INSTITUTE OF FOOD TECHNOLOGISTS

Institute of Food Technologists/Food and Drug Administration
Contract No. **223-04-2503**

Task Order No. 6
Traceability (Product Tracing) in Food Systems
Vol. 2 of 2 Economics Report
Revised

10/28/09

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Executive Summary

Improving the Food and Drug Administration's (FDA's) ability to trace a contaminated food product back to the source would allow the agency to conduct more rapid and thorough investigations. In addition, if a problem is identified, having a more rapid and effective trace-forward system would help narrow the scope of recalls by more quickly identifying the specific facility(ies) involved throughout the supply chain and the product recipients. Hence, it could improve the efficiency and speed of notification time for firms involved in the distribution and sale of product. Reducing the time required before an intervention is implemented following a triggering event, such as an outbreak, will better protect public health, help reduce the economic hardship faced by affected industries, and maintain consumer confidence in the U.S. food supply following such an incident. The Food and Drug Administration (FDA) requested the Institute of Food Technologists (IFT) conduct an in-depth review of the costs associated with implementing product tracing systems and technologies in the food industry. Per FDA request, costs of the recommended "best practices" in Volume 1 of this report were examined (IFT, 2009).

More than 50 discussions were held with representatives from various sectors in the food industry. Information provided showed that most of the firms have adopted various types of warehouse management systems. These systems provide product tracing information that varies widely in breadth, depth, precision, and accessibility to other members in the supply chain. Many companies consulted consider product tracing an integral part of their warehouse management, logistics or accounting initiatives. However, none of these systems were developed solely for product tracing. Therefore, firms assign costs related to these business operations to product tracing, although many of these costs are not limited to product tracing specifically. Also, firms may often overlook costs associated with the additional demands for data collection and record keeping, and especially the additional labor required. Subsequently, product tracing costs, as assigned by these companies, vary widely and tend to be over- or underestimated. Additional discussions were conducted with providers of various technologies that support product tracing systems.

Developing estimates of the costs to firms of product tracing systems requires estimates of both fixed and variable costs of the systems. At this time, many firms have incurred some of the costs, but estimates of other costs may be prospective. The types of costs associated with product tracing that firms may incur include capital investment and start up costs; costs of software and associated fees and equipment; external consultant costs; labor (including training); materials and supplies; and other direct costs generated by changes in harvesting and processing to support or operate product tracing systems. The costs may also include changes in operational efficiency. Many firms reported that the implementation of product tracing systems, or an upgrade of their existing practices, could result in additional costs or lower margins for their firms. Firms' representatives expressed that these costs are multiplied and margins lowered even further if multiple customers require different standards for their own product tracing initiatives. Thus, a single set of standards, or a single product tracing system could result in significant cost savings for these firms.

Although each situation is unique, case examples described in this report show representative costs for two examples: one based on the experience in fresh produce following the 2006 *E. coli*

O157:H7 outbreak related to spinach, and another based on costs incurred and expected by a firm that processes and distributes fresh produce and other products in a regional market. The first case study shows that although the costs of product tracing systems can be significant to the industry, the benefits of more rapid trace-forward following a triggering event may be greater than the costs in a given year. However, there is some uncertainty that accompanies the estimates presented in the case studies, as well as the need for an assessment that addresses the probability of occurrence of a triggering event per year versus the costs and potential benefits per industry sector. The second case example finds costs to be significant (about 1% of the product value), but viewed by the firm as value added to the type of product they sell. Their major concern was loss of market share if others did not employ similar product tracing systems.

Results of the case studies indicate that the losses to the industry and to the public in terms of public health were significant in the event of an outbreak. These examples suggest that the benefits of improved product tracing could outweigh the costs to industry and society in implementing a system to trace products. Firms that have implemented effective product tracing systems find benefits in improved supply chain management, inventory control, access to contracts and markets by having stronger product assurances, more targeted recalls and hence lower costs to recall, and other cost savings incurred during a foodborne illness outbreak. Product tracing systems may also help compartmentalize and reduce the region or type of product at risk of recall. Additionally, firms could benefit by protecting brand name, maintaining consumer confidence, and reducing possible liability claims.

Despite significant firm level and aggregate benefits, the costs of enhanced product tracing can be considerable. Firms that use paper-based and manual entry systems to track incoming supplies or outgoing shipments, and firms that have relatively complex systems, where many inputs are processed into products, could face added costs to increase their record keeping capabilities. Small and medium size enterprises may face particular challenges in meeting new product tracing requirements as they may lack adequate capital, labor, and technology expertise to implement electronic product tracing systems. This report does not quantitatively assess the specific costs incurred by small and medium firms resulting from the implementation of a product tracing system. Thus, research will be required to specifically address costs, benefits and strategies needed solely for small and medium size firms to develop technologically, as well as for them to develop cost effective product tracing systems.

Some of the additional costs associated with improved product tracing capacity could be transferred forward from firms to consumers. The private benefits to a firm incurred through the capacity for improved product tracing may be dissipated if its customers do not value these additional capabilities, and are not willing to pay these costs. Thus, firms could become less competitive than others companies that do not have product tracing systems in place. Moreover, according to the Bioterrorism Act of 2002 and the recommendations offered by IFT, records must be provided to FDA not more than 24 hours after requested. Thus, any failure in being able to trace one-step back and one-step forward, as well as link the movement of product internally, in a 24 hour period will undermine the effectiveness of the product tracing system and limit its efficacy. Thus, the cooperation of all links of the supply chain will be necessary for a product tracing system to be successful. A more rapid response to an accidental or intentional foodborne disease outbreak through improved product tracing would yield external social benefits beyond the direct benefits and cost reductions to the firms. Additional healthcare costs, social losses, loss of life, loss of consumer confidence, major psychological and emotional damages due to massive outbreaks, and indirect loss in economic output and productivity losses are just the most evident externalities that could be avoided with a functional product tracing system.

1.0 Introduction

The Food and Drug Administration (FDA) contracted the Institute of Food Technologists (IFT) to examine and conduct an in-depth review of the costs associated with implementing traceability systems and technologies in the food industry. Costs of the recommended "best practices" were to be addressed and detailed (IFT, 2009).

IFT conducted extensive discussions with firms in the food industry, and with technology providers. Additionally, conversations and analyses of specific case studies were conducted to supplement the information gathered from discussions with industry. This report provides a detailed discussion of the costs associated with implementing such a system, and the benefits that product tracing will bring to the public and to the food industry. A detailed case study of the 2006 spinach recall is used to examine closely the costs and benefits of product tracing to the firm and industry.

2.0 Costs and Benefits of Product Tracing – an Overview

An effective product tracing system will result in the direct benefits of improved public health by reducing the effects of a triggering event, such as an outbreak, thereby leading to a decrease in the potential number of illnesses. Effective product tracing also results in improved public confidence through more rapid resolution of the triggering event, and less disruption to commerce and markets. Consumers may stop buying product from sources directly implicated in a recall, as well as other related product not implicated. For example, recalled peanut products did not include retail peanut butter, but many consumers stopped purchasing it (US Grocery Shopper Trends, 2009). Sales of peanut butter dropped 60% and sales of peanut butter crackers (an implicated product) dropped 12%. Sales of leafy greens, including spinach in bulk and bags, fell precipitously in 2006 after bagged spinach was identified as the source of an *E. coli* O157:H7 outbreak. Although sales recovered, the level of bagged spinach sales did not return to the previous level one year after the outbreak (Calvin et al., 2006). Product tracing systems may also benefit firms in a supply chain directly through improved product flow, better inventory control, improved supply chain management, more targeted recalls and hence lower costs to recall, improved ability to meet regulatory requirements, and other cost savings realized during a foodborne illness outbreak. Firms also benefit from being able to take market advantage from enhanced food safety efforts (being able to avoid being implicated in an outbreak), protecting brand name, assuring product claims and maintaining consumer confidence.

Firms incur costs related to having a product tracing system in place, and use resources that may not be used for other productive purposes. These costs result from implementing and maintaining the capacity to identify the immediate source of all inputs/ingredients to all products (trace-back), to track product transformation within the facility, and to identify the shipment location and time of shipment for all products (trace-forward). At each of these "Critical Tracking Events" data must be collected. For example, resources used to acquire and maintain equipment dedicated to product tracing efforts, supplies used in labeling, or labor used in recording data instead of being used in other productive activities are costs of product tracing. Adoption of improved product tracing systems is underway in many firms and supported by several industry efforts for much of the industry. However, there will be additional costs required by implementing a system that allows efficient, electronic identification of Critical Tracking Events, including trace-back and -forward within a 24-hour period.

In many food and feed companies, manual record keeping is common. Making electronic data on product received, used and shipped, available to FDA within a 24-hour period will require regular and on-going updates of the information. This will cause additional costs for all firms, but especially for companies that continue to maintain manual data collection. Although we examine the nature of costs and some examples, it is difficult to predict all the implications for firm structure that may accompany any new product tracing requirements. Those firms with manual input and data systems will likely incur more costs with a requirement for electronic data availability. However, technological changes are occurring rapidly throughout the industries, and the benefits to the firms should be weighed against the additional costs.

3.0 Cost Components for Product Tracing Systems

Estimating costs incurred by firms and the industry to enhance traceability allows both public decision makers and firm managers to assess the additional resources required to achieve traceability. Estimation also allows the evaluation of these costs relative to the effectiveness or benefits achieved through improved traceability (that is, a system that has 24-hour rapid response for each participant where the nature and quality of data is such that links in a product pathway are captured) (IFT, 2009). The cost estimation and analysis allow firms to assess how the implementation of a new initiative, such as traceability, may affect their profitability margins. A variety of factors influence costs required to achieve a targeted ability to rapidly trace products in the food system. These factors include, for example, the size of the establishment and its technological sophistication, and the adaptability of existing tracking and record keeping systems within an establishment. The availability of existing "off the shelf" technologies from commercial vendors will also affect firms' costs, especially if establishments cannot adapt their existing systems. Costs may also vary depending on the nature of the product including the harvest and packing location, how product is packed and shipped, its perishability and whether it is used in further processed product. Ultimately, traceability occurs in a system, not at one firm alone. Thus, there are other costs, in addition to the individual firm, that may be associated with administrative and monitoring functions that are not accounted for at the firm level. However, to have an effective product tracing system in place, it needs to be successful at the firm level.

Each firm faces a different set of costs depending on its circumstances. However, to estimate industry level costs of a product tracing requirement, it is necessary to first develop a set of representative establishments that generally cover the range of possible circumstances. For each type of representative establishment, the existing system and required changes could be developed and described, and an assumption regarding the typical product volume could be assigned. Then, using data collected through discussions with technology providers and establishments, an establishment-level cost estimate could be developed for each type of representative establishment.

The cost information needed from establishments includes costs incurred to date, and estimates for costs that firms may expect to incur in the future to meet requirements for enhanced product tracing. For these future costs, establishment personnel would need to estimate prospective costs prior to implementation of the full product tracing system. In addition, it is important to note that only the incremental costs required for the purposes of product tracing should be included in the estimates. Other costs that may be incidental or used to achieve other purposes, such as inventory management or faster delivery times, should not be included. The allocation to different functions may be done by assigning a percentage of use to product tracing functions, and the remainder to the other functions.

The specific types of cost components that would need to be defined and estimated in a firm include the following:

- Capital equipment and software (e.g., labeling equipment, electronic scanners, computer systems)
  - Purchase cost and useful life of the equipment
  - Cost of installation paid to the vendor
  - Staff hours and type of staff involved in the purchase and installation
  - Costs of modifications to the plant layout or structure
  - Annual licensing fees if associated with the equipment or software

- External consultant costs for identifying, designing, or implementing the system
  - Type of consultant
  - Days of consulting time
  - Hourly or daily rate for consulting time

- Training costs associated with the system
  - External or on-site training
  - Type of staff trained
  - Number of staff trained
  - Number of hours of training
  - Costs of training paid to an outside vendor
  - Ongoing requirements (e.g., annual training)

- Labor costs for operating the system, including labor for record keeping requirements
  - Number of new employees hired
  - Type of new employees hired (different skills, higher degrees, etc.)
  - Hours of additional duties added to existing employees

- Additional materials for operating the system
  - Types of additional materials (e.g., paper, toner/ink, data storage media)
  - Annual costs of additional materials

- Effects of the system on line speed or efficiency of operations
  - Reductions (or possibly increases) in daily production
  - Types of changes required to offset the effects, if needed

Once defined, costs of a product tracing system would need to be assigned to two general categories:

1. One-time, initial purchase and installation costs (“fixed costs”)
2. On-going, operating costs (“variable costs”)

Fixed costs are expenses that are not dependent on the activities of the business. In this case, they are *one-time initial costs*, which include the costs of developing and implementing the product tracing system. Capital equipment costs can be amortized over the length of the anticipated life of the system based on an assumed interest rate to develop an annualized cost. Some of the software services and licenses may also be included in the initial purchase costs. There are many different types of software and licensing agreements, which are described in Volume 1 of this report (IFT, 2009). Some technology providers require an initial installation cost and subsequent renewal fees. Others include service agreements that are renewed annually and depend on the number of units processed. These costs will be assigned as either one-time, initial installation, or to the annual operating cost, depending on the type of agreement. Some systems, however, do not require fixed cost investments.

Variable costs are expenses that change in proportion to the activity of a business. Thus, they are expressed on a per-unit basis depending on the product volume of the establishment, and thus could vary by the size of the firm. This allows the cost estimates to be applied to establishments with different product volumes. These *on-going costs* include expenses associated with operating the system on a yearly basis such as labor, materials, and licensing fees (if volume dependent).

The annualized one-time costs and the annual ongoing costs need to be estimated for each type of representative establishment. Each establishment in the industry could then be assigned to the representative establishment category that most closely matches its operations. Then, the costs for each representative establishment could be multiplied by the total number of establishments to develop an industry-level cost estimate.

Finally, the total annualized cost estimate could be compared to measures of annual sales or profitability to provide an initial indication of the potential economic impacts of product tracing systems. If the costs are small relative to sales, this type of screening analysis would probably be sufficient. If the costs are relatively large, it would be necessary to consider whether there are off-setting benefits to the firm and industry, such as reduced costs incurred in the event of a recall, or improved supply management. Other considerations include whether the costs would be shared between producers and consumers (i.e., market price adjustments would occur).

4.0 Costs of Product Tracing Systems in the Food Sector

4.1 Data Obtained from Firms

IFT conducted a series of in-depth discussions with food companies to understand their product tracing efforts. Among the items investigated, companies provided information related to their investments in traceability systems and the costs associated with implementation. Information from 58 food companies in seven sectors was obtained. Sectors included produce, packaged consumer foods, processed ingredients, distributors, foodservice, retail and animal feed. The information collected provided ranges of values reported by firms, and can be interpreted as the costs that firms associate with traceability efforts. However, companies may view various components differently and they may fail to identify some costs. They may also attribute all the cost of capital equipment or management software to product tracing, when only a part is used in traceability efforts. Additionally, information collected from 58 firms cannot express all the variability typical in the food industry. Thus, these costs should be considered illustrative of the range of costs that firms associate with their product tracing efforts today.

A few companies shared with IFT their general idea of costs related to their traceability systems in place, or to systems they were considering implementing. Discussions show that most of the firms have adopted some type of warehouse management system. These systems have provided, to some extent, product tracing information, which varies in breadth, depth, precision and accessibility to other members in the supply chain. Most firms suggested that the implementation of product tracing systems, or an upgrade of their existing systems, could result in additional costs or lower margins for their firms. Moreover, firms' representatives expressed that these costs are multiplied and margins lowered even further if multiple customers require different standards for their own traceability initiatives.

Table 1 shows the cost information for the various sectors resultant from the discussions conducted. There is some distinction made by firm size because costs may differ between small and large firms for each sector. Enterprises were grouped on the basis of the number of Stock Keeping Units (SKUs) they handle. Large refers to companies handling thousands of SKUs; medium refers to firms that handle 300 to 1,000 SKUs; and small refers to enterprises that handle less than 300 SKUs. The size differentiation based on SKUs was done due to the lack of information on other more direct indicators, such as total sales or volume. For some segments of the supply chain, particularly grower/shipper/packers, total sales or volume is likely a better indication of firm size, since the number of products produced may be limited although the amount of each product produced may be relatively high. Therefore, grouping this segment based on the number of SKUs may underestimate the relative size of the firm. Additionally, number of employees was not used as an indicator of company size, since it is a better indicator of degree of mechanization in a company rather than its size, and may be sector dependent. The reported costs range widely in value. The costs of product tracing vary across industries depending on the size of the firm, the nature of the firm's product and operation, and system implemented. For example, a large produce company, with more than 30,000 food SKUs, reported the costs associated with the Global Trade Identification Number (GTIN) system implementation and software homogenization to be higher than $150,000 per facility. This company reported a cost of over $6 million for the complete integration of this system companywide. Small and medium produce companies, with 1000 SKUs or less, reported costs varying between $10,000 and $30,000 for Country of Origin Labeling (COOL) systems implementation or upgrade. However, one small firm reported the cost of software modification that allowed COOL records alone to be approximately $100,000. Another small produce company estimated that to scan the product information would cost approximately an additional $0.50/case (not in Table 1), which could represent up to a 4% increase. Since another producer expressed the need to maintain his utility margins below $0.25 per case, such a cost increase could result in the loss of a competitive advantage in the market.

Significant variability in costs can be attributed to the size and nature of the firm's operation. However, reports from the discussions also include differences in costs introduced by variation in what companies consider to be part of their product tracing program implementation and maintenance, and what is considered contributing to other functions. In some cases, the firms associate product tracing system upgrades and implementation with Country of Origin Labeling (COOL) requirements. The discussions suggest that companies consider product tracing an integral part of their warehouse management, logistics or accounting initiatives. Others confuse product tracing with warehouse management or logistics and use these terms interchangeably. Therefore, they assign costs related to these business operations as product tracing, even though these other costs could include, but are not limited to, items related specifically to product tracing. Also, firms may often overlook costs associated with the additional demands for data collection and record keeping, and especially the additional labor required. Hence, the reported costs from these discussions presented in Table 1 should be interpreted as firms' perceptions of traceability costs.

Table 1. Selected studies on costs of product tracing systems

Sector	# of SKUs*	Costs of product tracing system implementation, upgrade (fixed costs)	Other costs: Labor, maintenance fee, training, etc. (variable costs)
Produce processor	Large	Implementation (GTIN only): $100K -200K per facility	Full integration: 0 - $6M
	Medium	System implementation (COOL only): $30K - $350K System upgrade (COOL only): $5K-~$100K	Labor: 0 - $30K/year System maintenance: $500/year
	Small	System implementation (GTIN only): ~$8,000	
Packaged goods and Ingredient suppliers	Medium	System implementation: $0.5- $~2M	Not provided
	Large	System upgrade (SAP): $2M	
Foodservice	Large	System implementation (GTIN only): $600K - $900K	System maintenance: $150K Automated phone retrieval system: $25,000
Retail	Large	GTIN scanner purchase: $3-$6K	Not provided
Animal Feed	Large	Bar code system implementation: $120K	Not provided

*Enterprises were grouped on the basis of the number of SKUs they handle. Large refers to handling thousands of SKUs; medium refers to handling 300 to 1,000 SKUs; and small refers to handling less than 300 SKUs.

Based on the discussions, the types of costs firms have incurred that are associated with product tracing systems include:

1. Capital investment, start up (system acquisition). These costs are associated with developing and implementing a product tracing system. They include capital investment on physical infrastructure, facilities modifications, computers and database software supporting the product tracing system.
2. Labor, including training costs. Increased labor costs are incurred at different stages of the production, processing and distribution process. These are one-time costs related to implementation and training time, and on-going labor costs for data collection, data transfer and record keeping. These activities are required to maintain product information along the supply chain, regardless of how the product information is collected, besides on-going or recurring training. Additional labor costs are associated with the collection of the logged product data from invoices, proof of payment, or directly by electronic means (e.g., through use of scanners) through reading of bar codes or other types of electronic data transfer.

   Firms also mentioned recurring expenses related to training activities, including wages, travel, meals and accommodation costs; consultant costs related to the updating or revising of an existing product tracing system; and additional employees (labor) due to production chain changes.

   Although most companies could not provide an estimate of labor costs for their product tracing systems, all agreed that the labor-intensive documentation is the most significant cost associated with product tracing. Some small produce companies reported that labor to maintain COOL paperwork and documentation alone could be approximately $30,000 annually. Although traceability implementation is not synonymous with or related to COOL, the increase in record keeping could be viewed by firms as a representative assessment of product tracing costs.

3. Direct costs generated by changes in harvesting and processing needed to support the product tracing system, or required to operate the system. These costs include supplies, changes in packaging materials or additional labeling needed to provide required data for the system. Firms may incur additional costs related to changes in the farming and product handling practices that require additional input costs to meet traceability requirements. Additional costs may be required for design and printing of labels, and attaching the labels to pallets, cartons and individual items.

   System maintenance and retrieval costs may also be incurred during the year. Data system maintenance and retrieval costs are those costs associated with daily operations and the traceability system maintenance. These costs may include program administrative and service fees, and internet service (for the traceability system). For example, the product tracing system of a small produce company resulted in an annual maintenance cost increase between $5,000 -$10,000. In the case of another firm, the annual cost of an automated phone retrieval system alone amounted to around $25,000.

4. Effects of the system on line speed or operations' efficiency change. Some changes in the operation may lead to slower product handling, increased delivery time and reduced

efficiency if the processing requirements changes. Additional documentation could result in slower throughput per line or decreased productivity per facility. Reconfiguring product flow could lead to increased or decreased costs.

A recent study of specialty crop producers in California examined the producers' use of product tracing and other questions about the perceived benefits and costs of product tracing (Stuller and Rickard, 2008). The study surveyed 174 producers of specialty crops in California and reported on responses from the 47 respondents (29.3% response rate). The survey was designed to collect data to better understand the benefits of product tracing and provide information that could be used in a partial budget analysis of product tracing. The study examined the costs of implementing and maintaining a product tracing system for a representative firm in the California melon industry. The study reported that the tracing costs for melons, especially the initial costs, were representative of lettuce, citrus and melons (Stuller and Rickard, 2008). Based on the available information, the total non-discounted costs for a representative melon producer were reported as an average $206,000 compared with total non-discounted benefits of approximately $230,000 (Stuller and Rickard, 2008). Results of this report were based on actual average cost calculations for the implementation and maintenance of a product tracing program for 5 years, and thus ranges based on companies' sizes could not be estimated. The benefits in this case were measured in terms of the firms' perception of the value of benefits to their business operation. Firms attributed the benefits to firm reputation, likely reduced litigation issues, improved efficiencies and more targeted recalls, among other benefits. Thus, this study provides evidence that at the producer level in the fresh, specialty crop sector, firms experience benefits that outweigh the costs of a product tracing system.

For comparison, it is useful to examine recent estimates of costs for implementing a national animal identification system (NAIS) for the swine industry (APHIS/USDA 2009a, b.). A description of the NAIS is presented in Volume 1 of this report (IFT, 2009). Although this example and the food industry differ in many ways, the requirements for developing systems to collect and maintain tracing information on animals can be used to understand some of the costs incurred in product tracing. Data were collected at more than 50 stakeholder meetings with more than 100 stakeholders representing a broad range of the industry sectors for the different animal species considered.

The case of swine operations costs is presented and summarized in Table 2. Swine are identified by lot, not by individual animal. The only tracking is done by lots of animals from birth or as incoming weaned pigs to market delivery to the packer. Packer costs include tracking incoming hogs to product, in most cases by lot processed (except in very small plants where the tracking may be by individual pig). Total costs include fixed costs of implementing the traceability system, fixed costs of annual maintenance of the data system, and variable costs associated with electronic storage and transfer of information on lots of animals.

Table 2. NAIS Costs Associated with Swine *(APHIS/USDA, 2009a)

	Fixed Costs for Product tracing system implementation ($/operation)	Data costs		
		Annual maintenance ($/operation) (Fixed)	Variable data cost ($/ lot)	Labor ($/ lot)
Farrow-to-Finish Feeder-to-Finish[1, 2]	Computer costs[3]: $203 Software: $117	Computer costs - annual: $30 Software: $18 Internet: $95	Printing: $0.24 Data storage: $0.09	Data storage-clerical cost: $3.93
Total	$320	$143	$4.26/lot	
Lots & Total data cost/lot				
Farrow-to-Finish	203.4 head/lot 13.7 lots/year		$14.65/lot	
Feeder-to-Finish	792 head/lot 3.0 lots/year		$51.78/lot	
Packers	Less than $1,000 per packing plant/year			

*Results of this report were based on actual average cost calculations at the sector level and thus ranges based on firms' sizes could not be estimated

[1]The two types of operations that sell finished market hogs to packers are included: farrow-to-finish (birth to market weight) and feeder-to-finish (weaned pigs fed to market weight). Nearly 20% of hogs sold come from farrow-to-finish operations; over 80% come from feeder-to-finish operations.

[2]Both farrow-to-finish and feeder-to-finish are handled and identified by "lot". For each, costs for the medium size operation (2,000 – 4,999 pigs) are presented here. The pigs/hogs are identified by lot identification. Costs are associated with recording, reporting and storing data.

[3]Computer cost weighted by number of firms that needed to acquire a new computer, with 50% of computer costs assigned to traceability. Example costs used here are for a firm with 2,000 – 4,999 head (medium size).

As shown in Table 2, costs in the swine industry relate to operations that handle farrow-to-finish or feeder-to-finish. Farrow-to-finish operations raise hogs from birth to slaughter weight, while feeder-to- finisher producers buy feeder pigs and grow them to slaughter weight. Both types of operations provide market hogs (or final product) to packers. The variable costs of the NAIS represent a relatively smaller share of costs compared with the fixed costs of system implementation and annual maintenance. The variable costs include printing, data storage, and clerical time for aggregating and uploading information. Total costs would be approximately $0.072/head for farrow-to-finish operations and $0.065/head for feeder-to-finish operations. Costs at the packer level involved the costs of recording and reporting data on the group/lot identification of animals. These costs were significantly influenced by plant size and number of animals. Also, costs at the packer level fell quickly as plants processed more hogs. For all plants, except the smallest size facilities (handling less than 10,000 hogs per year), tracking costs were economically insignificant to the overall cost of plant operations (APHIS/USDA, 2009b).

A swine operation handles only a very small lot size per year on average. Thus, the lot size and production cycle for the swine industry differs from most firms in the food industry. However, the fixed costs per operation may be comparable to other firms in the food industry with more lots handled per period. With more lots handled, the fixed costs in other food industries would be spread over more lots and the share of variable costs would increase relative to fixed costs.

4.2 Costs of Product Tracing Technologies

Various "off the shelf" traceability solutions providers were also contacted by IFT, and data related to the costs of the technologies they offered were obtained. The information they provided included capital equipment costs, computer and software costs, installation costs, training costs (to learn the application of the product code system), and ongoing variable costs associated with operating the system (labor and energy, labeling and on-case coding costs). Costs may also vary by size of firm that required the service. For example, initial costs to obtain a GTIN number may range from less than $1000 for the smallest firms to over 10 times that amount for the largest firms. In addition, the firms incur an annual licensing renewal fee that varies by size of firm. Other costs that would be incurred by these firms include costs to upgrade computers and associated hardware and software, in addition to the labor required to record and update information (Arens, 2009).

Table 3 provides examples of the type of costs associated with different technology providers as classified by IFT (IFT, 2009). A more complete description of these systems is detailed in Volume 1 (IFT, 2009). Regardless of the type of technology associated with each system, costs vary widely depending on how the software and other services are bundled and provided to the firm. Also, who stores and manipulates the data varies across services. Moreover, most systems do not provide product tracing solutions alone. They provide additional services, such as warehouse or cold chain management, quality control tools, and even customer service. Hence, the costs need to be allocated among these other business functions as well as product tracing. Additionally, most of these systems are not interoperable, and take advantage of proprietary tools for data management. Therefore, firms could incur the costs of maintenance of multiple databases depending on the data needs of their internal systems, as well as their customers' systems. The standardization of required information could, at least in part, decrease costs associated with the development and maintenance of proprietary and non-interoperable databases.

Radio-frequency identification (RFID) tags hold some advantage to bar codes in the potential amount of information held and method of reading and recording information. However, they are more costly in comparison to bar codes, even at the industry's current *target* rate of 5 cents per use. RFID tag prices depend on the generation, signal range, shape, and whether they are "active" or "passive" (Arens, 2009). By comparison, bar codes are 100 to 1000 times less expensive than RFID tags that contain similar data. Bar codes can also be more easily printed and therefore are able to be made on a conventional printer. Other costs associated with RFID are RFID-enabled label printers, readers, antennas, software, middleware, computers, and network infrastructure that are only compatible with a particular generation of RFID tags.

RFID technology continues to improve rapidly. While it is likely that improvements in RFID technologies will result in required hardware upgrades, the RFID vendor community is working to ensure backwards compatibility in standards wherever possible. Recently, some companies have been developing technology to print RFID tags on paper. However, several attributes of the current RFID technologies may limit their use. Another important issue facing RFID technology is the challenge of removal and disposal, as well as potential effects on recycling. Tags designed to be disposed of (passive RFID tags) lead to electronic waste that is difficult (and therefore costly) to recycle. RFID tags, designed to attach to containers, may also interfere with recycling of the packaging material, or may have parts that need to be removed early in the pulping process as non-recyclable solid waste (Welt, 2009).

Firms that wish to continue to use paper documentation could incur additional costs due to the panel's recommendations (IFT, 2009). The requirement to have key data elements for all Critical Tracking Events available electronically will result in a regular (likely daily) upload of information to a third-party by firms, or in an upgrade to an internal electronic data management system. If information is uploaded, the third-party vendor would assemble and clean data, convert them to a uniform electronic form, and store them for the firm. Thus, the third party would maintain data and manage retrieval under a services contract. However, the responsibility of implementing the actual product tracing system, including identifying Critical Tracking Events, recording key data elements, and the associated costs, would fall upon the firm. Even those firms with some electronic systems currently maintain some records on paper. If this occurs at a Critical Tracking Event, the firm will need to add electronic systems within the firm or upload the information to third parties.

Companies that have electronic systems will be significantly affected by the suggested recommendations as well. Although these companies could have resources and systems in place, additional costs related to tighter compliance are foreseen. These will include requirements for additional documentation of inputs/ingredients and source matched to product (internal traceability). Costs could also include additional information be communicated, such as lot numbers. In some cases, the additional requirements can be met with existing technologies and systems. However, in other cases, firms may need to acquire additional software to better track and manage product input use, which will require additional training, record keeping and labor time.

Table 3. Cost Estimates for Product Tracing Solutions as Provided by Select Providers

Traceability Solution Category/Description	**Items Included in Technology Cost**	**Available Price Estimates**	**Comments**
Component of temperature monitoring			
Uses RFID-based temperature monitors: Tied to cold chain management; Used for perishables	-RFID tags -Tag readers -Software for data management & storage -Infrastructure to load & retrieve information	- $10 – 23.50/tag - $400/reader (GPS enabled) -Variable costs for data management & storage (provider may handle data for client at a fee)	-Tags can be used multiple times and for multiple uses -Tag prices decrease with quantity purchased -Providers offer service packages with reduced fee, i.e., various combinations of number of tags and readers software, and storage time
Unique traceability medium			
Uses unique medium such as bar code accompanied by a software system	-Unique ID registration, e.g., bar code with 16- or 24-digit number -Labels – preprinted or printed on site -Scanner -Software for data storage	-$5-10/ID -1-2 cents/label -$100 -500/scanner (could be even more according to producers/ processors)	-Cost of labels decreases with quantity purchased
Information transfer platform (software as a service)			
Offers software services for data capture and storage. Most software are compatible with existing data systems & can accommodate data from any source	-Software purchase -Set-up fee -Hardware, e.g., computers -Data management and storage service	-Average service fee is $6,000 – 25,000/year	-Cost is dependent on o size of the enterprise o number of facilities o number of trading partners involved -Fees for smaller companies may be as low as $3,600/year -Large companies with many facilities as high as $1,000,000/year including hardware

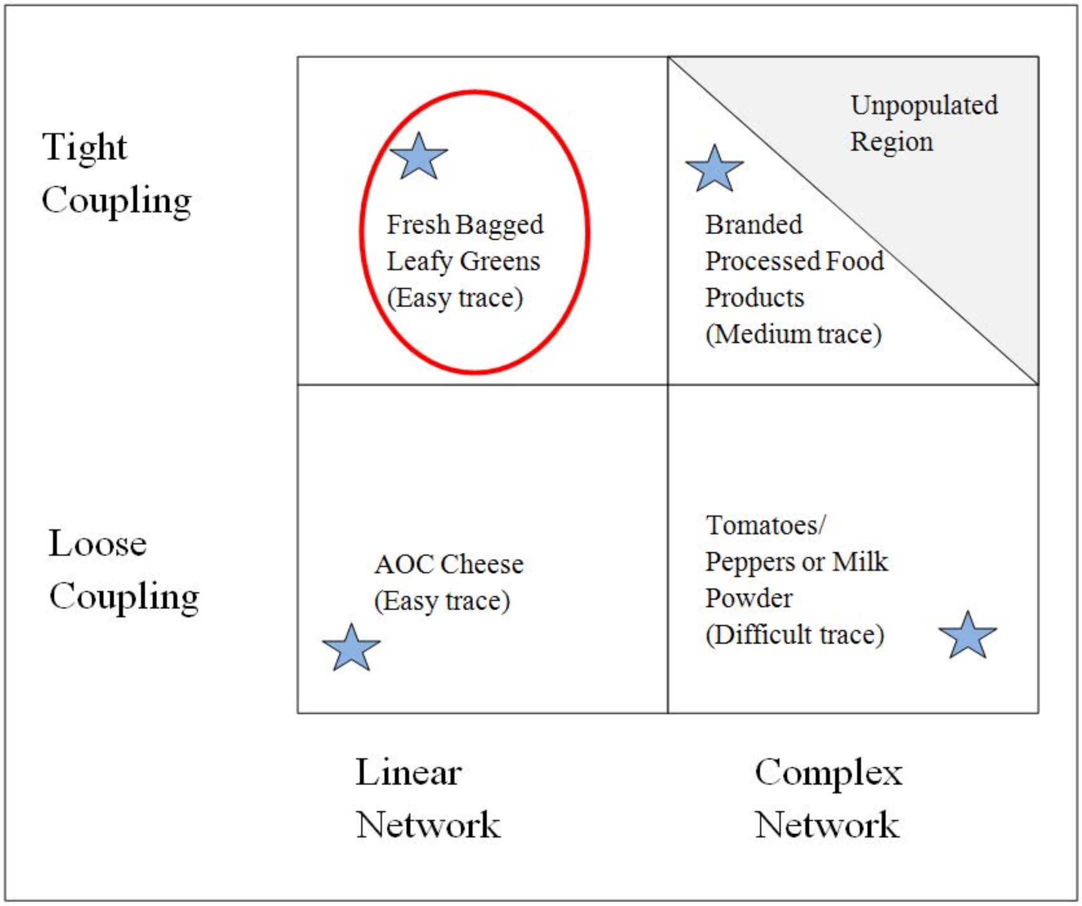
5.0 Case Study 1: Costs of Current System and Additional Costs of Best Practices: An Economic Analysis of LGMA and the 2006 Spinach Outbreak

A detailed case study of the California Leafy Green Marketing Agreement (LGMA) and the 2006 spinach outbreak was prepared as an example of the product tracing costs incurred in the leafy greens sector, and the benefits associated with improved product tracing systems. For the leafy greens industry, the California LGMA agreement now covers 75% of the total US market and 99% of the California market for greens. This example provides some insights for other produce and food systems as well. Details of the case study are available in a case study report, prepared by Nganje (2009). The case uses the outbreak of *E. coli* O157:H7 traced to bagged baby spinach from California in August-September 2006 to simulate the cost-effectiveness of rapid response product tracing systems. LGMA was formed in September 2007 in response to this outbreak.

The 2006 spinach outbreak case illustrates how the ability to trace product depends on the characteristics of the food supply networks (production, distribution and retail) and how information flows play a role in the ability of users to rapidly identify the sources and causes of adverse events in the food supply. This case analyzes the costs of information transfers that occur under product agreements today, when firms need to meet the requirements within their supply chain within a 24 hour period. This example shows the added industry costs required to comply with the LGMA – that is, to achieve the level of product tracing required under the agreement (described in later paragraphs). Another goal was to determine whether such product tracing systems may be a cost effective enhancement to minimize food safety losses when growers, distributors, and retailers are participants in such agreements.

The case example draws on a typology of food supply networks that distinguishes between networks that experience “tight” or “loose” coupling in the system, and are either in “linear” or “complex” networks (Figure 1). The case of the spinach industry under the LGMA as a system is placed as a “tight coupling” and linear network. Tightly coupled systems have fixed sequences or relationships that might exist under marketing contracts, for example. Loosely coupled systems do not have fixed sequences, and may retain slack resources or incur processing delays. Linear networks are relatively transparent in product flow and information, with fewer product transformations. Complex networks involve complex interactions and tracing of ingredients may be more complex. In this example, the spinach sector involves tight coupling (e.g., contracting relationships) and a linear network (i.e., relatively transparent relationships from growers’ fields to packing facilities to distributors and retailers).

Figure 1. Supply Network Complexity and Ease of Traceability (Skilton and Robinson, 2009)



Note: Fresh bagged leafy greens are highlighted as a linear network with tight coupling (Skilton and Robinson, 2009). Also, Appellation d'Origine Contrôlée (AOC) refers to cheese originating from a specific region in France.

Although the LGMA does not explicitly require that members implement an electronic tracking system, it does require that firms maintain up-to-date contact information on suppliers. Firms are registered according to the Public Health Security and Bioterrorism Preparedness and Response Act (2002) and the handler maintains a product tracing process. The majority of members claim to have adopted technologies to trace product back to the production source, including bar codes on boxes, pallets, and/or product packaging. Also, most member firms reported that they have moved to electronic product tracing systems to trace their product back to the production source.

Firms that use bar codes on boxes, pallets and/or product packaging, typically include information on grower, ranch location, planting block/lot, planting date, harvest date, harvest crew, ship date, ship-to locations, manufacturing plant, production shift and line, production date and a "Best if Used By" date. Firms rely on comprehensive documentation and record keeping procedures, and these records are primarily electronically stored, although some of the links across the supply channel may be paper-based. Usually, several stages link the retailer to the farm. One of the major changes that occurred among the participants in this industry was the move to primarily electronic systems. After the 2006 outbreak, over 60% of growers indicated increased use of electronic systems to improve food safety, record keeping and product tracing.

Tootelian (2008) conducted a survey of the California LGMA members to assess changes in handler practices since September 2006. The survey population was defined as the 118 members of the LGMA, and the response rate was 41.5%. The distribution of size of members responding was deemed representative of the overall LGMA membership, which is composed of produce handlers. Handlers source from growers, often under tight contracts, and many are growers themselves. Thus, the agreement ostensibly covers growers as well. Results from the survey indicate that the annual investment in food safety for members almost tripled since the introduction of LGMA. This translates to an average annual investment of $604,545 per member enterprise after September 2006. Combining the estimated annual operating costs for LGMA audit compliance (food safety employee costs, annual water testing expenses, annual LGMA membership funding) and the total estimated annual investment for LGMA compliance, the estimated total costs for LGMA members' compliance range from approximately $80 -91 million per year (Appendix A). These costs would cover costs incurred by growers and handlers, and the traceability systems in this tightly coupled, linear network system could represent costs for tracing forward from production to distributor. This estimate implies average annual expenses relating to compliance to the LGMA range from $0.0128 to $0.0158 per pound (Appendix A). Of the compliance costs, it is estimated that 20 to 45% of the cost can be attributed to record keeping and product tracing. However, as is evidenced by the findings in Volume 1 (IFT, 2009) and Table 1 of this Volume, the actual cost share varies widely for individual enterprises based on the type of product tracing systems used.

Within the industry, costs vary significantly by technology used and by grower size. Costs for two technologies (bar code and RFID) were estimated for representative firms by size, and then aggregated to obtain the estimated industry costs. It is important to note that the assumption is that the data collected are equivalent for both technologies. Therefore, only the cost of the medium is estimated. The costs to change practices and impacts on the amount of labor to record information are not considered in this evaluation. Each system's costs include both variable and fixed costs. Costs were computed for representative firms of three sizes measured in shipment volume (1= 0 - 100,000 pounds; 2 = 100,001 – 999,999 pounds; 3 = 1 million or more pounds) and are shown in Appendix B. Among the actual LGMA membership (n=118), 34.3% were in size category 1; 36.3% in category 2; and 29.4% in category 3 (Tootelian, 2008). The related costs for firms in each of the three size categories were aggregated by their share of industry members to get the total industry costs. Industry costs and parameters were based on Tootelian's report (2008), state/industry statistics (Appendix B), and other published documents (Nganje, 2009). Costs were estimated from the volume of leafy greens of the California leafy greens industry, which represents approximately 75% of the total U.S. volume (USDA, 2009).

For each of the technologies, total fixed cost is the sum of the individual fixed cost components. The fixed costs were depreciated over 5 years with a discount rate of 10% as the discount value for the cost of working capital. For example, the total fixed cost for the bar code system is $1,393,258. Variable costs differ by the size of the member groups. Total variable costs include the sum of the variable costs based on their assignment to the technology. For example, a bar code-based system has variable costs for the three size groups of $1,868,819 (sum of $91,405, $192,281 and $1,585,133). These costs are simulated from the volume of shipments for all members in that size category (see assumptions on the variable costs in Appendix B, section on

Variable Costs Individual Calculations). For the bar code system, variable costs include costs for bar code labels, bar code label printer, bar code handheld reader and employee training. Total cost is the sum of fixed and variable costs for all members. In the case of the bar code system, the total cost is $3,262,077, and applies if all firms adopted it.

The total industry costs were estimated for the two technologies (RFID and bar code) by aggregating the costs incurred by the firms in the industry across the three sizes of firms. For both technologies, total fixed and variable costs were highest for the RFID system ($109 million for passive tags and $1,372 million for active tags). As shown in Appendix B, costs also vary by firm size or sales volume (firm size categories assigned to member type 1, 2 or 3). For example, the RFID variable cost range for small and large sales volume varied between $195,821 and $87.6 million for passive tags. The variable costs for the bar code system ranged from nearly $91,000 to $1.6 million for the small and large sales volume, respectively (Appendix B).

Bar code technology was determined to be the least expensive in a tightly coupled, linear system, such as spinach. However, the use of active RFID tags and technologies that enable data to be rewritten at multiple locations could become technically cost-effective when a requirement for multiple bar codes exists. Yet, as suggested in Volume 1 of this report (IFT, 2009) standards are written to avoid data overwrite, so tags would serve only as “pointers” and not data sources themselves. Hence, requiring and enforcing information one-step back and one-forward, as recommended by the panel (IFT, 2009), has implications in this example for both cost and technology selected depending on firms’ size and processes.

In estimating cost and technology configurations for product tracing systems, it should be noted that when a pallet contains cases with different lot numbers, although each case would need to be bar coded, an additional hybrid bar code for the pallet, which communicates the number of cases of each lot number, would likely also be applied to reduce the amount of time spent scanning incoming cases. Additionally, practices that provide for internal product tracing should be implemented and data storage capabilities should be in place so that key data elements for all Critical Tracking Events could be provided in an electronic format within 24 hours of an FDA request.

The estimated benefits of having a product tracing system in place result from avoiding losses to the firm, public and industry, which are associated with an outbreak, such as the 2006 *E. coli* O157:H7 incident. The total costs of the 2006 spinach recall were estimated to be $129 million (see Appendix C). These costs include lost productivity due to recalled product (valued at retail price), losses due to the total medical and loss of life estimates related to the 204 cases of *E. coli* O157:H7 infection that were associated with the contaminated spinach, and losses due to lost sales following the outbreak. The industry losses are estimated at $80 million (Appendix C) (Nganje, 2009). In addition, this study included as losses the government payments that occurred due to the outbreak (payments to compensate farmers experiencing losses though not directly implicated in the recall, and additional research funding generated to address avoiding future outbreaks). These costs would not have been incurred without the outbreak, and thus are included in the costs of the outbreak. In this case, the benefits (the sum of losses avoided attributed to an outbreak) of $129 million could outweigh the costs of a product tracing system that varies between $3.3 million for a bar code-based system to $109.6 million for a system with passive RFID tags (Appendix B). Since some mix of the technologies is expected to be used across all members, and compliance is assumed to be 100%, these estimates could represent a lower and upper bound. Third party providers may also provide an option that may be competitive. Despite the potential benefits for firms, it should be noted that the cost of opportunity of the avoidance of a triggering event needs to be carefully assessed. Companies will incur costs related to product tracing every year, while the likelihood of an outbreak per year is fairly low, and varies per product category or sector. Thus, a specific analysis to address the probability of occurrence of a triggering event versus the costs and potential benefits per industry sector and per firm size needs to be done.

To assess the possible benefits of having a product tracing system in place, the case of LGMA was used to simulate the benefits of faster trace-forward response rates. The trace forward response rate of 47 days was the response time experienced in the 2006 recall of product (Appendix C). Two alternative scenarios were considered: one with a design intended to improve response to 50% of that time (24 days) and a second with a design to improve response to 25% of that time (12 days) relative to results reported under the LGMA implementation. The simulations included assumptions on expanded use of electronic systems and more targeted systems that incorporated more accurate lot/case level tracing. In the two cases simulated, the rapid response system reduced the losses from the outbreak (i.e., a measure of the improved the benefits of faster recall) by an estimated $9.8 - $93.6 million, depending on the assumptions used (especially related to the distribution of illness and deaths that might occur). These benefits are achieved through reduced illnesses because contaminated product was identified sooner and did not reach final consumer (hence, did not cause illness). These simulated "benefits" can be compared to the costs associated with improved (more rapid) product tracing of $16-41 million for LGMA members (that is, 20-45% of the aggregate cost of $80-91 million reported in Appendix A). Thus, having a more rapid product tracing system in place may present net economic benefits for the industry, according to this case study.

The assumptions of increased use of electronic systems and availability of linking the electronic information across firms in the food system are consistent with the recommendations by the panel for 24-hour electronic availability of key data elements for each Critical Tracking Event (IFT, 2009). Although the range of improved benefits is large, the study indicates the possible significant improvement by having access to suppliers and product destination information through electronic means. The estimated costs and simulation employed in the case of the LGMA for spinach indicates that there are significant savings from more rapid response. This response results from information technologies that improve the ability to track product flow. Compliance costs of LGMA membership of $80-91 million (or $0.0128 - $0.0158 per pound, with the associated record keeping and product tracing costs ranging from $0.0026 to $0.0071 per pound) are significantly lower than the potential benefits of avoiding a future outbreak similar to the 2006 *E. coli* O157:H7 event and product recall. The costs may also be lower than the benefits achieved when more rapid and targeted recall systems (24 hour system for each participant) reduce the trace forward response time to 50% (24 days) or 25% (12 days) in this case. Some of these costs are expected to be passed forward to consumers. For firms, the costs of having a system in place would be recurring costs to the industry. Any individual firm may not experience a recall within a year. It is likely to be a relatively rare event. However, for the industry, having a rapid response system in place reduces the costs (and provides benefit) across the industry when a recall does occur.

Two actual experiences with leafy greens recalls following the 2007 outbreak provide insight on the enhanced trace-back time for current electronic users (Nganje, 2009). In August 2007, a company employed their product tracing system after finding that 8,000 cartons of fresh spinach were potentially contaminated with *Salmonella*. Within three days of harvest, stores and restaurants were notified of the product recall, whereby more than 90% of the possibly tainted spinach never reached the market (CIDRAP, 2007). More recently, in the summer of 2009, romaine lettuce was recalled after random testing conducted by the Wisconsin Department of Agriculture found traces of *Salmonella*. The company involved was informed of the possible contamination on July 20th, which was the same day the product was distributed to 29 states, Canada and Puerto Rico (Withers, 2009). Within hours of being notified, this company was able to identify the harvest date of the potentially contaminated lot and alert their customers of the recalled product (FDA, 2009). Although in this case a relatively high share of product reached the retail level, no one was reported ill in association with the contaminated product. In both cases, having access to electronic records, as well as increased surveillance and rapid action, improved the speed of the recall and reduced losses associated with a potential food safety outbreak. Systems do require timely notification and the ability to effectively identify and withdraw product from the market. The costs of not having effective product tracing include loss of market for the firms involved and, for the industry as a whole, loss of sales and loss of public confidence in their product.

6.0 Case Study 2: Costs at the Firm Level of Implementing Increased Product Tracing: A Case of a Specialty Bulk and Pre-Cut Produce Distributor

The case of a regional enterprise that purchases bulk produce and distributes it to regional foodservice operations illustrates in greater detail the type and magnitude of costs such a firm would incur as it moves to full product tracing (one-step back to suppliers and one-step forward to points of delivery with internal tracing maintained) as recommended by the panel (IFT, 2009). The firm receives bulk produce (field and shed pack) and distributes bulk produce, as well as processes some of the produce into pre-cut and packaged product (such as shredded lettuce, peeled and pre-cut vegetables and sliced cabbage). Since 2007, the firm has been investing in product tracing systems, and expects to be compliant with the Produce Traceability Initiative (PTI) by 2011. The firm has their own Quality Assurance (QA) department which manages HACCP and their product tracing program that is in place.

Currently, the firm captures information on incoming material through handwritten and electronic means. This includes the date/temperature/time, condition of produce, the truck that transports it and other information at the truck level. They apply information in bar code format to raw bins of leafy greens. Stickers with the bar codes are printed and verified, matched to the inventory system, and put on all outgoing cases. Currently, much of the information is captured via manual entry. Outgoing material is identified by case and truck. Inventory is captured each morning and first-in and first-out (FIFO) is in place, but the current system does not allow full product tracing.

To date, the firm has made relatively minor investments in equipment, and changed some product handling and inventory management practices, but they anticipate significant changes as they implement a full product tracing system over the next two years. The costs they have incurred and expect to incur include the following:

6.1 Capital Equipment

To date, the company affixes bar codes to bins of high risk items (such as leafy greens) and scans bar codes for all produce that is processed (sliced, diced, shredded, etc.). The scanned information can be tracked through their inventory system. In the last two years, they have purchased two scanners and the associated software. This initiative also included some IT and technologist time. In total, the scanners and associated costs were $5000. There are some additional costs associated with upkeep on the scanners that they incur each year.

To implement a full product tracing system, the firm will convert to a fully electronic tracking system that includes electronic scanning of all incoming product (making the process compliant with PTI). The plan is to acquire GS1 GTIN numbers for all processed product, and label all cases in production with the product number. The initial fee for a third party provider of product identification numbers was $20,000, with additional annual fees estimated to be $1,500 per year.

The major investment anticipated is a software program that includes inventory, accounting and traceability data management capacities, at a cost of $400,000. Of this cost, the firm estimates 20-30% to be associated with product tracing – or approximately an $80,000 - $120,000 investment in software. The company also estimates annual additional total costs of up to $22,000. The latter costs are related to all additional activities that relate to the implementation and maintenance of the software. Since the fraction of these costs cannot be allocated directly to product tracing, these are not included in Table 4.

Additional scanners will also need to be purchased. It is estimated that they will need one scanner for each person loading or unloading product, one for each truck driver and two for backup. Given the number of routes/trucks the establishment uses and number of people involved, an estimated 55 additional scanners will be required with an estimated total cost of $45,000 – $50,000.

6.2 Labor

Labor costs associated with the product tracing system include a relatively small amount of labor, training, and additional QA services (devoted to traceability tasks alone). It is more difficult to estimate the incremental complexity that traceability-related labor will demand. These tasks now will include more data recording, use of scanners and other, more complicated chores.

Labor will also increase. Now employees print and affix pre-printed labels to cases and load boxes. When the full product tracing system is in place, they will print and affix stickers, scan each case and load the case on a truck. These additional tasks are expected to require two additional people (estimated at $23/hr, wages plus benefits), or approximately $100,000 of additional labor costs per year.

Additional costs due to the increment of skills needed are expected. Training costs would also be incurred to instruct labor in the use of scanners, labeling and handling of product. Some of these costs are on-going. However, currently the loader position is a semi-skilled position. Additional technical capabilities will be required from the training in the future. Currently the firm employs a part time IT consultant (3 days per week). The firm expects to move to a full time IT consultant, at an additional cost of $40,000. A part of the additional person’s time would be directly attributed to the product tracing system costs.

6.3 Supplies and Material Costs

Requirements for labeling cases will also increase. Currently, cases include only one label, but they plan to move to two labels per box. Although the cost of the label is small (1 cent per label), these costs (and associated time to affix to the case) will double. The estimated label costs required per month will be between $1,500 and $2,000. Acquiring the third party provider numbers would entail annual fees of approximately $1500.

Total costs for implementing and maintaining a product tracing system in this example are summarized below (Table 4). In sum, the full costs to implement a product tracing system for this produce supplier include a major investment in a software system, purchase of scanners, some supplies and additional labor costs, including training. Labor will need to conduct more complex tasks. The total cost is estimated to be approximately $0.10 - $0.15 per package (case). This amounts to about 1% of total costs, if the total cost per case is $14 - $15, as was expressed by this specific producer. Although the firm does not expect significant benefits in inventory control from the product tracing system components, having the system has benefits to the firm in terms of product quality and buyer requirements. Also, market advantage was foreseen by the firm in terms of compliance with PTI. However, there is concern that without a requirement for all suppliers, there may be some price differential in comparison to other firms, which would be disadvantageous for firms.

Table 4. Total costs: Case of a Specialty Bulk and Pre-Cut Produce Distributor **(Jensen, 2009)**

Fixed costs:	
Software (25% of system attributed to traceability)	$100,000
Scanners	50,000
GS1 number acquisition	20,000
Variable costs (annual):	
Software (25% of maintenance)	5,000
GS1 (renewal, annual fees)	1,500
Scanner maintenance/replacement	5,000
Labor (2)	100,000
IT (40% of IT consultant)	40,000
Labels (2/box for each case)	24,000
Estimated cost per case	**$0.10 – 0.15/case**

7.0 Social Costs and Value to Society

Economic efficiency requires that firms take all benefits and all costs into account when production levels are established, including costs imposed on those outside the firm (external) and benefits accrued to individuals other than the purchaser. If the "external" costs are not taken into account, too much of the consumer good in question will be produced. On the other hand, if spillover or social benefits are ignored too little of the good in question will be produced.

The "externality" problem exists to some extent for all goods and often is considered to be sufficiently small that it can be ignored. However, particularly where there is the potential for large negative impacts on public health, the externality argument provides a justification for public regulation. In the absence of regulation, profit maximizing firms may not allocate sufficient resources to activities protecting public health. This is particularly true when the potential threat is perceived to have a very low probability. The threat of the costs of dealing with potential legal claims by injured parties provides some incentive for firms to devote additional resources to protecting public health. However, in many instances the firm's resources are small compared to the potential damages. In those situations, private firms have little reason to invest in the protection of public health at a socially optimal level.

Improved product tracing systems could provide direct benefits to the firm, through increased efficiencies in the management of inventories, improvements in product flow and management of inputs, reduced costs associated with a recall of product (due to possible contamination or quality compliance), and access to markets where buyers require product tracing. Those direct benefits, and others described in earlier sections may be sufficient to overcome the costs of universally implementing product tracing systems, which would allow the food industry to respond more rapidly to triggering events such as product recalls. If that is true, rapid product tracing technologies would be adopted and become the industry standard throughout the food supply chain, and no public sector intervention would be necessary. However, it is more likely that there will be pockets within the food industry where the direct benefits to the firm are less than the direct costs of providing that additional information. In those instances estimates of the spillover benefits from improved product tracing are important. Often critical in product recall situations is that the failure to be able to fully trace product can have significant negative effects on the entire industry.

While most Americans are confident their food supply is safe from natural contaminants (Stinson et al., 2007), the Centers for Disease Control and Prevention (CDC) estimate that about one person in four contracts a foodborne illness each year; 325,000 hospitalizations and 5,000 deaths occur annually due to the consumption of inadvertently contaminated food (Mead et al,, 1999). Reducing the number of days lost to foodborne disease through more rapid and effective recalls clearly would provide social benefits. The value of those spillover benefits is likely to be significant. For example, if we focus solely on the CDC estimate of one in four contracting a foodborne illness each year (ignoring the more serious events resulting in hospitalization or death), then assume the illness lasts for one day and use average daily earnings as a measure of the social loss associated with the foodborne illness, we find that foodborne illnesses were responsible for social losses of $11.4 billion. Incorporating the costs of treatment and hospitalization and the loss of life the estimate of social loss due to foodborne disease would substantially increase. Reducing the incidence of foodborne disease by 1 percent through improved product tracing would then yield social benefits of $114 million. These benefits would be in addition to the benefits received directly by food industry firms.

In addition to product contamination that may arise from unintentional sources, deliberate contamination of the nation’s food supply is also a real possibility. An intentional contamination of the food supply could have major economic and psychological implications. In addition to the direct economic losses that include the value of lives, income lost and the business activity lost by the food industry, other losses that include the psychological and emotional damages resulting from a terrorist attack using the food system are likely to extend well beyond the area immediately affected. The damages would be national in scope and likely affect consumer spending and business investment decisions, and influence the performance of the entire U.S. economy over an extended period. Stinson (2006) estimates that the short-term indirect loss in economic output resulting from a terrorist attack in the United States could easily exceed $190 billion. He notes that the ongoing productivity losses caused by the allocation of additional resources to security activity would greatly exceed any GDP short-term losses. A more rapid and targeted trace of intentionally contaminated product might mitigate the economic impact of such an event.

8.0 Conclusions

Although each case is unique, the example of the 2006 spinach contamination indicates that the losses to the industry and the public in terms of health were significant. Up to $129 million in losses were attributed to the contamination of spinach with *E. coli* O157:H7. Costs to the industry of implementing product tracing systems were estimated to be between $3.3 and $109 million depending on the technologies adopted. Furthermore, significant benefits through reduced illnesses are achieved with more rapid product tracing, which could occur with electronic access to records ($10 – $94 million). In addition to these direct benefits, benefits related to more rapidly restoring consumer confidence, reduced market disruption and spillover to other fresh produce industries are foreseen. Although there is some uncertainty that accompanies such estimates, the order of magnitude suggests that the benefits of improved product tracing could outweigh the costs to industry and society in implementing a product tracing system. Despite, the potential benefits for firms, it should be noted that cost comparison needs to be further analyzed. Companies incur product tracing costs every year, while the likelihood of an outbreak per year is fairly low, and varies per product category or sector. Thus, a specific assessment that addresses the probability of occurrence of a triggering event versus the costs and potential benefits per industry sector needs to be done.

Firms that have implemented effective product tracing systems find benefits in improved supply chain management, inventory control, access to contracts and markets by having stronger product assurances, more targeted recalls and hence lower costs to recall, whether for safety or quality, and other cost savings incurred during a foodborne illness outbreak. Product tracing systems may help compartmentalize and reduce the region or type of product at risk of recall. Firms could also benefit by protecting brand name, maintaining consumer confidence, and the reduction of possible liability claims. Furthermore, product tracing could exclude firms' product from an investigation.

Despite significant firm level and aggregate benefits, the costs of enhanced product tracing can be significant. This is particularly true for firms where substantial amounts of ingredients are processed and need to be tracked into finished products, or when firms rely on paper-based systems. Costs of available technologies and services to provide firm level product tracing are likely to decrease with increased competition in the market. However, firms that use paper-based and manual entry systems to track incoming supplies or outgoing shipments, and firms that have relatively complex systems where many inputs are processed into products will face added costs in order to have required data available and electronic data access. The small and medium size enterprises may face particular challenges in meeting new product tracing requirements. Small and medium size enterprises lack adequate capital, labor, and technology expertise to implement electronic product tracing systems. Furthermore, there may be a fear of electronic systems and their potential of failure. Thus, a strong preference remains for using paper and pencil records. Research that assesses the needs as well as strategies for these firms to develop effective product tracing systems will be required. Additionally, some industry practices, such as mixing orders, may need to be carefully reconsidered because they will entail new record keeping costs.

The private benefits to a firm incurred through the improved product tracing capacity may be dissipated if the customers do not value – that is, they are not willing to pay – for some of the higher costs associated with having improved product tracing. If a product tracing system was not universally required, these firms would face competition from other firms that do not provide product tracing. Also, any failure in being able to trace the immediate source and destination of the product one-step back and one-step forward in a 24-hour period will undermine the effectiveness of the product tracing system and limit its efficacy in the case of a product recall. A rapid response to an accidental or intentional contamination or other triggering event through improved product tracing would yield social benefits beyond the direct benefits and cost reductions to the firms. Additional healthcare costs, social losses, loss of life, loss of consumer confidence, major psychological and emotional damages due to massive outbreaks, and indirect loss in economic output and productivity losses are just the most evident externalities that could be avoided with a functional product tracing system.

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Appendix A. Estimated Annual Industry Costs Relating to LGMA Compliance

Food Safety Employee Wages	**Range**
Average salary for food safety inspectors in the U.S. [1*]	$37,599
	267
Total Annual Food Safety Employee Wages	*$10,038,933*
Irrigation Water Testing Expenses[1*]	
Average cost for water testing (per test)[1*]	$42-$70
Approximate number of annual water tests	73,956
Total Annual Water Testing Expenses	*$3,106,152-$5,176,920*
Total Annual LGMA Membership Funding[2]	*$4,500,000*
Total Estimated Annual Operating Costs (LGMA Audit Compliance)	*$17,645085-$19,715,853*
Total Estimated Annual Investment Expenses	*$62,092,780-$71,000,000*
Total Estimated Costs Relating to LGMA Membership	***$79,737,865-$90,715,853***
Approximate annual volume of leafy greens in pounds (approx. 22-24 pounds per carton)[3]	5,720,000,000-6,240,000,000
Total Estimated Annual Costs (LGMA Audit Compliance) per lb	***$0.0128-$0.0158***
Total Estimated Annual Costs attributed to traceability per lb (20-45% of total estimated)	***$0.00256-$0.00711***

Source: Nganje, 2009. Compiled from Tootelian (2008)[1*], Cline 2007[2], USDA (2009)[3], and Oregon State University (2009).

*Costs for food safety employee wages and the water testing may include costs for other produce in addition to leafy greens. Tootelian (2008) does not report any disaggregated costs for members. Therefore, costs for these two components may be overestimated to the extent that the expenses on food safety and water testing also apply to other produce.

Appendix B. Simulated Annual Costs Relating to Implementing a Traceability System, by Technology and Size

RFID based System Components and Costs			
Type of Cost	**Est'd cost**	**Comments**	**References**
Variable Costs*			
Passive Tag Average Cost	$0.16 per tag	Firms can choose either passive or active tags	RFID Journal 2009; Ward 2004; RFID Labeling 2007; IDTechEx Ltd 2009
Active Tag Average Cost	$5.00 per tag		
RFID Label Average Cost	$0.175 per label	Average range $0.095 - $0.255 based on 1m tags	Mid-South RFID 2008
UHF Handheld Readers Average Cost	$800.00 per reader	Stationary readers average cost $900	Lahiri 2005
Employee Training	$85.60 per employee	Training ranges between 6 and 10 hours per employee (Average of 8 hours) at $10.70 per hour	Sweeney 2005; Bitsch 2008
Fixed Costs			
RFID Strategy and Application	$170,000	50 - 200 person days of labor (100,000 - 240,000)	Sweeney 2005
Third-party Service Provider Fee	$75,000	$75,000 for annual sales $1B to $10B	Shutzbert 2004
Employee RFID Certification Course	$1,249	RFID Certification Course	RFID4U 2009
Middleware License Average Cost	$400,000	One time investment in Middleware	O'Connor 2007
Servers Average Cost	$10,400	List price is $5,200/server (2 required)	Dem 2009
Information System Operating Costs	$210,000	Average of $17,500 monthly system maintenance & mgt	Sweeney 2005
RFID Maintenance and Consulting Costs	$70,000	15% to 20% of acquisition cost (license)	Shutzberg 2004
RFID System Integration Average Cost	$50,000	One time cost for system integration	RFID Journal 2005
Total fixed cost depreciated Over 5 Years	**$21,168,106**		
Total Variable Costs (Passive Tag)			
Total Variable Cost (Members 1)	$195,821		
Total Variable Cost (Members 2)	$598,520		
Total Variable Cost (Members 3)	$87,647,028		
Total Costs (Passive Tag): Fixed + Variable			**$109,609,475**
Total Variable Costs (Active Tag)			
Total Variable Cost (Members 1)	$599,154		
Total Variable Cost (Members 2)	$4,934,354		
Total Variable Cost (Members 3)	$1,345,849,563		
Total Costs (Active Tag): Fixed + Variable			**$1,372,551,177**

***** Results of this report were based on actual average cost estimates. Total costs are expressed as an average that varies per company size (members' 1, 2 or 3).

Appendix B (continued)

Bar code System Components and Costs			
Type of Cost	**Est'd cost**	**Comments**	**References**
Variable Costs definitions			
Bar code Label Average Cost	$0.005 per label	Lowest estimation 0.005 (print your own)	Cole 2009
Bar code Label Printer Average Cost	$850 per label printer	Zebra printers average between $400 - $1,500 in 09	Balle 2009
Bar code Handheld Readers Average Cost	$400 per reader	Stationary readers average cost $700	Lahiri 2005
Employee Training	$10.70 per hour	Estimate 1 hour of training per employee	Bitsch 2008
Fixed Costs			
Strategy and Integration Costs	$5,600	Software develop and integration 2,800 respectively	Patel 2005
Bar code Software Average Cost	$90	Reviewing products for sale	AccountPro 2009
Bar code Software License Average Cost	$5,000	Site License	Behnke 2009
Software Support/Hosting/Maintenance	$1,500	Annual Maintenance fee per site	Behnke 2009
General Bar code Hardware Average Cost	$2,750	Ranges between $2,000 and $3,500	Waugh 2009
Bar code System Integration Average Cost	$50,000	Ranges between $40,000 and $60,000	Waugh 2009
Total Fixed Cost Depreciated Over 5 years	**$1,393,258**		
Total Variable Costs per member category			
Total Variable Cost (Members 1)	$91,405		
Total Variable Cost (Members 2)	$192,281		
Total Variable Cost (Members 3)	$1,585,133		
		Total Costs: Fixed + Variable	**$3,262,077**

NOTE: Variable costs for both technologies result from the summation of total tag or label, total additional hardware (readers or printers) and total training for all members per category. In the case of RFID based system, 8 hours of training were assumed for variable costs estimation.

Appendix B (continued)

Shipment Volume by Member Category (lb)	***Number of Members***	***Average Cartons per Member Category****	***Reference***
0 to 100,000 (Member 1)	40	83,333	LGMA 2007
100,001 to 999,999 (Member 2)	43	895,833	
More than 1 million (Member 3)	35	259,959,201	
Standard Carton of Packed Leafy Greens	24	NOTE: 24 lb/carton (Approx.)	Oregon State 2009
Number of Total Cartons (AZ) – 15% LGMA	52,000,000		USDA 2009
Number of Total Cartons (CA) –75% LGMA	260,938,368		
Total Leafy Green Volume in CA (lb)	6,240,000,000		

Variable Costs Individual Calculations

UHF Handheld Readers ($800 per reader)

0 to 100,000 (3 readers)	$2,400	96,000 for 40 Members 1
100,001 to 999,999 (6 readers)	$4,800	206,400 for 43 Members 2
More than 1 million (12 readers)	$9,600	336,000 for 35 Members 3

Bar code Label Printer ($850 per printer)

0 to 100,000 (1 printer)	$850	34,000 for 40 Members 1
100,001 to 999,999 (2 printers)	$1,700	73,100 for 43 Members 2
More than 1 million (4 printers)	$2,550	89,250 for 35 Members 3

Bar code Handheld Reader ($400 per reader)

0 to 100,000 (3 readers/member)	$1,200	48,000 for 40 Members 1
100,001 to 999,999 (6 readers/member)	$2,400	103,200 for 43 Members 2
More than 1 million (12 readers/member)	$4,800	168,000 for 35 Members 3

Employee Training for all members per category ($10.70/hr/employee)

0 to 100,000 (840 employees/ 40 members)	$8,988	
100,001 to 999,999 (1,075 employees/43 members)	$11,502	
More than 1 million (2,625 employees/35 members)	$28,087	

Total Passive Tag Cost per Member Category

0 to 100,000 (Member 1)	$27,917	Total for 40 members
100,001 to 999,999 (Member 2)	$300,104	Total for 43 members
More than 1 million (Member 3)	$87,086,332	Total for 35 members

Total Active Tag Cost per Member Category

0 to 100,000 (Member 1)	$431,250	Total for 40 members
100,001 to 999,999 (Member 2)	$4,635,938	Total for 43 members
More than 1 million (Member 3)	$1,345,288,867	Total for 35 members

Total Active Tag Cost per Member Category

0 to 100,000 (Member 1)	$416.67	Total for 40 members
100,001 to 999,999 (Member 2)	$4,479	Total for 43 members
More than 1 million (Member 3)	$1,299,796	Total for 35 members

*Based on median volume

Appendix C. Estimated Costs Linked to the 2006 *E. coli* O157:H7 Outbreak and Recall

Recall Related Costs	
Retail value baby spinach (per unit of 3 lbs)	$3.89
Approximate number of units recalled	42,000
Total recall related costs	***$163,380***
Lost Productivity Expenses	
Lost productivity due to *E. coli* O157:H7 (per case)[1]	$1,871.96
Approximate number of *E. coli* O157:H7 cases linked to outbreak	204
Total lost productivity expenses	***$381,879.84***
Medical and Loss of Life Calculations	
Did not visit physician and survived (per case)	$28
Estimated unreported cases	6,000
Total	**$168,000**
Visited physician and survived (per case)	$495
Approximate number of cases	100
Total	**$49,500**
Did not have hemolytic-uremic syndrome (HUS) and survived (per case)	$6,550
Approximate number of cases	70
Total	**$458,500**
Had HUS and survived (per case) [2]	$36,525
Approximate number of cases	31
Total	**$1,132,275**
Had HUS and did not survive (per case)[3]	$6,766,498
Approximate number of cases	3
Total	**$20,299,494**
Total medical and loss of life estimate	***$22,107,769***
Industry Lost Sales Following Outbreak and Recall	***$80,000,000***
Federal Funding (within Iraq Bill) to Compensate "Not Implicated" Farmers	*$25,000,000*
USDA Grant Funding to Identify Source of Outbreak	*$1,200,000*
Total Estimated Failure Costs (2006 *E. coli* Outbreak)	*$128,853,028.84*
Approximate volume of contaminated product (pounds)	15,750

Source: Compiled from CIDRAP (2007), McKinley (2006)

[1] Loss of productivity refers to work-days lost due to the disease diagnosis and treatment

[2] Includes expenses (medical, hospitalization and productivity loss) associated with patients who presented the infection but survived

[3] Includes only patients who visited medical facilities and did not survive the infection

Appendix D. IFT staff and Economics Expert Panel

Staff Personnel
Project Director
Jennifer Cleveland McEntire, Ph.D., IFT Research Scientist and Manager, Science + Technology Projects
McEntire served as the Project Director and facilitated the Expert Panel's deliberations

Expertise: McEntire has expertise in food safety, food microbiology and food defense, training in physical security and classification, and experience working with groups of scientific and technical experts to produce scientific and technical documents, with organizational administration (e.g., personnel, project oversight, and other issues and procedures); and with Federal requirements of contracting and subcontracting personnel.

Staff Scientist
Carla Mejia, Ph.D., IFT Research Scientist.
Dr. Mejia began working on this task in January, 2009. She led the cost evaluation subpanel, and also analyzed data from the discussions with food industry members.

Expertise: Mejia has knowledge of food science and technology, food chemistry, nutrition, and food product development.

Economics Panel
Subpanel Leader
Helen Jensen, Ph.D., Professor, Dept of Economics, Iowa State University, Ames, IA Economics

Expertise: Dr Jensen's major areas of research are food demand analysis, food assistance and nutrition policies, issues related to food security, and the economics of food safety and food hazard control options.

Subpanel members
Kevin Keener, Ph.D., Purdue University; Mary K. Muth, Ph.D., RTI International; William Nganje, Ph.D., Arizona State University; Thomas Stinson, Ph.D., University of Minnesota

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