The Strategic Use of Private Food Safety Standards to Manage Complexity: a Moral Hazard Perspective

Carlo Russo[1], Maria Angel Perito[2], Antonella Di Fonzo[3]

[1] University of Cassino and Southern Lazio, Department of Economics and Law, Via S. Angelo loc. Folcara, 03043 Cassino, Italy, russocar@unicas.it

[2] University of Teramo, Faculty of Biosciences and Agri-food and Environmental Technology, Via C. Lerici1, 64023 Mosciano Sant'Angelo, Teramo, Italy, maperito@unite.it

[3] University of Cassino and Southern Lazio, Department of Economics and Law, Via S. Angelo loc. Folcara, 03043 Cassino, Italy, antonella.difonzo@unicas.it

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Abstract

Private food safety standards (PFSS) are widely adopted by firms in the agri-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.

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

1. Introduction

This paper investigates the benefits that firms can obtain by adopting private food safety standards (PFSS), in addition to the obvious advantages of ensuring the delivery of safe food. Our key finding is that PFSS can be used strategically to reduce the cost that buyers must bear to prevent opportunistic behavior of suppliers.

The food supply chain today faces a more complex and competitive environment than ever before. Modern retailers' supply chains require a high degree of coordination and cooperation among suppliers and customers at all levels to produce value for consumers and achieve efficiency (e.g. Duffy and Fearne, 2004). Global sourcing, integrated logistics, consumer-oriented supply are just few examples of the determinants of an increasing complexity in the agri-food chain that call for cooperation among the agents to be managed. 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). This paper presents a theoretical model discussing the strategic use of Private Food Safety Standard to manage the complexity in the agribusiness and prevent opportunistic behavior.

In the last decades, food retailers[1] have put considerable effort in establishing sets of contractually-binding rules (the private standards) to ensure the safety of their products, meeting an increasing consumer demand for safe food (Henson and Reardon, 2005). Retailers adopted strict safety standards to maintain a reputation and avoid possible liability (Henson and Humphrey, 2009; Marcoul and Veyssiere, 2010). Our study acknowledges this important role of PFSS, yet we focus on strategic use of standards in order to improve the coordination and manage complexity. Retailers may use PFSS to provide guarantees of food safety to the consumer, as well as to strengthen other dimensions in the supply chain, reducing the cost of coordination. We found that retailers can use PFSS to minimize the cost of dealing with moral hazard problems from heterogeneous suppliers. Furthermore, the theoretical model shows the benefits that firms realize from imposing unique private standards that are more restrictive than public regulation.

To the purpose of this paper it is important to stress that the suppliers' "hidden action" is not necessarily restricted to the delivery of the product attributes that are normed by the PFSS (such as quality and safety). It may affect any of the multiple dimensions of the complexity, including –for example logistics (such as timeliness and reliability of supply), information management, finance or other aspects of the supplier-customer interaction.

2. Private Food Safety Standards and supply chain coordination

A PFSS is a set of voluntary rules that are binding under a contractual agreement. 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 as specific technologies and logistics activities that allow them to deliver the right product, in the right quantity, in the right condition, in the right place, at the right time for the right cost.[2]

The PFSS provisions are stricter than existing public regulation and can be costly to implement under the prevailing 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 (Fischer et al., 2009; Graffham et al., 2007; Hatanaka et al., 2005).

The literature about the economic implications of PFSS is extensive. Since early 00s, the topic became a relevant research subject. Authors noted that PFSS reduce transactions costs and uncertainties between upstream suppliers and downstream retailers (Dolan and Humphrey 2000; Reardon et al., 2001). PFSS improve the supply chain management and promote the competitive advantage for retailers and suppliers (Casella, 1997; 2001).

The recent literature can be broken down into two sets. A first group of contributions focuses on the distinction between private and public standards and stresses the uses of PFSS as coordination and risk management tools (Humphrey and Schmitz, 2001). According to these authors the retail sector use PFSS to guarantee safety and quality of food and facilitate transactions along the supply chain (OECD, 2006). Humphrey (2008) noted that PFSS may 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 (Henson and Humphrey, 2009; Henson, 2007; Arfini and Mancini, 2004; Humphrey and Schmitz, 2001; Asfaw et al., 2007).

A second field of the literature studied the strategic use of PFSS to pursue multiple goals that include, but are not limited to, providing consumers safe food (Kariuki et al., 2012, Fulponi, 2006). Authors argued that PFSS can be used to exert market power (von Schlippenbach and Teichmann, 2012), create entry barriers against small suppliers (e.g. Hobbs, 2010; García 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 this literature by discussing the strategic use of PFSS to reduce the cost of solving information asymmetries along the supply chain.

We argue that PFSS, in addition to ensuring safety and facilitating information flows, can be used to improve vertical coordination and to ensure that the suppliers' incentives are aligned with the profit-maximization objective of the retailers. Because of the complexity of the interactions among operators, efficient supply chain management requires the full cooperation of all agents and it is vulnerable to opportunism. Retailers manage the risk of opportunistic behavior using multidimensional contracts (Arshinder et al., 2008). Our theoretical model shows that PFSS can be a tool in such a strategy.

3. The model

We developed a simple theoretical model to show that retailers can use PFSS to lower the cost of solving moral hazard problems with heterogeneous agents. We use a principal-agent model, focusing on a single transaction between a retailer and a supplier.

The simplest way to model the problem is to assume that the gain from coordination depends on the delivery of a "critical attribute" by suppliers.[3] Such critical attribute may or may not be related with food safety or quality, and it just represents the action that the supplier must take to ensure that an efficient coordination is achieved.[4]In order to focus on the moral hazard problem and minimize the algebraic complication we assume that the value of the gain from coordination

(G) is exogenously determined. If the suppliers deliver the product without such critical attribute, the transaction fails and gain from coordination is lost. For example, 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 from the outside option.

The production of the critical attribute requires that the suppliers take specific actions (effort) that are costly. The retailer cannot monitor the suppliers' effort and can only observe the outcome of the transaction, which is the value of the gain from coordination.

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 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 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 $p \in (0,1]$.[5] 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 $0 < C_L < C_H$.

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.[6] If the agent signs the contract and delivers the critical attribute, his/her profit is equal to $\Delta - c_i$, where i = L, H. 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.

$$(1)\quad \pi_A = \begin{cases} 0 & \text{outside option} \\ \Delta - c_A & \text{deliver the attribute} \\ p\Delta & \text{opportunism} \end{cases}$$

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.

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

If the principal could observe the actions of the agents, the solution of the problem is 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 $G\text{-}c_A$.

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:

min(Δ) s.t.
(3) $\Delta - c_A \geq p\Delta$
(4) $0 \leq \Delta \leq G$

where constraint (3) summarizes both the Individual Rationality (IR) constraint (being $p\Delta \geq 0$ by construction) and the Incentive Compatibility (IC) constraint.[7] 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:

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

By offering Δ_{PD} the perfectly discriminant principal gives no incentive to opportunistic behavior and gains non-negative profits.[8] 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.[9] 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.[10]

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 $C_H(1\text{-}p)^{-1} \leq G$ (i.e., the upper bound in constraints (4) is not binding for any c_A in the range $[C_L, C_H]$). 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 $\Delta \in \left[\dfrac{C_L}{1-p}, \dfrac{C_H}{1-p}\right]$, 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 (Δ-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 probability that the supplier fails to deliver the critical attribute is:

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

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 (7)

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

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 $G \square \frac{C_H}{1-p}$ 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.[11] 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*). In this way, any increase in retailer's profits is due to the coordination effect alone.[12]

We assume that the function *K*=*f*(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.[13]

We model the adoption of the standard as a specific sunk cost (*K*) paid by the supplier. Unlike c_A, K is observable by the retailer because the adoption of the standard is certified 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):

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

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 constraints:

$$(9) \qquad \Delta - c_A - K \geq p\Delta - K \text{ (IC)}$$

$$(10) \qquad \Delta - c_A - K \geq 0 \text{ (IR)}$$

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:

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

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

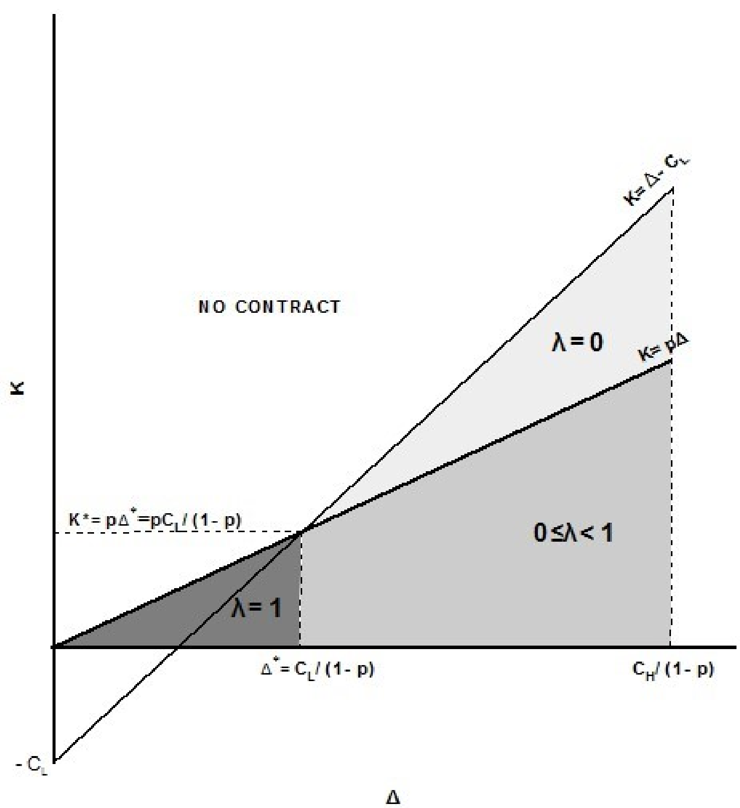
Because agents have no incentive to opportunism, the profits of a principal offering a contract $\{\Delta_X, K_X\}$ can be rewritten as:

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

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 $K^*=p\Delta^*$.[14] 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 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 $K \in [p\Delta, \Delta - C_L]$ (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.

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*).



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).[15]

The optimal contract with PFSS strictly dominates the optimal contract without the 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 explains why the PFSS regulations are more restrictive than public standards' ones and heterogeneous. The optimal contract requires that the adoption cost K is non-negligible (ie., the suppliers must take costly actions that they would not take under the public standard) and specific (i.e., at least part of the investment cannot be recovered if the supplier decides to sell to another retailer).

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 strategically to serve other purposes. Our paper presented a theoretical model showing how a PFSS can be used to address the complexities and improve the efficiency of the supply chain, reducing the cost of solving moral hazard problems. We found that PFSS can increase the retailer's profits even if they did not affect consumers' willingness to pay for food and if they did not increase the probability of detecting opportunistic behavior.

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.

The strategic use of PFSS requires that the adoption of the standard implies non-negligible specific investments by the agent. Therefore PFSS must be much stricter than public regulation, as they must imply a sizable incremental cost for the supplier. Furthermore, PFSS must be heterogeneous in order to prevent the opportunistic supplier from using the certification to enter a transaction with another retailer (and by doing so, recovering part of the costs). Heterogeneity and remarkable rigorousness are two empirically observed attributes of PFSS that can be explained by our model.

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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[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.

[2]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 FilièresQualitéCarrefour). 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.

[3] 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).

[4] 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.

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

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

[7] 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.

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

[9] 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 C_L-type or C_H-type producers, regardless of the reason why this might happen.

[10] 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.

[11] 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.

[12] 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.

[13]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.

[14] Note that since $c_X=C_L$, $p\Delta^*=\Delta^*-C_L$ and the type L supplier have no incentive to behave opportunistically.

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