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Brand-level Analysis of Demand for Mayonnaise in Northeast Texas

Rafael Bakhtavoryan*

School of Agriculture, Texas A&M University – Commerce, PO Box 3011, Commerce, TX 75429

ABSTRACT

Mayonnaise is one of the most important condiments in the U.S. with average annual sales of $2 billion and is mostly provided by a few major manufacturers. This makes the mayonnaise market resemble an oligopoly with various competitive forces and strategic firm interactions determining final mayonnaise prices. Therefore, there is an increasing need to better understand consumer preferences for mayonnaise and the market power potential of the major brands. Given that there have been relatively less studies on the issue of brand-level analysis, this study offers a brand-level empirical investigation of consumer preferences for mayonnaise along with the analysis of competition among the major mayonnaise brands such as Hellmann's, Kraft, and various store brands. The analysis estimates the Barten synthetic model using data from the Northeast Texas. Our findings reveal inelastic demand for private label, as well as Hellmann's and Kraft mayonnaise, while that for the remaining brands being elastic. Further, Kraft is found to be a major competitor to private label and other brands, while private label is shown to be a major competitor to Kraft. Finally, based on the expenditure elasticity estimates all the brands under study appear to be normal goods.

KEY WORDS: mayonnaise; brand competition; the Barten synthetic model; elasticities

INTRODUCTION

Mayonnaise is the favorite condiment in the U.S. with the domestic consumption amounting to about $2 billion followed by ketchup ($800 million), soy sauce ($725 million), barbecue sauce ($660 million), hot sauce ($550 million), mustard ($450 million), steak sauce, and other sauces (Ferdman and King 2014). Mayonnaise is predominantly provided by a few major brand manufacturers such as Hellmann's, Kraft, as well as some powerful store brands (private labels), which makes the market resemble an oligopoly. As such, various competitive forces coupled with strategic brand interactions have an important bearing on mayonnaise prices. The importance of the industry guarantees a closer look at brand competition and consumer preferences for various mayonnaise brands.

Prior literature has been instrumental in enhancing our understanding of factors underlying mayonnaise consumption. Majority of previous studies have been conducted at the product category level. For example, Jones et al. (2003) investigated consumer food shopping behavior and consumption patterns in a particular metropolitan market, using the Almost Ideal Demand System model of Deaton and Muellbauer (1980a, 1980b) and supermarket scanner data. This study revealed elastic demand for healthy mayonnaise (i.e.,

* Corresponding author: Rafael.bakhtavoryan@tamuc.edu

fat-free and low-fat mayonnaise) in high-income areas while consumers were found less responsive to mayonnaise price in low-income areas. At the same time, the demand for regular mayonnaise was inelastic in both areas, albeit this finding was statistically insignificant for consumers in the low-income areas.

Bergtold et al. (2004), on the other hand, estimated a set of unconditional, uncompensated own-price elasticities and expenditure elasticities for a range of products and one composite good based on data from 42 U.S. metropolitan areas. The study suggested that the demand for mayonnaise was elastic.

Teisl et al. (2001) calculated demand elasticities for mayonnaise in a study of the effects of nutritional information on consumer purchase behavior and consumer welfare. The study was conducted based on an augmented AIDS model using labeling experiment data from a range of supermarkets located in several states. Estimated uncompensated own-price elasticity estimates associated with both "healthy" (having low or reduced cholesterol) and "unhealthy" mayonnaise indicated an elastic demand for both types of mayonnaise. Cross-price elasticity estimates suggested that "healthy" and "unhealthy" mayonnaise were substitutes.

Demand for mayonnaise has also been studied at a more disaggregate level. Akbay and Jones (2005) applied the AIDS model to study demand for several private labels and national brands of mayonnaise for low- and high-income consumer segments in a metropolitan area. Both of these income segments were found to have elastic demand for private label and national brand mayonnaise. Further, private label and national brands appeared to be substitutes across the various income segments.

Akbay and Jones (2006) used demand elasticities for a series of national brands and private labels associated with nine food categories (breakfast cereal, ice-cream, salad dressing, cooking oil, chips, spaghetti, mayonnaise, fresh milk, and frozen vegetables) to calculate price-cost margins. Elasticities were obtained from the AIDS model based on weekly store-level scanner data from several supermarkets The results showed that demand for all mayonnaise brands was elastic among both low- and high-income consumers.

The current study complements the previous studies by incorporating the Barten's synthetic model which nests the differential versions of four other demand systems. Next, the brand-specific data used in the analysis permit us to account for the impact of coupons, which has not been addressed in the existing literature. Third, the demand elasticities are calculated at the brand-level using brand-specific data for the Dallas/Fort Worth Metroplex area (the largest inland metropolitan area in the United States). Our study further disaggregates the brand-level analysis of demand for mayonnaise vis-a-vis Akbay and Jones (2005, 2006), which categorized mayonnaise into private label and national brand products. Additionally, this study considers the remaining mayonnaise brands (labeled other brands), which collectively accounted for 26% of mayonnaise sales in 2013 (Kilts Center for Marketing 2013). As well, the present study ascertains the substitutability relationship (i.e., competition) among mayonnaise brands via the compensated cross-price elasticities, which was not the case in the study by Akbay and Jones (2006).

The main objective of this study is to estimate the demand for the major mayonnaise brands in Northeast Texas using a demand system approach. More specifically, the study aims at gaining an insight into: (1) competition among major mayonnaise brands in Northeast Texas, (2) consumer preferences for various mayonnaise brands in Northeast Texas, and (3) consumer price responsiveness and manufacturer market power potential in Northeast Texas.

The remainder of the paper proceeds in the following manner. The next section

provides the materials and method used in the present analysis, followed by the presentation and discussion of the results. Conclusions and discussion are presented in the last section.

MATERIALS AND METHOD

Barten (1993) introduced Barten's synthetic model (BSM), which includes the differential versions of the Almost Ideal Demand System (AIDS) model introduced by Deaton and Muellbauer (1980a, 1980b), the Rotterdam model introduced by Barten (1964) and Theil (1965), the NBR model introduced by Neves (1987), and the Dutch Central Bureau of Statistics (CBS) model introduced by Keller and van Driel (1985). The Barten model possesses a few characteristics that make it popular in empirical research. These characteristics include linearity in parameters, functional form flexibility, ability to introduce dynamics, and potential to render variables stationary because of the necessary first-differencing process. In addition, Barten's differential demand system assists in identifying specific functional form that is best supported by the data.

Following Matsuda (2005), the Barten model looks as follows:

$$w_i \, dlogq_i = (\beta_i + \lambda w_i) \, dlogQ + \sum_j (\gamma_{ij} - \mu w_i(\delta_{ij} - w_j)) \, dlogp_j + \varepsilon_i \quad i=1,\ldots,n \tag{1}$$

where w_i denotes the budget share of i^{th} brand which is calculated as the share of the i^{th} brand in the total expenditure on all brands; d denotes the difference operator, log denotes natural logarithm, q_i denotes the quantity of i^{th} brand; dlogQ denotes the Divisia Volume Index which is calculated as $\sum 0.5(w_{it} + w_{it-1})(logq_{it} - logq_{it-1})$, where w_{it} and w_{it-1} are the budget shares for i^{th} brand in time periods t and t-1, respectively, and $logq_{it}$ and $logq_{it-1}$ are the logarithm of quantities of i^{th} brand in time periods t and t-1, respectively; $\delta_{ij} = 1$ if $i = j$; $\delta_{ij} = 0$ if $i \neq j$; p_j denotes the price of brand j; β, λ, γ_{ij}, and μ are the model parameters to be estimated; and ε_i is the disturbance term.

Equation (1) reduces to the AIDS when λ=1and μ=1, to the Rotterdam when λ=0 and μ=0, to the NBR when λ=0 and μ=1, and to the CBS when λ=1 and μ=0. The model satisfies the following theoretical restrictions:

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

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

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

The Hicksian (compensated) price elasticities (e_{ij}^c) and the expenditure elasticities (e_i) from the Barten model are given by:

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

$$e_i = \frac{\beta_i}{w_i} + \lambda, \tag{6}$$

where w_i and w_j represent the budget shares of commodity i and j, respectively, and δ is the Kronecker delta. The uncompensated price elasticities (e_{ij}^u) are provided through the Slutsky equation:

$$e_{ij}^u = e_{ij}^c - e_i w_j. \quad (7)$$

According to the law of demand, the own-price elasticities were expected to be negative. Anticipating that all brands of mayonnaise were substitutes for each other, cross-price elasticities were expected to be positive. Expenditure elasticities were expected to be positive, since mayonnaise was anticipated to be a normal good.

For this analysis, weekly time series data covering the period of January 1 through December 28, 2013, and derived from the Nielsen Consumer Panel Data were used. Overall, the dataset included 52 weekly observations of total quantity purchased and prices (unit values) of four major mayonnaise brands: private label, Hellmann's, Kraft, and other brands. Store brands of mayonnaise comprised the private label mayonnaise brand. The Hellmann's mayonnaise brand consisted of Hellmann's, Hellmann's Light, Best Foods, and Best Foods Light. The Kraft mayonnaise brand included Kraft, Kraft Light, and Kraft Sandwich Shop. Finally, all the brands of mayonnaise except for Hellmann's Kraft, and private label brands comprised the other brands category (Mcilhenny, Heinz, Spectrum Naturals, Smart Balance Omega, State Fair, Blue Plate, Vegenaise, McCormick, Duke's, Walden Farms, Calder's Gourmet, etc.).

The quantity purchased of a mayonnaise brand was developed by summing weekly total ounces across households and then dividing this sum by the number of unique households that purchased that mayonnaise brand in that particular week. Since the actual prices were missing, unit values were used instead. To compute unit values, first total expenditures were adjusted by subtracting the value of coupons (if any), and then the adjusted total expenditures were divided by total ounces sold for each week. In addition, all prices were adjusted for inflation by dividing them by the weekly interpolated Consumer Price Index (CPI) with the base period equal to the average of the CPI from 1982 to 1984 obtained from the United States Bureau of Labor Statistics (2016).

Table 1 depicts the descriptive statistics of the variables used in this analysis along with corresponding market shares. By examining the descriptive statistics on quantities, prices, and market shares of major mayonnaise brands, important insights associated with market competition among major mayonnaise brands in Northeast Texas can be gained. Over the study period, the average weekly total amounts of mayonnaise purchased per household of private label, Hellmann's, Kraft, and other brands, were 30.61, 34.16, 32.45, and 27.45 ounces, respectively, indicating that Hellmann's was the leading brand followed by Kraft, private label, and other brands. Over the study period, the average real unit values of private label, Hellmann's, Kraft, and other brands were 0.04, 0.05, 0.05, and 0.06 dollars per ounce, respectively, indicating that of all the mayonnaise brands, other brands had the highest unit value followed by Hellmann's and Kraft, and private label. According to the Nielsen Consumer Panel Data for 2013, private label, Hellmann's, Kraft, and other brands had 19%, 29%, 26%, and 26% of market share over the study period, respectively, suggesting that Hellmann's was the market leader followed by Kraft and other brands, and private label. Also, based on the market shares, mayonnaise industry can be considered as a relatively concentrated industry possessing oligopolistic characteristics, with two major brands, Hellmann's and Kraft, controlling 55% of the market.

Table 1. Descriptive Statistics.

Variable	Units	n	Mean	Standard Deviation	Market Share (%)
Quantity					
Private label	oz	52	30.61	5.82	19
Hellmann's	oz	52	34.16	4.97	29
Kraft	oz	52	32.45	7.16	26
Other brands	oz	52	27.45	13.96	26
Price					
Private label	$/oz	52	0.04	0.00	
Hellmann's	$/oz	52	0.05	0.01	
Kraft	$/oz	52	0.05	0.01	
Other brands	$/oz	52	0.06	0.03	

Notes: [1]Nielsen Consumer Panel Data, 2013.
[2]Quantities reported are on per unique household basis.
[3]Prices are unit values.

RESULTS

The BSM model was estimated for the four mayonnaise brands with parametric restrictions in place applying an Iterated Seemingly Unrelated Regression (ITSUR) procedure and using SAS 9.3 statistical software package. The equation for other brands was left out from the estimation to circumvent the singularity of the variance-covariance matrix of disturbance terms, which arises from budget shares summing to unity in the BSM model. However, the parameters for the dropped equation were calculated using the parametric restrictions of adding-up, homogeneity, and symmetry. The R^2 for the other brands equation was calculated by squaring the correlation coefficient between the actual and the predicted values of the dependent variable. The Durbin-Watson statistic for the other brands equation was computed by dividing the sum of squared differences in successive residuals by the residual sum of squares (Durbin and Watson 1951). The issue related to the efficient estimation of system of equations in the case where error terms are contemporaneously correlated was first considered by Zellner (1962). To address the issue of serial correlation, a first-order autoregressive correction procedure (AR[1]) was used following Berndt and Savin (1975). Due to adding-up restriction, a common AR(1) coefficient was estimated for the system of equations. Finally, in this analysis, all statistical tests were done using significance level of 5%.

Table 2 presents the estimated coefficients, p-values, goodness-of-fit (R^2), and Durbin-Watson statistics associated with the Barten synthetic demand system. The range of R^2 was from 0.29 to 0.92, suggesting that the individual equations of the demand system explained a considerable amount of variability in each of the dependent variables (except for the private label equation, where R^2 was 0.29). Durbin-Watson statistics for the four equations along with the statistically significant serial correlation coefficient (rho1) indicated that serial correlation was corrected in the Barten model. Of the 17 parameter estimates, seven were statistically significant.

Table 2. Coefficients of the BSM, R^2, and Durbin-Watson Statistic (n = 52).

Brand	R^2	Durbin-Watson
Private label	0.2867	2.0892
Hellmann's	0.4922	2.1658
Kraft	0.6642	2.0245
Other brands	0.92	1.9926
Parameter	**Coefficient**	**p-value**
g_{11}	-0.1076*	0.0448
g_{12}	0.0183	0.5931
g_{13}	0.0616	0.0533
g_{14}	0.0278	0.0583
g_{22}	-0.0296	0.64
g_{23}	0.0168	0.6216
g_{24}	-0.0055	0.73
g_{33}	-0.1137	0.0567
g_{34}	0.0354*	0.0297
g_{44}	-0.0576	0.1463
b_1	-0.3608*	0.0019
b_2	-0.5825*	0.0005
b_3	-0.3341*	0.0261
b_4	0.0483	0.7664
λ	2.2291*	0.0002
μ	0.2813	0.2537
rho1	-0.4039*	0.0001

Notes: [1]The parameters g_{ij} indicate interactive effects. Subscript 1 refers to private label, 2 refers to Hellmann's, 3 refers to Kraft, 4 refers to other brands. For instance, g_{12} denotes the price effect of Hellmann's on the volume of private label.
[2]The estimates of b_4 and g_{44} were recovered using adding-up restriction as $b_4 = 1 - (b_1 + b_2 + b_3 + \text{lambda})$ and $g_{44} = 0 - (g_{14} + g_{24} + g_{34})$.
[3]rho1 is the autocorrelation coefficient on the error terms, the AR(1) process. To ensure adding up, a common rho1 is evident in any demand system.
[4]Asterisk indicates significance at the 0.05 level.

Table 3 shows the results of joint hypothesis tests of λ and μ. The significance of the chi-squared (χ^2) statistic for the joint hypothesis tests of λ and μ suggested that the general BSM was statistically superior to the Rotterdam model, the Linear Approximate AIDS model, the NBR model, and the CBS model.

Table 3. Joint Hypothesis Tests of λ and μ.

Hypothesis	$\chi 2$	p-value
H_0: λ =0, μ =0 (Rotterdam)	28.62	0.0001
H_0: λ =1, μ =1 (AIDS)	9.73	0.0077
H_0: λ =1, μ =0 (CBS)	11.26	0.0036
H_0: λ =0, μ =1 (NBR)	18.18	0.0001

Even though the estimated Barten model parameters do not have a direct economic interpretation, they were used along with budget shares to compute compensated and uncompensated price elasticities, and expenditure elasticities at the sample means for all the mayonnaise brands. Table 4 shows the uncompensated own-price elasticities, compensated cross-price elasticities, and expenditure elasticities with p-values reported below each elasticity value.

Table 4. Uncompensated (Marshallian) Own-Price, Compensated (Hicksian) Cross-Price, and Expenditure Elasticities of the Mayonnaise Brands.

	Private label	Hellmann's	Kraft	Other brands	Expenditure elasticity
Private label	-0.853*	0.177	0.39*	0.216*	0.364
	(0.0001)	(0.2793)	(0.01)	(0.0001)	(0.0977)
Hellmann's	0.117	-0.371*	0.129	0.054	0.245
	(0.2793)	(0.0183)	(0.1548)	(0.1048)	(0.0521)
Kraft	0.296*	0.149	-0.89*	0.211*	0.92*
	(0.01)	(0.1548)	(0.0001)	(0.0001)	(0.0001)
Other brands	0.162*	0.061	0.209*	-1.055*	2.416*
	(0.0001)	(0.1048)	(0.0001)	(0.0001)	(0.0001)

Notes: [1]Elasticities on the diagonal are uncompensated own-price elasticities, off-diagonal elasticities are compensated cross-price elasticities.
[2]All elasticities are calculated at the sample means.
[3]Asterisk indicates statistical significance at the 0.05 level.
[4]Numbers in parentheses are p-values.
[5]Uncompensated cross-price elasticities and compensated own-price elasticities are available upon request.

As expected, all the uncompensated own-price elasticity estimates were negative and statistically significant. In particular, for every 1% increase in the own price, the quantity demanded of private label, Hellmann's, Kraft, and other brands decreased by 0.853%, 0.371%, 0.89%, and 1.055%, respectively, holding everything else constant.

The demand for other brands was found to be elastic (-1.055), while the demand for private label (-0.853), Hellmann's (-0.371), and Kraft (-0.89) mayonnaise brands was found to be inelastic. While the demand is normally anticipated to be elastic at the brand level, this inelastic demand for most of the mayonnaise brands can be possibly explained by the fact that mayonnaise occupies a relatively small share in consumer's budget. Inelastic demand for such consumer products as peanut butter and gum brands was also found in studies by Bakhtavoryan et al. (2012) and Toro-Gonzalez et al. (2012), respectively. Given the estimates of own-price elasticities, at least in the short run, a price

decrease for other brands and a price increase for private label, Hellmann's, and Kraft was recommended in order to increase total revenue from the sale of the product.

Important information as far as competition among mayonnaise brands can be obtained by studying the compensated cross-price elasticities since they provide a better picture regarding substitutability (i.e., competition) among brands, as they are net of income effects. All the compensated cross-price elasticities were positive, implying that these mayonnaise brands were net substitutes for each other. Out of 12 cross-price elasticities, six were statistically significant. The statistically significant cross-price elasticities are discussed below.

For every 1% increase in the price of Kraft and other brands, the quantity demanded of private label increased by 0.39% and 0.216%, respectively, holding everything else constant. As such, Kraft was the major competitor to private label, since the cross-prices elasticity for private label demand with respect to the price of Kraft (0.39) was greater than that with respect to the price of other brands (0.216). For every 1% increase in the price of private label and other brands, the quantity demanded of Kraft increased by 0.296% and 0.211%, respectively, holding everything else constant. Therefore, private label was the major competitor to Kraft, since the cross-prices elasticity for Kraft demand with respect to the price of private label (0.296) was greater than that with respect to the price of other brands (0.211). A 1% increase in the price of private label and Kraft led to 0.162% and 0.209% increases in the quantity demanded of other brands, respectively, holding everything else constant. Hence, Kraft was the major competitor to other brands, since the cross-prices elasticity for other brands demand with respect to the price of Kraft (0.209) was greater than that with respect to the price of private label (0.162).

In accordance with our expectations, all computed expenditure elasticities presented in Table 4 were positive with only two of them being statistically significant, which suggests that mayonnaise brands are normal goods and that the quantity purchased of mayonnaise brands went up when expenditure for mayonnaise increased, everything else held constant. In addition, expenditure elasticities revealed that Kraft can be further classified as a necessity since its expenditure elasticity was between zero and one, while other brands can be classified as luxury goods, since the associated expenditure elasticity was greater than one. In particular, as the expenditure for mayonnaise rose by 1%, the quantity demanded of Kraft and other brands increased by 0.92% and 2.416%, respectively, holding everything else constant, making the other brands category the most sensitive to changes in total expenditure.

CONCLUSIONS AND DISCUSSION

Mayonnaise is the most consumed condiment in the U.S. with the domestic consumers spending some $2 billion on its consumption and with a couple of brands controlling a significant portion of the market. However, the demand for mayonnaise at the brand level has not been studied extensively in previous research. In this study, the Barten synthetic model was estimated to investigate the demand for mayonnaise and competition among major mayonnaise brands (private label, Hellmann's, Kraft, and other brands) in Northeast Texas. Fifty-two weekly observations used in this study were derived from scanner data ranging from January 1 through December 28, 2013. These data contained information on total quantity purchased and prices (unit values).

The estimation results showed that the general Barten model was superior to other forms of demand systems for studying the demand for mayonnaise and competition among

major mayonnaise brands in Northeast Texas. As evidenced by the uncompensated own-price elasticity estimates, the demand was inelastic for private label, Hellmann's, and Kraft, and the demand for other brands was elastic. Inelastic demand at the brand level seems counterintuitive, but not if one considers the fact that mayonnaise normally does not have a significant share in a consumer's budget. In addition, according to the uncompensated own-price elasticity estimates, to raise total revenue a price increase was necessary for private label, Hellmann's, and Kraft, while a price decrease was necessary for other brands.

All the computed expenditure elasticities were positive, suggesting that mayonnaise brands are normal goods and that the quantity demanded of mayonnaise brands increased as expenditure for mayonnaise went up, holding everything else constant. Other brands category was the most responsive to changes in total expenditure. Compensated cross-price elasticity estimates revealed that Kraft was the major competitor to private label and other brands. At the same time, private label was the major competitor to Kraft.

In addition, this study shed some light on the competition pattern among major mayonnaise brands in Northeast Texas by calculating their market shares. In particular, this analysis revealed that in 2013 both Hellmann's and Kraft accounted for 55% of total market share, leaving the remaining 45% to private label and other brands. Per market share numbers, the mayonnaise industry can be considered as a relatively concentrated oligopolistic industry.

A few recommendations for future research need to be pointed out. First, additional data encompassing a larger region (possibly the entire United States) and covering multiple years would enhance the representativeness of the findings. Second, the study would benefit from considering information on substitutes for mayonnaise (ranch, olive oil, etc.). Third, future research should extend the findings by the present research by considering household characteristics. Nonetheless, despite the foregoing recommendations for future research, the present analysis is a solid contribution to studying brand-level demand and competition in the mayonnaise industry.

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