Impact of Firm Characteristics on Expected and Actual Traceability Costs and Benefits in the Italian Fishery Supply Chain

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Abstract

Since 2005, the implementation of a traceability system is mandatory to all European food chain operators. The balance of costs to build and maintain the traceability system and benefits of traceability depends on the firm's traceability objectives and its resources, as reflected in characteristics, such as adopted quality management systems (QMS) or firm size. Mora and Menozzi (2005) mention that the cost of traceability is lower when firms already have a QMS in place. Moreover, US producers exporting to multiple destinations, in particular EU and Japan, need to comply with more stringent traceability regulations (De Souza Monteiro and Caswell 2004). This may request the adoption of more sophisticated and costly traceability systems. Food operators tend to have a good understanding of traceability cost, while performance benefits are usually more difficult to grasp (Verdenius 2006). This research aims at improving the understanding of how expected and actual costs and perceived benefits are influenced by firm characteristics (Meuwissen et al. 2003).

This paper proposes a conceptual decision model that incorporates firm characteristics and both expected and actual costs and benefits of traceability. It is hypothesized that firm characteristics influence both expected and actual costs and benefits, while the level of traceability is influenced by expected and actual costs and perceived benefits as well as firms' characteristics. Costs can be divided into implementation and operation/maintenance costs. Benefits can arise from compliance with regulatory requirements, enhanced recall performance, improved marketing performance and increased supply chain efficiency (Sparling and Sterling 2004).

The analysis uses a sample of 60 Italian fish processing businesses that were surveyed in 2008. Indicators of firm's characteristics such as number of QMS certifications, operations complexity, firm size and complexity of customer requirements, are entered as independent variables in regression analyses to predict expected and actual costs and perceived benefits which were measured on 9-point semantic scales and constant sum scales.

The findings show that none of the firm characteristics investigated influence costs, while firm size and QMS certifications influence benefits in different ways. Somewhat surprisingly, firm size was found to be negatively correlated with expected and actual benefits; i.e. larger firms reported lower benefits both expected *ex-ante* and realized *ex-post* traceability system implementation. Finally, the number of QMS certifications is positively associated with expected benefits; i.e. expected benefits increase with the number of QMS certifications acquired by a firm, but no association with actual perceived benefits of traceability was found.

Keywords: *Traceability, firm characteristics, business performance, fishery operators*

1 Objectives of the study

Traceability is not a new concept, but it is a system innovation that European food operators need to implement in their plants to comply with the so-called “European General Food Law” (EGFL, Regulation (EC) No 178/2002) (European Commission 2002). Traceability can be defined in several ways depending on its purposes, such as regulation, food safety, supply chain management, marketing, etc. The EGFL defines traceability as “*the ability to trace and follow a food, feed, food-producing animal or substance through all stages of production and distribution”.*

According to Golan et al. (2004) the definition of traceability is necessarily broad because the food industry is complex due to the variety of food products available for consumers and to the range of inputs and ingredients used. Thus, the EGFL does not state any specific methods or techniques that food business operators have to follow to establish a traceability system (Canavari et al. in press). As firms can customize the most appropriate approach (Folinas et al. 2006), a plethora of traceability initiatives, guidelines and standards is currently evolving.

Furthermore, traceability is a tool for achieving a number of different objectives. According to Can-Trace (2004) it has to be acknowledged that traceability is part of the food business systems and thus has to be integrated with logistic processes, good manufacturing/ agricultural practices and food safety programs, such as Hazard Analysis Critical Control Points (HACCP). As a result, traceability definitions or levels differ between operators depending on the business activity, stage in the supply chain and applicable legislation (ECR Europe 2004).

The level of traceability capacity may be described using three dimensions (Golan et al. 2004):

- precision, reflecting the size of a traceable lot or batch that is uniquely identified. It can range from a single product package to a whole day of production.
- breadth, describing the amount of information collected that can be connected with the lot.
- depth, describing how far back or forward the system regularly traces the relevant information. According to the EGFL the minimum legal requirement is “... *one step forward and one step backward*” of the business relationship, while a whole chain coverage would require a traceability spanning the entire food supply chain.

According to Golan et al. (2003) firm’s resources and objectives, as summarized as firms characteristics, influence costs and benefits associated to traceability system implementation. Firm characteristics, such as size (Bulut and Lawrence 2008; Mora and Menozzi 2003), quality management system (QMS) adopted (Mora and Menozzi 2005), technological sophistication of firm, nature of product, how product is packed, processed and shipped, type of customers (Mejia et al. 2010), etc. may affect costs and benefits associated with potentially appropriate traceability levels. Thus, firm’s investments in a traceability system will vary in costs and benefits. That is not an indicator of inadequacy, but of efficiency as a result of careful balancing of costs and benefits (Golan et al. 2004). Thus, firms balance costs and benefits of traceability and tend to efficiently allocate resources to build and

maintain the traceability system only when the benefits outweigh the costs (Golan et al. 2004).
To date, few empirical studies are available that investigate the estimation of traceability costs and benefits (Mejia et al. 2010; Stuller and Rickard 2008) or on the measurement of costs and benefits of improved traceability (Hurburgh 2003; Wilson et al. 2008), or on firms' incentives for implementing tracking and tracing technologies (Hobbs 2004). While it is rather straightforward to assess costs, many benefits are difficult to assess due to low probability, difficulty in isolating them from other causes or due to their intangible nature. This is one reason why adoption of traceability has been slow in the food sector (Verdenius 2006) and few studies analyse benefits at the firm level.
Thus, this paper aims at contributing to closing this knowledge gap through an empirical analysis to provide answers to specific questions:

- Are the firm characteristics linked to expected/actual costs and benefits perceived by food industry?
- Which is the relevance of *ex-ante* and *ex-post* specific costs and benefits categories associated to traceability system implementation perceived by food industry?

Further, our analysis goes beyond previous research by differentiating between expected and actual costs and benefits. It thus addresses the issue of investment under uncertainty, which has so far received little attention in the literature and allows identifying particularly stark discrepancies between expectations and outcomes to inform policy and business decision makers.

2 Background

Amongst others, costs of traceability can depend on the regulatory environment, firm size, strategy or philosophy of the firms, the technology adopted by the firm, characteristics of products and production processes, structure and complexity of the supply chain and the amount of information required to be stored (FSA 2002). Moreover, the presence of small-scale production systems and spot-market transactions are obstacles to tracking and tracing products and result in high costs to improve traceability (Theuvsen and Hollman-Hespos 2005).
Table 1 divides traceability costs into implementation and maintenance/operation costs. "*Time and effort*", which includes production line, supervisory staff, managerial/ administrative staff time and disruption of production, is an important traceability cost both for implementation and maintenance (Meuwissen et al. 2003.)

Table 1. Categories of traceability costs

CATEGORY	IMPLEMENTATION	OPERATION/MAINTENANCE
Time and effort (of workforce, administration and management)	Information search/processing Change management Test runs/interruptions	Slow down/interruption of operations Additional reporting/mock recalls
Equipment and software	New purchases/installation	Upgrades and service contracts
Training	Extensive, comprehensive	Ongoing, for new staff
External consultants	For system choice/design	For specific challenges
Materials	Switch to new materials “system”	Labels/Packaging
Certifications and audits	Initial audits/certification	Repeat audits/certification

Source: Adapted and expanded from Meuwissen et al. (2003), and Mora and Menozzi (2003).

Such costs depend on the specialized skills and knowledge of human resources necessary for system implementation and use (Theuvsen and Hollman-Hespos 2005). In a study conducted by Mora and Menozzi (2003) on a sample of 15 firms representing 20% of the companies working in the Italian beef processing, the medium and large companies classified on the basis of annual turnover had to hire additional personnel to comply with requirements introduced by traceability regulations. The disruption of operations is also an important cost that may also be linked with reluctant workforce, because additional effort is required for strictly separating each lot, inputting data and printing different labels, etc.

“*Equipment and software*” are fundamental for the management of traceability systems (Meuwissen et al. 2003). Such costs could be very important depending upon whether such equipments (e.g. computers, palmtops, barcode systems, printers, etc.) or software are already installed in the plant and appropriate or not.

“*Training*” of staff and management is an important traceability cost. Basically, it is a cost of implementation, but it also could be a maintenance/operation cost when, for instance, there is an upgrading of the traceability software, new software functions are added or new staff is hired.

The cost of “*external consultants*” is particularly important for firms that do not have specialized personnel and expertise within the firm. The external consultants primarily deal with the design and implementation of the traceability software (e.g. IT – engineer), understanding and complying with traceability, labeling and hygiene regulations and assistance for certification and audits and, to a lesser extent, with tasks after implementation.

The cost of “*materials*” is associated to using pallets, boxes, labels (Stuller and Rickard 2008) etc required to conduct physical handling of traceability. For instance, a high level of precision requires lots to be kept separate using different pallets and/or boxes as well as the use of a unique identification through labels.

Finally, “*certifications and audit*” costs are associated with the adoption of traceability certification standards (e.g. ISO 22005:2007) by food operators.

Traceability produces various benefits in the food supply chain. In accordance with Sparling and Sterling (2004) we divide benefits into four groups (Table 2).

Table 2. Main categories of traceability benefits

CATEGORY	DESCRIPTION/EXAMPLES
Regulatory	Avoiding penalties for non-compliance No legal barriers to market access
Recall and risk management	More targeted, quicker recall reduces cost Reduced cost of liability insurance
Market and customer response	Reputation (build-up or regain after crisis) New customers and easier market access Real-time information for sales calls Increased demand/price for output
Supply chain operations	Improved inventory management More efficient communication with customers and/or suppliers

Source: Sparling and Sterling (2004).

"*Regulatory benefits*" constitute the first category, as compliance with regulation is a main driver (FSA 2002). Regulatory compliance is a fundamental prerequisite to having access to different food markets. Furthermore, traceability satisfies the legislation requirements of labeling regulations with reference to the potential development of a brand (Verbeke 2001).

"*Recall and risk management benefits*" constitute the second category, as also pointed out by Folinas et al. (2006) and Gellynck et al. (2007) because traceability can significantly reduce recall scopes or the amount of product which must be destroyed in response to a food safety issue. According to Theuvsen and Hollman-Hespos (2005) risk management in agriculture and food industry aims at lowering losses due to product recalls. The amount of losses is influenced by the likelihood as well as the short-term and long-term damages of recalls. Short-term damages stem from logistic costs of recalls, reduced turnover due to out-of-stock items, costs of laboratory analyses, crisis of communication with retailers and consumers, liability claims and improvements in internal processes. Long-term damages stem from costs of corporate image, firm reputation and brand value, costs of product re-launches and intensified marketing over a more fundamental redesign of internal processes and supply chain.

The third category of benefits are "*Market and customer response benefits*". Benefits are generated when traceability allows business partners to meet the specific needs requested by customers. In addition to a direct demand of traceability, traceability can also provide market benefits through product differentiation based on credence attributes, such as organic and through increasing consumer trust (Meuwissen et al. 2003). Further, the availability of accurate real-time information about production and stocks improves customer relationships.

This is closely linked with "*Supply chain benefits*" as traceability assists supply chain partners to eliminate inefficient practices without value to consumers. The main point of supply chain benefits is that traceability can reduce transaction costs. According to Sodano and Verneau (2003), this is particularly important for small to medium sized firms to gain market access and a higher market share with reduced investment in quality control systems and processes innovation. Furthermore, supply chain management benefits include the improvement of real-time inventory management, which in turn reduces product waste as well as ensuring a more consistent quality delivery to supply chain end users (Sparling and Sterling 2004).

As mentioned above, firm characteristics may influence costs and benefits associated to traceability system implementation. QM systems adopted by firms may affect the costs and benefits, but maybe in an ambiguous way. Mora and Menozzi (2005) mention that the cost of traceability is lower when firms already have a quality management system (QMS) in place (e.g. ISO 9001:2000). QMS require data collection and verification that the necessary actions are taken, and the input stage is a critical point for such systems. HACCP rule Part 417.2 (a) states that firms must conduct hazard analysis "*to determine the food safety hazards reasonably likely to occur before, during and after entry into the establishment*". A high number of QMS certifications facilitate the implementation of traceability system, because each QMS certification contains elements of traceability. Thus, firms with well functioning QMS's in place may have expected lower traceability costs than firms with less well functioning quality management systems or even none in place, all else being equal. Firms maybe without QMS could benefit very much and more than firms that have a certain level of QMS, simply because they start from zero benefits. Therefore with a higher number of QMS adopted, the costs and benefits may go down, while with a low level of QMS the costs and benefits may go up.

An in-depth study, was conducted by the Institute of Food Technologists (Mejia et al. 2010) in 58 food companies in seven sectors such as produce, packaged consumer foods, processed ingredients, distributors, food service, retail and animal feed, they found that firm size could affect the expected costs and benefits of traceability. The variable costs of traceability practices may increase with the firm size. In fact, it is reasonable that large firms have larger and more complicated operations than small firms; therefore, in order to satisfy a traceability requirement, large firms need to do more arrangements to comply with these standards thus increasing the cost. At the same time, the average fixed costs of implementing traceability decrease with the production or processing volume (Bulut and Lawrence 2008). As a consequence, the overall effect of firm size on cost of traceability is ambiguous. This ambiguity may be reduced through the simultaneous measurement of the level of complexity of operations and customers, that may be strongly related to the firm size. Bulut and Lawrence (2008) also point out that the large firms may have a disadvantage over small and mid-size firms in implementing traceability. This is because large firms who have a higher number of suppliers may not fill a single batch in the big scale operations and this may complicate the traceability practices and may increase its cost, because they need more sophisticated technologies and managerial efforts. In terms of the overall traceability cost out of total cost of production (traceability cost/overall cost of production) Mora and Menozzi (2005) in a study conducted on the Italian beef supply chain, found that the percentage varies between 0.5% to 2.5%. Regarding firm size, the highest cost for quantity produced was for mid-sized firms. While for larger firms (annual turnover higher than 80 million Euro) low costs for quantity produced are mainly linked to economies of scale, for smaller firms (annual turnover lower than 10 million Euro) low cost may conceal a more limited compliance with regulation, in terms of structures and IT systems.

Complexity of operations of firms may affect the costs and benefits of traceability. Costs may also vary depending on the nature of the products including harvest and packing location, how product is packed and shipped. Traceability practices consist of data collection through the food chain (Mejia et al. 2010). Thus, when operations are more complicated, the cost of data collection and data management increases. The diversity of food processing operations means that the way in which traceability records are kept by any business is practically unique and businesses make individual and widely varying decisions with regard to the size of batches that are produced and hence the size of any recall (FSA 2002). Firms may incur additional costs related to changes in the farming and product handling practices that require additional input costs to meet traceability requirements. As a consequence, the complexity of operations is expected to increase the costs of traceability.

Complexity of customer requirements could affect costs and benefits by traceability practices. Traceability costs are multiplied and margins lowered even further if multiple customers require different standards for their own traceability initiatives (Mejia et al. 2010). According to De Souza Monteiro and Caswell (2004) beef export supply chains to Japan and the EU are subject to more stringent and sophisticated traceability systems compared to other countries. This may determine high difficulties and management complications for a processor to deal increasing costs of traceability (i.e. more time spent by users, more sophisticated software required, etc.), because more and different mechanisms have to be in place. On the other hand, a traceability system may facilitate the management of different customers. According to Golan et al. (2004) traceability systems provide the basis for good supply management. A business's traceability system is a key to finding the most efficient ways to produce, assemble, warehouse and distribute products. Although a high of complexity of customer requirements determines, for instance, more complex management, firms could benefit from traceability practices.

3 Conceptual and Empirical Model

The simple theoretical model for this study proposes that a firm's resources and objectives:

- determine *ex-ante* balancing of costs and benefits is optimal or adequate to maximize net benefits when firms implement traceability.
- influencing *ex-post* costs and benefits as resulting of traceability system implementation.

While *ex ante*, expected costs and benefits are a function of the firm's resources and objectives, summarized as firm characteristics, the *ex-post* cost and benefits are function of a

certain level of traceability chosen by firms. Thus, *ex-post* costs and benefits of traceability would be directly influenced by the level of traceability and indirectly through firm characteristics, as could be modelled in a structural equation model approach.
However, while the theoretical analysis is straightforward, in a survey-based empirical analysis as proposed for this study, a valid measurement of the level of traceability adopted has proven to be difficult to obtain. First, in the literature reviews there are only few studies that measure the level of traceability. Bulut and Lawrence (2008) measure the depth of traceability (backward and forward). No literature at all informs us about how to quantify the levels of traceability dimensions. Second, the level of traceability adopted at the time of system implementation may not be observable any more, as it might have been adjusted in response to changes in the business environment and because of technological upgrading. Third, it would also be complicated to assess a unique level of traceability for firms, because they may adopt many levels of traceability depending on types and suppliers of raw materials, types of customers, etc. Breadth, depth and precision within firms may also vary depending on products; for example, a certain level of precision may be required at input stage and a different level may be adopted at output stage.

Due to these challenges, the analysis will focus on the expected and actual costs and benefits, as reported for firm characteristics. In other words, we hypothesize that firm characteristics affect actual costs and benefits, leaving out the measure of the level of traceability. The conceptual model thus proposes that expected and actual costs and benefits are a function of the firm characteristics.

(1) $Cost_{trace\ implement} = f\ (size)$
(2) $Cost_{trace\ maintenance} = f\ (size)$
(3) $Benefit_{trace} = f\ (size)$
(4) $Cost_{trace\ implement} = f\ (operations\ complexity)$
(5) $Cost_{trace\ maintenance} = f\ (operations\ complexity)$
(6) $Benefit_{trace} = f\ (operations\ complexity)$
(7) $Cost_{trace\ implement} = f\ (complexity\ of\ customer\ requirements)$
(8) $Cost_{trace\ maintenance} = f\ (complexity\ of\ customer\ requirements)$
(9) $Benefit_{trace} = f\ (complexity\ of\ customer\ requirements)$
(10) $Cost_{trace\ implement} = f\ (QMS)$
(11) $Cost_{trace\ maintenance} = f\ (QMS)$
(12) $Benefit_{trace} = f\ (QMS)$

For the empirical estimation we specify a linear bivariate OLS regression model accordingly for the dependent cost and benefit variables for firm *i*:

$$Y_i = b_0 + b\ X_i + e$$

Y_i is the dependent variable (e.g. Actual Benefits); b_0 stands for the constant, b is vector of regression coefficient for independent variable X_i (e.g. size); e represents the error term of the estimation.

4 Methodology

Data analysis is based on a questionnaire that was pre-tested in spring 2008 and then administered among a sample of 60 Italian fish processors through a phone survey in summer 2008. The sample frame has been produced by cross-checking the entire population of fish processors listed in the most recent Italian Census of Industry and Service of Istat (2001)[1] and a list provided in the Yearbook of Fishery and Fishing (2007/2008, n.18)[2]. The overall population was composed of 415 firms, of which 303 were contacted so that the resulting response rate of usable questionnaires was 20%. Although no data is available that would allow assessing the representativeness of the sample, it is reasonable to assume that larger firms are overrepresented. In fact, the Italian fish processing industry mainly consists of very small, locally operating firms, but their manager-owners tend to be reluctant to participate in surveys.

The following tables 3 and 4 present how the variables that enter the analysis to represent firm characteristics and cost and benefit indicators were measured and, where applicable, recoded into indices[3].

Firm characteristics that were elicited in the survey do not include any measurement of strategic orientation or firm objectives, as this was deemed to considerably increase the risk of overburdening the respondents. However, some of the variables included are reflective of strategy components that are certainly relevant for costs and benefits of traceability. E.g., the number of sales destination regions can be expected to be positively related with the cost of implementing and running a traceability system.

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1. Istat, 2001. Website: http://dwcis.istat.it/cis/index.htm
2. The Yearbook is published by Edizioni Pubblicità Italia s.r.l. (http://www.pubblicitaitalia.com) that is largely considered by the Italian fishery operators as the most important professional Italian publishing house in the fishery supply chain.
3. A copy of the questionnaire is available from the authors upon request.

Table 3. Firm characteristics indicators

VARIABLE	CODING	RANGE OF SCORES
SIZE	Equally weighed average score of labor force size index (Scores between 0.5 and 8) and revenue categories (1: below EURO 250,000; 8: above EURO 25 million).	Min score: 1.5 Max score: 16
OPERATIONS COMPLEXITY	Number of different raw material types that are used in operation: seafood; freshwater fish; shellfish; crustaceous (Scores assigned: 1 for each type of raw material). Number of different product categories that are produced at facility: fresh; frozen; deep-frozen; other (Scores assigned: 1 for each type of product categories) and preserved/pickled; dried/salted/smoked (Scores assigned: 2 for each type of product categories).	Min score: 2 Max score: 12
COMPLEXITY OF CUSTOMER REQUIREMENTS	Number of different customer types to which output is sold: Regional/local retailer; Local fishery shop; Pitchman; Wholesaler; Wholesale market; Other Food service operator; Direct to the final consumer; Other processors; Other (Scores assigned: 1 for each type of customers). International/national retailer; Food service chain; Institution (Scores assigned: 2 for each type of customer). Number of different regions to which output is sold: Italy; other EU countries; other European countries; North America; South America; Africa; Asia; others (Scores assigned: 2 for each type of customers).	Min value: 2 Max value: 23
QMS	Number of food quality or safety assurance/management standard to which the firm is certified: ISO 9000:2000; HACCP, ISO22000:2005; MSC, ISO14001; IFS; BRC; EUREPGAP; others (Scores assigned: 1 for each type of QMS).	Min score: 0 Max score: 9

As shown in table 4, costs and benefits were measured at two levels. The overall level was measured using 9-point rating scales as described in the table below.

Table 4. Indicators of expected and actual cost and benefits and discrepancies

INDEX	EXPLANATION	RESPONSE SCALE	RANGE OF SCORES
EXPECTED COST OF IMPLEMENTATION	Magnitude of expected implementation costs	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
ACTUAL COST OF IMPLEMENTATION	Magnitude of actual implementation costs	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
IMPLEMENTATION COST DISCREPANCY	Discrepancy between expected and actual implementation costs	Actual implementation cost – Expected implementation cost	Min score: -8 Max score: +8
EXPECTED OPERATING COSTS	Magnitude of expected operating costs	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
ACTUAL OPERATING COSTS	Magnitude of actual operating costs	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
OPERATING COSTS DISCREPANCY	Discrepancy between expected and actual operation costs	Actual operating cost – expected operating cost	Min score: -8 Max score: +8
EXPECTED BENEFITS	Magnitude of expected overall benefits	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
ACTUAL BENEFITS	Magnitude of actual overall benefits	Rating scale: *from 1 (Very low) to 9 (Very high)*	Min score: 1 Max score: 9
BENEFITS DISCREPANCY	Discrepancy between expected and actual benefits	Actual benefits – expected benefits	Min score: -8 Max score: +8

Specific cost and benefit categories were reported using constant sum scales of one hundred points to reflect percentage shares of specific categories. These measurements will be addressed in more detail when the importance of *ex-ante* and *ex-post* specific costs and benefits are discussed in the descriptive analysis following the regression results. Although the collected data does not allow to put a dollar value to costs and benefits of traceability, nor to calculate a net benefit, the scale level of the measurement facilitates an assessment of the impact of the firms characteristics on costs and benefits and a clear identification of discrepancies between expected and actual outcomes.

5 Results

Starting with the descriptive statistics of the firms characteristics, it is confirmed that the larger firms sizes are overrepresented in the sample as 45% of the sample reported operating revenues above 10 million Euro in 2007 (Table 5).
Italy (85%) and EU (78%) are the main suppliers of raw materials which are used in the operations, whereas the sample is quite homogenous in terms of fish typologies being used as input (seafood, shellfish and crustaceous), with seafood (90% usage rate) being the main category. All the firms interviewed sell finished products to Italy and 85% to EU markets, while the most important typologies of customers are wholesalers (83%) and International/ national chain (77%). With regard to the quality management systems, almost all the firms interviewed adopt HACCP systems while 42% adopt ISO 9000:2000 certification. Seven out of sixty firms have been certified according to UNI 10939:2001, UNI 11020:2002 and ISO 22005:2007. Given that traceability certification has only become available in 2001, a share of more than 10% traceability certified firms in the sample is rather high.

Table 5. Describing sample: firms' characteristics

VARIABLE	PERCENTAGE
RESPONDENTS	*Quality Managers (45%), CEOs (23%)*
REVENUE > EURO 10 MILLION	*45%*
RAW MATERIALS	*Seafood (90%), Shellfish (77%), Crustaceous (67%)*
AREAS OF SUPPLIER	*Italy (85%), EU (78%)*
AREAS OF SALES	*Italy (100%), EU (55%)*
TYPES OF PRODUCTS MANUFACTURED	*Frozen (62%), Fresh (53%), Preserved and semi-preserved (42%)*
CUSTOMERS	*Wholesaler (83%), International/National chain (77%)*
HACCP	*88%*
ISO 9000:2001 CERTIFIED	*42%*
TRACEABILITY CERTIFIED	*12%*

Next, tables 6 and 7 provide descriptive statistics are presented to give an overview of the data structure with respect to measures of central tendency and dispersion for the firm characteristics indices and expected and actual costs and benefits. The descriptive statistics shown that the sample frame has the following firms' characteristics. The mean and standard deviation show that firms spans over the whole range of values in terms of size and operations complexity. On the other hand, firms show a low level of QMS certification. The level of complexity of customer requirements shows a wide variability (S.D. 2.95), but the average and the distribution are shifted towards the lower values of the scale.

Table 6. Descriptive statistics of firms' characteristics

INDEX	SCALE		MEAN	STANDARD DEVIATION	MIN	MAX
FIRM SIZE	1.5	16	8.52	2.92	2	14
OPERATIONS COMPLEXITY	2	12	5.63	2.12	2	11
COMPLEXITY OF CUSTOMER REQUIREMENTS	2	23	7.98	2.95	3	15
QMS	0	9	2.07	1.23	0	5

As shown in table 7, the descriptive statistics of business performance indicates that respondents were overly optimistic on operation costs *ex-ante* traceability system implementation (Discrepancy = + 0.20) whereas they discovered lower implementation costs than expected (Discrepancy = - 0.39). Furthermore, respondents were overly optimistic about benefits prior traceability system implementation: the results show that actual benefits are less important than expected (Discrepancy = - 0.35).

Table 7. Descriptive statistics of cost and benefit indicators

INDEX	N	SCALE		MEAN	Standard deviation	MIN	MAX
EXPECTED IMPLEMENTATION COST	57	1	9	5.81	1.97	1	9
ACTUAL IMPLEMENTATION COST	57	1	9	5.41	2.58	1	9
DISCREPANCY IMPLEMENTATION COST (a)	57	-8	+8	-0.39	2.33	-8	4
EXPECTED OPERATING COST	56	1	9	5.03	2.18	1	9
ACTUAL OPERATING COST	56	1	9	5.23	2.46	1	9
DISCREPANCY OPERATING COST (a)	56	-8	+8	0.20	1.72	-3	5
EXPECTED BENEFITS	57	1	9	6.67	2.01	1	9
ACTUAL BENEFITS	57	1	9	6.32	2.07	1	9
DISCREPANCIES BENEFITS (a)	57	-8	+8	-0.35	1.80	-7	5

(a) DISCREPANCY = ACTUAL Costs (OR Benefits) – EXPECTED Costs (OR Benefits).

As shown in table 8, for all the measures of traceability costs and benefits the relation between firm characteristics was found to be rather weak. Only two of the variables (SIZE and QMS) had a regression coefficient that was significant at least at the 10% error probability level.

The firm SIZE is negatively linked to expected (βst= - 0.249) and actual (βst = - 0.246) benefits which means that maybe large firms are disadvantaged, in terms of benefits perceived, than smallest in the traceability systems implementation. Although, traceability is basically a component of a quality management system, it is plausible that large firms, which are overrepresented in the sample, already had in place some QM systems to monitor and control production, therefore they do not take advantage of the implementation on this respect.

The number of QMS certifications is positively linked to expected benefits (βst = 0.261) which means, that with an increasing number of QMS certifications adopted firms were expected to have high overall benefits. Since the number of QMS adopted by firms is low, as showed in the descriptive statistics, perhaps a firm with few QMS certifications would expect to benefit more, simply because they start from zero benefits, than firms that already have a certain level of QMS in place.

The absence of significant relations between OPERATIONS COMPLEXITY and costs and benefits may be due to the fact that low values of complexity of operations, as showed in the descriptive statistics, request simples or unsophisticated traceability systems which may do not affect costs and benefits in a relevant manner.

On the other hand, no meaningful relations were also found between COMPLEXITY OF CUSTOMERS REQUIREMENTS and costs and benefits, which have no plausible and good sense explanation and require further investigation.

Table 8 . Bivariate regression results for perceived expected and actual costs and benefits

INDEX	SIZE		OPERATIONS COMPLEXITY		COMPLEXITY OF CUSTOMER REQUIREMENTS		QMS	
	R^2	βst[(b)]	R^2	βst[(b)]	R^2	βst[(b)]	R^2	βst[(b)]
EXPECTED IMPLEMENTATION COSTS	.010	-.100	.015	.124	.032	-.178	.027	.165
ACTUAL IMPLEMENTATION COSTS	.000	-.018	.005	.069	.026	-.162	.015	.124
DISCREPANCY IMPLEMENTATION COSTS (a)	.000	.021	.000	.016	.001	-.030	.000	.008
EXPECTED OPERATION COSTS	.001	-.035	.017	-.129	.031	-.177	.000	.011
ACTUAL OPERATION COSTS	.002	-.045	.014	.065	.031	-.176	.008	.090
DISCREPANCY OPERATION COSTS (a)	.000	-.017	.032	.178	.032	-.056	.004	.062
EXPECTED BENEFITS	.062	**-.249***	.000	-.067	.026	-.161	.068	**.261****
ACTUAL BENEFITS	.061	**-.246***	.000	-.021	.000	.001	.022	.147
DISCREPANCY BENEFITS (a)	.000	-.008	.002	.045	.035	.187	.017	-.129

(a) DISCREPANCY = ACTUAL Costs (OR Benefits) – EXPECTED Costs (OR Benefits).
(b) βst is the standardised coefficient.
*Coefficients are significant at the 10% level (2-tailed).
**Coefficient is significant at the 5% level (2-tailed).

Finally, the survey also included a section in which respondents were asked to distribute 100 points across seven specific categories of benefits and also 100 points across five specific categories of implementation costs both for expected and actual outcomes.

As shown in table 9, descriptive statistics indicate that the three most important specific benefits are: "*Meeting current and anticipated future regulatory requirements*", "*Meeting customer's requirements and increasing his trust*" and "*Increasing consumer trust*". As a consequence, it appears that the adoption of traceability system is mainly due to the request from "external" factors, such as the complying of regulations and/or customers requirements, than "internal" factors, such as the improving management within the company. In addition, when comparing expectations with actual outcomes, firms have underestimated relevance of "*Improving management within the company and reducing the possibility of errors for data input and data management*", "*Reducing customer complaints, recalls, risk and product liability*", "*Meeting customer's requirements and increasing his trust*" and "*Meeting current and anticipated future regulatory requirements*". On the other hand, firms have overestimated the "*Increasing consumer trust*" and "*Increasing market share or accessing new markets and obtain a price premium*". Thus, while seems that firms have underestimated supply chain management, recall and regulatory benefits, on the other hand they overestimated market benefits.

Table 9. Descriptive statistics of specific benefits

SPECIFIC BENEFITS	Min	Max	Mean	S.D.
EXPECTED "Meeting current and anticipated future regulatory requirements"	0	70	21.77	15.96
ACTUAL "Meeting current and anticipated future regulatory requirements"	4	70	23.04	16.07
EXPECTED "Meeting customer's requirements and increasing his trust"	0	50	16.18	10.75
ACTUAL "Meeting customer's requirements and increasing his trust"	0	50	17.29	9.85
EXPECTED "Increasing consumer trust"	0	40	15.67	8.80
ACTUAL "Increasing consumer trust"	0	40	14.96	9.72
EXPECTED "Improving management within the company and reducing the possibility of errors for data input and data management"	0	50	12.91	9.22
ACTUAL "Improving management within the company and reducing the possibility of errors for data input and data management"	0	40	14.52	9.51
EXPECTED "Reducing customer complaints, recalls, risk and product liability"	0	30	10.68	7.41
ACTUAL "Reducing customer complaints, recalls, risk and product liability"	0	30	12.46	8.62
EXPECTED "Improving supply chain management"	0	50	11.67	11.17
ACTUAL "Improving supply chain management"	0	40	11.58	10.65
EXPECTED "Increasing market share or accessing new markets and obtain a price premium"	0	40	11.12	8.84
ACTUAL "Increasing market share or accessing new markets and obtain a price premium"	0	25	8.43	7.70

As shown in table 10, the three most important specific costs are: "*Purchase new equipment and software*", "*Production line, supervisory staff and managerial administrative time*" and "*Certification and audit and external consultants*". In addition, when comparing expectations with actual outcomes, firms have underestimated the "*Purchase new equipment and software*" and "*Training course*" aspects, while firms have overestimated the "*Production line, supervisory staff and managerial administrative time*" and "*Certification and audit and external consultants*".

Table 10. Descriptive statistics specific costs

SPECIFIC BENEFITS	Min	Max	Mean	S.D.
EXPECTED “Purchase new equipment and software”	0	90	32.64	21.69
ACTUAL “Purchase new equipment and software”	0	70	30.74	20.21
EXPECTED “Production line, supervisory staff and managerial administrative time”	0	50	21.97	11.74
ACTUAL “Production line, supervisory staff and managerial administrative time”	0	70	24.26	13.94
EXPECTED “Certification and audit and external consultants”	0	50	18.17	12.83
ACTUAL “Certification and audit and external consultants”	0	60	20.14	14.15
EXPECTED “Training course”	0	70	13.00	9.53
ACTUAL “Training course”	0	50	11.67	8.93
EXPECTED “Materials”	0	30	12.50	9.81
ACTUAL “Materials”	0	50	12.75	11.23

Thus, it seems that while firms have underestimated costs related to labour, they overestimated costs related to technologies purchasing and its use.

6 Conclusions remarks

The proposed decision model hypothesize that firm characteristics may affect implementation and operation/maintenance costs and benefits in different ways. Our empirical analysis confirmed some of the hypotheses. First, firm size was found to be negatively correlated with expected and actual benefits. Thus, larger firms reported relatively lower benefits both expected *ex-ante* and realized *ex-post* traceability system implementation. Second, the index for “QMS certifications” is positively associated with expected benefits which means that expected benefits increase with the number of QMS certifications acquired by a firm, but no association with actual perceived benefits of traceability was found. Third, operations complexity and complexity customer requirements were not found to be significantly linked to costs and benefits.

Moreover, the choice of adoption of traceability system might be motivated by complying to “external“ factors of firms, such as to government regulations or customers standards, rather than “internal” factors such as improving management within firm. On the other hand, while firms have seemingly underestimated the importance of supply chain management, recall and regulatory benefits and costs related to labour, they overestimated market benefits and costs associated to the implementation and using of traceability technology.

The findings above may have important implications for fishery processing firms that have implemented or will implement traceability. First, larger firms will likely obtain lower benefits by traceability implementation. This result is important because firms which would like to implement a traceability system have to take into consideration when they will decide the strategic plan that the traceability benefits tend to decrease for larger firms. Second, firms with a few of QMS certifications already in place will not benefit much from the adoption of a traceability system.

Other relationships do not appear to be significant in the proposed model. However, a different model specification and different approaches may be used to analyze these data more thoroughly. In any case, we deem the analysis of the relationships between costs and benefits of traceability and firm characteristics that this paper addressed as an issue deserving more attention in the scientific literature.

7 Reference

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