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Consumer acceptance of food irradiation: a test of the recreancy theorem

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Abstract

Consumers living in both developed and developing nations rely upon foods that have been produced and processed in many countries and in a wide variety of ways. Therefore, it is not surprising that they express concerns about the safety of their food supplies. A technology proposed to improve consumer trust in food safety is irradiation. Despite extensive education efforts and endorsements given by many health-related organizations worldwide, food irradiation has been slow to gain widespread acceptance. This ineffectiveness of diffusion efforts might indicate a need to broaden our theoretical perspectives of consumer acceptance of controversial technologies. Most theoretical approaches explain acceptance primarily as a function of perceived risks associated with a technology. The recreancy theorem, in contrast, explains acceptance as a function of public trust in societal institutions to effectively manage a technology. This study investigated the extent to which the recreancy theorem explained acceptance of food irradiation by US consumers, while statistically controlling for perceived risk and social-demographic variables. The study used a longitudinal field design to survey one adult each in 116 households located in the Minneapolis, Minnesota area during the first large-scale market test of irradiated food. The results indicate that the recreancy theorem might provide a valid conceptual approach to gaining a broader understanding of consumer acceptance of controversial new technologies.

Introduction

Globalization of trade and consumer trust in food safety

Globalization of trade has, over the past several decades, significantly altered the nature of food systems in both developed and developing nations (Senauer and Venturini, 2001). These changes include increased foreign direct investments, the expansion and relocation of processing facilities and a rapid growth in large-scale retailing (Regmi and Gehlhar, 2005). Globalized trade, in conjunction with advances in food processing, information processing and transportation logistics, also has encouraged substantial increases in the volume and nature of foods exported worldwide (e.g. Athukorala and Jayasuriya, 2003; Rae and Josling, 2003; Baldwin and Winters, 2004). For example, from 1975 to 1985, the value of processed food traded globally increased at a near steady rate of about 5% per year (Athukorala and Jayasuriya, 2003). This rate nearly doubled from 1985 to 1995 and since has grown slowly, now representing approximately 6% of worldwide processed food sales (Regmi and Gehlhar, 2005). Similarly, growth in trade of bulk commodities has risen over the past 30 years, such that today approximately 16% of commodities are traded internationally (Regmi and Gehlhar, 2005).

Increases in global food trade have been accompanied by rising consumer concerns about the safety of the food supply. To note a few examples, consumers living in Canada (e.g. Williams, 2006), Western Europe (e.g. Meunier, 1999; Sanders, 1999; Ohlsson, 2004; Ansell and Vogel, 2005), Central and South America (e.g. Hogan and Tolmasquim, 2001; Jatib, 2003), Australia (e.g. Riethmuller, 2006), India (Marthi, 1999; Shiva, 2005; Ministry of Food Processing Industries, 2008), Africa (e.g. Medical News Today, 2005; Tomlins, 2008), China (e.g. Ramzy, 2008), Japan (e.g. Associated Press, 2007) and the United States (e.g. Wimberly, 2003; Garber, 2008) express doubts about the ability of institutional actors to deliver safe food globally and the accountability of these actors when systems fail. Central themes of public unrest about food safety include concerns about inadequate training and supervision of food producers and processors, insufficient food inspection systems, shifts of responsibility for food safety compliance from governmental agencies to private industries and inadequate regulations regarding the production, processing and international transport of foods (e.g. Wimberly, 2003; Ansell and Vogel, 2005; Tomlins, 2008). This sense of vulnerability to the global food system is heightened when the public learns about large-scale outbreaks of food borne illnesses related to consuming tainted foods (e.g. Ramzy, 2008) and foods containing dangerous levels of harmful bacteria (Garber, 2008). It is heightened also when the public becomes exposed to life-threatening diseases related to food consumption such as spongiform encephalopathy and Variant Creutzfeldt-Jakob Disease (Brown *et al.*, 2001).

In response to increasing consumer concerns, government- and industry-related groups assert that food safety must become a priority issue on the political agendas of their countries. These groups have been instrumental in developing improved food management systems, identifying food safety hazards, improving food safety legislation and control systems, promoting educational efforts aimed at consumers and food handlers, and improving the evaluation and inspection of foods both imported and domestically produced (e.g. Medical News Today, 2005; Food Safety Information Center, 2008; Ministry of Food Processing Industries, 2008). One approach that has been advocated for improving food safety and restoring consumer confidence in globally produced and distributed foods is irradiation.

Irradiation as a food safety technology

Irradiation kills harmful bacteria in meats and destroys insects on fruits and vegetables by exposing them either to gamma rays emitted by a radioactive source such as cobalt-60, or high-intensity X-rays emitted by an electron beam accelerator (Murano *et al.*, 1995). In the United States, irradiation of a wide variety of foods, including beef, has been approved by the US Food and Drug Administration (FDA). Also, the process has been endorsed by the American Medical Association (AMA), the American Dietetic Association (ADA) and public health agencies throughout the nation. Nevertheless, the process has been slow to gain widespread acceptance among the American public (ADA, 2000). For example, for a 2-year period following the 2000 market test described here later, irradiated beef patties were sold in hundreds of groceries located throughout the US. Little demand was shown for the product; however, such that today many fewer groceries offer irradiated products. A company organized to build electron beam accelerators – SureBeam, Inc. – was dissolved in 2004. Then, in 2006, the SureBeam plant reopened as Sadex, Inc., which currently is irradiating animal feed and anticipating a potential renaissance of US consumer support for food irradiation. Whether food irradiation will receive widespread acceptance among US consumers is a question; however, as its proponents still must address concerns about nutrient loss, the formation of toxic chemicals linked to cancer and birth defects as well as unfavorable changes to the taste, texture and smell of irradiated foods (e.g. Center for Food Safety, 2008). Furthermore, the technology has met with similar consumer disinterest or complaints in other world markets (e.g. Food Commission, 2002; European Public Health Alliance, 2005; Consumers Union of Japan, 2007; Taubenfeld, 2007).

The slow adoption rates for irradiated food show that intensive education efforts and endorsements made by relevant agencies are not necessarily effective at gaining consumer's acceptance of controversial food technologies. To some extent, slow adoption rates might indicate consumers' adherence to a precautionary principle. That is, consumers might feel that when science discovers plausible risks associated with a new technology, even in the absence of sound scientific evidence that a significant risk exists, it is best to delay adoption (e.g. Andorno, 2004). Or it might be that consumer's willingness to pay for irradiated foods is exceeded by the costs involved in the irradiation process (e.g. Frenzen *et al.*, 2000). The outcomes of diffusion efforts for food irradiation, *themselves*, are not necessarily the primary concern of scholars of consumer studies. Of greater concern is the *theoretical* issue regarding the extent to which extant models of attitude formation and change accurately portray consumer opinions in a manner that lend themselves to effective risk communication efforts.

To the extent that risk communication efforts show limited effectiveness indicates possible limitations to our understanding of consumer opinion formation. Consumer studies scholars therefore seek a greater understanding of how consumer opinions about a food safety technology can seemingly run counter to scientific support for and health-related agency endorsements of this technology. To this end, we investigated the extent to which the recreancy theorem might explain consumer acceptance of food irradiation. The purpose is not to propose that a single approach is sufficient to serve as a comprehensive model of consumer acceptance of controversial technologies but to explore the extent to which the recreancy theorem might broaden scientific understanding of consumer opinions about controversial technologies.

The recreancy theorem

In keeping with previous literature regarding consumer acceptance of controversial technologies, we investigated determinants of interpersonal trust between the consumer and the proponents of a new technology (e.g. Slovic, 2000; Rogers, 2003). The conceptual foundations of interpersonal trust typically are specified to be motivational relevance and expectations of competent and reliable performance (see especially Deutsch, 1958; Barber, 1983; Rasmussen, 1983). Approaches to modelling this form of trust have been dominated by technical approaches advanced within the fields of engineering and mathematics (see Bradbury, 1989; Renn, 1992; Alario and Freudenburg, 2003). These approaches emphasize informing the public about the results of quantitative risk assessments, i.e. on obtaining accurate technical risk assessments and informing the public about the competence – the skills and expertise – of those involved in technology development and management (e.g. Starr, 1969). These approaches typically assume that quantitative risk assessments are correct, unbiased and unaffected by political and economic contingencies, assumptions that in practice are unrealistic (Adams, 1995) and fail to account for the many societal-related elements that affect technical risk assessments (e.g. Freudenburg 1988; Krimsky and Golding, 1992).

Social science theories, in contrast with technical approaches, assert that social elements also affect trust. The psychometric approach (e.g. Covello *et al.*, 1988; Frewer *et al.*, 1998; Slovic, 2000), e.g. posits that emotional heuristics such as perceived voluntariness, control and fear of the unknown affect interpersonal trust. The cultural approach (Douglas and Wildavsky, 1982) asserts that the nature of culturally located customs, beliefs and social organization affect what people consider as risky. The diffusion of innovations approach (Rogers, 2003) assumes that consumer trust in respected opinion leaders will sway them to accept new technologies endorsed by these leaders. Each of these approaches – associated with the disciplines of psychology, anthropology and sociology respectively – has proven effective in understanding consumer opinion formation regarding controversial technologies. Yet, it might be worthwhile to explore lines of

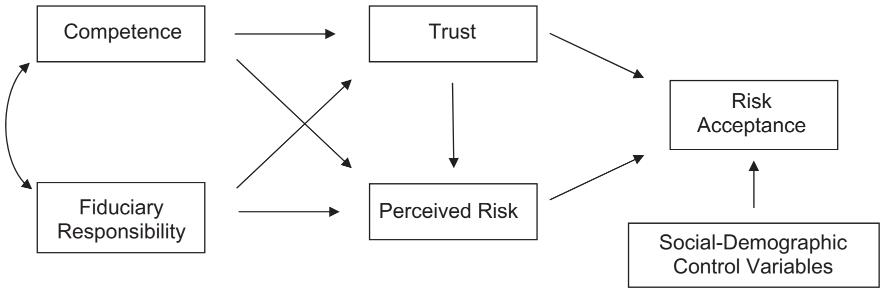

Figure 1 Theoretical model of risk acceptance.

inquiry that can broaden our understanding of consumer opinion formation and thereby further improve efforts at communication about controversial technologies.

More recently, developed social science approaches to understanding consumers' risk perceptions focus upon the extent to which these perceptions reflect evaluations of the ability of *societal institutions* to adequately develop and manage advanced technologies. These approaches investigate consumer confidence in the abilities of institutions to effectively protect the public within a technologically advanced, global trade system (Giddens, 1990, 1992; Beck, 1992). The recreancy theorem (Freudenburg, 1993; Alario and Freudenburg, 2003) represents one example of this approach to understanding consumer opinions.

The foundations of this theorem rest in the sociological premise that citizens living in technologically advanced societies might have become more dependent upon, rather than in control over, their technologies (Giddens, 1990, 1992; Beck, 1992). Therefore, it is assumed that citizens to an increasing extent base their risk assessments upon their perceptions of the abilities of societal institutions to adequately manage and regulate risk. The recreancy theorem (Freudenburg, 1993) thereby states that trust is explained by people's perceptions of the competence of institutional actors and their confidence that these actors will behave with fiduciary responsibility (i.e. with honesty and integrity, with the right values as guidelines and with the consumer in mind). The term 'recreancy' is used to avoid implications of malfeasance by those responsible for technology development and oversight. Within this context, recreancy refers either to a lack of available knowledge or expertise to adequately control technological risks or to a perception by the public that societal institutions are not adequately understanding consumer values in technology development or regulation.

Like other social science approaches, the recreancy theorem recognizes the importance of perceived risks in affecting trust in the proponents of a new technology and eventual acceptance of it. The theorem differs from other social science approaches in positing that perceived risks, trust in proponents of a technology and acceptance of the technology primarily reflect people's evaluations of the performance of institutional actors. It posits for example that consumer opinions reflect the degree to which they perceive that institutions in the realms of science, business and government have the necessary skills and abilities to produce reasonably safe technologies and regulate them in a competent manner. In addition, it posits that consumers respond to their confidence that institutional actors will behave with fiduciary responsibility, with a sense of integrity towards the public. As such, the theory posits that risk assessments are related to consumers' evaluations of the ability of individual specialists within institutions and institutional operating systems as a whole to fulfil their responsibilities, i.e. responsibilities related to competence and to treating consumers responsibly (Freudenburg, 1993).

To date, few studies have empirically evaluated the efficacy of the recreancy theorem. Freudenburg (1993) found that individual's trust in institutions responsible for technological developments and dissemination explained approximately three times as much variance in public concerns about nuclear waste disposal than social-demographic (i.e. age, sex, employment sector) and ideological (i.e. political party affiliation, political ideology) characteristics did. Sapp *et al.* (2009) found that confidence and fiduciary responsibility explained approximately 70% of the variance in consumer trust in institutional actors within the US food system, wherein the effects of fiduciary responsibility outweighed the effects of confidence on trust by a factor of about three to one.

Theoretical Model

We relied upon the recreancy theorem to posit a theoretical model of acceptance of food irradiation (Fig. 1). In keeping with the recreancy theorem, a key factor affecting acceptance is specified as trust in institutional actors responsible for food irradiation. To statistically evaluate the relative influence of the recreancy theorem to explain trust and acceptance in relation to other well-documented social science approaches, we included perceived risk as both a dependent variable and as a control variable on acceptance. The two central factors affecting perceived risk and trust, in accordance with the recreancy theorem, were posited to be the perceived competence of institutional actors responsible for food irradiation and the perceived fiduciary responsibility of these actors to behave responsibly in the development and management of the technology. We note that social-demographic variables have been found to affect perceived risk, trust and acceptance of food irradiation (e.g. Sapp and Korsching, 2004). Therefore, characteristics such as sex, years of formal education, age and household income of the respondent were added to the model as statistical controls. The central research question therefore is to assess the extent to which the key concepts of the recreancy theorem – competence and fiduciary responsibility – explain trust and acceptance, while statistically controlling for perceived risk and social-demographic characteristics.

Methodology

The sample and research design

Huisken's Meats, Inc. began the first large-scale, commercially funded market test of irradiated food in the spring of 2000. At the outset of this market test, we contacted potential respondents at random from households with listed telephone numbers located within the Minneapolis, Minnesota interstate highway loop. In this initial contact ($n = 482$), we requested to speak with either a male or female adult based upon a random selection procedure. The identified person was asked to participate in a study of food safety (i.e. food irradiation was not mentioned at this time). Those who agreed to participate ($n = 253$) were sent a background questionnaire and an incentive fee of $15.00. The background instrument was used to collect social-demographic information. It also asked subjects to indicate how much they worried about food safety issues and how much they trusted scientists and public health officials for food safety information. At this stage of the recruitment process, potential subjects were contacted just once to solicit their participation.

Persons who completed the background questionnaire ($n = 217$) were sent an information packet along with Questionnaire 1. Because most persons are unfamiliar with food irradiation, we reasoned that an information packet was necessary to elicit informed responses. The information packet contained two 15-min videotapes. A videotape produced at Iowa State University (1996) presented food irradiation in a favourable manner. It contained performance-related information in noting, e.g. the substantial amount of scientific research conducted on irradiation and that irradiation reduces food-borne bacteria and increases the shelf-life of food. The Iowa State University tape also included endorsements from university scientists, representatives from the FDA, the AMA, the ADA and other public health agencies. A second videotape (Enviro Close-Up, 1993) showed an interview with Mr. Michael Colby, the executive director of Food & Water, Inc., which at the time of the study was the leading advocacy organization opposed to food irradiation. This tape contained unfavorable performance-related information in noting that the technology reduces the nutritional value of food, claiming that eating irradiated food may cause cancer. The information packet also contained written materials. It included photocopied pages from an Iowa State University (2000) web site that presented food irradiation in a favourable manner along with photocopied endorsements of food irradiation that had been posted on the AMA and ADA web sites. Also in the packet was a copy of Food and Water's (2000) *Activist's Primer*, a published booklet that presented concerns about irradiated food and informed persons about how to stop it from being adopted. Subjects were given no instructions as to the order in which they should view and read the information materials. This procedure allowed subjects to examine the materials as they wished but provides us with no opportunity to examine potential ordering effects of information acquisition.

Questionnaire 1 contained items used to measure subjects' beliefs, attitudes and intentions regarding irradiated food and their evaluations of the institutional actors who promote its consumption. Those persons who returned a completed Questionnaire 1 ($n = 141$) were sent Questionnaire 2 3 months later. The content of Questionnaire 2 was nearly identical to that of Questionnaire 1. A total of 116 persons completed and returned Questionnaire 2. The subjects were informed at the time they received Questionnaire 1 that they were not required to purchase or eat irradiated food to be eligible to participate in the study. In summary, the methodology was a two-stage panel study of adults living in the region of the first large-scale market test of irradiated food. We sent to a sample of 217 households an information packet that highlighted the favourable and unfavourable arguments regarding food irradiation. One hundred and sixteen (53.5%) of these households completed the two questionnaires on this topic, which were spaced 3 months apart. The advantage of this approach was that we evaluated consumer opinions within an actual test-market area. The disadvantage of this field experiment, however, was that we were unable to physically control the ordering in which the information materials were viewed and read. Previous research indicates that exposure to unfavourable arguments about food irradiation is a more important factor in influencing opinions than the ordering of this information (Sapp and Harrod, 1994), but we cannot assess the extent of possible ordering effects here.

Measurement of variables

We measured the model variables based upon responses to Likert-type items using a 7-point response scale, coded as -3 to 3, with a 0 mid-point (see descriptions of these scales in Table 1). Principal components factor analysis indicated that all multi-item constructs were one-dimensional. The Cronbach's (1951) alpha reliability coefficients for the scales are shown in Table 1.

Acceptance was measured by responses to items that assessed the extent to which respondents thought that eating irradiated food would be good, desirable and beneficial and that the technology was a good idea. Trust was measured with an expression of trust in 'scientists who support food irradiation' and 'public health officials who support food irradiation'. Perceived risk was measured with items that assessed the likelihood of contracting cancer, experiencing health problems later in life and decreasing the nutrient value of one's diet from eating irradiated food, along with an item that asked respondents if eating irradiated food was safer than eating non-irradiated food. Competence is an assessment of the skills and expertise of the proponents of food irradiation. Therefore, we measured this latent variable with items that addressed the extent to which proponents were scientific in their approach and experts on the topic of food irradiation. Fiduciary responsibility is an assessment of the extent to which proponents of food irradiation share similar values with the respondent. This latent variable was measured with items that asked whether proponents share similar values and 'are truly concerned about food safety'.

The theoretical model included social-demographic variables as statistical controls. Age was measured in years and education was measured as years of formal schooling (either in school or at home). Income was measured as the total household income before taxes in the calendar year prior to the survey.

Results

Descriptive statistics

The subjects, who by reading and viewing the materials in the information packet were exposed to the viewpoints of proponents and opponents of food irradiation, had unfavourable opinions of the technology at both Time 1 and Time 2 (Table 2). Acceptance of irradiated food, however, improved significantly during the 3-month time period. At Time 1, acceptance was significantly lower than the scale mid-point of 0. Three months later, acceptance still was unfavourable but was no longer significantly lower

Table 1 Description of the model variables and Cronbach's α reliability estimates for the indexes by time period ($n = 116$)

Variable	Description	Alpha reliability	
		Time 1	Time 2
Acceptance	For me, eating irradiated food would be: [good, desirable, beneficial].	0.96	0.94
	I think that eating irradiated food is a good idea.		
	Eating irradiated food is a safe thing to do.		
Trust	I trust the scientists who support food irradiation.	0.87	0.81
	I trust the public health officials who support food irradiation.		
Perceived Risk	Eating irradiated food will increase my likelihood of contracting cancer.	0.88	0.75
	Eating irradiated food will decrease the nutrient value of my diet.		
	Eating irradiated food will increase my likelihood of experiencing health problems later in life.		
	Eating irradiated food is safer than eating non-irradiated food.[a]		
Competence	Proponents of food irradiation are scientific in their approach.	0.88	0.76
	Proponents of food irradiation are experts about food irradiation.		
Fiduciary responsibility	Proponents of food irradiation are truly concerned about food safety.	0.76	0.72
	The people who support food irradiation have a different set of values than I do.[a]		

[a]The numerical coding of these variables was reversed in the data analysis.

Table 2 Descriptive statistics for the model variables by time period ($n = 116$)

Variable	Range	Mean scores	
		Time 1	Time 2
Acceptance of food irradiation	–3 to 3	–0.852[a]	–0.100[b]
Trust in proponents	–3 to 3	–0.928[a]	–0.204[b]
Perceived risk of food irradiation	–3 to 3	0.451[a]	–0.346[a,b]
Competence of proponents	–3 to 3	–0.059	0.558[a,b]
Fiduciary responsibility of proponents	–3 to 3	–0.252	0.627[a,b]
Descriptive statistics for social-demographic variables			
Age	Mean = 50.89		
Sex	Males = 44 (37.9%)		
Education	Mean = 3.54 (post high school to college).		
Income	Mean = 3.05 (approx. $50 750)		

[a]The mean score is statistically different than the mid-point of its response scale at $P < 0.05$.
[b]The difference in mean scores from T1 to T2 is statistically significant at $P < 0.05$.

than the scale mid-point. Similarly, trust in proponents was negative at Time 1 and statistically lower than the scale mid-point. At Time 2, trust in proponents still was negative, but no longer statistically lower than the scale mid-point. The effect of time on perceived risk was particularly noteworthy. At Time 1, the mean score on perceived risk was negative (indicating that eating irradiated food was considered as risky) and statistically lower than the scale mid-point. At Time 2, however, perceived risk was positive (indicating that eating irradiated food was *not* risky) and statistically higher than the scale mid-point. The expressions of both competence and fiduciary responsibility were negative but not significantly lower than their scale mid-points at Time 1, but they were positive and significantly higher than their scale mid-points at Time 2.

To summarize, perhaps as a function of thinking more about the topic or sharing information with friends and family, opinions of food irradiation (and correspondingly assessments of trust, perceived risk, competence and fiduciary responsibility) changed significantly in favour of food irradiation from Time 1 to Time 2. Perhaps, exposure to diverse perspectives forced consumers to develop a more moderate stance towards food irradiation and made them less fearful of the technology. That is, while the subjects had access to activist literature that portrayed the technology as a threat, they also had access to traditional scientific literatures that portrayed it as safe. Perhaps the exposure to the scientific literature helped to allay their fears. And perhaps, they were more open to the arguments of the proponents of the technology *because* we gave them the opponents' arguments as well – so they did not suspect the project of trying to bias their opinions.

Inferential statistics

The data tested were univariately normal and the sample size was sufficiently large to use maximum likelihood algorithms for model estimation. At the same time, we did not believe that the sample size was sufficiently large to estimate both the measurement model and structural equations simultaneously. So, we chose to use scores on the summated scales in model estimation. This decision seemed justified given that principle components factor analyses indicated that the summated scales were one-dimensional and had acceptable levels of alpha reliability (Table 1). Furthermore, by averaging the responses to the scale items, the resulting number of response levels for the latent variables ranged from 32 to 59, which seemed sufficient to treat the measures of the latent variables as interval-level data. Multivariate analysis of outliers (Bollen, 1989) indicated no data points sufficiently influential to justify dropping a case from the data.

The results of the estimation of the theoretical model at Time 1 and Time 2 were similar to one another. At both time periods, we found moderately strong and statistically significant (at prob. < 0.01) standardized estimates in the anticipated direction for the effects of trust and perceived risk on acceptance and for trust on perceived risk. Also, we found moderately strong and statistically significant (at prob. < 0.01) standardized estimates in the anticipated direction for the effects of competence on trust

Table 3 Standardized parameter estimates and total effects for the estimation of the model variables on acceptance of food irradiation by time period and from Time 1 to Time 2 ($n = 116$)

Model paths	Time 1	Time 2	Cross-lagged[a]
Parameter estimates			
Trust → Acceptance	0.451**	0.429**	0.449**
Perceived risk → Acceptance	–0.481**	–0.562**	–0.500**
Trust → Perceived risk	–0.391**	–0.498**	–0.420**
Competence → Trust	0.500**	0.340**	0.345**
Competence → Perceived risk	–0.066	–0.007	–0.074
Fid. resp. → Trust	0.343**	0.420**	0.340**
Fid. resp. → Perceived risk	–0.462**	–0.254**	–0.170*
Total effects on acceptance			
Trust → Acceptance	0.639**	0.709**	0.659**
Perceived risk → Acceptance	–0.481**	–0.562**	–0.500**
Competence → Acceptance	0.352**	0.245**	0.264**
Fid. resp. → Acceptance	0.441**	0.440**	0.309**
Minimum fit function chi-squared	140.841	240.700	900.292
Probability of chi-squared	0.536[b]	0.075[b]	0.037[c]
R-squared for acceptanced	0.838	0.815	0.814
R-squared for trust	0.644	0.459	0.482
R-squared for perceived risk	0.729	0.474	0.550

[a]The cross-lagged effect at Time 2, which represents the effect of the percent change in the independent variable from Time 1 to Time 2 on the percent change in the dependent variable from Time 1 to Time 2.
[b]Degrees of freedom = 16.
[c]Degrees of freedom = 68.
*Estimate is statistically significant at $P < 0.05$.
**Estimate is statistically significant at $P < 0.01$.

and of fiduciary responsibility on trust and perceived risk. At both time periods, the standardized estimate for the effect of fiduciary responsibility on perceived risk was weak and not statistically significant. The chi-squared statistics at 16 degrees of freedom for estimating acceptance at Time 1 and Time 2 indicated acceptable fit for both estimations at the $P > 0.05$ level (Table 3). The standardized total effects indicated that competence and fiduciary responsibility significantly (prob. < 0.01) affected acceptance at both Time 1 and Time 2. The *R*-squared values for acceptance at Time 1 and Time 2 equaled 0.838 and 0.815 respectively.

The longitudinal panel design permitted an examination of the extent to which changes in the independent variables influenced changes in acceptance from Time 1 to Time 2. This examination was conducted by testing a cross-lagged version of the theoretical model, which took the form (Finkel, 1995):

$$Y_{T2} = BX_{T2} + BX_{T1} + \varepsilon_1 \quad (1)$$

$$X_{T2} = BX_{T1} + \varepsilon_2 \quad (2)$$

for each set of endogenous constructs at Time 1 and Time 2, where Y represents the dependent variable, X represents the independent variable, B represents a vector of parameter estimates and ε represents the residuals for each equation. Thus, estimating the effect of change in acceptance because of change in fiduciary responsibility, for example, requires simultaneous estimation of the effects of fiduciary responsibility at Time 1 on fiduciary responsibility at Time 2, fiduciary responsibility at Time 1 on acceptance at Time 2 and fiduciary responsibility at Time 2 on acceptance at Time 2. We used the LISREL 8 statistical package (Jöreskog and Sörbom, 1995) to calculate these sets of parameter estimates simultaneously for all sets of constructs in the cross-lagged model.

The cross-lagged model predicted over 80% of the variance in the change in acceptance from Time 1 to Time 2. The results of fitting this model indicated that changes in trust and perceived risk significantly affected changes in acceptance. The change in perceptions of competence significantly affected changes in perceived trust, but not in perceived risk. Changes in fiduciary responsibility significantly affected changes in trust (prob. < 0.01) and perceived risk (prob. < 0.05). The standardized total effects for the cross-lagged model indicated that changes in competence and fiduciary responsibility significantly (prob. < 0.01) affected changes in acceptance from Time 1 to Time 2.

Conclusions

Theoretical approaches to explaining consumer acceptance of complex and controversial technologies have been effective in identifying the psychometric, cultural and utilitarian determinants of acceptance. And educational programmes aimed at gaining adoption of innovations based upon these social science approaches have proved themselves effective across a broad range of innovations and in many different settings worldwide. Nevertheless, sometimes these theories and the risk communication approaches derived from them have failed to achieve the level or rate of adoption thought possible (and desirable) by proponents of a technology. This limitation seems evident in the case of food irradiation, which has been slow to gain acceptance in many nations by a majority of their citizens, despite receiving the approval of regulatory agencies and endorsements from health-related organizations for over 25 years.

Whether one favours or opposes the adoption of food irradiation as a process to improve food safety, the *theoretical* issue of importance for consumer studies scholars, is the extent to which extant theories are sufficient to explain the sometimes broad dimensions of technology acceptance. This study examined the efficacy of the recreancy theorem to broaden social science approaches to understanding consumer acceptance of controversial technologies. This theorem differs from other social science approaches in its emphasis upon the extent to which consumers place trust in societal institutions held responsible for public safety.

The data were collected from a panel of one adult each in 116 households twice during a 3-month period after subjects were introduced to the topic of food irradiation during a market test in the Minneapolis, MN metropolitan area. The analysis of structural equation models at two time periods and a cross-lagged model to assess determinants of change across these two periods indicates that the recreancy theorem can be effective in explaining trust and acceptance of a controversial technology. An important finding was that presenting consumers with a variety of information from alternative perspectives was related to their increase in acceptance. Furthermore, the results support the contention that the two key determinants of trust as specified by the recreancy theorem – competence and fiduciary responsibility – can explain trust in societal institutions, with about equal effects on trust.

These findings must be placed within the context of the limitations of a field experiment. We assumed that respondents carefully reviewed the information materials and considered them salient to their decisions. We also assumed that they discussed their viewpoints with their significant others during the 3-month time period between the administrations of the two survey instruments. Thus, as a field experiment, this study could not control information acquisition and discussion as well as could be done in a laboratory experiment. The field experiment, on the other hand, offers important advantages not available within the laboratory: it occurs within a natural setting and allows individuals to develop their beliefs, attitudes and intentions over a longer period of time than can be allocated within a laboratory setting.

To the extent to which the recreancy theorem successfully broadens social science understanding of consumer acceptance of controversial technologies, we can speculate about possible extensions to risk communication strategies inferred by this theorem. We believe that current approaches that focus upon knowledge acquisition, appeals to emotional heuristics and gaining endorsements from opinion leaders (e.g. Slovic, 2000; Covello and Sandman, 2001; Rogers, 2003) will continue to be successful in educating the public about controversial technologies. The results here imply that risk communication strategies might be broadened to include partnership building between citizens and societal institutions.

Fischhoff (1995) , in reviewing 20 years of progress in risk communication strategy just over a decade ago, recommended such an approach as an effective way to link consumers with the institutions that develop and promote new technologies. Therefore, the types of activities suggested as mechanisms for facilitating partnership formation such as efforts at corporate social responsibility and greater responsiveness to public concerns about the limitations of a technology are well known to institutional actors involved in educating the public about controversial food technologies (e.g. Levine, 2008). The results here imply that perhaps such strategies should be considered as having more relevance for consumer acceptance than has been previously acknowledged. Thus, the results imply that undertaking a more sociological approach to explaining consumer opinions of controversial new technologies might improve social science understanding of opinion formation under conditions of uncertainty. The results also imply that sociological perspectives might be effective in improving consumer opinions of increasingly complex and globalized food systems.

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