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Abstract

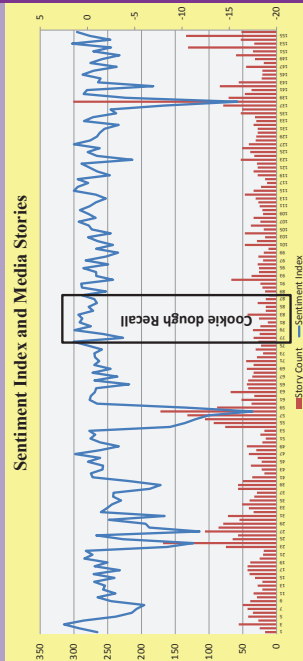
Not only does information about food recalls play a vital role in changing the demand for implicated food products, but it also impacts the demand for close substitutes. The study aims to identify the structural change in demand for cookie dough due to the 2009 cookie dough recall of Brand1, one of the most publicized single brand recalls in recent years. The study utilizes Barten's synthetic differential demand system, and introduces a sentiment analysis technique to identify the tone of media publicity and its effect on demand. To our knowledge this is the first study to use a sentiment index created using a natural word processing algorithm. The results suggest a spillover effect in the cookie dough market and finds that media sentiment has an effect on consumption.

Objective

- To estimate the change in **consumer demand relationships** for the refrigerated cookie dough market after a food safety outbreak was announced.
- To identify the change in **substitution effect and expenditure share** of Brand1 products in the post-recall period.
- To **create a sentiment index identifying the tone of information using an algorithm** to replace regular media indices created using number of news stories.
- To identify the tone of the information and estimate the **spillover effect of media sentiment on the refrigerated cookie dough brand** in general.

Data

- The study used Nielsen HomeScan data from years 2008, 2009 and 2010 to identify consumer purchases. The data was aggregated on weekly basis across the households.
 - Recall period: 19th June 2009-18th Aug 2009
- Media tracking and Sentiment Analysis
 - The media stories were collected from major media sources (*national and local newspapers, network and cable TV, radio, news magazines, and the internet*) using keywords identifying/referring to the food safety incidence.
 - We used a natural word processing algorithm to identify the tone (positive or negative) of the articles using certain keywords and assigned a sentiment score, between +2 to -2.
 - Sentiment scores were aggregated over each week by taking net differences. The score was reversed and moved to a base value of 100.



Method

- The study adopts a demand system approach, a differential demand system called Barten's Synthetic Model (BSM). BSM nests four demand systems viz. Rotterdam, CBS, NBR, and AIDS.
- Matsuda(2005) has argued that BSM is not only an artificial composite of known differential demand systems, but is a model in its own right.
- The differential form of data series was tested to identify presence of unit-root. The Augmented Dickey-Fuller and Phillips-Perron test confirmed the stationarity of data.
- The structural change of demand for cookie dough was determined by comparing price elasticities from the pre-recall (73 weeks) and post-recall (72 weeks) period.
- The models with different autoregressive orders and lags of sentiment index were tested. A Likelihood Ratio hypothesis test was conducted to identify the appropriate lag length for the model.
- The final model chosen for the study was AR(1) model with the two lags of the sentiment index.

Barten's Synthetic Model

$$w_i d \log q_i = (\beta_i + \lambda w_i) d \log Q + \sum_{j=1}^n (\gamma_{ij} - \mu w_i (\delta_{ij} - w_j)) d \log p_j + \varepsilon_i, i = 1, \dots, n$$

Divisia Volume Index:

$$d \log Q = \sum_{i=1}^n w_i d \log q_i$$

Adding up:

$$\sum_{i=1}^n \beta_i = 1 - \lambda_i \text{ and } \sum_{j=1}^n \gamma_{ij} = 0, j = 1, \dots, n,$$

Homogeneity:

$$\sum_{i=1}^n \gamma_{ij} = 0, j = 1, \dots, n,$$

Symmetry:

$$\gamma_{ij} = \gamma_{ji}, i, j = 1, \dots, n, i \neq j$$

Table 1: Compensated Own Price and Cross Price Elasticities, Expenditure Elasticity, and Sentiment Elasticity for Refrigerated Cookie Dough Brands during Pre-Recall and Post-Recall Periods

Product \ Elasticity	Recall Periods			Pre-Recall	Post-Recall
	Compensated Own Price Elasticity	Store brand Elasticity	Other brands Elasticity		
Brand1	-0.83***	0.41***	0.29***	0.14***	0.79***
Brand2	0.40***	-0.58***	0.15***	-0.71***	0.45***
Store brand	0.40***	0.21***	0.02	-0.73***	0.51***
Other brands	0.16***	0.04	0.02	-0.22***	2.31***
Brand1	-0.45***	0.29***	0.06	0.10***	0.57***
Brand2	0.25***	-0.53***	0.20**	0.88***	0.47***
Store brand	0.08	0.29**	-0.40***	0.03	0.52***
Other brands	0.10***	0.09***	0.03	-0.21***	2.41***
					-0.83***
					0.95*

The number of weekly observations for pre-recall period was 73 and for post-recall period was 72. For confidentiality purposes, the major or brands in the cookie dough market are called Brand1 and Brand2. Brand1 was included in the 2009 cookie dough recall.

* indicates statistical significance at the 0.10 level, ** at the 0.05 level, *** at the 0.01 level. All elasticities are calculated at the sample mean.

Results

- The results show all the compensated own-price elasticities were negative in accordance with the law of demand. The results also show a significant structural change from a pre-recall to a post-recall period.
- The results for the compensated cross-price elasticities indicated a strong substitution effect between Brand1 and Brand2 in the pre-recall period, with magnitudes decreasing from pre-recall to post-recall period.
- The substitution effect between Brand1 and Store Brand in the pre-recall period was absent in the post-recall period. However, the magnitude of substitution effect between Brand2 and Store Brand increased in the post-recall period.
- The expenditure elasticity of all the brands except for Brand1, did not change from pre-recall to post-recall period. The change in expenditure elasticity of Brand1 indicates that the share of expenditure on Brand1 suffered in the post-recall period.
- As expected, the information did not affect consumption in the pre-recall period.
- The sentiment elasticity was significant for Brand1 and Other brands in post-recall period. Which meant an increase in bad sentiment in media coverage during the recall of Brand1 products decreased consumption of Brand1 and increased consumption of Other brands in the post-recall period.

Table 2: Test for Differences in the Selected Pre-recall and Post-recall Elasticities

	χ^2 statistics	p-value	χ^2 statistics	p-value
Compensated Own-Price Elasticity				
Brand1	18.84	<.0001	Brand1_Brand2	-0.1170
Brand2	0.23	0.6327	Brand1_Store brand	-0.2261
Store brand	0.2273	0.1306	Brand2_Store brand	-0.1444
Sentiment Elasticity				
Brand1	-0.8407	0.0237	Store brand_Brand1	-0.3198
Other brands	0.1083	0.1355	Store brand_Brand2	0.0440
			Store brand_Other brands	0.40

Conclusion

- By using BSM, the study finds the 2009 cookie dough recall of Brand1 had an effect on the demand of refrigerated cookie dough brands.
- We found decrease in substitution effect between Brand1 and Brand2 and an increase between Brand2 and Store Brand suggesting a spillover effect in this market.
- The negative sentiment during and after the recall of Brand1 products decreased its consumption after the recall was over.
- The results of tests confirming significant differences for own-price and cross-price elasticities of Brand1 for two periods, suggests that the rest of the cookie dough brands grew at the expense of Brand1 in the post-recall period.

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