$):

-If $1<\xi<U$ (then $\hat{e}(\xi)<\overline{e}(\xi)<1$), consumer surplus $S_1(e_0)$ is given by:

$$S_1(e_0)=\begin{cases}\dfrac{[J(1-\underline{e}(\xi))]^2}{2} & \text{if } e_0 \le \underline{e}(\xi)\\ \dfrac{\hat{x}_0^2}{2} & \text{if } \underline{e}(\xi) \le e_0 \le \hat{e}(\xi)\\ \dfrac{y(e_0)^2}{2}+\dfrac{\xi J}{2}(1-e_0)^2 \ln\left(\dfrac{y(e_0)}{\hat{x}_0}\right) & \text{if } \hat{e}(\xi) \le e_0 \le \overline{e}(\xi)\\ \dfrac{\alpha^2 J^2}{8(J+1)^2} & \text{if } e_0 \ge \overline{e}(\xi)\end{cases} \tag{A18}$$

Hence, $S_1(e_0)$ is constant on $[0,\underline{e}(\xi)]$ and a decreasing function of e_0 on $[\underline{e}(\xi),\hat{e}(\xi)]$. Using the same simulation values as previously illustrated, we verify that $S_1(e_0)$ increases in e_0 (or has a local maximum) on $[\hat{e}(\xi),\overline{e}(\xi)]$ and then is constant on $[\overline{e}(\xi),1]$. Note that $S_1(e_0)$ is discontinuous on $e_0=\overline{e}(\xi)$ and $S_1(\overline{e}_-)$ may be less or greater than $S_1(\overline{e}_+)$. Using simulations we verify that $S_1(\overline{e}_-)>S_1(\overline{e}_+)$ if ξ is less than $\xi' \approx 1.45$ (with $\xi'<\tilde{\xi}$ previously defined). Consumer surplus $S_1(e_0)$ given by (A18) is the case represented in Figure 4 ($\xi = 1.4 < \xi' \approx 1.45$).

- If $U \le \xi < 2$ (then $\underline{e}(\xi)<\overline{e}(\xi)\le\hat{e}(\xi)$), consumer surplus $S_1(e_0)$ is given by:

$$S_1(e_0)=\begin{cases}\dfrac{[J(1-\underline{e}(\xi))]^2}{2} & \text{if } e_0 \le \underline{e}(\xi)\\ \dfrac{\hat{x}_0^2}{2} & \text{if } \underline{e}(\xi) \le e_0 \le \overline{e}(\xi)\\ \dfrac{\alpha^2 J^2}{8(J+1)^2} & \text{if } e_0 \ge \overline{e}(\xi)\end{cases} \tag{A19}$$

Hence, $S_1(e_0)$ is constant on $[0,\underline{e}(\xi)]$, a decreasing function of e_0 on $[\underline{e}(\xi),\overline{e}(\xi)]$, and constant on $[\overline{e}(\xi),1]$. Note that in this case $S_1(e_0)$ is continuous on $e_0=\overline{e}(\xi)$.

Given (A17)-(A18), we then verify the following:

(i) Private standard with pure selection strategy (when $e_0<\underline{e}(\xi)$).

In this case $e_1^*(e_0)=\underline{e}(\xi)\le\hat{e}(\xi)$. By using (A18), we obtain the optimal surplus $S_1(e_0)=S_1(e_1^*(e_0))\equiv\dfrac{[J(1-\underline{e}(\xi))]^2}{2}$. Given that $\dfrac{[J(1-\underline{e}(\xi))]^2}{2}<S_0(e_0=0)$ (under the hypothesis $\alpha>J+\xi/2$) and that $S_1(\underline{e})=S_0(\underline{e})$, we verify that $S_1(e_0)<S_0(e_0)$ for each level of e_0 whereby $e_0<\underline{e}(\xi)$.

(ii) Private standard with proactive strategy (when $\overline{e}(\xi)<e_0<1$).

In this case $e_1^*(e_0)=1>\hat{e}(\xi)$. By using (A18), we obtain the optimal surplus $S_1(e_0)=S_1(e_1^*(e_0))\equiv\dfrac{\alpha^2J^2}{8(J+1)^2}$.

Given $S_1(e_0)$ for each level of e_0 whereby $\bar{e}(\xi) < e_0 < 1$ and simulations on the variations of $S_0(e_0)$ on $[\hat{e}(\xi),1]$ previously detailed, and given that $S_1(\bar{e}(\xi)) < S_0(\bar{e}(\xi))$ if $1 < \xi < \xi'$, we now compare $S_1(e_0)$ and $S_0(e_0)$ on $[\bar{e}(\xi),1]$. The following situations may arise corresponding to increasing levels of ξ in this context:

- If $1 < \xi < \xi'$, consumer surplus $S_0(e_0)$ adopts a sinusoidal shapeon $]\hat{e}(\xi),1[$ with maximum surplus achieved between $\hat{e}(\xi)$ and 1, and $S_1(\bar{e}(\xi)) < S_0(\bar{e}(\xi))$: hence, there exist $\hat{e}_0$ (with $\bar{e}(\xi) < \hat{e}_0 < 1$) whereby $S_1(e_0) > S_0(e_0)$ iff $\hat{e}_0 < e_0 < 1$. (figure 4)

-If $\xi' < \xi < \tilde{\xi}$, consumer surplus $S_0(e_0)$ adopts a sinusoidal shapeon $]\hat{e}(\xi),1[$ with maximum surplus achieved between $\hat{e}(\xi)$ and 1, and $S_1(\bar{e}(\xi)) > S_0(\bar{e}(\xi))$; hence, there exist $\hat{e}'_0$ and $\hat{e}_0$ (with $\bar{e}(\xi) < \hat{e}'_0 < \hat{e}_0 < 1$), whereby $S_1(e_0) > S_0(e_0)$ if $\bar{e}(\xi) < e_0 < \hat{e}'_0$ or $\hat{e}_0 < e_0 < 1$,

- If $\tilde{\xi} < \xi < \hat{\xi}$ consumer surplus $S_0(e_0)$ admits a local maximum and a local minimum on $]\bar{e}(\xi),1[$ with maximum surplus achieved for $e_0 = 1$, and $S_1(\bar{e}(\xi)) > S_0(\bar{e}(\xi))$; hence, $S_1(e_0) > S_0(e_0)$ for each level of e_0 whereby $\bar{e}(\xi) < e_0 < 1$.

- If $\hat{\xi} < \xi < U$ consumer surplus $S_0(e_0)$ increases in e_0 on $]\bar{e}(\xi),1[$ and $S_1(\bar{e}(\xi)) > S_0(\bar{e}(\xi))$; hence, $S_1(e_0) > S_0(e_0)$ for each level of e_0 whereby $\bar{e}(\xi) < e_0 < 1$.

- If $U < \xi < 2$ consumer surplus $S_0(e_0)$ decreases in e_0 from $\bar{e}(\xi)$ to $\hat{e}(\xi)$ and then increases from $\hat{e}(\xi)$ to 1 with $S_1(\bar{e}(\xi))) = S_0(\bar{e}(\xi))$; hence, $S_1(e_0) > S_0(e_0)$ for each level of e_0 whereby $\bar{e}(\xi) < e_0 < 1$.

Effect on the risk

By substituting (7) into (5) we first verify that the average risk $\bar{\sigma}_0(e_0)$ in the benchmark situation is given using (A5) after posing $e_1 = e_0$.

-*Private standard with pure selection strategy*. By using (A5), we verify that the risk $\bar{\sigma}_1(e_1^*(e_0))$ is given by $\bar{\sigma}_1(e_1^*(e_0)) = \frac{1}{2}(1 - \underline{e}(\xi))$, then $\sigma_1(e_1^*(e_0)) < \sigma_0(e_0)$ for each level of e_0 whereby $e_0 < \underline{e}(\xi)$.

-*Private standard with proactive strategy*. By using (A5), we verify that the risk $\bar{\sigma}_1(e_1^*(e_0))$ is given by $\bar{\sigma}_1(e_1^*(e_0)) = 0$, then $\sigma_1(e_1^*(e_0)) < \bar{\sigma}_0(e_0)$ for each level of e_0 whereby $\bar{e}(\xi) < e_0 < 1$.