Costs and Benefits of Traceability in the Canadian Dairy-Processing Sector

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Currently there is a great deal of discussion about the need for and benefits of implementing product-traceability systems in food-supply chains. Golan et al. (2004) define traceability as "Traceability systems are record-keeping systems designed to track the flow of product or product attributes through the production process or supply chain," a definition which incorporates the concepts of product flow and product attributes. Traceability itself is not a guarantee of anything in particular, but can provide the means through which specific attributes are supplied and may be a prerequisite for food suppliers to enter certain markets (Viaene and Verbeke 1998). Hobbs (2004) differentiates between ex-post and ex-ante traceability related to food safety and quality. Ex-post traceability is a latent capability used in the event of a food-safety or serious product problem to trace food back to the source so that affected products may be identified and withdrawn. Ex-post traceability helps both in locating the source of a problem and in assigning liability. Ex-ante traceability provides a mechanism for quality verification by providing continuous tracking and reporting on the quality attributes of products moving along the supply chain. It reduces information costs for customers arising from quality verification (for example organic production). This function is an active capability in that data collection and reporting is an ongoing activity in the chain.

From a technical perspective, full chain traceability is achievable. However, from an economic and/or business perspective, traceability must offer an overall net benefit which exceeds the implementation and ongoing costs incurred through investments in traceability systems. Most food-industry managers view traceability as a regulatory-compliance issue targeted at improving food safety. Decision-makers may not fully comprehend the associated costs and/or benefits, especially if they are intangible in nature (Henson and Holt 2000).

The costs of establishing a system of traceability are relatively easy to define, although perhaps less easy to measure. Can-Trace (2004) distinguishes between "start-up costs" such as hardware, software, systems engineering, and training, and "ongoing costs" including traceability supplies (for example tags and forms), training, support, and system upgrades. Golan et al. (2004), however, take a broader perspective, distinguishing between the costs of record keeping and costs of product differentiation, including the cost of certifying that a product meets certain standards and/or has attributes that are the basis of differentiation. According to Sparling and Sterling (2004) there are four major categories of benefits that can be associated with traceability systems: regulatory benefits, market and customer-response benefits, recall and risk-management benefits, and supply-chain benefits. They recommend that managers approach these as a hierarchy of potential value and understand the contribution of each to total benefits.

Although traceability is viewed as an essential component of future agri-food systems, there has been little research on the level and nature of traceability systems in the Canadian agri-food industry (exceptions include Hobbs, Spriggs, and Fearne 2001; Hobbs, 2003, 2004). There is also a paucity of research that translates potential costs and benefits into the real incentives for the adoption of traceability. The studies that do exist generally lack specifics and fail to assess management perceptions of costs and benefits before and after implementation.

This study adds to the knowledge base by examining traceability in the Canadian dairy-processing industry. The objective is to better understand the drivers behind the implementation of product traceability in the Canadian dairy-processing sector, the challenges facing managers during implementation, and the costs and benefits experienced by firms implementing traceability.

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Methods

The study involved two phases of data collection from April 2004 to January 2005. The first stage involved six in-depth, semi-structured interviews with quality-assurance managers at dairy-processing facilities in Ontario and Manitoba. The first-stage analysis formed the major input to the design of the mail survey used in the second stage. The survey was tested in a ten-facility pilot study. The final postal survey of 386 processing facilities across Canada in late 2004 generated 130 responses, a 34% response rate.

Survey Results

Firm Characteristics

Almost 94% of the respondents were headquartered in Canada, and 56% operated out of a single location. Average size was around 49 employees, slightly above the national average of 45. Annual sales for half of respondents were in the range C$501,000 to C$10 million, with 24% below C$500,000 and 26% above C$10 million. On average, more than 71% of revenue came from sales within their home province, with only 4% from exports. Approximately 44% of respondents produced only one category of dairy products, 27% produced two categories and 29% produced more than two categories of dairy products. However, 68% of respondents manufactured products with at least one "speciality" characteristic, products for which traceability would be an asset in confirming product characteristics.

The majority of the sales revenue of the surveyed plants was derived from products sold under the company's own name to the final consumer (Table 1). Although 53% of plants supplied products that were sold under a food retailer's or food-service operator's brand name, on average this only accounted for 18% of sales revenue. Table 2 shows the frequency and percentage of revenue derived from the different distribution outlets.

The surveyed dairy-processing plants supplied a wide range of customers. The most important were other food retailers (for example small grocery outlets) and major supermarket chains that accounted for 25% and 17%, respectively, of sales revenue on average and were supplied by more than half of the sample. Around 42% of the plants supplied wholesalers, which accounted for 17% of sales revenue. Although 41% sold products direct to the final consumers, this typically accounted for only 11% of sales revenue.

Only 38% of respondents had actually implemented hazard analysis and critical control points (HACCP), but 49% had implemented some other food-safety control system, most commonly good manufacturing practice (GMP), Canadian Food Inspection Agenty (CFIA) standards, provincial standards, and organic standards. Only five plants were ISO 9000 certified.

Results

Adoption of Traceability

Almost 91% of the respondents to the survey had implemented a system of product traceability. For those with traceability systems, around 89% were able to track their products fully to the level of retail distribution, while 79% could trace their inputs back to named individual or groups of farmers. Most (67.5%) had implemented traceability more than four years earlier. Only 12% implemented traceability within the last two years. Forty-eight percent with traceability could trace to multiple batches within a

Table 1. Plant Sales Revenue by Branding of Products of Respondent Plants.

Market	Frequency	Mean % sales revenue
Company brand name to final consumer	119 (91.5%)	65.4%
Food retailer or food service operator brand name	69 (53.1%)	18.2%
Bulk to wholesaler, processor, retailer etc.	59 (45.4%)	13.0%
Other	2 (1.5%)	0.2%

day and 42% could trace to a full day.

Product traceability systems deal with a variety of attributes. Traceability for general product safety was the most commonly cited reason (86%), but systems tracked specific product attributes like antibiotic-free (46%), unpasteurized (30%), and organic (29%), among others. In 66.1% of cases the traceability system was manual. Of the 33.9% of plants that had implemented a computer/electronic system, 52.5% had purchased or developed specific software for the purpose. Interestingly less than one-quarter (23%) of plants that had implemented a system of product traceability had experienced a product recall and/or withdrawal in the three years prior to implementation. A greater proportion of these plants (35.0%) had experienced a product recall and/or withdrawal since implementing their traceability system.

Motivation to Implement a Product-Traceability System

In order to identify and assess the motivations for implementing product-traceability systems, respondents were asked to score 19 potential motivators in the decision to implement on a five-point Likert scale from "very important (5)" to "very unimportant (1)" (Table 2). Prior to implementation managers were motivated by factors related to reducing risks, liability and impact of recalls. Market factors and efficiency were less important.

Table 2. Mean Score and Principal Components Analysis of Motivators to Implement a System of Product Traceability.

Variable	Mean score	Factor 1: Product problems	Factor 2: Market drivers	Factor 3: Legal/ regulatory
To reduce the risk of a product problem occurring	4.79	0.654	0.137	0.543
To reduce the impact when a product recall occurs	4.69	0.641	0.321	0.362
To reduce product liability	4.46[a]	0.064	0.205	0.732
To meet current regulatory requirements	4.45[a]	0.301	0.086	0.683
Reduce risk of product recalls	4.43[a]	0.727	0.231	0.383
So I can worry less about a product recall occurring	4.31[b]	0.702	0.104	0.174
I think it is good practice	4.29[b]	0.402	0.093	0.153
To meet current customer requirements	4.16[c]	0.273	0.676	0.073
To meet anticipated future customer requirements	4.15[c]	0.074	0.376	0.152
Reduce customer complaints	4.04[d]	0.691	0.743	0.295
Improve inventory management	4.03[d]	0.153	0.671	0.015
Reduce spoilage or improved freshness	4.00[d]	0.485	0.286	0.164
Improve coordination of supply chain	3.99[d]	0.053	0.691	0.095
Access new markets	3.72	0.127	0.743	0.132
Recommended by trade/industry organization	3.57[e]	0.045	0.294	0.629
Reduce costs of production or improved yield	3.56[e]	0.302	0.282	0.074
Increase share of current markets	3.45[f]	0.083	0.721	0.037
Reposition products in current markets	3.43[f]	0.126	0.764	0.139
Obtain higher price for products	3.28	0.029	0.693	0.059
% variance	3.09	38.4%	25.5%	18.3%

Note: Mean rank scores with same letter suffix are not significantly different at the 5% level.

Principle-components analysis (PCA)[1] was used to group motivators into broad categories reflecting three fundamental drives for implementing product traceability which collectively accounted for 82.2% of the variance in importance scores across the 19 motivators. Loadings were derived for each of these factors using a Varimax rotation (Table 2). Motivating factors related to product problems accounted for 38% of the variation in importance scores.

The PCA indicates a relatively a strong correlation between Factor 2 and each of the market drivers. This finding suggests that when a traceability system is implemented due to one market driver, there is a relatively high likelihood (between 0.676 and 0.764) that the traceability system will be employed for other marketing purposes.

Problems Experienced with Product-Traceability Systems

Respondents were asked to score problems experienced during implementation on a five-point Likert scale from "very important (5)" to "very unimportant (1)" (Table 3). The most highly ranked problems were associated with staff, but customer and supplier support also ranked high (Table 3). The least important problems were the development and availability of appropriate software and availability of reliable consultants.

While more than 70% of respondents indicated that implementing traceability had required some readjustment of production and/or personnel duties/responsibilities, in the majority of cases these were minor. Only 10% needed significant reconfiguration of their production systems, while 14% made major changes to personnel duties and/or responsibilities.

Costs and Benefits Associated with Product-Traceability Systems

The most important costs incurred during implementation were inspections/audits; laboratory testing; and the time of supervisors, production workers, and managerial/administrative staff. External consultants and purchase of software were generally considered unimportant. The most highly ranked costs of maintaining and operating

[1] For more details of principle-components analysis see Hair et al. (1998).

Table 3. Significance of Problems Implementing, Maintaining, and/or Operating Traceability Systems.

Factor	Mean score
Attitude/motivation of production/supervisory staff	4.20[a]
Need to retrain production/supervisory staff	4.19[a]
Attitude/motivation of managerial/administration staff	4.00
Need to retrain managerial/administration staff	3.79[b]
Support and co-operation of customers	3.76[b]
Support and co-operation of suppliers	3.62[c]
Number of product attributes/processes to be recorded	3.59[c]
Flexibility of production processes	3.45[d]
Lack of clear standards for traceability systems	3.44[d]
Ability to manufacture new products	3.24
Takes production/supervisory staff away from other duties	3.08[e]
Takes management/administrative staff away from other duties	3.06[e]
Availability of reliable consultants	2.89
Development and availability of appropriate software	2.72

Note: Mean rank scores with same letter suffix are not significantly different at the 5% level.

product-traceability systems in dairy-processing plants are production worker and supervisor time, the cost of monitoring suppliers, and costs of regular inspections/audits. External consultants and ongoing training courses are unimportant costs of maintaining and/or operating systems of product traceability.

Respondents were asked to rank 17 potential impacts of implementing a product-traceability system on a five-point scale from "very positive (+2)" to "very negative (-2)," with a mid-point of "no change (0)." The main benefits of product traceability were considered to be the way in which the company was perceived by commercial customers and/or regulators and the ability to meet customer and/or regulatory requirements. These benefits are rather intangible compared to impacts on product prices and the number of recalls, which were considered less significant benefits of implementing traceability. The majority (66.4%) of plants had not experienced any change in production costs as a result of implementing product traceability, while 26.4% felt that costs had increased and 7.3% felt costs had decreased.

In total, 60% of respondents considered that the benefits of implementing traceability in their plant exceeded the costs (Figure 1). Broadly, the benefits associated with implementing traceability were in accordance with prior expectations. Indeed, only 27.8% of respondents considered that the benefits exceeded expectations. However, 44.3% indicated that the costs incurred exceeded their a priori expectations, most notably those associated with staff time.

Characteristics of Firms Perceiving Positive Benefits

Although 60% of respondents perceived benefits as greater or much greater than cost, the percentage perceiving positive net benefits varied with the following firm characteristics:

Revenue: 50% of firms with annual revenue below C$10 million perceived positive net benefits vs. 68% of firms with revenue exceeding C$10 million annual revenue.

Number of plants: Only 47% of firms with one plant perceived positive net benefits vs. 76% of firms with more than one plant.

Percentage of sales under customer brand: About 52% of firms selling less than 20% of their product under their customers' brands perceived positive net benefits. As the percentages of their product sold under customer brands rose to the 20–45% and 45–75% ranges the percentages perceiving positive net benefits increased to 62% and 67%, respectively. All respondents who sold more than 75% of sales under a customer brand perceived positive net benefits.

HACCP Implemented: Only 50% of firms without HACCP perceived positive net benefits, compared to 73% of firms with HACCP.

Manual vs computerized traceability system: Interestingly, the percentage of firms perceiving positive benefits was higher (61%) for plants with a manual system than for plants with computerized systems (59%).

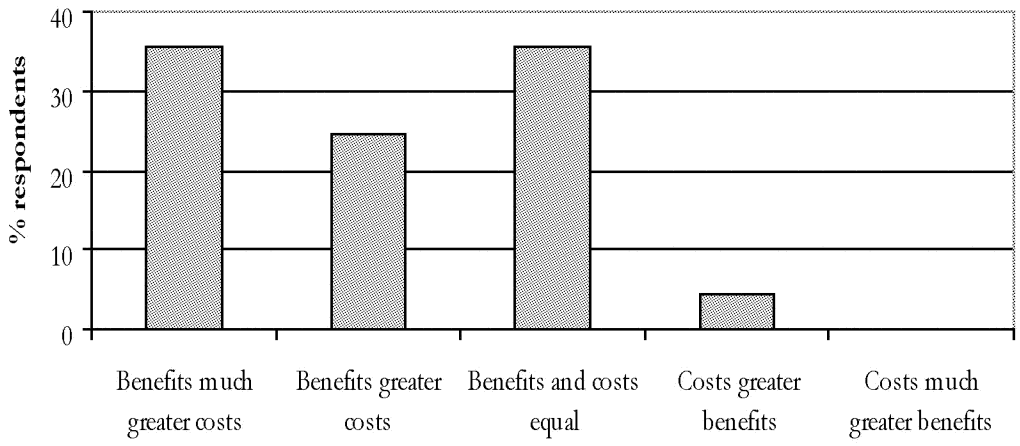

Figure 1. Perceptions of Benefits versus Costs of Implementing Traceability System.

Conclusions

This study has provided the first in-depth insight into the implementation of product-traceability systems in the Canadian dairy-processing sector. Although product traceability is relatively widespread in the sector, the level of sophistication of the systems is relatively low. Most systems were manual rather than computer-based, but they generally permit traceability to the level of at least one day's production, through to retail distribution and back to single or at least groups of milk producers.

One of the interesting results was the difference between factors motivating implementation and perceived benefits after implementation. The main motivations for implementing product traceability in the dairy-processing sector were risk related—reductions in the risk of product problems, diminished impacts where recalls occurred, and reduced product liability. However, after implementation, benefits such as improved perception by customers, regulators, and consumers were most highly rated. Gaining access to new markets, higher prices, and repositioning in current markets were relatively unimportant. When the survey respondents were clustered according to three broad motivators—market drivers, product recall, and legal requirements—around half were classified as being driven by the management of risks related to product recalls, customer complaints and legal requirements. These were generally smaller dairy-processing facilities that predominantly sold products under their own brand name through small food retailers. Market drivers were more important for plants that had greater sales to the major supermarkets and/or were more involved in the manufacture of private-label products for food retailers or food-service operators.

The most prominent problems experienced in implementing, maintaining, and/or operating a system of product traceability in the dairy-processing sector related to the attitude and motivation of staff and/or the need for retraining. Traceability systems were also hindered by problems with customer cooperation and the flow of information from suppliers to their customers. Lesser problems

Table 4. Impact of Traceability System on Company Performance.

Impact	Mean score
How company perceived by commercial customers	1.19[a]
How company perceived by regulators	1.18[a]
Ability to meet customer requirements	0.96[b]
Ability to meet regulatory requirements	0.95[b]
How company perceived by consumers	0.81[c]
Scope of product recalls/withdrawals	0.78[c]
Motivation of managerial/administration staff	0.78[c]
Costs in the event of a product recall/withdrawal	0.65[d]
Number of product recalls/withdrawals	0.64[d]
How company perceived by rest of industry	0.63[d]
Motivation of production/supervisory staff	0.53[e]
Levels of product wastage/reworking	0.51[e]
Ability to increase share of existing markets	0.51[e]
Prices realized for products	0.36[f]
Ability to access new markets	0.36[f]
Inventory costs	0.10
Production costs	-0.07

Note: Mean rank scores with same letter suffix are not significantly different at the 5% level.

related to such issues as the removal of labels containing traceability information and/or lack of compatibility of traceability systems.

The major implementation costs related to auditing and inspection and laboratory analysis, and the opportunity cost of supervisory, production, and managerial/administrative staff time. Staff costs were also the predominant operating cost. Production-cost increases as a result of implementing product traceability were generally modest, but 45% of the survey respondents indicated that implementation and operating costs had exceeded prior expectations.

Positive net benefits were more likely to be perceived by larger firms with more than one plant, with HACCP in place, and who sold a significant percentage of their product under customer brand names. There was relatively little difference between paper and computerized systems.

These results as a whole suggest that product traceability has been implemented widely in the Canadian dairy-processing sector, reflecting a range of motivating factors related to management of the risks associated with product recalls, customer complaints, and legal requirements and a broad range of market drivers related to customer requirements, management of the supply chain, etc. The relative importance of these drivers varies according to the size of the plant and the markets served. Across the sector as a whole, there appear to be good economic and commercial reasons for implementing a system of product traceability; it is widely perceived that there are significant benefits that exceed the costs of implementing, maintaining, and/or operating systems of product traceability.

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