Food Product Recalls, Agbiotech and Consumer Response: The Case of Starlink

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> *"The products appear to contain the genetic material (DNA) necessary for the production in corn (trade name: Starlink) of the pesticide Cry9C protein derived from Bacillus thuringiensis subspecies tolworthi. The pesticide is not allowed for use in foods for human consumption." Official recall policy statement recorded in the weekly FDA Enforcement Report, Foods – Class II section, November 15, 2000.*

INTRODUCTION

In April 1997, Aventis applied for a license with the U.S. Environmental Protection Agency (EPA) to sell Bt Starlink corn. By May 1998, the EPA had approved the license and 9,000 acres of Starlink corn were planted. Plantings increased over the next several years from 247,000 to 350,000 acres.

In July 2000, Larry Bohlen of Friends of the Earth, an activist group, purchased 23 corn-based food products from a Safeway store in Maryland and shipped them to Genetic ID in Iowa for testing. Some of the products repeatedly tested positive for the Cry9C protein. In mid-September 2000, another activist group, Genetically Engineered Food Alert, held a press conference in Washington D.C. to "alert the public" of the findings. Dan Rather ran the story on the CBS evening news on September 18, 2000 and an unprecedented recall of genetically modified (GM) foods was born in the U.S. food industry.

From October 2000 to April 2001, two hundred and ten final consumer food products that had been manufactured with ingredients partly derived from Starlink corn were reported as recalled in the Foods - Class II section of various issues of the weekly Food and Drug Administration (FDA) Enforcement Report. These products included corn-based taco shells, tostada shells, tortillas, tortilla chips, and chili seasoning kits[1]. Although the broader recall involved business-to-business (B2B) sales and other business-to-consumer (B2C) sales in the food-away-from-home distribution channel, we focus on just those B2C sales in the food-at-home distribution channel for the salted snacks and chili seasonings product categories. Specifically, our empirical objective is to model the consumer response to the Starlink recall using a conditional nonlinear Almost Ideal Demand System that also controls for the effects of relative prices, per capita real expenditure, holidays, post-recall demand trends and the media.

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[1] The only recalled product, a 4-ounce Carroll Shelby's Original Texas Brand chili seasonings kit, includes approximately one ounce of corn masa flour to help thicken the chili while it is cooking.

MODEL DEVELOPMENT

A microeconomic model of consumer choice has been well-developed in the literature to address the role information plays in decision-making (Swartz and Strand, 1981; Smith, van Ravenswaay and Thompson, 1988; Brown and Schrader, 1990; Wessells, Miller and Brooks, 1995). Let Z_1 be the perceived quality of good X_1, where the perceived quality is affected by information in the media, M. This relationship is given by $Z_1 = Z_1(M)$. We can specify the consumer's quasiconcave, twice differentiable utility function as $U(X_1(Z_1(M)), X_2)$ where X_2 represents all other goods. This format fits our Starlink application quite well. For example, in the salted snacks product category in which corn tortilla chips were recalled beginning October 13, 2000, the variable X_1 represents recalled corn tortilla chips and X_2 represents all non-Starlink corn tortilla chips and other salted snacks such as potato chips. The primal utility maximization problem may be written as $L = U(X_1(Z_1(M)), X_2) + \lambda(I - P_1X_1 - P_2X_2 - P_M M)$ where L is the Lagrangian function, λ is the Lagrangian multiplier, I is taken to be income spent on salted snacks, P_1 and P_2 are the respective prices of X_1 and X_2, and, consistent with the literature, P_M is assumed to be zero (i.e., the information is essentially costless to obtain). Hence, the consumer chooses X_1 and X_2 in an effort to maximize U subject to the budget constraint. The solution to the system of first-order conditions is given by the Marshallian or uncompensated demands as $X_1 = X_1(P_1, P_2, I, M)$ and $X_2 = X_2(P_1, P_2, I, M)$. Represented in expenditure share form, we have $w_1 = P_1X_1/I = P_1X_1/(P_1X_1 + P_2X_2)$ and $w_2 = P_2X_2/I = P_2X_2/(P_1X_1 + P_2X_2)$. Using duality theory, Tiesl, Roe and Hicks (2002) arrive at expenditure shares by applying Shephard's lemma to the consumer's expenditure function.

The Conditional Nonlinear AIDS Model

Consistent with the contemporary time series, revealed preference literature, we econometrically model the expenditure shares, w_i, with the well-known Almost Ideal Demand System (AIDS) model (Deaton and Muellbauer, 1980).

The items in each product category affected by the Starlink recall are aggregated into two groupings: Starlink and all other non-Starlink products. For example, we compare recalled Starlink corn tortilla chips with all other salted snack products (i.e., non-Starlink corn tortilla chips and potato chips). For the chili seasonings product category, we compare

Carroll Shelby's Original Texas Brand chili seasonings kit to all other non-Starlink chili seasonings kits. Our nonlinear conditional expenditure share model controls for the observable, separate influences of relative prices, per capita real expenditure for the product category, holiday effects, the recall, and post-recall demand trends. As indicated in our microeconomic framework, consumer response could also be affected by emerging information regarding the Starlink recall. To account for this, we include several media explanatory variables. Our AIDS model is specified as

$$w_{it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \log p_{jt} + \beta_i \log\left(x_t / P_t\right) + \phi_i holiday_t + \theta_i recall_t + \eta_i trend_t + \lambda_i media + \varepsilon_{it} \qquad (1)$$

where

$$\log P_t = \alpha_0 + \sum_{k=1}^{N} \alpha_k \log p_{kt} + \frac{1}{2} \sum_{j=1}^{N} \sum_{k=1}^{N} \gamma_{jk} \log p_{jt} \log p_{kt} \,, \qquad (2)$$

i = 1 indicates the Starlink recalled products in each food product category, i = 2 represents all other items in each food product category, and t indicates time measured in weeks. Hence, the 2-equation system (i = 1, 2) specified in (1) is estimated for both of the product categories affected by the Starlink recall (salted snacks and chili seasonings). A third model for the Mexican dinners product category is under development at the time of this writing.

To clarify the specification above, consider the recalled Carroll Shelby's chili seasonings kit market share equation (w_{1t}) in week t. It is a function of own price ($\log p_{1t}$), the price of all other non-Starlink chili seasonings kits ($\log p_{2t}$), per capita real expenditure for the entire chili seasonings product category ($\log(x_t / P_t)$), holiday effects ($holiday_t$), a variable to control for the recall ($recall_t$), post-recall demand trends ($trend_t$), the media ($media_t$) and a stochastic error. Equation (2) is the unobservable nonlinear price index.

The conditional expenditure shares sum to one when the following adding up conditions hold: $\alpha_1 + \alpha_2 = 1$, $\gamma_{11} + \gamma_{21} = 0$, $\gamma_{12} + \gamma_{22} = 0$, $\beta_1 + \beta_2 = 0$, $\phi_1 + \phi_2 = 0$, $\theta_1 + \theta_2 = 0$, $\eta_1 + \eta_2 = 0$, and $\lambda_1 + \lambda_2 = 0$. The homogeneity conditions are given by $\gamma_{11} + \gamma_{12} = 0$ and $\gamma_{21} + \gamma_{22} = 0$, and the symmetry conditions imply that $\gamma_{12} = \gamma_{21}$. The homogeneity and symmetry conditions represent statistically testable hypotheses regarding the theoretical consistency of the empirical nonlinear conditional expenditure share system. For each product category, one share equation is estimated with nonlinear least squares while the estimates for the other share equation are recovered using the adding up conditions.

Since the dependent variables in an AIDS model are expenditure shares, not quantities demanded, the γ parameters do not have a direct interpretation as an own or cross price elasticity. Similarly, the β parameters do not have a direct interpretation as conditional expenditure elasticities. Own and cross price elasticities are a somewhat complex function of the estimated and recovered α, γ and β parameters as well as mean expenditure shares and prices. In the case of Marshallian or uncompensated price elasticities (E_{ij}^U), we use the expression

$$E_{ij}^U = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \beta_i\left(\alpha_j + \sum_{k=1}^{N}\gamma_{kj}\log p_k\right)\right) \tag{3}$$

where α, γ and β are defined in equations (1) and (2), expenditure shares and prices are taken at their sample means, and δ_{ij} is the Kronecker delta which equals 1 when $i = j$ and zero otherwise. In the case of Hicksian or compensated price elasticities (E_{ij}^C), we use the expression

$$E_{ij}^C = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \beta_i\left(\alpha_j + \sum_{k=1}^{2}\gamma_{kj}\log p_k - w_j\right)\right) + w_j. \tag{4}$$

Finally, the conditional expenditure elasticity ($E_{i,X}$) is given by

$$E_{i,X} = 1 + \frac{\beta_i}{w_i}. \tag{5}$$

A priori, we expect the demands to have the usual properties; $E_{ij}^U < 0$ and $E_{ij}^C < 0$ for $i = j$, $E_{ij}^U > 0$ and $E_{ij}^C > 0$ for $i \neq j$, and $E_{i,X} > 0$ for all i.

Demand Shift Variables

In each model, the seven calendar holidays (New Year's Day, Easter, Memorial Day, Independence Day, Labor Day, Thanksgiving and Christmas) were tested, in addition to several product category specific holidays (i.e., Halloween, Cinco de Mayo, etc). In the case of chili seasonings, two holiday effects ($holiday_t$) were ultimately constructed. The first holiday effect, lasting three weeks, was created for the week preceding, the week of and the week following Halloween. Those three weeks were set to one, otherwise zero. The second holiday effect, also lasting three weeks, was created for the week preceding, the week of and the week following Christmas. Similarly, those three weeks were set to one, otherwise zero. The second holiday essentially combined the Christmas and New Year's Eve calendar holidays into a Winter Holiday composite effect. A priori, if both subsets of products (Starlink and non-Starlink) promote during the same holidays, then we would expect $\phi_i = 0$ in general. This in fact is the case in the salted snacks model as discussed in the Empirical Results section. However, in the chili seasonings model, the Starlink-recalled products are just the Carroll Shelby's Original Texas Brand chili kits. That presents an opportunity to model holidays as described above if that particular brand promotes its products differently than the others in the product category. A priori, if a holiday effect is present for the Carroll Shelby brand in the chili seasonings data, we would expect $\phi_1 > 0$ and $\phi_2 < 0$.

The recall variable ($recall_t$) in the Starlink share equation controls for any presence of bare shelves immediately following the press release announcing a specific recall. Constructed as a dummy variable, it is set to one in the week of the recall, otherwise zero. Effectively it serves as an intercept shifter and allows the model to absorb an acute yet temporary supply restriction spawned by efforts to rid the supply chain of tainted product. Given the adding up properties, the recall variable non-intuitively must appear in non-Starlink share equation. Hence, amongst non-Starlink products, it is the potential windfall or transfer in market share associated with the Starlink recall. In the case of salted snacks, the Mission Foods Company of Dallas, Texas issued a press release on Friday October 13, 2000 (i.e., the 39th week of our database) to recall the Starlink corn tortilla chips.[2] Since our weekly data ends on a Saturday we capture the first 48 hours of that recall with our dummy. For robustness we also estimate the model with the recall dummy set to one in the week of and the week following the press release and zero otherwise. Similarly, the Reily Foods Company of New Orleans, Louisiana initiated a recall for their flagship chili seasoning brand, Carroll Shelby's, on Thursday March 29, 2001 (the 63rd week of our database). Although we capture the first 72 hours of that recall with our dummy variable, we also re-estimate the model with both weeks 63 and 64 set to one and zero otherwise. A priori, if a recall effect is present in the data, we would expect $\theta_1 < 0$ and $\theta_2 > 0$.

Smith, van Ravenswaay and Thompson (1988) construct their fluid milk recall variable as a dummy too in their monthly time series data, but set its value to one in the month of the recall (March 1982) and *every* month post-recall through the end of their data set (15 months). This potentially confounds post-recall demand trends, both short-run and long-run, with the supply restriction control variable. Presumably, a recall would only take a

[2] Specific non-sample information regarding the precise timing of the recalls was taken from various issues of the weekly FDA Enforcement Report, Foods – Class II section.

few days to remove the contaminated product and replenish inventories. To disentangle these effects, we construct $recall_t$ as described and introduce two post-recall demand trends with $trend_t$. The first linear trend increments by one unit for the eight weeks following the recall, and is set to zero otherwise. Similarly, the longer run linear trend increments by one unit for the 52 weeks following the recall and is set to zero otherwise. A priori, if consumer preferences shifted away from the recalled products, we would expect $\eta_1 < 0$ and $\eta_2 > 0$.

Over time, consumers could also alter their purchasing behavior for the recalled products in response to relevant new information disseminated in the media. Since our study examines consumer behavior over a three-year period, influences from external information necessarily must be modeled. Over 90% of consumers receive information about food and biotechnology primarily through the popular press and television (Hoban and Kendall, 1993). We expect consumer reaction to be amplified during information-augmenting events, which raise awareness about biotechnology. Gaskell et al. (1999) and Durant, Bauer and Gaskell (1998) have found that heightened media coverage increases awareness about biotechnology. We therefore expect that shifts in consumer demand, if they do exist, to be more distinguishable around heightened media coverage (Marks, Kalaitzandonakes, and Zakharova, 2002).

One of the media variables ($media_t$) is the frequency of the word 'Starlink' appearing in the USA Today, The Washington Post, and The Wall Street Journal newspapers. The information in the three media frequency series is collapsed into one composite series using their first principal component. Additionally, since the USA Today is essentially a national newspaper, its separate effect is tested in lieu of the first principal component in each model. Use of a frequency series is entirely consistent with the literature (Swartz and Strand, 1981; Teisel, Roe and Hicks, 2002), although some papers have also investigated tone of message (Smith, van Ravenswaay, and Thompson, 1988; Wessells, Miller and Brooks, 1995). Also, on the heels of the Genetically Engineered Food Alert press conference, Dan Rather's breaking newscast on the CBS evening news is worthy of separate investigation. A dummy variable is set to one in the week ending Saturday September 23, 2000 (the 36th week of the database) and zero otherwise. There is a striking parallel between this media event and that of the release of the controversial Sam La Budde (of the Earth Island Institute) video in which the dolphins were documented to have drown in tuna fishing nets. Our modeling approaching therefore closely follows that of the Teisl, Roe and Hicks (2002) video dummy variable. A priori, if contemporaneous media coverage adversely impacts the recalled products, we would expect $\lambda_1 < 0$ and $\lambda_2 > 0$.

Data Description and Empirical Results

A syndicated point-of-purchase scanner data set at the total U.S. level is used for the Starlink recall analysis. Two product categories, salted snacks and chili seasonings, are explored here. However, data for a third, Starlink-affected product category (i.e., Mexican dinners) is still being processed at the time of this writing. The data set spans 154 consecutive weeks, from the Saturday ending January 22, 2000 to the Saturday ending December 28, 2002. The scanner data were assembled by AC Nielsen and collected from a sample of grocery stores spatially dispersed throughout the U.S. The sample maintains only those stores with annual sales in excess of $2 million, and, hence, excludes smaller food retailers. The natural experiment is nicely bracketed in this time frame, allowing for nearly one year of data pre-recall and two years post-recall for our analysis. In order to construct the media frequency series, Lexis Nexis was searched extensively using a 'Starlink' keyword. The search was conducted on the USA Today, The Washington Post and The Wall Street Journal. The daily series was further aggregated into a weekly series exactly matched to the scanner data set. Finally, population data were collected from the U.S. Census Bureau.

For the 52 weeks ending December 28, 2002 the domestic salted snacks industry registered a staggering $4.2 billion in nominal sales. This translates into an annual per capita expenditure of nearly $14.50 (i.e., roughly 5 pounds at mean prices). Of the three product categories affected by the Starlink recall, salted snacks by far had the deepest household penetration compared to chili seasonings ($71.3 million) or Mexican dinners ($1.1 billion). The salted snacks industry is made up of two segments, corn tortilla chips and potato chips. Corn tortilla chips, with $1.7 billion in annual sales, is roughly 40 percent of the market. The range of products offered is quite extensive too. In the AC Nielsen database, there are 2,637 products of which 540 are private label and 2,097 are non-private label.[3] The November 1, 2000 weekly FDA Enforcement Report identified 75 recalled corn tortilla chip products. Of these, we captured 21 private label and 24 non-private label recalled products in our database. The remaining 30 products were not in the sample of stores tracked by AC Nielsen. We do not view this as particularly damaging to the empirical objectives of our study since most of

[3] It would be inaccurate to characterize all 2,097 products as 'national' brand products as there are many smaller regional brands in distribution. Hence, the term 'non-private label' will be used to classify the set of national and regional brand products.

these products were either generic, private label or smaller regional brands and were distributed in smaller retail outlets. Their share of the overall market would thus be negligible. Potato chips make up the balance (60 percent) of the product category. There are 4,596 potato chip products in the AC Nielsen database, of which 485 are private label and 4,111 are non-private label.

Figures 1a and 1b chronicle the total expenditure and expenditure shares in the domestic salted snacks industry. The market is quite mature with little if any nominal growth in industry demand over the analysis period, and maintains very stable shares. Sales are seasonally high in the summer and low in the winter. It is noted that the corn tortilla chip recall coincided with the seasonal trough for the market. The descriptive statistics in table 1 indicate the recalled corn tortilla chips make up a miniscule fraction (0.36 percent) of the salted snacks market. Still, 0.36 percent of the market is a fairly sizable $15.1 million annually. Interestingly, because of the generic, private label and small regional brand nature of the products, the Starlink corn tortilla chips represent the lowest price point in the product category at roughly $1.44 per pound (compared to $2.75 and $2.99 for non-Starlink corn tortilla chips and potato chips, respectively).

The chili seasonings product category is much smaller maintaining only 148 products of which 15 are private label and 133 are non-private label. The April 11, 2001 weekly FDA Enforcement Report identified 4 recalled chili seasonings products. Actually, there was only one product recalled (the national brand 4-ounce Carroll Shelby Original Texas Brand chili kit), but this product is distributed in 12, 60, 96 and 120 count cases. These were all captured in our database under the UPC code 72396-10000. Figures 2a and 2b depict total expenditure and expenditure shares for the domestic chili seasonings industry. Again, the market is quite mature with little if any nominal growth in industry demand over the analysis period, and maintains very stable shares. However, sales are seasonally high in the winter and low in the summer. Just as was the case in salted snacks, the chili seasonings recall coincided with the seasonal trough for the market. The descriptive statistics in table 1 indicate Carroll Shelby's is a major player in the market with nearly 12 percent of the market share. Their product retails for roughly $8.56 per pound and again is the lower of the two price points. Annually, Americans on average spend roughly 25 cents per capita on chili seasonings.

Parameter Estimates

Tables 2a and 2b catalog the empirical parameter estimates and statistical significance of α, γ, β, ϕ, θ, η and λ from equations (1) and (2) for the salted snacks and chili seasonings product categories, respectively. As with any singular system, (*N*-1) of the *N* system equations are estimated and the parameter estimates for the remaining equation are recovered using the adding up conditions and other relevant parameter restrictions of the model. The chili seasonings model is a 2-equation system in which the parameter estimates for the non-Starlink conditional expenditure share equation are recovered. In the salted snacks model, however, the non-Starlink salted snacks conditional expenditure share equation was further disaggregated into non-Starlink corn tortilla chips and potato chips. In doing so, we can test interesting product switching hypotheses rarely addressed in the literature. By having a third choice, potato chips, we can ascertain how non-Starlink corn tortilla chip consumption may have been adversely impacted by the recall. This is the spirit of the literature (Swart and Strand, 1981; Wessells, Miller, and Brooks, 1995). Additionally, we can determine whether switching was 'narrow' (i.e., from Starlink to non-Starlink corn tortilla chips) or 'wide' (i.e., from Starlink corn tortilla chips to potato chips). Although Schucker et al. (2001) and Teisl, Roe and Hicks (2002) incorporated other goods into their model to account for switching, neither study addressed a food recall.

Since equation (2), the unobservable price index, is itself a highly nonlinear function, the Starlink equation in the chili seasonings category is estimated using nonlinear least squares and both corn tortilla chip equations are estimated with nonlinear seemingly unrelated regressions. The parameter estimates for the non-Starlink chili seasonings equation and the potato chips equation are obtained from the appropriate adding up conditions. For both models, Linear Approximate AIDS (LA/AIDS) model parameter estimates were employed as initial feasible solutions (i.e., starting values for the unknown parameter estimates) to the nonlinear conditional AIDS model (Alston, Foster and Green). Moreover, consistent with the AIDS literature (Buse), the parameter α_0 in equation (2) was restricted to zero in all estimations. In the specification testing phase, the homogeneity restrictions and the symmetry conditions were rejected and so were not imposed on either demand system. Finally, in each estimated equation, an *AR*(1) term was used to successfully purge first-order autocorrelation from the empirical residual series.

In table 2a the intercept parameters (α_1 and α_2) were 0.0049 and 0.4686 and found to be statistically significant (p<0.01). From the adding up restriction $\alpha_1 + \alpha_2 + \alpha_3 = 1$, we find

α_3 equals 0.5265. Although these deviate slightly from the average salted snack expenditure shares found in Table 1, which is very common in applied demand analysis, the models fit the underlying data generation process well with adjusted *R*-square values of 0.87 and 0.63, respectively. Three of the six price parameter estimates (γ) were statistically significant (p<0.01) and one parameter estimate (β) for per capita real expenditure was also statistically significant (p<0.01). The role these play in the elasticity estimates will be discussed shortly.

The parameter estimates (θ) for the recall variable were both statistically insignificant (p>0.10) indicating that the recall was carried out very expeditiously. That is to say there were no 'bare shelf' effects. But this is not too surprising as the recall hit during the seasonal trough when the logistics of mass inventory destruction and replenishment are presumably most forgiving. These results are robust too. When the recall dummy was constructed for the week of and the week following the press release (weeks 39 and 40), nearly the same exact results were obtained across the entire demand system. Although there was no short run effect post recall, twelve months out we found a negative albeit weakly statistically significant (p<0.10) parameter estimate for η in the Starlink share equation. Thus, a miniscule share of expenditure shifted out of Starlink corn tortilla chips into potato chips indicating 'wide' switching.

Dan Rather's newscast had no statistically significant (p>0.10) impact on consumer response. Teisl, Roe and Hicks (2002), however, found the Sam La Budde video to, as expected, have a negative and statistically significant (p<0.05) effect on tuna consumption. The parameter estimate (λ) for the USA Today newspaper coverage was negative and highly statistically significant (p<0.01) in the Starlink share equation. Again, this share of expenditure was absorbed by the potato chip segment of the market. The model was re-estimated in various forms to account for lagged and cumulative effects, but the contemporaneous effect of the media remained the only significant variable. Also, the model in table 2a was re-estimated using the first principal component of the three media frequency series. The parameter estimate on the composite frequency was nearly identical the parameter for just the USA Today newspaper (–0.00002 versus –0.00001) but its p-value was 0.1310; the rest of the parameter estimates in the model remained nearly the same. This result underscores the national reach of the USA Today paper in addition to its intense coverage at the beginning of the recall. The other two newspapers had higher average Starlink word counts (see Table 1) but the messages were dispersed over a longer period as evidenced by their standard deviation statistics. Our finding of a contemporaneous negative media effect is entirely consistent with the literature; Swartz and Strand (1981), Smith, van Ravenswaay and Thompson (1988), and Wessells, Miller and Brooks (1995) each estimated a negative coefficient on contemporaneous media effects.[4]

In table 3a, the α , γ and β parameters were combined, according to equations (3) to (5), into uncompensated, compensated and expenditure elasticities, respectively. Uncompensated and compensated own price elasticities are, as expected a priori, negative indicating usual downward sloping salted snacks demand equations. For example, a one percent increase in own price results, on average, in a 1.4354 percent decrease in quantity demanded of Starlink corn tortilla chips. Off diagonal, in the uncompensated case, all but one of the cross price elasticities is positive indicating a substitute relationship, while three are positive in the compensated case. Finally, the conditional expenditure effects are positive indicating the quantity demanded of all salted snack segments grew as per capita real expenditures for salted snacks grew. Price and expenditure elasticities of this magnitude are commonplace in empirical demand studies based on weekly point-of-purchase scanner data.

The empirical results for the chili seasoning product category depart from the salted snacks model (Table 2b). The intercept parameter (α_1) equals 0.1458 and is statistically significant (p<0.01). From the adding up restriction $\alpha_1 + \alpha_2 = 1$, we find α_2 equals 0.8542. Again, these approximate the mean chili seasonings expenditure shares found in Table 1. The model fits the data adequately with an adjusted *R*-square value of 0.68. The own price parameter (γ) is statistically significant (p<0.01), but the cross price term is not (p>0.10). The parameter (β) for per capita real expenditure was also statistically significant (p<0.05).

As mentioned earlier, since the only product recalled in the chili seasonings category was Carroll Shelby's we have the opportunity to model their specific holiday promotions. In fact, the parameter estimates (ϕ) on two promotions, Halloween and the Winter Holiday, emerged as positive and statistically significant (p<0.01 and p<0.05, respectively). Both holidays occurred during their seasonal peak demand.

The parameter estimate for the recall variable (θ) was statistically insignificant (p>0.10) again indicating that the recall was well orchestrated. Similar to salted snacks, this result is not too surprising as the recall hit during the seasonal trough. We again subjected these parameters to robustness tests. When the recall dummy was constructed for the week of

[4] Media, however, in these papers measures frequency of negative articles. Not surprisingly our results corroborate their findings as the word search on 'Starlink' in the time period of the recall would not likely have a positive connotation.

and the week following the press release (weeks 63 and 64), similar results were obtained across the entire demand system. The parameters (η) on both post-recall demand trends were statistically insignificant (p>0.10).

Not surprisingly, neither the parameter estimate for Dan Rather's breaking newscast nor the parameter for the USA Today newspaper coverage (λ) was statistically significant (p>0.10). These results are sensible for two reasons. First, the chili seasonings recall was initiated six months after the Rather broadcast and initial newspaper media frenzy. Teisl, Roe and Hicks (2002) found newspaper coverage of dolphin-free tuna to be statistically insignificant (p>0.10) in their conditional expenditure share equation for tuna; perhaps consumers could not recall the message at the point of purchase. Second, most consumers probably would not associate Carroll Shelby's chili seasonings kit with corn, Starlink-tainted or otherwise. In fact, even their cooking instructions now mask the use of corn: "For thicker chili, mix Masa flour (White Packet) with 1/3 cup of water, stir in and let simmer for 5 more minutes." Only an astute consumer would notice that the 'Masa flour' referred to in the cooking directions was the processed corn listed in the package's ingredients. Moreover, utilizing white corn was a similar strategy to that employed by the Taco Bell subsidiary of Yum! Brands Inc. to signal product safety to consumers after the Starlink recall. The parameter estimate on newspaper coverage was also statistically insignificant when measured as the first principal component of the three newspaper frequency series indicating the results were robust.

Table 3b catalogs uncompensated, compensated and expenditure elasticities. Uncompensated and compensated own price elasticities are, as expected a priori, negative indicating usual downward sloping chili seasonings demand equations. Off diagonal, in the uncompensated case, one of the cross price elasticities is positive indicating a substitute relationship. Finally, the conditional expenditure effects are both positive indicating the quantity demanded of all chili seasonings grew as per capita real expenditures for chili seasonings grew.

CONCLUDING REMARKS

Although the Starlink recall was an unprecedented event in the history of the U.S. food industry, the marvel of modern day supply chain management triumphed. Consumer response was at best muted despite all the sensationalism and hype. In the case of salted snacks, there was some limited empirical evidence that coverage of the story in the USA

Today newspaper resulted in some lost share from the corn tortilla chip segment of the market. But even this was short-lived as better than 70 percent of the coverage of the story had been published within three months of the initial recall. By the end of 2002, post-recall shares resumed pre-recall levels. Given the nature of the product and the fact its recall occurred six months after the initial Genetically Engineered Food Alert press conference, there was no impact to the chili seasonings product category. Perhaps if the activists staged their media event so that it would not have coincided with the seasonal trough in the affected product categories the consumer response may have been more detectable.

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Figure 1a. Dollar Sales of Salted Snacks

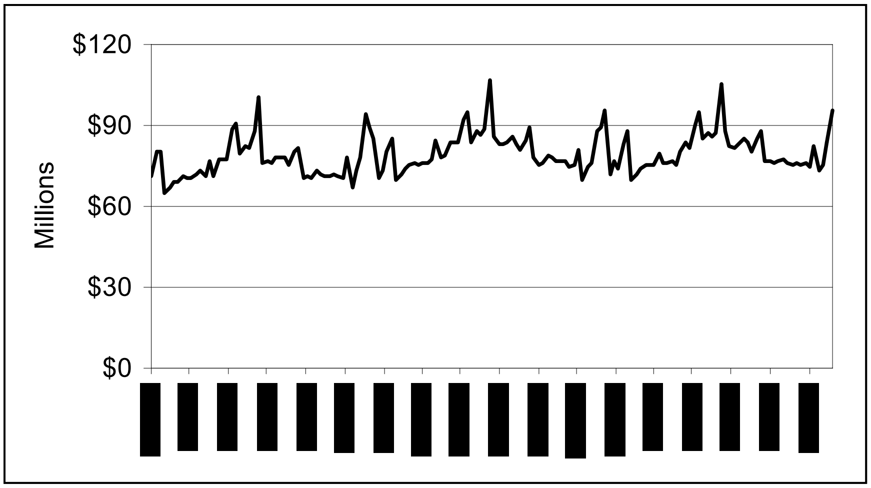

Figure 1b. Expenditure Shares of Salted Snacks

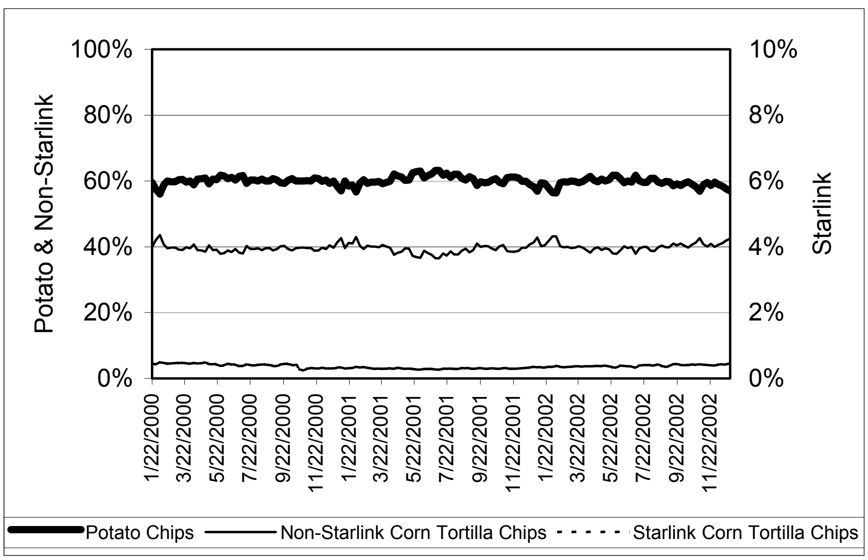

Figure 2a. Dollar Sales of Chili Seasonings

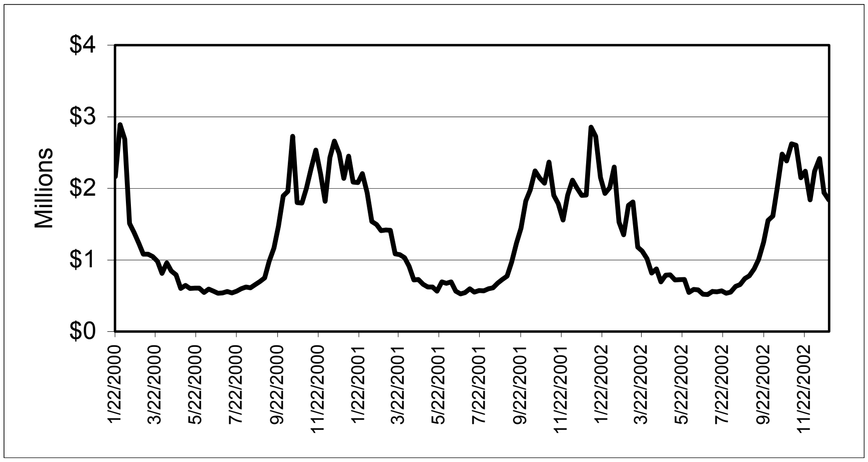

Figure 2b. Expenditure Shares of Chili Seasonings

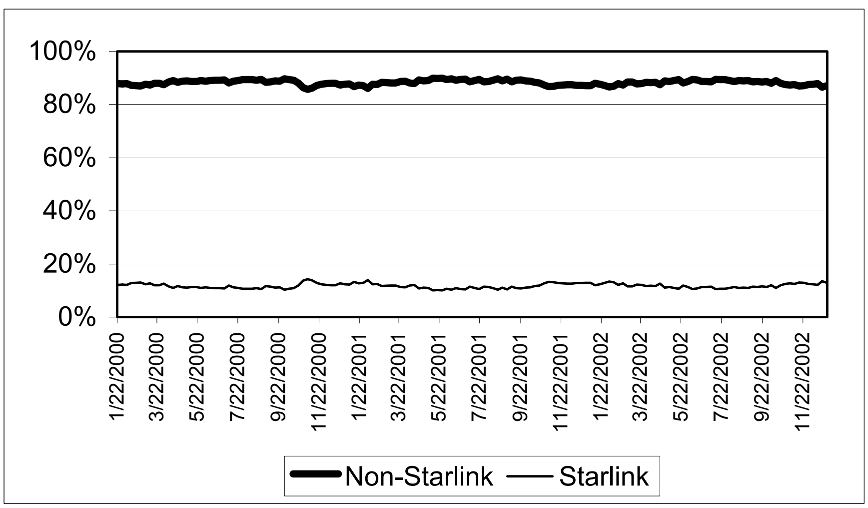

Table 1. Descriptive Statistics of Selected Demand System Variables[1]

	Mean	Standard Deviation	Minimum	Maximum
Expenditure Shares				
Corn Tortilla Chips				
Starlink	0.0036	0.0006	0.0024	0.0050
Non-Starlink	0.3966	0.0130	0.3648	0.4353
Potato Chips	0.5997	0.0132	0.5598	0.6324
Chili Seasonings				
Starlink	0.1173	0.0090	0.1004	0.1432
Non-Starlink	0.8827	0.0090	0.8568	0.8996
Prices ($/pound)				
Corn Tortilla Chips				
Starlink	1.4446	0.0393	1.3561	1.5314
Non-Starlink	2.7493	0.0824	2.5323	2.9494
Potato Chips	2.9913	0.1377	2.5581	3.2385
Chili Seasonings				
Starlink	8.5551	0.2753	7.6680	9.0395
Non-Starlink	10.8035	0.3019	10.0912	11.3725
Per Capita Total Category Expenditure ($/week)				
Salted Snacks	0.2784	0.0255	0.2307	0.3747
Chili Seasonings	0.0046	0.0025	0.0018	0.0102
Media Frequency (Count)				
USA Today	0.5130	3.2221	0.0000	38.0000
Washington Post	2.4805	6.3608	0.0000	32.0000
Wall Street Journal	2.4351	7.4175	0.0000	63.0000

[1] Based on 154 consecutive weeks of data.

Table 2a. Estimated Conditional Expenditure Share Equations: Salted Snacks

	Corn Tortilla Chips		
	Starlink	*Non-Starlink*	Potato Chips[1]
Intercept (α)	0.0049*	0.4686*	0.5265
Log of Price (γ)			
Corn Tortilla Chips			
Starlink	-0.0016	-0.0488	0.0504
Non-Starlink	0.0007	-0.2721*	0.2714
Potato Chips	0.0025*	0.1877*	-0.1902
Per Capita Real Expenditure (β)	0.0003	0.0485*	-0.0488
Recall Dummy[2] (θ)	0.0003	0.0021	-0.0024
Demand Time Trends (η)			
2 Months Post Recall	-0.0002	0.0011	-0.0008
12 Months Post Recall	-0.0004***	-0.0009	0.0012
Media (λ)			
Rather Newscast Dummy	0.0001	0.0002	-0.0003
USA Today	-0.00001*	-0.0001	0.0001
Adjusted *R*-square	0.8705	0.6338	---

[1] The parameter estimates in the potato chip share equation are recovered using the adding up restrictions.
[2] Set to one for the week ending October 14, 2000 and zero otherwise.
* denotes significance at 0.01 level, ** denotes significance at 0.05 level, *** denotes significance at 0.10 level

Table 2b. Estimated Conditional Expenditure Share Equations: Chili Seasonings

	Starlink	*Non-Starlink*
Intercept (α)	0.1458*	0.8542
Log of Price (γ)		
Starlink	-0.0730**	0.0730
Non-Starlink	-0.0020	0.0020
Per Capita Real Expenditure (β)	0.0046**	-0.0046
Holiday Effects (ϕ)		
Halloween	0.0069*	-0.0069
Winter Break	0.0055**	-0.0055
Recall Dummy[2] (θ)	-0.0047	0.0047
Demand Time Trends (η)		
2 Months Post Recall	-0.0042	0.0042
12 Months Post Recall	0.0013	-0.0013
Media (λ)		
Rather Newscast Dummy	0.0016	-0.0016
USA Today	0.0001	-0.0001
Adjusted *R*-square	0.6755	---

[1] The parameter estimates in the non-Starlink share equation are recovered using the adding up restrictions.
[2] Set to one for the week ending March 31, 2001 and zero otherwise.
* denotes significance at 0.01 level, ** denotes significance at 0.05 level, *** denotes significance at 0.10 level

Table 3a. Estimated Price and Expenditure Elasticities for Salted Snacks

	Corn Tortilla Chips		
	Starlink	*Non-Starlink*	Potato Chips
Uncompensated			
Corn Tortilla Chips			
Starlink	-1.4354	0.1629	0.6675
Non-Starlink	-0.1236	-1.7429	0.4086
Potato Chips	0.0844	0.4903	-1.2742
Compensated			
Corn Tortilla Chips			
Starlink	-1.4389	-0.2053	0.1109
Non-Starlink	-0.1268	-2.0910	-0.1178
Potato Chips	0.0805	0.0615	-1.9227
Expenditure	1.0718	1.1223	0.9187

Table 3b. Estimated Price and Expenditure Elasticities for Chili Seasonings

	Starlink	*Non-Starlink*
Uncompensated		
Starlink	-1.6282	-0.0507
Non-Starlink	0.0835	-0.9933
Compensated		
Starlink	-1.7408	-0.8986
Non-Starlink	-0.0344	-1.8806
Expenditure	1.0395	0.9948