Journal of Agricultural and Applied Economics, 46,4(November 2014):559–573

The Impact of Food Safety Incidents Across Brands: The Case of the Peter Pan Peanut Butter Recall

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The effect of negative publicity on consumer demand for brands is examined in the context of recall of a peanut butter brand as a result of pathogen contamination. The recall was associated with negative impacts for the implicated brand and positive effects on the leading competitor brand. Consumers responded to the foodborne illness outbreak within three weeks. The case demonstrates that consumer response is an incentive for companies to prevent safety lapses and that the problems of one brand do not necessarily harm rivals within the category.

Key Words: consumer demand, food safety, product recall, spillover effects, the Barten model

JEL Classification: D12

Negative publicity is a key determinant affecting consumers' buying decisions (Ahluwalia, Burnkrant, and Unnava, 2000) and consequently is an integral part of decisions made by manufacturers. Adverse publicity that arises from food safety problems is a special case of negative publicity that fits within the research agenda on product harm crises. Although the impacts of foodborne illness outbreaks vary, incidents can have devastating effects on the implicated firms in the form of financial losses (Grocery Manufacturers Association, 2011) and damaged brand equity (Dawar and Pillutla, 2000). A 2011 survey of 36 U.S. companies revealed that 77% of the firms that experienced product recalls resulting from food safety suffered financial losses of up to $30 million for the incident with the remaining 23% of companies reporting even higher costs (Grocery Manufacturers Association, 2011).

Clearly, costs to the implicated firm are considerable, but do competitors also suffer when a rival has a food safety problem? We address the issue of spillover within a consumer goods category that was affected by a foodborne illness linked to a major national brand. Peter Pan brand and a private label, Great Value, were recalled from distribution on February 14, 2007 (Centers for Disease Control and Prevention [CDC], 2007). This recall came two years before

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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.

the Peanut Corporation of America conducted a massive recall of peanut products in January 2009 (The New York Times, 2012).

To the extent that consumers associate problems with one brand to the image of another brand, all companies in an industry face the risk that there will be spillover from a rival's product harm crisis. Such spillover may be the result of consumers associating the risk to the food item itself rather than the processes specific to the implicated firm. Alternatively, consumers might be confused as to which brand has been implicated in the safety problem. Regardless of the reason, the existence of negative consequences to competitors in the product category is an interesting research question that bears empirical study. The 2007 incident affecting peanut butter allows for exactly this question to be analyzed. More generally, this econometric analysis may be replicated for various products and not just be limited to peanut butter.

The three major peanut butter manufacturing firms in the United States are Proctor and Gamble Company, ConAgra, and CPC International Inc., producers of the national brands Jif, Peter Pan, and Skippy, respectively. As evidenced by the data (ACNielsen Homsescan panels for household purchases, 2006, 2007, and 2008), throughout the study period from January 2006 to December 2008, private label, Jif, Peter Pan, Skippy, and other brands had 23%, 35%, 10%, 20%, and 12% market shares, respectively. Because most of the market share (65%) is concentrated chiefly in the hands of the three major brands (Jif, Skippy, and Peter Pan), a food safety crisis associated with any of these brands may affect the other brands in the same category through spillover effects. The interactive effects can presumably be positive or negative: negative where consumers do not differentiate among brands and positive where one brand can capitalize on the recall by a competitor. In the incident that we study, competing brands had 27 weeks to take advantage of the absence of Peter Pan brand from the market before it was returned to store shelves in August 2007 (NewsInferno, 2007).

In an effort to restore consumer confidence in the safety of the recalled peanut butter brand, ConAgra undertook a large-scale marketing campaign on returning Peter Pan peanut butter to distribution. ConAgra sent out two million coupons for free Peter Pan peanut butter, $1-off coupons, and updated the design of its packaging (NewsInferno, 2007).

The objectives of the present study are: 1) to empirically analyze whether the peanut butter recall significantly impacted the demand for the implicated brand; 2) to ascertain the spillover effects among competing peanut butter brands caused by the peanut butter recall event; and 3) to determine the length of time it took consumers to respond to the recall. The primary outcome of the empirical analysis is the cross-price elasticity of demand measure, which indicates the degree to which competition is strengthened during the foodborne illness outbreak. The indicators of the dynamic pattern of consumer response are the short-run and long-run elasticities associated with the variable measuring the foodborne illness event. These elasticities are estimated in a demand system with a polynomial distributed lag (PDL) specification applied to the variable associated with the food safety event.

We proceed by first presenting the review of relevant literature. Then the theoretical framework is discussed. The model specification is presented in the ensuing section. Subsequently, data are described and followed by the discussion of the estimation procedure and results. The summary, conclusions, implications, and recommendations for future research comprise the final section.

Literature Review

The literature on product harm crises, and in particular on food safety crises, is largely silent on the nature and extent of brand competition surrounding the crisis. Relatively few food safety incidents have been attributed to a specific brand. Some researchers choose to aggregate to the category level even where brand attribution was made, as in the case of the consumer warnings and recalls of leafy greens (Arnade, Calvin, and Kuchler, 2008; Fahs, Mittelhammer, and McCluskey, 2009).

Safety issues in nonfood products have been studied by several researchers. Those who address the question of spillover effects with an empirical approach include Cawley and Rizzo (2005), Crafton, Hoffer, and Reilly (1981), and Freedman, Kearney, and Lederman (2012). The findings indicate that spillover from the implicated company to other firms was prevalent. In the automobile industry, similar models from other manufacturers were harmed (Crafton, Hoffer, and Reilly, 1981). Pharmaceutical products in the same therapeutic class experienced negative spillover in terms of lost sales (Cawley and Rizzo, 2005). Likewise, the entire toy industry experienced loss of sales as a result of a contaminant in one brand (Freedman, Kearney, and Lederman, 2012). Like in our study, these studies all took an econometric approach and their empirical evidence is indicative of industry-wide damage when one firm experiences a product-harm event.

The manner in which consumers receive information about the likelihood of harm influences their purchase decisions and is a key issue in the empirical research on impact of safety events. Some studies establish a comparison of consumer demand before and after an event (Bakhtavoryan, Capps, and Salin, 2012; Cawley and Rizzo, 2005) under the hypothesis that once an event occurs, there is a "structural change" in the demand because of the new information. Others take into account the possibility that consumers' reaction takes time or can build over time as more people become aware because of psychological, technological, and institutional reasons (Griliches, 1967). There is little consistent evidence on this point. Those studies that find contemporaneous impact are Kalaitzandonakes, Marks, and Vickner (2004) and Piggott and Marsh (2004), whereas those that identify delays using a PDL specification (Almon, 1965) include Smith, van Ravenswaay, and Thompson (1988), Swartz and Strand (1981), and Van Ravenswaay and Hoehn (1991). Implicit in our study is the assumption that information about the food safety crisis associated with the affected brand reached consumers instantaneously.

In addition to the dynamic component of consumer information, there remains the issue of how to measure consumer exposure to the negative publicity. Nearly all previous studies are based on an index of publicity, constructed from newspaper articles or database searches of compiled news reports. There have been no prior studies in which the information set is tied to the outbreak as it progresses over time, as is done in the present study.

The empirical studies that estimate spillover effects as well as those that are concerned with solely the category-level use econometric approaches to estimate demand for various products. Formal demand systems have been used by Burton and Young (1996), Marsh, Schroeder, and Mintert (2004), Piggott and Marsh (2004), Pritchett et al. (2007), and Verbeke and Ward (2001). Alternatively, single-equation structural models of demand have been estimated by Freedman, Kearney, and Lederman (2012), Smith, van Ravenswaay, and Thompson (1988), Swartz and Strand (1981), and Van Ravenswaay and Hoehn (1991).

The 2007 Peter Pan recall has been studied from various perspectives in the previous research. In particular, Bakhtavoryan, Capps and Salin (2012) analyzed spillover effects, competition, and possible structural change in peanut butter demand in the presence of the Peter Pan peanut butter recall. By statistically comparing the prerecall price elasticities with the corresponding postrecall price elasticities, the authors were able to show that the Peter Pan recall contributed to structural change in consumer demand for peanut butter brands (the own-price, cross-price, and expenditure elasticities generally increased across the two periods). Also, the results indicated that there were both negative and positive spillover effects among the leading national peanut butter brands with the leading national brand (Jif) emerging as beneficiary of the recall.

The present study differs from the earlier study of Bakhtavoryan, Capps, and Salin (2012) in a few aspects. First, in the current study, the analysis of competition was done from the perspective of brands responding to the Peter Pan recall based on the outbreak variable as an information source about the recall. Second, the current study incorporated dynamics associated with the consumer response to the foodborne illness outbreak by applying a polynomial distributed lag procedure to the outbreak variable.

Third, the results from the current study allowed for obtaining information concerning the consumer response to the foodborne illness outbreak as measured by the short-run and the long-run elasticities associated with the outbreak variable. Fourth, although not an issue in the previous study, in the current study, the estimation of a demand system allowed us to gather information concerning Peter Pan when no information regarding that brand was available throughout the recall period.

In another study, using weekly observations derived from the Nielsen Homescan panel data on household purchases of peanut butter from January of 2006 through December of 2008, Bakhtavoryan, Capps, and Salin (2013a) investigated the influence of the 2007 Peter Pan food safety event on the demand for peanut butter at the category level. The impact of the recall was measured by three variables. According to the variable controlling for a structural shift in the demand for peanut butter, the average consumption of peanut butter decreased in the postrecall period relative to the prerecall period. However, this negative impact wore off with the passage of time after the recall as suggested by the variable that counted number of weeks starting from the recall week as well as the outbreak variable included in the model with a polynomial distributed lag structure applied to it.

The present study differs from the earlier study of Bakhtavoryan, Capps, and Salin (2013a) in a couple aspects. First, unlike the previous study dealing with peanut butter at the product category level in the presence of the recall, the present study considered peanut butter at the brand level in the presence of the recall shedding light on the issues of spillover effects and competition among brands. Second, unlike the previous study that used a single-equation model for peanut butter estimation, the current study used a demand system approach.

Finally, in another study by Bakhtavoryan, Capps, and Salin (2013b), the 2007 Peter Pan recall was investigated at the household-level using observations from the Nielsen Homescan panel data on household purchases of peanut butter ranging from January 2006 through December 2008. A multinomial logit model was estimated to empirically ascertain the effects of various socioeconomic characteristics of households on the three purchasing patterns (buying in the prerecall period and not buying in the postrecall period, not buying in the prerecall period but buying in the postrecall period, and buying in both periods) associated with Peter Pan peanut butter across the prerecall and the postrecall periods. The findings showed that employment status of the household head, region, race, ethnicity, age, and presence of children in the household were statistically significant factors associated with the respective actions taken by households in the presence of the Peter Pan recall. In the same study, the estimation results obtained from the Heckman sample selection model showed that the change in the price of Peter Pan, region, race, age and presence of children in the household, and household size were statistically significant drivers impacting the change in quantity purchased of Peter Pan across the pre- and the postrecall periods.

The present analysis differs from the earlier study of Bakhtavoryan, Capps, and Salin (2013b) in a few aspects. First, the present study focused on the peanut butter demand in the presence of the recall considering all the brands, whereas the previous study considered only Peter Pan. Second, the current study dealt with the peanut butter demand in the presence of the recall at the market level, whereas the previous study examined the demand for Peter Pan at the household or micro level. Third, the present study applied a structural demand systems approach to examine the peanut butter demand in the presence of the recall, whereas the previous study used a discrete choice model (multinomial) and the Heckman sample selection model for studying the household-level demand for Peter Pan in light of the recall. Fourth, the dynamics were introduced into the current analysis through the application of the polynomial distributed lag procedure to the outbreak variable. In the previous study, the dynamics was accounted for by partitioning the entire study period into two distinctive periods: prerecall and postrecall. Finally, although not done in the current study because it was impossible given the market-level data actually used, the previous study profiled households corresponding to a particular purchasing pattern associated with Peter Pan across the prerecall and the postrecall periods in light of the recall.

The present study follows the well-established approach of a demand systems methodology with an additional focus on the interaction among the brands. The use of the demand systems method permits us to recover information about the affected brand when no information was available on that brand as a result of the fact that it was not available on store shelves for the entire recall period. This situation is possible because of the structural nature of the demand system, theoretical restrictions imposed on the system, and the necessity to leave one of the equations out of the system during the estimation process to accommodate the singularity issue in the variance–covariance matrix of error terms.

To the best of our knowledge, this study is different from prior research concerning food safety incidents in the United States in two aspects: 1) the analysis was conducted at the peanut butter brand level allowing us to determine spillover effects among brands and characterize the manner of competition in light of a food safety crisis; and 2) the number of confirmed cases of illness resulting from the consumption of peanut butter was used in constructing the outbreak variable in an effort to capture the influence and the severity of the recall. This information had not been used previously in the extant literature.

Theoretical Framework

The impact of a food recall event on demand can be analyzed within the theoretical framework developed by Basmann (1956). A consumer's utility function is represented by $U_t = U(q_t, \theta[r_t])$, where q_t is the vector of the product consumed and $\theta(r_t)$ denotes consumer preferences for q_t and is a function of r_t, which stands for attributes of quality and safety and the consumer's personal attributes. By assumption, changes in the product attributes lead to changes in the consumer's consumption decisions regarding q_t, which in turn results in changes in the parameters of the utility function. Assuming a quasi-concave and twice differentiable utility function for a rational consumer, the solution of the first-order conditions of the utility maximization with respect to q_t, given r_t, and subject to a budget constraint, gives the Marshallian demands $q_t = q_t(y, p, \theta[r_t])$, where y is the total consumption budget and p is the vector of prices.

This theoretical framework is quite amenable for analyzing the effects of both negative food safety information (e.g., recalls) and advertising (Capps and Schmitz, 1991). Particularly, regarding negative food safety information (recalls), by assumption, consumer utility depends not only on quantities of goods consumed, but also on consumer perceptions concerning the quality of the goods, which in turn is dependent on the information available to consumers. The demand shifts leftward conditional on the severity of negative publicity, because consumers adjust their consumption based on their perceptions concerning the quality of the good.

Model Specification

Barten (1993) developed a Barten's synthetic model (BSM) that nests the differential versions of the Rotterdam model developed by Barten (1964) and Theil (1965), the AIDS model developed by Deaton and Muellbauer (1980) as well as the Dutch Central Bureau of Statistics (CBS) model introduced by Keller and van Driel (1985) and the NBR model introduced by Neves (1987). The BSM has a few appealing features such as functional form flexibility, linearity in parameters, potential to render variables stationary resulting from the required first-differencing process, and its ability to introduce dynamics. All of these, along with the fact that the BSM allows a determination of the specific functional form that is best supported by the data used, enhance its practical application.

The demand systems approach has been used previously with respect to brands (Bakhtavoryan, Capps, and Salin, 2012; Cain, 2005; Cotterill and Samson, 2002). The estimated Barten model is given as follows:

$$
\begin{aligned}
w_{it} d\,logq_{it} &= (\beta_i + \lambda w_{it}) d\,logQ \\
&+ \sum_j (\gamma_{ij} - \mu w_{it}(\delta_{ij} - w_{jt})) d\,logp_{jt} \\
&+ \sum_{l=0}^{m} z_{il} sqrtCDCCASE_{t-l} + \varepsilon_{it}, \\
& i, j = 1, \ldots, n,\ l = 0.1, \ldots, m^{1}
\end{aligned} \tag{1}
$$

where w_{it} is budget share of i^{th} brand in time period t; q_{it} is quantity of i^{th} product in time period t; $dlogQ$ is a Divisia Volume Index,[2] δ_{ij} = one if $i = j$, and δ_{ij} = zero if $i \neq j$; p_{jt} is the price of brand j in time period t; $sqrtCDCCASE_{t\text{-}l}$ is the square root of the outbreak variable with lag l, β, λ, γ_{ij}, μ, and z_{il} are the parameters to be estimated; and ϵ_{it} 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.

The BSM presented in equation (1) was estimated using a second-degree PDL specification applied to the $sqrtCDCCASE_{t\text{-}l}$ variable with a lag length of three weeks and head and tail endpoint restrictions imposed. Various combinations of the BSM were estimated using alternative lag lengths. However, based on the Schwarz Information Criterion, the specification with lag length of three was chosen as the best.

The omission of one equation is necessary in the demand system to accommodate the problem of singularity of the variance–covariance matrix of error terms. The choice to drop the recalled brand (Peter Pan) from the model is prompted by the fact that this brand was not available in stores during the recall. Therefore, no quantity information regarding the amount of Peter Pan sold could be collected for the analysis for the duration of the recall. However, the application of a formal demand systems approach allows us to recover the parameter estimates related to the omitted equation using the following theoretical restrictions:

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

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

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

As such, the choice of Peter Pan as the omitted equation results in the use of information to the greatest extent possible. The compensated price elasticities of equation (1) are given by

$$
e_{ij}^{c} = \frac{\gamma_{ij}}{w_{it}} - \mu(\delta_{ij} - w_{jt}), \tag{5}
$$

where w_{it} and w_{jt} denote the budget shares of commodity i and j in time period t, respectively, and δ is the Kronecker delta.

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

$$
e_{ij}^{u} = e_{ij}^{c} - e_i w_{jt}. \tag{6}
$$

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

$$
e_{ij}^{u} = \left(\frac{w_{jt}}{w_{it}}\right) e_{ji}^{u} + w_{jt}(e_j - e_i), \tag{7}
$$

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

The expenditure elasticity is given by

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

To conform to the law of demand, the own-price elasticities were anticipated to be negative. Hypothesizing substitutability between peanut butter brands, the cross-price elasticities

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[1] Initially equation (1) was estimated controlling for the price of jelly, coupons, structural change, and seasonality. However, all these variables were dropped from the model in the final estimation because none of them was found to be statistically significant at the 0.05 significance level.

[2] Divisia Volume Index (DVI) is denoted by dlogQ and is calculated as $dlogQ = \sum 0.5(w_{it} + w_{it-1})(logq_{it} - logq_{it-1})$ where w_{it} and w_{it-1} are the budget shares for i^{th} brand in time periods t and t-1, respectively, and $logq_{it}$ and $logq_{it-1}$ are the logarithm of quantities of i^{th} brand in time periods t and t-1, respectively. The average of the DVI is 0.00043 with a standard deviation of 0.05441 and the minimum and the maximum are –0.38954 and 0.33512, respectively.

were expected to be positive. Finally, expenditure elasticities were anticipated to be positive. According to theory, the issuance of recalls likely results in a consumer response that ultimately leads to a decrease in the demand for the affected good. However, theory does not reveal any information regarding the magnitude and duration of this negative consumer response, which largely depends on consumer perceptions of the health risks and extent of knowledge associated with recalled products. As such, the elasticity associated with the outbreak variable for Peter Pan was anticipated to be negative, whereas it was expected to be positive for the competing peanut butter brands.

Data

For our analysis, the data regarding the quantities purchased and prices of peanut butter were derived from the ACNielsen Homescan Panel for calendar years 2006, 2007, and 2008. ACNielsen Homsescan panels are the largest ongoing household scanner data survey system, tracking purchases made by households in the United States. In this study, the time-series data set spans 156 consecutive weeks, from Wednesday, January 4, 2006, to Tuesday, December 30, 2008, and includes weekly totals of quantities purchased and prices (unit values).

The chronological sequence of the Peter Pan recall event was as follows: the prerecall period ranging from January 4, 2006, through February 13, 2007 (a total of 58 weekly observations); the recall period, when Peter Pan was removed from the shelves of the stores, going from February 14, 2007, through August 21, 2007 (a total of 27 weekly observations); and the postrecall period, when Peter Pan came back to the stores, spanning from August 22, 2007, through December 30, 2008 (a total of 71 weekly observations). As such, we see that the CDC illness counts overlapped with prerecall weeks as well as the actual recall period. The reintroduction of Peter Pan overlapped entirely with the postrecall period.

The quantity purchased of a peanut butter brand was constructed by aggregating weekly total ounces across households and then dividing this sum by the number of unique households that bought that peanut butter brand in the given week. Five peanut butter brands were examined in this analysis: private label, Jif, Peter Pan, Skippy, and other brands. The private label peanut butter brand included store brands of peanut butter. The Jif peanut butter brand included Jif, Simply Jif, Jif Smooth Sensations, and Jif To Go. The Peter Pan peanut butter brand incorporated Peter Pan, Peter Pan Whipped, and Peter Pan Plus. The Skippy peanut butter brand included Skippy, Skippy Carb Options, and Skippy Natural. Finally, other brands included all the brands of peanut butter except for Jif, Peter Pan, Skippy, and private label brands.

As a result of unavailability of prices, unit values were used as a proxy for prices. Unit values were calculated by dividing total expenditures by total ounces sold for each week. The value of coupons, if any, was deducted from the total expenditure in the construction of unit values. As well, prices were adjusted for inflation using the Consumer Price Index (CPI) with 1982 – 84 = 100 reported by the Bureau of Labor Statistics (2011). Because the CPI is reported on a monthly basis, weekly interpolation of this series was done to deflate the unit values.

During the recall period (February 14, 2007, through August 21, 2007), Peter Pan was not available on the shelves of the stores for a total of 27 weekly observations. As such, weekly observations of the unit value of Peter Pan were missing and had to be imputed for these 27 weeks. To impute Peter Pan missing unit values, four regressions were successively run, in each case regressing Peter Pan unit values on one of the other brand's unit values. Then, the predicted Peter Pan unit values for the missing observations were collected from the four regression models and averaged, yielding the imputed values to fill in for the missing unit values. The basis for this regression-based imputation rests on the hypothesis that prices of substitutable brands move together. Additionally, Kyureghian, Capps, and Nayga (2011) advocate the type of imputation we adopted for prices. Finally, in the wake of the recall, ConAgra undertook repairs of its malfunctioned peanut processing plant in Sylvester, Georgia. Particularly, ConAgra announced that it had spent considerable amount of money on upgrading machinery, technology, and design throughout the plant before reopening it and returning Peter Pan on store shelves in August 2007 (ConAgra Foods Inc., 2007). This disruption in the supply, rather than a conscious decision on the part of ConAgra to keep the brand off the market as a result of concerns about consumer acceptance, may have caused it to demand the imputed prices that were used in the analysis. As suggested by the data, the average imputed Peter Pan price for the recall period was 0.38 cents/ounce greater than that in the prerecall period. Because Peter Pan was not available on store shelves during the recall period, the quantity for Peter Pan was zero over the recall weeks.

The product recall event associated with the outbreak variable was developed based on the weekly number of confirmed cases of *Salmonella* Tennessee infection resulting from the consumption of peanut butter (Centers for Disease Control and Prevention, 2007). The first 29 observations of this variable are zeroes, observations from 30 through 68 correspond to the actual number of confirmed cases, and observations running from 69 through 156 are all zeroes again. The square root transformation was used for the outbreak variable to handle zero observations and to capture diminishing marginal returns. Descriptive statistics of the variables incorporated in the model are presented in Table 1.

The average weekly total amounts of peanut butter purchased per household of private label, Jif, other brands, Skippy, and Peter Pan are 31.49, 35.74, 22.60, 34.96, and 30.46 ounces, respectively, over the studied period, suggesting that Jif is the leading brand followed by Skippy, private label, Peter Pan, and other brands.

The average real unit values of private label, Jif, other brands, Skippy, and Peter Pan are 4.14, 5.17, 7.40, 5.16, and 4.84 cents per ounce, respectively, revealing that of all the peanut butter brands, other brands had the highest unit value followed by Jif, Skippy, Peter Pan, and private label. Finally, the average of the number of confirmed illnesses associated with the consumption of peanut butter (*CDCCASE*) is roughly three with a standard deviation of 7.3.

Estimation Procedure and Results

The four equations in the Barten model were estimated with parametric restrictions imposed for private label, Jif, other brands, and Skippy leaving Peter Pan out. The unit values were treated as exogenous, whereas total expenditure on the category was assumed to be endogenous, as is common in the literature (Attfield, 1985;

Table 1. Descriptive Statistics of the Variables Used in the Analysis of Peanut Butter Brands

Variable	Units	n	Mean	Standard Deviation	Minimum	Maximum
Quantity						
Private label	oz	156	31.49	1.33	28.68	35.12
Jif	oz	156	35.74	2.48	30.93	44.49
Other brands	oz	156	22.60	1.15	19.93	27.98
Skippy	oz	156	34.96	2.18	29.93	43.13
Peter Pan[a]	oz	129	30.46	3.41	24.29	42.80
Price						
Private label	cents/oz	156	4.14	0.23	3.67	4.61
Jif	cents/oz	156	5.17	0.19	4.78	5.77
Other brands	cents/oz	156	7.40	0.27	6.54	8.13
Skippy	cents/oz	156	5.16	0.37	4.20	6.35
Peter Pan[b]	cents/oz	156	4.84	0.51	3.07	7.09
CDCCASE	No. of confirmed cases	156	3.08	7.30	0.00	36.00

Source: Derived from ACNielsen Homsescan panels for household purchases, 2006, 2007, and 2008.

[a] Peter Pan was not available during the recall period for 27 weeks.

[b] Includes imputed unit values of Peter Pan.

Capps et al., 1994). To handle the issue of endogeneity, in the final estimation, we used the predicted values of total expenditure from regressing it on real unit values of all peanut butter brands and real disposable personal income (reported by the U.S. Department of Commerce (2011)) (Capps et al., 1994).

To correct for serial correlation, a first-order autoregressive correction was applied. The Barten model parameter estimates and associated p values are exhibited in Table 2. The level of significance chosen for this analysis was 0.05. SAS 9.3 was the statistical software package used to estimate the BSM.

The R^2 for the omitted equation (Peter Pan) was calculated 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 computed as the ratio of the sum of squared differences in successive residuals to the residual sum of squares.

The R^2s range from 0.43 to 0.81 indicating relatively good fits for all the estimated equations, especially because the dependent variables are related to logarithmic differences. The Durbin-Watson statistics for the five equations together with the statistically significant serial correlation coefficient (ρ_1) suggested that serial correlation was handled in the Barten model. The significance of the χ^2 statistic testing the various joint hypotheses associated with λ and μ indicated that the data best supported the general BSM at the 5% significance level. Of 43 BSM parameter estimates, 18 were statistically significant.

The estimated coefficients associated with the outbreak variable were statistically significant for only Jif and Peter Pan. Consistent with our expectations, the parameter estimates associated with the outbreak variable for Jif were positive implying beneficial spillover and suggesting that the recall of a competing brand had a demand-enhancing impact on the demand for Jif, *ceteris paribus*. A possible explanation for this positive spillover might be the replacement of Peter Pan with Jif by households. This finding compares favorably with the study by Bakhtavoryan, Capps, and Salin (2012). Also, as anticipated, the parameter estimates associated with the outbreak variable for Peter Pan were negative indicating that the recall led to a decrease in the demand for Peter Pan with everything else held constant. The parameter estimates for the rest of peanut butter brands were positive, as expected, although they were statistically insignificant.

The three lags on the outbreak variable mean that consumers responded to the food-borne illness outbreak within three weeks. Based on this information, the mean lag was calculated. The mean lag, defined as $\sum sw_s / \sum w_s$, where w_s is the coefficient associated with lag period s, may be interpreted as the average length of time for unit changes in the outbreak variable to be transferred to changes in quantity of peanut butter purchased. Owing to the fact that a second-degree PDL with a lag length of three weeks was applied with endpoint restrictions imposed, the mean lag was one and a half weeks for all peanut butter brands, suggestive of a rather quick response on the part of consumers. This response is consistent with the extant literature (Smith, van Ravenswaay, and Thompson, 1988; Swartz and Strand, 1981; Van Ravenswaay and Hoehn, 1991).

Both the short-run and the long-run elasticities associated with the outbreak variable were computed at the sample means for all the peanut butter brands. The short run is defined as the contemporaneous period and the long run is defined as three weeks, the optimal length of lag determined using model selection criteria. These elasticities measure the sensitivity of the response by consumers to the number of confirmed cases of *Salmonella* Tennessee infection associated with consumption of peanut butter reported by the CDC in the short run and the long run. Overall, each of the competing name brands and the private label aggregate category experienced a modest yet positive consumer response both in the short run and in the long run, whereas the recalled Peter Pan experienced a negative consumer response in both periods.

The short-run and the long-run elasticities associated with the outbreak variable are shown in Table 3. In the short run, for every 10% increase in the outbreak variable (the number of

Table 2. Parameter Estimates and Goodness-of-Fit Statistics for the Barten Synthetic Model (n = 156)

Brand	R^2	Durbin-Watson
Private label	0.5091	2.1959
Jif	0.4287	2.0358
Other brands	0.4838	2.1600
Skippy	0.4708	2.1814
Peter Pan (omitted)	0.8092	1.9159
Parameter	Estimate	*p* Value
g_{11}	–0.0634	0.0750
g_{12}	0.0697*	0.0002
g_{13}	–0.0032	0.8165
g_{14}	–0.0025	0.8523
g_{15}	–0.0006	0.9221
g_{22}	–0.1375*	0.0054
g_{23}	0.0493*	0.0128
g_{24}	0.0154	0.4285
g_{25}	0.0031	0.7140
g_{33}	–0.0503	0.2467
g_{34}	0.0083	0.6465
g_{35}	–0.0041	0.6675
g_{44}	–0.0411	0.3558
g_{45}	0.0198	0.0903
g_{55}	–0.0183	0.3822
b_1	0.2329*	<0.0001
b_2	0.3415*	<0.0001
b_3	0.3163*	<0.0001
b_4	0.3643*	<0.0001
b_5	0.8334*	<0.0001
λ	–1.0885*	0.0002
μ	0.4406	0.0740
ρ_1	–0.4270*	<0.0001
Parameter	Estimate	*p* Value
sqrtCDCCASE_Private Label_Lag0	0.00003	0.4371
sqrtCDCCASE_Private Label_Lag1	0.00004	0.4371
sqrtCDCCASE_Private Label_Lag2	0.00004	0.4371
sqrtCDCCASE_Private Label_Lag3	0.00003	0.4371
sqrtCDCCASE_Jif_Lag0	0.00009*	0.0487
sqrtCDCCASE_Jif_Lag1	0.00014*	0.0487
sqrtCDCCASE_Jif_Lag2	0.00014*	0.0487
sqrtCDCCASE_Jif_Lag3	0.00009*	0.0487
sqrtCDCCASE_Other Brands_Lag0	0.00006	0.3004
sqrtCDCCASE_Other Brands_Lag1	0.00008	0.3004
sqrtCDCCASE_Other Brands_Lag2	0.00008	0.3004
sqrtCDCCASE_Other Brands_Lag3	0.00006	0.3004
sqrtCDCCASE_Skippy_Lag0	0.00007	0.3094
sqrtCDCCASE_Skippy_Lag1	0.00010	0.3094
sqrtCDCCASE_Skippy_Lag2	0.00010	0.3094
sqrtCDCCASE_Skippy_Lag3	0.00007	0.3094
sqrtCDCCASE_Peter Pan_Lag0	–0.0002*	0.0242
sqrtCDCCASE_Peter Pan_Lag1	–0.0004*	0.0242
sqrtCDCCASE_Peter Pan_Lag2	–0.0004*	0.0242
sqrtCDCCASE_Peter Pan_Lag3	–0.0002*	0.0242

Note: The parameters g_{ij} indicate interactive effects. Subscript 1 refers to private label, 2 refers to Jif, 3 refers to other brands, 4 refers to Skippy, and 5 refers to Peter Pan. 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 $g_{55} = 0 - (g15 + g25 + g35 + g45)$. ρ_1 denotes the autocorrelation coefficient on the error terms, the AR(1) process. To ensure adding up, a common ρ_1 is evident in any demand system. * indicates significance at the 0.05 level.

Table 3. Short-Run and Long-Run Elasticities Associated with the Outbreak Variable by Brand

	Short-Run Elasticity	Long-Run Elasticity
Private label	0.00003	0.00015
Jif	0.00008	0.00038
Other brands	0.00005	0.00026
Skippy	0.00006	0.00030
Peter Pan	–0.00032	–0.00161

Note: All elasticities are computed at the sample means of the data.

cases of *Salmonella* reported by the CDC), the quantity purchased of Jif peanut butter increased by 0.0008% with everything else held constant. In the long run, a 10% increase in the outbreak variable is associated with a 0.0038% increase in the quantity purchased of Jif peanut butter, *ceteris paribus*.

In the short run, as the outbreak variable went up by 10%, the quantity purchased of the Peter Pan peanut butter decreased by 0.0032%, *ceteris paribus*. In the long run, a 10% increase in outbreak variable is associated with a 0.0161% decrease in the quantity purchased of the Peter Pan peanut butter with other factors held constant. All these computed short-run and long-run elasticities are rather small in absolute value, suggestive of consumer loyalty to peanut butter brands.

Based on the parameter estimates and budget shares, compensated, uncompensated, and expenditure elasticities were calculated at the sample means for all the peanut butter brands. Compensated own-price and cross-price elasticities are presented in Table 4. As anticipated, all the compensated own-price elasticities were negative and statistically significant varying from –0.498 (Peter Pan) to –0.915 (Jif). In addition, all the compensated own-price elasticity estimates were less than one in absolute value indicating inelastic demands for all the peanut butter brands.

Compensated cross-price elasticities are net of income effects; thus, they provide a viable picture of substitution among brands. All the compensated cross-price elasticities were positive indicating that these peanut butter brands are net substitutes with 10 of 20 of them possessing statistical significance. Significant net substitution relationships were evident between private label and Jif, Jif and other brands, and Jif and Skippy. In addition, statistically significant net substitution relationships were found between other brands and Skippy and Skippy and Peter Pan. The strongest significant net substitution relationship was observed between private label and Jif (0.521). The weakest significant net substitution relationship was observed between Skippy and other brands (0.131). Competition between national brands becomes evident from these computed compensated cross-price elasticities. In particular, Jif was the major competitor for Skippy (0.171), whereas Skippy was the major competitor for Peter Pan (0.236). The latter result is consistent with the findings by Bakhtavoryan, Capps, and Salin (2012).

Table 4. Compensated Own-Price and Cross-Price Elasticities Associated with the Peanut Butter Brands

	Private Label	Jif	Other Brands	Skippy	Peter Pan
Private label	–0.746*	0.521*	0.076	0.087	0.062
	(0.0001)	(0.0001)	(0.1943)	(0.1132)	(0.1367)
Jif	0.367*	–0.915*	0.302*	0.167*	0.080
	(0.0001)	(0.0001)	(0.0001)	(0.0031)	(0.0646)
Other brands	0.059	0.334*	–0.580*	0.141*	0.046
	(0.1943)	(0.0001)	(0.0001)	(0.0151)	(0.3442)
Skippy	0.063	0.171*	0.131*	–0.517*	0.151*
	(0.1132)	(0.0031)	(0.0151)	(0.0001)	(0.0047)
Peter Pan	0.070	0.126	0.067	0.236*	–0.498*
	(0.1367)	(0.0646)	(0.3442)	(0.0047)	(0.0068)

Note: All elasticities are computed at the sample means of the data. * indicates statistical significance at the 0.05 level. Numbers in parentheses are p values.

Table 5 shows the uncompensated own-price and expenditure elasticities. As anticipated, all the uncompensated own-price elasticity estimates were statistically significant and negative ranging from –0.629 (Skippy) to –1.17 (Peter Pan). Inelastic demands were observed for private label, other brands, and Skippy. In contrast, more elastic demand (–0.998) was found for Jif implying that Proctor and Gamble, the manufacturer of Jif, operated in the relatively more elastic portion of the demand curve. A possible explanation for relatively inelastic demand for the competing brands may be explained by the fact that the recall initiated spillover responses to other unaffected brands and this may have led them to dealing with their relatively inelastic demand response with profit maximization not necessarily being a viable objective. This statement is supported by the pricing strategy implemented by the competing firms during the recall period compared with the prerecall period. In fact, as evidenced by the data, the prices of all competing brands were decreased relative to their prerecall levels, which is not consistent with economic theory of a profit-maximizing firm facing an inelastic demand. For example, the average prices of private label, Jif, Skippy, and other brands were lower by 0.03, 0.07, 0.09, and 0.07 cents/ounce, respectively, during the recall compared with the corresponding average prices in the prerecall period.

Another possible explanation for relatively inelastic demand for the competing brands is that peanut butter commands a small share of the consumer's budget. As such, even at the brand level, own-price elasticities associated with consumer products that comprise small budget shares sometimes are in the inelastic range (Bakhtavoryan, Capps, and Salin, 2012; Toro-Gonzalez et al., 2012).

The uncompensated own-price elasticity for Peter Pan was greater than one in absolute value indicating an elastic demand for this brand and implying a relatively high sensitivity on the part of consumers to price changes for this brand. This result was expected because Peter Pan was involved in the recall. All the calculated expenditure elasticities were statistically significant and positive, implying that the quantity demanded of all peanut butter brands increased as real expenditure for peanut butter rose with all other factors held constant. Peter Pan was the most sensitive peanut butter brand to changes in total expenditure (4.530). The fact that Peter Pan was pulled off the store shelves for the entire duration of the recall (27 weeks) may have contributed to this unusually high value of the expenditure elasticity. Private label was the least sensitive peanut butter brand to changes in total expenditure (0.303).

Summary, Conclusions, Implications, and Recommendations for Future Research

The impact of a major product recall on the competition among peanut butter brands was evaluated by estimating the Barten synthetic model allowing for dynamic effects. Clearly,

Table 5. Uncompensated Own-Price, Cross-Price, and Expenditure Elasticities Associated with the Peanut Butter Brands

	Private Label	Jif	Other Brands	Skippy	Peter Pan	Expenditure elasticity
Private label	–0.797*	0.449*	0.010	0.017	0.017	0.303*
	(0.0001)	(0.0001)	(0.8607)	(0.7556)	(0.6816)	(0.0001)
Jif	0.309*	–0.998*	0.227*	0.086	0.027	0.349*
	(0.0001)	(0.0001)	(0.0001)	(0.1159)	(0.5238)	(0.0001)
Other brands	–0.005	0.243*	–0.662*	0.052	–0.010	0.382*
	(0.9149)	(0.0003)	(0.0001)	(0.3638)	(0.8341)	(0.0001)
Skippy	–0.019	0.056	0.026	–0.629*	0.079	0.488*
	(0.6614)	(0.3710)	(0.6461)	(0.0001)	(0.1402)	(0.0001)
Peter Pan	–0.688*	–0.951*	–0.908*	–0.812*	–1.170*	4.530*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)

Note: All elasticities are computed at the sample means of the data. * indicates statistical significance at the 0.05 level. Numbers in parentheses are *p* values.

the foodborne illness event had a negative impact on the demand for the implicated brand. However, we also find positive spillover effects for the leading brand. The impact of the recall of Peter Pan on the demand for the brands that have smaller market shares was positive, albeit statistically insignificant.

It took consumers three weeks to respond to the foodborne illness outbreak. Also, the average length of time it took before changes in quantity purchased of any peanut butter brand were observed was one and a half weeks. This finding suggests that consumers were paying close attention, and they responded promptly to the event. The computed short-run and long-run elasticities associated with the illness outbreak were small in magnitude, suggestive of consumer loyalty to peanut butter brands. As revealed by the compensated cross-price elasticities, competition existed among national peanut butter brands vying for strengthening their positions in the market.

Using the 2007 peanut butter recall as a case study, this empirical piece demonstrates the value of the demand systems approach in studies of product harm crises. The methodology formally takes into account demand interrelationships of the respective brands. Additionally, the demand systems approach enabled us to obtain information regarding the affected brand, although observations on the product are not available during the recall period. Furthermore, the lag structure on the variable capturing the illness outbreak allowed us to obtain valuable information on the average length of time associated with consumer response to the recall. Simply put, our work represents a contribution to the literature concerning the competitive environment in light of a food safety crisis.

As an extension to the current analysis, one can estimate the demand system (or an ad hoc demand model) over the periods for which complete data are available and then use the imputed prices to forecast what would have happened to the competing brands had Peter Pan not been recalled and removed from the market. The comparison of these "but for" forecasts to what actually happened would allow to ascertain the spillover effects. Also, future research should consider the use of the media variable for capturing the impact of the recall for the sake of comparing the results with those obtained in the current study as well as checking the robustness of the results of the current study.

[Received July 2013; Accepted March 2014.]

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