Heterogeneous Efforts in Voluntary Programmes on Food Safety: Theory and Evidence from French Imports of Fresh Produce.*

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Abstract

In this article we discuss the efforts made by importers of fresh produce within a voluntary food safety programme. We show theoretically that the larger firms the lower their efforts directed at food safety. We test this proposition econometrically, 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.

Keywords: Food Safety, Heterogeneity, Safety Effort, Pesticide, Voluntary Programme

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*The authors thank JS. Ay, E. Brousseau, J.A. Caswell, G. Grolleau, Y. Perez, A. Plantinga, A. Thomas and M. Tidball. This research was supported by the working package 2 of the French project ADD "Eco-Serre". The authors would also like to thank participants at the congress of EAERE (2007), the XIIth SMYE (2007), the Annual conference of ISNIE (2006) and seminars participants at Queen's University of Belfast (Ireland), at the Wageningen University (The Netherlands), at INRA-Economie Publique (France), at INRA-CESAER (France).

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JEL: Q18; L5; D81

1 Introduction

Food safety is a major preoccupation for consumers and public authorities. Since the "mad cow" crisis in 1998, the reporting of food safety problems and their media coverage have increased. One of major causes of food poisoning is contamination by pathogenic bacteria, such as salmonella or Escherichia coli O157:H7. The fresh produce industry has concerns over pathogenic contamination and pesticide residues. In September 2006, the US Food and Drug Administration (FDA) announced that the bacterium Escherichia coli O157:H7 had been found in spinach. In 2007, excessive pesticide levels were detected in sweet peppers from the south of Spain (Andalusia). These food safety incidents are scaring people and reducing their confidence in the food safety procedures implemented by both public authorities and food processors.

The recent food scares have been the motivation for voluntary programmes on food safety being promoted by public authorities and voluntarily implemented by food operators. We have empirical evidence that food operators are voluntarily adopting individual or collective quality management systems to guarantee food quality and/or safety and promote public health. For example, the British Egg Industry Council 10 years ago 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]

In the US, the Federal Department of Agriculture has proposed guidelines to reduce the risk of microbial contamination and to help spinach growers develop food safety plans (Calvin, 2007). However, in the fresh produce industry, these kinds of voluntary programmes are not well developed although the main French import market for fresh produce, located in Perpignan[2] (South

[1] http://www.britisheggindustrycouncil.com

[2] There are three import markets in France: Perpignan, Rungis and Marseille. In 2004, France imported 2 659 000 tonnes of produce. The Perpignan market accounts for 50.8% of this volume, followed by the market Rungis (34.4%) and the market in Marseille (14.8%). www.saintcharlesinternational.fr

of France) has developed a voluntary programme. In 2001 French importers negotiated with public authorities to introduce a voluntary safety programme to monitor the amounts of pesticide residues (carrying laboratory analyses) on fresh produce imported into the European Union.

In this article we investigate why firms adopt differentiated behaviours 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[3] about the safety of produce he is marketing and therefore decides to monitor some boxes to be sold. To do so, he makes 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 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 failure of safety. We show theoretically that the larger the firm the lower the safety effort. We test this theoretical prediction using primary data collected in 2006 from the exhaustive sample of importers of fresh produce who participated 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 (see Reyniers and Tapiero, 1995a and 1995b and Starbird, 2005) of a single product in the presence of moral hazard. 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

[3]Some scholars have highlighted that uncertainty is at the core of differentiated behaviour among firms. E.g., Craswell and Calfee (1986) - Shimshack and Ward (2008). We argue that uncertainty over the safety of produce appears to be fundamental in explaining importers' behaviour in the voluntary programme studied here.

firm's environmental efforts within a voluntary programme.[4]

Our result runs counter to the findings of this literature which sets that the larger the firm the greater the environmental effort. However, interpretations of this size effect vary across studies. On the one hand, scholars focused on the purpose of the environmental effort. For instance, 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 food operators are more likely to make a greater environmental effort to improve their on-site management. On the other hand, studies emphasised the causes of the environmental effort. 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 are small firms. King and Lenox (2000) 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 effort may imply fixed costs that could explain the size effect.

The originality of our paper is twofold. First, to our knowledge, our contribution is one of the first econometric analyses on the determinants of

[4]See Khanna (2001) for an extensive survey of research that analyse the motivations of polluting firms to improve their environmental record through voluntary programmes.

safety efforts from food operators. Food safety is a sensitive topic which explains that data are quite rare. Our dataset is the first and 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 run counter to the findings of a positive influence of size on effort. Indeed, the case previous studies made is absent in our context. Importers do not have any reputation on the end market and do not benefit from economies of scale in safety effort. One should have expected no link between effort and size. However, we highlight a negative link combining theoretical and empirical analyses.

The paper 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 some concluding remarks.

2 Analytical framework

We consider an importer who faces a fixed demand of n boxes of imported produce. The boxes are arranged by the 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. Cross box pesticide contamination is highly unlikely[5], we thus assume that the occurrence of a safety failure (a given box of produce

[5]If we were dealing with bacterial contamination (e.g. Escherichia coli or Salmonella), this assumption would be unreasonable.

found to be unsafe) is independent[6] 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. But 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[7]: 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 (Figure 1. depicts this scenario): (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, 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 higher 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

[6] A box corresponds to a given producer, a given plot of land (that is homogeneous soil and climate) and a given day of the harvest. Despite the fact that boxes can come from the same producer, this definition leads us to think that our hypothesis of independence across boxes is satisfactory.

[7] Mandatory full traceability suggests that there might be some kind 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' failures (which are not numerous). Further research would be necessary to understand why there is no kind of safety reputation.

unsafe box can be reported as safe.[8] If the importer detects an unsafe box, either he will return the box to the foreign sender or he will destroy it.[9] 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.[10] 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. Let introduce $0 < s < 1$ the probability that an unsafe box (the importer did not detect or check) 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.

FIGURE 1 Scenario for one box of produce

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

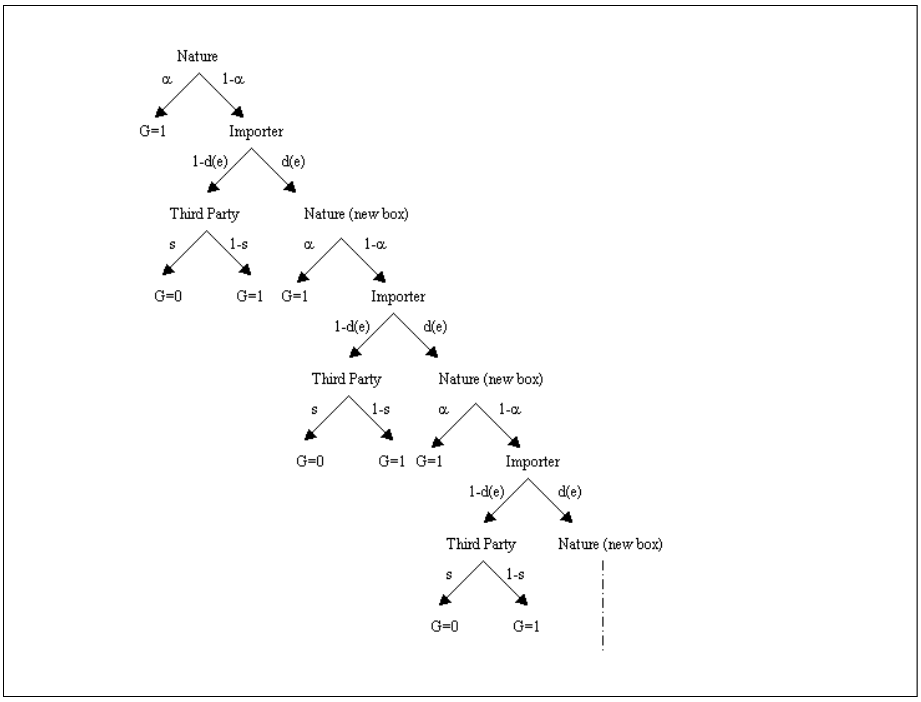
$$p = (\alpha + (1-\alpha)(1-d(e))(1-s)) \sum_{j=0,\dots,+\infty} [(1-\alpha)\, d(e)]^j \qquad (1)$$

In order to explain equation (1), let us build it step by step. We consider the case of an importer who faces a demand from its customers of one box. We calculate the probability for this importer to get a commission of 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 then when he has the ability to replace it twice.

[8] 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. Buzby and Frenzen (1999) underline that it is difficult for consumers to prove causality between consumption and illness. This is even more difficult in the case of pesticide contamination.

[9] At this stage, our results will not be affected if we consider that the importer can choose whether to sell the box or to destroy it. In any case, the importer will never sell the box.

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



First, we examine the case of an importer who will not have the ability to replace the box if he detects the box as unsafe. The importer will receive a commission 1 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 of 1 is given by $p_0 = \alpha + (1-\alpha)(1-d(e))(1-s)$.

Second, we examine the case of an importer who has the ability to replace once a box he detects as unsafe. The probability to get 1 becomes $p_1 = p_0 + (1-\alpha)\, d(e)\, p_0$. The first right hand side term (p_0) refers to the probability that the box is sold without any reported detection. The second term $((1-\alpha)\, d(e)\, p_0)$ refers to the probability that the box is detected as unsafe by the importer $((1-\alpha)\, d(e))$ and replaced by a new box, which one is sold without any reported detection (p_0).

Third, imagine 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 new box as unsafe and he changes it for a third one. The third one is sold and not 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, 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 the importer sold passes through all the steps of the supply chain. It can be rewritten such as

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

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 higher 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 has been influenced by production practices from upstream suppliers and s which is influenced by downstream operators. Moreover, 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. Formally,

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

In our empirical case (see section 3.1), 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 above, the importer only supports the costs for the boxes he is going to sell (and not the costs incurred for boxes he will return or will destroy).

We can now define the expected utility of an importer. 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 others 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 $u(0)=0$, $u'>$ and $u''\leq 0$. The importer's objective is to maximise the expected utility with respect to his effort e:

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

To highlight equation (5), let us calculate the utility of an importer who faces a demand of 2 boxes. With a probability $(1-p(e,X))^2$, the two boxes are detected by third parties as unsafe and the importer gets a utility of $u(0)=0$. With probability $2p(e,X)(1-p(e,X))$, third parties report either the first box as unsafe and the second box as safe, or they report the first box as safe and the second one as unsafe. In this situation, the importer will get 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 parties and the importer gets $u(2)$. Therefore, the expected utility of the importer who sells 2 boxes can be written: $Eu(2,e,X)=2p(e,X)(1-p(e,X))u(1)+(p(e,X))^2u(2)-2ce-C(2)$. Equation (5) is the generalisation of this formula for an importer who faces a demand 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 support 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.) That is, 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,

$$u(k) = -\delta \exp(-ak) + \beta, \tag{6}$$

with $\delta > 0$ and $a = -\frac{u''}{u'} > 0$ is the 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 holds:

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

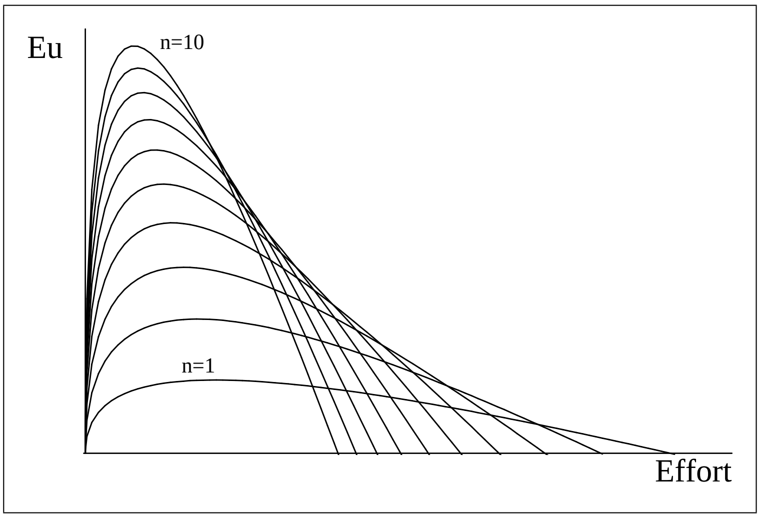
(The proof is reported in Appendix 1) Proposition 2 suggests that an increase in the number of boxes increases diversification of the risk. In others words, an importer who sells a small number of boxes is in a more risky situation than an importer who sells a higher number of boxes. If the importer 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 to sell one box of produce to comply with the demand he faces. He faces the following situation: either his box passes all the step 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 to sell 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) one of the two boxes is reported by a third party as unsafe, which means he will only receive a commission of 1 for the box that passes the entire supply chain. This 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.

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 $X = (x_i)_{i=1,\ldots,t}$. 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 is developed further in the empirical section. Consider the importer's propensity to work with supermarkets (CustFrce1, 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 these facts, we can assume that the propensity to work with supermarkets increases s. According to equation (8), the effect of an increase in s on the optimal effort is

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

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

In the next section, we test our main theoretical prediction with our primary data. It was impossible to find a good proxy for risk aversion. 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. One consequence is that the empirical section can only provide information on the second prediction (Proposition 2). 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 Maximum Residue Limits for pesticides (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 E-coli, Salmonella, etc.[11].

Any 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.[12] As producers, 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 (e.g. a box of tomatoes, a box of apples, etc.), take one or two

[11] In the United States, several microbiological hazards have been linked to the consumption of contaminated fresh produce (FDA, 1998). Methods of handling, processing, packaging and distribution of fresh produce have been developed in an effort to minimise the risk of illness associated with consumption of fresh produce (Beuchat, 1996).

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

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 able to reduce the risk of excess pesticide residues in or on produce prior to consumption. 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 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.[13]

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

The first motivation 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 others advantages. The frequency of public controls is reduced.[14] And, 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 import market, 66 of whom were members of the programme in 2006. Most (61.5%) joined the first year. The number of firms enrolling decreases every year, with only four new members between 2004 and 2006.

The goal of this voluntary programme is to achieve better levels of safety in the fresh produce entering the French market. As a condition of joining the voluntary programme, importers must arrange 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 more likely to show excess pesticide residues (e.g., strawberries are more likely to exceed residue limits than tomatoes). 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. Also, Spain has been hit by a new disease (Bemisia Tabaci or the med fly), and producers have resorted to massive use of pesticides. In terms of produce, importers do not usually specialise in the sale of only one or two products:

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

for more than eight out of ten firms less than the half of their total sales is represented by one product type and they target all their produce for analyses.

The programme requires 1 analysis for 1 M€ of sales. In others 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. 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 and they also have to allocate human and financial resources to monitoring. Pesticide residues analyses are costly: €300 for a standard analysis, although participants in the programme receive a discount.[15] The marginal cost of the analysis is thus constant.

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 exhaustive sample (66 members) of firms participating in the Perpignan voluntary safety programme (with the support of the importers' board). 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.

[15] This discount is about 20%.

Only participants in the voluntary scheme benefit from due care.

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).[16] Our questionnaire 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).[17]

PLEASE INSERT TABLE 1

We approximate the number of boxes by the total amount of sales (in million euro) in 2005 – variable ($Sales$). Firm sales (size) range from €1.4 million up to €69 million with a mean at €17.43 million 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.

The absolute number of laboratory analyses carried out by importers in 2005 ($Nbrepest05$) 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% of the average. The importer's safety effort ($Safetyeffort$)[18] relative to firm size, namely the ratio ($Nbrepest05/Sales$) varies widely, from 0.25 to 42.85 (number of analyses per million €). The effort made by importers widely

[16] Survey available upon request.

[17] Our econometric analysis is run over a final sample of 62 firms (rather than the 66 members) because of missing values. We present descriptive statistics only for the observations in the estimation.

[18] This way of defining *(Safetyeffort)* allows us to capture the intensity of effort and to cancel out the effect of size. Then we can safely use size as an exogenous variable in the econometric analysis.

differs from one to each other : The average behaviour is 2.73 analyses per million €, the median being 2 and 90% of firms report less than 3.8 analyses per million €. 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.[19] We test the following model :

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

As endogenous variable, we consider the logarithm of the safety effort ($\ln(Safetyeffort)$) 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 millions of Euros ($Sales(\ln)$). *Specialisation* represents the proportion of 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 approximate for 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. We characterise downstream relationships by the main type of French customer. $CustFce1$ is 0 if the customer is a wholesaler, and 1 if

[19] Our analysis might suffer from a selection bias since we only refer to firms that participate in the programme. They were thus not selected randomly in the entire population. We test for selection bias using the Heckman two-step procedure (Heckman, 1979). Since the Inverse Mills Ratio is not significant, the use of OLS is not invalidated. See Appendix 2.

it is a supermarket. Finally, we approximate for how the firm has implemented procedures to ensure delivery of safe fruit and vegetables. QMS (Quality Management System) is a dummy variable that takes the value 1 if the firm has adopted an additional QMS 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 implementation of the voluntary programme, otherwise it is 0. We also consider the number of public inspections imposed on the firm in 2005. For the sake of relevancy, we converted this number per unit of sales ($NbPuMo$). 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 ($Puthreat$) is 1 if the threat is considered important (very high or high), and 0 if not important (low or very low). Similarly, we created a dummy variable ($CMthreat$) to measure the firm's perception of the pressure exerted by the main customer. ($Puthreat$) and ($CMthreat$) are both subjective variables[20].

3.4 Results

Table 2 presents the results of the Ordinary Least Squares regression. The Breush-Pagan test does not reject the constant variance assumption of the residuals.

PLEASE INSERT TABLE 2

Firm characteristics:

Some of the variables for firm characteristics are significant. Firm size (i.e. ($Sales$(ln))) has a negative effect on the safety effort exerted by the

[20] Note that these two subjective variables have low correlation with other variables. If we drop them the results are consistent with those presented in the following estimation.

firm. Large firms expend lower safety efforts than small firms, which contradicts previous findings and the conventional wisdom. However, this empirical result fits with our second theoretical proposition.

Importers that are more specialised ($Specialisation$) tend to make lower 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 producers.

Upstream and Downstream Relationships :

We find that reliance on a direct procurement system 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 that 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 transaction requires commitment from both parties, leading to transaction costs and a situation of double moral hazard) the importer may also exert higher levels of effort in order to protect his investment. The quantitative variable ($NbSuppliers$)[21] has a positive effect on the level of safety effort. This result suggests that importers will be more likely to exert a higher level of effort if their procurement is atomised.

In terms of downstream operators type of the main customer ($CustFrce1$) is significant. The propensity for firms to work with supermarkets indirectly increases their safety efforts. In our specific case, working with a 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).

Other Quality Management Systems:

[21] at the 10% level

Firms that have implemented some other quality management system than the voluntary safety programme (QMS) exert a lower level of effort over safety. 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 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 relative to those importers that previously did not implement 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.

Subjective Data:

We suspect the endogeneity of ($Puthreat$): we expect that the fear of being inspected, defaulting and being detected, then sanctioned by public authorities, approximated by ($Puthreat$), is endogenous to the decision about the level of effort made by the firm. The higher the level of safety effort that the firm exerts, 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. Differences between the IV and OLS estimates are random.

The perceived pressure from customers ($CMthreat$) does not influence the firm's safety effort although type of main customer does. However, the pressure exerted by public authorities regarding food safety ($Puthreat$) 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. Our interpretation of this correlation is that the response of these importers was a protest. Our qualitative survey shows that some importers feel that monitoring produce at the point of import is useless, since they (the importers) are not the growers but are held liable under criminal law if they introduce unsafe produce. Implicit in their protest response is the desire for changes in French food safety regulation and liability.

4 Concluding remarks

The recent evolution of European food safety regulations is characterised by the increased involvement and responsibility of private actors 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 imports 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 showed theoretically that the larger the firm, the lower the number of analyses relatively to its size. We validated this prediction using original primary data (for the year 2005) drawn from the exhaustive sample of importers who participate in the voluntary programme 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. More research is needed to know whether our results can be generalised to other food industries.

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5 Table 1: Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Safetyeffort (number of analyses/M€)	62	2.73	5.38	0.25	42.85
Nbrepest05 (number of analyses)	62	28.9	30.68	5	150
Firm Characteristics					
Sales (M€)	62	17.43	16.67	1.4	69
Sales(ln)	62	2.47	0.89	0.33	4.23
Specialisation (Proportion of sales)	62	0.36	0.184	6	80
Upstream Operators					
DirectSuppliers (dummy)	62	0.37	0.48	0	1
NbSuppliers (number of suppliers)	62	42.25	35.53	1	141
Downstream Operators					
CustFrce1 (dummy)	62	0.40	0.49	0	1
Other Quality Management Systems					
QMS (dummy)	62	0.21	0.41	0	1
PrevLabAna (dummy)	62	0.53	0.50	0	1
NbPuMo	62	0.41	0.469	0.018	2.38
Subjective Variables					
Puthreat	62	0.74	0.44	0	1
CMthreat	62	0.69	0.46	0	1

Table 2: OLS estimates

Dependent Variable: Safety Effort	**Coefficients (Std. Err.)**
Firm Characteristics	
Sales(ln)	-0.620 (0.111) ***
Specialisation	-0.910 (0.44)**
Downstream & Upstream Operators	
Directsupply	0.431 (0.155)***
NbSuppliers	0.003 (0.002)*
CustFrce1	0.415 (0.163)**
Other Quality Management Systems	
QMS	-0.413 (0.197)**
PrevLabAna	0.461 (0.160)***
NbPuMo	-0.29 (0.20)
Subjective Variables	
Puthreat	-0.480(0.18)**
CMthreat	0.001(0.16)
Observations	62
Adjusted R-squared	0.56

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

Table A: (Appendix 2) Heckman Two Step Estimates (second step results reported)

Dependent Variable: Safety Effort	**Coefficients (Std. Err.)**
Mills' ratio	-0.326
Firm Characteristics	
Sales(ln)	-0.624 (0.102) ***
Specialisation	-0.791 (0.433) *
Downstream & Upstream Operators	
Directsupply	0.471 (0.151)***
NbSuppliers	0.004 (0.002)**
CustFrce1	0.439 (0.153)***
Other Quality Management Systems	
QMS	0.420 (0.182)**
PrevLabAna	0.410 (0.162)**
NbPuMo	0.335 (0.199)*
Subjective Variables	
PUthreat	-0.543 (0.185)***
CMthreat	0.44 (0162)
Observations (Censored Observations)	*62(10)*

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

Appendix 1: Proofs

Proof of Proposition 1

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

$$\begin{aligned} Eu(n,e,X) &= \gamma \sum\nolimits_{i=0,..,n} \left[\binom{n}{k} (p(e,X))^{k} (1-p(e,X))^{n-k} k \right] \quad (11) \\ & \quad +\mu \sum\nolimits_{i=0,..,n} \left[\binom{n}{k} (p(e,X))^{k} (1-p(e,X))^{n-k} \right] \\ & \quad -cne - C(n) \\ &= n(\gamma p(e,X) - ce) + \mu - C(n). \end{aligned}$$

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

$$Eu(n+1,e,X) = \frac{n+1}{n} \left[Eu(n,e,X) - \mu + C(n) \right] + \mu - C(n+1). \quad (12)$$

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:

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

Or,

$$Eu(n,e,X) = -\delta (1 - (1-\exp(-a))\, p(e,X))^{n} + \beta - cne - C(n), \quad (13)$$

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

$$\delta (1 - \exp(-a)) (1 - (1 - \exp(-a)) p (e^*(n, X), X))^{n-1} \frac{\partial p}{\partial e} (e^*(n, X), X) = c \tag{14}$$

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

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

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

$$\begin{aligned} \frac{\partial Eu}{\partial e} (n+1, e^*(n, X), X) &= -(n+1)(1 - \exp(-a)) p (e^*(n, X), X) \\ &< 0. \end{aligned} \tag{15}$$

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

Appendix 2 : Robustness Check - Selection Bias

In our empirical framework, our underlying population is the exhaustive sample of firms that participate in the safety programme. Therefore, the results of our main estimation hold at least for the population of firms within the voluntary programme. However, if we want to extend our finding to the whole industry our analysis may suffer from the presence of a potential selection bias.

Over the 98 importers operating in the Perpignan market, we surveyed the 66 members of the programme and 12 non participants firms which report no analysis. In order to test for selection bias, we apply the two step Heckman selection model (Heckman, 1979) procedure.

The equation of interest is the same as in the body of the article:

$$\ln(Safetyeffort_i) = \theta_0 + W_i'\theta_1 + \varepsilon_i \tag{16}$$

where i denotes firm i and W_i represents a set of variables summarising the characteristics of the firm :

Firm size is approximated by the logarithm of its 2005 sales expressed in million of Euros ($Sales$(ln)). *Specialisation* is the proportion of the importer's main produce in total sales. *DirectSupp* stands for the type of the main supplier and is 1 if fresh produce comes directly from producers and zero if there is an intermediary between producer and importer (cooperative, exporter, other type of supplier). *NbSuppliers* gives the number of upstream suppliers (direct or indirect) the importer deals with. $CustFce1$ is 0 if this customer is a wholesaler, and 1 if it is a supermarket. QMS (Quality Management System) is 1, if the importer adopts a QMS, different from the voluntary agreement. *PrevLabAna* is 1 when the firm ran laboratory analyses on fresh produce before implementation of the voluntary agreement. $NbPuMo$ is the number of public inspections per unit of sales imposed on the firm during 2005. (*Puthreat*) and ($CMthreat$) are both subjective variables; (*Puthreat*) is 1 if the threat from public authorities is considered important (very high or high) and 0 if not important (low or very low). Similarly, we created a dummy variable ($CMthreat$) to measure the firm's perception of the pressure exerted by its main customer.

We then add an explicit selection equation (17) to the primary equation of interest:

$$Selection_i = \gamma_0 + Z_i'\gamma_1 + v_i, \tag{17}$$

where Z_i is a set of variables that contains 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. The results of Heckman procedure (second step) are provided in Table A.

PLEASE INSERT TABLE A HERE

We only provide the results for 72 observations over the 78 surveyed because of missing values (that is 62/66 participants & 10/12 non participants are in the final sample). Since the inverse Mills ratio is non-significant, there is no selection bias and (Based on our sample (62 participants and 10 non-participants), there is no selection bias.) the use of an OLS regression is not invalidated.

However, we have to acknowledge for this result to be fully satisfactory, we should have data for the remaining 20 firms that declined to answer the questionnaire.