Consumer Support for Food Tracing with RFID Technology

By

Dr. Ronald B. Larson
Department of Marketing, Western Michigan University,
1903 West Michigan Avenue, Kalamazoo, MI 49008-5430

and

Kulmani Rana
Recent Haworth College of Business and Lee Honors College Graduate
Western Michigan University

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Abstract

Foodborne illness continues to be a significant problem and food traceability may help reduce the number and severity of outbreaks. One technology that could improve food tracing is radio frequency identification tags or RFID. However, some consumers may oppose the use of this technology because of its potential for reducing personal privacy. A survey of consumers asked about their support for an RFID tracing system for produce and for meat. Results suggest that some consumer privacy attitudes and privacy behaviors were negatively related to support for RFID tracing. Proponents of traceability with RFID may need to spend more time explaining the technology to consumers to reduce their concerns and anxieties. In addition, the results for produce tracing and meat tracing were different, suggesting that consumer support for food traceability may vary by product category.

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Many believe food tracing could hasten the identification of foodborne illness causes which could reduce the number of outbreaks and limit the severity of each outbreak. Foodborne illness continues to be a significant problem. In the U.S., foodborne pathogens caused an estimated 9.4 million illnesses, 66,961 hospitalizations, and 1351 deaths in 2006 (Scallan et al. 2011). The pathogens responsible for about 95 percent of these foodborne illnesses cost the U.S. $14 billion per year (Batz, Hoffmann, and Morris 2011). Incentives created by traceability could improve food safety (Pouliot and Sumner 2008). Other benefits from being able to trace food through the supply chain and back to its source include: 1) ascertain origin and ownership and deter theft and misrepresentation; 2) surveillance, control, and eradication of pests; 3) biosecurity protection; 4) compliance with international requirements and country-of-origin labeling rules; 5) improve supply chain management; and 6) facilitate value-based and value-added marketing (Smith et al. 2005). Although these benefits appear to be quite significant, the current system does not provide U.S. consumers or retailers the ability to trace many products back through the supply chain. As part of an exercise by the Office of Inspector General (2009), Department of Health and Human Services, 40 food items were purchased in U.S. retail stores and only five could be traced back to the farm or border. Some believe a system based on radio frequency identification (RFID) technology could help producers, processors, wholesalers, and retailers quickly identify all the checkpoints each item has passed through, tracing foods back to their farm or water source. This leads to questions of whether a system using RFID technology could be a cost-effective solution for improving food traceability and whether consumers, who would pay a large portion of the system's cost, perceive a RFID-based tracing system to be worthwhile.

Background

RFID technology has been around for more than sixty years. When used for tracking items, the system has two components: a tag, perhaps as small as a grain of rice, with an attached antenna and a reader that scans for tags and receives their signals. A signal could be an item's identifying code or could contain information collected about the item and the conditions it experienced. For tracing food, a database would contain the code for each item along with a pedigree showing all the checkpoints along the path an item traveled on the way to the consumer. After scanning the RFID tag, the retrieved code would be looked up in the database to learn the item's source and how it traveled through the supply chain. Various applications and case studies have demonstrated the feasibility of an RFID tracing system (e.g., Tonsor and Schroder 2006; Regattieri, Gamberi, and Manzini 2007; Eddy 2008; Peets et al. 2009; Mai et al. 2010).

For many applications, the adoption of RFID technology has not been as rapid as some predicted. A number of issues have emerged. There were problems with interference from packaging materials and products, with the positioning of RFID antennas and readers, with tag dependability, and with readers being unable to handle multiple signals. Differing standards emerged around the world and some standards were not secure (e.g., tags could be copied or rewritten and malware could be added to the signals sent by some tags etc.). Large databases and considerable cooperation will be needed throughout the supply chain. Proponents had predicted that RFID tag costs would decline, making systems cost-effective, but costs have not fallen far enough yet. In addition, a few people were concerned about how consumers might react to this technology because it could be used to invade people's privacy. As more of the technological problems are solved and costs decline, RFID tags could become a cost-effective tool for food traceability.

Most prior consumer food tracing research has focused on red meat and has dealt with its economic implications. Loureiro and Umberger (2007) found that consumers placed more value on food safety and country-of-origin information than on traceability and meat tenderness. Dickinson and Bailey (2005) conducted several willingness-to-pay studies and found that the average U.S. consumer would pay 18 percent more for pork traceability and 23 percent more for improved pork meat safety. For beef, buyers would pay 7 percent more for traceability and 20 percent more for improved safety. A review of 23 studies suggested that consumer's willingness to pay for traceability was nearly as high as their willingness to pay for food safety (Cicia and Colantuoni 2010). Results are mixed on whether a tracing system would generate a large enough domestic demand increase for beef to offset the animal identification and technology costs (Resende-Filho and Buhr 2006; Pendell et al. 2010).

Few studies have looked at consumer reactions to RFID applications. In Germany, Rothensee and Spiekermann (2008) showed people a film about RFID applications at retail and in the home. They evaluated the reactions and found about 15 percent of the sample were "extreme rejecters." Some U.S. critics have suggested that RFID could fulfill a dictator's wildest evil dreams by providing near total control over every aspect of society (Albrecht and McIntyre 2005). Strickland and Hunt (2005) examined consumer reactions to smart cards with RFID chips (e.g., credit cards) and airline baggage tracking and found a general lack of support. This differs from a Cap Gemini Ernst & Young survey in 2003 that asked more than 1000 U.S. consumers if they would buy a RFID-enabled product with eleven specific benefits. The benefits ranged from faster recovery of stolen items to reduced out-of-stocks and at least 40 percent of the sample said they would buy a product with the RFID benefits and at least 19 percent said they would consider paying more for it (*Supermarket News* 2004). Consumer surveys and focus groups across Europe

concluded that support for tracing may be linked with the provision of benefits to consumers (Chrysochou, Chryssochoidis, and Kehagia 2009; van Rijswijk et al. 2008). The tradeoffs that consumers make in deciding if they support an RFID application are relatively unknown.

This research attempts to fill some gaps in the literature by considering consumer reactions to both produce and meat traceability and by including some value statements and behaviors in the analysis that may be associated with consumer support or resistance to RFID.

Methodology

In early 2010, a four-page survey was mailed to about 4900 adults aged 25 to 60 in four Midwestern states, Illinois, Indiana, Michigan, and Ohio. There were 306 usable responses. The relatively low response rate was expected because the mailing list was generated at random, the survey dealt with a "futuristic" technology, and there was no incentive for survey completion. The respondent profile was similar to the target population. After describing RFID, two questions dealt with traceability and suggested some benefits to the consumer. The first question: "Fruit and vegetable growers could attach RFID tags to their harvest containers to make it simpler to follow their products through the supply chain to supermarkets and restaurants and make it easier to grocers and restauranteurs to highlight the farm source of the produce. Please rate your support for this possible use of RFID tags on produce cartons and cases." Respondents rated their support using a 7-point scale with "7" indicating "very supportive." The second question: "Livestock farmers are placing RFID tags in animal ear tags which makes it possible to link an animal's number with the RFID code on each meat package. If a problem was discovered with a meat package, it could be traced back to the meat packer and ultimately to the farm where the animal was raised. Please rate your willingness to pay a price premium (less than 20-cents per package) for meat that can be traced back to its origin." Again a 7-point scale was

used.

Food safety studies have found mixed results on the value of socio-demographics. Kennedy et al. (2008) reviewed the literature and found significant results for education, income, marital status, ethnicity, gender, size of household, and age. Their study concluded that education, income, and presence of young children were important. Jussaume and Judson (1992) reported significant results for age, presence of children, and income while Mazzocchi et al. (2008) did not find any relationships for socio-demographic variables. This study included many demographic variables.

Table 1: Attitude Statements about Privacy

1. When companies ask me for personal information, I sometimes think twice before providing it.
2. Computer databases that contain personal information should be protected from unauthorized access – no matter how much it costs.
3. I am anxious and concerned about the pace of automation in the world.
4. Sometimes I am afraid the data processing department will lose my data.
5. Companies should never sell the personal information in their computer databases to other companies.
6. Computers are a real threat to privacy in this country.
7. Companies should have better procedures to correct errors in personal information.
8. It bothers me to give personal information to so many companies.
9. Companies should take more steps to make sure that the personal information in their files is accurate.
10. Companies should never share personal information with other companies unless it has been authorized by the individuals who provided the information.

11. I am easily frustrated by computerized bills.
12. I am sometimes frustrated by increasing automation in my home.
13. People should refuse to give information to a business if they think it is too personal.

Table 2. Behavioral Practices Related to Privacy

1. Do you regularly use a cellular telephone?
2. Do you regularly shop and buy items on the internet?
3. Do you regularly shop and buy items by phone?
4. Do you regularly use on-line banking services?
5. Do you regularly enter promotional sweepstakes sponsored by companies?
6. Do you regularly use a credit or debit card for making purchases?
7. Have you asked a firm to remove you from their mailing list in the last year?
8. Have you joined a "Do Not Call" phone list to reduce unwanted calls?
9. Have you decided to not purchase an item from a firm or not use their services because of their privacy policy (i.e., the way they use personal information)?
10. Do you regularly destroy personal documents using a paper shredder?

Besides demographics, other measures were included in the survey that could be associated with support for RFID tracing technology. The survey asked how frequently people attended organized religious services during the last year to measure religiosity (attending at least once per month was considered religious). Table 1 shows 13 questions dealing attitudes toward privacy that were developed by Smith, Milberg, and Burke (1996) and Parasuraman and Igbaria (1990). Respondents showed their agreement with each statement using a 7-point scale. The survey also included 10 questions about the behaviors related to privacy (Table 2).

Results

The average answer for the support of produce tracing was 5.25. A total of 91 people

gave produce tracing with RFID a "7" and 16 respondents gave it a "1." For meat tracing, the average score was 4.80. A total of 90 people gave this application a "7" and 28 gave it a "1." The Pearson correlation between the two sets of responses was 0.57, suggesting that some people had different opinions about the two RFID applications. Variables for two models were developed to explain the levels of support given by consumers.

Responses to the questions about privacy attitudes had some similar patterns. Cronbach's alpha for the 13 questions was 0.814, suggesting a relatively high level of reliability (Cronbach 1951). Principle component analysis (using a Varimax rotation with Kaiser normalization and an extraction criterion that eigenvalues must exceed one) was used to reduce the 13 variables into three factors. The first factor was primarily made up from questions 12, 11, 3, 4, and 6 from Table 1. This factor was similar to the computer anxiety scale developed by Parasuraman and Igbaria (1990). The second factor, nicknamed company information policies, was primarily made up from questions 9, 7, 2, 5, and 10. The third factor, nicknamed individual information control, was primarily made up from questions 1, 8, and 13.

Responses to the 10 questions about privacy behaviors also had some similar patterns. Cronbach's Alpha was not as high, 0.561. Factor analysis was repeated using these questions and three factors emerged. The first factor, nicknamed financial and communication, was primarily made up from questions 2, 4, 6, and 1. The second factor, nicknamed risk reducing, was primarily made up from questions 7, 8, 9, and 10. The third factor, nicknamed volunteering data, was primarily made up from questions 5 and 3. A separate factor analysis with both attitude and behavior questions produced 7 factors, suggesting that 3 attitude factors and the 3 behavior factors measured different things.

Ordinal discrete choice probit analysis in SAS was used to evaluate the respondent

support for each of the RFID tracing applications. Independent variables were gender (female=1), two age groupings (omitted group was those over age 45), three household income groupings (omitted group was those with incomes under $30,000), two education groupings (omitted group was those without any college), presence of children (no children=1), race (nonwhite=1), religiousness, three privacy attitude factor variables, and three privacy behavior factor variables.

In the produce traceability model results, shown in Table 3, religiousness had a significant negative sign (reducing support) at the 95 percent level. This might be expected because some opponents (e.g., Albrecht and McIntyre 2005) use quotes from the bible to criticize RFID technology. The first privacy attitude factor had a significant negative sign (i.e., high computer anxiety was associated with lower support), and the first privacy behavior factor, financial and communication, had a significant positive sign (i.e., users of on-line banking, internet shopping, cell phones, and/or credit or debit cards had higher support).

In the meat traceability model results, shown in Table 4, were different from the produce results. Young people, aged 25 to 35, had a significant negative sign, suggesting they were less supportive of the technology, the first privacy attitude factor (computer anxiety) had a significant negative sign. At a slightly lower confidence level, nonwhites tended to be more supportive, the second privacy attitude factor had a positive sign (i.e., concerns about company information policies were associated with higher support) and the third privacy attitude factor had a negative sign (i.e., belief in individual information control was linked with lower support for traceability). Note that gender, presence of children, education, income, and two of the behavior factors did not have significant associations with either produce traceability support or meat traceability support. Dickinson and Bailey (2005) concluded that age, income and education were not related

to willingness to pay for red meat traceability.

Table 3. Parameter Estimates for Produce Traceability Model

Parameter	DF	Estimate	Standard Error	t Value	Approx Pr > | t |
Intercept	1	2.051189	0.281054	7.30	<.0001
Female	1	-0.055432	0.130058	-0.43	0.6700
Age2534	1	-0.073425	0.166896	-0.44	0.6600
Age3544	1	-0.028402	0.147476	-0.19	0.8473
NoKids	1	0.110021	0.131673	0.84	0.4034
Religious	1	**-0.283598**	0.127417	**-2.23 ****	0.0260
SomColDeg	1	-0.149805	0.195973	-0.76	0.4446
PostColl	1	-0.109363	0.233433	-0.47	0.6394
NonWhite	1	-0.045171	0.199149	-0.23	0.8206
Incom30-59K	1	-0.298777	0.196037	-1.52	0.1275
Incom60-89K	1	0.017285	0.208109	0.08	0.9338
Incom90K+	1	0.099367	0.209342	0.47	0.6350
CompAnxiety	1	**-0.214910**	0.068336	**-3.14 ****	0.0017
InfoUse	1	0.044918	0.065725	0.68	0.4943
InfoControl	1	-0.071140	0.069538	-1.02	0.3063
FinCommun	1	**0.165928**	0.079015	**2.10 ****	0.0357
RiskReduce	1	-0.020585	0.071392	-0.29	0.7731
VolunData	1	0.107776	0.077624	1.39	0.1650
_Limit2	1	0.248132	0.079889	3.11	0.0019
_Limit3	1	0.603394	0.107072	5.64	<.0001
_Limit4	1	1.089001	0.122228	8.91	<.0001
_Limit5	1	1.670861	0.131828	12.67	<.0001
_Limit6	1	2.326616	0.140833	16.52	<.0001

Table 4. Parameter Estimates of Meat Traceability Model

Parameter	DF	Estimate	Standard Error	t Value	Approx Pr > | t |
Intercept	1	1.661588	0.271444	6.12	<.0001
Female	1	-0.015888	0.130146	-0.12	0.9028
Age2534	1	**-0.404842**	0.167978	**-2.41 ****	0.0159
Age3544	1	-0.241147	0.147088	-1.64	0.1011
NoKids	1	-0.083077	0.131424	-0.63	0.5273
Religious	1	-0.099223	0.127498	-0.78	0.4364
SomColDeg	1	-0.127877	0.196171	-0.65	0.5145
PostColl	1	-0.011886	0.232336	-0.05	0.9592
NonWhite	1	0.354183	0.200591	1.77 *	0.0774
Incom30-59K	1	-0.017552	0.195568	-0.09	0.9285
Incom60-89K	1	0.065166	0.204603	0.32	0.7501
Incom90K+	1	0.206285	0.207919	0.99	0.3211
CompAnxiety	1	**-0.181200**	0.067885	**-2.67 ****	0.0076
InfoUse	1	0.107380	0.065038	1.65 *	0.0987
InfoControl	1	-0.114100	0.069302	-1.65 *	0.0997
FinCommun	1	0.086565	0.079050	1.10	0.2735
RiskReduce	1	-0.059767	0.071266	-0.84	0.4017
VolunData	1	0.099763	0.075299	1.32	0.1852
_Limit2	1	0.432208	0.079911	5.41	<.0001
_Limit3	1	0.721313	0.093458	7.72	<.0001
_Limit4	1	1.102025	0.104047	10.59	<.0001
_Limit5	1	1.511171	0.112111	13.48	<.0001
_Limit6	1	2.020335	0.120829	16.72	<.0001

Implications

Foodborne illness continues to be a significant problem and a RFID food tracing system might help reduce the number and severity of outbreaks. Proponents of traceability need to consider consumer opinions when comparing tracing options. Failure to consider consumer attitudes about RFID technology could lead to overly-optimistic forecasts. Some respondents to this survey were not particularly supportive of one or both of the RFID tracing applications. Those favoring a RFID system for improved traceability may need to spend time addressing consumer concerns and anxieties about the technology in order to get consumer buy-in and support. Differences between produce tracing model and meat tracing model results suggest that support for an RFID system varies by category. Generalizations based on one product may not reflect consumer support or willingness-to-pay for the traceability of other food products.

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