Impact of Food Contamination on Brands: A Demand Systems Estimation of Peanut Butter

Rafael Bakhtavoryan, Oral Capps, Jr., and Victoria Salin

A 2007 food-borne illness incident involving peanut butter is linked with structural change in consumer demand. Compensated and uncompensated own- and cross-price elasticities and expenditure elasticities were calculated for leading brands before and after the product recall using the Barten synthetic model and weekly time-series data from 2006 through 2008. Statistically significant differences in price elasticities for the affected brand, Peter Pan, were absent. After a period of 27 weeks, this brand essentially recovered from the food safety crisis. Significant differences in price elasticities were evident among non-affected brands. Hence, spillover effects and heightened competition are associated with the recall.

Key Words: food safety, 2007 Peter Pan recall, demand system models, scanner data

The Centers for Disease Control and Prevention (CDC) and state health departments reported cases of salmonella contamination linked to peanut butter beginning in November 2006. The cases were associated with consumption of two peanut butter brands, Peter Pan and Great Value, manufactured by ConAgra Foods Inc. at its Sylvester, Georgia, processing plant. As a result, on February 14, 2007, ConAgra voluntarily issued a nationwide recall of its Peter Pan and Great Value peanut butter products (CDC 2007).

In an effort to restore consumer confidence in the safety of the peanut butter brands, ConAgra repaired its peanut processing plant in Sylvester, Georgia, and started a large-scale marketing campaign. Particularly, ConAgra claimed that it had spent a considerable amount of money on upgrading machinery, technology, and design throughout the plant before re-opening it and returning the Peter Pan peanut butter to store shelves in August 2007 (ConAgra Foods Inc. 2007, NewsInferno 2007). During its massive marketing campaign, ConAgra sent out 2 million coupons for free Peter Pan peanut butter, sent out \$1-off coupons, and updated the design of Peter Pan peanut butter jars (Dorfman 2007). According to ConAgra, this marketing campaign was the largest investment the company had ever made in Peter Pan. To encourage customers, ConAgra redesigned the Peter Pan peanut butter jars with a "New Look" label and implemented a 100 percent satisfaction guarantee, in which a full purchase price refund was available in case customers were not satisfied with their purchase (Dorfman 2007).

The U.S. peanut butter industry is concentrated in the hands of three firms—Procter and Gamble Company, ConAgra, and CPC International Inc.—producing national brands Jif, Peter Pan, and Skippy, respectively. The remaining share of the market is attributed to regional and/or store-brand peanut butter producers. Specifically, over the study period from January 2006 to December 2008, private label (store brands), Jif, Peter Pan, Skippy, and other brands accounted for 23 percent, 35 percent, 10 percent, 20 percent, and 12 percent market shares, respectively (Nielsen Homescan panels for household purchases, 2006, 2007, and 2008).

Rafael Bakhtavoryan is Post-Doctorate Research Associate at the Agribusiness, Food, and Consumer Economics Research Center in the Department of Agricultural Economics at Texas A&M University in College Station, Texas. Oral Capps, Jr., is Executive Professor and Regents Professor, and holder of the Southwest Dairy Marketing Endowed Chair, also at the Agribusiness, Food, and Consumer Economics Research Center in the Department of Agricultural Economics at Texas A&M University. Victoria Salin is Associate Professor, also in the Agribusiness, Food, and Consumer Economics Research Center in the Department of Agricultural Economics at Texas A&M University.

The authors gratefully acknowledge the support for this research under Cooperative Agreement No. 58-4000-9-0058 with the Economic Research Service, U.S. Department of Agriculture.

Because the peanut butter category is characterized by competition among three major brands and several private label brands, a crisis in a particular brand might impact the whole category via spillover effects (Dahlen and Lange 2006). Spillover among brands, initiated by a food safety issue within a product category, is of interest in this study. Specifically, the focus is on whether a brand can withstand a food-borne illness problem or whether it is at risk when there is competition among similar branded goods. The issue relates to the potential efficacy of private market incentives for the supply of safe foods.

Specifically, the objectives of this study are as follows: (i) to empirically investigate whether the peanut butter recall resulted in a significant structural change in demand relationships, (ii) to determine the "best" demand systems specification nested within the Barten synthetic model (BSM) for studying the peanut butter recall event, and (iii) to capture changes in the own-price and cross-price effects across peanut butter brands brought about by the peanut butter recall event.

This analysis differs from previous research in several ways. First, a comparison of the respective elements of demand elasticity matrices is used to detect a structural change in the demand for peanut butter initiated by a recall. The conventional approach has been to incorporate dummy variables, which, as intercept shifters, affect only the level of the dependent variable. Elasticities also capture the impacts of changes in prices and total expenditure (or income) on the dependent variable. Second, the study is done at the brand level using Nielsen Homescan data as opposed to the use of aggregate data on products. The brand-level data add to our understanding of the competition among the peanut butter brands in the presence of the recall and provide the opportunity to assess spillover effects at the appropriate level of analysis.

The remainder of the paper is structured as follows. The next section provides a literature review on the empirical application of demand systems for studying the impact of information on consumer demand. Following the presentation of the model, the data used in the analysis are discussed. The subsequent section provides the estimation procedure and the empirical results. Summary, conclusions, and implications are presented in the final section.

Literature Review

The issue of consumer responsiveness to public health information provided via different types of media indices and communicated through various sources of media has been extensively studied in previous research. Some studies investigated consumer response to health information knowledge (e.g., cholesterol index) (Brown and Schrader 1990, Capps and Schmitz 1991, Kinnucan et al. 1997). Another group of studies analyzed consumer response to negative health information, such as Bovine Spongiform Encephalopathy (Burton and Young 1996, Peterson and Chen 2005, Pritchett et al. 2007), Salmonella (Smed and Jensen 2002), and general recall (or food safety) announcements associated with various food products (Vickner, Marks, and Kalaitzandonakes 2003, Marsh, Schroeder, and Mintert 2004, Piggott and Marsh 2004, Arnade, Calvin, and Kuchler 2008). Finally, another group of studies evaluated consumer responsiveness to both negative and positive (e.g., advertising) information (Verbeke and Ward 2001, Fousekis and Revell 2004).

To capture the impact of information on the demand for a variety of food products, in most cases a demand systems approach was employed (generally variations of the Almost Ideal Demand System and the Rotterdam model), oftentimes including dummy variables in an attempt to detect a structural change in demand associated with events. In addition to demand system estimation at the market level, one can also use experimental design to examine the influence of food safety information on consumer willingness to pay for a product (Buzby et al. 1998, Dillaway et al. 2011). Our empirical analysis corresponds to a natural experiment, in lieu of using experimental methods. But both approaches are appropriate and have a common goal: that is, to examine both the short- and longer-term impacts of media information on consumer purchasing behavior. It is interesting to contrast the time frames over which the consumer responses are measured. In particular, in the experimental lab setting, Dillaway et al. (2011) were able to track over 7 weeks. In our study, the Peter Pan recall event covered 27 weeks, and then we track for another 71 weeks covering the post-recall period.

This study empirically analyzes in a dynamic framework the issue of a structural change in the demand for peanut butter initiated by the recall of

Peter Pan. In using a demand system, our approach is similar to that used in most of the studies referenced above; however, in our analysis the dynamics were introduced through the use of the BSM. Further, there have been no studies that differentiated periods and checked for the structural change associated with events measured with changes in corresponding elasticity estimates. Unlike a conventional method of incorporating a dummy variable, the presence of a structural change in the demand for peanut butter was ascertained through the comparison of corresponding price elasticities from the pre- and post-recall periods. Also, our use of brand-specific data is unique in the literature in that it allows us to control for price reductions (e.g., coupons), which, to the best of our knowledge, have not been considered by previous research but are clearly part of a marketing effort to repair a brand after a crisis.

Model

Demand systems often have been favored over single equations when dealing with consumer demand analysis (Lee, Brown, and Seale 1994), perhaps due to the ease with which theoretically consistent restrictions such as homogeneity and symmetry are imposed. Barten (1993) developed a general model, known as Barten's synthetic model, that nests the differential versions of the Rotterdam model developed by Barten (1964) and Theil (1965), the Almost Ideal Demand System (AIDS) model developed by Deaton and Muellbauer (1980), the Dutch Central Bureau of Statistics (CBS) model introduced by Keller and van Driel (1985), and the NBR model introduced by Neves (1987). Barten's differential demand system possesses a few appealing features including functional form flexibility, linearity in parameters, potential to render variables stationary due to the required first-differencing process, and its ability to introduce dynamics. All of these, coupled with the fact that the BSM allows a determination of the specific functional form best supported by the data set used, enhance its practical application.

The Barten model is given as follows:

(1)
$$w_i d\log q_i = (\beta_i + \lambda w_i)\, d\log Q + \sum_j \left(\gamma_{ij} - \mu w_i(\delta_{ij} - w_j)\right) d\log p_j + \varepsilon_i, \quad i = 1,\ldots,n,$$

where w_i is the budget share of ith brand; q_i is the quantity of ith product; $d\log Q$ is a Divisia Volume Index; $\delta_{ij} = 1$ if $i = j$; $\delta_{ij} = 0$ if $i \neq j$; p_j is the price of brand j; β, λ, γ_{ij}, and μ are the parameters to be estimated; and ε_i is the error term. Equation (1) becomes the Rotterdam model when both λ and μ are restricted to zero, the CBS model when λ is equal to one and μ is equal to zero, the NBR model when λ is equal to zero and μ is equal to one, and, finally, the AIDS model when both λ and μ are restricted to one.

Equation (1) was estimated in this study with a correction for serial correlation. During the estimation one of the equations was dropped to circumvent the problem of singularity of the variance-covariance matrix of error terms. The parameters of the omitted equation were recovered using the following theoretical restrictions:

(2) adding-up:
$$\sum_{i=1}^{n} \beta_i = 1 - \lambda_i \text{ and } \sum_{i=1}^{n} \gamma_{ij} = 0, \quad j = 1,\ldots,n,$$

(3) homogeneity:
$$\sum_{j=1}^{n} \gamma_{ij} = 0, \quad i = 1,\ldots,n,$$

(4) symmetry:
$$\gamma_{ij} = \gamma_{ji}, \quad i, j = 1,\ldots,n, i \neq j.$$

The compensated price elasticities of equation (1) are given by

(5)
$$e_{ij}^{c} = \frac{\gamma_{ij}}{w_i} - \mu(\delta_{ij} - w_j),$$

where w_i and w_j denote the budget shares of commodity i and j, respectively, and δ is the Kronecker delta.

Using Slutsky's equation, the uncompensated price elasticities are computed as

(6)
$$e_{ij}^{u} = e_{ij}^{c} - e_i w_j.$$

The uncompensated cross-price elasticities are used to reveal the symmetry property in elasticity form using the following equation:

(7)
$$e_{ij}^{u} = \left(\frac{w_j}{w_i}\right) e_{ji}^{u} + w_j(e_j - e_i),$$

where e_i and e_j are the expenditure elasticities of commodity *i* and *j*, respectively.

The expenditure elasticity is given by

$$e_i = \frac{\beta_i}{w_i} + \lambda. \tag{8}$$

The own-price elasticities were hypothesized to be negative based on the law of demand. Positing that all brands of peanut butter would be substitutes, it was anticipated that the cross-price elasticity estimates would be positive. Finally, expenditure elasticities were expected to be positive, as we did not expect to find peanut butter to be an inferior good.

Data

Weekly data used in the estimation of the BSM were derived from the Nielsen Homescan panels for 2006, 2007, and 2008. Nielsen Homescan panels are the largest ongoing household scanner data survey system, tracking purchases made by households in the United States. For our analysis, the time-series data set ranged from Wednesday January 4, 2006, to Tuesday, December 30, 2008, and included weekly totals of quantities purchased and prices (unit values). The entire data set was broken into two separate data sets: the pre-recall and the post-recall. The timeline associated with the Peter Pan recall event was as follows:

- the pre-recall period—January 4, 2006, through February 13, 2007—for a total of 58 weekly observations;
- the recall period, when Peter Pan was not available on the shelves of the stores—February 14, 2007, through August 21, 2007—for a total of 27 weekly observations; and
- the post-recall period, when Peter Pan returned to the stores—August 22, 2007, through December 30, 2008—for a total of 71 weekly observations.

To be included in our sample, households must have made at least one purchase of peanut butter over the three-year study period (2006, 2007, and 2008). So, our analysis explicitly focuses on the behavior of peanut butter consuming households. The quantity purchased of a peanut butter brand was constructed by aggregating weekly total ounces across households and then dividing by the number of unique households that purchased that peanut butter brand in the given week. Through this division, we place emphasis on quantities purchased per household. This approach is similar to the conventional per capita transformation. Unit values were used as a proxy for prices. For each week, peanut butter unit values were calculated by dividing total expenditures by total ounces. Total expenditures were adjusted for appropriate price reductions by subtracting the value of coupons; consequently, prices also reflected that adjustment. In addition, prices were deflated using the Consumer Price Index (CPI) with the base period equal to the average of the CPI over the years 1982 to 1984 reported by the Bureau of Labor Statistics (2011). Given that the CPI is reported on a monthly basis, weekly interpolation of this series was derived to obtain inflation-adjusted measures.[1]

The entire data set was broken into five distinct peanut butter variables, one for each of the three national brands (Jif, Peter Pan, and Skippy), one for private labels (aggregated), and one for other brands.[2] The Jif peanut butter brand group included Jif, Simply Jif, Jif Smooth Sensations, and Jif To Go. The Peter Pan peanut butter brand group included Peter Pan, Peter Pan Whipped, and Peter Pan Plus. The Skippy peanut butter brand consisted of Skippy, Skippy Carb Options, and Skippy Natural. Finally, the Other Brands group included all the brands of peanut butter except for Jif, Peter Pan, Skippy, and Private Label brands.

As exhibited in Table 1, the number of unique households purchasing the respective brands is not the same week to week. In this way, we do capture, albeit at the aggregate level, those households that did not buy the brand because of knowledge of the recall. In particular, the number of unique households increases for all the brands going from the pre-recall to the recall period. This finding may be explained by the fact that the households that were consuming Peter Pan switched

[1] Details of this interpolation process are available from the authors upon request.

[2] No *separate* household purchase data on the Great Value peanut butter, which also was involved in the recall, were available. Rather, Great Value store brand was included in the Private Label category. As such, obtaining data on the Great Value peanut butter and incorporating Great Value into the analysis as a separate brand may be worth considering for future research.

Table 1. Descriptive Statistics of Peanut Butter Quantities Purchased, Prices (Real Unit Values[a]), Market Shares, and Number of Unique Households for Pre-Recall, Recall, and Post-Recall Periods[b]

	N	Quantity (ounces)		Price (cents/ounces)		Market Share (%)	Number of Unique Households (unit)	
	(weeks)	Mean	Std. Dev.	Mean	Std. Dev.		Mean	Std. Dev.
PRE-RECALL								
Private Label	58	31.93	1.56	4.01	0.13	16	641.31	143.62
Jif	58	33.51	1.83	5.09	0.13	22	683.41	213.13
Peter Pan	58	30.49	2.95	4.68	0.16	18	357.45	91.18
Skippy	58	35.46	2.24	4.96	0.26	22	395.47	150.09
Other Brands	58	22.67	1.52	7.44	0.31	21	265.00	60.01
RECALL								
Private Label	27	31.67	1.14	3.93	0.10	20	1189.74	108.41
Jif	27	35.43	0.91	5.01	0.06	28	1276.15	243.11
Skippy	27	33.68	1.61	5.01	0.17	26	774.07	182.28
Other Brands	27	22.57	0.88	7.23	0.24	26	481.44	30.69
POST-RECALL								
Private Label	71	31.07	1.06	4.32	0.19	16	1021.08	163.02
Jif	71	37.69	1.61	5.26	0.22	24	1100.31	170.56
Peter Pan	71	30.44	3.77	4.90	0.59	18	472.06	302.37
Skippy	71	35.03	2.15	5.37	0.40	22	625.62	154.08
Other Brands	71	22.56	0.88	7.43	0.23	20	414.18	52.39

[a] Prices reported in the table are the unit values, which also account for coupons.
[b] Derived from Nielsen Homescan panels for household purchases over the calendar years of 2006, 2007, and 2008.

Note: Peter Pan was not on the shelves of stores during this recall period.

to the consumption of the competing brands in light of the absence of Peter Pan from supermarket shelves. Recall that to be in our sample a household must have made at least one purchase of a peanut butter brand over the three-year period from 2006 to 2008. However, the number of unique households decreases for all the competing brands moving from the recall to the post-recall period. This situation may be partially explained by the re-entry of Peter Pan to the market.

In the pre-recall period, Skippy was the top brand in terms of average quantities purchased per week, at 35.46 ounces, followed by Jif, Private Label, Peter Pan, and Other Brands, at 33.51, 31.93, 30.49, and 22.67 ounces, respectively (Table 1). During the recall period, Jif ranked first in terms of average quantities purchased per week, at 35.43 ounces, followed by Skippy, Private Label, and Other Brands, at 33.68, 31.67, and 22.57 ounces, respectively. In the post-recall period, the average total quantity purchased was the highest for Jif, at 37.69 ounces. Also, in terms of average quantity, in the post-recall period Skippy ranked second, at 35.03 ounces, followed by Private Label, Peter Pan, and Other Brands, at 31.07, 30.44, and 22.56 ounces, respectively. Hence, in terms of average quantities purchased per week, the recall slightly affected the ordering of brands across the pre-recall and post-recall periods.

Across the pre-recall and post-recall periods, the percentage change in terms of average quantity purchased for Jif was 12.46 percent, for Skippy -1.21 percent, for Other Brands -0.45 percent, for Private Label -2.67 percent, and for Peter Pan -0.15 percent. As such, only Jif recorded a positive change in sales volume, while the rest of the brands posted a negative change in their corresponding sales volumes going from the pre-recall period to the post-recall period. Also of interest is the variability in quantities across the two recall periods reflected by the standard deviations. There was less variability in quantities for all the brands in the post-recall period relative to the pre-recall period except for Peter Pan.

As shown in Table 1, in the pre-recall period Other Brands were the most expensive, with an average weekly price of 7.44 cents per ounce. In the pre-recall period, the second most expensive peanut butter brand was Jif, with an average price of 5.09 cents per ounce, followed by Skippy and Peter Pan, with average prices of 4.96 and 4.68 cents per ounce, respectively. Finally, not surprisingly, Private Label was the lowest-priced brand in the pre-recall period. During the recall period, Other Brands was the most expensive brand, with an average weekly price of 7.23 cents per ounce, followed by Jif, Skippy, and Private Label with average weekly prices of 5.01, 5.01, and 3.93 cents per ounce, respectively. In the post-recall period, Other Brands was still the highest-priced peanut butter brand, with an average price of 7.43 cents per ounce. In the post-recall period, the second most expensive peanut butter brand was Skippy, at 5.37 cents per ounce, followed by Jif, Peter Pan, and Private Label, with average prices of 5.26, 4.90, and 4.32 cents per ounce. As for the average prices, the ordering of the prices of the leading brands changed from the pre- to the post-recall periods, with Jif switching places with Skippy.

Except for Other Brands, the average inflation-adjusted prices for all the peanut butter brands increased from the pre- to the post-recall periods. Particularly, Skippy recorded an 8.2 percent increase; Private Label recorded a 7.5 percent increase; Peter Pan recorded a 4.7 percent increase; Jif recorded a 3.4 percent increase; and, finally, Other Brands posted a 0.1 percent decrease. In addition, standard deviations reported in Table 1 show that, except for Other Brands, there was more variability in prices of all brands in the post-recall period relative to the pre-recall period, which may be attributed to couponing strategies implemented by the manufacturing firms.

According to Table 1, in terms of market share in the pre-recall period, Jif and Skippy led the way (with 22 percent each), followed by Other Brands (21 percent), Peter Pan (18 percent), and Private Label (16 percent). During the recall period, Jif had the largest market share (28 percent), followed by Skippy and Other Brands (with 26 percent each) and Private Label (20 percent). In the post-recall period, Jif enjoyed the largest market share (24 percent), followed by Skippy (22 percent), Other Brands (20 percent), Peter Pan (18 percent), and Private Label (16 percent). Across the two recall periods, interestingly, there was relatively little change in market shares for the peanut butter brands. Interestingly, if one compares market shares after the recall, it becomes evident that Peter Pan, in particular, recaptured the market share that the brand had in the pre-recall period.

Estimation Procedure and Results

To obtain the matrices of uncompensated and compensated price elasticities of demand, two Barten models, one for the pre-recall period and the other for the post-recall period, were estimated using an Iterated Seemingly Unrelated Regression (ITSUR) procedure with parametric restrictions imposed. Each demand system consisted of five equations, one for each peanut butter brand (Private Label, Jif, Peter Pan, Skippy, and Other Brands). To avoid the singularity of the variance-covariance matrix of disturbance terms, the equation for Other Brands was omitted and its parameters were computed using restrictions from equations (2), (3), and (4).

The R^2 for the omitted equation was computed by squaring the correlation coefficient between the actual and the predicted values of the dependent variable. The Durbin-Watson statistic for the omitted equation was calculated as the ratio of the sum of squared differences in successive residuals to the residual sum of squares. To account for serial correlation, a first-order autoregressive correction [AR(1)] was used. The joint test of the significance of quarterly dummy variables indicated that seasonality was not a significant determinant, and, hence, was not accounted for in the final estimation.

Augmented Dickey-Fuller and Phillips-Perron tests further supported the differential form of the variables used in the estimation. All the MacKinnon approximate p-values for the first-differenced variables were less than 0.0001, indicative of the stationarity property. Finally, all statistical tests were performed using a significance level of 0.10 owing to the relatively small amount of weekly observations available in the analysis.

In Table 2, details are presented concerning the Durbin-Watson statistic, the goodness-of-fit (R^2) statistic, parameter estimates, and p-values for the Barten models associated with the pre- and post-recall periods. For the pre-recall period, the R^2s ranged from 0.53 to 0.73, and for the post-recall period, the R^2s varied from 0.34 to 0.81. For most of the peanut butter brands, the Barten models provided relatively good fits for both periods. The Durbin-Watson statistics for the five estimated equations coupled with the statistically significant $\rho 1$ coefficient indicated that serial correlation was accounted for in the Barten models for both periods. All but two parameter estimates were found to be statistically significant for the pre-recall period, while all the parameter estimates were statistically significant for the post-recall period. The significance of the chi-squared (χ^2) statistic for the joint hypothesis tests of λ and μ shown in Table 3 indicates that the general BSM is best supported by the data for the pre- and post-recall periods.

Compensated Price Elasticities

Compensated own-price and cross-price elasticities, uncompensated own-price elasticities, and expenditure elasticities for the pre-recall and the post-recall periods computed at the sample means of the budget shares are presented in Table 4. In the pre-recall period, the compensated own-price elasticities varied from -0.49 (Skippy) to -0.85 (Peter Pan). In the post-recall period, the compensated own-price elasticity estimates ranged from -0.51 (Other Brands) to -1.13 (Jif). For both periods, all the compensated own-price elasticity estimates were statistically significant, satisfying the law of demand for all the peanut butter brands. With the exception of Jif, the compensated own-price elasticity estimates were less than unity in absolute value for both periods, suggesting inelastic demands for the respective brands. For Jif, the compensated own-price elasticity was -0.69 in the pre-recall period and -1.13 in the post-recall period. Across the two recall periods, the magnitudes of the compensated own-price elasticities for Private Label and Other Brands decreased; those for Jif, Skippy, and Peter Pan increased. Consequently, the Peter Pan recall was followed by a rise in the compensated own-price elasticity estimates for the major peanut butter brands.

In the pre-recall period, all the compensated cross-price elasticity estimates were positive, suggesting a net substitutability among peanut butter brands, with ten out of 20 of them possessing statistical significance. In the post-recall period, only one cross-price elasticity (between Private Label and Other Brands) was negative, albeit insignificant, while the rest of the off-diagonal elements were positive, indicating that net substitutability among brands continued after the event.

In the pre-recall period, significant net substitution relationships were present between Private Label and Jif, Private Label and Peter Pan, Private Label and Other Brands, Jif and Other Brands, and Peter Pan and Skippy. In the post-recall period, significant net substitutability was observed between Private Label and Jif, Jif and Peter Pan, Jif and Skippy, Jif and Other Brands, Peter Pan and Skippy, and Peter Pan and Other Brands. Significant net substitution relationships between Private Label and Jif, Jif and Other Brands, and Peter Pan and Skippy persisted from the pre-recall period to the post-recall period, implying that the recall did not affect the substitution pattern between these brands. Of particular interest was the increase in the compensated cross-price elasticity between Peter Pan and Skippy, suggesting strengthening of substitutability between these two national brands after the affected brand returned to the market. In addition, according to the magnitudes of the compensated cross-price elasticity estimates, in the pre-recall period, the strongest significant net substitutability was observed between Peter Pan and Skippy and between Jif and Other Brands. Weaker but significant net substitutability existed between Other Brands and Private Label. In the post-recall

Table 2. Parameter Estimates and Goodness-of-Fit Statistics for the Barten Synthetic Model for the Pre-Recall and Post-Recall Periods

	Pre-Recall		Post-Recall	
Brand	Durbin-Watson	R-squared	Durbin-Watson	R-squared
Private Label	2.0758	0.7286	2.1883	0.3425
Jif	2.2493	0.6048	1.9668	0.6559
Peter Pan	2.2648	0.6573	2.2619	0.8121
Skippy	2.4840	0.5334	2.0676	0.6066
Other Brands (omitted)	2.2785	0.6840	2.4010	0.5822
Parameter	Estimate	p-value	Estimate	p-value
g_{11}	0.8247	0.0277	0.9689	0.0044
g_{12}	-0.2062	0.0395	-0.2004	0.0476
g_{13}	-0.1703	0.0409	-0.2240	0.0019
g_{14}	-0.2423	0.0158	-0.2860	0.0018
g_{15}	-0.2060	0.0321	-0.2585	0.0016
g_{22}	1.0434	0.0252	1.1749	0.0098
g_{23}	-0.2452	0.0235	-0.2810	0.0051
g_{24}	-0.3359	0.0121	-0.3716	0.0067
g_{25}	-0.2560	0.0477	-0.3219	0.0088
g_{33}	0.8880	0.0307	1.0031	0.0046
g_{34}	-0.2252	0.0536	-0.2494	0.0104
g_{35}	-0.2473	0.0258	-0.2486	0.0045
g_{44}	1.1107	0.0197	1.2551	0.0040
g_{45}	-0.3073	0.0181	-0.3482	0.0026
g_{55}	1.0165	0.0274	1.1772	0.0034
b_1	0.6250	0.0929	-1.2568	<.0001
b_2	0.7800	0.1133	-1.7385	0.0001
b_3	0.9240	0.0337	-1.1442	0.0009
b_4	0.9095	0.0773	-1.6256	0.0002
b_5	0.8755	0.0745	-1.5285	<.0001
λ	-3.1140	0.1728	8.2935	<.0001
μ	7.0232	0.0109	7.9695	0.0016
$\rho 1$	-0.5464	<.0001	-0.5413	<.0001

Notes:

Subscript 1 refers to Private Label, 2 refers to Jif, 3 refers to Peter Pan, 4 refers to Skippy, and 5 refers to Other Brands. For instance, g_{12} denotes the price effect of Jif on the volume of Private Label.

The estimates of b_5 and g_{55} were recovered through adding-up restriction as $b_5 = 1-(b_1+b_2+b_3+b_4+\lambda)$ and $g_{55} = 0-(g_{15}+g_{25}+g_{35}+g_{45})$.

"$\rho 1$" denotes the autocorrelation coefficient in the error terms, the AR(1) process. To ensure adding-up, a common $\rho 1$ is evident in any demand system.

The number of weekly observations for the pre-recall period was 58, and the number of weekly observations for the post-recall period was 71.

Table 3. Joint Hypothesis Test of λ and μ for the Pre-Recall and Post-Recall Periods

	Pre-Recall		Post-Recall	
	χ^2 statistic	p-value	χ^2 statistic	p-value
H_0: $\lambda = 0, \mu = 0$ (Rotterdam)	8.15	0.0170	36.79	< .0001
H_0: $\lambda = 1, \mu = 1$ (LA/AIDS)	7.62	0.0222	28.34	< .0001
H_0: $\lambda = 1, \mu = 0$ (CBS)	9.33	0.0094	31.44	< .0001
H_0: $\lambda = 0, \mu = 1$ (NBR)	6.41	0.0407	33.62	< .0001

Note: The number of weekly observations for the pre-recall period was 58, and the number of weekly observations for the post-recall period was 71.

Table 4. Compensated Own-Price and Cross-Price Elasticities as Well as Uncompensated Own-Price and Expenditure Elasticities Associated with the Peanut Butter Brands for the Pre-Recall and Post-Recall Periods

	Compensated					Uncompensated Own-Price Elasticity	Expenditure Elasticity
	Private Label	Jif	Peter Pan	Skippy	Other Brands		
PRE-RECALL							
Private Label	-0.82*	0.26*	0.23*	0.09	0.24*	-0.94*	0.72*
Jif	0.20*	-0.69*	0.14	0.03	0.33*	-0.80*	0.48*
Peter Pan	0.21*	0.17	-0.85*	0.33*	0.14	-1.21*	1.98*
Skippy	0.06	0.03	0.27*	-0.49*	0.13	-0.70*	0.95*
Other Brands	0.19*	0.33*	0.12	0.14	-0.78*	-0.98*	0.97*
POST-RECALL							
Private Label	-0.65*	0.64*	0.01	0.01	-0.01	-0.73*	0.46*
Jif	0.44*	-1.13*	0.22*	0.23*	0.25*	-1.36*	0.97*
Peter Pan	0.01	0.30*	-0.88*	0.38*	0.19*	-1.20*	1.81*
Skippy	0.01	0.24*	0.30*	-0.59*	0.05	-0.83*	1.06*
Other Brands	-0.01	0.29*	0.17*	0.06	-0.51*	-0.65*	0.69*

Notes:
All elasticities are computed at the sample means of the data.
An asterisk indicates statistical significance at the 0.10 level.
The number of weekly observations for the pre-recall period was 58, and the number of weekly observations for the post-recall period was 71.

period, the strongest significant net substitutability was observed between Private Label and Jif, and the weakest significant net substitutability was between Other Brands and Peter Pan.

Uncompensated Own-Price Elasticities

For both periods, all the uncompensated own-price elasticity coefficients were statistically significant and negative, in accordance with expectations. In the pre-recall period, the uncompensated own-price elasticities for Private Label and Other Brands were close to unity in absolute value, while the demand for these two brands was inelastic in the post-recall period. The demand for Jif went from inelastic in the pre-recall period to elastic in the post-recall period. The demand for Peter Pan was elastic for both periods, implying a relatively high sensitivity on the part of consumers to price changes for this brand. Finally, the demand for Skippy was inelastic in both periods.

Expenditure Elasticities

For both periods, all expenditure elasticity estimates were statistically significant and positive, indicating that the quantity demanded increased for all peanut butter brands as real expenditure for peanut butter rose, *ceteris paribus*. For increases in inflation-adjusted total expenditure for peanut butter, Peter Pan benefited the most. Jif was the brand least sensitive to changes in total expenditure in the pre-recall period, while Private Label was the brand least sensitive to changes in total expenditure in the post-recall period.

Discussion of Estimation Results Across the Pre- and Post-Recall Periods

Compensated elasticities provide the most accurate picture of substitution among brands. Consequently, the discussion of changes in the magnitudes of price elasticities across the two periods is detailed in terms of compensated price elasticity estimates reported in Table 4. The determination of the significance of the changes in the magnitudes of elasticities across the two periods is based on the results of chi-squared tests presented in Table 5. Chi-squared tests were used since tests of the compensated price elasticities involved non-linear combinations of the parameters. Associated p-values from testing each element in the matrices from the pre-recall (post-recall) period against its respective counterpart from the post-recall (pre-recall) period also are exhibited in Table 5. The null hypothesis for all of the respective tests is that the elasticity estimates from the two periods are equal. The test results in Table 5 are shown for compensated own- and cross-price elasticities and expenditure elasticities, a total of 30 tests for each period.[3]

The conclusions reached from corresponding tests of compensated price elasticities are the same. For example, Test 1 in the pre-recall column deals with the hypothesis that the compensated own-price elasticity associated with Private Label for the pre-recall period (e_ctlbr_ctlbr_C_pre) is equal to that for the post-recall period (-0.65443). This test is similar to Test 1 in the post-recall column, which deals with the hypothesis that the compensated own-price elasticity associated with Private Label for the post-recall period (e_ctlbr_ctlbr_C_post) is equal to that for the pre-recall period (-0.82378). In both instances, the null hypothesis that the two elasticity estimates from the two periods are equal is not rejected.

Emphasis is placed on statistically significant differences associated with compensated price elasticities across the pre-recall and post-recall periods. We conclude that the compensated cross-price elasticity estimates between Private Label and Jif, Private Label and Peter Pan, and Private Label and Other Brands changed significantly across the two sample periods. The compensated own-price elasticity for Jif rose from -0.69 to -1.13, and this change was statistically significant. Jif had the largest market share (22 percent in the pre-recall period and 24 percent in the post-recall period); Procter and Gamble, the manufacturer of this brand, operated in the elastic portion of the demand curve in the post-recall period, consistent with profit-maximizing behavior of a dominant firm. Test results indicated that the cross-price elasticity estimates changed significantly between Jif and Skippy. However, we find no statistically significant evidence of a change in the magnitudes of cross-price elasticity estimates between Jif and Peter Pan and between Jif and Other Brands. The own-price elasticity of demand for Peter Pan increased slightly across both periods, but this change was not statistically significant. This result may be attributed to the marketing campaign that ConAgra undertook in an attempt to regain consumer trust in the safety of the recalled peanut butter brands. The demand for Other Brands became more inelastic going from

[3] The test results for the uncompensated own- and cross-price elasticities are available from the authors upon request.

Table 5. Tests of the Difference in the Respective Pre- and Post-Recall Elasticities

	Pre-Recall			Post-Recall		
Test	Label	χ^2 statistic	p-value	Label	χ^2 statistic	p-value
COMPENSATED OWN- AND CROSS-PRICE ELASTICITIES						
Test1	e_ctlbr_ctlbr_C_pre= -0.65443	2.65	0.1034	e_ctlbr_ctlbr_C_post= -0.82378	0.99	0.3196
PRIVATE LABEL						
Test 2	e_ctlbr_jif_C_pre= 0.643647*	11.68	**0.0006**	e_ctlbr_jif_C_post= 0.261134*	5.52	**0.0188**
Test 3	e_ctlbr_ppan_C_pre= 0.0104*	3.84	**0.0499**	e_ctlbr_ppan_C_post= 0.229856*	10.56	**0.0012**
Test 4	e_ctlbr_skippy_C_pre= 0.009289	1.13	0.2881	e_ctlbr_skippy_C_post = 0.088958	0.64	0.4242
Test 5	e_ctlbr_obrand_C_pre= -0.00891*	8.16	**0.0043**	e_ctlbr_obrand_C_post = 0.243836*	6.07	**0.0137**
Test 6	e_jif_ctlbr_C_pre= 0.43521*	8.06	**0.0045**	e_jif_ctlbr_C_post= 0.196343*	4.71	**0.0300**
JIF						
Test 7	e_jif_jif_C_pre= -1.12852*	6.37	**0.0116**	e_jif_jif_C_post= -0.69209*	7.22	**0.0072**
Test 8	e_jif_ppan_C_pre= 0.222285	0.48	0.4873	e_jif_ppan_C_post= 0.143282	1.55	0.2132
Test 9	e_jif_skippy_C_pre= 0.22571*	7.11	**0.0077**	e_jif_skippy_C_post= 0.025808*	4.83	**0.0280**
Test 10	e_jif_obrand_C_pre= 0.245318	0.94	0.3323	e_jif_obrand_C_post= 0.326655	0.80	0.3712
Test 11	e_ppan_ctlbr_C_pre= 0.009464*	3.84	**0.0500**	e_ppan_ctlbr_C_post= 0.206972*	10.33	**0.0013**
PETER PAN						
Test 12	e_ppan_jif_C_pre= 0.299142	0.88	0.3491	e_ppan_jif_C_post= 0.171591	2.23	0.1353
Test 13	e_ppan_ppan_C_pre= -0.8779	0.01	0.9063	e_ppan_ppan_C_post= -0.85116	0.05	0.8229
Test 14	e_ppan_skippy_C_pre= 0.377188	0.12	0.7244	e_ppan_skippy_C_post= 0.330825	0.26	0.6123
Test 15	e_ppan_obrand_C_pre= 0.192107	0.13	0.7164	e_ppan_obrand_C_post= 0.141774	0.44	0.5070
Test 16	e_skippy_ctlbr_C_pre= 0.006636	1.13	0.2870	e_skippy_ctlbr_C_post = 0.064811	0.67	0.4140
SKIPPY						
Test 17	e_skippy_jif_C_pre= 0.238474*	8.63	**0.0033**	e_skippy_jif_C_post= 0.025007*	4.93	**0.0264**
Test 18	e_skippy_ppan_C_pre= 0.296128	0.07	0.7892	e_skippy_ppan_C_post=0.267674	0.16	0.6920

Notes:
Subscript “ctlbr” refers to Private Label, “ppan” refers to Peter Pan, “obrand” refers to Other Brands, “C” stands for compensated, “pre” stands for the pre-recall period, and “post” stands for the post-recall period.
Asterisks and bolding of the p-value values denote statistical significance at the 0.10 level.

the pre-recall period to the post-recall period. This change was statistically significant.

In short, after the recall of Peter Pan, there were statistically significant changes in selected own-price and cross-price relationships among peanut butter brands. As such, spillover effects brought about by the recall were evident. In general, the recall contributed to a structural change in the demand for peanut butter across brands.

Summary, Conclusions, and Implications

Employing weekly scanner data from January 4, 2006, through February 13, 2007 (the pre-recall period), and from August 22, 2007, through December 30, 2008 (the post-recall period), two separate Barten demand system models were estimated, one for the pre-recall period, and one for the post-recall period. Matrices of compensated and uncompensated own-price and cross-price elasticity and expenditure elasticity estimates were obtained for the pre-recall and post-recall periods. Elements of compensated price elasticity matrices for the two periods were compared against each other to identify a possible structural change in the demand for peanut butter initiated by the recall of Peter Pan.

The general BSM was favored over other forms of differential demand systems for studying the impact of the recall on the demand for peanut butter. Indeed, there were changes in the own-price and cross-price relationships among peanut butter brands, which suggests that the recall contributed to the structural change in the demand for peanut butter. The findings were substantiated by statistical tests of the significance of the changes in the magnitudes of the compensated price elasticities across the pre-recall and post-recall periods. Significant differences in compensated cross-price elasticities across the pre-recall and post-recall periods were evident for (i) Private Label and Jif, (ii) Private Label and Peter Pan, (iii) Private Label and Other Brands, and (iv) Jif and Skippy. Hence, notable spillover effects were detected after the recall of Peter Pan. Additionally, the cross-price elasticities among the major brands (Jif, Peter Pan, and Skippy) rose in absolute value from the pre-recall period to the post-recall period, suggestive of heightened competition. Significant differences in compensated own-price elasticity estimates were evident for Jif and Other Brands.

Interestingly, statistically significant differences in own- and cross-price elasticities for the Peter Pan brand were absent (except for Private Label and Peter Pan). Thus, after a period of only 27 weeks, the duration of the recall period, this brand essentially recovered from the food safety crisis. The evidence clearly shows that the efforts of image restoration in dealing with this issue were successful.

Going forward, lessons learned from this case study of a food recall incident reveal the importance of using a demand system approach associated with pre- and post-recall periods, considering brands in lieu of the entire product category, and considering not only own-price and cross-price elasticities of the affected brand, but also own-price and cross-price elasticities of the other brands in the market. Further, the delineation of pre- and post-recall periods allows the determination of whether or not competition among brands increased or decreased, whether or not the affected brand recovered from the food safety incident, and if it did, the length of time for the recovery. This is a significant contribution to the literature on the impact of the competitive environment in which firms aim to maintain safety of the food supply.

References

Arnade, C., L. Calvin, and F. Kuchler. 2008. "Market Response to a Food Safety Shock: The 2006 Food-Borne Illness Outbreak of E. coli O157:H7 Linked to Spinach." Paper presented at the American Agricultural Economics Association meetings, Orlando, Florida, July 27–29, 2008. Available at http://ageconsearch.umn.edu/bitstream/6448/2/467354.pdf (accessed December 20, 2010).

Barten, A.P. 1964. "Consumer Demand Functions Under Conditions of Almost Additive Preferences." *Econometrica* 32(1/2): 1–38.

____. 1993. "Consumer Allocation Models: Choice of Functional Form." *Empirical Economics* 18(1): 129–158.

Brown, D.J., and L.F. Schrader. 1990. "Cholesterol Information and Shell Egg Consumption." *American Journal of Agricultural Economics* 72(3): 548–555.

Bureau of Labor Statistics. 2011. "Consumer Price Index: Average Price Data." Bureau of Labor Statistics, U.S. Department of Labor, Washington, D.C. Available at http://data.bls.gov/PDQ/servlet/SurveyOutputServlet?series_id=APU0000716141&data_tool=XGtable (accessed January 17, 2011).

Burton, M., and T. Young. 1996. "The Impact of BSE on the Demand for Beef and Other Meats in Great Britain." *Applied Economics* 28(6): 687–693.

Buzby, J.C., J.A. Fox, R.C. Ready, and S.R. Crutchfield. 1998. "Measuring Consumer Benefits of Food Safety Risk Reductions." *Journal of Agricultural and Applied Economics* 30(1): 69–82.

Capps, Jr., O., and J.D. Schmitz. 1991. "A Recognition of Health and Nutrition Factors in Food Demand Analysis." *Western Journal of Agricultural Economics* 16(1): 21–35.

Centers for Disease Control and Prevention. 2007. "Multistate Outbreak of Salmonella Serotype Tennessee Infections Associated with Peanut Butter—United States, 2006–2007." *Morbidity and Mortality Weekly Report* 56(21): 521–524. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5621a1.htm (accessed October 30, 2010).

ConAgra Foods Inc. 2007. "ConAgra Foods Announces the Renovation of Its Peanut Butter Plant and Enhanced Food Safety Measures." News release. Available at http://media.conagrafoods.com/phoenix.zhtml?c=202310&p=irol-newsArticle&ID=1008473&highlight= (accessed November 5, 2010).

Dahlen, M., and F. Lange. 2006. "A Disaster Is Contagious: How a Brand in Crisis Affects Other Brands." *Journal of Advertising Research* 46(4): 388–397.

Deaton, A., and J. Muellbauer. 1980. "An Almost Ideal Demand System." *American Economic Review* 70(3): 312–326.

Dillaway, R., K.D. Messer, J.C. Bernard, and H.M. Kaiser. 2011. "Do Consumer Responses to Media Food Safety Information Last?" *Applied Economic Perspectives and Policy* 33(3): 363–383.

Dorfman, B. 2007. "ConAgra Sets Peter Pan Re-Launch." *Reuters.* Available at http://www.reuters.com/article/2007/08/08/us-conagra-peterpan-idUSN0724255020070808 (accessed November 20, 2010).

Fousekis, P., and B. Revell. 2004. "Food Scares, Advertising, and the Demand for Meat Cuts in Great Britain." *Acta Agriculturæ Scandinavica* 1(3): 121–136.

Keller, W.J., and J. van Driel. 1985. "Differential Consumer Demand Systems." *European Economic Review* 27(3): 375–390.

Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79(1): 13–23.

Lee, J.-Y., M.G. Brown, and J.L. Seale, Jr. 1994. "Model Choice in Consumer Analysis: Taiwan, 1970–89." *American Journal of Agricultural Economics* 76(3): 504–512.

Marsh, T.L., T.C. Schroeder, and J. Mintert. 2004. "Impacts of Meat Product Recalls on Consumer Demand in the USA." *Applied Economics* 36(9): 897–909.

Neves, P.D. 1987. "Analysis of Consumer Demand in Portugal, 1958–1981." Memoire de maitrise en sciences economiques, University Catholique de Louvain, Louvain-la-Neuve, Belgium.

NewsInferno. 2007. "Peter Pan Peanut Butter Back in Stores Following Salmonella Recall." Available at http://www.newsinferno.com/legal-news/peter-pan-peanut-butter-back-in-stores-following-salmonella-recall/1762 (accessed November 20, 2010).

Peterson, H.H., and Y.J. Chen. 2005. "The Impact of BSE on Japanese Retail Meat Demand." *Agribusiness* 21(3): 313–327.

Piggott, N.E., and T. Marsh. 2004. "Does Food Safety Information Impact U.S. Meat Demand?" *American Journal of Agricultural Economics* 86(1): 154–174.

Pritchett, J., K. Johnson, D. Thilmany, and W. Hahn. 2007. "Consumer Responses to Recent BSE Events." *Journal of Food Distribution Research* 38(2): 57–68.

Smed, S., and J.D. Jensen. 2002. "Food Safety Information and Food Demand—Effects of Temporary and Permanent News." Paper prepared for presentation at the Tenth European Association of Agricultural Economists Congress, Zaragoza, Spain, August 28–31, 2002. Available at http://ageconsearch.umn.edu/bitstream/24811/1/cp02sm49.pdf (accessed December 20, 2010).

Theil, H. 1965. "The Information Approach to Demand Analysis." *Econometrica* 33(1): 67–87.

Verbeke, W., and R. Ward. 2001. "A Fresh Meat Almost Ideal Demand System Incorporating Negative TV Press and Advertising Impact." *Agricultural Economics* 25(2/3): 359–374.

Vickner, S.S., L.A. Marks, and N. Kalaitzandonakes. 2003. "Food Product Recalls, Agbiotech and Consumer Response: The Case of Starlink." Paper presented at the American Agricultural Economics Association's annual meetings, Montreal, Canada, July 27–30, 2003. Available at http://ageconsearch.umn.edu/bitstream/22050/1/sp03vi01.pdf (accessed December 20, 2010).