EMPIRICAL INVESTIGATION OF THE IMPACT OF THE 2007 RECALL ON THE DEMAND FOR PEANUT BUTTER BRANDS

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Abstract

The US Food and Drug Administration confirmed in February 2007 that a major foodborne illness outbreak was caused by 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 produced since May 2006 and sold through grocery and retail stores throughout the United States. Using the ACNielsen Homescan Panel for calendar years 2006, 2007 and 2008, this study investigates the impacts of the recall on the demand for peanut butter by estimating a second degree polynomial distributed lag with a lag length of three and endpoint restrictions imposed. The estimation results showed that the recall did have a statistically significant positive impact on the demand for peanut butter as a category. Also, the recall appeared to have had a statistically significant demand-enhancing effect on the Jif peanut butter brand and a demand-diminishing effect on the Skippy peanut butter brand. In all the cases, the maximum impact of the recall took place one to two weeks after the release of the recall.

Keywords: food recalls, polynomial distributed lag model, consumer behavior

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Introduction

Among quite a few food recalls taking place in recent years was the peanut butter (PB) recall. Based on the increase in the number of reports at the Centers for Disease Control and Prevention (CDC) and state health departments in November of 2006 linking PB to salmonella contamination, the U.S. Food and Drug Administration (FDA) launched a multistate control-study during February 5-13, 2007 (CDC, 2007). The study confirmed that the foodborne illness was caused by the consumption of two PB brands, Peter Pan and Great Value, manufactured by ConAgra Foods Inc. at its Sylvester, Georgia, processing plant. As a result, ConAgra ceased the production of PB at its plant, destroyed all affected products in their possession, and, on February 14, 2007, through a press release to media, voluntarily issued a nationwide recall of its Peter Pan and Great Value (a brand made for Wal-Mart by ConAgra) PB products produced since May 2006 with product code 2111 and sold through grocery and retail stores throughout the United States (CDC, 2007).

It was believed to be the first salmonella outbreak involving PB in the United States. Opened and unopened jars of the affected PB brands, together with environmental samples collected from the plant, were used to conduct tests for possible contamination. The test results helped isolate an outbreak strain of Salmonella serotype Tennessee. This strain of salmonella sickened 628 persons from 47 states since August 1, 2006 (CDC, 2007).

Initially the source of contamination was unknown; however, later it was revealed that the PB was contaminated because of moisture resulting from a leaky roof and sprinkler malfunctioning during a rainstorm in Sylvester, Georgia. This moisture mixed with dormant salmonella bacteria from peanut dust and raw peanuts stored in the facility, led to this food safety issue (Manufacturing.net, 2007).

In an effort to restore the consumer confidence in the safety of the recalled PB brands, ConAgra undertook repairs of its peanut processing plant in Sylvester, Georgia, and started a large-scale marketing campaign. Particularly, ConAgra claimed that it had spent 15 million dollars on fixing problems that had led to the salmonella contamination before re-opening its peanut processing plant in Georgia and returning Peter Pan PB on store shelves in August 2007. During its massive marketing campaign, ConAgra sent out 2 million coupons for free Peter Pan PB, $1-off coupons, and updated the design of Peter Pan PB jars (NewsInferno, 2007). According to ConAgra, this marketing campaign was the largest investment the company had ever made in Peter Pan.

To encourage customers, ConAgra introduced a new design of the Peter Pan PB jars with a "New Look" label and a 100 percent satisfaction guarantee in which a full purchase price refund was available in case customers were not satisfied with the purchase (NewsInferno, 2007).

The release of negative information by federal agencies or individual companies concerning a specific product the consumption of which might cause health issues for humans may entail a lagged response from consumers due to psychological, technological, and institutional reasons (Gujarati, 2003; Griliches, 1967). Through application of polynomial distributed lag (PDL) specifications, economists attempt to better explain the dynamics related to the dissemination of negative information.

By estimating a PDL specification, this study attempts to shed light on the following: (1) whether or not the recall had a statistically significant impact on the demand for PB; (2) how the impacts of the PB recall were distributed over time; (3) whether or not consumers returned to pre-recall purchase levels of PB, and if so, the length of time it took to reach this situation; (4)

ascertaining the substitutability and complementarity effects among PB brands; and (5) estimating the short-run and long-run elasticities associated with the recall.

To the best of our knowledge, this study is different from prior research in a few aspects: (1) the analysis is conducted both at the PB category and at the brand level, allowing us to capture spillover effects among PB brands and shed light on the identification of major competition among brands;
(2) the number of confirmed cases of infections due to the consumption of a specific product (in our case the product is PB) never has been used previously in constructing the outbreak variable; (3) the demand for the PB has not been extensively studied in the light of the recall.

The significance of the findings of our analysis is important for PB producing firms given the competitive environment in the PB industry where three national brands (Jif, Peter Pan and Skippy) comprise over 65% of market share over the study period from January 2006 through December 2008. Having accurate coefficient estimates from the PDL model enables PB producing firms to render better decisions when undertaking a specific business strategy in dealing with short-run and long-run consumer responses to negative information.

This chapter proceeds by first presenting the relevant literature review. Then the theoretical framework is discussed, and the methodology is presented. Subsequently, data indigenous to this econometric analysis are described in the next section. The model specification and estimation results are discussed in the ensuing section. The conclusions, limitations, and recommendations for future research comprise the final section.

Literature Review

A PDL method developed by Almon (1965) can be used to study the response of consumption of particular food product to negative information (recalls, food safety announcements). Swartz and Strand (1981) studied the influence of information about oyster contamination in the James River due to kepone on the demand for shucked oysters in Baltimore, a spatially separated area from the contaminated region, using a second-order and four-lag PDL model and employing biweekly data from 1973 through 1976. The negative information variable was developed using articles from the four major Baltimore and Washington newspapers. First, articles were assigned values based on their probability of negatively affecting the demand for oysters. Particularly, articles stating that oysters were tainted with kepone were given a probability of 1, articles that talked about general fisheries having kepone contamination issues were given a probability of 0.75, articles covering only finfish were awarded a probability of 0.5, articles that presented general information on James River contamination were assigned a probability of 0.25, and other articles were given a probability of zero. Next, these values were weighted based upon the probability of being read. In this case, advertisement expenditures across newspapers were used as weights considering size, location and day of sale of the newspaper. Then the weighted values were weighted one more time by the market shares of each newspaper in the Baltimore/Washington market to accommodate the likelihood of the information reaching oyster consumers. The parameter estimates for all the negative media indices were statistically significant. After eight weeks, the consumers returned to pre-announcement consumption levels.

Smith, van Ravenswaay, and Thompson (1988) used a second degree PDL specification with lag length of three to evaluate the response of fluid milk sales to the negative newspaper coverage regarding the incident of heptachlor contamination of fresh fluid milk in Oahu, Hawaii utilizing monthly data from January 1977 to June 1983. A negative media variable was constructed first by identifying newspaper articles concerning the food contamination incident from two major Honolulu newspapers during the period of analysis that contained negative information on milk quality, the level of government protection, and the integrity of milk processors in handling the incident problem. Next, the negative newspaper articles were assigned weights from 0 to 5 based on the distinction of each article. Finally, aggregating the assigned weights yielded a monthly measure representing the negative media coverage. Other sources of information (in-store, word of mouth) related to the contamination incident were incorporated into the model via a dummy variable. According to the estimation results, the coefficients associated with current and lagged negative media variables were negative and significantly different from zero. The negative information effect reached its maximum contemporaneously with the announcement of the food contamination and subsequent impacts followed a geometric decay pattern.

Van Ravenswaay and Hoehn (1991) estimated a PDL model with three lags to empirically evaluate the effect of Alar on apple demand utilizing monthly data from January 1980 to July 1989. The risk information regarding Alar was included in the model as an index which consisted of monthly number of articles in New York Times that had words "Alar" or "daminozide" located in Nexis electronic database during the period from July 1984 to July 1989. Also, incorporated in the model were cumulative measures of monthly articles and a dummy variable assuming a value of 0 before the announcement about Alar, and 1 thereafter. The parameter estimates for the current and lagged risk information variables from the model, which excluded the cumulative measure and the aforementioned dummy variable, were all negative in sign; however, only the first-lag and the third-lag of the risk information variable were significant.

The aforementioned articles emphasize the empirical analysis of the impact of a recall on the demand for various products taking into account the delayed response of consumers to the recall announcement. However, these articles did not focus attention on the possible spillover effects both among brands within a product category and within the same brands in other product categories. Spillover effects were considered in the marketing literature, as evidenced by the articles reviewed in Chapter 2; however, the marketing literature did not address delayed consumer responses to recalls. Our study combines both approaches, a combination of information economics and marketing. Particularly, by estimating the PDL specification, consumer responsiveness to the recall is evaluated along with determining possible cross-brand effects resulting from the recall.

Theoretical Framework

The impact of a food recall event on demand can be analyzed within the theoretical framework developed by Basmann (1956). In this framework, consumer's utility function is represented by

$$U_t = U\big(q_t, \theta(r_t)\big), \tag{3.1}$$

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 q_t (quality, safety) and consumer's personal attributes. By assumption, changes in the product attributes lead to changes in 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 budget constraint, gives the Marshallian demands $q_t = q_t\big(y, p, \theta(r_t)\big)$, where y is 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), the focus of our study, by assumption, consumer utility depends not only on quantities of goods consumed, but also on consumer perceptions concerning the quality of the good, $\theta(r)$, which in turn is dependent on the information available to consumers, r. The demand decreases conditional on the severity of negative publicity, because consumers adjust their consumption based on their perceptions concerning the quality of the good.

Methodology

The PDL model, also known as Almon distributed lag model, is a k*th*-order distributed lag model as follows:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3} + \cdots + \beta_k X_{t-k} + \varepsilon_t \qquad (3.2)$$

where α is the intercept and β_0 is called the short-run multiplier, since it shows the change in Y given a unit change in X in the same time period. If the change in X is the same over the period of study, then, following the same logic, $(\beta_0 + \beta_1)$ shows the change in Y in the next period, and $(\beta_0 + \beta_1 + \beta_2)$ yields the change in Y in the following period. These sums of β's are referred to as interim multipliers. And, the long-run multiplier, β, which shows the total effect if the change is sustained permanently, is the sum of all the βs after k periods given by

$$\beta = \sum_{i=0}^{k} \beta_i \qquad (3.3)$$

In (3.2) ε_t is the disturbance term with mean 0 and constant variance, $E(\varepsilon_t)=0$, $var(\varepsilon_t)=\sigma^2$, and $cov(\varepsilon_t\ \varepsilon_s)=0$ for $t \neq s$. Equation (3.2) can also be written the following way:

$$Y_t = \alpha + \sum_{i=0}^{k} \beta_i X_{t-i} + \varepsilon_t \tag{3.4}$$

According to Almon, β_i can be approximated by the polynomial in i of m degree as follows:

$$\beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2 + \alpha_3 i^3 + \cdots + \alpha_m i^m \tag{3.5}$$

A constraint that must be put in place is that the degree of the polynomial must be less than the maximum length of lag, m < k (Fouda, 2010). For the sake of illustration simplicity, let's assume β_i can be approximated by the second-degree polynomial, that is

$$\beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2 \tag{3.6}$$

Plugging (3.6) into (3.4) we get

$$Y_t = \alpha + \sum_{i=0}^{k}(\alpha_0 + \alpha_1 i + \alpha_2 i^2) X_{t-i} + \varepsilon_t = \alpha + \alpha_0 \sum_{i=0}^{k} X_{t-i} + \alpha_1 \sum_{i=0}^{k} i X_{t-i} + \alpha_2 \sum_{i=0}^{k} i^2 X_{t-i} + \varepsilon_t \tag{3.7}$$

Given k, equation (3.7) can be rewritten as

$$Y_t = \alpha + \alpha_0 (X_t + X_{t-1} + \cdots + X_{t-k}) + \alpha_1 (X_{t-1} + 2X_{t-2} + \cdots + kX_{t-k}) + \alpha_2 (X_{t-1} + 4X_{t-2} + \cdots + k^2 X_{t-k}) + \varepsilon_t \tag{3.8}$$

Equation (3.8) can be estimated using the method of ordinary least squares as long as the disturbance term ε follows the classical assumptions. Once (3.8) is estimated and the α's are obtained, the original β's can be recovered using (3.6).

Oftentimes, researchers impose endpoint restrictions on the β's by assuming that $\beta_{-1} = 0$ and $\beta_{k+1} = 0$. The first assumption means that no relationship exists between the value of explanatory variable before the current period and the value of the dependent variable in the current period. In other words, the relationship between the dependent variable and the value of the explanatory variable before the current period is not anticipatory. The second assumption concerning endpoint restrictions, implies that after some time period of lag k, the explanatory variable no longer has any effect on the current value of the dependent variable. In other words, at some lag the relationship between the current value of the dependent variable and the explanatory variable is going to die out.

During the estimation process, the issue that arises is the determination of the appropriate length of lag as well as the degree of the polynomial. Normally, metrics such as Schwarz Information Criterion (SIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQC) are used to determine the length of lag and the degree of polynomial.

Data

For our analysis, the data regarding the quantities purchased, prices, and coupons of PB were derived from the ACNielsen Homescan Panel for calendar years 2006, 2007 and 2008. ACNielsen Homsescan panels are the largest on-going household scanner data survey system, tracking purchases made by households in the United States. Since the analysis is conducted both at the PB category level and at the brand level, overall, two separate data sets were derived, one for each level.

Data for Analyzing PB at the Category Level

In this analysis, 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, prices (unit values), and coupons. The data set also was supplemented with interpolated weekly income and a set of information variables. Despite the availability of detailed demographic information on participating households in the ACNielsen Homescan panels, this information was forgone because the final data set actually used in our analysis was of time series nature developed from aggregating of relevant variables over weeks across the households. This approach taken during data preparation was justified since the present analysis was not concerned about the impact of selected households, which is the focus of the next paper.

A variable pertaining to the household quantity purchased of PB was constructed by aggregating weekly total ounces of all PB brands across households and then dividing it by the number of unique households who purchased PB in the given week. Because PB prices were unavailable, unit values were used as a proxy for them. For each week, PB unit values were calculated by dividing total expenditures by total ounces. The same imputation procedure was used to derive weekly unit values for jelly. The coupon variable for PB was developed first by aggregating weekly values of coupons used and then dividing it by the number of unique households to express the variable on per household basis.

Real disposable personal income was reported on monthly basis, however, weekly interpolation of these data were used in the estimation. To obtain weekly interpolations of the income, first, a weekly growth rate for each quarter over the entire study period was calculated as $r_i = \left(\frac{Q_c}{Q_p}\right)^{1/13} - 1$, where r_i is the weekly growth rate for quarter i, Q_c is the current quarter, Q_p is the previous quarter, and the exponent 1/13 is for rendering the growth rate on weekly basis (13 weeks in a quarter). Next, starting from the income given for the first month of 2006, each successive interpolated weekly income was calculated as $I_p * (1 + r_i)$, where I_p is the income in the previous week.

The outbreak variable was developed based on the histogram reported by CDC that showed weekly number of confirmed cases of Salmonella Tennessee infection associated with consumption of PB (CDC, 2007). The first 29 observations of this variable are zeros, observations from 30 through 68 correspond to the actual number of confirmed cases, and observations running from 69 through 156 are all zeros again. Due to unavailability of the actual data underlying the histogram, a simple iterative procedure attempting to come up with the data that would replicate the original histogram was conducted. After multiple similar iterations, a one-to-one matching between histograms was achieved. It needs to be pointed out that the square root transformation was used for the outbreak variable to handle the zero observations and to capture diminishing marginal returns associated with it.

To test the hypothesis that with the passage of time after the initial release of the recall announcement consumers gradually increase their consumption of PB, a variable which counts the weeks from the recall was created. The first 58 observations of this variable are zeros, the 59th observation is 1, and the last observation is 98, with intermediate observations running chronologically.

A possible permanent shift in the demand for PB was modeled as a dummy variable taking on a value of 0 before the issuance of the recall and 1 afterwards. This permanent shift corresponds to an abrupt structural change. To assess the effects of seasonality on PB demand, the 52 weeks in a year were divided into 4 13-week periods. Using the 4th 13-week period as a reference period, three dummy variables were used in the actual estimation to circumvent the dummy variable trap.

Unit values, coupon, and income variables are deflated using the consumer price index with 1982-84=100 reported by Bureau of Labor Statistics of U.S. Department of Labor (BLS). Descriptive statistics of the continuous variables incorporated in the model are presented in Table 3.1 (see Table A1 in Appendix A for the description of the variable labels).

Table 3.1. Descriptive Statistics of the Variables Used in the Analysis of PB at the Category Level [a]

Variable	Units of Measurement	N	Mean	Std Dev	Min	Max
QPB	Oz	156	33.22	1.29	30.54	36.97
PPB	Cents/Oz	156	4.99	0.23	4.39	5.65
PJ	Cents/Oz	156	3.22	0.24	2.76	4.26
COUPPB	Cents	156	5.22	2.75	0.81	18.96
INC	Dollars	156	84,840.09	693.77	83,071.55	86,114.40
CDCCASE	Number of confirmed cases	156	3.08	7.30	0.00	36.00

[a] Derived from ACNielsen Homsescan panels for household purchases, 2006, 2007, and 2008

The average weekly total amount of PB purchased (QPB) per household was 33.22 ounces with a standard deviation of 1.29 over the sample period. The average real unit value of PB (PPB) was about 5 cents per ounce with standard deviation of 0.23 cents. The average real unit value of jelly (PJ) was 3.22 cents per ounce with standard deviation of 0.24. The standard deviation of the average real coupon values on per household basis (COUPPB) of 2.75 was more than half its mean of 5.22 cents. Real per household income (INC) on average was $84,840 with standard deviation of $694. Finally, the average of CDC confirmed cases (CDCCASE) was approximately three with standard deviation of roughly seven.

Data for Analyzing PB at Brand Level

The time-series data set for the brand level analysis covers 156 consecutive weeks from Wednesday January 4, 2006 to Tuesday December 30, 2008 and includes weekly totals of quantities purchased, prices (unit values), and coupons. The final data set also included interpolated weekly income and a set of information variables.

This data set differs from the one used for PB category analysis in that it is broken into five distinct PB brands. As a result, instead of having one unit value (or total amount of PB purchased variable, or coupon) for the entire PB category, we now have five unit values (and five total amounts of PB purchased variables, and five coupons), one for each PB brand. Particularly, one general group for jelly and five groups of PB brands are explored in this study: Private Label, Jif, Peter Pan, Skippy, and Other Brands.

The Private Label PB brand group includes store brands of PB. The Jif PB brand group includes Jif, Simply Jif, Jif Smooth Sensations, and Jif To Go. The Peter Pan PB brand group incorporates Peter Pan, Peter Pan Whipped, and Peter Pan Plus. The Skippy PB brand consists of Skippy, Skippy Carb Options, and Skippy Natural. Finally, Other Brands include all the brands of PB except for Jif, Peter Pan, Skippy, as well as Private Label brands.

While the description and construction of the variables for the analysis are exactly the same as before, the imputation process of the missing values for Peter Pan unit values is different. 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 ones. The basis for this regression-based imputation rests on the hypothesis that prices of substitutable brands move together. Also, it needs to be mentioned that the quantity information for Peter Pan was zero over the recall weeks. Descriptive statistics of the variables included in the model are given in Table 3.2.

Table 3.2 shows that the average weekly total amounts of PB purchased per household of Private Label (QPL), Jif (QJIF), Peter Pan (QPPAN), Skippy (QSKIPPY), and Other Brands (QOBRAND) were 31.49, 35.74, 30.14, 34.96, and 22.60 ounces, respectively, over the studied period, suggesting that Jif is the leading brand followed by Skippy, Private Label, Peter Pan and Other Brands. Also, the average real unit values of Private Label (PPL), Jif (PJIF), Peter Pan (PPPAN), Skippy(PSKIPPY), Other Brands (POBRAND), and jelly (PJ) were 4.14, 5.17, 4.84, 5.16, 7.40, and 3.22 cents per ounce, respectively, revealing that of all the PB brands Other Brands had the highest unit value, followed by Jif, Skippy, Peter Pan, and Private Label.

Table 3.2. Descriptive Statistics of the Variables Used in the Analysis of PB at the Brand Level [a]

Variable	Units of Measurements	N	Mean	Std. Dev.	Min	Max
QPL	Oz	156	31.49	1.33	28.68	35.12
QJIF	Oz	156	35.74	2.48	30.93	44.49
QPPAN	Oz	156	30.14	5.94	18.00	79.33
QSKIPPY	Oz	156	34.96	2.18	29.93	43.13
QOBRAND	Oz	156	22.60	1.15	19.93	27.98
PPL	Cents/Oz	156	4.14	0.23	3.67	4.61
PJIF	Cents/Oz	156	5.17	0.19	4.78	5.77
PPPAN	Cents/Oz	156	4.84	0.51	3.07	7.09
PSKIPPY	Cents/Oz	156	5.16	0.37	4.20	6.35
POBRAND	Cents/Oz	156	7.40	0.27	6.54	8.13
PJ	Cents/Oz	156	3.22	0.24	2.76	4.26
COUPPL	Cents	156	1.63	1.42	0.22	8.63
COUPJIF	Cents	156	5.60	3.69	0.10	20.34
COUPSKIPPY	Cents	156	8.27	5.50	0.58	24.84
COUPOBRAND	Cents	156	4.25	1.94	0.79	12.09

[a] Derived from ACNielsen Homsescan panels for household purchases, 2006, 2007, and 2008

The average of real per household coupon values of Private Label (COUPPL), Jif (COUPJIF), Skippy (COUPSKIPPY), and Other Brands (COUPOBRAND) were 1.63, 5.60, 8.27, and 4.25 cents, respectively, implying that, on average, larger coupon values were offered for Skippy, followed by Jif, Other Brands, and Private Label.

According to the law of demand, there is a negative relationship between price and quantity demanded. As such, all the coefficients associated with the own real unit values of PB were expected to be negative. Also, theory posits a positive relationship between the price of a substitute good and the quantity of the good demanded in question. Thus, the coefficients associated with the real unit values of other PB brands were hypothesized to be positive. Theory suggests a negative relationship between the price of a complement good and the demand for the good in question. Hence, it was expected that the coefficients associated with the unit value of jelly would be negative. Based on theory and the good in question (PB) the income effects were hypothesized to be positive, suggesting that PB is a normal good rather than an inferior good. Theory suggests a positive relationship between positive information and the demand for the good in question. Hence, the coefficient estimate associated with the coupon variable was anticipated to be positive, since coupon is a form of promotion (positive information).

The parameter estimate for the variable that counts weeks from recall was expected to be positive implying that as more and more weeks pass from the announcement of the recall, consumers would increase their consumption of PB. 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, a negative sign was anticipated on all the coefficients associated with current and lagged outbreak variables, as well as the parameter estimate for the dummy variable associated with the beginning of the recall.

Empirical Specification and Estimation Results

One single-equation model and one system of equations concerning the demand for PB were estimated. The single-equation model dealt with the analysis of PB as a category and was specified as follows:

$$lnQPB_t = f(lnPPB_t,\ lnPJ_t,\ lnCOUPPB_t,\ lnINC_t,\ WKSFRRECALL_t,\ Q1,\ Q2,\ Q3,\ SQRTCDCCASE_t, \ldots SQRTCDCCASEt_{t-j}\ DUMMY_t) + v_t \quad (3.9)$$

where $lnQPB_t$ is the natural logarithm of quantity purchased of PB per unique household;

$lnPPB_t$ is the natural logarithm of the real unit value of PB;

$lnPJ_t$ is the natural logarithm of the real unit value of jelly;

$lnCOUPPB_t$ is the natural logarithm of values of coupons used when purchasing PB per unique household;

$lnINC_t$ is the natural logarithm of real disposable personal income on per household basis;

$WKSFRRECALL_t$ counts number of weeks from the recall announcement;

Q1, Q2, and Q3, are seasonality dummy variables;

$SQRTCDCCASEt_{t-j}$ is the square root of the outbreak variable with lag j;

$DUMMY_t$ is the dummy variable;

v_t is the disturbance term in time t.

A system of equations dealing with the analysis of PB at the brand level was specified as follows:

$$lnQPB_{it} = f(lnPPB_{it}, lnPPB_{jt},\ lnPJ_t,\ COUP_{it},\ lnINC_t,\ WKSFRRECALL_t,\ Q1,\ Q2,\ Q3,\ SQRTCDCCASE_t, \ldots SQRTCDCCASEt_{t-j},\ laglnQPB_{it},\ DUMMY_t) + \varepsilon_t \quad (3.10)$$

where $\ln QPB_{it}$ is the natural logarithm of quantity purchased of PB of brand i per unique household;

$\ln PPB_{it}$ is the natural logarithm of the real unit value of PB of brand i;

$\ln PPB_{jt}$ is the natural logarithm of the real unit value of PB of brand j;

$\ln PJ_{t}$ is the natural logarithm of the real unit value of jelly;

$COUP_{it}$ is the values of coupons used when purchasing PB of brand i per unique household;

$\ln INC_{t}$ is the natural logarithm of real disposable personal income on per household basis;

$lag\ln QPB_{it}$ is the dependent variable lagged one time period;

ε_t is the disturbance term in time t.

The description of $WKSFRRECALL_{t}$, Q1, Q2, Q3, $SQRTCDCCASEt_{t-j}$, and $DUMMY_{t}$ variables is the same as in the case of single-equation discussed above.

Both single-equation and the system of equations were estimated using a second degree PDL specification with length of lag three. Head and tail endpoint restrictions were imposed and their use was supported through statistical tests. Also, it needs to be noted that various combinations of both models were estimated using alternative lag lengths and degrees of polynomial. However, based on SIC, the specification with lag length of 3 and a polynomial degree of 2 was chosen as the best (see Table A2 in Appendix A). SAS 9.2 was the statistical software package used to estimate the double-log models without intercepts to circumvent degrading collinearity problems (see Tables A3, A4, A5, and A6 in Appendix A).

The four equations in the system were estimated simultaneously using a seemingly unrelated regressions (SUR) procedure for Private Label, Jif, Skippy, and Other Brands leaving Peter Pan out. In this way, we attempt to account for possible spillover effects among PB brands resulting from the recall of Peter Pan PB. Before the estimation of the SUR, four equations with one for each PB brand, were estimated and the results from these four single-equation estimations were later compared to the ones from the SUR procedure. The comparison showed that the reductions in the standard errors of the coefficient estimates in the SUR approach were small implying weak cross-equation correlations. This finding also was confirmed by the correlation coefficients reported in Table 3.3 based on the residuals from the SUR procedure.

Notwithstanding the rather small improvement in the statistical significance of parameter estimates, the SUR procedure was ultimately used. In the SUR procedure, all the insignificant variables were sequentially dropped from the system of equations based on their extent of insignificance as measured by p-values before arriving at the final coefficient estimates presented in Table 3.5. To account for serial correlation, a first order autoregressive correction was utilized. The R^2 was calculated by squaring the correlation coefficient between the actual and the predicted values of the dependent variables.

The estimated coefficients, which also are the elasticities, and associated p-values from single-equation and system of equations specifications are reported in Tables 3.4 and 3.5, respectively. The significance of coefficient estimates is indicated with asterisks; these correspond to p-values below the 0.05 level of significance chosen for this analysis.

According to Table 3.4, the R^2 for the PB category was 0.66 meaning that 66 percent of variation in the dependent variable was explained by the model. As expected, the parameter estimate for the unit value of PB was negative and statistically significant implying that the demand for PB is inelastic and suggesting that a 10 percent decline in PB unit value would lead to 8.5 percent increase in the quantity of PB demanded, holding all other factors constant. The result of inelastic demand for PB compares favorably with the finding by Deodhar and Fletcher (1998) who calculated the long-run own price elasticity of demand for PB to be -0.23.

Table 3.3. The Variance-Covariance Matrix of Residuals in Correlation Form

	resid_lnQPL	resid_lnQJIF	resid_lnSKIPPY	resid_lnOBRAND
resid_lnQPL	1	0.0588	-0.01741	0.15738
resid_lnQJIF	0.0588	1	0.08186	0.11414
resid_lnSKIPPY	-0.01741	0.08186	1	-0.03442
resid_lnOBRAND	0.15738	0.11414	-0.03442	1

The parameter estimate for the unit value of jelly was negative, as hypothesized, however, it was statistically insignificant. As expected, the parameter estimate for the coupon was positive and statistically significant indicating that a 10 percent increase in the value of coupon would result in a 0.1 percent increase in the demand for PB, *ceteris paribus*.

The parameter estimate associated with income was positive and significantly different from zero implying that PB is a normal good and a 10 percent increase in income will lead to 4.3 percent increase in the demand for PB, controlling for all other factors. The parameter estimated for WKSFRRECALL variable was positive and statistically significant, as hypothesized. The estimated coefficient for the DUMMY variable, which controls for the structural shift in the demand for PB, was negative; however, it was statistically insignificant. Based on the joint test of the significance of the quarterly dummy variables, seasonality appeared to be an insignificant determinant of the demand for PB.

Contrary to our expectations, all estimated coefficients associated with the outbreak variable were positive and statistically significant suggesting that the recall had a demand enhancing impact on the PB category. This finding is in line with the conclusion by Wittenberger and Dohlman (2010) who rationalized the overall increase in the consumption of PB after the recall based on the fact that consumers and retailers were able to promptly identify the contaminated jars of PB by product codes, destroyed them, and switched to the consumption of other PB brands. The maximum influence of the recall announcement took place one to two weeks after its release.

Table 3.4. Estimated Coefficients for the Peanut Butter Demand at the Category Level

Variable	Estimate	P-value
lnPPB	-0.8479*	<.0001
lnPJ	-0.0163	0.6706
lnCOUPPB	0.011*	0.0394
lnINC	0.4259*	<.0001
WKSFRRECALL	0.001349*	<.0001
Q1	-0.0148	0.0607
Q2	-0.00096	0.8268
Q3	-0.00288	0.2905
DUMMY	-0.0103	0.2236
SQRTCDCCASE(0)	0.001123*	0.0088
SQRTCDCCASE(1)	0.001684*	0.0088
SQRTCDCCASE(2)	0.001684*	0.0088
SQRTCDCCASE(3)	0.001123*	0.0088
AR1	-0.2679*	0.0017

$R^2 = 0.66$
Durbin-Watson = 1.90
F= 1.54, Pr > F= 0.2077 (joint test of the significance of the quarterly dummy variables)
* Statistically significant at the 5 percent level

Letting w_s stand for the weight for lag period s, the short-run response in the quantity purchased of PB for a unit change in outbreak variable, evaluated at the sample means, is computed by $\frac{\sum w_0}{2}\mathrm{CDCCASE}^{-0.5}\mathrm{QPB}$ and the short-run recall elasticity is calculated by $\frac{\sum w_0}{2}\mathrm{CDCCASE}^{0.5}$. In addition, the long-run response in the quantity purchased of PB given a one unit change in outbreak variable, at the sample means, is given by $\frac{\sum w_s}{2}\mathrm{CDCCASE}^{-0.5}\mathrm{QPB}$ and the long-run recall elasticity, at the sample means, is given by $\frac{\sum w_s}{2}\mathrm{CDCCASE}^{0.5}$.

For the PB category the short run response was 0.011 indicating that each successive unit increase in the outbreak variable increases the short-run quantity purchased of PB by 0.011 ounces, *ceteris paribus*. The short-run elasticity was 0.001 indicating that as the outbreak variable goes up by 10 percent, the short-run quantity purchased of PB increases by 0.01 percent, *ceteris paribus*.

For the PB category the long-run response was 0.053 meaning that for every unit increase in the outbreak variable, the long-run quantity purchased of PB will increase by 0.053 ounces, everything else held constant. The long-run recall elasticity was 0.005 meaning that, in the long-run, a 10 percent increase in outbreak variable results in a 0.05 percent increase in the quantity purchased of PB, other factors held constant.

Table 3.5 is broken down into four blocks with each block representing a specific PB brand. As such, the discussion of the results in Table 3.5 is done one block at time and then summarized across the blocks.

Table 3.5. Estimated Coefficients for the Peanut Butter Demand at the Brand Level

Brand	Variable	Estimate	P-value
lnQPL	**(a1)*lnPPL**	-1.02524*	<.0001
	(a3)*lnPPAN	-0.06056*	0.0249
Test: a10=0, a11=0, a12=0,	**(a8)*lnINC**	0.440098*	<.0001
Wald's ChiSquared=14.51, P-value=0.0023	**(a9)*WKSFRRECALL**	0.001561*	<.0001
	(a10)*Q1	-0.01854*	0.0416
R^2=0.51	**(a11)*Q2**	-0.00723	0.1037
DW=1.97	**(a12)*Q3**	-0.01038*	0.0003
	SQRTCDCCASE(0)	0.00056	0.2529
	SQRTCDCCASE(1)	0.00084	0.2529
	SQRTCDCCASE(2)	0.00084	0.2529
	SQRTCDCCASE(3)	0.00056	0.2529
	(a15)*DUMMY	-0.04962*	<.0001
	AR(1)	0.164132	0.0502
lnQJIF	**(b2)*lnPJIF**	-1.03956*	<.0001
	(b8)*lnINC	0.457355*	<.0001
Test: b10=0, b11=0, b12=0,	**(b9)*WKSFRRECALL**	0.002229*	<.0001
Wald's ChiSquared=7.76, P-value=0.0513	**(b10)*Q1**	-0.01813	0.0543
	(b11)*Q2	0.002474	0.6167
R^2=0.81	**(b12)*Q3**	0.001087	0.7215
DW=2.00	**SQRTCDCCASE(0)**	0.00232*	<.0001
	SQRTCDCCASE(1)	0.00348*	<.0001
	SQRTCDCCASE(2)	0.00348*	<.0001
	SQRTCDCCASE(3)	0.00232*	<.0001
	(b15)*DUMMY	0.022809*	0.0316
	AR(1)	0.234685*	0.0053
lnQSKIPPY	**(d4)*lnPSKIPPY**	-0.80908*	<.0001
	(d8)*lnINC	0.42851*	<.0001
Test: d10=0, d11=0, d12=0,	**(d9)*WKSFRRECALL**	0.001818*	<.0001
Wald's ChiSquared=8.21, P-value=0.0419	**(d10)*Q1**	0.035001*	0.0051
	(d11)*Q2	0.010658	0.1061
R^2=0.5	**(d12)*Q3**	0.004858	0.2259
DW=1.96	**SQRTCDCCASE(0)**	-0.00193*	0.0053
	SQRTCDCCASE(1)	-0.0029*	0.0053
	SQRTCDCCASE(2)	-0.0029*	0.0053
	SQRTCDCCASE(3)	-0.00193*	0.0053
	(d15)*DUMMY	-0.08191*	<.0001
	AR(1)	0.118375	0.1552
lnQOBRAND	**(e5)*lnPOBRAND**	-0.77572*	<.0001
	(e8)*lnINC	0.412347*	<.0001
Test: e10=0, e11=0, e12=0,	**(e10)*Q1**	-0.01534	0.1493

Wald's ChiSquared=5.03, P-value=0.1698	**(e11)*Q2**	-0.00662	0.2324
	(e12)*Q3	-0.00774*	0.0309
R^2=0.38	**SQRTCDCCASE(0)**	0.00044	0.4034
DW=1.99	**SQRTCDCCASE(1)**	0.00066	0.4034
	SQRTCDCCASE(2)	0.00066	0.4034
	SQRTCDCCASE(3)	0.00044	0.4034
	AR(1)	0.128731	0.1162

* Statistically significant at the 5 percent level

lnQPL block

The R^2 for the Private Label model was 0.51 meaning that 51 percent of variation in the dependent variable was explained by the regression model. As hypothesized, the parameter estimate for the unit value of Private Label was negative and statistically significant indicating that the demand for Private Label PB is elastic and that for 10 percent decrease in the unit value of Private Label the quantity of Private Label PB demanded will go up by 10.25 percent, *ceteris paribus*. Contrary to our expectations, the parameter estimate for the unit value of Peter Pan was negative and significant making Peter Pan a complementary brand for Private Label products or store brand. Thus, a 10 percent decrease in the unit value of Peter Pan would lead to 0.61 percent decline in the demand for the Private Label PB, other factors held invariant.

The coefficient estimate associated with income was positive and significantly different from zero meaning that Private Label PB is a normal good and a 10 percent increase in income will lead to 4.4 percent increase in the demand for Private Label PB, *ceteris paribus*. The coefficient estimate associated with WKSFRRECALL variable was positive and statistically significant, as anticipated, showing that as time passed by from the issuance of the recall, the demand for Private Label PB went up. The result of the joint test of the significance of the quarterly dummy variables implied that seasonality was a significant factor of the demand for Private Label PB. Particularly, the demand for Private Label PB was lower in the first three quarters relative to that in the fourth quarter. As anticipated, the coefficient estimate of the DUMMY variable was negative and significantly different from zero suggesting a structural decline in the demand for Private Label PB.

Contrary to our expectations, all the parameter estimates for the current and lagged outbreak variables were positive with the most impact occurring one to two weeks after the issuance of the recall, however, they were all statistically insignificant. For the Private Label PB the short-run response was 0.005 meaning that for each additional unit increase in the outbreak variable, the short-run quantity purchased of Private Label PB will increase by 0.005 ounces, all else held fixed. The short-run recall elasticity of Private Label was 0.0005 meaning that, in the short-run, a 10 percent increase in outbreak variable results in an increase of the quantity purchased of Private Label PB 0.005 percent, everything else held fixed.

For the Private Label PB the long-run response was 0.025 implying that for every unit increase in the outbreak variable, the long-run quantity purchased of Private Label PB will increase by 0.025 ounces, *ceteris paribus*. The long-run recall elasticity of Private Label PB was 0.002 meaning that, in the long-run, a 10 percent increase in outbreak variable will result in 0.02 percent increase in the quantity purchased of Private Label PB, *ceteris paribus*.

lnQJIF block

The R^2 for the Jif model was 0.81 meaning that 81 percent of variation in the dependent variable was accounted for by the model. As expected, the coefficient estimate of the unit value of Jif was negative and significantly different from zero indicating that the demand for Jif PB is elastic and that a 10 percent decrease in the unit value of Jif will result in the 10.4 percent increase in the quantity of Jif PB demanded, all other factors held constant. The income coefficient estimate was positive and statistically significant rendering Jif PB a normal good and indicating that a 10 percent increase in income will increase the demand for Jif PB by 4.6 percent, everything else held constant. The parameter estimate for WKSFRRECALL variable was positive and statistically significant, as expected, meaning that with passage of time from the recall announcement, the demand for Jif PB increased. Seasonality was concluded to be a statistically insignificant factor affecting the demand for Jif PB according to the joint test of the significance of the quarterly dummy variables. Contrary to our anticipation, the coefficient estimate of the DUMMY variable was positive and significantly different from zero suggesting a structural increase in the demand for Jif PB.

Contrary to our hypothesis, the recall had a demand enhancing impact on the demand for Jif with its biggest influence taking place one to two weeks after the release of the recall with all the parameter estimates associated with the current and lagged outbreak variables exhibiting statistical significance.

For the Jif PB the short-run response was 0.024 meaning that, in the short-run, as the outbreak variable goes up by one unit, the quantity purchased of Jif PB will go up by 0.024 ounces, everything else held constant. The short-run recall elasticity of Jif PB was 0.002 meaning that, for every 10 percent increase in outbreak variable, the short-run quantity purchased of Jif PB will increase by 0.02 percent, everything else held constant.

For the Jif PB the long-run response was 0.118 indicating that for every unit increase in the outbreak variable, the long-run quantity purchased of Jif PB will increase by 0.118 ounces, controlling for the other variables. The long-run recall elasticity of Jif PB was 0.01 meaning that, in the long-run, 10 percent increase in outbreak variable will result in 0.1 percent increase in the quantity purchased of Jif PB, *ceteris paribus*.

lnQSKIPPY block

The coefficient of determination for the Skippy model was 0.5 implying that half of the variation in the dependent variable was explained by the model. As anticipated, the coefficient estimate associated with the unit value of Skippy was negative and statistically significant indicating that the demand for Skippy PB is inelastic and that a 10 percent decrease in the unit value of Skippy will result in the 8.1 percent increase in the quantity of Jif PB demanded, holding everything else fixed. The income parameter estimate was positive and significantly different from zero making Skippy PB a normal good and implying that a 10 percent increase in income will increase the demand for Skippy PB by 4.3 percent, everything else held fixed. In line with our expectations, the coefficient estimate associated with WKSFRRECALL variable was positive and statistically significant, indicating that the demand for Skippy PB increased, as more and more time went by from the announcement of the recall. Joint test of significance done on the seasonality dummies showed that seasonality was a statistically significant driver of the demand for the Skippy PB. Though the demand for Skippy PB was higher in the first three quarters relative to the fourth quarter, however, it was the strongest in the first quarter. The parameter estimate associated with the DUMMY was negative and significant, which was consistent with the hypothesis, pointing out that, on average, the demand for Skippy PB decreased after the recall.

Consistent with our expectations, the recall had a distorting impact on the demand for Skippy with its maximum effects occurring one to two weeks after the recall announcement and with all the coefficient estimates associated with the current and lagged outbreak variables displaying statistical significance.

For the Skippy PB the short-run response was -0.019 indicating that for each additional unit increase in outbreak variable, in the short-run, the quantity of Skippy PB will decrease by 0.019 ounces, *ceteris paribus*. The short-run recall elasticity of Skippy PB was -0.002 indicating that for every 10 percent increase in outbreak variable, there will be 0.02 percent decrease in the quantity purchased of Skippy PB, *ceteris paribus*.

For the Skippy PB the long-run response was -0.096 meaning that for every unit increase in the outbreak variable, the long-run quantity purchased of Skippy PB will decrease by 0.096 ounces, everything else held fixed. The long-run recall elasticity of Skippy PB was -0.008 meaning that, in the long-run, 10 percent increase in outbreak variable will result in 0.08 percent decrease in the quantity purchased of Skippy PB, everything else held constant.

lnQOBRAND block

The coefficient of determination for the Other Brands model was 0.38 meaning that 38 percent of the variation in the dependent variable was accounted for by the model. As expected, the coefficient estimate of the unit value of Other Brands was negative and statistically significant indicating that the demand for Other Brands PB is inelastic and that a 10 percent decrease in the unit value of Other Brands will lead to 7.8 percent increase in the quantity of Other Brands PB demanded, controlling for all the other factors. The income coefficient estimate was positive and statistically significant meaning that the Other Brands PB was a normal good and 10 percent increase in income will increase the demand for the Other Brands PB by 4.1 percent, *ceteris paribus*. Seasonality did not appear to be a significant determinant of the demand for Other Brands PB, as evidenced by the joint test of the significance of the seasonality dummy variables.

Like Jif, Other Brands PB experienced a positive impact of the recall with the peak of the influence taking place one to two weeks after the public release of the recall announcement, however, in this case, the effects of the current and lagged outbreak variable were statistically insignificant.

For the Other Brands PB the short-run response was 0.003 indicating that as the outbreak variable increases by one unit, the short-run quantity purchased of Other Brands PB will increase by 0.003 ounces, holding all other factors fixed. The short-run recall elasticity of Other Brands was 0.0004 indicating that the short-run quantity purchased of Other Brands PB will increase by 0.004 percent, as the outbreak variable goes up by 10 percent, everything else held fixed.

For the Other Brands PB the long-run response was 0.014 meaning that for every unit increase in the outbreak variable, the long-run quantity purchased of Other Brands PB will increase by 0.014 ounces, *ceteris paribus*. The long-run recall elasticity of Other Brands PB was 0.002 meaning that, in the long-run, 10 percent increase in outbreak variable will result in 0.02 percent increase in the quantity purchased of Other Brands PB, *ceteris paribus*.

General discussion of the results in Tables 3.4 and 3.5

The general discussion of the results in Tables 3.4 and 3.5 helps to answer the questions posed in the first section of this chapter. First, it needs to be pointed out that the sporadic significance of the DUMMY variable and the SQRTCDCCASE variable, throughout the PB category and brand analysis, made it obvious that the recall did have an impact on the demand for the PB. The results showed that the peak effect of the recall occurred one to two weeks after its issuance. The statistically significant positive coefficient estimates of the current and lagged outbreak variables for the PB category and for the Jif brand attested to the fact that the recall had demand enhancing effects on the PB category as a whole and on the Jif PB brand in particular. At the same time, the statistically significant negative coefficient estimates of the current and lagged outbreak variables for Skippy brand imply that the recall had demand diminishing effects on the Skippy PB brand. The influence of the current and lagged outbreak variables associated with the Private Label brand and Other Brands on the demand for the PB was statistically insignificant. The estimation results revealed that only own-price and income variables consistently exhibited statistical significance across the brands. According to the results, jelly was never a statistically significant complement for PB on any level and Peter Pan turned out to be a complement for the Private Label brand. Coupons had a significant positive influence on PB demand only at the category level. Seasonality appeared to have had a statistically significant effect on the demand for the Private Label brand and the Skippy PB brand. Finally, the calculated short-run and long-run elasticities associated with the recall provided evidence that the percentage changes in PB, both at the category and brand levels were small in magnitude. These results are consistent with the extant literature associated with measuring the impacts of either positive information (advertising and promotion) or negative information (food safety).

Conclusions, Limitations, and Recommendations for Future Research

The impacts of a recall on the demand for PB were evaluated by estimating a second degree PDL with three lags (a lag length of three weeks) and endpoint restrictions imposed. The estimation results showed that the recall did have a statistically significant positive impact on the demand for PB as a category. Also, the recall appeared to have had a statistically significant demand-enhancing effect on the Jif PB brand and a demand-diminishing effect on the Skippy PB brand. In addition, it needs to be mentioned that in all the cases the maximum impact of the recall took place one to two weeks after the release of the recall. The demand-enhancing impact of the recall on the demand for PB at the category level is consistent with the finding by Wittenberger and Dohlman (2010).

Jelly was not found to be a statistically significant complement for PB either at the category or at the brand level. The seasonality was found to be a significant determinant of the demand for the Private Label brand and the Skippy brand. Finally, the demand for the PB was inelastic in the short-run and long-run both at the category level and at the brand level.

A few limitations should be mentioned. First, considering the fact that the recall also involved the Great Value brand, it would be appealing to have purchase data as well as sufficient information to construct a distinct outbreak variable for the Great Value brand too. However, since the data on this brand were collapsed into the group of the Private Label brand, it was impossible to disaggregate information on this brand from the rest of the private label PB products. Hence, future research should attempt to gather information on Great Value brand and include it in the model as a separate brand to assess the impact of the recall associated with Great Value on the demand for the PB. Second, the outbreak variable used in our analysis did not reflect the likelihood of households being exposed to the information associated with the recall event. As such, appropriate adjustments or weighting of the outbreak variable or obtaining a separate measure that would account for this likelihood would be useful to include in future research focusing on recall events. Third, given the time-series nature of the data, demographic variables such as age, sex, race, size of the households were not incorporated into the analysis. A future study associated with the consideration of detailed demographic variables merits consideration.

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Appendix A

Table A1. Description of Variable Labels

Variable	Units of Measurements	Description
QPB	Oz	weekly total amount of peanut butter purchased per household
PPB	Cents/Oz	real unit value of peanut butter
PJ	Cents/Oz	real unit value of jelly
COUPPB	Cents	real coupon values per household
INC	Dollars	real per household income
CDCCASE	Number of confirmed cases	Number of CDC confirmed cases of Salmonella Tennessee
QPL	Oz	weekly total amounts of Private Label PB purchased per household
QJIF	Oz	weekly total amounts of Jif PB purchased per household
QPPAN	Oz	weekly total amounts of Peter Pan PB purchased per household
QSKIPPY	Oz	weekly total amounts of Skippy PB purchased per household
QOBRAND	Oz	weekly total amounts of Other Brands PB purchased per household
PPL	Cents/Oz	real unit values of Private Label
PJIF	Cents/Oz	real unit values of Jif
PPPAN	Cents/Oz	real unit values of Peter Pan
PSKIPPY	Cents/Oz	real unit values of Skippy
POBRAND	Cents/Oz	real unit values of Other Brands
PJ	Cents/Oz	real unit values of jelly
COUPPL	Cents	real coupon values of Private Label per household
COUPJIF	Cents	real coupon values of Jif per household
COUPSKIPPY	Cents	real coupon values of Skippy per household
COUPOBRAND	Cents	real coupon values of Other Brands per household

Table A2. SIC for Alternative Number of Lags and Degrees for Peanut Butter Category, N=156

Number of lags and degree	SIC
3 lag and 2nd degree	-671.81038
4 lag and 2nd degree	-666.75334
5 lag and 2nd degree	-661.57798
6 lag and 2nd degree	-656.50303
7 lag and 2nd degree	-651.17487
8 lag and 2nd degree	-645.90238
9 lag and 2nd degree	-640.95414
10 lag and 2nd degree	-635.79147
11 lag and 2nd degree	-630.56607
12 lag and 2nd degree	-625.37891
13 lag and 2nd degree	-624.87558
3 lag and 3rd degree	-669.3443

Table A3. Multicollinearity Analysis for the Peanut Butter Category

Variable	Variance Inflation Factor
Intercept	0
lnPPB	3.44961
lnPJ	1.95466
lnCOUPPB	1.64897
lnINC	17.47676
WKSFRRECALL	15.18755
Q1	2.77466
Q2	2.91682
Q3	2.58811
DUMMY	7.09570
SQRTCDCCASE	4.76555

Table A4. Multicollinearity Analysis for the Peanut Butter Category

Collinearity Diagnostics													
			Proportion of Variation										
Num	Eigenvalue	Condition Index	Intercept	lnPPb	lnPJ	lnCOUPPB	lnINC	WKSFRRECALL	Q1	Q2	Q3	dummy	SQRTCDCCASE
1	7.06172	1	5.81E-10	0.00000449	0.00003704	0.00122	5.85E-10	0.00039775	0.00141	0.00116	0.00156	0.000757	0.00061919
2	1.3567	2.2815	2.60E-11	9.39E-08	0.00000263	0.00049712	2.57E-11	0.00354	0.05251	0.01621	0.00747	0.00312	0.04685
3	1.0192	2.6322	4.41E-11	3.17E-07	0.0000038	0.00049665	4.40E-11	0.00042542	0.00174	0.12585	0.133	8.2E-06	0.00001053
4	0.80502	2.9618	1.97E-10	0.00000124	0.00001083	0.00042514	1.97E-10	0.00486	0.1136	0.03978	0.05075	0.00404	0.04059
5	0.42726	4.0655	3.72E-10	0.00000171	0.00000561	0.0001033	3.66E-10	0.01803	0.11372	0.03832	0.11376	0.00847	0.10978
6	0.17748	6.3079	4.07E-09	0.00003327	0.00051278	0.06312	4.08E-09	0.00001723	0.18246	0.11419	0.17727	0.09188	0.08536
7	0.0964	8.5590	2.97E-09	0.00000903	0.00021699	0.00078147	2.99E-09	0.1528	0.15168	0.19569	0.11169	0.1936	0.03259
8	0.05463	11.36929	2.72E-08	0.00025837	0.00292	0.83059	2.73E-08	0.00428	0.00206	0.19792	0.01678	0.01697	0.01241
9	0.00141	70.85338	0.00000244	0.00953	0.94681	0.02002	0.00000245	0.00076793	0.12561	0.24758	0.36628	0.02037	0.00023004
10	0.00018943	193.07748	0.00002256	0.8401	0.04882	0.08012	0.0000233	0.19395	0.00199	0.00748	0.00358	0.04967	0.00076897
11	1.48E-08	21846	0.99997	0.15006	0.00066341	0.00263	0.99997	0.62093	0.2532	0.01582	0.01787	0.61111	0.67079

Table A5. Multicollinearity Analysis for Peanut Butter Brands

Variable	Variance Inflation Factor
Intercept	0
lnPPL	5.669
lnPJIF	4.43801
lnPPPAN	1.59463
lnPSKIPPY	3.84905
lnPOBRAND	1.23264
lnPJ	2.16354
COUPPL	1.16484
COUPJIF	1.68962
COUPPPAN	1.58427
COUPSKIPPY	1.69098
COUPOBRAND	1.57537
lnINC	11.24855
WKSFRRECALL	28.21241
Q1	2.58177
Q2	3.12045
Q3	2.77041
SQRTCDCCASE	3.78056

Table A6. Multicollinearity Analysis for Peanut Butter Brands

Collinearity Diagnostics																																					
			Proportion of Variation																																		
Number	Eigenvalue	Condition Number	lnPPLa1	lnPPANa3	lnINCa8	WKSFRECALLa9	Q1a10	Q2a11	Q3a12	SQRTCDCASEa13	DUMMYa15	lnPJIFb2	lnINCb8	WEEKSFRRECALL b9	Q1b10	Q2b11	Q3b12	SQRTCDCCASEb13	DUMMYb15	lnPSKIPPYd4	lnINCd8	WKSFRECALLd9	Q1d10	Q2d11	Q3d12	SQRTCDCASEd13	DUMMYd15	lnPOBRANDe5	lnINCe8	Q1e10	Q2e11	Q3e12	SQERCDCASEe13	AR1_Agg_ctlbr_totoz_ph_l1	AR1_Agg_jif_totoz_ph_l1	AR1_Agg_skippy_totoz_ph_l1	AR1_Agg_otherbrand_totoz_ph_l1
1	5.356878	1.0000	0.0000	0.0001	0.0000	0.0012	0.0031	0.0031	0.0038	0.0029	0.0030	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0003	0.0003	0.0004	0.0000	0.0000	0.0000	0.0000
2	4.670181	1.0710	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0017	0.0026	0.0021	0.0028	0.0020	0.0027	0.0000	0.0000	0.0015	0.0024	0.0020	0.0027	0.0018	0.0027	0.0000	0.0000	0.0006	0.0005	0.0005	0.0008	0.0000	0.0000	0.0000	0.0000
3	3.901862	1.1717	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0028	0.0023	0.0030	0.0022	0.0029	0.0000	0.0000	0.0022	0.0035	0.0030	0.0040	0.0026	0.0039	0.0000	0.0000	0.0003	0.0002	0.0003	0.0004	0.0000	0.0000	0.0000	0.0000
4	2.827730	1.3764	0.0000	0.0000	0.0000	0.0002	0.0001	0.0004	0.0005	0.0000	0.0005	0.0000	0.0000	0.0006	0.0004	0.0005	0.0007	0.0001	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0176	0.0093	0.0108	0.0250	0.0000	0.0000	0.0000	0.0000
5	1.517641	1.8788	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0034	0.0527	0.0087	0.0059	0.0630	0.0017	0.0000	0.0000	0.0025	0.0407	0.0061	0.0052	0.0497	0.0015	0.0000	0.0000	0.0097	0.0069	0.0044	0.0097	0.0000	0.0027	0.0042	0.0012
6	1.454881	1.9189	0.0000	0.0000	0.0000	0.0028	0.0715	0.0150	0.0105	0.0951	0.0024	0.0000	0.0000	0.0001	0.0003	0.0000	0.0001	0.0010	0.0001	0.0000	0.0000	0.0001	0.0006	0.0000	0.0001	0.0010	0.0000	0.0000	0.0000	0.0243	0.0162	0.0102	0.0237	0.0052	0.0001	0.0001	0.0042
7	1.261666	2.0606	0.0000	0.0000	0.0000	0.0002	0.0015	0.0000	0.0006	0.0032	0.0001	0.0000	0.0000	0.0026	0.0420	0.0112	0.0020	0.0496	0.0015	0.0000	0.0000	0.0048	0.0714	0.0069	0.0130	0.0879	0.0028	0.0000	0.0000	0.0052	0.0063	0.0003	0.0044	0.0000	0.0061	0.0171	0.0013
8	1.198970	2.1137	0.0000	0.0000	0.0000	0.0001	0.0003	0.0213	0.0252	0.0004	0.0000	0.0000	0.0000	0.0006	0.0015	0.0391	0.0533	0.0024	0.0001	0.0000	0.0000	0.0000	0.0006	0.0250	0.0199	0.0007	0.0000	0.0000	0.0000	0.0001	0.0742	0.0859	0.0000	0.0020	0.0020	0.0013	0.0002
9	1.127322	2.1799	0.0000	0.0000	0.0000	0.0005	0.0002	0.0808	0.0810	0.0016	0.0001	0.0000	0.0000	0.0002	0.0002	0.0466	0.0435	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0331	0.0315	0.0000	0.0000	0.0000	0.0000	0.0005	0.0140	0.0086	0.0005	0.0239	0.0110	0.0022	0.0047
10	1.060605	2.2474	0.0000	0.0000	0.0000	0.0018	0.0105	0.0091	0.0011	0.0423	0.0016	0.0000	0.0000	0.0020	0.0090	0.0001	0.0008	0.0202	0.0009	0.0000	0.0000	0.0001	0.0001	0.0017	0.0004	0.0003	0.0000	0.0000	0.0000	0.0766	0.0180	0.0378	0.0338	0.0080	0.0564	0.0009	0.2526
11	1.016280	2.2959	0.000	0.000	0.000	0.0000	0.004	0.000	0.003	0.0000	0.0000	0.000	0.0000	0.0004	0.000	0.000	0.001	0.0037	0.0003	0.0000	0.000	0.0000	0.000	0.001	0.002	0.0004	0.0000	0.0000	0.000	0.016	0.021	0.001	0.0192	0.6627	0.0171	0.0008	0.1151

			0	0	0		7	0	7			0			5	5	0				0		1	1	6				0	7	3	2					
12	1.009968	2.3030	0.0000	0.0000	0.0000	0.0001	0.0003	0.0004	0.0010	0.0007	0.0000	0.0000	0.0000	0.0002	0.0011	0.0008	0.0018	0.0062	0.0002	0.0000	0.0000	0.0011	0.0014	0.0000	0.0029	0.0184	0.0007	0.0000	0.0000	0.0036	0.0001	0.0021	0.0001	0.0013	0.2212	0.6372	0.0008
13	0.993786	2.3217	0.0000	0.0000	0.0000	0.0002	0.0006	0.0004	0.0002	0.0041	0.0002	0.0000	0.0000	0.0006	0.0019	0.0001	0.0074	0.0135	0.0002	0.0000	0.0000	0.0007	0.0000	0.0148	0.0124	0.0057	0.0002	0.0000	0.0000	0.0109	0.0036	0.0032	0.0042	0.0000	0.5332	0.2287	0.0011
14	0.963021	2.3585	0.0000	0.0000	0.0000	0.0011	0.0001	0.0009	0.0003	0.0158	0.0011	0.0000	0.0000	0.0001	0.0011	0.0027	0.0021	0.0017	0.0002	0.0000	0.0000	0.0001	0.0000	0.0153	0.0141	0.0000	0.0000	0.0000	0.0000	0.0247	0.0018	0.0217	0.0093	0.1712	0.0105	0.0024	0.5642
15	0.944450	2.3816	0.0000	0.0000	0.0000	0.0000	0.0000	0.0100	0.0122	0.0007	0.0000	0.0000	0.0000	0.0002	0.0000	0.0543	0.0450	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000	0.1115	0.1183	0.0008	0.0000	0.0000	0.0000	0.0002	0.0069	0.0044	0.0001	0.0383	0.0641	0.0212	0.0391
16	0.836896	2.5300	0.0000	0.0000	0.0000	0.0011	0.0116	0.0000	0.0285	0.0117	0.0013	0.0000	0.0000	0.0093	0.0793	0.0481	0.0270	0.0517	0.0050	0.0000	0.0000	0.0046	0.0453	0.0167	0.0285	0.0262	0.0031	0.0000	0.0000	0.0004	0.0095	0.0052	0.0099	0.0068	0.0044	0.0485	0.0000
17	0.818512	2.5583	0.0000	0.0000	0.0000	0.0014	0.0101	0.1097	0.0371	0.0046	0.0006	0.0000	0.0000	0.0000	0.0022	0.0368	0.0678	0.0021	0.0002	0.0000	0.0000	0.0003	0.0020	0.0016	0.0007	0.0013	0.0002	0.0000	0.0000	0.0014	0.0982	0.1120	0.0031	0.0233	0.0017	0.0019	0.0009
18	0.770151	2.6374	0.0000	0.0000	0.0000	0.0052	0.1304	0.0197	0.0916	0.0602	0.0057	0.0000	0.0000	0.0001	0.0114	0.0000	0.0107	0.0024	0.0001	0.0000	0.0000	0.0009	0.0128	0.0037	0.0067	0.0071	0.0006	0.0000	0.0000	0.0073	0.0022	0.0177	0.1163	0.0353	0.0002	0.0056	0.0020
19	0.696213	2.7739	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0073	0.0740	0.0198	0.0458	0.0507	0.0043	0.0000	0.0000	0.0128	0.1043	0.0394	0.0718	0.0732	0.0085	0.0000	0.0000	0.0043	0.0001	0.0004	0.0196	0.0000	0.0010	0.0217	0.0000
20	0.548774	3.1243	0.0000	0.0000	0.0000	0.0056	0.0033	0.0197	0.0330	0.0016	0.0048	0.0000	0.0000	0.0062	0.0023	0.0127	0.0222	0.0018	0.0031	0.0000	0.0000	0.0004	0.0011	0.0007	0.0014	0.0010	0.0002	0.0000	0.0000	0.2826	0.0026	0.0003	0.4899	0.0010	0.0006	0.0000	0.0011
21	0.439663	3.4906	0.0000	0.0000	0.0000	0.0056	0.0478	0.0166	0.0314	0.0587	0.0033	0.0000	0.0000	0.0194	0.1190	0.0328	0.0604	0.1259	0.0067	0.0000	0.0000	0.0143	0.0998	0.0248	0.0528	0.0999	0.0055	0.0000	0.0000	0.0011	0.0001	0.0000	0.0041	0.0000	0.0076	0.0017	0.0000
22	0.386121	3.7247	0.0000	0.0000	0.0000	0.0148	0.1858	0.0464	0.0895	0.2278	0.0078	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0146	0.1057	0.0261	0.0546	0.1061	0.0055	0.0000	0.0000	0.0110	0.0033	0.0015	0.0649	0.0001	0.0000	0.0012	0.0000
23	0.360130	3.8568	0.0000	0.0000	0.0000	0.0027	0.0386	0.0091	0.0174	0.0469	0.0014	0.0000	0.0000	0.0283	0.1847	0.0485	0.0916	0.1964	0.0095	0.0000	0.0000	0.0168	0.1093	0.0296	0.0605	0.1093	0.0066	0.0000	0.0000	0.0035	0.0022	0.0013	0.0304	0.0000	0.0063	0.0010	0.0000
24	0.174557	5.5397	0.0000	0.0006	0.0000	0.0009	0.0073	0.0252	0.0205	0.0615	0.0402	0.0000	0.0000	0.0011	0.0000	0.0008	0.0003	0.0100	0.0059	0.0000	0.0000	0.0000	0.0002	0.0005	0.0004	0.0015	0.0016	0.0003	0.0003	0.3792	0.4747	0.4846	0.0654	0.0000	0.0001	0.0000	0.0001
25	0.148470	6.0067	0.0001	0.0015	0.0001	0.0050	0.0537	0.1093	0.1215	0.0927	0.1630	0.0001	0.0001	0.0098	0.0203	0.0336	0.0417	0.0414	0.1324	0.0002	0.0002	0.0058	0.0089	0.0155	0.0207	0.0199	0.0760	0.0000	0.0000	0.0221	0.0291	0.0295	0.0049	0.0000	0.0009	0.0001	0.0000

26	0.131046	6.3936	0.0001	0.0010	0.0001	0.0046	0.0404	0.0797	0.0903	0.0607	0.1143	0.0000	0.0000	0.0207	0.0085	0.0127	0.0206	0.0110	0.0959	0.0004	0.0004	0.0279	0.0206	0.0354	0.0520	0.0443	0.2409	0.0001	0.0001	0.0698	0.0922	0.0938	0.0178	0.0000	0.0002	0.0003	0.0007
27	0.116691	6.7754	0.0000	0.0001	0.0000	0.0004	0.0035	0.0069	0.0079	0.0051	0.0099	0.0002	0.0002	0.0393	0.0405	0.0651	0.0888	0.0695	0.3166	0.0006	0.0005	0.0249	0.0297	0.0508	0.0695	0.0642	0.2770	0.0000	0.0000	0.0092	0.0123	0.0124	0.0026	0.0000	0.0009	0.0002	0.0002
28	0.097025	7.4304	0.0000	0.0006	0.0000	0.1007	0.0708	0.1287	0.0757	0.0593	0.1409	0.0001	0.0001	0.1622	0.1214	0.1800	0.1269	0.0918	0.0906	0.0002	0.0003	0.0787	0.0626	0.0938	0.0678	0.0519	0.0458	0.0000	0.0000	0.0003	0.0004	0.0004	0.0001	0.0009	0.0030	0.0000	0.0000
29	0.087782	7.8118	0.0000	0.0013	0.0001	0.1593	0.1445	0.2624	0.1658	0.1214	0.1943	0.0000	0.0000	0.0627	0.0489	0.0721	0.0513	0.0341	0.0386	0.0002	0.0004	0.1069	0.0833	0.1244	0.0893	0.0672	0.0663	0.0000	0.0000	0.0117	0.0163	0.0158	0.0032	0.0012	0.0009	0.0000	0.0005
30	0.078655	8.2527	0.0000	0.0001	0.0000	0.0062	0.0064	0.0117	0.0076	0.0054	0.0070	0.0001	0.0002	0.2279	0.1652	0.2460	0.1723	0.1240	0.1335	0.0005	0.0008	0.2495	0.1848	0.2760	0.1956	0.1506	0.1586	0.0000	0.0000	0.0016	0.0023	0.0022	0.0005	0.0000	0.0027	0.0000	0.0001
31	0.003110	41.5037	0.0215	0.9548	0.0153	0.0077	0.1322	0.0090	0.0025	0.0142	0.0235	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0116	0.0000	0.0000	0.0003
32	0.000475	106.2025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.9950	0.9945	0.4269	0.0088	0.0402	0.0003	0.0067	0.0914	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0000
33	0.000191	167.2693	0.0071	0.0007	0.0077	0.0057	0.0001	0.0001	0.0002	0.0001	0.0050	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.9895	0.9895	0.0029	0.0740	0.0307	0.0352	0.0006	0.0000	0.0000	0.0094
34	0.000170	177.3657	0.9708	0.0389	0.9761	0.6646	0.0195	0.0044	0.0390	0.0005	0.2678	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0096	0.0096	0.0001	0.0008	0.0004	0.0004	0.0063	0.0001	0.0000	0.0000
35	0.000126	206.2624	0.0003	0.0003	0.0005	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.9988	0.9988	0.3910	0.0053	0.0218	0.0030	0.0203	0.1455	0.0028	0.0028	0.0012	0.0000	0.0001	0.0000	0.0000	0.0002	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0452	0.0000	0.0001