Traceability Adoption at the Farm Level: An Empirical Analysis of the Portuguese Pear Industry

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Abstract: Traceability is becoming a condition for doing business in European food markets. Retailers are adopting standards that are more stringent than what is mandatory. An example is EurepGAP, a quality standard for good agricultural practices that includes traceability as a main requirement. We analyze EurepGAP implementation in the Portuguese pear industry and find that implementation cannot be distinguished from sales to British supermarkets. Discrete choice models show the odds of traceability adoption increase with farm size and previous compliance with quality assurance schemes, while farm productivity has a negative impact on the probability of adoption.

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Traceability adoption is becoming a condition for doing business in European food markets. A variety of traceability systems associated with quality assurance systems coexist. Some are private initiatives while others are public (Sterns, Codron, and Reardon). Mandatory traceability was first established in the beef sector through European Union (EU) Commission and Parliament regulations 1760/2000 and 1825/2000. Then EU regulation 178/2002 established new food laws and imposed traceability on all foods destined for human consumption. Traceability is defined in article 3 as the "ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through, all stages of production, processing, and distribution" (p. 8). While this regulation is clear about the need to establish a path of information across food supply chains, it is vague on what types of information have to be shared and about system requirements and characteristics.

As more stringent food regulations have been put forth by public authorities, the private sector, namely retailers, have been implementing their own standards responding to growing consumer demand for safer food (Giraud-Héraud, Hammoudi and Soler). Since voluntary traceability is typically associated with quality assurance systems, it is almost impossible to distinguish the motivation for traceability adoption from the decision to comply with a quality standard. However, traceability is not a requirement of every current quality assurance system.

While there are studies on the demand for traceability (see for example Hobbs et al.), empirical studies on the supply of traceability and why firms adopt it are still scarce. This paper's objective is to employ econometric methods to analyze traceability adoption at the farm level, using the Portuguese pear industry as a case study. Fruit producers in the area northwest of Lisbon are organized in cooperatives and other types of organizations. Many of them have been exporting to British supermarkets chains for the past decade. Starting in 2000, the producer organizations were pressured to adopt EurepGAP (Euro Retailer Produce Working Group Good Agricultural Practices) certification. While the number of farmers certified by EurepGAP is increasing, the majority as yet have not adopted this quality standard. As a result, they may be prevented from exporting to the more profitable British market.

This paper starts with a discussion of the motivations for traceability in food chains, a brief description of the EurepGAP quality assurance. Then we present theoretical and empirical models of adoption at the farm level. Following we describe Western region of Portugal and the methodology we used to gather the data. The final sections include a discussion of the results and concluding remarks.

Motivations for Traceability Adoption

Firms have a variety of motivations to adopt traceability. For example, Meuwissen et al. identify the following benefits in the beef sector: increased transparency, reduced exposure to liability, improved effectiveness of recalls, enhanced logistics, improved control of livestock epidemics, easier product licensing, and a price premium. Since traceability reduces levels of information asymmetry, it may decrease transaction costs thus increasing trust levels and facilitating contracting. Golan et al. surveyed several traceability systems in the US agro-food industries. They found that systems varied widely across industries and depending upon motivations for implementation.

In a study of traceability adoption in the European meat and poultry sectors, Buhr found that the main drivers are: larger production uncertainty; higher chances of moral hazard and opportunistic behavior; increasing quality monitoring costs; and the inability to identify traits. Goldsmith discusses how to impose a flow of information in grain supply chains. He argues that producers, processors, and retailers have different valuations of information, which may prevent traceability adoption. This occurs because while the producers would expect to receive a premium, processors and retailers may not be willing to offer one. However, retailers or processors will seek to develop and enforce contracts for traceability with their suppliers when they are faced with consumer willingness to pay for it or opportunities for risk mitigation through traceability.

Research to date on motivations for traceability adoption in food supply chains has been collected mainly using case study methodology. In recent years, however, there has been attempt to develop a better empirical understanding of traceability implementation. Soldano and Verneau, for example, conducted a series of interviews with managers in the Italian tomato processing industry. Their preliminary results suggest that 33 per cent of the firms interviewed have adopted traceability. The reported benefits from traceability are improved food safety, stronger consumer warranties, increased supply chain management efficiencies, and potential competitive advantages. These benefits may increase with the size of the firm.

Analyzing the impact of mandatory traceability in the Italian beef supply chain, Mora and Menozzi surveyed breeding farms and processing industries focusing on the cost components and cost drivers of traceability. Their survey of 15 slaughterhouses revealed that scale and previous adoption of traceability provide a competitive edge to firms. The results also indicate the existence of complementarities with both HACCP and ISO 9002 certification, i.e. traceability is less costly when firms are already complying with a quality assurance scheme. Moreover, while traceability raised costs across the board, these costs were perceived differently depending upon the size of the firm. They found that the costs of traceability appear to be larger for medium sized firms. Meat processors transforming less than 10,000 head per year had a traceability cost of 1.5 to 2 euros per metric ton, while those transforming more than 50,000 head per year had costs of 1 Euro per metric ton. Medium size firms, processing between 10,000 and 50,000 head per year, faced costs of traceability per head of 2.5 to 3.5 euros. In terms of the total production costs, traceability costs varied from 1.5 and 4 percent depending upon the size of the firm. The benefits reported by respondents were grouped into three categories: reduction of internal defects, reduction of external defects, and strategic advantages. Finally the authors analyze how a retailer (COOP Italia) is using contracts to force its suppliers to implement a more stringent traceability system. This system is complementary to a quality assurance system seeking to differentiate quality beef. This traceability system uses computer technologies to provide information to consumers.

Banterle, Stranieri, and Baldi carried out another empirical analysis relating traceability and transaction costs in the Italian meat processing supply chain. They administrated a questionnaire to determine how traceability changed key transaction factors and costs in firms certified under UNI 10939, an Italian quality standard. The results are based on a subsample of 32 meat processing firms. Using a combination of multivariate analysis procedures (factor, cluster, and principal components analysis) they found three clusters with diverse impacts of traceability on vertical coordination. Voluntary traceability had a bigger impact on contractual relations, especially for small firms that no longer have to rely on informal relationships to choose partners. Larger firms also reported a reorganization of their supply chain management strategies. However, this reorganization was less extensive because they had previously adopted quality assurance system that facilitated traceability adoption. In terms of risk management, the results show that while small firms avoid risk of contractual infringements through contracts, larger firms use price incentives to reduce opportunistic behavior. Overall the authors found traceability adoption created benefits through improved information flow, reinforcement of trust, and the assignment of liability across the supply chain.

To date there are few empirical studies of traceability adoption in the fruit and vegetables industries. In 2000, the Euro-Retailer Produce Working Group, which is associates the largest Northern European retailers, created EurepGAP. Adopted by all the affiliated companies, EurepGAP is a common generic standard for good agricultural practices. In 2001, this standard became mandatory for suppliers of fruit and vegetables to Eurep affiliated retailers. In 2003 it was extended to include meats. The EurepGAP standard is reviewed every three years. The 2004 version includes a checklist of 214 major and minor obligations, and recommendations (EurepGAP). Traceability is the first of 49 major obligations.

Fresh produce is a strategic asset for most retail operations. Sterns, Codron, and Reardon used a series of in-depth interviews with quality assurance and marketing managers in the leading German and British supermarket chains to study the EurepGAP quality assurance system in the produce sector. They report that the proliferation of quality assurance systems is mainly driven by retailers due to their market power from concentration, role as the consumer's gatekeeper, and comparative advantages in logistics. Industry quality standards such as EurepGAP seem to be leading to a private consensus on how to define, manage, and impose higher quality and safety standards along the supply chain.

Increasing consumer concern about food safety and the environment have led the larger retailing operators in the EU such as Marks and Spencer in Great Britain and Carrefour in France to propose their own independent quality assurance schemes. These often have more stringent requirements than are included in public regulations (Giraud-Héraud, Hammoudi and Soler). Giraud-Héraud, Hammoudi and Soler model the impact of industry wide private quality assurance systems such as EurepGAP and conclude that they may lead to a reduction in contracting and a return to spot-markets.

Peris and Juliá compare the costs of production under EurepGAP and standard practices in the citrus industry of the Valencia Region in Spain. The production costs evaluation is carried out using a full costing methodology that accounts for variable, fixed, and opportunity costs. However, opportunity costs could not be included in the estimation due to a lack of data. The results were based on the analysis of nine plots cultivated with two different varieties of oranges. The average sum of variable and fixed costs of production under EurepGAP totaled 2,388.19 euros per hectare for the plots considered. The variable costs accounted for over 60 percent of the total and varied significantly across plots. Even after accounting for the higher certification costs of EurepGAP, production under EurepGAP was found to be less costly than the conventional production system in the region. The conventional system had an average cost of 0.13 euros per kilo of oranges compared to a cost of 0.11 euros per kilo under EurepGAP.

Souza Monteiro and Caswell propose a model of voluntary traceability adoption that reflects the food supply chain under EurepGAP certification. The model has three firms linked vertically in a supply chain. The downstream 3rd tier firm, having buyer power, decides to implement a farm to fork traceability system, motivated by consumer demand and stochastic losses from inadequate food safety assurance. A contract for traceability provision is offered to an upstream 2nd tier firm. To assure participation, the contract specifies a level of traceability and a corresponding premium. In turn, the 2nd tier firm, assumed to also have buyer power over farmers, proposes a contract to assure their participation in the traceability system. If participation and incentive compatibility constraints are met, an efficient level of traceability, seen as a flow of information throughout the supply chain, can be achieved.

Empirical studies of factors that affect traceability adoption can be conducted with discrete choice models, such as those applied to the analysis of new technologies or agricultural practices. Traceability can be thought of as a new process to share information with partners. A related case is the introduction of information technologies, as analyzed by Huffman and Mercier, who study the adoption of microcomputer technologies at the farm level. They analyzed data gathered through surveys of farmers using multinomial logistic models to derive the results. Results show that education and farm structure have the largest impact on the probability of adoption. In their extensive study of farm organization, Allen and Lueck provide both theoretical and empirical evidence of contracting in agriculture. They seek to demonstrate how transaction costs are prevalent in agriculture and influence the terms of contracts. The decision to take a contract is discrete in most of the circumstances they analyze. They use either logistic or ordinary least squares regressions to obtain their results.

Here a similar data analysis methodology is followed using probabilistic models. The model will analyze the probability that a producer is certified by EurepGAP as the dependent variable, which is a proxy for implementation of a traceability system. This is regressed, through different Logit specifications, on a set of variables indicating farmer and farm characteristics.

A Model of Traceability Adoption

Traceability is a supply chain problem; it implies a flow of information through all firms involved in the production, processing, and distribution of food. Traceability can be imposed by governmental agencies, processors or retailers with market power in the supply chain, or both. Food regulation is forcing firms supplying EU food markets to implement traceability systems. As noted above, these regulations can be broadly interpreted and it is possible to adjust the types of system to the needs of a particular industry or supply chain.

Our model of the decision to adopt traceability at the farm level assumes a farmer maximizes total profits (Π^T). It obtains profits (π) from selling output; these profits are an increasing and concave function of traceability. This captures the opportunities offered in export markets where traceability is a requisite. Farmers obtain a premium (p) assumed to be linear in traceability levels. Implementing traceability is costly with variable and fixed costs, represented respectively by c^v and c^f. Since the literature suggests that the size of the farm matters, as it may lessen the burden of investments in traceability, we introduce the parameter α to account for farm size. The decision to adopt traceability (γ) by a farmer is the solution to the following problem:

$$\text{Max } \Pi^T = \pi(\gamma) + p\gamma - \frac{c^v\gamma^2 + c^f\gamma}{\alpha} \tag{1}$$

The necessary condition for profit maximization implicitly defines the optimal choice of traceability given by:

$$\frac{\partial \Pi^T}{\partial \gamma} = \pi' + p - \frac{2c^v\gamma + c^f}{\alpha} = 0 \tag{2}$$

Where π' is the first derivative of the output profit function with respect to the traceability level. This says that the level of traceability offered by a farmer is defined where benefits from marginal output profitability and the traceability premium equal its marginal costs. In the equation, the sufficient condition is verified; hence by the implicit function theorem the necessary condition defines the optimal level of traceability chosen by the farmer.

The optimal level of traceability is impacted by changes in the parameters of the model, i.e., p, c^v, c^f, and α. Table 1 summarizes these effects and their expected signs under several testable hypotheses. First, the probability of adopting traceability increases with the amount of the premium. Second, the larger are the fixed and variable costs of implementing traceability, the lesser are the chances of traceability being implemented. Third, larger farms are hypothesized to a better opportunity to obtain the benefits of traceability; therefore size is positively related to adoption. Other factors may influence traceability adoption. The literature on introduction of new technologies suggests that younger and more educated farmers are more likely to adopt. Farmers already involved in quality assurance schemes, such as those associated with Protected Designations of Origin products, may be more inclined to adopt traceability as they have already had to establish registries and comply with certification. Finally, sales to more profitable markets, such as to retailers affiliated with EurepGAP, is hypothesized to increases the probability of traceability adoption.

The first order condition for the farmer's problem shows that the decision to implement traceability depends upon marginal increments of profitability, premiums, costs, and on farm size. From this condition, the discrete choice empirical model can be defined as:

$$\gamma_i^* = \beta_i X_i + \varepsilon_i \tag{3}$$

$$\gamma_i = \begin{cases} 1, \text{ if } \gamma_i^* > 0 \\ 0, \text{ if } \gamma_i^* \leq 0 \end{cases} \tag{4}$$

where γ_i^* is an unobservable level of the traceability variable chosen by the i^{th} farm, while γ_i is the observable binary choice of the type of traceability scheme. When this variable takes the value of 1, the farm chooses a higher level of traceability, for example that required by EurepGAP. Otherwise, the farm chooses the minimum level of traceability necessary to remain in the market. X_i is a row vector of exogenous variables affecting the farmer's choice, β_i is a column vector of unknown coefficients, and ε_i is a farm specific error term. The vector of exogenous factors includes: farmer's age and education level, size of the farm, farm production and productivity, farm location, affiliation to a farmer organization, type of farmer, and whether the farmer sells to the export and/or domestic markets. Following Maddala, the empirical model is specified as:

$$\begin{aligned} \mathrm{Prob}(\gamma_\mathrm{i}=1) &= \mathrm{Prob}(\varepsilon_\mathrm{i} > -\mathrm{X_i}\beta_\mathrm{i}) \\ &= 1-\mathrm{F}(-\mathrm{X_i}\beta) \end{aligned} \tag{5}$$

Assuming the cumulative distribution of the error term is logistic, the Logit specification (Maddala) is:

$$\mathrm{Prob}(\gamma_\mathrm{i}=1)=\frac{e^{\beta_i X_i}}{1+e^{\beta_i X_i}} \tag{6}$$

This specification can be used with survey data to test the hypotheses suggested above to determine what affects the probability of implementing traceability in the case study industry.

The Portuguese Pear Industry

The Portuguese pear industry provides an interesting case study of traceability adoption for several reasons. The Western central region of Portugal is a costal area of about 2000 square kilometers located between the cities of Lisbon and Leiria. This region produces 80% of the total Portuguese pear production, which varies between 100,000 and 200,000 tons a year (Silva et al.). About one fifth of the annual crop is exported, mainly to European countries, Canada, and Brasil. The local pear is the *Rocha* variety, which is currently the 3rd most exported variety in the world. It was recognized as a Protected Designation of Origin (PDO) by the European Union in the 1995. Producers selling under this regional label have since adopted quality assurance and certification schemes. On average, producers in this region have exported about 15% of total production to United Kingdom supermarket channels (Soares, Silva, and Alexandre). British retailers have been imposing EurepGAP accreditation on the producers and processing facilities in this region since 2001, leading to traceability adoption by those who want to keep their contracts. Farmers and their organizations were asked to upgrade the traceability system already in place to comply with integrated crop protection and production schemes, improve environmental practices related to usage and storing of agro-chemicals, and assure proper working conditions for rural workers (the social dimension of EurepGAP). Production in this region is organized in several types of cooperatives, exporting companies, and other types of organizations. The farmer organizations in this region are recognized as being among the more professionalized in Portugal.

British supermarkets associated with EurepGAP have long being purchasing fruit in the area. About 30 percent of the annual crop from several different pear processing facilities in Portugal is sold to these supermarkets. They offer an annual contract for fruit supply to Portuguese farmer organizations. In turn these organizations contract with their affiliated pear orchards. Firms not willing to be certified under this scheme risk losing access to the profitable British market.

Survey Methodology and Data

To analyze what impacts traceability adoption in the Portuguese pear industry we contacted Portuguese researchers and, in a field trip to Portugal, identified a group of seven pear producers organizations in the western region north of Lisbon that have implemented traceability systems from the farm to supermarkets. In our contacts, we found that traceability is always associated with some sort of assurance or regulatory scheme. Typically, its adoption is not an initiative of farmers; rather it is a response to changes in market or regulatory conditions. Hence it is not possible to decouple traceability adoption from other forms of quality differentiation strategies.

In the case study region there are three categories of farmers regarding traceability adoption: those that have not yet adopted it, those who adopted it to the degree necessary to comply with integrated crop management regulations, and those who comply with EurepGAP requirements. Recall, that traceability is the first major must control points of this quality standard. Other major musts are closely related to the practices of integrated crop management; additionally there must be registries on how pesticides and herbicides are stored, water use, and conditions for workers. Thus we can assume that the system of registries at the farm level, which is the base of traceability, is more stringent under EurepGAP than is required to comply with integrated management regulations.

To obtain the data we first contacted the directors of seven marketing oriented farmer organizations by phone, asking them for information on types of traceability systems implemented and whether they would participate in a survey. Additionally, we contacted the Associação Nacional de Produtores de Pêra Rocha, which is the organization managing the PDO *Pêra Rocha do Oeste*, asking for their collaboration in data collection. Then an email questionnaire was sent to the directors of all these organizations during the month of April 2006. Each was asked to gather a random sample of farmers affiliated to his organization and, for each of these, answer a questionnaire designed to obtain information on the type of traceability system implemented, characteristics of the farm and farmer, location, and markets to which production was sold. A translation of the instrument is available upon request. All the variables in the survey were binomial or categorical. To increase the response rate, we did not include direct measures of monetary costs and benefits of traceability to farmers. We obtained data from 6 of the 8 organizations contacted; the sample totals 140 observations, however due to missing data not all could be used in the analysis.

Table 2 shows descriptive statistics on each of the variables in the survey. In order to estimate the Logit model we first separated the categorical data into dummy variables. Even though our dependent variable (TRACESIS) was designed to have three categories, thus permitting a multinomial Logit analysis, it was not possible to obtain observations on farmers who did not implement traceability. Hence, the comparison is between EurepGAP traceability adoption (36.43% of the observations) and the benchmark of a regulatory traceability scheme linked to integrated crop management.

The variable CENTRAL indicates to which of the six producer organization the farmer is associated. For the analysis, the six organizations were grouped into a binomial variable. One group includes the larger organizations of Frutus, CoopVal, and Frutoeste; they were the first to adopt EurepGAP. The other three smaller and later adopting organizations, Ecofrutas, Cooperfrutas, and Eurohorta, were also grouped together. AGE indicates the age group of the farmer or manager; the data was collected in five categories that were then merged into 4 dummy variables. EDUCATION captures the schooling level and leads to 2 dummy variables. TONHAPE measures the productivity of the pear orchard in tones per hectare, three dummy variables where derived from this variable. UKSALES is a dummy variable taking the value 1 if the producer sells pears to British supermarkets. Finally, since 4 municipalities in this region account for over 60% of the total national pear production, the variable MUNICIP was recoded as a dichotomous variable taking the value 1 if the farm is located in one of the top four municipalities.

We use reduced form indicators to capture the effect of different factors on the type of traceability system adopted. The literature reviewed and preliminary results from a study being carried out in the region by Pinto and Fragata suggest that productivity, compliance with an existing quality assurance system, and fragmentation of farmland are proxies for the costs of implementing traceability. For orchards of the same size, a more productive farm will have higher production volume, need more registry activity, and have higher traceability costs. As Mora and Menozzi pose, having complied with some type of quality assurance system facilitates implementation of traceability. In this region producers may be meeting PDO standards and thus would have a lower cost of traceability adoption. Hence, we hypothesize that the dummy variables TONHA2 and TONHA3 (derived from the variable TONHAPE) will decrease the odds of traceability implementation, while PEARPDO, an indicator of prior quality assurance activity, will increase them. We could not obtain information on the number of parcels held by each farm so this proxy for traceability costs is not included in the analysis. Using these exogenous variables, we estimated a set of models using the logistic procedure in SAS.

Factors Affecting Traceability Adoption in the Portuguese Pear Industry

Table 3 reports the results of the analysis of maximum likelihood estimates for the full model of traceability choice, using all the exogenous variables described in the previous section. The matrix of correlations did not show evidence of multi-collinearity between the independent variables of the model. However, in estimating this model we were confronted with a problem of quasi-complete separation of data points. This is a sign of convergence failure, in which case the maximum likelihood estimate may not exist (Allison). Quasi-complete separation issues occur in logistic regression estimation when samples are small, the explanatory variables perfectly or nearly perfectly predict the values of the endogenous variable, and when there is multi-collinearity. Typically the maximum likelihood estimator algorithm does not converge, and what is reported is the last iteration before the process stops. The coefficients reported have the correct signs and magnitudes; however inferences should be avoided as the significance tests are incorrect (SAS). To diagnose what independent variable is causing the problem, Allison suggests checking for covariates with large coefficients and standard errors. An immediate remedy is to estimate the model without the culprit variables; however this may cause biases because what causes the problem is that these covariates are too good. A prescribed alternative is to report the results of the non-converged solution with an infinity symbol for each variable causing the problem (Allison).

The full model has a good and significant fit (-2LL is 86.31) at the 1% level. The predictive power is also very good (R^2 of 68%). We do not report the Wald chi-square significance tests for the parameter estimates because they are not reliable when there is quasi-complete separation of data points (SAS). Table 3 shows that the signs of PEARPDO, PEARAREA2, TONHA2, and TONHA3 conform with our hypotheses. Following Allison, the estimates for the variable UKSALES are reported with an infinity symbol, indicating that it perfectly predicts the observations of the dependent variable and indicating that it is the variable causing the quasi-complete separation problem. This should not be surprising, since EurepGAP certification is only imposed on farms that want to continue to sell to the UK supermarkets. Table 4, reports the cross frequencies between the dependent variable TRACESIS and the exogenous UKSALES. The cell corresponding to no sales to the UK and EurepGAP traceability has zero observations.

The results shown in table 3 indicate that the choice of the traceability level by a farmer in this region cannot be separated from the choice of the market where sales occur. Hence, the problem of the farmer can be decoupled into a two step decision process: first the farmer (or the organization to which he or she is affiliated) chooses whether to enter into contracts with British supermarket chains. Second, the farmer decides on the type of traceability to implement. An empirical strategy to model this decision process is to use a nested Logit model as described by Maddala. Here we use an alternative approach that first models the choice of sales to the UK by regressing the binomial variable UKSALES on the set of exogenous variables used in the estimation of model 1. This is model 2 reported in table 5; it uses the complete set of observations excluding those with missing values. In a second step, we model the choice of traceability system (TRACESIS) adopted by the subset of 89 out of 140 farmers selling to the UK, using the same set of exogenous variables. The results are reported as model 3 in table 5.

The results show that both models have a good fit, as shown by the likelihood ratio statistic (-2LL) and at least one of the parameters is significantly different from zero at the 1% significance level. The predictive power of both models is quite good for Logit models, as the adjusted R^2 statistic is .63 for model 2 and .44 for model 3.

The model 2 results suggest that the odds that a farmer sells to the UK market increase with farm size, if the farm sells pears under a PDO label, and if the farmer is associated with one of the larger producer organizations. The model 3 results support the hypotheses formed from theoretical model. The coefficients on PEARPDO and PEARAREA2, which capture the effects of using a quality assurance system and having a larger farm, are positive, increasing odds of adopting EurepGAP traceability by 13.34 and 1.53 times. Also as hypothesized the more productive a farm is the lower are the odds of EurepGAP traceability adoption. More productive farms have to do more registries and therefore have higher traceability costs. Other factors that increase the odds of adopting EurepGAP traceability are: being a full time producer (increases odds 6.77 times) and affiliation with one of the larger producer organizations (increases odds 5.00 times). Farmers who are 36 to 45 and from 56 to 65 years old have a higher propensity to adopt EurepGAP traceability. The level of education seems to have a very small effect on the odds of adopting more demanding traceability systems.

Conclusions and Future Research

We analyzed traceability adoption at the farm level in the Portuguese Pear Industry using discrete choice models. We gathered data on farm's and farmers characteristics from six producer's organizations from the western region of Portugal, which is the leading pear producing area in the country. Since, 2001 farmers in this region were asked to upgrade their traceability and comply with EurepGAP quality assurance system. Traceability should be seen as a complement or as an integrate component of quality assurance systems. Our research and interviews with farmer's organizations indicate that it does not make economic or technical sense to implement traceability if the farmer is not yet complying with some quality standard. Traceability may not stand alone.

The main results are based on a sub-sample of the original dataset, composed only by those pear producers exporting to the UK. We provide evidence for our theoretical hypothesis that the size of the farm and previous compliance with a quality assurance system increase the probability of adoption of more stringent traceability systems, while farms with higher productivity have lower odds of adoption.

This study has important policy implications. First, it shows that there may be complementarities between mandatory and voluntary traceability systems. Second, if firms with market power are required to implement traceability systems, they can use their influence to force their partners in the supply chain to implement more stringent traceability systems. Finally, if public authorities and managers of farmer's organization want to improve the number of farmers adopting traceability they should concentrate their efforts on helping smaller and more productive farmers.

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Table 1 Effects of changes in the premium, costs and size of the farm in optimal traceability

Effect	**Result**	**Expected Sign**
$\frac{\partial \gamma^*}{\partial p}$	$\frac{\alpha}{2c^v - \alpha\pi''}$	+
$\frac{\partial \gamma^*}{\partial c^v}$	$\frac{1}{-2c^v + \alpha\pi''}$	-
$\frac{\partial \gamma^*}{\partial c^f}$	$\frac{2\gamma}{-2c^v + \alpha\pi''}$	-
$\frac{\partial \gamma^*}{\partial \alpha}$	$\frac{c^f + 2c^v\alpha}{2c^v - \alpha\pi''}$	+

Table 2 Descriptive statistics of farm characteristics and farmer demographics for the sample

Variable	Value	Valid Percent	Variable	Value	Valid Percent
CENTRAL	Frutus	21.43	**TONHAPE**	<10 ton/ha	10.22
	Ecofrutas	10.71		11-15 ton/ha	40.15
	CoopVal	21.43		16-20 ton/ha	39.42
	Frutoeste	21.43		>21 ton/ha	10.22
	Cooperfrutas	24.29	**PRODCPEAR**	<100 ton	64.23
	Eurohorta	0.71		>101 ton	35.77
PRODTYPE	Full time	80.00	**UKSALES**	Yes	64.49
	Part time	20.00		No	35.51
AGE	25-35	14.60	**MUNICIP**	Top 4	78.57
	36-45	16.06		Others	21.43
	46-55	21.90	**PEARAREA**	< 5 ha	54.29
	56-65	36.50		6-15 ha	36.43
	>66	10.95		> 16 ha	9.29
EDUCATION	Middle School	57.25	**PEARPDO**	Yes	86.43
	High School	29.71		No	13.57
	Tertiary education	13.04			

Table 3 Logistic regression estimates for EurepGAP adoption

	Model 1 *(N=138)*
Intercept	-18.39
PRODTYPE (1=Full time)	1.91 (6.77)[a]
CENTRAL (1=Larger organizations)	1.61 (5.01)
AGE1 (1=25-35)	1.07 (2.91)
AGE2 (1=36-45)	2.39 (10.96)
AGE3 (1=46-55)	1.07 (2.91)
AGE4 (1=56-65)	2.00 (7.43)
EDUC1 (1=Middle school)	-2.50 (.08)
EDUC2 (1=High School)	-2.05 (.13)
TONHA1 (1=<15 ton/ha)	.83 (2.30)
TONHA2 (1=16-20 ton/ha)	-.65 (.52)
TONHA3 (1=21-25 ton/ha)	-1.59 (.20)
PEARAREA1 (1=<5 ha)	-.46 (.36)
PEARAREA2 (1=6-15 ha)	.43 (1.53)
PEARPDO (1=yes)	2.59 (13.34)
MUNICIP (1=Top 4)	-.31 (.73)
UKSALES (1=Yes)	∞

[a]Odds ratio.

Table 4 Cross tabulation of the variables TRACESIS and UKSALES

Frequency (Percent)	UKSALES (0=no)	UKSALES (1=yes)
TRACESIS (0=no)	49 (35.51)	38 (27.54)
TRACESIS (1=yes)	0 (0)	51 (36.96)

Table 5 Logistic regression estimates for Sales to the UK (Model 2) and EurepGAP adoption (Model 3)

	Model 2 (N=138)	*Model 3 (N=89)*
Intercept	3.64	-2.98
PRODTYPE (1=Full time)	-.81 (.44)[a]	1.91** (6.77)
CENTRAL (1=Larger ones)	3.75*** (42.66)	1.61** (5.00)
AGE1 (1=25-35)	0.60 (1.81)	1.07 (2.91)
AGE2 (1=36-45)	-1.14 (0.32)	2.39* (10.96)
AGE3 (1=46-55)	-.78 (.46)	1.07 (2.91)
AGE4 (1=56-65)	-2.12** (.12)	2.00* (7.43)
EDUC1 (1=Middle school)	-1.66 (.19)	-2.49** (.08)
EDUC2 (1=High School)	-.87 (.42)	-2.05** (.13)
TONHA1 (1=<15 ton/ha)	-4.23** (.02)	.83 (2.30)
TONHA2 (1=16-20 ton/ha)	-4.09*** (.02)	-.65 (.52)
TONHA3 (1=21-25 ton/ha)	-1.36 (.26)	-1.59* (.20)
PEARAREA1 (1=<5 ha)	-1.45 (.23)	-.46 (.63)
PEARAREA2 (1=6-15 ha)	.07 (.93)	.42 (1.53)
PEARPDO (1=yes)	2.31** (10.08)	2.59 (13.34))
MUNICIP (1=Top 4)	-.45 (.64)	-.31 (.73)
-2LL	96.25***	86.31***
Pseudo R^2	.63	.44

[a]Odds ratio. *** p<0.001; ** p<0.05; * p<0.1.