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Available online at www.fooddynamics.org

Int. J. Food System Dynamics 2(4), 2011, 357-375

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Perceived Traceability Costs and Benefits in the Italian Fisheries Supply Chain

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Received March 2010, accepted September 2010, available online March 2012

ABSTRACT

The paper proposes a model in which it is hypothesized that firm characteristics influence both costs and benefits of traceability. The proposed model differentiates between aggregate measures and specific categories, as well as between expected costs and benefits on the one hand and perceived actual outcomes on the other, and is tested in a series of regression analyses based on a survey sample of 60 Italian fish processors. The findings indicate that firm characteristics are not strongly associated with any specific cost or benefit measure. However, expected overall benefits are highly significantly impacted by firm size and the number of quality management systems certified, while actual overall benefits only by firm size. Finally, the study also finds considerable discrepancies between expected and actual costs and benefits. The managerial implications of the findings are discussed.

Keywords: Traceability, firm characteristics, costs, benefits, Italy, fishery processors

1 Introduction and Objectives of the Study

Traceability is not a new concept, but it is a management practice that European food operators need to implement to comply with the "European General Food Law" (EGFL, Regulation (EC) No 178/2002) (2002). 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. 2010). As firms can customize the most appropriate approach (Folinas et al. 2006), a plethora of traceability initiatives, guidelines and standards is currently evolving. As a result, most specific 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 Golan et al. (2003) firm's resources and objectives, as summarized as firms characteristics, influence costs and benefits associated with traceability system implementation. Firm characteristics, such as size (Mora and Menozzi 2003; Bulut and Lawrence 2007), adopted quality management systems (QMS) (Mora and Menozzi 2005), technological sophistication or strategic orientation of the firm, the type of customers and specific features of production, processing, packaging, and shipping (Mejia et al. 2010) determine appropriate traceability levels and thus may affect costs and benefits correspondingly. 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 have investigated in-depth traceability costs and benefits (Pouliot 2008; Stuller and Rickard 2008; Chryssochoidis et al. 2009; Mejia et al. 2010) or 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 fill this knowledge gap through an empirical analysis to provide answers to specific questions:

- Are firm characteristics linked to costs and benefits associated with traceability, as observed by management in the food industry?
- Are there discrepancies between *ex-ante* (expected) and *ex-post* (actual) specific cost and benefit categories associated with traceability system implementation reported by managers in the food industry?

By differentiating between expected and actual costs and benefits, our study addresses the issue of investment under uncertainty, which has so far received little attention in the literature. Hence, our survey approach allows identifying particularly stark discrepancies between expectations and outcomes to inform policy and business decision makers.

2 Background

2.1 Costs of Traceability

Amongst others, costs of traceability can depend on the regulatory environment, firm size, firm strategy, 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). 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 Italian beef processing, the medium and large companies had to hire additional personnel to comply with regulatory traceability requirements. The disruption of operations is an important cost that may also be linked to 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.

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
CERTIFICATION AND AUDITS	Initial audits/certification	Repeat audits/certification

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

'Training' of staff and management is an important traceability cost. Basically, it is a cost of implementation, but it also could be an 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 with using pallets, boxes or labels (Stuller and Rickard 2008) 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 unique identification through labels. Finally, 'Certification and audit' costs are associated with the adoption of traceability certification standards (e.g. ISO 22005:2007) by food operators.

2.2 Benefits of Traceability

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 enhanced 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 (e.g. logistic costs of recalls, etc.) and long-term damages of recalls (e.g. firm reputation and brand value). 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 and through increasing consumer trust (Meuwissen et al. 2003). The last category of benefits include 'Supply chain benefits' as traceability assists supply chain partners to eliminate inefficient practices without value to consumers. According to (Sodano and Verneau 2003), traceability can reduce transaction costs: 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 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).

2.3 Firm Characteristics

As mentioned above, firm characteristics may influence costs and benefits associated with traceability system implementation. For example, quality management systems (QMS) adopted by firms may affect the costs and benefits. Mora and Menozzi (2005) mention that the cost of traceability is lower when firms already have a QMS in place (e.g. a QMS complying with the ISO 9001:2008 standards). This is because, quality management systems usually include elements of traceability. On the other hand, firms without QMS could benefit very much and more than firms that have a certain level of QMS, simply because they start from zero benefits.

An in-depth study conducted by the Institute of Food Technologists (Mejia et al. 2010) in 58 food companies in seven sectors covering all supply chain stages found that firm size could affect costs and benefits of traceability. Variable costs of traceability practices may increase with firm size, as large firms have larger and more complicated operations than small firms which in turn request more arrangements to comply with these standards thus increasing the cost. At the same time, Bulut and Lawrence (2007) found that the average fixed costs of implementing traceability decrease with the production or processing volume, but they also point out another advantage of small and mid-size firms in implementing traceability: large firms that have a higher number of suppliers may not be able to always fill a single batch with input from one supplier only. This complication of traceability practices may require more sophisticated technologies and managerial efforts and thus increase costs. Operations complexity captures differences between firms relating to the nature of the products including harvest and packaging location, how the product is packaged 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).

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). De Souza Monteiro and Caswell (2004) points this out for beef exports to different countries, as, for example, beef export supply chains to Japan and the EU are subject to more stringent and sophisticated traceability systems compared to other countries.

3 Conceptual and Empirical Model

The theoretical model for this study proposes that a firm's resources and objectives, as captured by its key firm characteristics:

- determine *ex-ante* (or expected) costs and benefits of traceability implementation;
- and due to uncertainties at the time of decision making, *ex-post* (or actual) costs and benefits can differ from ex-ante (or expected) costs and benefits of traceability 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, the literature reviews only found a few studies that measure the level of traceability. Bulut and Lawrence (2007) 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, or types of customers. 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 relationship between firm characteristics and expected and actual perceived costs and benefits. In other words, we hypothesize that firm characteristics affect expected and actual costs and benefits, leaving out the intermediate variable 'level of traceability'. The conceptual model thus proposes that expected and actual costs and benefits are a function of the firm characteristics:

$$Cost_{implement} = f(\text{firm size; operation complexity; complexity of customer requirements; number of QMS adopted}) \quad (1)$$

$$Cost_{maintenance} = f(\text{firm size; operation complexity; complexity of customer requirements; number of QMS adopted}) \quad (2)$$

$$Benefit_{trace} = f(\text{firm size; operation complexity; complexity of customer requirements; number of QMS adopted}) \quad (3)$$

Accordingly, for empirical estimation we specify a linear OLS regression model for each of the dependent cost and benefit variables for firm *i*:

$$Cost_{implement,\,i} = \beta_0 + \beta_1 S_i + \beta_2 O_i + \beta_3 C_i + \beta_4 Q_i + e \quad (4)$$

$$Cost_{maintenance,\,i} = \beta_0 + \beta_1 S_i + \beta_2 O_i + \beta_3 C_i + \beta_4 Q_i + e \quad (5)$$

$$Benefit_{trace,\,i} = \beta_0 + \beta_1 S_i + \beta_2 O_i + \beta_3 C_i + \beta_4 Q_i + e \quad (6)$$

In all the equations β_0 stands for the constant, β_1 for the regression coefficient of firm size S_i, β_2 for the coefficient of operation complexity O_i, β_3 for the coefficient of complexity of customer requirements C_i, and β_4 for the coefficient of the number of QMS adopted Q_i, while *e* represents the error term.

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)[*] and a list provided in the Yearbook of Fishery and Fishing (2007/2008, n.18)[†]. 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, 4 and 5 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[‡].

Firm characteristics (Table 3) 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 both the cost and the benefits of traceability.

[*] Istat, 2001. Website: http://dwcis.istat.it/cis/index.htm

[†] 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.

[‡] A copy of the questionnaire is available from the authors upon request.

Table 3.
Firm characteristics indices

VARIABLE	CODING	RANGE OF SCORES
SIZE	Equally weighted cumulative 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, 5 and 6 costs and benefits were measured at two levels. In the first level, we measured overall costs and benefits using 9-point rating scales as described in the table 4.

Table 4.
Indicators of overall 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

At the second level, specific cost and benefit categories were reported using constant sum scales of 100 points to reflect percentage shares of specific categories (Tables 5 and 6).

Table 5.
Indicators of specifics benefits

INDEX	RESPONSE SCALE*
MEETING CURRENT AND ANTICIPATED FUTURE REGULATORY REQUIREMENTS	*0 to100*
MEETING CUSTOMER'S REQUIREMENTS AND INCREASING HIS TRUST	*0 to100*
INCREASING CONSUMER TRUST	*0 to100*
INCREASING MARKET SHARE OR ACCESSING NEW MARKETS AND OBTAIN A PRICE PREMIUM	*0 to100*
REDUCING CUSTOMER COMPLAINTS, RECALLS, RISK AND PRODUCT LIABILITY	*0 to100*
IMPROVING MANAGEMENT WITHIN THE COMPANY AND REDUCING THE POSSIBILITY OF ERRORS FOR DATA INPUT AND DATA MANAGEMENT	*0 to100*
IMPROVING SUPPLY CHAIN MANAGEMENT	*0 to100*

** All items were rated on a 100 point constant sum scale.*

Table 6.
Indicators of specifics costs

INDEX	RESPONSE SCALE*
PURCHASE NEW EQUIPMENT AND SOFTWARE	*0 to100*
PRODUCTION LINE, SUPERVISORY STAFF AND MANAGERIAL ADMINISTRATIVE TIME	*0 to100*
CERTIFICATION AND AUDIT AND EXTERNAL CONSULTANTS	*0 to100*
TRAINING COURSE	*0 to100*
MATERIALS	*0 to100*

** All items were rated on a 100 point constant sum scale.*

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. 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

5.1 Describing 1: Firm characteristics

Starting with the descriptive statistics of the firms characteristics, it is confirmed that the larger firm sizes are overrepresented in the sample as 45% of the sample reported operating revenues above 10 million Euro in 2007 (Table 7).

Table 7.
Describing the 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 9001:2000 CERTIFIED	42%
TRACEABILITY CERTIFIED	12%

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 types 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 55% to EU markets, while the most important typologies of customers are wholesalers (83%) and international/national retail chain (77%). With regard to the quality management systems, almost all the firms interviewed had adopted a HACCP system while 42% were ISO 9001:2000 certified. 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. This might indicate that the sample is above industry average with regard to the level of traceability practices.

Next, table 8 provides the measures of central tendency and dispersion for the firm characteristics indices and expected and actual costs and benefits. The results show that scores span large parts of the index scales for firm size, operations complexity and complexity of customer requirements. Given that the industry predominantly consists of (very) small businesses, an average of two QMS certifications appears to be high, lending further support to the suspicion that the sample is above average with regard to managerial sophistication.

Table 8.
Descriptive statistics of firms' characteristics

INDEX	SCALE		MEAN	S.D.	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

5.2 Descriptives 2: Expected versus actual benefits and costs of traceability

As shown in table 9, respondents were, on average, optimistic on operation costs *ex-ante* traceability system implementation. With a mean discrepancy score of + 0.20, actual operating costs *ex post* were slightly higher than expected (or *ex ante*). On average, respondents were also optimistic about benefits from traceability: the score of actual benefits was less than that of expected ones (Discrepancy = - 0.35). Opposite to that, actual implementation costs were, on average, reported to be less than expected (Discrepancy = - 0.39). For all three business performance measures, discrepancies could be quite substantial in both directions for an individual firm, as is apparent from the minimum and maximum scores.

Table 9.
Descriptive statistics of overall cost and benefit indicators

INDEX	N	SCALE		MEAN	S.D.	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
DISCREPANCY BENEFITS (a)	57	-8	+8	-0.35	1.80	-7	5

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

As shown in table 10, descriptive statistics of the scores from the 100 point constant sum scale, 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'. One interpretation is that the adoption of traceability system is mainly driven by external requests, rather than by improvements in processes and efficiencies. However, the low score for market driven incentives may point to a disconnect between these external requests and a tangible reward in market performance. This is further accentuated by the fact 'Increasing market share, accessing new markets or obtaining a price premium' is also characterized by the sharpest drop from ex ante to ex post score among all items, - 2.69 absolute or - 24%.

Similarly but not as pronounced, firms have overestimated the benefits of 'Increasing consumer trust' and 'Improving supply chain management'. Opposite to that, firms have underestimated benefits from '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 customers' requirements and increasing their trust' and 'Meeting current and anticipated future regulatory requirements'.

Table 10.
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, accessing new markets or obtaining a price premium"	0	40	11.12	8.84
ACTUAL "Increasing market share, accessing new markets or obtaining a price premium"	0	25	8.43	7.70

As shown in table 11, 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 overestimated the costs of 'Purchase new equipment and software' and 'Training course', while they have underestimated the 'Production line, supervisory staff and managerial administrative time' and 'Certification and audit and external consultants'.

Table 11
Descriptive statistics specific costs

SPECIFIC COSTS	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 of purchasing new equipment and the training for its use.

5.3 Regression Analysis

The expected (*ex ante*) and actual (*ex post*) measures of overall and specific costs and benefits were treated as dependent variables in a series of regression analyses in which the four firm characteristics described earlier were entered as independent variables. None of the regressions for the 24 specific cost and benefit measures was found to be significant at the 5% significance level and only one at the 10% level (see Appendix). The goodness of fit was similarly low: all regressions had adjusted R^2 values below 0.1 and sometimes negative. Of the 96 regression coefficients in total, four were found to be significant at the 5% level and six more at the 10% level. This overall regression outcome for the specific benefit and cost measures is well in the range of a purely chance outcome, from which we can infer that specific benefits or costs are not significantly correlated with the proposed measures of firm characteristics. This finding would lead us to argue that the diversity of food processing operations leads to unique traceability benefits and costs that cannot be linked with firm characteristics in a systematic way. We therefore do not provide the results here or any attempt of interpreting the results, i.e. the signs of significant coefficients. However, we would like to point out two observations at the aggregate level of significant coefficients. With two coefficients significant at the 5% and three at the 10% level, 'Firm size' does seem to matter, and more so for cost than for benefits. Further, firm characteristics were found to be more often associated with actual outcomes than with expected ones. Of the ten coefficients that were found to be significant, seven, including all four that are significant at the 5% level are found in regressions for actual costs and benefits. At the level of overall costs and benefits, this is exactly the opposite, as will be discussed next.

Table 12 reports the results of the model estimations regressing overall benefit scores, as well as overall implementation and operating costs on firm characteristics.

Table 12.
Regression analysis results for perceived expected and actual benefits and costs

DEPENDENT VARIABLE	ADJ. R^2	F-VALUE	INDEPENDENT VARIABLES			
			FIRM SIZE	OPERATION COMPLEXITY	COMPLEXITY CUSTOMER REQUIREMENTS	NUMBER OF QMS ADOPTED
EXP. "Overall benefits"	0,140	3,367**	-0,291**	0,018	-0,232*	0,350***
ACT."Overall benefits"	0,027	1,391	-0,287 **	0,063	-0,034	0,186
EXP. Implementation costs	0,045	1,701	-0,148	0,151	-0,226*	0,220
ACT. Implementation costs	-0,009	0,869	-0,058	0,091	-0,207	0,176
EXP. Operating costs	-0,020	0,714	-0,002	-0,127	-0,187	0,063
ACT. Operating costs	-0,014	0,810	-0,082	0,093	-0,210	0,144

*** , **, * indicate coefficients that are significant at the 1%, 5% and 10% significance level, respectively.

There are two perspectives for interpreting the results. First, in a traditional way, the proposed conceptual model is to be assessed based on each regression's overall significance and goodness of fit and the significance of individual regression coefficients. Second, comparison of significance levels between expected to actual outcomes may help identify particular expectations being confirmed or not.

Although significance levels and goodness of fit are improved over the regressions for the specific costs and benefits, the overall performance of the six regressions is poor. Only one model, 'Overall benefits', is significant at the 5% level; three of the 24 coefficients are significant at the 5% level, and two more at the 10% level. However, four of these five significant coefficients are linked with expected outcomes, which is in contrast to the findings for the specific cost and benefit measures. So how could it be that firm characteristics impact expectations for aggregate impacts of traceability, in particular overall benefits? An adjusted R^2 of 0.140 is reported for this regression, which is not negligible for cross sectional data. Both firm size and the complexity of customer requirements are negatively correlated with the benefit score, which would need to be interpreted on the basis of the argument put forward by (Bulut and Lawrence 2007). For the number of QMS certifications being positively and highly significantly – at the 1% level – correlated with the overall benefit score, the following explanation appears plausible. The implemented traceability system or set of traceability practices was expected to provide a common platform for all certification requirements for data collection and storage for traceability and quality management and assurance. This would not only reduce cost of data management and analysis but also enhance the services that can be provided to customers requiring a specific QMS certification.

Comparing the regression results for the expected with the actual 'Overall benefits' then shows that these expectations were not confirmed after traceability was implemented. The 'Number of QMS adopted' is not significant any more, and neither is the regression as a whole. This result should caution any expectations in the managerial decision making process toward traceability investments about potential synergy effects between a traceability investment and the number of certified quality management systems on the other.

Finally, while the 'Complexity of customer requirements' has also become insignificant, 'Firm size' remains significant at similar magnitude so that one might argue that the argument by (Bulut and Lawrence 2007) holds for both expected and actual outcomes.

6 Concluding remarks

Our empirical study provided the following three insights on the relationship between firm characteristics and expected and actual costs and benefits of traceability in the Italian fish processing industry:

- Expected overall benefits are correlated with firm characteristics, while actual benefits are not. More specifically, stated expected benefits are negatively correlated with firm size and the complexity of customer requirements, while they are positively correlated with the number of QMS certifications. The fact that actual benefits remain only (negatively) correlated with firm size may point to false, or better: not confirmed expectations that enhanced traceability automatically provides a unified platform for data collection, storage and analysis that can also be utilized by QMS requirements. Opposite to expectations, actual benefits are neither linked to the complexity of customer requirements, as approximated in this study by the number of different customer types.
- For the more specific cost and benefit measures, no significant relation to firm characteristics was found. At this point we have no other explanation to offer than the uniqueness of each fish processor's customer relations and thus traceability practices and costs and benefits concealing any link to rather broad measures of firm characteristics, as applied in this study.
- Finally, we found considerable discrepancies between expected and actual costs, as well as between expected and actual benefits, both at the overall and the more specific levels. Most striking are the discrepancies for market-oriented benefits related to market share and access and price premium and for the time demand at all management and staff levels as an important cost factor. For both, the managerial implications are straightforward. Any potential market related benefits, e.g. as might be based on notifications of increased business prospects or price premiums with current customers, should be vetted thoroughly and intensively in cost-benefit analyses prior to investing in traceability. The same applies to estimates of time requirements for the implementation of traceability practices or systems, which tend to be underestimated.

Moreover, descriptive statistical analysis reveal that the choice of adopting a traceability system might be motivated by "external" factors such as the need of complying with government regulations or customer standards, rather than "internal" factors such as the need of improving management performance. On the other hand, while the interviewed 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 with the implementation and use of the traceability technology.

These results are important because firms implementing a traceability system have to take into consideration the anticipated traceability benefits when deciding the strategic plan. In particular, we found that costs and benefits may be different according to 'firm size' as well as the level of 'Operation complexity' and the 'Number of QMS adopted'. Practitioners may also learn from the fact that in our sample benefits and costs related to the implementation and use of traceability technology were more relevant than expected considering supply chain management, recall capacity and regulatory compliance, while market benefits proved to be relatively less important than expected.

However, we acknowledge that our results are not to be considered ultimate, since the adopted model's general performance was not satisfactory in regards to explaining the variance of costs and benefits. Different model specifications and different approaches may be used to analyze these data more thoroughly. Therefore, we deem the analysis of the relationships between traceability costs and benefits and firm characteristics deserves more attention in the scientific literature in the future.

Acknowledgements

Financial support from the "Marco Polo" Program of the University of Bologna and from Ontario Commercial Fishery Association is acknowledged.

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Appendix

Table A1.
Regression results for specific expected and actual benefits

DEPENDENT VARIABLE	Adj. R^2	F-VALUE	INDEPENDENT VARIABLES			
			FIRM SIZE	OPERATION COMPLEXITY	COMPLEX. CUSTOMER REQUIR.	NUMBER QMS ADOPTED
EXP."Meeting regulatory requirements"	-0,028	0,619	0,196	-0,051	-0,096	-0,026
ACT."Meeting regulatory requirements"	-0,038	0,498	0,149	-0,051	-0,130	-0,023
EXP."Increasing consumer trust"	-0,028	0,623	0,044	-0,116	0,182	-0,017
ACT. "Increasing consumer trust"	-0,027	0,640	-0,117	0,050	0,149	0,097
EXP."Customer's requirements and trust"	-0,043	0,420	-0.064	0,172	-0,042	0,030
ACT. "Customer's requirements and trust"	-0,055	0,277	0,135	-0,005	0,036	-0,070
EXP. "Increasing market share, accessing new markets or obtaining a price premium"	0,065	1,970	-0,306	0,071	-0,171	0,170
ACT. "Increasing market share, accessing new markets or obtaining a price premium"	0,098	2,486*	-0,353**	0,257*	-0,110	0,184
EXP. "Reducing complaints, recalls, liability"	-0,036	0,511	-0,038	-0,021	0,175	-0,112
ACT. "Reducing complaints, recalls, liability"	-0,074	0,055	-0,041	0,037	0,036	0,026
EXP."Improving management within and data management"	-0,062	0,180	0,063	-0,068	0,052	-0,077
ACT. "Improving management within and data management"	-0,050	0,351	0,114	-0,020	-0,125	0,023
EXP. "Improving supply chain management"	-0,075	0,027	-0,038	0,913	0,010	0,025
ACT. "Improving supply chain management"	-0,067	0,142	0,044	0,048	-0,057	0,057

Table A2.
Regression results for specific expected and actual costs

DEPENDENT VARIABLE	ADJ. R^2	F-VALUE	INDEPENDENT VARIABLES			
			FIRM SIZE	OPERATION COMPLEXTY	COMPLEX. CUSTOMER REQUIR.	NUMBER QMS ADOPTED
EXP. "Purchase new equipment and software"	0,061	1,921	0,188	0,218	0,112	0,070
ACT. "Purchase new equipment and software"	0,030	1,428	0,263*	-0,003	0,179	-0,027
EXP."Certification, audit, consultants"	0,016	1,235	-0,251*	-0,046	-0,001	0,148
ACT. "Certification, audit, consultants"	0,068	2,025	-0,287**	-0,035	-0,047	0,253**
EXP. "Production line, supervisory staff and managerial administrative time"	0,041	1,609	0,005	-0,228*	0,015	-0,230*
ACT. "Production line, supervisory staff and managerial administrative time"	0,029	1,425	0,052	-0,281**	-0,032	-0,149
EXP. "Training course"	0,030	1,441	-0,232*	-0,097	-0,138	-0.031
ACT. "Training course"	-0,004	0,945	-0,191	-0,089	0,070	0,102
EXP."Materials"	-0,024	0,662	0,002	-0,096	0,022	-0,194
ACT."Materials"	-0,038	0,484	-0,053	0,013	0,047	-0,180