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Traceability Adoption by Specialty Crop Producers in California

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Surveys were sent to specialty crop producers in California, predominantly grower-packer-shippers, during the first half of 2006 to better understand the motives for traceability adoption. The questions in our survey allowed respondents to consider the benefits of tracing. A representative tracing system for melons was developed and costs for the system were collected from industry sources. Values were assigned to the benefits of traceability based on the cost of the representative system, responses collected in our survey, and using Borda's rule. Results suggest that litigation concerns and firm reputation are the key drivers for maintaining traceability.

Key Words: Borda's rule, California, partial budget, specialty crops, survey, traceability

Traceability systems are methods of record keeping used to trace a product along the agricultural supply chain (Golan et al., 2004). Tracing may provide information about the origin of a food product, the product's location at a given time, and a history of production practices that were used to create the product. Implementing traceability is costly, but the information obtained by tracing a product's history provides benefits to growers, handlers, and consumers of food. The purpose of this research is to develop a better understanding of the specific benefits of traceability for producers[1] of specialty crops (i.e., fruits, vegetables, and tree nuts) in California.

Each year in the United States, there are millions of cases and approximately 5,000 deaths stemming from foodborne illnesses (Mead et al., 1999). Economic research has studied traceability and food safety issues associated with animal products (e.g., Dickinson and Bailey, 2002; Meuwissen et al., 2003; Gracia and Zeballos, 2005; Hobbs et al., 2005), yet there is relatively little research examining

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[1] We use the term "producers" to describe a group that includes growers, grower-packers, and grower-packer-shippers. Approximately 85% of the survey respondents classified themselves as grower-packer-shippers.

traceability topics for plant products. Moreover, there have been several recent cases concerning food safety for various fruit, vegetable, and tree nut products.

The Food and Drug Administration (FDA) annually publishes a list of all product recalls, market withdrawals, and safety alerts. In 2006, the FDA list included 105 product recalls, of which 29 were specific to plant-based food products and 18 were specific to animal-based food products [U.S. Department of Health and Human Services (USDHHS)/FDA, 2006]. During the second half of 2006, there were several highly publicized cases of food contamination in specialty crop markets, including outbreaks of *E. coli* O157:H7 found in spinach and green onions (for details, see Centers for Disease Control, 2006), and *Listeria* bacteria in strawberries (Clayton, 2006). A marketing agreement was developed in 2007 by members of California's fresh produce sector to address the growing concern regarding outbreaks of foodborne pathogens in leafy green vegetables (California Department of Food and Agriculture, 2007). Food safety for specialty crops is an important issue, and one that is expected to remain a top priority for food consumers, food manufacturers, and the U.S. government.

A two-step procedure was used to examine traceability adoption among specialty crop producers in California. First, we distributed a mail-based survey to producers in March 2006. Responses to the survey were collected prior to the outbreak of *E. coli* found in California spinach in September 2006, and therefore our analysis was based on producers' perspectives prior to a significant event associated with food safety. Second, a partial budget was constructed to assess the costs and benefits for a representative tracing system. Implementation and operating costs were collected for a traceability system that could be used by melon producers. The total costs of the representative tracing system, coupled with our survey responses, were used to allocate financial values for selected benefit categories.

The Drivers of Traceability Adoption in Agriculture

Operations along the agricultural supply chain implement traceability systems for various reasons. Golan et al. (2003) stated that the benefits of traceability can be linked to three general motives: (*a*) to improve supply management, (*b*) to facilitate traceback for food safety and quality reasons, and (*c*) to differentiate and market foods with subtle or undetectable quality attributes. These three motives outlined by Golan et al., anecdotal evidence from industry sources, and other suggestions in the literature led us to develop eight categories of potential benefits from traceability use in agriculture. Our eight benefit categories included the ability to: (*a*) pinpoint high yield and/or high quality, (*b*) improve efficiencies, (*c*) lower operating costs, (*d*) increase firm reputation, (*e*) decrease the concern about legal liability, (*f*) add value, (*g*) enable product differentiation, and (*h*) enter international markets. Categories (*a*), (*b*), and (*c*) in our list roughly follow the first motive from Golan et al.; items (*d*) and (*e*) follow the second motive; and items (*f*), (*g*), and (*h*) follow the third motive. Questions in our survey were designed to facilitate an understanding of how producers would rank the relative importance of the eight benefit categories.

Based on informal discussions with grower-packer-shippers in California's citrus industry, traceability enables firms to pinpoint geographical production areas with certain quality characteristics. The ability to pinpoint key production areas would provide greater information about agronomic practices and also lead to sorting efficiencies and lower operating costs. Survey work conducted by Fouayzi, Caswell, and Hooker (2006) showed that fresh-cut produce firms have adopted quality management systems to develop an understanding of quality traits and increase operating efficiencies. Also, Zaibet and Bredahl (1997) found evidence suggesting implementation of ISO 9000 generated management efficiencies through lower operating costs.

It has been widely documented that traceability increases food safety because it facilitates a food recall relatively quickly (e.g., Golan et al., 2003). Benefits of traceability, therefore, may include an increase in a firm's reputation if it has a system in place that can provide customers with detailed tracing information. Further, the ability to avoid (or shift) litigation concerns in the event of a food recall is a benefit that would encourage traceability adoption. Examining how inspection and traceability influence suppliers' willingness to supply safer food, Starbird and Amanor-Boadu (2006) concluded the liability function of tracing is not effective in providing incentives for firms to supply safer food when the potential for an inspection error is small.

Buzby and Frenzen (1999) investigated 294 cases of food contamination in the United States and argued that the legal incentives to produce safer food were relatively weak. However, specific cases of food contamination have led to serious consequences for affected firms. Meuwissen et al. (2003) and Hobbs (2004) found traceability was adopted, in some capacity, for legal reasons, and the possibility of litigation increased the incentive to reduce microbial pathogens in food products. Pouliot and Sumner (2008) modeled the linkages among traceability, liability, and food safety incentives in the supply chain. They concluded that an increase in the likelihood of litigation activity increased the level of traceability. Also, as the number of firms involved in production and marketing increased, both the consumers' willingness to pay and the incentive to produce a safer food product decreased; food safety was expected to be higher in an industry with fewer firms.

Smyth and Phillips (2002) defined traceability as one system of product differentiation available for agricultural and food products. A product that can be traced enables differentiation from products that cannot be traced. Furthermore, as a greater share of firms implement traceability systems, products may continue to be differentiated based on the type of tracing method used. Research performed by agricultural economists has found consumers attach additional value to meat products with tracing attributes. Based on results of laboratory auction markets conducted by Dickinson and Bailey (2002) in the United States and Hobbs et al. (2005) in Canada, consumers were willing to pay a small premium for meat products with traceability assurance. Survey work carried out by Gracia and Zeballos (2005) following the bovine spongiform encephalopathy outbreak in Europe showed European consumers and retailers placed significant value on traceability assurance.

Given that U.S. tracing requirements are less stringent relative to many of the significant importers of U.S. food products such as Canada, the European Union, and Japan (Liddell and Bailey, 2001), traceability adoption may provide an opportunity for accessing international markets. Although Golan et al. (2003) did not explicitly state that tracing may enable greater access to international markets, we included this as a benefit category based on feedback from industry sources in California (Dresick, 2006). Trade is important for California's specialty crops. Approximately 25% of the value of agricultural production in California was traded internationally in 2005; for some specialty crops, the share of production which was exported reached 80% (Rowhani and Sumner, 2007). We expect tracing will continue to be an important consideration for California specialty crop producers interested in maintaining and expanding sales to key export markets.

The Survey

Our 21-question survey was mailed to 174 producers of specialty crops in California during the first half of 2006. We compiled a stratified sample of producers from members of various agricultural marketing associations in California (membership lists are publicly available on each association's website). We then randomly chose a proportion of producers from each association's membership list to develop our sample. Our mailing list was comprised of producers across a wide range of specialty crops.

The survey was mailed with a cover letter and a self-addressed return envelope in March 2006, and in April 2006, a reminder note was distributed. Survey results were returned to us between late March and early June 2006. Responses were received from 51 of the 174 producers, of whom four respondents indicated they had not adopted any form of traceability. We suspect a significant share of the non-responding group had not adopted tracing systems. Therefore, we assumed the information received from survey respondents was representative of specialty crop growers in California who have adopted traceability systems. The information provided by the remaining 47 respondents who had adopted some level of traceability was used in our analysis, yielding a survey response rate of 29.3%.

The purpose of the survey was to advance a better understanding of the benefits received by traceability adopters, and the survey results were used to develop a ranking of the benefits. The questions in the survey were not designed with an econometric model in mind. Estimating the relationships between demographic characteristics and the decision to adopt traceability was outside the scope of this study (however, it would be an interesting topic for extended research). Furthermore, because the survey questions were developed for specialty crop producers in California, our results should not be extrapolated to describe the benefits of traceability across all agricultural sectors in the United States.

The survey included 10 background questions allowing us to identify the types of firms being surveyed, and to gain a general overview of why traceability was used by specialty crop producers. Following the background questions, 11 financial questions were included to assess information about specific benefit categories and cost issues. Frequency results are reported in table 1 for the background questions, and in table 2 for the financial questions.[2]

The first three questions were used to identify general characteristics about the specialty crop producers who were surveyed. Table 1 shows the majority of respondents classified themselves as grower-packer-shippers; vegetable producers comprised 36.2% of all respondents, followed by tree nut producers with 31.9%. The largest share of respondents (44.2%) had an average annual gross income between $10 and $50 million.

The purpose of question #5 was to gain insight about the general motivation for initial adoption of traceability; question #6 allowed producers to select more specific reasons for maintaining a tracing system. The possible responses from question #6 are revisited individually in questions #11 through #18. The responses to question #5 show 72.3% of producers chose *Buyer requested* as an initial reason to adopt traceability. In question #6, over 70% indicated that food safety—for both legal and reputation-related reasons—was the driving force for maintaining traceability. In addition, all of the response options in question #6 were selected by at least 20% of the producers. Package labeling was the predominant tracing method used among producers who completed our survey (74.5%); only 10.6% used the radio frequency identification (RFID) method of tracing. According to results from question #9, each firm implemented a single tracing system that conformed to the requirements set by its most demanding customer.

The second section of the survey consisted of questions focusing on the costs and benefits of traceability in specialty crop production. For questions #11 through #18, the answer choice was comprised of four interval-scaled responses: *Not at all*, *Somewhat*, *Moderately*, and *Quite extensively*. These questions were designed to determine the respondents' rankings of specific traceability benefits that were also listed as responses, and may have been chosen previously in question #6. Question #6 and questions #11 through #18 from the survey were designed with a framework for assessing the benefits of traceability in mind.

Results reported in table 2 show that 54.4% of respondents chose *Quite extensively* when asked if traceability decreased their concerns about litigation (question #15), and 40.4% chose *Quite extensively* when asked if traceability adoption increased firm reputation (question #14). The ability to pinpoint quality characteristics (question #11) and differentiate products (question #17) were also important reasons to trace. For both questions, *Quite extensively* was chosen by 36.2% of producers. The responses also reveal that producers did not associate

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[2] A copy of the survey is available from the authors upon request.

Table 1. Responses to Background Questions from the Survey (questions 1–10)

No.	Question / *Response Options*	%	No.	Question / *Response Options*	%
1	Type of operation:		6	Reason(s) to maintain tracing:	
	Grower	4.3		*Pinpointing yield/quality*	21.3
	Grower-shipper	10.9		*Improve efficiencies*	29.7
	Grower-shipper-packer	84.8		*Lower operating costs*	53.2
2	Type of industry:			*Firm reputation*	70.2
	Processing tomatoes	21.3		*Litigation concerns*	72.3
	Tree nuts	31.9		*Adds value*	36.2
	Stone fruit	19.1		*Product differentiation*	51.1
	Berries	10.6		*International markets*	43.5
	Grains/oilseeds	8.5		*Other*	4.3
	Melons	10.6	7	Technology used in tracing:	
	Vegetables	36.2		*Bar codes*	36.2
	Other	23.4		*RFID*	10.6
3	Annual gross income:			*Package labeling*	74.5
	< $10 million	25.6		*Other*	17.0
	$10 to $50 million	44.2	8a	Is traceability mandatory?	
	> $50 million	30.2		*Yes*	51.1
	Did not answer	7.8		*No*	48.9
4a	Was traceability adopted?		8b	If mandatory, by whom?	
	Yes	100		*All buyers*	8.5
	No	0		*Majority of buyers*	23.4
4b	Relative trace levels:			*International buyers*	2.1
	Below similar firms' levels	11.1		*Government*	27.7
	Equal to similar firms' levels	44.4	9a	Is tracing system designed for highest priority customer?	
	Exceeds similar firms' levels	44.4		*Yes*	66.0
5	Influence(s) that initially provided the incentive to adopt traceability:			*No*	34.0
	Buyer requested	72.3	9b	Same level of tracing for all?	
	Government regulation	36.2		*Yes*	70.2
	Consumer demand	40.4		*No*	29.8
	Profitability	21.3	10	Should tracing be mandatory?	
	Management efficiency	36.2		*Yes*	40.4
	Other	14.9		*No*	59.6

Table 2. Responses to Financial Questions from the Survey (questions 11–21)

No.	Question / *Response Options*	%	No.	Question / *Response Options*	%
11	Does tracing pinpoint quality characteristics?		18a	Do you participate in international markets?	
	Not at all	14.9		*Yes*	87.2
	Somewhat	19.1		*No*	12.8
	Moderately	29.8	18b	If yes, does tracing increase sales to international markets?	
	Quite extensively	36.2		*Not at all*	6.4
12	Improve efficiency?			*Somewhat*	31.9
	Not at all	27.7		*Moderately*	25.5
	Somewhat	40.4		*Quite extensively*	23.4
	Moderately	12.8	19a	Cost of initial implementation:	
	Quite extensively	19.1		*Insignificant*	12.8
13	Lower distribution cost?			*Somewhat significant*	42.6
	Not at all	72.3		*Moderately significant*	38.3
	Somewhat	12.8		*Relatively extensive*	6.4
	Moderately	12.8	19b	Cost to maintain system:	
	Quite extensively	2.2		*Insignificant*	26.1
14	Increase firm reputation?			*Somewhat significant*	45.7
	Not at all	10.6		*Moderately significant*	28.3
	Somewhat	29.8		*Relatively extensive*	0
	Moderately	19.1	20a	With your system, can you increase the precision of trace?	
	Quite extensively	40.4		*Yes*	78.7
15	Does tracing decrease your concerns about litigation?			*No*	21.3
	Not at all	0	20b	If yes, are additional costs of further precision recovered?	
	Somewhat	13.7		*Yes*	10.6
	Moderately	31.9		*No*	66.0
	Quite extensively	54.4	21	Is your traceability system more costly than beneficial?	
16	Does trace add value?			*Yes*	19.1
	Not at all	22.2		*No*	78.7
	Somewhat	40.1			
	Moderately	24.4			
	Quite extensively	13.3			
17	Does tracing increase product differentiation?				
	Not at all	10.6			
	Somewhat	25.5			
	Moderately	27.7			
	Quite extensively	36.2			

traceability with lower distribution costs (72.3% selected *Not at all* for question #13) or with adding value to their products (62.3% chose *Not at all* or *Somewhat* for question #16).

Respondents indicated that the initial costs of traceability were more significant than the ongoing costs of maintaining the ability to trace. Responses to question #20 revealed the degree of traceability was quite variable within a given system, and higher costs were linked with greater tracing precision. The responses to question #20 were interesting when juxtaposed with the responses to question #9; overall, the results implied the benefits of changing the level of trace for different customers did not outweigh the costs. More specifically, the benefits of tailoring a tracing system for selected customers were not enough to offset the costs of adjusting the level of traceability. Firms instead chose to set their overall tracing level equal to that of their most demanding customer.

Partial Budget Analysis

A partial budget framework was developed and used to evaluate the financial implications of adopting traceability for an existing operation. To do this, the analysis considered all the additional costs and benefits from introducing a tracing system including the initial costs, increases in expenses (plus any decreases in revenue), and increases in revenue (plus any decreases in expenses). We outlined the costs for a representative traceability system that could be implemented by a mid- to large-sized operation which grows, packs, and ships melons. Our representative system was designed for a grower-packer-shipper operation because this group comprised 84.8% of our survey respondents.

Although only 10.6% of survey respondents identified themselves as melon growers, we chose to focus the partial budget analysis on melons for three reasons. First, although more than 30% of respondents classified themselves as vegetable producers, tracing systems vary widely across vegetable products. There is also a range of tracing systems used for tree nut products and stone fruit products. Over 20% of respondents classified themselves as processing tomato producers; however, we wanted the analysis to focus on a fresh fruit or vegetable product. Second, we had access to cost data for tracing systems used in lettuce, citrus, and melons, and found that the tracing costs for melons—notably the initial costs—were representative of all three crops. Third, tracing systems for melons are typically more advanced than those used in other specialty crop sectors. Furthermore, the systems used in melon production have spurred the development of tracing technologies applied to many other fruit and vegetable products (Dresick, 2006). This is likely due, in part, to food safety and food contamination concerns that have been prevalent in the cantaloupe industry (Hooker and Murano, 2000; Roos, 2002).

There are various types of traceability systems used by specialty crop producers in California; two of the most common methods are field pack tracing and shed pack tracing (Dresick, 2006). Producers using a field pack system would be able to trace a product to a specific pallet.[3] The field trace method would be able to identify the lot and the block within the lot,[4] the crew that packed the product, and when the product was harvested. Shed packing producers harvest and ship their crops to a packing facility in bulk trailers; the product would be graded and packed in the shed and traceability would begin at the shed. A shed pack system would be capable of tracing to a specific lot. In the event of a recall, a producer using shed pack tracing would need to recall an entire lot, whereas a firm using field pack tracing would only need to recall a portion of a lot. Producers create variations of these systems to meet the demands and needs of both their operation and their customers.

Our partial budget analysis included the costs of establishing and maintaining an advanced field trace system. The field trace method is used by producers of melons, lettuce, onions, and other types of produce commonly packed in the field (Dresick, 2006). Most food retailers have not yet required suppliers to implement the level of tracing used in our representative system, but this level is expected to be standard in California by 2010 (Dresick).

Figure 1 provides an illustration of the supply chain for melons and highlights the components of the appropriate tracing system. The wide arrows denote the ability to trace downstream and the thin arrows denote the ability to trace upstream. The upper left-hand corner of figure 1 shows that melons are harvested by crews of packing groups. The crews manually pick, sort, grade, and package the fruit in the field before it goes to the cooler. The process of harvesting and field labeling each box is shown along the top row of figure 1. Crew 1 included four packing groups and Crew 2 included three packing groups; each crew was assigned a number (for tracing purposes) for the duration of the harvest season.

The second row in figure 1 shows the harvested fruit was packed into boxes that included a label to identify the variety and grade of the product. The box label also included the tracing information identifying where and when the fruit was harvested, and by which crew. Boxes of fruit were assembled on pallets in the field; fifty-four 20-pound boxes of melons were placed on each pallet. Pallets of fruit originating from the same lot were then grouped together prior to shipping. Figure 1 shows the movement of pallets to the cooler and pre-shipping storage. At this stage the tracing information would be updated to reflect the time the product enters storage, the temperature in storage, and any additional handling crews involved. The final link in this field trace system was the confirmation that the shipped product was received at its given destination, as shown in the bottom left-hand corner of figure 1.

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[3] In melon production, a pallet is comprised of 56 boxes of fruit. Pallets have seven layers of boxes, with each layer consisting of eight boxes. The dimensions of a box are 12″ × 18″ × 16″, and each box weighs approximately 20 pounds.

[4] A lot is defined as a quarter section production unit (160 acres), and each lot typically includes four blocks. The lot identification number is characterized by three numbers, where the first two digits in the lot identification number denote the section and the final digit denotes the quarter. For example, the lot identification number 341 denotes quarter 1 in section 34.

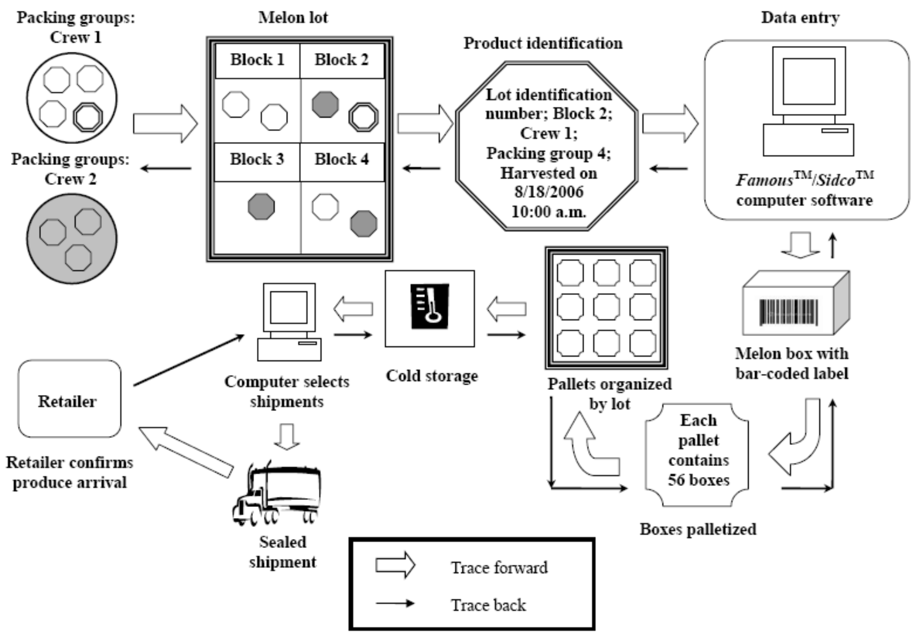

Figure 1. Tracing capabilities in the supply chain for melons

Costs of Implementing Traceability in Melon Production

The representative tracing system was developed to accommodate an operation that grows, packs, and ships approximately 50,000 boxes of melons per day. The representative system is a reasonable characterization of one that would be used by a mid- to large-sized melon operation in California (Dresick, 2006). A list of required start-up items and costs for these items was collected from vendors who distribute and service traceability components (DataMax, Inc., 2006; Sidco Labeling Systems, 2006; Symbol Technologies, Inc., 2006). The annual expenses resulting from operating a traceability system were supplied by industry sources.

All expected costs for the representative trace system over a five-year period are detailed in table 3. The net present value of each cost item (using a discount rate of 5%) is shown in the final column of table 3. The discounted cost of computer hardware equipment was approximately $46,000, representing the largest initial cost. Due to the volume handled by a field trace system of this size, it was equipped with two large data servers that were linked to four mobile computers using a network router. The processors were installed with the *Famous*™ tracing and *Sidco*™ inventory management software, which collectively accounted for a discounted cost of approximately $38,500, as reported in table 3. The total increase in costs of implementing and operating our representative field trace system for a five-year period would be approximately $206,000, and the discounted value of total costs would be $189,712.

Table 3. Costs of Establishing and Maintaining the Representative Field Trace System

	Cost ($)					5-Yr	NPV of
System Items	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Cost ($)**	**5-Yr Cost ($)**
Computer Hardware:							
Data server	37,078	0	0	0	0	37,078	35,312
Network router	4,397	0	0	0	0	4,397	4,188
Desktop computers	3,774	0	0	0	0	3,774	3,594
Laptop computers	3,228	0	0	0	0	3,228	3,074
Computer Software:							
Traceability software	15,000	0	0	0	0	15,000	14,286
Inventory tracker	19,000	0	0	0	0	19,000	18,095
Printing software	6,500	0	0	0	0	6,500	6,190
Printing Equipment:							
Label printer	14,000	0	0	0	0	14,000	13,333
Label materials	2,000	1,000	1,000	1,000	1,000	6,000	5,282
Scanning Equipment:							
Wireless access point	6,000	0	0	0	0	6,000	5,714
Symbol scanner	12,000	0	0	0	0	12,000	11,429
Installation							
Labor and materials	19,150	8,740	9,210	9,830	10,580	57,510	50,498
Training	5,000	0	0	0	0	5,000	4,762
Repair and updates	0	5,670	0	10,710	0	16,380	13,954
Total						205,867	189,712

Benefits of Adopting Traceability in Melon Production

The responses to question #21 indicated that the majority of producers believed there were net benefits from adopting traceability. Given this response and the widespread use of traceability in California, the total discounted benefits from adopting traceability were assumed to be 5% greater than the total discounted costs of adoption. Survey responses for the initial question (question #6) and follow-up questions (questions #11 through #18) were used to compute financial weights for each of the eight benefit categories using Borda's rule.

Borda's rule is a simple ranking method that was first used to develop an ordinal ranking and weighting procedure for political candidates across voters. Levin and Nalebuff (1995) outlined the strengths and weaknesses of Borda's rule and provided a description of alternative ranking methods, many of which are an extension of Borda's rule. Borda's rule has been applied in studies that rank and assign weight to economic indicators (e.g., Young, 1974; Rahman, Mittelhammer, and Wandschneider, 2003). Here we used Borda's rule to assign ordinal rankings to the eight survey response options. Equation (1) shows how Borda's rule assigns a rank B (between 1 and s) to survey response option s for question q:

$$B_s(q) \in \{1, \ldots, s\}. \tag{1}$$

For every question, each response was assigned a rank; the value of the rank represented the number of survey response options that were equal to, or fell below, the response rate for that option. For example, if s = 8 and $B_s(q)$ = 7, the ranking reveals that the survey response option had the second highest response rate for question q.

Our initial question is denoted q_i, and our follow-up question is denoted q_f. Multiple responses were possible for the initial question, and a single response was possible for each of the follow-up questions. All questions were closed-ended. The calculation used to compute our total Borda score for survey response option s, denoted TB_s, is expressed as:

$$TB_s = \left[B_s(q_i) + B_s(q_f)\right] \Big/ \left[\sum_s B_s(q_i) + \sum_s B_s(q_f)\right]. \tag{2}$$

For each response option, the total Borda score was the sum of its Borda rankings as a share of all Borda rankings across response options and questions.

Table 4 summarizes how Borda's rule was applied to assign ranks and allocate weights to the benefit categories. The eight possible responses to question #6 are listed in the first column and the response rate for each option is reported in the second column. The percentage of respondents who chose *Quite extensively* to each of the follow-up questions is shown in the fourth column of table 4. Borda rankings for question #6 are displayed in the third column, and the fifth column displays the Borda rankings for the follow-up questions. The final column gives the total Borda scores for the survey response options. We used the total Borda scores as weights for the relative economic importance of the benefit categories.

The total value of discounted benefits in table 5 was set equal to 105% of the total value of discounted costs shown in table 3. Adoption of the representative tracing system would generate benefits of approximately $199,200.[5] The values allocated to the benefit categories in table 5 were based on the total Borda scores in table 4. For example, the total Borda score for an operation's ability to pinpoint yield or quality characteristics was 9.7%. The first row in table 5 shows that pinpointing yield or quality characteristics would generate $19,322 in total discounted benefits across five years. This category would generate $22,315 in non-discounted benefits across five years and, distributed equally, would generate $4,463 in benefits per year. In some cases, it might not be reasonable to expect the benefits of tracing would occur equally in all years; nevertheless, our results

[5] In the results presented here, we assumed that the ratio of total discounted benefits to total discounted costs was 1.05; a lower (higher) ratio would generate proportionately lower (higher) values across the eight benefit categories.

Table 4. Allocation of Weights to the Benefit Categories Using Borda's Rule

	Question #6 Response Rate		Follow-up Question Response Rate [a]		Total Borda Score
Response Options from Question #6	**%**	**Borda Ranking**	**%**	**Borda Ranking**	**(%)**
Pinpointing yield/quality	21.3	1	36.2	6	9.7
Improve efficiencies	29.7	2	19.1	3	6.9
Lower operating costs	53.2	6	2.2	1	9.7
Firm reputation	70.2	7	40.4	7	19.5
Litigation concerns	72.3	8	54.4	8	22.2
Adds value	36.2	3	13.3	2	6.9
Product differentiation	51.1	5	36.1	5	13.9
International markets	43.5	4	23.4	4	11.1
Total		36		36	100.0

Notes: Each Borda ranking denotes the number of response options that were equal to, or fell below, the response rate for that option. The total Borda score shown in the final column is the sum-weighted rank for each response option.

[a] The follow-up question response rate was the percentage of respondents who selected *Quite extensively* in questions #11 through #18 in the survey.

Table 5. Computed Benefits from Traceability Implementation

	Benefit ($)						NPV of
Response Options from Question #6	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**5-Yr Benefit ($)**	**5-Yr Benefit ($)**
Pinpointing yield/quality	4,463	4,463	4,463	4,463	4,463	22,315	19,322
Improve efficiencies	3,197	3,197	3,197	3,197	3,197	15,985	13,844
Lower operating costs	4,463	4,463	4,463	4,463	4,463	22,315	19,322
Firm reputation	8,972	8,972	8,972	8,972	8,972	44,860	38,844
Litigation concerns	10,215	10,215	10,215	10,215	10,215	51,075	44,222
Adds value	3,197	3,197	3,197	3,197	3,197	15,985	13,844
Product differentiation	6,395	6,395	6,395	6,395	6,395	31,975	27,688
International markets	5,107	5,107	5,107	5,107	5,107	25,535	22,111
Total						230,045	199,198

illustrate the relative benefits across categories and across the expected life of the tracing system.

As shown in table 5, traceability adoption would generate total discounted benefits of approximately $44,222 due to the decrease in litigation concerns and approximately $38,844 for reasons related to firm reputation. Overall, the results in tables 4 and 5 confirm that the greatest benefits of traceability were related to the second motive listed by Golan et al. (2003)—namely the motive concerning food safety. Our findings also highlight that although tracing improved supply management, it was the motive that generated the least amount of benefits for producers.

Conclusion

Methods of tracing products through the supply chain have been adopted by specialty crop producers in California. Producers in California's specialty crop sectors reported benefits associated with traceability, with the majority of producers claiming that the marginal benefits of traceability outweighed its marginal costs. Eight potential benefits of traceability were studied. While producers stated all were important, the primary factors for maintaining traceability were related to litigation issues and firm reputation. The ability to pinpoint production areas with high yield or quality, improve efficiencies, lower operating costs, add value, differentiate products, and pursue international markets were not the most important drivers for maintaining traceability; however, they may have provided the additional benefits that enabled the overall feasibility of traceability implementation.

A partial budget model was developed to assess the costs and benefits for a representative tracing system that could be applied to a melon operation. First, we provided a detailed evaluation of the costs associated with the representative traceability system based on discussions with industry sources. Second, the results from our survey were used to allocate values to specific benefit categories such that the total value of discounted benefits exceeded the total value of discounted costs by 5%. The total non-discounted costs of our representative tracing system were approximately $206,000 and total non-discounted benefits amounted to approximately $230,000. Of the total benefits for maintaining a tracing system, 22.2% was allocated to the category regarding the decreased concern about litigation. An additional 19.5% was allocated to the category considering the benefits for a firm's reputation from tracing.

Our results were built from a pool of survey responses collected during the first half of 2006. This research sheds light on producers' reasons for maintaining traceability in specialty crop agriculture just prior to a significant food safety event. Given the *E. Coli* cases that occurred during the second half of 2006, we believe producers currently would be even more likely to agree that the key benefits of traceability are for reasons related to litigation and firm reputation. Further work examining costs of traceability systems for other specialty crops could employ our survey results and partial budgeting framework to compute the associated benefits of tracing.

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