Sales Responses to Recalls for *Listeria monocytogenes*:
Evidence from Branded Ready-to-Eat Meats

Michael R. Thomsen
University of Arkansas

Rimma Shiptsova
Utah State University

Sandra J. Hamm
University of Arkansas

Selected Paper prepared for presentation ath the Southern Agricultural Economics Association Annual Meeting, Tulsa, Oklahoma, February 2004

Correspondence:
Mike Thomsen
University of Arkansas
217 Agriculture Building
Fayetteville AR, 72703
479 575-2256
mthomsen@uark.edu

*This research is based in part on Information Resources, Inc.'s InfoScan Reviews Data.

Sales Responses to Recalls for *Listeria monocytogenes*: Evidence from Branded Ready-to-Eat Meats

Introduction

A large number of studies have addressed the impact of unfavorable product safety information on the demand for food commodities. The foodborne hazards examined to date include those with chronic and long-term consequences such as pesticide residues (Brown; Swartz and Strand; Johnson; Smith van Ravenswaay and Thompson; Liu, Huang, and Brown) or more recently concerns over Bovine Spongiform Encephalopathy and Variant Creutzfeldt-Jakob Disease (Verbeke and Ward; Burton and Young). Studies also address unfavorable information related hazards that pose immediate health effects. These include foodborne pathogens (Dahlgren and Fairchild; Brown and Folsom; Richards and Patterson) and paralytic shellfish poisoning (Wessells, Miller, and Brooks). In most cases, unfavorable information is measured in terms of media coverage of the foodborne hazard in question and/or as a binary variable controlling for periods of time affected by an outbreak or food scare.

A main question addressed by these studies is to what extent do markets respond to unfavorable product safety information. Another concern raised in many of these studies is that "innocent" producers also suffer losses in the wake of a food scare because consumer confidence in the safety of their commodity is diminished. For example, Swartz and Strand suggested that government provided information assuring consumers that available supply is safe could lower the magnitude of producer welfare losses.

Later findings do suggest that positive information either in the news media (Smith, van Ravenswaay, and Thompson; Liu, Huang, and Brown) or through advertising expenditures (Verbeke and Ward) can play some role in reassuring consumers, but the impact of positive information is considerably smaller than that of negative information.[1] Verbeke and Ward, for example, estimate that positive advertising has an impact that is 5 times smaller than negative information. Richards and Patterson explain the disproportionate impact of negative information in terms of attribution theory and note that given a concave utility function that incorporates information about product attributes, the utility change resulting for negative information is larger in absolute value than the utility change resulting from positive information.

One source of information that has not been addressed in earlier studies is information provided through branding. A well-developed theoretical literature suggests that for goods with experience attributes, investments in brand equity provide signals to consumers with less than perfect a priori information about product quality (Nelson; Klein and Leffler; Kihlstrom and Riordan; Ippolito).[2] The essential logic is that brand identity is a bond that the firm forfeits in the event that it provides the consumer with less than the expected level of quality (see Ippolito for a discussion of the bonding nature of brand signals). Brands can be effective in this capacity because brand awareness is firm specific, has value, is costly and usually can only be developed over time. Kirmani and

---

[1] Smith, van Ravenswaay, and Thompson construct an index of positive media coverage for use in their study, but specification tests they conducted suggested a model incorporating negative information only was superior. They do, however, compare the impact of positive information to previously published findings on the impact of advertising to conclude that the impact of negative information is large in magnitude than the impact of positive information.

[2] Following Nelson, experience attributes refer to those that cannot be determined by the consumer pre-sale. Examples include taste, texture, and for purposes of the present study, product safety.

Rao provide a review of empirical studies in both marketing and economics and find empirical evidence for the signaling ability of brands and advertising.

Invariably, the products examined in earlier studies of food scares involve food commodities with little or no brand identities, e.g., milk, fresh seafood, strawberries, and fresh meat and poultry products. In these cases, it is likely that a consumer with less than perfect information would err on the side of caution in the wake of a food scare by avoiding the product or decreasing the amount of consumption. With branded products a food scare that can be directly linked to one or more brands the effect of avoidance costs are less clear.

This study seeks to build on earlier work by examining whether brands can ameliorate spillover effects to firms not directly implicated in a food safety incident. The analysis presented here examines frankfurters, a highly branded ready-to-eat (RTE) meat product. The food safety events analyzed are recalls for *Listeria (L.) monocytogenes*. *L. monocytogenes* is an environmental pathogen that can contaminate a wide variety of food products. Those who become ill from consuming foods contaminated with this pathogen experience symptoms ranging from a mild and flu-like to serious involving neurological infections, spontaneous abortion, and death. Foods at greatest risk for contamination with this pathogen include raw milk products, RTE meats, and soft cheeses. In December 1998 an outbreak of Listeriosis was attributed to frankfurters and luncheon meats and resulted in recall of 35 million pounds of these products. This was and remains the largest meat and poultry recall in history. Several other recalls of various sizes followed in 1999 and 2000, the period analyzed in the study.

The objectives of this study are to:

(1) Quantify sales declines for frankfurter brands implicated in a recall for *L. monocytogenes*.

(2) Determine whether frankfurter brands, not directly implicated in a recall, experience sales declines.

(3) Provide information on brand recovery following a recall for *L. monocytogenes*.

Data

Retail sales data are from Information Resources, Inc.'s (IRI) InfoScan data for the frankfurters category. These data reflect supermarket sales in 64 US markets. Observations provided in the Infoscan data are market level aggregates. Each observation reflects a given brand sold in a given market over a four-week period. The data used for this study include 28 quad-week observations for hundreds of brands of frankfurters over the period of November 1998 to December 2000. The specific InfoScan measures used in this study are volume sales (lbs), dollar sales, percent all commodity volume weighted distribution (a measure of a brand's distribution exposure within a market), and percent of sales in the presence of merchandising activities such as features and/or displays. The retail price per pound was obtained by dividing dollar sales by volume sales. Data for recall events were obtained from the USDA's Food Safety and Inspection Service (FSIS). FSIS records provide the date of the recall, the reason for the recall, the product recalled, the brand names implicated in the recall, and the geographic region affected by the recall. These records also provide the size of recalls in terms of pounds subject to recall and pounds actually recovered.

The recall data were matched to the InfoScan data by brand, by market, and by date. Table 1 provides the number of recalled brands identified in each of the 64 markets. Some issues in matching the two data sets are as follows:

1. Brand names listed in the InfoScan data were sometimes more specific than those listed in the FSIS records. For example, if FSIS records indicated that a given brand was recalled, that brand might appear several times in the InfoScan data with qualifiers such as "Old Fashioned", "Home style", "Plump and Juicy", and the like. When this type of sub-branding was apparent and prior to identifying matches with the FSIS data, volume sold was recomputed as the sum over the various sub-brands and weighted averages were computed for the price, merchandising, and distribution variables using the sales of each sub-brand as the weight.

2. In some cases, brand names in the FSIS records were not in the InfoScan data. Most, if not all, of these cases appear to be product recalled from foodservice and institutional channels or private label brands not specifically identified by name in the InfoScan data.

3. When the geographic scope of the recall was less than nationwide, FSIS records usually indicated one or more states that were affected by the recall. In these cases, implicated brand names sold in markets other than those within the geographic purview of the recall were not considered to have been recalled for purposes of database preparation. For example, if a given brand was implicated

in a recall that only affected product shipped to Ohio, that brand was considered to be a recalled brand in the Cleveland, Toledo, Cincinnati, and Columbus markets but was considered to be a non-recalled brand in other market.

4. A meat recall is initiated by a processing establishment and is supervised by the FSIS. In frankfurter production, co-packing is commonplace and one establishment may produce products for several brand names. It is not uncommon for a single FSIS recall to affect more than one brand.

5. The entry and exit of brands within markets was fairly commonplace over the study period. To account for sporadic distribution among some brands, we removed brand/market combinations that did not have positive sales during all 28 quad-week periods. We also eliminated brand/market combinations that showed a greater than 500 percent increase in volume sold during any period.

In total 9 recalls from the FSIS records were successfully matched to brands in the InfoScan data. Table 2 reports the dates of these recalls, their size, and the number of brands and markets affected by each recall. In total, there were 166 brand/market time series that were affected by at least one recall over the study period. Only one brand was twice implicated. Once in recall #1 and then later in recall #6. There was a great deal of heterogeneity among markets in terms of the brand offering. In many cases a leading brand in one market was not even distributed in others. Consequently the number of brand market series affected by a given recall reported in table 2 will generally not be the product of brands affected and markets affected by the recall.

The sales impact of recalls

To estimate effects of individual recalls we estimate a system of seemingly unrelated regressions for each of the 64 markets. Each system has a number of equations equal to the number recalled brands in the market (table 1) plus one additional equation for an aggregate non-recalled brand[3]. The brand equations are specified to be of the form:

(1) $$Q^*_{ijt} = \mathbf{X}^*_{ijt}\boldsymbol{\theta}_{ij} + \sum_{s=0}^{2}\gamma^s_{ij}D^s_{ijt} + \varepsilon_{ijt}$$

where i indexes the brand, j indexes the market, and t indexes the time period. The dependent variable is calculated as the percent change in volume sold,

(2) $$Q^*_{ijt} = \left[\frac{Q_{ijt} - Q_{ijt-1}}{Q_{ijt-1}}\right] \times 100,$$

Explanatory variables are $\mathbf{X}^*_{ijt}$, a row vector measuring percent changes in demand variables that include: percent change in own price, change in own merchandising intensity, change in the brand's distribution within the market, and percent change in market expenditures for frankfurters. The D^s_{ijt} are binary variables equal to equal to one if the brand was implicated in a recall *s* periods ago. In the aggregate non-recalled brand equation, D^s_{ijt} takes the value of 1 if there was a recall affecting any brand in the market *s* periods ago. The vector $\boldsymbol{\theta}_{ij}$ and scalars γ^0_{ij}, γ^1_{ij}, and γ^2_{ij} are parameters to be estimated.

[3] The aggregate non recalled brand reflects the sum of volume sold for all non-recalled brands in the market, with price and other demand variables calculated as a weighted average.

Note that both the dependent variable and the demand variables in $\mathbf{X}_{ijt}^{*}$ are normalized to have a percent change interpretation. This normalization facilitates a comparison across brands that vary greatly in terms of sales volumes.

After estimating the parameters of the 64 SUR systems, one system for each market, we aggregate over the estimates of γ_{ij}^{0}, γ_{ij}^{1}, and γ_{ij}^{2} to obtain an estimate of the average cumulative effect of a given recall. Let r = 1, 2, …., 9 index the recalls observed over our study period and reported in table 2. The immediate impact of the r^{th} recall is obtained by averaging the γ_{ij}^{0} over brands and markets that were affected by r^{th} the recall. To obtain estimate of the average cumulative effect one four week period and two four week periods after the recall, estimates of γ_{ij}^{1} and γ_{ij}^{2} that correspond to the r^{th} recall were included in the average as well.

To conduct hypotheses tests about the average immediate and cumulative impacts of the r^{th} recall we first compute the variance of aggregations involving the j^{th} market using the variance covariance matrix of the parameter estimates of the SUR system as:

(3) $$s_{jr}^{2} = \mathbf{k}'_{jr}\mathbf{V}_{j}\mathbf{k}_{jr},$$

where $\mathbf{k}_{jr}$ is a vector with elements taking the values of zero or one.[4] Values of one are placed strategically to include the needed variance and covariance terms for estimates of the γ_{ij}^{s} that correspond to brands affected by the r^{th} recall. The standard error for the average effect of a recall is then computed by combining the s_{jr}^{2} across markets as follows:

[4] $\mathbf{V}_{j} = [\mathbf{X}'_{j}(\mathbf{\Sigma}_{j} \otimes \mathbf{I})\mathbf{X}_{j}]^{-1}$, where $\mathbf{\Sigma}_j$ is the cross model inverse covariance matrix, and $\mathbf{X}_j$ is a block diagonal regressor matrix with $\mathbf{X}_{ij}^{*}$ on the diagonal blocks.

(4) $$SE_r = \sqrt{\frac{1}{N_r^2}\sum s_{jr}^2}$$

Note that in estimating the average effect of a recall, we assume independence across markets. We do not, however, assume independence between brand equations from the same market.

Table 3 presents the aggregated cumulative brand sales impact. The immediate sales drop attributed to a recall ranged from -7.7 percent to -43.4 percent. With exception of three small recalls (recalls #3, #5, and #7), the average sales drop is statistically significant. However, there is not necessarily a clear relationship between recall sizes (either in terms of pounds subject to recall or pounds actually recovered) and magnitude of sales losses. For instance, recalls #4 and #8 involved 2.1 million and 15,000 pounds, respectively and caused sales drops that are in line with losses resulting from the two large 35 million pound recalls. The average impact computed over all recalls in the sample shows a 22 percent drop in sales during the 4 week period of the recall.

Table 3 provides some evidence about when brand recovery might start to occur following a recall. The cumulative impact during the period of the recall and 4 weeks following suggests that sales continued to decline for the two large recalls (#1 and #2) and for recalls #8 and #9. Aside from some of the very small recalls, only brands affected by recall #4 show evidence of recovery during the 4 week period immediately following the recall. During the next 4 weeks (roughly 2 months after the recall occurred) there is evidence that sales did start to recover. The three period cumulative impacts resulting from the two largest recalls are statistically significant at only the 10 percent level. Only recall #8 continues to show a highly significant sales drop two periods after the recall. The averages over all recalls suggests an overall pattern wherein recalled brands continue to lose sales during the 4 weeks after the recall period but start to recover approximately two months after the recall.

There is no evidence that non-recalled brands suffer collateral damage when competing brands are implicated in a recall. If anything, there is evidence that non-recalled brands increase sales during and immediately after a recall. On average, sales of non-recalled brands increased 2.70 percent during the four weeks of a recall and were 4.05 percent higher than pre-recall levels during the next four week period.

Further analysis of brand recovery

One advantage of the above specification is that coefficients of the model are allowed to be different for across brands and markets and aggregations conducted post-estimation can provide information on whether some recalls have bigger impacts than others. However, the shortness of the available time series and accompanying degree of freedom problems does not permit a satisfactory examination of longer-term effects of recalls. To examine the issue of brand recovery in more detail we pool the data series for both recalled and non recalled brands. The idea is to construct treatment groups consisting of (1) brands implicated in a recall situation, and (2) non-recalled brands in markets that were affected by a recall. The pooled dataset consists of 42,066 observations.

As in the previous specification, the dependent variable is the percent change in quantity sold and explanatory variables include percent change in own price, change in own merchandising intensity, change in the brands distribution exposure within the market, and percent change in total expenditure on frankfurters in the market. Degrees of freedom are not a concern with the pooled data set and additional regressors are included to control for seasonality, the percent change in the weighted average price of all competing brands, and the percent change in the weighted average merchandising intensity of all competing brands. As in the previous specification, a series of binary variables, D_{ijt}^{s}, are included and equal 1 if brand i in market j was subject to a recall s periods ago. A second series of binary variables is included in the pooled regression and are set equal to 1 if the brand was not implicated in a recall but was sold in a market that experienced a recall s periods ago. The number binary recall variables included in the regression model was based on Akaike's information criterion.

Table 4 presents coefficient estimates for the demand variables in the pooled regression model. The dataset is largely cross-sectional and heteroskedasticity is a problem. Test statistics reported in Table 4 are based on White's consistent estimates of the variance covariance matrix. The signs, magnitudes, and statistical significance associated with the coefficients for the demand variables are largely as would be expected. The only demand variable that is statistically insignificant is that associated with changes in the weighted average price of competing brands.

The estimated coefficients and t ratios for the recall variables are reported in figure 1. Because the dependent variable is expressed as a percent change measure, the estimated coefficients for the recall variables can be interpreted as the period-to-period growth rate in sales for brands following a recall and can be used track whether sales revert to pre-recall levels over time. Figure 1 presents indexes for recalled brands and non recalled brands, both arbitrarily set to a value of 100 in the period before a recall. As in the disaggregate analysis presented above, results from the pooled regression model suggest an average 22.7 drop in sales during the 4 weeks of a recall. Sales begin to recover 8 to 12 weeks after a recall has occurred and approach pre-recall levels 16 to 20 weeks after the recall. Again, there is no evidence that non-recalled brands sold in markets that experience a recall suffer sales losses. There is actually statistical evidence that non-recalled brands increase sales after a recall has occurred.

Discussion

The finding that recalled brands experience sales declines following a recall is not unexpected. Common sense suggests that in the vast majority of recall cases could only hurt a brand's sales. However, the estimated magnitudes of sales declines – on average, sales of recalled brands fell 22 to 27 percent during the four to eight week period after a recall – is interesting and suggests very real economic incentives to minimize the potential for a contamination incident involving *L. monocytogenes* and thereby lower the risk of a recall situation.

One unresolved problem is determining what proportion of the observed sales declines are attributable to the consumer avoiding recalled brands and what proportion is attributable to product being removed from distribution and thus not being accessible for consumer purchase. Unfortunately, there was no way to isolate these two effects given the level of detail provided in FSIS records on recall activity. The records provide information about the total size of a recall, the total pounds actually recovered from distribution, and brand names effected. However, because many recalls affect multiple brands there is no way to attribute how many pounds of a single brand were recovered. The problem is further complicated by the fact that many recalls affected product sent to both food service as well as to retail channels and in some cases the total volume subject to recall included other types of RTE meats in addition to frankfurters.

While a temporary reduction in supply is certainly one cause of the decline in sales, the brand recovery pattern is consistent with at least some degree of consumer aversion to recalled brands. On average, sales do not revert to pre-recall levels for four to five months after a recall is initiated. This exceeds the shelf-life of frankfurters and it is unlikely that sales would remain low much longer than one to two months because frankfurters intended for commerce were unavailable for purchase.

The most interesting finding is that non recalled brands did not experience sales losses in the wake of a recall. If anything, non recalled brands experience an increase in sales when a competing brand is implicated in a recall. This suggests that if recalls do provide product safety information to consumers, consumers view the problem to be a brand problem and not a category problem. One interpretation of this finding is that brand equity does provide a signal to the consumer about product safety and can insulate firms from an industry wide safety problem.

References

Brown, J. D. “Effect of a Health Hazard “Scare” on Consumer Demand.” *American Journal of Agricultural Economics* 51(1969):676-78.

Brown, J. W. and W. D. Folsom. “Economic Impact of Hard Clam Associated Outbreaks of Gastroenteritis in New York State.” National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFC-121. August 1983.

Burton, M. and T. Young. “The Impact of BSE on the Demand for Beef and Other Meats in Great Britain.” *Applied Economics* 28(1996):687-93.

Dahlgren, Roger A. and D. G. Fairchild. “The Demand Impacts of Chicken Contamination Publicity—A Case Study.” *Agribusiness* 18(2002):459-74.

Ippolito, P. M. “Bonding and Nonbonding Signals of Product Quality.” *Journal of Business*. 63(1990):41-60.

Johnson, F. R. “Economic Costs of Misinforming About Risk: The EDB Scare and the Media.” *Risk Analysis* 8(1988):261-69.

Kihlstrom, R. E. and M. H. Riordan. “Advertising as a Signal.” *Journal of Political Economy*. 92(1984):427-50.

Kirmani, A.. and A. R. Rao. “No Pain, No Gain: A Critical Review of the Literature on Signaling Unobservable Product Quality.” *Journal of Marketing* 64(2000):66-79.

Klien, B. and K. B. Leffler. “The Role of Market Forces in Assuring Contractual Performance.” *Journal of Political Economy* 89(1981):615-41.

Liu, S. J.-C Huang, and G. L. Brown. “Information and Risk Perception: A Dynamic Adjustment Process.” *Risk Analysis* 18(1998):689-99.

Nelson, P. "Advertising as Information." *Journal of Political Economy* 82(1974):729-754.

Richards, T. J. and P. M. Patterson. "The Economic Value of Public Relations Expenditures: Food Safety and the Strawberry Case." *Journal of Agricultural and Resource Economics* 24(1999):440-62.

Smith, M. E., E. O. van Ravenswaay, and S. R. Thompson. "Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii." *American Journal of Agricultural Economics* 70(1988):513-520.

Swartz, D. G. and I. E. Strand. "Avoidance Costs Associated with Imperfect Information: The Case of Kepone." *Land Economics* 57(1981):139-150.

Verbeke, W. and R. W. Ward. "A Fresh Meat Almost Ideal Demand System Incorporating Negative TV Press and Advertising Impact." *Agricultural Economics* 25(2001):359-374.

Wessells, C. R., C. J. Miller, and P. M. Brooks. "Toxic Algae Contamination in Demand for Shellfish: A Case Study of Demand for Mussels in Montreal." *Marine Resource Economics* 10(1995):143-159.

Table 1: Number of Recalled Brands Identified in Each IRI Market

Market	Brands	Market	Brands	Market	Brands	Market	Brands
Albany	2	Grand Rapids	4	Mississippi	2	Roanoke	7
Atlanta	6	Green Bay	1	Nashville	5	Sacramento	1
Baltimore	1	Harrisburg	3	New England	3	Salt Lake City	1
Birmingham	7	Hartford	5	New Orleans	2	San Antonio	2
Boise	1	Houston	2	New York	5	San Diego	1
Boston	2	Indianapolis	2	Oklahoma	2	San Francisco	1
Buffalo	2	Jacksonville	3	Omaha	1	Seattle	2
Charlotte	5	Kansas City	3	Orlando	3	South Carolina	8
Chicago	2	Knoxville	6	Peoria	2	Spokane	1
Cincinnati	1	Little Rock	2	Philadelphia	3	St Louis	2
Cleveland	2	Los Angeles	1	Phoenix	1	Syracuse	2
Columbus	1	Louisville	3	Pittsburgh	2	Tampa Bay	3
Dallas	4	Memphis	2	Portland	2	Toledo	1
Denver	1	Miami	2	Providence	2	Tulsa	2
Des Moines	2	Milwaukee	3	Raleigh	5	West Texas	2
Detroit	4	Minneapolis	2	Richmond	2	Wichita	1

Table 2. Recall Cases Matched to IRI Data

Recall #	Date of Recall	Pounds Recalled	Pounds Recovered	Brands Affected	Markets Affected	Mkt/ Brand Series (N)
1	22/12/98	35 mil.	5.92 mil.	2	63	81
2	22/01/99	35 mil.	8.43 mil	6	32	44
3	05/02/99	1,545	1,507	1	1	1
4	13/10/99	2.1 mil.	377,922	1	10	10
5	18/11/99	1,020	650	1	1	1
6	24/03/00	34,500	200	1	30	30
7	24/05/00	2,870	2,335	2	1	2
8	29/05/00	15,000	5,856	2	5	10
9	03/10/00	900,000	409,620	3	10	17

Table 3: Aggregate Cumulative Impact of Recalls

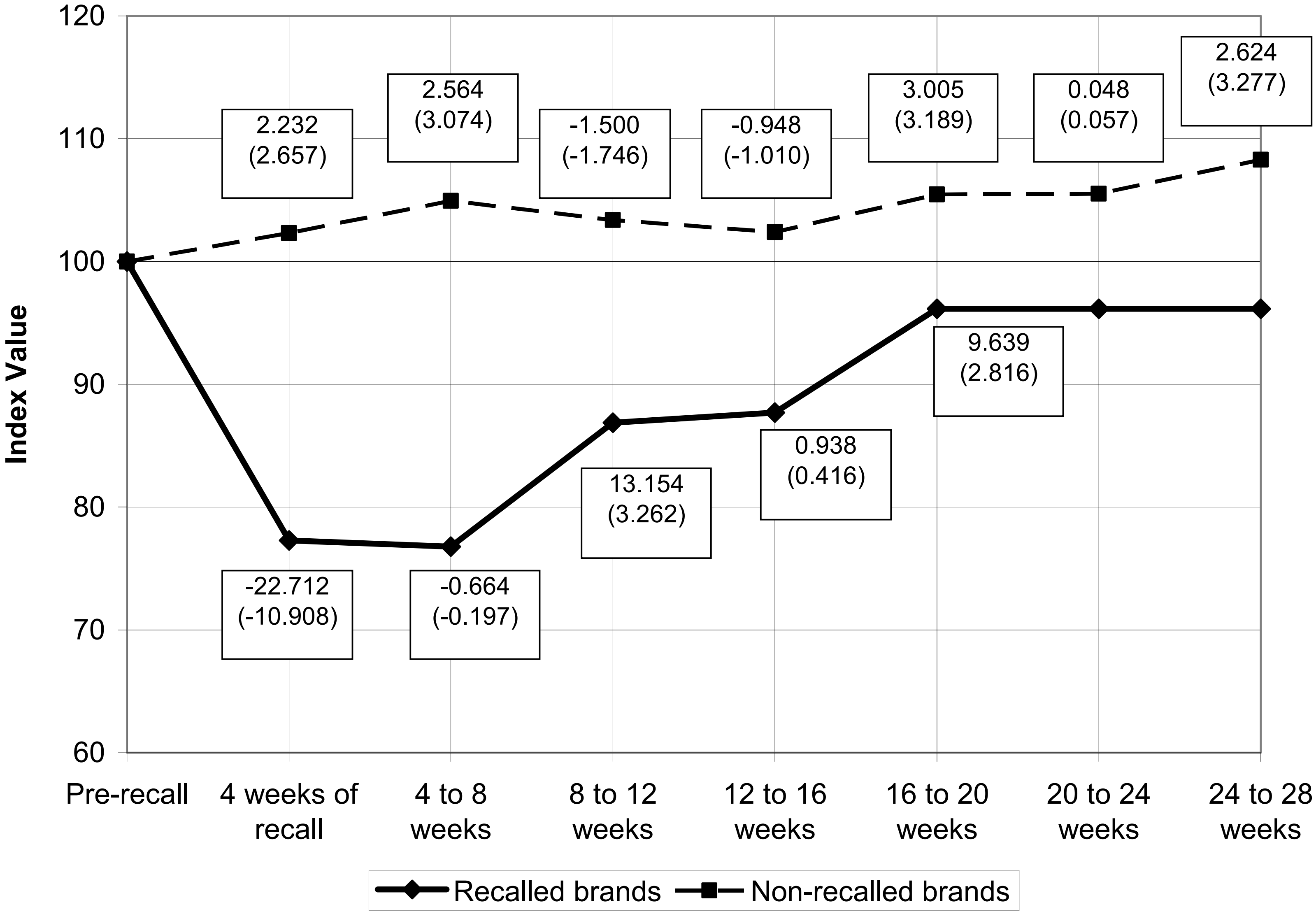
Recall #	Date of recall	Pounds	Pounds Recovered	N	Recall Period		Recall Period and 4 weeks after		Recall Period and 8 weeks after	
1	22/12/98	35 mil.	5.92 mil.	51	-14.57	***	-19.23	***	-9.71	*
					(-3.77)		(-3.17)		(-1.45)	
1b	22/12/98			30	-12.54	***	-7.19	*	-4.34	
					(-4.23)		(-1.55)		(-0.74)	
2	22/01/99	35 mil.	8.43 mil	44	-34.49	***	-50.44	***	-27.19	*
					(-3.45)		(-3.57)		(-1.59)	
3	05/02/99	1,545	1,507	1	-4.75		55.46		82.40	
					(-0.12)		(1.00)		(1.18)	
4	13/10/99	2.1 mil.	377,922	10	-43.35	***	-30.73	*	23.44	
					(-3.26)		(-1.55)		(0.98)	
5	18/11/99	1,020	650	1	-12.71		-15.55		-29.64	*
					(-1.10)		(-0.95)		(-1.41)	
6	14/05/99	16,392	10,290		Estimated with Recall 1b					
7	24/05/00	2,870	2,335	2	-7.66		117.18		103.64	
					(-0.48)		(5.24)		(3.69)	
8	29/05/00	15,000	5,856	10	-31.90	***	-40.16	***	-34.81	***
					(-4.55)		(-4.15)		(-2.99)	
9	03/10/00	900,000	409,620	17	-14.55	*	-43.86	***	-16.32	
					(-1.48)		(-3.17)		(-0.93)	
Additional Aggregations										
All Recalls				166	-22.10	***	-27.69	***	-11.76	**
					(-6.79)		(-5.88)		(-2.08)	
Non-recalled brands				64	2.70	***	4.05	***	2.34	**
					(3.92)		(4.87)		(2.31)	

* Asterisks indicate significance: *** at the one percent level, ** at the 5 percent level, and * at the 10 percent level. Hypotheses tests are based on a t-test (in parenthesis) with 19 degrees of freedom and except for non recalled brands are one tailed.

Table 4: Parameter Estimates for Control Variables

Variable		Estimate	t ratio
Intercept		3.089	3.864
%Δ Price		-1.300	-30.564
%Δ Merchandising		0.996	51.557
%Δ Distribution		2.283	28.006
%Δ Expenditure		0.613	23.000
(%Δ Price) × (Δ Merchandising)		-0.020	-12.059
%Δ Price of competing brands		0.031	0.715
%Δ Merchandising of competing brands		-0.643	-18.547
Dependent Variable is %Δ in Quantity	N		42,066
	R^2		0.3998
	Adj. R^2		0.3993

Figure 1: Parameter Estimates for Recall Variables and Sales Recovery Pattern. [a]



[a.] t ratios are in parenthesis.