Using Private Food Safety Standards to Manage Complexity: A Moral Hazard Perspective

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Abstract

Private food safety standards (PFSS) are widely adopted by firms in the agro-food system, as they meet an increasing consumer demand for safety and quality. Yet, recent economic literature found that PFSS might serve other purposes than just ensuring food safety. Our paper contributes to this literature, framing PFSS within a contract-theory model. We conclude that PFSS can be used to lower the coordination costs along the supply chain and that their effects go beyond ensuring the production of quality and safety attributes. The model shows that PFSS can reduce the cost of solving moral hazard problems for non-discriminating buyers facing heterogeneous suppliers. Noticeably, the opportunism may concern any of the many dimensions of the transaction, without being limited to the production of quality or safety attributes that are normed by the standard.

The optimal strategy requires that the supplier's adoption cost of the standard must be a non-negligible specific investment. This condition explains why we observe PFSS that are heterogeneous (i.e., the certification cannot be used in other transaction freely) and much more rigorous than public regulations (i.e., they require incremental costs).

Keywords*: Private food safety standard; Supply chain management; Moral hazard*

1. Introduction

In the last decades, food retailers[1] have put considerable effort in establishing sets of contractually-binding rules (the private food safety standards) to ensure the safety of their products, meeting an increasing consumer demand for safe food (Reardon et al. 2001; Henson and Reardon 2005). Retailers adopted strict safety standards to maintain a

[1] For simplicity, we use the term "retailer" to indicate the variety of buyers (such as supermarkets, processing firms, etc.) requiring that suppliers adopt a PFSS. Similarly, we summarize in the term "suppliers" the variety of agents implementing PFSS, including farmers, processing firms, cooperatives, etc.

reputation and avoid possible liability (Henson and Humphrey 2009; Marcoul and Veyssiere 2010). Furthermore, food safety and quality assurance affects the cost of carrying out transactions, providing incentive for adopting voluntary quality assurance systems (Holleran et al. 1999).

This paper investigates the benefits that firms can obtain by adopting private food safety standards (PFSS), in addition to the above-mentioned obvious advantages of ensuring the delivery of safe food. To address the study question we develop a principal-agent model focusing on a single transaction between a retailer and a supplier. The retailer buys a product from the supplier and he/she resells it to a consumer. Complexity arises because consumers demand a large bundle of attributes Z including safety, quality and many other dimensions. In order to meet consumer demand and achieve efficiency, the retailer requires that the supplier delivery a bundle of attributes T, including Z and all other attributes that can increase the efficiency of the supply chain. Because some attributes in the set T are not observable, the retailer requires that suppliers adopt a PFSS. The standard monitors a subset $X \subset T$ of attributes directly, preventing opportunistic behavior with respect to such quality and safety attributes.[2,3] Our objective is to investigate if PFSS can attenuate the opportunism problem with respect to the set T-X of attributes that are not covered by the standard. It is important to stress that the suppliers' opportunism we focus on does not concern the delivery of product attributes that are normed by the PFSS. It may affect any other aspect of the supplier - customer interaction – for example information management, finance or other dimensions of the transactions.

The study question is relevant because transactions along the supply chains are becoming more and more complex (Arshinder et al. 2008). Consumers are attaching new demand to food consumptions and the vector of attributes that they require from the retail industry is increasing in dimension. Similarly, integrated logistics, global sourcing and consumer-oriented supply are associated with more complex supplier-buyer interaction. Modern retailers' supply chains require a high degree of coordination and cooperation among suppliers and customers at all levels to manage such complexity and produce value for consumers and achieve efficiency (e.g. Duffy and Fearne 2004, Goodhue 2011). In this context, opportunistic behavior can be a source of transaction costs and cause a substantial decrease in the gain from coordination (e.g. Loader 1997).

Our key finding is that PFSS can be used strategically to reduce the cost that buyers must bear to ensure that heterogeneous suppliers deliver unobservable attribute set T-X. PFSSs have an indirect effect in improving the efficiency of the buyers' supply chains with respect to aspects that are not directly related to food safety and quality. Such benefit adds up to the direct effect of PFSS, which is the monitoring of quality and safety. Consequently, overlooking the indirect effect might result in an undervaluation of the benefits of PFSSs.

The paper is organized as follows. In section 2 we provide a brief overview of the PFSS and a summary review of related literature. In section 3 we illustrate the theoretical model, and in section 4 we summarize our conclusions.

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[2] For the purpose of this paper we define opportunistic a supplier who purposely fails to deliver an unobservable attribute.

[3] There are multiple possible reasons why PFSSs do not monitor the whole set T. For example, some attributes are costly to monitor and/or not related to quality or safety.

2. Private Food Safety Standards and supply chain coordination

A PFSS is a set of voluntary rules that are binding under a contractual agreement. These private standards lead retailers to reduce the use of the spot market and establish formalized contractual relationships, as vertical alliances, with the suppliers (Giraud-Héraud et al. 2006). Such rules establish controls and conformance in the production, transport and processing of food. Although the provisions of the standards focus primarily on food safety, over time their scope has been evolving and nowadays many PFSS include rules about a broad set of issues such as animal welfare, packaging or environmental responsibility. Ultimately, PFSS is not confined to product certification, but a retailer can require it suppliers to provide a number of additional requests, not connected with the safety, as specific technologies and logistics activities.[4]

The PFSS provisions are stricter than existing public regulation and the agreement including the PFSS can be costly to implement under systems of production (Jaffe and Henson 2004). In exchange of such sizable investments, retailers grant suppliers market access and the benefit of an integrated logistics and information system. Usually retailers do not offer a price premium because the certification is considered a prerequisite to enter the transaction (Mènard and Valceschini 2005). Private food safety standards create the preconditions for the establishment of a partnership between the actors, justifying the flow of information in addition to the movement of materials and services and involves the supply of specific resources (Russell and Taylor 2009).

The implementation of a PFSS is based on a multilateral agreement. The retailer requires that the supplier obtains a certification by a third-party agent (or by a retailer's agent) who ensures that the goods and the production process comply with the standard requirements. Suppliers pay the costs of the certification process. Retailers bear the cost of participating to the definition of the standard and to connect with the third party certifier, but this cost is almost fully passed onto suppliers (Hatanaka et al. 2005; Graffham et al. 2007; Fischer et al. 2009).

Our contribution focuses on the economic implications of PFSSs. The literature about this topic is extensive, fully developing since early 00s when the topic became a major research subject (Hammoudi et al. 2009). Contributions can be divided into two main groups.

A first set of papers study PFSS as a tool to improve efficiency. Scholars noted that PFSSs reduce transactions costs and uncertainties between upstream suppliers and downstream retailers (Dolan and Humphrey 2000), improve the supply chain management (Humphrey and Schmitz 2001; Fulponi 2006; OECD 2006; Kariuki et al. 2012) and promote the competitive advantage for retailers and suppliers (Casella 1997; 2001).

[4] PFSS can be of two different types: firm-specific standards and collective standards (Berdegué et al., 2005; Codron et al. 2005; Giraud-Héraud et al. 2006). Retailers can implement firm-specific private standards that are defined, controlled and used by an individual retailer (e.g. Tesco Nature's Choice and Filières Qualité Carrefour). Collective standards (such as BRC, IFS and Globalgap) are developed by independent organizations and are adopted by more than one retailer. Usually the standard is defined in partnership with major retailers and its content reflects their requirements about food safety and quality. In recent years several individual and collective standards have been introduced and the heterogeneity of PFSS is increasing.

Humphrey (2008) found that PFSS might help manage the supply chain when global sourcing increases distances, fragmentation and cultural diversities among operators. Other authors stressed that PFSS are a mean of facilitating information transmission and foster innovation (Humphrey and Schmitz 2001; Arfini and Mancini 2004; Asfaw et al. 2007; Henson and Humphrey 2009).

A second group of contributions discuss the strategic use of PFSS. The provisions of the private standards used in the supply chain can affect distribution of the market power and limit supplier autonomy (Charlier and Valceschini 2010). PFSS can be used to improve bargaining power towards suppliers (von Schlippenbach and Teichmann 2012), create entry barriers against small suppliers (e.g. Hobbs 2010; García Martinez et al. 2004; Balsevich et al. 2003; Boselie et al. 2003) or even to pre-empt and influence public regulation about food safety (McCluskey and Winfree 2009; Lutz et al. 2000).

Our paper contributes to the first field of literature using a principal-agent model to discuss the use of PFSS to reduce the cost of solving moral hazard problems along the supply chain. Such approach is well-established in the economic literature about food safety. For example Weiss (1995) considered the impact of information issues on both suppliers and buyers in the market for food safety, Starbird (2005) applied a principal-agent model to study the impact of sampling inspections, Hirschauer and Musshoff (2007) modeled efficient contract design under incomplete and costly inspections, King et al. (2007) presented a dynamic principal-agent analysis of incentive systems for Salmonella control, Resende-Filho and Buhr (2008) discussed the optimal level of investment in traceability and the level of incentive payments in the beef industry.

The mentioned literature focuses on the direct effect of the food safety monitoring system (such as inspections, traceability or standards), which is the providing of safe food. The original contribution of our study is the focus on the indirect effect of the PFSS on opportunistic behavior regarding the attributes that are not covered by the standard provision.

3. The model

We developed a simple theoretical model to find out if retailers can use PFSS to lower the cost of solving moral hazard problems attaining the delivery of product attributes that are not monitored in the certification process (the set T-X defined in the introduction to the paper). We refer to this possible benefit as an indirect effect of PFSS, which adds up to the obvious direct effect, the delivery of safe food.

In our analysis we use a principal-agent model, focusing on a single transaction between a retailer and a supplier. The retailer may or may not require that the supplier adopts and complies with a PFSS as a prerequisite for the transaction.[5]

[5] In our presentation of the model we focus on firm-specific PFSS because they can be represented as a simpler model. However, the results can be easily generalized to include collective PFSS. The main modeling difference is that, if a collective standard is adopted, the retailer cannot set the technical provisions of the standard (and the consequent adoption cost) freely, but a compromise with other stakeholders must be found. A collective standard incorporate the inputs of multiple retailers who might face different market conditions and/or suppliers. The resulting technical provisions can be considered as an attempt to compose the different requirements. Therefore, the optimal contract in section 3.2 can

The simplest way to model the study questions to assume that again from coordination (G) depends on the delivery of a "critical attribute" provided by the supplier.[6] Such critical attribute belongs to the set T-X of attributes that are not covered by the standard, and it represents an action that the supplier must take to ensure that an efficient coordination is achieved.[7] If the suppliers deliver the product without such critical attribute, the transaction fails and gain from coordination is lost. - G may represent a cost reduction or an increase in the value of the good or any other factor resulting in a profit increase above the level achieved in the absence of coordination. For example, if the critical attribute is the compliance with the requirements of the retailer's integrated logistic system, G may measure a reduction in the cost of logistic services. In order to focus on the moral hazard problem and minimize the algebraic complication we assume that the value of the gain from efficient coordination (G) is exogenously determined.

Our thesis is that, if a PFSS is adopted, the retailer must pay a smaller incentive to the supplier to avoid opportunistic behavior (i.e., to ensure that the supplier delivers the critical attribute). The moral hazard problem may arise because

i) the production of the critical attribute is costly for the supplier and
ii) the retailer cannot monitor the suppliers' effort and can only observe the outcome of the transaction (i.e., G).

The moral hazard problem can be discussed using a principal-agent model. A profit-maximizing principal (the retailer) offers a profit-maximizing agent (the supplier) the following contract on a take-it-or-leave basis: the supplier delivers the retailer an exogenously determined quantity of the product with the critical attribute and – in exchange – he/she receives an extra-compensation Δ in addition to the current spot market price. If the supplier fails to deliver the critical attribute the compensation is reduced by a penalty equal to $(1-p)\Delta$. The parameter Δ is the premium for the delivery of the critical attribute (it is not a premium for complying with the PFSS, which is assumed a prerequisite for entering the transaction). Δ summarizes the economic value of the benefits that the supplier receives when entering the transaction: it may include a price premium, logistic services, training, information, consulting, other benefits or any combination of

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be considered as the retailer's "ideal contract" and he/she will choose the collective standard that is closest to such ideal contract among the available alternatives. Nevertheless, the basic incentive mechanism that we describe for firm-specific PFSS is applicable to collective standards.

In the case of a collective standard, supplier's investment exhibits a lower degree of specificity because the certified supplier can enter in a transaction with other retailers. This circumstance can be captured in the model assuming that p (the expected share of benefits that the supplier can retain in the case of opportunistic behavior) is higher under a collective standard than under a firm-specific one.

[6] The gain from coordination G we focus on in our model is not related to value of safe food, because this is assumed to be ensured by the delivery of the attribute set X, that are disciplined by the standard. To the purpose of this paper we define the gain from coordination as the increase in the aggregate supplier-retailer profits that is achieved if they act according to the contractual agreement (i.e., if the agent delivers the critical attribute) compared to the profits they achieve if they act independently (i.e., the critical attribute is not delivered).

[7] Obviously, the adoption of a PFSS solves the information asymmetries concerning the product attributes that are normed by the standard, because the third-party certifier can observe them directly. The critical attribute that we refer to in the model concerns any of the dimensions of the transaction that are not covered by the PFSS.

the above. The parameter p is the fraction of Δ that the supplier can expect to keep if he/she fails to deliver the critical attribute. It may represent the probability of avoiding detection/liability, the share of benefit that is cashed in before the transaction (for example, logistic services, training, information) or any value the supplier can retain. In order to focus on the case of interest we assume that $p \in (0, 1]$.[8] We assume that the agent is randomly drawn from an infinite number of possible suppliers that are homogeneous except for the cost of providing the critical attribute (c_A), which is uniformly distributed with $c_A \in [C_L, C_H]$ and $0 < C_L < C_H$ where C_L is the production cost of the critical attribute for the most efficient supplier and C_H is the cost for the least efficient supplier.

If the supplier rejects the contract, he/she can sell the product to an outside option. In this case the profit is normalized to zero.[9] If the agent signs the contract and delivers the critical attribute, his/her profit is equal to $\Delta - c_A$. If the agent behaves opportunistically, he/she signs the contract and fails to deliver the critical attribute. In this case he/she saves the cost c_i and gains $p\Delta$. Equation (1) summarizes the supplier's payoff.

$$\pi_A = \begin{cases} 0 & \text{outside option} \\ \Delta - c_A & \text{deliver the attribute} \\ p\Delta & \text{oppurtunism} \end{cases} \tag{1}$$

The agent chooses his/her action according to a profit-maximization principle. To simplify the discussion we assume that the agent signs the contract if the profit is non-negative and chooses an opportunistic behavior only if the profit from opportunism is strictly greater than the profit from delivering the attribute.

The principal's profit depends on the agent's action. If the supplier rejects the contract, the principal can offer the contract to another agent or can purchase the product without the critical attribute from an outside seller. We normalize the principal's profit from the outside option to zero, meaning that the gain from coordination is lost. If the supplier delivers the critical attribute, the principal can collect the gain from coordination (G) and pays the compensation Δ to the agent. If the supplier behaves opportunistically, the principal cannot collect the gain from coordination and still must bear the cost of the unrecoverable benefits paid to the agents ($p\Delta$). Equation (2) summarizes the principal's payoff.

$$\pi_P = \begin{cases} 0 & \text{outside option} \\ G - \Delta & \text{the critical attribute is deliverd} \\ -p\Delta & \text{oppurtunistic supplier} \end{cases} \tag{2}$$

If the principal could observe the actions of the agents, the solution of the problem was simple: he/she could offer a compensation $\Delta = c_A$ and monitor the delivery of the critical attribute. In this case, the principal could take the full gain from trade $G - c_A$.

If the retailer cannot monitor the supplier's action, the moral hazard problem occurs. A perfectly discriminant principal can set the value of Δ based on the agent's actual cost of providing the critical attribute and can design an optimal contract by solving the following problem:

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[8] If $p = 0$, there is no incentive to opportunism, as it will be apparent shortly.

[9] Normalizing the profits from the outside option to zero implies that the profits from the other options are expressed as deviations.

$$\min(\Delta) \text{ s.t.}$$

$$\Delta - c_A \geq p\Delta \tag{3}$$

$$0 \leq \Delta \leq G \tag{4}$$

where constraint (3) summarizes both the Individual Rationality (IR) constraint (being $p\Delta \geq 0$ by construction) and the Incentive Compatibility (IC) constraint.[10] The inequality requires that the gain from delivering the critical attribute is greater than or equal to the gain from cheating. Constraints (4) require that the principal gains non-negative profits from the contract and restrict the compensation to be non-negative.

The solution of the program is:

$$\Delta_{PD} = \begin{cases} \dfrac{c_A}{1-p} & \text{if } c_A \leq (1-p)G \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

By offering $-\Delta_{PD}$ the perfectly discriminant principal gives no incentive to opportunistic behavior and gains non-negative profits.[11] As expected, the derivative of Δ_{PD} with respect to c_A is strictly positive.

This solution requires that the contract is tailored to the supplier's cost function. If such form of price discrimination is not feasible, the value of Δ must be determined as if the value c_A is not known by the principal.[12] For simplicity, we refer to a principal who cannot offer different Δ's for the same service (the delivery of the product with the critical attribute) to different types of agents as a non-discriminating principal.[13]

We compare the solution of the problem with or without the adoption of a PFSS and find that the standard can increase the principal's profits.

To simplifying the discussion, we restrict the analysis to the case that $C_H(1-p)^{-1} \leq G$ (i.e., the upper bound in constraints (4) is not binding for any c_A in the range $[C_L, C_H]$).

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[10] The individual rationality (IR) constraint states that the agent must have incentive to sign the contract. In this setting it requires that the profit from the contract is greater or equal than the profit from the outside option, which is zero. The Incentive compatibility (IC) constraint states that the agent must not have incentive to opportunistic behavior. In this setting, it requires that agent's profit from delivering the critical attribute must be greater or equal to the gain from opportunism.

[11] Offering $\Delta_{PD} = 0$ implies that the principal is buying the product on the spot market.

[12] The solution (5) requires that first the supplier is randomly selected and his/her cost structure is observed, then the contract is offered. This scheme might be unfeasible for many reasons. For example, such form of price discrimination might be illegal: regulations against offering different prices for the same goods or services (in this case, the product with the critical attribute) do exist in many countries. An alternative assumption is that the supplier cost is not observable. In the latter case, we have a combination of two classic asymmetric-information problems: moral hazard (hidden action) and adverse selection (hidden type). The model shows that the adoption of PFSS can solve both problems and prevent the efficient suppliers from gaining an information rent. To the purpose of our model, the PFSS can improve coordination as long as the principal cannot offer different Δ's to heterogeneous producers, regardless of the reason why this might happen.

[13] As is it will be shown in Case 2, the adoption of PFSS can create a separating equilibrium where inefficient suppliers have no incentive to accept the contract and therefore the principal can "discriminate" them. The term "non-discriminating" simply refers to the absence of price discrimination against agents.

The conclusions of the paper fully hold, though, if this assumption is relaxed.

Case 1. No PFSS

Assume that a principal offers an arbitrary compensation Δ, with $\Delta \in \left[\frac{C_L}{1-p}, \frac{C_H}{1-p}\right]$, to a randomly selected agent before the value of c_A is revealed. The agent always signs the contract –regardless of the value of c_A – because the value of the contract (i.e, max $(\Delta - c, p\Delta)$) is always equal or greater than the value of the outside option by construction. The supplier chooses to deliver the critical attribute only if $\Delta \geq \Delta_{PD}$ (i.e. if $\Delta(1-p) \geq c_A$) and behaves opportunistically otherwise. For any given value of Δ the unconditional probability that a supplier fails to deliver the critical attribute is:

$$\lambda(\Delta) = \frac{C_H - \Delta(1-p)}{C_H - C_L}. \tag{6}$$

A risk-neutral principal maximizes the expected profits taking into account that increasing values of Δ decrease the probability of opportunistic behavior but decrease the payoff in each state. The principal expected profit from the contract is defined by equation

$$E(\pi_{NDP}) = [1-\lambda(\Delta)](G-\Delta) + \lambda(\Delta)(-p\Delta). \tag{7}$$

The value of Δ that maximizes equation (7) subject to the constraint $0 \leq \lambda(\Delta) \leq 1$ is:

$$\Delta_{NDP} = \min\left[\frac{C_L}{1-p} + \frac{(G-C_L)(1-p)-(C_H-C_L)p}{2(1-p)^2}, \frac{C_H}{1-p}\right].$$

Since $G > \frac{C_H}{1-p}$ by assumption, $\Delta_{NDP} > \frac{C_L}{1-p}$.

In the absence of PFSS, the principal maximizes the expected profits offering the supplier a compensation equal to Δ_{NDP} and facing the probability $\lambda(\Delta_{NDP})$ of suffering from the agent's opportunistic behavior.[14] In the next section we show that a non-discriminating principal adopting a PFSS can pay a compensation Δ_{PFSS} such that $\Delta_{PFSS} < \Delta_{NDP}$ and $\lambda(\Delta_{PFSS}) \leq \lambda(\Delta_{NDP})$. Moreover we show that if $\Delta_{PFSS} = \Delta_{NDP}$ then $\lambda(\Delta_{PFSS}) < \lambda(\Delta_{NDP})$. The proof shows that the adoption of PFSS strictly dominates the strategy without PFSS.

Case 2. Adopting PFSS

In this section we show that the retailer can achieve higher profits by imposing a PFSS to suppliers. In order to focus on the coordination issues, we assume that the adoption of a PFSS

i) does not affect consumer demand (i.e., it does not affect G) and
ii) does not increase the probability of ex-ante detection of opportunistic behavior (i.e., it does not affect p).

[14] Note that $E(\pi_P)$ is greater or equal zero for $\Delta = C_H(1-p)^{-1}$ and $G \geq C_H(1-p)^{-1}$. This result implies that the principal always maximized expected profits by offering a contract.

In this way, any increase in retailer's profits is due to the coordination effect alone.[15]

We assume that the function $K = f(\text{PFSS})$, linking the implementation cost to the technical provisions of the PFSS, is public knowledge. Thus, the principal can choose any given value of K, by setting the technical requirements of the standard strategically.[16]

We model the adoption of the standard as a specific sunk cost (K) paid by the supplier.[17] Unlike c_A, K is observable by the retailer because the adoption of the standard and the implementation of the safety system is ascertained by a third party organization (or by the retailer itself).For simplicity, we assume that K is equal for all suppliers.

If a PFSS is adopted, the contract has two strategic variables: the compensation Δ (paid by the principal) and the adoption cost K (paid by the agent). Note that, consistent with the observed business practice, the retailer does not offer a price premium for the adoption of the PFSS, as Δ – the benefit of entering in a transaction with the retailer – is the incentive for the delivery of the critical attribute, not for the PFSS adoption. As mentioned in section 2, the adoption of the standard (i.e., the payment of the cost K) is a pre-requisite for being offered a contract.

The principal can choose a pair K^*, Δ^* such that

i) inefficient suppliers (with $c_A > C_L$) have no incentive to sign the contract,
ii) Δ the expected profits of a non-discriminating principal are maximized
iii) $\lambda(\Delta^*)$ is equal to zero (no opportunistic behavior) and
iv) the agents gains zero profits (the principal keeps the whole gain from trade).

If a PFSS is adopted, the supplier's profits are defined in equation (8):

$$\pi_A = \begin{cases} 0 & \text{outside option} \\ \Delta - c_A - K & \text{deliver the attribute} \\ p\Delta - K & \text{oppurtunistic behavior} \end{cases} \tag{8}$$

Equation (8) is derived from equation (1) by subtracting the cost K if the supplier enters the transaction with the principal.

The principal sets K and Δ to maximize the expected profits (equation (7)) under two

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[15] These assumptions simplify the comparison and the main conclusions of the analysis still hold if they are relaxed. The PFSS increasing G is the mainstream justification for adoption. Our goal is to show that PFSS can act as a device to increase coordination along the supply chain beyond their effects on consumers' willingness to pay or the direct monitoring of product characteristics.

[16] In retailer's PFSS (see section 2) the principal can set K directly. In collective PFSS, the Standard Organization (such as IFS or GlobalGap) sets K taking into account retailers' demand. Usually, retailers are members of the board or sit in steering committees of Standard Organizations and have a non-negligible influence in the definition of the technical provisions of the collective PFSS. To simplify the discussion we overlook the distinction between collective and retailer's PFSS in the model, but the general conclusions of the paper hold as long the retailer can influence the Standard Organization.

[17] K represents the costs that suppliers are forced by the retailers to bear to apply the quality standard and obtain a certification. Such costs are not instantaneous and usually suppliers must undergo a time period when they are under strict confirmation surveillance. This fact implies that K is paid in advance and well before time zero when the supplier-retailer transaction happens. Consequently, K must be considered as the present value at time zero of investment the supplier paid to obtain the certification in advance.

constraints:

(9) $\Delta - c_A - K \geq p\Delta - K$ (IC)

(10) $\Delta - c_A - K \geq 0$ (IR)

The two constraints state that the supplier's profits from delivering the critical attributes must be greater or equal to the gain from opportunism (equation (9) and greater than or equal to the gain from the outside option (equation 10).

The constraints (9) and (10) are jointly satisfied for any pair $\bar{\Delta}$ and $\bar{K}$ such that:

(11) $\bar{\Delta} \in \left[\frac{c_A}{1-p}, \frac{C_H}{1-p}\right]$ and $\bar{K} \in [p\bar{\Delta}, \bar{\Delta} - c_A]$.

If the principal offers a contract that satisfies conditions (11), there is no incentive to opportunistic behavior, because the gain from opportunism is always non-positive. The supplier maximizes his/her own profits by signing the contract and delivering the critical attribute.

Now, assume that the principal chooses an arbitrary value $c_X \in [C_L, C_H]$ and offers the supplier a contract

$$\{\Delta_X, K_X\}, \text{ where } \Delta_X \in \left[\frac{c_X}{1-p}, \frac{C_H}{1-p}\right] \text{ and } K_X \in [p\Delta_X, \Delta_X - c_A].$$

This contract satisfies the IC and IR for any supplier such that $c_A \leq c_X$. Such supplier maximizes its own profits signing the contract and delivering the critical attribute. Any supplier with $c_A > c_X$ has no incentive to enter the transaction because he/she gains negative profits from signing the contract. Thus, for any arbitrary value of c_X, the contract $\{\Delta_X, K_X\}$ makes the probability of opportunistic behavior $\lambda(\Delta_X)$ equal to zero.

Because agents have no incentive to opportunism, the profits of a principal offering a contract $\{\Delta_X, K_X\}$ can be rewritten as:

(12) $\pi_{NDP} = G - \Delta_X$,

which is monotonically decreasing in Δ_X. The principal maximizes profits minimizing the value of the benefits provided to the agent, that is setting $\Delta^* = \frac{C_L}{1-p}$ and $K^* = p\Delta^*$. The optimal strategy for the principal is to offer a contract $\{\Delta^*, K^*\}$ and iterate the offering until an agent accepts the contract. Any agent entering the transaction is an efficient supplier (i.e., $c_A = C_L$) who has no incentive to behave opportunistically.

Figure 1 illustrates this result. The contract space (the set of all possible combinations of Δ and K) is broken down into four areas. If $K \geq \max(p\Delta, \Delta - C_L)$ (the un-shaded area in Figure 1), no agent has incentive to sign the contract because the adoption cost of the PFSS is too high. If $\Delta < C_L/(1-p)$ and $K < p\Delta$ (the heavily shaded area in Figure 1), all agents have incentive to sign the contract and behave opportunistically ($\lambda = 1$). If $\Delta \geq C_L/(1-p)$ and $K < p\Delta$ (the medium-shaded area in Figure 1), all agents

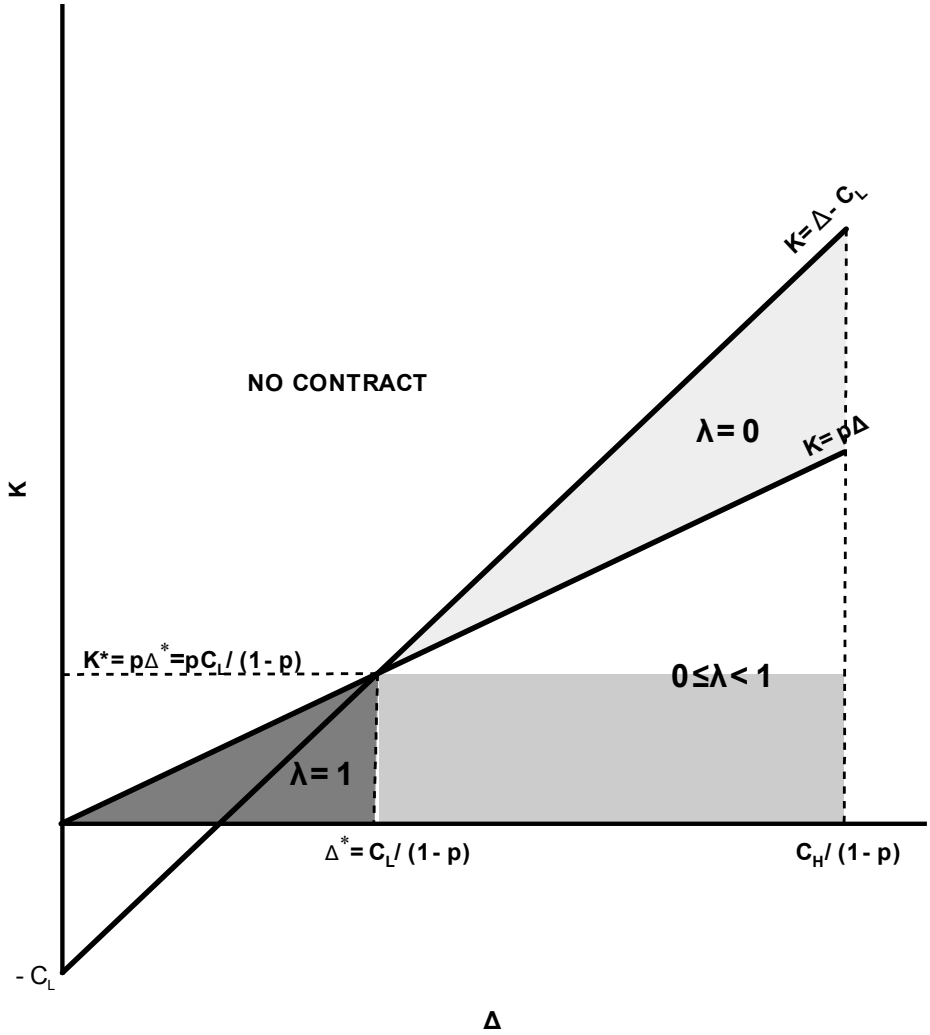

Figure 1: *Representation of PFSS in contract space. The dimensions of the contract are the price premium (Δ) and the implementation cost of the PFSS (K).*

have incentive to sign the contract and the probability of opportunism (equation (6)) is $0 \leq \lambda(\Delta) < 1$, with $\lambda = 0$ only for $\Delta = C_H/(1-p)$. If $\Delta \geq C_L/(1-p)$ and $K \geq [p\Delta, \Delta - C_L]$ (the lightly shaded area in Figure 1), conditions (11) are satisfied, there is no incentive to opportunism and suppliers with $c_A < \Delta(1-p)$ do not sign the contract. The pair Δ^*, K^* is the combination in the no-opportunism area ($\lambda = 0$) that minimizes principal's expenditure.

Under the optimal contract, the agent gains zero profits (as $\Delta^* = C_L + K^*$) and obtains no information rent. The principal achieves positive profits ($G - \Delta^*$) that are higher than in the absence of PFSS, but lower than the full information case with an observable critical attribute ($G - C_L$). The total gain from coordination ($G - K^*$) is lower than in the absence of PFSS (G).[18]

The optimal contract with PFSS strictly dominates the optimal contract without the

[18] This conclusion does not hold if we relax the assumption that G is exogenous and independent from the adoption of the standard.

standard because $\Delta^* < \Delta_{NDP}$ and $\lambda(\Delta^*) = 0 \leq \lambda(\Delta_{NDP})$. The adoption of a PFSS increases the principal's expected profits by reducing the agent's compensation and eliminating the risk of opportunistic behavior.

The model concludes that the PFSS can be used strategically to mitigate possible opportunistic behavior with respect to the delivery attributes that are not monitored by the certifier organization. The incentive mechanism is based on imposing a transaction-specific fixed cost on suppliers. In this way, suppliers can recover the upfront investment only if the transaction is successful (i.e., they deliver the unobservable critical attribute).

The optimal contract requires that the adoption cost K is non-negligible and specific. The theoretical results are consistent with the observed stylized facts about PFSS. The heterogeneity of the standards implies that at least part of the investment cannot be recovered if the supplier decides to sell to another retailer. The strict technical provisions imply that the suppliers must take costly actions that they would not take under the public standard. Our analysis suggests that the current implementation of PFSS might favor their indirect effect and reduce the cost of preventing opportunism even with respect to attributes that are not covered by the standard.

4. Conclusions

Retailers are actively promoting their PFSS among suppliers, claiming that they are acting only in response to regulatory and consumers concerns for safety. Yet, recent literature pointed out that PFSS might be used to serve other purposes. Our paper presented a theoretical model showing how a PFSS can be used to address complexity and improve the efficiency of the supply chain, reducing the cost of solving moral hazard problems that are not related with food safety or quality. Ignoring such indirect effect might result in an undervaluation of the benefits from PFSS.

Our conclusions rely on three key assumptions: the amount of the gain from coordination depends on a hidden action of the agent, the cost of the hidden action is heterogeneous across agents, and the principal cannot price-discriminate among agents. In this setting, the adoption of a PFSS allows a retailer to minimize the incentive compensation, select the most efficient agents and eliminate the risk of opportunistic behavior.

Our results suggest that the concern for consumer safety might not be the only rationale for the adoption of PFSS. In fact, the strategic use of such standards can grant retailers a more efficient control over the supply chain.

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