Adoption Behavior in Food Retailers' Decision to Offer Fresh Irradiated Ground Beef

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Abstract: *During the 14-month period from May 2002 to June 2003, approximately 10 percent of U.S. supermarkets began to offer fresh irradiated ground beef under the stores' own labels. Using a survey of supermarket store managers from this time period, this paper investigates the factors that influenced stores' adoption of irradiated ground beef. Results from the adoption model show that factors associated with competition, merchandising philosophy, and structure in the food retailing industry play a strong role in the decision. Among other results, we find that variables relating to a competitor's adoption status and proximity can increase the likelihood of a store's adoption decision.*

In February 2000, U.S. Department of Agriculture and Food and Drug Administration authorizations became effective that permitted the use of ionizing radiation to reduce pathogens and extend the shelf-life of fresh and frozen red meat products. Because radiation was considered an effective treatment against *E. coli* (O157:H7) and other pathogens found in raw meat, this new authorization carried important implications not just for the meat processing and food retailing industries, but also for public health. Earlier, using a cost-of-illness approach, Buzby *et al.* (1998) estimated the cost of premature deaths from *E. coli* in the U.S. to be between $160 million and $700 million annually. With its high sales and its history with meat recalls and pathogen contamination, fresh ground beef was anticipated to be among the first irradiated red meat product introduced. However, in the two years that followed authorization, introduction of irradiated ground beef by meat processors and food retailers could be characterized as cautious or sporadic. For example, early introductions often featured frozen, branded products, and were marked by regional emphases, in states such as Wisconsin and Minnesota, or by test market offerings by supermarket chains.

The industry changed in May 2002 when Wegmans Food Markets, a regional supermarket based in Rochester, NY, announced that it would become the first supermarket chain to launch a company-wide introduction of fresh irradiated ground beef packaged under its own name. Over the next few months, the 62-store Wegmans prominently featured irradiated ground beef in its ads and promotions, focusing on the food safety aspects of the new product. In September 2002, a second supermarket, Virginia-based Lowes Foods, followed Wegmans lead and announced it would offer a similar fresh irradiated ground beef product in 48 of its 110 stores. According to press releases issued by supermarket companies and the leading irradiation technology provider, over the ten months from September 2002 to June 2003, 31 more supermarket chains with over 3,800 stores collectively made similar announcements.[1] By June 2003, a bit more than 10 percent of all U.S. supermarket stores were offering fresh irradiated ground beef under their own label.

Figure 1 illustrates the activity of store adoption in the 14 months from May 2002 to June 2003. The timing of adoption suggests the beginnings of a widely observed S-curve of cumulative new product introductions or technology adoptions. Mahajan, Muller, and Bass (1990) describe how the cumulative adoption curve can stem from models of individual adoption decisions: a potential adopter's utility is based on perceptions of the innovation or product's benefits. Perceptions change, however, as the potential adopter learns more about the innovation. When the perceived net economic benefits exceed the status quo, one adopts. The S-curve results, therefore, from aggregation across various potential adopters.

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[1] The technology provider, SureBeam Corp., claimed the number of U.S. supermarkets adopting fresh irradiated ground beef under the store label was over 4,825. The lower number used here, reflects the cumulate count of stores where adoption press releases were obtained by the authors. The discrepancy in store numbers may come from at least two sources: (i) the authors may have been unable to locate or obtain a press release of an adopting store, or (ii) subsequent to an adoption, a supermarket company may have opened additional stores.
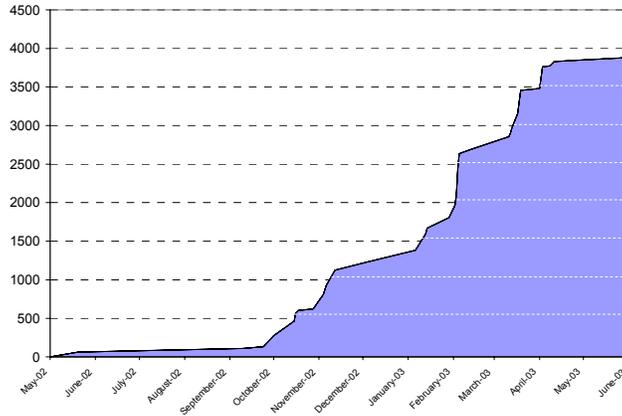
Source: Press releases, various supermarkets companies and SureBeam Corp.

Figure 1: Number of Stores Adopting Fresh Irradiated Ground Beef and Timing of Adoption Announcements
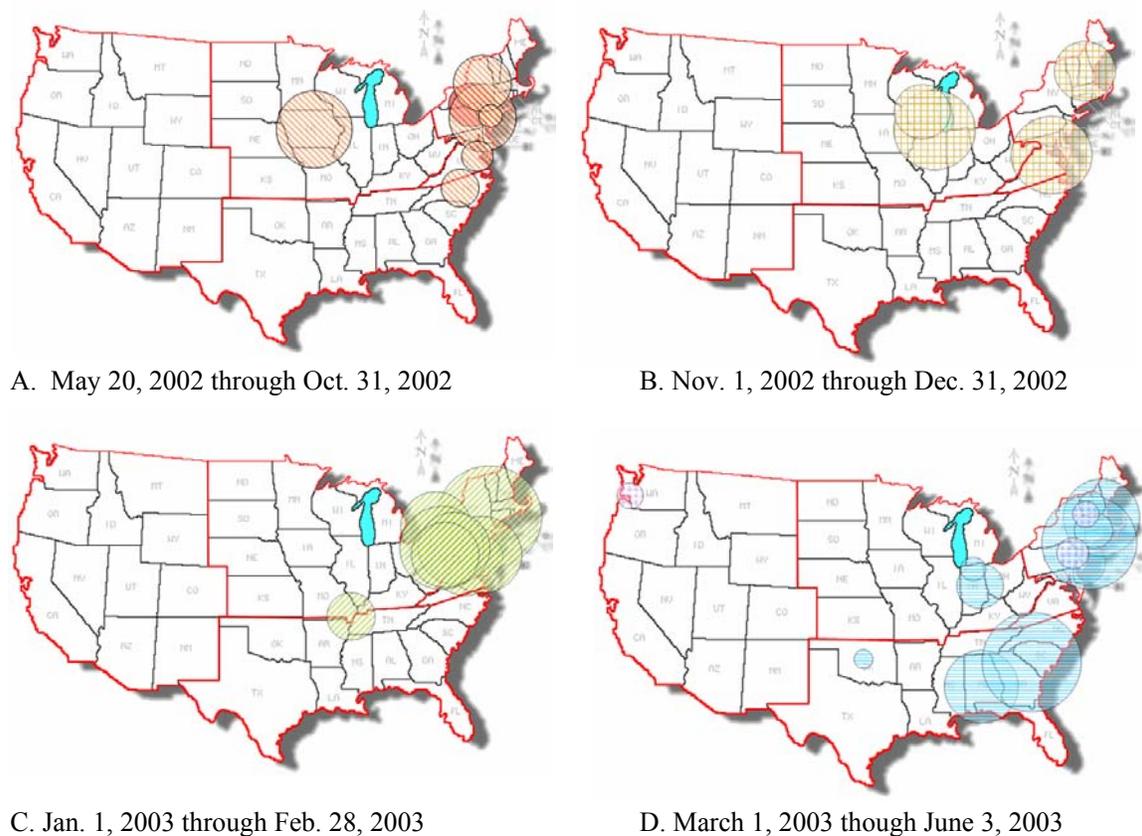
The adoption announcements depicted in Figure 1 do not, however, capture the whole story. When spatial as well as chronological information is considered, the adoption activity may suggest that other competitive forces are at work. Figure 2 depicts the spatial nature of the adoptions from May 2002 through June 2003. In this figure, circles are approximately positioned over the market areas or corporate headquarters of food retailers that announced the adoption of irradiated ground beef. The sizes of the circles accurately correspond to the relative number of supermarket stores to which the adoption announcement applied. Thus, in panel B, of Figure 2, the circle centered on Landover, MD, which represents Giant Food, Inc.'s Nov. 2, 2002, announced introduction of fresh irradiated ground beef to 188 stores has roughly three times the area of the circle in panel A centered on Rochester, NY, which represents Wegmans' introduction at 62 stores. While the circles in Figure 2 only approximate the scope of each store's market, one can see that many circles overlap. Figure 3 presents the complete spatial picture. When this spatial information is coupled with chronological information, we observe that the adoption of fresh irradiated ground beef is not randomly distributed over the U.S., but rather is related to market areas and geographic rivalries. In other words, while we may witness the beginnings of a standard S-curve adoption pattern along a temporal dimension, we see a richer story when we consider both temporal and spatial factors.

Previous research suggests that a more complete story of new product adoption may draw upon factors from three broad categories: product-related attributes, structural supply-channel attributes, and characteristics of industry competition. The first two categories are the focus of Rao and McLaughlin (1989) ; McLaughlin and Rao (1990); McLaughlin and Fredericks (1994); Desai (200); and Park (2001). This research emphasizes the merchandizing procedures and needs of "gate keeper" buyers in addition to how product attributes affect profitability perceptions. For example, from a survey of supermarket managers, Park (2001) finds that the three attributes that receive the most consideration are the new product's potential to increase overall store sales, the potential to increase overall store profit, and the potential to increase product movement. Park also finds that the top preferences for suppliers' promotional campaigns were in-store demonstrations and sampling, slotting allowances, television or radio advertising, and some form of coupon programs.

A related line of research focuses on broadly defined competition among food retailers and the role that new product introductions play as part of broader non-price competitive strategies.[2] Forms of non-price competition among retailers extend to include shelf-space allocations (Chen et al., 1999); quality-of-service versus low-price philosophies (Popkowski Leszczyc, Sinha, and Timmermans, 2003); retail format choices (Bhatnagar and Ratchford, 2004); product variety decisions

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[2] Alternatively, Connor provides a summary of research on price competition in grocery retailing.

(Swann, 1990; Ratchford, 1990; Krishnan, Koelemeijer, and Rao, 2002); and geographic or spatial forces (Allaway, Berkowitz, and D'Souza, 2003; Sinha, 2000; Walden, 1990; Benson and Faminow, 1985). Allaway, Berkowitz, and D'Souza's (2003) analysis of spatial diffusion of new loyalty card programs contains a number of similarities to the diffusion of irradiated ground beef. A number of factors that Allaway, Berkowitz, and D'Souza find particularly important, including the effects of spatial distance and the role of previous adopters, may be equally important in explaining the cumulative adoption of irradiated ground beef.


A. May 20, 2002 through Oct. 31, 2002

B. Nov. 1, 2002 through Dec. 31, 2002

C. Jan. 1, 2003 through Feb. 28, 2003

D. March 1, 2003 though June 3, 2003

Note: Circle placements are approximate. Circle sizes accurately reflect the relative number of stores in each operating company

Figure 2: Chronological and Geographic Patterns of Irradiated Ground Beef Adoption

In this paper, we analyze supermarket adoption depicted graphically in Figures 1, 2, and 3 by investigating the factors that lead to the adoption of fresh irradiated ground beef by food retailers. To accomplish this objective, we arranged for the University of Minnesota's Food Industry Center to add questions about irradiated ground beef to its 2003 panel survey of supermarkets. The Food Industry Center (TFIC) has surveyed store managers of supermarket for seven years, from 1998 to 2004, and in that time it has developed a continuing panel of survey participants. As the 2003 survey was being designed and implemented, we also interviewed upper level managers – e.g., corporate directors of meat products – at a small handful of supermarket firms to help us decide what issues might be important in the adoption decision. In this paper, we first discuss these potential factors and then apply a Logit model to the TFIC 2003 supermarket data to formally analyze the adoption question. Results from the adoption model show that factors associated with competition, merchandising philosophy, and structure in the food retailing industry play a very strong role in the adoption. Among other results, we find that a competitor's adoption status can significantly affect a store's decision to offer irradiated ground beef.

Before we provide the necessary background information and develop the model, we must acknowledge one other very important industry development. In January 2004, the leading irradiation technology provider, SureBeam, Inc., declared bankruptcy for, among other reasons, accounting irregularities associated with the sale/purchase of irradiation facilities. SureBeam began to dismantle itself almost immediately, jumping straight to Chapter 7 liquidation rather than Chapter 11 reorganization. As a result, the industry lost its main technology provider. Currently, neither Wegmans nor any other supermarket is offering a fresh irradiated ground beef product under the store's own label.[3] Adoption, therefore, was curtailed at approximately 10 percent of supermarket stores, well before one could know for sure whether or not adoption of fresh irradiated ground beef would follow the typical S curve. Despite this development, the adoption story has important implications for other products that carry some public health attributes, especially those where the attribute in question is part of an ongoing controversy.
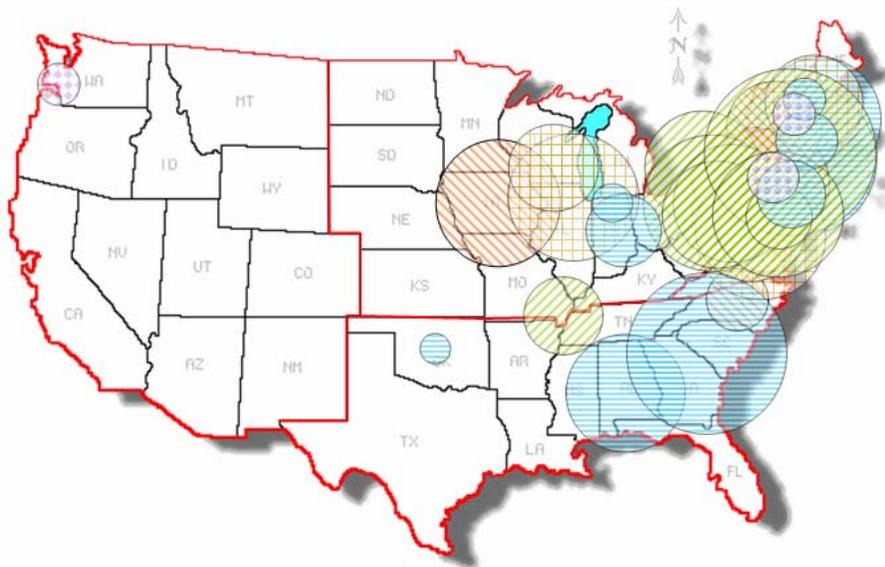
Notes: Circle placements are approximate. Circle sizes accurately reflect the relative number of stores in each operating company
Source: Press releases, various supermarkets companies and SureBeam Corp.

Figure 3: Cumulative Irradiated Ground Beef Adoption

Preliminary Thinking on Adoption of Irradiated Ground Beef

At the time federal approval was given to fresh or frozen irradiated meat products, the conventional wisdom about industry adoption of the new technology focused on how familiar supermarket managers were about the product's expected profitability, consumer opinions, and managers' own opinions about the new product (Jensen and Jaenicke, 2004). For example, two politically and socially controversial issues were those dealing with the unique attributes associated with the irradiation technology and whether consumers would accept the product. First were potential environmental concerns heightened by the words radiation and irradiated, which can evoke images of nuclear reactors (Demetrakakes, 1998). In reality, there are three separate technologies used to irradiate food. Two use high voltage electricity to create electron beams, either in the form of beta

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[3] A Wegman's press release dated Oct. 1, 2004, announced that Wegmans would offer frozen irradiated beef patties marketed by Huisken.

rays or X-rays. Only the third technology uses radioactive isotopes, e.g., Cobalt-60, as a source of gamma rays. Wegmans' irradiated ground beef product used patented electron beam technology developed by SureBeam, Inc. After Wegmans' product launch, nearly every other supermarket that likewise adopted fresh irradiated ground beef used SureBeam's "e-beam" technology. This technology choice may have diffused many of the environmental concerns.

A second related issue thought to affect adoption was whether or not the product would be perceived as "unnatural" by consumers. This issue, therefore, also dealt with irradiation technology, but now as a product attribute rather than a production technology. Many consumer acceptance studies of irradiated food were conducted before and during the time when approval was granted (Bailey, 1996; Fox et al., 1996, Hashim, Resurreccion, and McWatters, 1995; Henson, 1995; Resurreccion et al., 1995; Sapp, Harrod, and Zhoa, 1995). Frenzen et al. (2000) found that 49.5 percent of consumers would accept irradiated ground beef or poultry products and 31.8 percent would not, with the remainder not sure. A deeper look at the Frenzen et al.'s results, however, found that of those consumers that found the irradiated product acceptable, only 22.7 percent would purchase if the product were more costly than regular ground beef. More recently, using consumer intercept interviews, Nayga, Poghosyan, and Nichols (2004) found that 58 percent of interviewed consumers would be willing to buy irradiated ground beef. In many of these studies, consumer information is thought to play a strong role in consumer acceptance: For example, Nayga, Aiew, and Nichols (2005) find that the percentage of consumers self-identifying as "strong buyers" increased after information was provided, while the percentage self-identifying as "doubters" decreased.

The Frenzen et al. (2000) findings also provide insight regarding the product's underlying economics, which is the third important issue thought to affect adoption. Not counting the public health benefits from potentially removing pathogens from ground beef, in-store economic decisions centered on the potential extra cost of the product balanced against in-store benefits associated with the product's longer shelf life. Cost estimates of the technology ranged from $0.05 to $0.06 per pound (Bogart and Tolstum, 1999; Engeljohn, 1999; Kaye and Turman, 1999). The benefits from longer shelf life are less well known. From a supermarket's perspective, however, the most important unknown was consumer demand: demand for irradiated ground beef had not been estimated, nor was it known how the new product would affect demand for regular ground beef.

Wegmans' introduction provided a number of insights into these issues. First, the environmental issue was diffused by the specific e-beam technology choice. (Wegmans reported only a handful of protesters at its highly publicized launch.) Second, Wegmans dealt with the "unnatural" issue by emphasizing choice in its promotional materials. For example, Wegmans' ads stressed that shoppers now had a choice of buying regular or irradiated ground beef. And third, while the in-store economic issues were not well publicized, Wegmans' did publicize both the price and relative sales of its irradiated ground beef, which sold for about $0.10 to $0.30 above regular ground beef. However, the irradiated product was often on sale for the same price as the regular product (Groom, 2002). Wegmans has indicated that, across all its stores, irradiated ground beef sales represented as much as 15 percent of total fresh ground beef sales (Hartnett, 2003).

Adoption as Part of Competitive Strategy

Two industry observations suggest that "post-Wegmans" adoption decisions for irradiated ground beef may center less on the potentially controversial aspects of product attributes and more on the broader aspects of industry competition. First, Wegmans' product introduction strategy, which was highly publicized, appears to have successfully addressed and diffused the three issues discussed above – environmental concerns, consumer acceptance, and in-store economics. Second, supermarket adoptions picked up speed as more companies launched the product. These observations coupled with a number of personal interviews with corporate-level meat managers point to several factors that might affect adoption decisions. More specifically, we have identified three broad factors that may influence stores' adoption of irradiated ground beef: (i) competitive landscape, (ii) merchandising philosophy, and (iii) size, corporate structure, and demographics.

Competitive landscape: Despite trends in consolidation among food retailers and their increasing power with respect to suppliers, competition between retailers is generally considered intense.   Food retailers compete in many different dimensions, including pricing policies (e.g., Everyday Low Prices), variety of offerings, and service offerings. Other studies of competition among food retailers or new product introductions emphasize geographic proximity as part of a broader model of firm behavior (e.g., Sinha, 2000; and Walden, 1990). Stores facing intense competition may be more concerned with mimicking their competition.   In this way, stores compete for the median shopper. Regarding irradiated ground beef, stores may feel more pressure to adopt if their direct competitor is already offering it.

Merchandising philosophy: Some stores are known to be variety or service leaders – i.e., stores attempt to attract shoppers by offering the newest and largest variety of products, technologies, or services. An irradiated ground beef product could complement these philosophies in a number of ways: it adds to product variety, it represents the latest technology, and it arguably provides a higher degree of food safety, which could be loosely considered to be one of a store's service functions. Therefore, it may be the case that stores that identify with variety or service philosophies may be more likely to adopt and offer irradiated ground beef.

TFIC data contain a number of variables that may indicate a store's commitment to service or variety. One possibility is a question that asked store managers to rate the relative important of carrying organic produce. Other more direct possibilities are composite indexes, constructed from a number of variables in the panel, meant to reflect a service or variety philosophy. More specifically, TFIC creates a service index composed of 17 variables, a variety index composed of seven variables, and three versions of supply-chain indexes (Kinsey et al., 2003). Because one variable contained in the variety index is in fact a store's status regarding irradiated ground beef, this index as constructed cannot explain adoption. However, another of the seven variables – a store's relative importance of carrying organic produce – may serve as a proxy for a store's commitment to variety.

Store size, structure, demographics: Interviews with corporate meat managers suggest that store size, and the connected issue of corporate structure, may have a mixed impact on the adoption decision. In essence, the question focuses on how easy it would be to add a new product to store shelves. Store size, in terms of available selling space, seems likely to have a generally positive impact on the adoption of any new product. However, companies with extremely large selling areas may also have a different selling format – i.e., extremely large stores may place a higher emphasis on general merchandize. For these "mega" stores, large size may not be an indicator of how easily a new product is added to shelves. One might expect, therefore, that store size may positively impact the adoption of irradiated ground beef up to some size threshold.

The size and operation of the meat department itself may also influence a store's decision to offer irradiated ground beef. One corporate meat manager said that his company was quite satisfied with the sales velocity and margins in the meat department and, for the time being, was reluctant to alter the product mix. One variable in TFIC's panel that may reflect this factor is the weekly number of inventory turns. Higher inventory turns in the meat department could serve as a signal that there is little interest in altering the product mix.

Corporate structure, as measured by the number of stores in a chain, is another factor that affects how easily it is to add a new product. Kinsey et al. (2003) report that 58 percent of surveyed stores rely on an independent wholesaler or distributor for product supply. They further report that more than 90 percent of supermarkets with 50 or fewer stores rely on outside wholesalers. These independent or small supermarket chains that rely on outside distributors, therefore, may find that accessibility to an irradiated ground beef product is not completely under the store's control.

Data

   The data used in this analysis are from TFIC's 2003 Supermarket Panel. Kinsey et al. (2003) detail the survey instrument and 2003 Panel results. This survey, conducted annually since 1998, is based on a random sample of U.S. supermarkets. More specifically, the sample is drawn from the 32,695 establishments classified as supermarkets by the USDA that accept food stamps. Approximately 2,000 supermarkets were invited to take part in the 2003 Panel survey and 391 supermarkets responded. The overall response rate was 19.6 percent, with 47 percent (182) of these responses collected via the Internet. About 69 percent of respondents had participated in at least one prior Panel survey. Table 1, reproduced from Kinsey et al. (2003), shows how the 2003 Panel's median store characteristics compare to those reported by the Food Marketing Institute and Progressive Grocer in similar studies. In 2003, the survey was offered over the Internet for the first time.

Table 1: Median Store Characteristics for U.S. Supermarkets (*Kinsey et al.*)

	Median Store Characteristics		
Characteristic	TFIC Panel	FMI[a]	Progressive Grocer[b]
Selling Area (sq. ft.)	30,000	44,000	28,838
Annual Store Sales	$11.71 M	$18.80 M	$12.49 M
Weekly Store Sales	$225,210	$361,564	$240,000
Annual Sales Growth	0.6%	2.4%	–
Sales per Transaction	$22.12	$24.63	$27.61
Weekly Sales per Sq.Ft.	$7.75	$11.13	$8.33
Sales per Labor Hour	$123.20	$137.68	–
Annual Inventory Turns	16	17	–
Gross Profit as % of Sales	25.0%	28.4%	–
Payroll as % of Sales	10.0%	9.4%	–

[a] *Source: The Food Marketing Industry Speaks, 2003, Food Marketing Institute, 2003 (Data from 2002).*
[b] *Source: 70th Annual Report of the Grocery Industry, a special supplement to Progressive Grocer, April, 2003.*

   From this study's perspective, the most important change to the survey actually makes the current analysis possible: TFIC added a multipart question that asked store managers about the status of fresh irradiated ground beef. Out of 361 valid responses to the irradiated ground beef question, 25 said their store have offered fresh irradiated ground beef for more than six months; 29 said they offered it within the last six months; 15 said they would start offering the product within the next three months; 46 said adoption plans were under discussion; 143 said they had no plans to adopt; and the remainder (103) said they did not know. These data, excluding the "don't know" responses, are presented in Figure 4. Also found in Figure 4 are the store managers' responses to similar questions about the store's self-identified top three competitors.
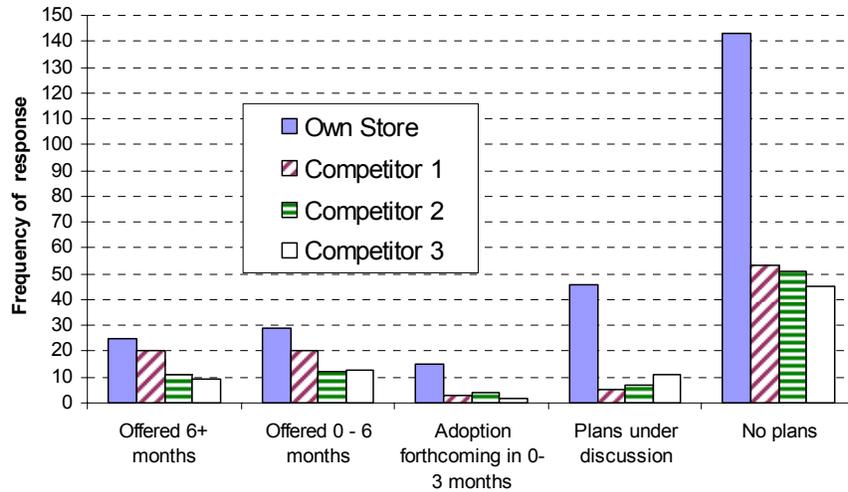
Figure 4: Survey Responses Regarding Adoption Status of Own Store and Top Three Competitors

TFIC data, while practical, may not be the best choice to analyze the decision to offer irradiated ground beef. Based on a small handful of interviews, that decision appears to be typically made at the corporate level: that is, upper-level corporate management including those in the corporate meat department would decide positively or negatively whether all company stores would offer irradiated ground beef. TFIC data, however, target individual store managers who, for the most part, may not have been consulted in the irradiated ground beef decision. Nonetheless, some of the store-level TFIC data may do an adequate job of reflecting corporate-level factors. Store-level responses on competitors' adoption status, store size, and other factors, for example, may not vary much for individual stores within a large chain.[4] Instead, to some extent, these data may capture corporate instead of individual-store attributes. Therefore, the analysis presented next will rely on TFIC store-level data, but we will discuss whether the data may or may not reflect corporate-level attributes.

The Food Industry Center's survey instrument contained 46 multipart questions, which are described in detail by Kinsey et al. (2003). Based on previous research and interviews with corporate-level meat managers, our analysis focuses on three categories of variables to explain the probability of adopting fresh irradiated ground beef: (i) variables that describe the competitive landscape between supermarkets; (ii) variables that describe a store's merchandising philosophy; and (iii) variables that reflect issues of size, structure, and demographics. Table 2 provides a description of these variables.

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[4] We are precluded from empirically analyzing how data vary within a supermarket chain because the identity of TFIC stores has been kept confidential.

Table 2: TFIC 2003 Data Used in to Model the Probability of Fresh Irradiated Ground Beef Adoption

Variable	Description	Min.	Mean	Max.
Dependent Variable				
Adoption Status	1 if store has adopted irradiated ground beef or adoption is forthcoming within 3 months; 0 otherwise	0	0.181	1
Variables that describe the competitive landscape				
Competitor Status	1 if a store's self-identified competition has adopted irradiated ground beef; 0 otherwise	0	0.187	1
Distance to Primary Competitor	Estimated mileage to store's self-identified primary competitor	0.01	5.533	130
Variables that describe a store's merchandising philosophy				
Supply Chain Technology Index	Measures adoption rate of 15 store-level technologies related to supply-chain management (e.g., electronic shelf tags or scanner data for automatic inventory refill). (Constructed by TFIC.)	0	0.398	1
Service Index	Measures adoption rate of 17 services (e.g., carryout service, in-store bakery, in-store banking). (Constructed by TFIC.)	0	0.377	0.88
Organic Produce	1 if store listed organic produce as a key competitive advantage or standard offering; 0 if not used, planned for discontinued use, or no plans	0	0.566	1
Weekly Inv. Turns, Meat	Estimated annual inventory turns for the meat department	0	41.73	152
Variables reflecting size, structure, and demographics				
Store Size	Estimated total size (selling area and backroom) of the store in 1,000 square feet.	2.5	38.28	210
Corporate Structure Stratum	1 if independent store; 2 if belongs to a company 2 – 10 stores; 3 if belongs to a company with 11 – 50 stores; 4 if belongs to a company with 51 – 750 stores; 5 if belongs to a company with more than 750 stores	1	2.658	5
Northeast Region	1 if within CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, or VT; 0 otherwise	0	0.143	1
Midwest Region	1 if within IA, IL, IN, KS, KY, MI, MN, MO, ND, NE, OH, SD, WI, and WV; 0 otherwise	0	0.503	1
South Region	1 if within AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, and TX; 0 otherwise.	0	0.137	1
Median HH Income	Median household income (in dollars) based on U.S. Census zip code data	20,287	42,470	91,431

Some of the variables in Table 2 are directly available from the 2003 Panel response data, some require minor manipulation, and still others require a proxy variable based on other information drawn from the Panel. For example, as seen in Figure 4, the 2003 Panel data have very detailed information on adoption status. However, because we are interested only in a yes/no adoption status, we convert this response into a binary variable by assigning a 1 to all responses where a store is already offering fresh irradiated ground beef, or where an offering is imminent. The same conversion is made for the status of the store's self-identified primary competitor. Distance to the primary competitor comes directly from the Panel, as does store size. The variables reflecting the degree to which the store has adopted supply-chain technologies or followed a service philosophy are composite variables calculated directly by TFIC, who constructs indexes based on responses to 15 and 17

supply-chain and service-related questions, respectively.[5] Of the 391 overall responses in the Panel, 342 had complete information on the variables presented in Table 2.

The Logit Model and Results

Supermarkets' adoption decisions can be modeled as a discrete choice where the dependent variable, y, takes the value of 1 if a supermarket commits to offering irradiated ground beef and 0 if it rejects it. The factors thought to explain this decision compose a vector, x, so that

(1)   Prob $(y = 1) = F(x'\beta)$, and

(2)   Prob $(y = 0) = 1 - F(x'\beta)$,

where $x'\beta$ here takes a linear form. Choosing a logistic distribution, (1) becomes

(3)   Prob $(y = 1) = \dfrac{e^{\beta'x}}{1 + e^{\beta'x}}$.

One should note that the marginal effects from the Logit model are given by the following expression:

$$(4) \qquad \frac{\partial E[y]}{\partial x} = \left(\frac{e^{\beta'x}}{1+e^{\beta'x}} \right)\left(1 - \frac{e^{\beta'x}}{1+e^{\beta'x}} \right)\beta,$$

where this expression is calculated using the means of the variables in x.

Model 1 in Table 3 presents Logit results for the entire list of variables listed in Table 2 plus one related variable, store size squared, to account for any nonlinear effect store size has on adoption, as discussed above. The results show that very few estimated coefficients are statistically significant: Only coefficients for the East and Midwest regions are significantly different from zero at the 95 percent confidence level; while coefficients for distance to the primary competitor, the supply-chain technology index, organic produce, weekly meat inventory turns, and the South region are significant at the 90 percent level. These results may indicate at least two problems with Model 1. First, as discussed above, they may suggest that some of the variables reflect store-level rather than corporate-level decision making. A good example of this problem might be the median household income variable, which is collected at the zip code level and may not accurately reflect the average income of a particular supermarket chain's customers. Second, Model 1 may have a multicolinearity problem. Model 1 has a condition number of 19.61, a value just under the threshold value of 20 that Greene (2003, p. 57-58) suggests is indicative of a problem.

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[5] See Kinsey et al. (2003), for more information on these two composite indexes. While TFIC constructs a similar index that reflects a store's commitment to a variety-based merchandising philosophy, that index includes the adoption status of irradiated ground beef, and therefore its inclusion could bias the model estimation.

Table 3: Logit Results for Supermarkets' Adoption of Fresh Irradiated Ground Beef (t-stats in parentheses)

Independent Variable	Model 1	Model 2	Model 3		Model 3 Marg. Probs.
Constant	-4.773* (-3.487)	-4.437* (-3.913)	-6.301* (-6.261)		- 0.527*
Competitor Status	0.449 (0.919)	0.474 (1.010)	0.709† (1.925)		0.071
Distance to Competitor	-0.136† (-1.930)	-0.143* (-2.132)	-0.085† (-1.683)		- 0.007†
Supply Chain Technology Index	3.119† (1.721)	2.690† (1.863)			
Service Index	0.502 (0.336)	0.847 (0.586)	2.315* (2.076)		0.193*
Organic Produce	1.132† (1.825)	1.081† (1.826)			
Weekly Inv. Turns, Meat	-0.022† (-1.927)	-0.019† (-1.706)			
Store Size	2.65×10^{-5} (1.044)		5.63×10^{-5}* (2.146)		0.000*
Store Size Squared	-1.67×10^{-10} (-0.971)		-4.05×10^{-10}† (-1.904)		- 0.000
Corp. Structure Stratum	-0.220 (-0.972)		0.266† (1.653)		0.022
East Dummy	3.142* (3.338)	3.275* (3.604)	3.277* (4.384)		0.557*
Midwest Dummy	1.616* (1.978)	1.695* 2.114	1.735* (2.595)		0.153*
South Dummy	1.591† (1.687)	1.394 (1.507)	1.770* (2.424)		0.244*
Median HH Income	1.12×10^{-5} (0.556)				
Pseudo R-squared	0.2834	0.2669	0.2540		
Pct. Correct Predictions	85.29	84.69	86.54		
Condition Number	19.61	11.34	14.36		

Notes: * = Significantly different from zero at the 0.05 level; † = Significant at the 0.10 level.

In Table 4, a correlation matrix for most of the variables (i.e., not the regional dummy variables), confirms that two pairs of variables have correlation coefficients of over 0.5, while six other pairs (not counting the regional dummies) have correlation coefficients of between 0.3 and 0.5. Upon closer examination of Table 4, one sees that several of the variables that describe a store's merchandising philosophy (e.g., the supply-chain technology index and the organic produce variable) may be correlated with some of the variables reflecting size or corporate structure. This potential correlation could be explained by bigger chains and bigger stores having the physical room necessary to offer organics and supply-chain services.

Table 4: Correlation Matrix for Table 2 Variables (Excluding Regional Dummies)

	Competitor Status	Dist. to Competitor	Supply Chain, Tech.	Service Index	Organic Produce	Weekly Meat Inv. Turns	Store Size	Corp. Structure Stratum	Median HH Income
Competitor Status	1.00000	0.08767	0.05793	0.04830	-0.01663	0.00465	0.00794	0.03588	-0.01008
Dist. to Competitor	0.08767	1.00000	-0.09314	-0.02051	-0.24064	0.10380	-0.27521	-0.35059	-0.21441
Supply Chain Tech. Index	0.05793	-0.09314	1.00000	0.26808	0.31077	-0.01457	0.41068	0.54469	0.11745
Service Index	0.04830	-0.02051	0.26808	1.00000	0.32956	-0.05449	0.15834	0.08349	0.08457
Organic Produce	-0.01663	-0.24064	0.31077	0.32956	1.00000	-0.07090	0.35051	0.34309	0.30335
Weekly Meat Inv. Turns	0.00465	0.10380	-0.01457	-0.05449	-0.07090	1.00000	-0.00189	-0.10458	-0.01347
Store Size	0.00794	-0.27521	0.41068	0.15834	0.35051	-0.00189	1.00000	0.57168	0.30155
Corp. Structure Stratum	0.03588	-0.35059	0.54469	0.08349	0.34309	-0.10458	0.57168	1.00000	0.25756
Median HH Income	-0.01008	-0.21441	0.11745	0.08457	0.30335	-0.01347	0.30155	0.25756	1.00000

To correct for potential multicolinearity problems, two new models were estimated that exclude some suspect explanatory variables. These results are presented in Table 3 under the labels Models 2 and 3. Model 2 excludes store size, store size squared, the corporate structure stratum, and median household income. Alternatively, Model 3 excludes the supply-chain technology index, organic produce, weekly meat inventory turns, and median household income. Table 3 shows that the condition number drops to 11.34 and 14.36, respectively, for Models 2 and 3.

Results in Table 3 show that a number of estimated coefficients that were not significantly different from zero in Model 1 now become significant in Model 2 (but not Model 3). Model 3 is best at correctly predicting adoption (86.65 percent) but worst in terms of the pseudo R-squared. Relevant to the earlier discussion of the competitive landscape, the estimated coefficient on the irradiate ground beef status a store's primary competitor now becomes significant at the 90 percent level in Model 3. The coefficient on a store's distance to its primary competitor remains significant at the 90 percent level. These two Model 3 results, therefore, provide limited support for the hypothesis that a store's decision to adopt irradiated ground beef is part of the competitive landscape.

A store's service index has a positive and significant impact on a store's likelihood of offering fresh irradiated ground beef in Model 3. As Kinsey et al. (2003) state (p. 39-49), service offerings can be a way for stores to differentiate themselves from competitors. In the specific case of irradiated ground beef, it may be that stores who are already committed to being service leaders see the new product offering as providing a new service to their customers. For its new product launch, for example, Wegmans' promotional materials stressed that its new offering provided added food safety benefits.

Store size has two effects on the likelihood of adoption in Model 3. The positive sign on store size implies that larger stores are more likely, and may find it easier, to adopt. But this relationship changes as stores get larger, as evidenced by the negative sign on squared store size. Combined, the two results imply that store size may have a positive effect on adoption until the size becomes too large, at which time the relationship reverses. In other words, the ease of adopting a new product may increase with store size up to the point where a store's large size may indicate an alternative format.

The positive coefficient on corporate structure stratum in Model 3 suggests that as firms increase the number of stores from one category to another, the odds of adoption increase. Finally, the positive coefficients on the regional dummy variables for East, Midwest, and South all suggest that the odds of adoption increase compared to the West region.

Table 3 also presents the marginal probabilities (change in probability) of the Logit coefficients for Model 3. Among other findings, these results show that a store is 7.1 percent more likely to adopt irradiated ground beef if one of its competitors has also adopted (although this marginal probability is not statistically different from zero). Also, a store in the East region is 55.7 percent more likely to adopt than a store in the West region; a store in the Midwest is 15.3 percent more likely to adopt; and a store in the South is 24.4% more likely to adopt.

In an attempt to gain further insight into the relationship between a competitor's status and a store's own adoption decision, we identified two groups of stores that decided to adopt irradiated ground beef. Based on the survey responses associated with Figure 4, we split the adopters into two groups: "leaders" and "followers." Leaders were those stores that adopted in advance of any of their three competitors; followers were those stores that adopted but were not leaders. A total of 46 stores were classified as leaders; 22 were classified as followers. Based on the two groups, we reexamined TFIC 2003 panel data to look for statistically significant differences in store attributes or demographic variables. More specifically, we investigated the following variables: the supply-chain, service, and variety indexes created by TFIC; self-identified price, service, quality, or variety leadership variables; whether the store was domestically owned; size of selling area; number of employees, the percentage of total sales assigned to private label products; the number of inventory turns; the number of SKUs,

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and the average weekly store sales. We found very few significant differences in these variables between leader and follower groups. In total, we found significant differences (using a one-tail t-test) in only three variables: the technology-based supply chain index constructed described in Table 2, the median household income (also described in Table 2), and the median house value from Census information.   For example, the median income for the zip code served by leader stores is more than $4,000 higher for leader stores, and the median house value is more than $20,000 higher for leader stores. Table 5 presents these results.

Table 5: T-Test Results for Statistical Differences Between Leaders and Followers

Number of Leaders: 46
Number of Followers: 42

Variable	Mean-Leader	Mean-Follower	t-stat	p-value (one tail)
Supply chain-technology index	0.53	0.461	1.735	0.046
Median HH Income	$47,985	$43,863	1.328	0.095
Median House Value	$131,941	$110,030	1.791	0.039

Conclusions and Implications

Taken collectively the Logit results of store-level adoption behavior generally describe an adoption rationale that is partially consistent with the spatial and chronological patterns shown in Figure 2. The supermarket adoption maps in Figures 2 and 3 suggest that once a leader enters the market, other supermarkets in the same geographic market are more likely to follow suit. Based on TFIC Panel data, the Logit results offer limited support for this hypothesis by providing some evidence that a supermarket is more likely to adopt if its competitors have also adopted, and if it is in close proximity to the competitor. The results also indicate that other factors such as store size and corporate structure play an important role.

In addition, the results support the hypothesis that supermarkets' decision to offer fresh irradiated ground beef moved beyond a number of controversial issues surrounding unusual product attributes and uncertain consumer acceptance. Instead, the results suggest that this new product offering may be part of broader strategies that involve non-price competition between local or regional rivals. For example, we find that supermarkets are more likely adopt and offer irradiated ground beef if they scored higher on an index that reflects a store's commitment to a service philosophy.

While the issue of irradiated ground beef adoption has been taken off the table, at least temporarily, by the bankruptcy of the industry's leading technology provider, this research may have important implications for other retail food products where attributes are associated with a particular production technology and where retailers perform a gatekeeper role. Examples of these types of products may include certified organic fresh and processed foods, so-called nutraceuticals and functional foods, and in some international markets genetically modified foods. When considering the potential adoption of generically modified foods, for example, European supermarkets may play an even stronger gatekeeper role than their U.S. counterparts. In this case, European supermarkets may draw a qualified lesson both from Wegmans' successful introduction of fresh irradiated ground beef and our study's results. Wegmans successfully diffused some consumer concerns by emphasizing consumer choice. Further, our results provide evidence that supermarkets were more comfortable introducing the new irradiated ground beef product if their competitors did likewise. This lesson is qualified, however, by stressing our study deals only the adoption of irradiated ground beef in the U.S. and not in Europe or any other international market.

While these results demonstrate the influence that a leader can have in a geographic market, they only begin to provide insight into what attributes might characterize the leader, i.e., the first supermarket in a region to adopt irradiated ground beef. We now know that Wegmans Food Stores' decision in May 2002 was an important spark to subsequent adoptions. But we can say very little about what attributes or demographic variables describe a leader in this issue. We see, for example, that only a very few store demographic variables or store attributes separate leaders from followers. Continuing to investigate what separates the leaders from the followers would be the logical continuation of this line of research. Knowing this answer would be very valuable to marketers who are tasked with introducing a new product. In the case of irradiated ground beef, supermarket adoption was at best cautious or limited until the technology provider SureBeam found a leader like Wegmans (or vice versa).

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