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Elodie Rouviere, Raphael Soubeyran, Céline Bignebat

HAL Id: hal-01323208
https://agroparistech.hal.science/hal-01323208

Submitted on 30 May 2016

Heterogeneous Efforts in Voluntary Programmes on Food Safety.

Elodie Rouviere;[*] Raphael Soubeyran[†] and Céline Bignebat[‡]

Abstract

In this article we discuss the efforts made by importers of fresh produce within a voluntary programme on food safety. We show theoretically that the larger the firms the lower their efforts directed at food safety. We test this proposition using original primary data from a voluntary programme implemented by French importers of fresh produce. Our results contrast with evidence from environmental economics that large firms are more likely to be proactive with respect to environmental safeguards.

Keywords: Food Safety, Safety Effort, Voluntary Programme.

JEL: Q18; L5; D81

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[*]Corresponding author: Agrosup Dijon-CESAER, 26 bd Dr Petitjean 21 079 Dijon, France. E-mail: e.rouviere@enesad.inra.fr.

[†]INRA-LAMETA, Montpellier, France.

[‡]INRA-MOISA, Montpellier, France.

1 Introduction

Past food scares have prompted the development of voluntary programmes on food safety being promoted by public authorities and voluntarily implemented by food operators. Food operators (producers, handlers, retailers) have voluntarily adopted individual or collective quality management systems to guarantee food quality and/or safety and promote public health. For example, 10 years ago the British Egg Industry Council introduced the Lion Quality Scheme which sets high standards of food safety and animal welfare and currently accounts for 85% of egg production in the United Kingdom.[1] More recently, in 2007, the California Department of Food and Agriculture approved the California Leafy Green Products Handler Marketing Agreement which gathers together 71 handlers who represent more than 99 % of all California leafy green production. Once in the agreement handlers commit to handling California products only from growers who can show that they follow good agricultural practices and use a traceability system (Calvin, 2007). In France, voluntary programmes have been developed in the import industry of fresh produce. In 2001, in Perpignan[2] (south of France) importers negotiated with public authorities to introduce a voluntary safety programme to better check the safety (the amounts of pesticide residues) of fresh produce that enter the French market and thus the European Union.

In this article we investigate why firms adopt differentiated behaviour in voluntary programmes on food safety by developing an analytical framework and making a theoretical prediction. We consider a risk averse importer who is uncertain about the safety of fresh produce he markets and therefore decides to monitor some boxes to be sold. To do so, he conducts laboratory analyses to check if there are pesticide residues on produce. Indeed, food safety in the French fresh fruit and vegetables industry relies on Maximum Residue Limits (MRLs) for pesticides. The importer's safety effort increases the probability that each box will pass successfully through all the steps in the supply chain (wholesaler, retailer) to the consumer, without any safety failure. We show theoretically that the larger the firm the lower the safety effort. We test this theoretical prediction using primary data collected in 2006 for importers of fresh produce who par-

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[1]Source: http://www.britisheggindustrycouncil.com. Accessed 20 September 2010.

[2]In 2004, France imported 2.7 tons of fresh produce through 3 imports market. The Perpignan market accounts for 50.8% of this volume, followed by the market Rungis (34.4%) and the market in Marseille (14.8%). Source: www.saintcharlesinternational.fr. Accessed 20 September 2010.

ticipate in the voluntary programme of the Perpignan import market. We thus estimate the determinants of their safety effort according to several firm characteristics (size, supplier, customer, etc.). Our empirical setting validates the negative link between firm size and the level of safety effort.

As far as we know, the theoretical literature on quality management in supply chains has not yet analysed the link between firm size and the level of monitoring. Indeed, scholars mostly focused on the design of contracts and inspection policies of a single product in the presence of moral hazard (see Reyniers and Tapiero, 1995a and 1995b and Starbird, 2005). By contrast both theoretical and empirical studies in environmental economics have established that firm size influences firm environmental efforts. Most of these studies analyse whether firm size (total sales or number of employees) explains the firm's participation in a voluntary programme. They show that the larger firms are more likely to participate in environmental voluntary programmes. However, interpretations of this size effect vary across studies. Arora and Cason (1995) evaluate why polluting firms participate in one of the most important voluntary programmes implemented in the US by the Environmental Protection Agency (EPAs 33/50 program). They underline that larger firms have the ability to influence the design of standards and thus to preempt regulatory threats. Scheffman (1992) suggests that this strategy allows firms to increase the costs for smaller rivals to achieve competitive advantage in the market. Grolleau *et al.* (2007) in a study of the agro-food industry looked at the incentives for French food operators to improve their environmental efforts through a certification process. They show that the larger the food operator the more likely he will make environmental efforts to improve his on-site management. Some research argues that greater visibility to consumers might explain voluntary environmental efforts. Videras and Alberini (2000) analyse the types of firms that participate in three voluntary environmental programmes (EPAs 33/50 program, Waste Wise Program, Green Lights Program). Regardless of the programme, the authors show that larger firms are more likely to participate in these schemes because they are more visible to consumers than small firms. King and Lenox (2000) have obtained a similar result in their analysis of the participation of chemical firms in the chemical industry's Responsible Care Program. Some research argues that the presence of economies of scale in environmental effort explains the size effect (Dasgupta et al. (2000), King and Lenox (2000)). DeCanio and Watkins (1998) establish that the implementation of environmental efforts may imply fixed costs that could explain

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the size effect.

The originality of our article is twofold. First, to our knowledge, our contribution is one of the first econometric analyses on the determinants of safety efforts from food operators in a voluntary programme. Food safety is a sensitive topic, such that finding adequate data is often very difficult. Our dataset is the only one to combine both data on French importers characteristics (size, suppliers, customers) and on the number of pesticide residue analyses. Second, this novelty in data and topic leads us to contrast with the findings of a positive influence of size. Indeed, the case made in previous studies is absent in our context. Importers don't have any reputation on the end market. Also, they don't benefit from economies of scale in monitoring the level of pesticides residues on produce. Moreover, since we focus on a safety hazard which does not induce cross-contamination, small firms are in a riskier situation than large firms and therefore make greater safety effort.

The article is organised as follows: Section 2 presents the model, the benchmark situation (risk neutral importers) and sets out our main theoretical proposition (risk averse importers). Section 3 describes the empirical context, the data and the econometric analysis. Section 4 provides conclusions.

2   Analytical framework

We consider an importer who can sell n boxes of imported produce because of its capacity constraint (size of his warehouse).[3] The boxes are packed by foreign suppliers who send fresh produce to importers. A box contains one kind of fresh produce, for instance citrus fruit, tomatoes, strawberries, etc. The safety of the produce is determined by the activities of the grower (who may spray too much pesticides) and importers do not have any information on the grower's production practices. Thus, a percentage of the boxes the importer receives may contain levels of pesticide residues above the maximum levels defined by the law (unsafe boxes). The remaining boxes do not (safe boxes). Therefore, for the importer the percentage of safe boxes (and then the percentage of unsafe boxes) is exogenous. There isn't any cross-contamination between boxes, as the type of food safety hazard we consider is pesticide residues (compared with microbi-

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[3]We assume this constraint is binding. Empirically, this assumption is realistic because importers operate "just-in-time transactions" and they always use their warehouses at their maximum capacity.

ological contamination e.g. *Salmonella*). Therefore, the occurrence of a safety failure (a given box of produce found to be unsafe) is independent[4] across boxes. In order to check the safety of the produce, the importer runs pesticide residue laboratory analyses on a random sample of boxes. If the importer detects a box as unsafe, he will be able to replace it at insignificant costs. Indeed, any importer can easily find any quantity of produce they need. There are always more boxes of produce available on the market than the number needed by importers because some boxes of produce reach the market without any addressee.

The importer, as a broker, receives a commission for each box he sells. However the importer can sell unsafe boxes (he has not checked them or has not detected them as unsafe). In such a case, there is a probability that a public authority, one of the downstream operators or a consumer (thereafter a 'third party') detects a product defect. In the fresh produce industry, full traceability is mandatory:[5] when a third party detects a box as unsafe the importer will receive no commission.

2.1 The model

For each of the boxes the importer receives, the scenario is the following (see Figure 1): (1) the importer receives a box of produce. For this box, there is some exogenous probability, $0 < \alpha < 1$, that it is safe. (2) The importer makes some effort, $e \geq 0$, to discover if the box is safe. The probability that an unsafe box is detected as unsafe by the importer is $d(e)$ and depends positively on the effort e with $d'(e) > 0$. In other words the greater the effort the higher the chance to detect unsafe boxes. The technology is such that it never incorrectly reports a safe box to be unsafe. However, an unsafe box can be reported as safe.[6] If the importer detects an unsafe box, either he returns the box
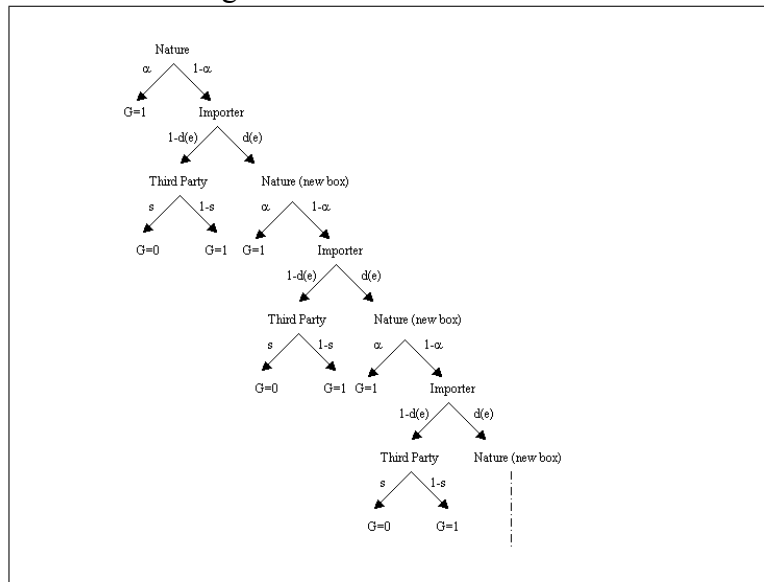
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[4]A box corresponds to a given producer, a given plot of land (that is homogeneous soil and climate) and a given day of harvest.

[5]Mandatory full traceability suggests that there might be some notion of reputation for importers through the records of their failures by retailers. However, according to our qualitative survey among importers and retailers, importers do not have any reputation with retailers and retailers do not record importers' safety failures (which are not numerous). Further research would be necessary to understand why there isn't any notion of safety reputation.

[6]The detection technology (at any step) is imperfect and even when checks reveal no default this does not mean that the produce checked is safe.

to the foreign sender or he destroys it.[7] In this situation, the foreign sender supports all the costs induced. That is the costs of handling the box, the costs of analyses and the costs of return to sender or destruction. In such a case, the importer substitutes the default box by a replacement (new) box.[8] The scenario for this new box starts at point (1). The box is safe with probability α and so on and so forth. The importer sells the boxes he does not report as unsafe. (3) Those boxes being sold can be inspected by a third party. We define $s \ \varepsilon \ (0,1)$ as the probability that an unsafe box is detected as unsafe by a third party. The importer will receive a commission (G in Figure 1) for each box sold without any detected safety failure. He will receive zero for each box sold and detected as unsafe by a third party.[9]

Figure 1: Scenario for one box

Nature
α / \ $1-\alpha$
G=1   Importer
$1-d(e)$ / \ $d(e)$
Third Party   Nature (new box)
s / \ $1-s$ α / \ $1-\alpha$
G=0   G=1   G=1   Importer
$1-d(e)$ / \ $d(e)$
Third Party   Nature (new box)
s / \ $1-s$ α / \ $1-\alpha$
G=0   G=1   G=1   Importer
$1-d(e)$ / \ $d(e)$
Third Party   Nature (new box)
s / \ $1-s$
G=0   G=1

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[7]At this stage, our results will not be affected if we consider that the importer can choose whether to send back or to destroy the box.

[8]At this stage, our results will not be affected if we assume that the importer can choose whether to replace the box or not.

[9]Here we assume that once the importer has sold a box he is unable to say if the box has been analysed or not: the recording system (of analysed products) is imperfect. It might be more costly for the importer (search, organisational and transactions costs) to recoup the testing costs (300 EUR) once he has sold the box than to assume them. If we had assumed that the recording system worked perfectly, once a third party had detected an unsafe box, the importer would have been able to recoup the testing costs. Leaving out the latter assumption doesn't change our result. Proofs are available from the authors upon request.

This scenario allows us to define p the probability (for each box) that the importer receives a commission normalised to 1. This probability is given by

$$p = (\alpha + (1-\alpha)(1-d(e))(1-s)) \sum_{j=0}^{+\infty} [(1-\alpha)d(e)]^j \qquad (1)$$

In order to explain equation (1), let us build it step by step. We consider an importer who has a capacity of one box. We calculate the probability for this importer to get a commission $G = 1$ when he is not able to replace an unsafe box by a new one, when he has the ability to replace the box once and when he has the ability to replace it twice. First, we examine the case of an importer who has not the ability to replace the box if he detects the box as unsafe. The importer will receive a commission only if the produce is safe or if the produce is unsafe but not detected as unsafe by himself or by a third party in the supply chain. In this situation the probability to get a commission is given by $p_0 = \alpha + (1-\alpha)(1-d(e))(1-s)$. Second, consider an importer who has the ability to replace once a box he detects as unsafe. The probability to get 1 becomes $p_1 = p_0 + (1-\alpha)d(e)p_0$, where (p_0) refers to the probability that the box is sold without any reported detection, while the term $(1-\alpha)d(e)p_0$ refers to the probability that the box is detected as unsafe by the importer and has been replaced by a new box, that is then sold without any reported detection. Third, imagine that the importer can replace the box at most twice: he detects the first box as unsafe and he replaces it by a new one. The importer also reports this second box as unsafe and he changes it for a third one. The third one is sold and has not been detected as unsafe by a third party. Therefore, the probability becomes: $p_2 = p_0 + (1-\alpha)d(e)p_0 + ((1-\alpha)d(e))^2 p_0$. To get the probability p in equation (1), we keep on this reasoning up to the situation where the importer will replace a box each time he detects it as unsafe.

The probability p is also the probability that a box sold by the importer passes through all the steps of the supply chain. It can be rewritten as

$$p = \frac{\alpha + (1-\alpha)(1-d(e))(1-s)}{1 - (1-\alpha)d(e)}, \qquad (2)$$

and this probability p increases with respect to e:

$$\frac{\partial p}{\partial e} = \frac{\alpha s (1 - \alpha) d'(e)}{(1 - (1 - \alpha) d(e))^2} > 0. \tag{3}$$

The greater the safety effort the importer makes, the higher the chance for a box to reach the consumer without any safety defect. As suggested in equation (2), p depends on α which is influenced by production practices from upstream suppliers and on s which is influenced by downstream operators. We assume that p also depends on additional parameters which we will specify in the empirical part (the adoption of a quality management system, etc.). We then define X as a vector which includes α, s and these additional parameters. We assume that those parameters do not affect the marginal effect of effort and then $\frac{\partial p}{\partial e} > 0$ still holds. Formally,

$$p \equiv p(e, X) \tag{4}$$

In our empirical analysis, the cost per laboratory analysis is constant, therefore in our setting the cost of running $n \times e$ pesticide residue analyses is linear, with marginal cost being $c > 0$. In addition, the cost of handling n boxes is $C(n)$. As we have already mentioned, the importer only assumes the costs for the boxes he is going to sell.

We can now define the expected utility of an importer who has a capacity of n boxes. Let k be a random variable for the number of boxes the importer has sold and which pass through all the steps in the supply chain without any detected safety failure, i.e. k represents the total commission. In other words, k is the number of successes in a random experiment (repeated n times) with a binomial probability of success p. The probability that k boxes among n pass successfully through all the steps in the supply chain without any detected default is given by $\binom{n}{k} (p(e, X))^k (1 - p(e, X))^{n-k}$ where $\binom{n}{k} = \frac{n!}{k!(n-k)!}$.

Let u denote the importer's utility function (as a function of his total commission), with $u(0) = 0$, $u' > 0$ and $u'' \leq 0$. The importer's objective is to maximise his expected utility with respect to his effort e:

$$\max_{e} Eu(n,e,X) = \sum_{k=0}^{n} \left[\binom{n}{k} (p(e,X))^{k} (1-p(e,X))^{n-k} u(k) \right] \quad (5)$$
$$-cne - C(n).$$

To illustrate equation (5), let us calculate the utility of an importer who has a capacity of 2 boxes. With a probability $(1-p(e,X))^{2}$, the two boxes are detected by the third party as unsafe and the importer obtains a utility of $u(0) = 0$. With probability $2p(e,X)(1-p(e,X))$, the third party reports either the first box as unsafe and the second box as safe, or he reports the first box as safe and the second one as unsafe. In this situation, the importer obtains a utility $u(1)$ for the box which passes through the supply chain. With probability $(p(e,X))^{2}$ none of the two boxes are reported as unsafe by the third party and the importer obtains $u(2)$. Therefore, the expected utility of the importer who has sold 2 boxes can be written: $Eu(2,e,X) = 2p(e,X)(1-p(e,X))u(1) + (p(e,X))^{2}u(2) - 2ce - C(2)$. Equation (5) is the generalisation of this formula for an importer who has a capacity of n boxes.

2.2 Importers and safety efforts

First we develop the case of a risk neutral importer in order to provide a benchmark to sustain the risk averse case. Let the importer's utility function u, be linear, $u(k) = \gamma k + \mu$, with $\gamma > 0$. $e^{*}(n,X)$ denotes the optimal effort of the importer, n and X being given. Therefore, the following result holds:

Proposition 1 *When the importer is risk neutral, the optimal effort e^{*} does not depend on the number of boxes he sells, $e^{*}(n+1,X) = e^{*}(n,X)$.*

(The proof is reported in Appendix 1.) For a risk neutral importer the benefits and costs increase proportionally relative to the number of boxes he sells, n.

Next, we analyse the situation when the importer is risk averse focusing on Constant Absolute Risk Aversion (CARA) utility functions, i.e. u is such that,

$$u(k) = -\delta \exp(-ak) + \beta, \quad (6)$$

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where $\delta > 0$ and $a = -\frac{u''}{u'} > 0$ is the Arrow-Pratt measure of absolute risk aversion of the importer. In this situation, we assume that for all n there exists an interior optimal effort $e^*(n,X)$. Therefore, the following result holds:

Proposition 2 *When the importer is risk averse $(a > 0)$, $e^*(n+1,X) < e^*(n,X)$. Namely, the higher the number of boxes, the lower the safety effort.*

(The proof is reported in Appendix 1.) Proposition 2 suggests that an increase in the number of boxes increases diversification of the risk. In other words, an importer who sells a small number of boxes is in a more risky situation than an importer who sells a higher number of boxes. If the importer is risk averse, then, the higher the level of risk diversification, the lower the safety effort.

Let us illustrate this insurance effect with a simple example that involves two importers. Importer A has a capacity of one box. He faces the following situation: either his box passes all the steps in the supply chain with a probability p and he receives a commission of 1, or, with a probability $(1-p)$ the box is detected by a third party as being unsafe and no commission is forthcoming. Importer B has a capacity of two boxes of produce. He faces three potential situations: i) the two boxes pass all the steps in the supply chain and he receives a commission of 2; ii) the two boxes are detected as being unsafe and there is no commission; iii) only one of the two boxes is safe, which means he will receive a commission of 1. It is the potential for the third situation to occur that provides an insurance effect. Figure 2 illustrates Proposition 2. It represents the expected utility as a function of the importer's effort when the number of boxes varies between 1 and 10.

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Figure 2: Expected utility, effort and size.
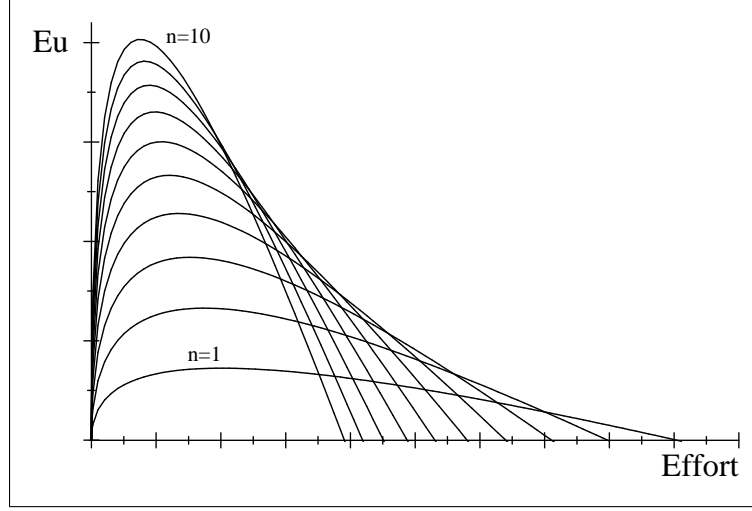
Specification: $p(e,X) = \frac{\sqrt{e}}{0.5+\sqrt{e}}$, $\alpha = 0.5$, $\beta = 5$, $a = 0.5$, $c = 0.5$, and $C(n) = 0$

Complementary comparative statics: Let $X = (x_i)_{i=1,\dots,t}$. The effect of a marginal change in the characteristics x_i on the optimal effort $e^*(n,X)$ is,

$$\frac{\partial e^*}{\partial x_i} = \frac{\frac{\partial^2 Eu}{\partial e \partial x_i}}{-\frac{\partial^2 Eu}{\partial e^2}}. \tag{7}$$

Therefore, for CARA utility functions with $a > 0$, we obtain:

$$\frac{\partial e^*}{\partial x_i} \propto \frac{\partial^2 p}{\partial e \partial x_i} - \frac{(n-1)(1-\exp(-a))}{1-(1-\exp(-a))p} \frac{\partial p}{\partial e} \frac{\partial p}{\partial x_i}. \tag{8}$$

We illustrate this with an example that we develop in the empirical section. Consider the importer's propensity to work with supermarkets ((*SupM*), in the empirical part). Supermarkets are most of the time assumed to have strict safety standards and thus are more likely to detect unsafe products (Fulponi, 2006). According to this fact, we can assume that the propensity to work with supermarkets increases s. According to

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equation (8), the effect of an increase in s on the optimal effort is

$$\frac{\partial e^*}{\partial s} \propto \frac{\alpha\,(1-\alpha)\,d'\,(e^*)}{(1-(1-\alpha)\,d\,(e^*))^2}$$
$$+\frac{(n-1)\,(1-\exp\,(-a))}{1-(1-\exp\,(-a))\,p}\,\frac{\alpha s\,(1-\alpha)^2\,d'\,(e^*)\,(1-d\,(e^*))}{(1-(1-\alpha)\,d\,(e^*))^3}, \tag{9}$$

Therefore, $\frac{\partial e^*}{\partial s} > 0$. To protect himself against the risk that supermarkets detect unsafe boxes, the importer would provide a greater level of safety effort. In other words, the importer's propensity to work with supermarkets increases his level of safety effort.

We have just dealt with the behaviour of a risk averse importer who monitors boxes of produce in an industry where cross-contaminations are highly unlikely and monitoring costs are linear. In the empirical section, we test our second theoretical prediction with primary data on the monitoring behaviour of French importers of fresh produce because this context fits with the previously mentioned assumptions. Indeed, it was impossible to find a good proxy for risk aversion and we were then not able to segment the sample into risk-neutral and risk-averse importers and then to compare the results predicted by the two propositions within a sample consisting of both kinds of importers. An implicit assumption behind our empirical model is that all importers are risk averse.

3 Evidence from the French fresh produce imports industry

3.1 Context

3.1.1 French safety regulation related to pesticide residues

The definition of food safety for fresh fruit and vegetables in France relies on the MRLs set by the European authorities (Regulation (EC) No 396/2005) or French law (Decree 04/08/1992, as amended). Residues found in or on produce are judged, according to these laws, as being above, at or below the limit. Safety of fresh fruit and vegetables in France and in Europe is one-dimensional, as opposed to the United States where regulation on the safety of those produce also refers to the presence of microbiological hazards such as Salmonella, etc.

All French food operator (producers and importers) must comply with a 'performance standard', as defined in Henson and Caswell (1999): the food product they market should reach the prescribed product quality standards and/or safety levels. How they do reach the standard is left to the discretion of the food operators. In French law, importers are considered as producers, because they are the very first to introduce foreign produce into the national market.[10] Importers of fresh produce are thus liable under criminal law if produce do not comply with the regulations in force.

The DGCCRF (General Service for Consumption, Competition and the Repression of Fraud), the public agency in charge of enforcing law and monitoring food safety, mostly conducts regular on-site and product-oriented inspections. In the case of fresh produce, samples are collected and laboratory analyses are carried out to check that residue levels are within the legal limits. In an official inspection, inspectors randomly select a box of fruit or vegetables, take one or two pieces of the produce as a sample of the box and send them to the official laboratory which conducts multi-residue analyses. If excess levels are found, importers are found guilty of an offence. Sanctions range from a warning letter to prosecution and fines. Warning letter and fines are the most common sanctions used by the public agency while prosecutions are quite rare. In the same time, the whole box of the incriminated produce is taken off the market.

3.1.2 Laboratory analyses

The producer is the only person in control of pesticide use during the production and post-harvest periods and, thus, the only person who is able to reduce the risk of excess pesticide residues in or on produce. The remaining downstream operators can adopt two courses of action: i) they can impose codes of good agricultural practices, like Global GAP systems, on producers; ii) they can conduct laboratory analyses to check the safety of produce they enter on the market.

In 2001, European Regulation (EC) No 178/2002 was issued, and imposed greater responsibility on food operators for monitoring and provision of food safety. In response to this requirement which came into force in 2007, French importers of fresh produce started to order laboratory analyses to check the safety of their produce (Codron *et al.*, 2007). However, the French regulation remains in force and importers continue to have

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[10]Art. L 221-1 ; Art. L 212 -1, French Consumption Law.

to abide by the performance standard whatever other efforts they have introduced to monitor safety.

3.1.3 The voluntary safety programme of Perpignan

Our empirical analysis focuses on the voluntary programme that French importers developed and initiated in 2001 in order to better comply with the new European food safety regulation. Before 2001, few French importers ordered laboratory analyses to detect levels of pesticide residues.[11]

The most important motivation of the negotiation was to achieve a specification rather than a performance standard. For the importers participating in the programme, there is a gap between the letter of the law and its enforcement. In the event of a safety failure an importer that subscribes to the programme will be considered by public authorities as having acted in good faith, and a negligence based rule will apply. This is the main commitment of the public authorities in recognising the programme: the programme allows participants to be found liable (under a strict liability rule) if and only if they have failed to take due care (no analysis). Membership in the programme provides firms with other advantages. The frequency of public controls is reduced.[12] Also, customs clearance at the border is quicker (for produce from Morocco), since inspection by French customs is waived.

There are 98 firms operating on the Perpignan imports market, 66 of whom were members of the programme in 2006; 61.5% of the 66 members joined the programme the first year.

The goal of this voluntary programme is to achieve better levels of safety of fresh produce entering the French market. As a condition of joining the voluntary programme, importers must carry out individual laboratory analyses and must assign an employee to manage quality control. The voluntary safety procedure is based on the principles of the Hazard Analysis Critical Control Point method (HACCP). Importers must set out a sampling plan for fresh produce at the beginning of every year, based on the volumes and types of produce being imported. In terms of the type of produce, importers must identify fruit and vegetables that are more likely to show excess pesticide residues (e.g.,

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[11]According to the qualitative survey conducted in 2004 by one of the authors prior to data collection.

[12]According to the same qualitative survey with public authorities conducted in summer 2004.

strawberries). The risk of pesticide residue levels being exceeded varies widely according to the produce and country of origin - in our case, mostly Spain and Morocco. In terms of produce, importers do not usually specialise in the sale of only one or two products: for more than eight out of ten firms less than half of their total sales is represented by one product type and they target all their produce for analyses.

The programme requires one analysis for 1 million EUR of sales. In other words, the 'theoretical' effort in the programme should be identical for all importers whatever their size and would equal 1. We will see below this is not the case for some surveyed firms. The importers board gathers information on the number of analyses conducted by the firms participating in the programme. However, this is not made publicly available and remains a sensitive topic. Thus, retailers, wholesalers, public authorities and consumers have no information on (one importer) individual safety effort.

There are costs involved in joining the programme: firms have to pay an annual subscription fee of 1,000 EUR and they also have to allocate human and financial resources to monitoring. Pesticide residues analyses are costly: 300 EUR for one multiresidue analysis of pesticides. The marginal cost of the analysis is thus constant and importers carry out at most one analysis per box of produce.

In the event of a safety defect, importers will have to report the results to the public authorities, and the whole box of the incriminated produce will be removed from the market. Only results that exceed the legal MRLs need to be reported.

3.2   Survey & Data

We conducted our survey during the summer 2006 covering the whole sample of firms (66 members) participating in the Perpignan voluntary safety programme. We also collected data from 12 firms that did not subscribe to the programme, none of which conduct any laboratory analysis. These firms represent 40% of the firms that are not part of the programme, and 12% of the whole sample of firms operating in the Perpignan market. The remaining 20 firms declined to answer our questionnaire. Firms that do not belong to the voluntary programme cannot reduce their risk of being fined even if they do conduct laboratory analyses. Only participants in the voluntary scheme benefit from the due care clause.

Interviewees, owners and employees, were asked questions, face-to-face, about the

firm situation in 2005, and particularly about characteristics such as total amount of sales, main produce, specialisation, resources allocated to safety controls, and also about their operating environment (procurement and suppliers, customers).[13] Our question-naire also included some questions about the firm's perception of the pressure exerted by public authorities and their main customer with respect to safety issues.

For our empirical framework, we are interested in what determines differentiated behaviour within the voluntary programme. Therefore our underlying population is the exhaustive sample of firms that participate in the safety programme (see table 1 for descriptive statistics).[14]

Table 1: Descriptive statistics (62 observations)

Variables	Acronym	Units of measures	Mean	Std. Dev	Min	Max
Safety Effort	Safetyeffort	analyses/million EUR	2.73	5.38	0.25	42.85
Number of analysis in 2005	Nbrepest05	number of analyses	28.9	30.68	5	150
Sales in 2005	Sales	million EUR	17.43	16.67	1.4	69
Sales in log form	Salesln	million EUR	2.47	0.89	0.33	4.23
Specialisation in one product	Specialisation	% of sales	0.36	0.184	6	80
Direct Supply for the main product	DirectSupp	dummy	0.37	0.48	0	1
Number of Suppliers	NbSuppliers	number of suppliers	42.25	35.53	1	141
Supermarket as the Main customer	SupM	dummy	0.40	0.49	0	1
Other Quality Management System implemented	QMS	dummy	0.21	0.41	0	1
Laboratory Analysis before the programme	PrevLabAna	dummy	0.53	0.50	0	1
Number of public monitoring in 2004	NbPuMo	inspections/million EUR	0.41	0.469	0.018	2.38
Evaluation of Pressure exerted by public authorities	PuPress	dummy	0.74	0.44	0	1
Evaluation of Pressure exerted by customers	CuPress	dummy	0.69	0.46	0	1

We approximate the number of boxes by the total amount of sales (in million EUR) in 2005 – variable (*Sales*). Firm sales (size) range from 1.4 million EUR up to 69 million EUR with a mean at 17.43 million EUR and a standard deviation of about 100% of the average. The bottom of the distribution includes a high number of small firms and the median is less than 10 million EUR.

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[13] The survey is available upon request.

[14] Descriptive statistics are for the observations in the estimation (62/66 firms) because of missing values.

The absolute number of laboratory analyses carried out by importers in 2005 (*Nbrepest*05) is 28.9 on average, ranging from 5 to 150. Firms are concentrated at the lower end of the distribution with 75% of firms reporting less than 30 analyses. There is also wide diversity in importers' behaviour (in doing analyses): the standard deviation of this variable is 106.1%. The importer's safety effort (*Safetyeffort*) relative to firm size, namely the ratio (*Nbrepest*05/*Sales*) varies widely, from 0.25 to 42.85 (number of analyses per million EUR). We observe that 15 out of 66 members don't comply with the rule of one analysis per 1 million EUR of sales. Nonetheless, we know that those firms are still in the programme today. This observation might reveal that the rule is not strictly enforced. However, we would need more data to conclude that this behavior persists over time. The effort made by importers widely differs from one to each other: the average behaviour is 2.73 analyses per million EUR, the median being 2 and 90% of firms reporting less than 3.8 analyses per million EUR. Because of this fact, we decide to establish the real nature of the link between firm effort and size and to highlight the determinants of this safety effort.

3.3 Econometric Analysis

In this section, we study the determinants of the firms' safety effort for importers who participate in the voluntary programme.[15] We test the following model:

$$\ln\left(Safetyeffort_i\right) = \theta_0 + W_i'\theta_1 + \varepsilon_i \tag{10}$$

As endogenous variable, we consider the logarithm of the safety effort ($\ln\left(Safetyeffort\right)$) because we suspect the relation between firm safety effort and firm size might not be linear.

As exogenous determinants, we select a set of variables, W_i', to describe firm heterogeneity. Firm size is approximated by the logarithm of 2005 firm total amount of sales expressed in million euro (*Sales*(ln)). *Specialisation* represents the proportion of

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[15] Our analysis might suffer from a selection bias since we only use data for participating firms. We test for selection bias using the Heckman two-step procedure (Heckman, 1979). We add an explicit selection equation to the primary equation of interest with the whole vector W_i and one variable: *SalesCustFce*, which is the level of dependence of the firm, approximated by the proportion of sales the firm realised in 2005 with its main customer. Since the Inverse Mills Ratio is not significant, the use of OLS is not invalidated.

sales realised by importers from sales of their main product, i.e. the produce that represents the highest proportion in the firm's total sales. We characterise the importer's upstream relationships with: *i) DirectSupp* that stands for the type of the main supplier. *DirectSupp* is 1 when fresh produce comes directly from producers rather than through an intermediary between producer and importer (cooperatives, exporters and other types of suppliers). *ii) NbSuppliers* is the number of upstream suppliers (direct or indirect) the importer normally deals with: the larger this number, the more difficult to monitor safety because of supplier dispersion. *NbSuppliers* is the only quantitative variable which is not on a 'per sales' basis. We think that the absolute number of suppliers provides a more accurate picture with respect to diversity of the importers' suppliers. We characterise downstream relationships by the main type of French customer. *SupM* is 0 if the customer is a wholesaler, and 1 if it is a supermarket. Finally, we approximate for how the firm has implemented the procedures to ensure delivery of safe fruit and vegetables. *QMS* is a dummy variable that takes the value of 1 if the firm has adopted an additional Quality Management System to the voluntary programme, i.e. ISO 9001/9002 certification, or HACCP certification, etc. If the voluntary safety programme is the only QMS in place, then *QMS* is 0. *PrevLabAna* is 1 if the firm conducted laboratory analyses on fresh produce before the implementation of the voluntary programme, otherwise it is 0. We also consider the number of public inspections per unit of sales imposed on the firm in 2005 (*NbPuMo*). As regards the firm's perception of public pressure, interviewees were asked: 'As regards safety, would you consider that the pressure exerted on your business by public authorities is very high, high, low or very low?'. We aggregated the categories because the answers were concentrated in the two values in the middle (high and low) making the two extremes (very high and very low) not workable due to the very small number of observations. The aggregate dummy variable (*PuPress*) is 1 if the importer felt that the pressure was important (very high or high), and 0 if the importer felt that it was not important (low or very low). Similarly, we created a dummy variable (*CuPress*) to measure the firm's perception of the pressure exerted by the main customer. (*PuPress*) and (*CuPress*) are both subjective variables.[16]

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[16]Note that these variables have low correlation with the others. To keep the richest model we ran a likelihood ratio test between the models with and without the subjective variables : $LR(\chi^2(2)) = 8.42$, $p.value = 0.0149$.

3.4 Results

Table 2 presents the results of the Ordinary Least Squares regression and the results of diagnostic tests.

Table 2: OLS estimates (Dependent variable: Safetyeffort)

	Coefficients	t-ratios
Sales(ln)	-0.620^{***}	-5.57
Specialisation	-0.910^{**}	-2.07
Directsupply	0.431^{***}	2.77
NbSuppliers	0.003^{*}	1.77
SupM	0.415^{**}	2.54
QMS	-0.413^{**}	-2.10
PrevLabAna	0.461^{***}	2.87
NbPuMo	-0.29	1.38
PuPress	-0.480^{**}	-2.66
CuPress	0.001	0.01
Observations	62	
Adjusted R-squared	0.56	
Test for heteroskedasticity[a]	$\chi^2(1) = 0.52$ $p.value = 0.4717$	
F-Statistic (10, 51)	8.89^{***}	
LR (10)	62.582^{***}	

Note: *; **, *** denote 10, 5 and 1 % significance respectively.

(a): Breusch-Pagan/Cook-Weisberg test.

Some of the variables for firm characteristics are significant. As our second theoretical proposition predicts, firm size (i.e. *Sales*(ln)) has a negative effect on the safety effort exerted by the firm. Firm's size reduces safety effort, which differs from previous findings in the literature and conventional wisdom.

Specialisation tends to reduce safety efforts. The few highly specialised firms operate in very specific sectors (baby carrots, frozen broccoli). They secure their market share (niche market) by ensuring quality. For these products, the value of the whole supply chain depends on quality management. In those supply chains, all suppliers must

make efforts to ensure food safety (at all stages in the chain). The importer is the one of final links and his effort in terms of monitoring is marginal relative to the ones of producers.

We find that reliance on a direct procurement system (*DirectSupp*) has a significant and positive influence on the number of pesticide analyses. However, we expected that this should decrease the need for downstream safety controls. The way we built the variable implies that the firm has a direct or indirect commitment in the production process. By investing upstream, the importer devotes resources to the produce he is selling in the French market. Even if the supplier is well-known to the firm, the importer may also make greater levels of effort in order to protect his investment. The quantitative variable *NbSuppliers* has a positive effect[17] on the level of safety effort. This result suggests that importers will be more likely to make a greater level of effort if their procurement is atomised.

In terms of downstream operators, the type of the main customer (*SupM*) is significant. The propensity for firms to work with supermarkets indirectly increases their safety efforts. In our specific case, working with supermarkets and safety efforts are complementary in marketing safe produce, although some studies show that French supermarkets are not explicitly asking for safety (Fulponi, 2006; Garcia Martinez and Poole, 2004).

The fact that firms have implemented another Quality Management System (*QMS*) has a negative effect on safety effort. Other quality management systems implemented by firms tend to be more stringent than the requirements of the voluntary safety programme. Laboratory analyses would appear to be a marginal tool within a broader initiative designed to ensure quality and safety. Therefore, quality management systems, which are long-term investments, may act as substitutes for regular checking for pesticide residues, which is a short-term investment. The fact that firms ordered laboratory analyses (*PrevLabAna*) before implementation of the voluntary programme gives some idea of their awareness of safety issues in their industry. The programme allows them to maintain their level of awareness and even to increase it relatively to importers that previously did not implement any laboratory analyses. Finally, the number of public inspections of the firm per unit of sales (*NbPuMo*) has no influence on the safety effort exerted by importers in 2005.

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[17]at the 10% confidence level.

We suspected the endogeneity of (*PuPress*): we expect that the fear of being inspected and, if detected, sanctioned by public authorities, approximated by (*PuPress*), is endogenous to the decision about the level of effort made by the firm. The greater the level of safety effort that the firm makes, the less likely it will perceive pressure from the public authorities. We use the instrumental variables (IV) method (two stage least squares) to deal with the endogenous explanatory variables. There are no restrictions on the distribution of the exogenous and endogenous variables. One or both can be binary variables (Wooldridge, 2002: 85). We ran the two stage least squares and the Durbin-Wu-Hausman test. Since the Durbin-Wu-Hausman test does not reject the null, IV are not warranted, while differences between the IV and OLS estimates are random.

The pressure exerted by public authorities regarding food safety (*PuPress*) has a rather surprising negative impact on safety effort. This result is counter-intuitive: although firms claim that pressure from the public authorities is high, their behaviour concerning safety does not reflect this. However, the perceived pressure from customers (*CuPress*) does not influence the firm's safety effort, although the type of main customer (*SupM*) does.

4   Conclusions

The recent evolution of European food safety regulations is characterised by the increased involvement and responsibility of food operators in food safety controls. The 2001 European Regulation (EC) No 178/2002 that came into in force in 2007 had this objective. At that time, in the French import industry of fresh produce this evolution led importers to implement and participate in a voluntary programme to check the safety of imported produce. The main feature of the programme is that it translates performance standards into specification standards. In the event of a safety failure being detected, participants are held liable if and only if they have failed to implement safety efforts (laboratory analyses). In other words, the programme relieves importers of their liability in the event of a safety failure.

Our analysis focused on the reasons why French importers adopt differentiated behaviour in terms of food safety efforts within this voluntary programme. We have showed theoretically that the larger the firm, the lower the number of analyses relatively to its size. We validate this prediction using original primary data (referring to

the year 2005) drawn from the exhaustive sample of importers who participate in the voluntary programme on food safety implemented on the Perpignan market. We also have established that the propensity for a firm to work with supermarkets and the safety effort are positively correlated.

Our empirical results suggest that public authorities could work to ensure food safety through two means. First, public authorities could directly affect firms' behaviour by taking account of their intrinsic characteristics. Second, they could indirectly influence firms' safety efforts. They could exert pressure on downstream operators who would transfer this pressure to their suppliers. Hovever, more research is needed to know whether our results can be generalised to other food industries.

Acknowledgements

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Appendix 1: Proofs

Proof of Proposition 1

The expected utility of an importer who sells n boxes can be written as:

$$Eu(n,e,X) = \gamma \sum_{k=0}^{n} \left[\binom{n}{k} (p(e,X))^k (1-p(e,X))^{n-k} k \right]$$

$$+\mu \sum_{k=0}^{n} \left[\binom{n}{k} (p(e,X))^k (1-p(e,X))^{n-k} \right] \tag{A.1}$$
$$-cne - C(n)$$
$$= n(\gamma p(e,X) - ce) + \mu - C(n).$$

Hence, the expected utility of an importer who sells $n+1$ boxes is,

$$Eu(n+1,e,X) = \frac{n+1}{n} [Eu(n,e,X) - \mu + C(n)] + \mu - C(n+1). \tag{A.2}$$

Thus, the expected utility of an importer who sells $n+1$ boxes is an increasing linear function of the expected utility of an importer who sells n boxes. We conclude that the optimal probability p^* is the same for n or $n+1$ boxes.

Proof of Proposition 2

The expected utility of an importer who sells n boxes can be rewritten as:

$$Eu(n,e,X) = -\delta \left(\sum_{k=0}^{n} \left[\binom{n}{k} (\exp(-a)p(e,X))^k (1-p(e,X))^{n-k} \right] \right)$$
$$+\beta \left(\sum_{k=0}^{n} \left[\binom{n}{k} (p(e,X))^k (1-p(e,X))^{n-k} \right] \right) - cne - C(n),$$

Or,

$$Eu(n,e,X) = -\delta (1 - (1-\exp(-a))p(e,X))^n + \beta - cne - C(n), \tag{A.3}$$

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For an interior maximum, $e^*(n,X)$, we must have,

$$\delta(1 - \exp(-a))(1 - (1 - \exp(-a))p(e^*(n,X),X))^{n-1}\frac{\partial p}{\partial e}(e^*(n,X),X) = c \quad \text{(A.4)}$$

Moreover, the derivative of $Eu(n+1,e,X)$ with respect to e is,

$$\frac{\partial Eu}{\partial e}(n+1,e,X) =$$
$$(n+1)\left[\delta(1 - \exp(-a))(1 - (1 - \exp(-a))p(e,X))^n\frac{\partial p}{\partial e}(e,X) - c\right]. \quad \text{(A.5)}$$

Hence, at the point $e^*(n,X)$, this derivative is,

$$\frac{\partial Eu}{\partial e}(n+1,e^*(n,X),X) = -(n+1)(1 - \exp(-a))p(e^*(n,X),X)c < 0. \quad \text{(A.6)}$$

When the second order condition holds, the expected utility will be concave in e, and we can conclude that $e^*(n+1,X) < e^*(n,X)$.