Invited presentation at the 2018 Southern Agricultural Economics Association Annual Meeting, February 2-6, 2018, Jacksonville, Florida

Examining Demand Elasticities for Differentiated Yogurt

Rezgar Mohammed

Graduate Research Assistant, Department of Agricultural and Applied Economics, Texas Tech University, 124 Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (517) 580-9172; e-mail: rezgar.mohammed@ttu.edu.

Olga Murova

Associate Professor, Department of Agricultural and Applied Economics, Texas Tech University, 301D Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (806) 843-3257; e-mail: olga.murova@ttu.edu.

Benaissa Chidmi

Associate Professor, Department of Agricultural and Applied Economics, Texas Tech University, 204A Agricultural Sciences Building, Lubbock, TX, USA 79409-2132. Phone: (806) 742-1921; e-mail: benaissa.chidmi@ttu.edu.

Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2018 Annual Meeting, Jacksonville, Florida, February 2-6, 2018

Abstract

This article applies the quadratic almost ideal demand system model to a scanner data from Eau Claire, Wisconsin and Pittsfield, Massachusetts retailers augmented with consumer characteristics to analyze consumer choices and estimate demand elasticities in a differentiated yogurt market after the introduction of Chobani brand in 2005. Choices are made at the brand level and at the style level. Main brands of Chobani, Dannon, Yoplait and the private level are used at the brand level while brands are grouped to the Greek and non-Greek yogurt at the style level. Empirical results show that consumers' loyalty for Dannon and Yoplait brands are more than the new brand of Chobani which the latter has the highest own-price elasticity among yogurt brands. Demand is price elastic at the style level with almost same magnitude for both styles. Unlike at the brand level, at the style level, the substitution among groups is symmetric. A majority of groups are expenditure elastic with the highest magnitude for Chobani among brands. Finally, demand estimates are used to analyze the variation in own-price elasticities at the style level using the meta-analysis. The difference in price sensitivity between different groups of consumers suggests that retailers can have area-specific pricing.

Key words: yogurt; demand; elasticity; quaids

JEL codes: C33, D11, Q11

Introduction

The United States dairy industry offers a wide array of dairy products (Davis *et al*., 2010a). The per capita consumption of dairy products has changed over the last four decades. While, the consumption of fluid milk has decreased over time, the consumption of other manufactured dairy products such as cheese, ice cream, butter, and yogurt has increased (Blayney, 2010). Yogurt is the fourth largest dairy category at the retail level (Hovhannisyan and Bozic, 2013) where its popularity is on the rise in the United States. Yogurt per capita consumption has increased from 4.0 pounds per person in 1985 to 14.7 pounds per person in 2015 (United States Department of Agriculture, 2016). In 2015 alone, refrigerated yogurt made a sale of $7.7 billion[1].

Yogurt production differentiated both vertically and horizontally to meet the needs of consumers. In the context of marketing, product differentiation initiates making a product slightly different in its characteristics from that of its competitors by contrasting its unique qualities with other competing products to make it more attractive to a particular target market. The General Mills, for example, offers four brands of yogurt: Yoplait, Mountain High, Liberte, and Annie's. Yoplait which is a leader in the multi-billion dollar U.S. yogurt category, offers "Regular Yogurt", "Greek Yogurt", and "Kid Yogurt". Each of these vertically differentiated products is also horizontally differentiated based on different flavors.

The primary goal of most businesses is to make profit. The market demand is one of the many factors that affect the profitability of a business. Decision makers in the dairy sector require contemporary demand analysis (Maynard and Veeramani, 2003). The decision to alter the price of a product is very important and basically depends on both the own price elasticity and the substitutability of other products for the product in consideration (Hovhannisyan and Khachatryan,

[1] Source: Nielsen Answers, retrieved from: frbuyer.com/2016/02/yogurt-sales-top-7-7-billion/

2017). How consumers respond to price changes is very important question for retailers in order to manage and develop their future marketing strategies in order to maximize their profit. The main objective of this study is to determine the price sensitivity of yogurt by estimating the demand elasticities at the brand level and at the style level in the yogurt market. Demand estimates will be used to analyze the variation in own-price elasticities at the style level which considers the main contribution of this paper. Results of this study can also be useful for policy analysis in policy-oriented agencies or for future marketing strategies of retailers.

Our analysis of examining demand fits in the limited literature of yogurt market. Early studies identified yogurt as a single aggregated product. Boehm (1975) used household panel data from April 1972 to April 1973 to estimate household demand structure for thirteen major dairy products in the Southern United States. The paper was basically aimed to capture the effect of income on household consumption response and to estimate the short-run market response to changes in product's own price, to changes in the product's substitutes and complements. The study revealed that household consumption of dairy products in the South tend to be lower than the national average due to the higher prices of dairy products and lower household income in the South compared to the national household income. The study suggests that an increase in income may lead to increase the purchases of yogurt more than other dairy products in the Sothern United States.

Davis *et al.*, (2010b) used Nielsen 2005 Homescan dataset to estimate the effect of total expenditure and demographic factors that affect demand of refrigerated, frozen and drinkable yogurt using translog demand system. The study showed that each of refrigerated yogurt and drinkable yogurt were net substitutes for frozen yogurt and the latter did not play any major role in consumers' preferences. Demographic factors found to be significant only for frozen and drinkable yogurt. Presence of children in a household had a negative impact on demand of frozen yogurt and a positive impact on demand of drinkable yogurt. The paper revealed that yogurt prices and household's income have an important impact on the demand of yogurt. In another study, Davis et al., (2011) used Nielsen 2007 Homescan purchase data to derive the demand elasticities for sixteen products including refrigerated and frozen yogurt using a censored Almost Ideal Demand System (AIDS) model. Both uncompensated and compensated own-price elasticities showed elastic demand for frozen yogurt but not for refrigerated yogurt.

Most recent studies have focused on estimating demand at the brand level. Villas-Boas (2007) used different supply models to analyze the vertical relationships between manufacturers and retailers using data from the yogurt market in the supermarket industry in a Midwestern metropolitan area from June 1991 to June 1993. She estimated demand using a random coefficients discrete choice model, and then used the demand estimates to compute price-cost margins for retailers and manufacturers. Results revealed an average own-price elasticity of -5.48, -5.65, and -6.15 for Dannon, Yoplait, and the private label respectively.

Mehta *et al*., (2010) examined demand elasticities at the brand level using an integrated framework proposed by Hanemann (Hanemann, 1984) model of consumer demand. The main objective of this study was to uncover the reasons behind why the quantity elasticities estimated using this method in previous works are around -1, and to attempt and propose approaches to get true elasticities. Using ACNielsen scanner level yogurt data in Sioux Falls, South Dakota market from 1986 to 1988, they found inelastic demand for all studied brands of yogurt where the quantity elasticities were -0.6, -0.66, and -0.85 for Dannon, Yoplait and the private label respectively.

In this study, the Quadratic Almost Ideal Demand System (QUAIDS) model is applied to 2008-2011 yogurt purchases data in Eau Claire, Wisconsin and Pittsfield, Massachusetts to estimate the demand for main brands in the yogurt market, Yoplait, Dannon, Chobani in addition to the private label, and also to estimate the demand of Greek and non-Greek yogurt in general. Yogurt is chosen because of its fast growing market due to a greater health awareness. The availability of scanner data at the manufacturer level and the substantial variation of yogurt and consumer characteristics, offer a good opportunity for a case study in estimating the demand elasticities. Villas-Boas (2007) reports the highly elastic own price elasticity for all national brands and the private label of yogurt. This paper follows Villas-Boas paper to address the important, but yet unanswered, question of how the demand elasticities are changed after the introduction of Chobani which is founded in 2005 and produces the majority of the country's Greek yogurt. One more difference between this study and previous studies is that this study attempted to estimate demand for overall brands by estimating elasticities at the style level after the change in yogurt consumers' preferences toward the Greek style yogurt during the last decade. According to the National Public Radio (NPR) report[2], Greek yogurt sales grew by 2500% between 2006 and 2011. Information Resources Inc. (IRI) reported that, from 2011 to 2012, Greek-style yogurt volume rose 72% while non-Greek-style yogurt volume fell 10% (Boynton and Novakovic, 2013). In the first part of this study, we will estimate the own and cross price elasticities of main yogurt brands, Yoplait, Dannon and Chobani in addition to the private label, while in the second part we will focus on estimating elasticities for Greek[3] and non-Greek yogurt in general. In the next section, the quadratic almost ideal demand system model is introduced. Then data definitions and sources are presented following by the main findings of the study. Finally, the conclusion of this study and suggestions for future research are presented.

---

[2] Retrieved from: http://www.huffingtonpost.com/2011/08/23/greek-yogurt-sales_n_933986.html

[3] Manufacturers who produce Greek yogurt are AGRO FARMA INC, CABOT CREAMERY INC, FAGE USA DAIRY INDUSTRY INC, GENERAL MILLS INC, GREECE BY TYRAS S A, GROUPE DANONE S A, HEALTHY FOOD HOLDINGS, KRAFT FOODS INC, SUN VALLEY DAIRY INC, THE HAIN CELESTIAL GROUP INC, and PRIVATE LABEL.

Model

The traditional approach to estimate demand systems is using the Almost Ideal Demand System (AIDS) introduced by Deaton and Muellbauer (1980) which allows for consistent aggregation of individual demands to market demands. The AIDS model have budget shares that are linear functions of log total expenditure. Empirical studies on the relationships between a commodity's budget share and total expenditure which is known as the Engel curve indicate that further terms in total expenditure are required for some expenditure share equations (Lewbel, 1991; Blundell *et al*., 1993). Banks *et al*. (1997) show that a nonparametric analysis of consumer expenditure patterns suggests that Engel curves require quadratic terms in the logarithm of expenditure. They derive an extension of the AIDS model - the quadratic almost ideal demand system (QUAIDS) which also has a higher order total expenditure term. In this study, we estimate the demand parameters and the price and income elasticities using the QUAIDS model as it is recently used by some demand analysis studies (Bopape, 2006; Lambert et al., 2006; Cembalo et al., 2014).

The quadratic aids model is based on the expenditure function:

$$\ln c(\mathbf{p}, u) = \ln a(\mathbf{p}) + \frac{ub(\mathbf{p})}{1 - \lambda(\mathbf{p})b(\mathbf{p})u} \quad (1)$$

where u is utility, $\mathbf{p}$ is a vector of prices, $a(\mathbf{p})$ is a function that is homogenous of degree one in prices, $b(\mathbf{p})$ and $\lambda(\mathbf{p})$ are functions that are homogeneous of degree zero in prices.

The corresponding indirect utility (V) function is:

$$\ln V(\mathbf{p}, m) = \left[\left\{ \frac{\ln m - \ln a(\mathbf{p})}{b(\mathbf{p})} \right\}^{-1} + \lambda(\mathbf{p}) \right]^{-1} \quad (2)$$

where *m* is total expenditure.

ln *a*(**p**) is the transcendental logarithm function:

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{k} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{k} \gamma_{ij} \ln p_i \ln p_k \quad (3)$$

where *i=1,…,k* denote the number of goods entering the demand model.

$b(\mathbf{p})$ is the cobb-Douglas price aggregator:

$$b(\mathbf{p}) = \prod_{i=1}^{k} p_i^{\beta_i} \quad (4)$$

and the specific functional form for $\lambda(\mathbf{p})$ is:

$$\lambda(\mathbf{p}) = \sum_{i=1}^{k} \lambda_i \ln p_i \quad (5)$$

where α_i, β_i, γ_{ij}, and λ_i are parameters to be estimated. The value of α_0 are set by Banks, Blundell, and Lewbel (1997) to be slightly less than the lowest value of ln *m* observed in the data.

Adding up, homogeneity of degree zero in (**p**,*m*) for Marshallian demands, and Slutsky symmetry impose the requirements that:

$$\sum_{i=1}^{k} \alpha_i = 1, \quad \sum_{i=1}^{k} \beta_i = 0, \quad \sum_{j=1}^{k} \gamma_{ij} = 0 \ \forall i, \quad \sum_{i=1}^{k} \lambda_i = 0, \quad \text{and } \gamma_{ij} = \gamma_{ji} \tag{6}$$

Let q_i denote the quantity of good *i* consumed by a household, and define the expenditure share for good *i* as $w_i = p_i q_i / m$. Applying Shepard's lemma to the cost function (1) or Roy's identity to the indirect utility function (2) gives the QUAIDS model in budget shares form:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(\mathbf{p})} \right\} + \frac{\lambda_i}{b(\mathbf{p})} \left\{ \ln \left[\frac{m}{a(\mathbf{p})} \right] \right\}^2 \tag{7}$$

where adding-up requires $\sum_i w_i = 1$.

Notice that When $\lambda_i = 0$ for all *i*, the quadratic term in each expenditure share equation drops out and we are left with Deaton and Muellbauer's (1980) original AIDS model. Hence, the AIDS model is nested within QUAIDS, and the AIDS specification can be tested based on the statistical significance of the λ's.

Sociodemographic variables are typically incorporated into demand system analysis through the linear demographic translation method of Pollak and Wales (1978) in order to control for varying preference structures and heterogeneity across households. Let $h = 1, \ldots, N$ denote households, the budget shares equations for household *h* can then be represented as follow[4]:

$$w_{ih} = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_{jh} + \beta_i \ln \left\{ \frac{m_h}{a(\mathbf{p}_h)} \right\} + \frac{\lambda_i}{b(\mathbf{p}_h)} \left\{ \ln \left[\frac{m_h}{a(\mathbf{p}_h)} \right] \right\}^2 + \sum_{s=1}^{S} \delta_{is} z_{sh} + \varepsilon_{ih} \tag{8}$$

[4] Notice that the price index and the cobb-Douglas price aggregator will be indexed by *h*.

where $z_s = (z_{1h}, \dots, z_{sh})$ is a set of demographic variables for household h.

The term m_h is defined as expenditure on all food items consumed by the household. The reason commodity prices are indexed with the household superscript because households in different clusters face different prices which is some cases the price data are means at the store level.

In most scanner-level data, prices are not observed directly and it must be calculated from the dollars paid by the household during each shopping trips. The calculated price must be endogenous since households are more likely tend to determine quantity and quality purchased simultaneously. Since the difference between different brands of yogurt is small compared to other differentiated products, we argue that the effect of price endogeneity on estimation is very small. The effect of quality endogeneity is ignored because the quantity purchased cannot be adjusted for quality differences. In the same way, how much of each brand to buy and how much to spend on yogurt is another households decision that makes the expenditure endogeneity. Expenditure endogeneity is also arises by other unobserved components in the budget share equations. Therefore, we include household income and family size as instruments in addition to the original price and other demographic variables to augment the demand system (see Dhar, *et al*., 2003; Thompson, 2004; Xiong, *et al*., 2014). The total expenditure equation has the reduced form:

$$\ln m_h = z' \omega_h + \sum_{j=1}^{4} \theta_{ij} \ln p_j + \tau_1 \, income_h + \tau_2 \, size_h \tag{9}$$

where ω is a vector of sociodemographic variables explaining the total expenditure, and z is the corresponding conformable parameter vector.

Handling the large number of "zero" purchases is one of the econometric challenges in the analysis of consumption survey data (Deaton, 1997). In the differentiated yogurt market, percentages of zero-brand consumption (censoring) are severe. Each of Chobani and private label yogurt is consumed by 32 percent of households while Dannon and Yoplait are consumed by 83 and 91 percent of households respectively. We apply the two-step procedure developed by Shonkwiler and Yen (1999) to handle the censoring problem. For each brand, the censoring process is assumed to be formalized as:

$$w_{ih} = \begin{cases} w_{ih}(\mathbf{p}_h, m_h; \psi) + \epsilon_{ih} & \text{if } z'_{ih}\varphi_i + u_{ih} > 0 \\ 0 & otherwise \end{cases} \tag{10}$$

where w_{ih} is observed budget share of brand i for household h, ψ is a vector containing all parameters in a particular demand equation, z_{ih} is a vector of exogenous variables governing the purchasing decision, φ_i is a conformable vector of parameters, and ϵ_{ih} and u_{ih} are random errors and are assumed to be bivariate normal distributed and the covariance of the errors $E(\epsilon_h u'_h) = \delta_i$ where δ_i is a parameter entering the correction factor of the i^{th} budget share equation.

Based on Shonkwiler and Yen (1999) the unconditional mean of the expenditure share for yogurt brand i is derived:

$$E(w_{ih}) = \Phi(z'_{ih}\varphi_i) w_{ih}(\mathbf{p}_h, m_h; \psi) + \delta_i \emptyset(z'_{ih}\varphi_i) \tag{11}$$

where $\emptyset(.)$ and $\Phi(.)$ are the cumulative distribution function and standard normal probability density function, respectively.

Estimation of budget share equations can be performed in two steps: in the first step, known as the purchase decision, the maximum-likelihood probit estimates $\hat{\varphi}_i$ of φ_i are obtained[5] using the binary outcomes of $w_{ih} = 0$ and $w_{ih} > 0$, and then in the second step calculate $\emptyset(z'_{ih}\hat{\varphi}_i)$ and $\Phi(z'_{ih}\hat{\varphi}_i)$ for all *i* and estimate ψ and δ's in the augmented system:

$$w_{ih} = \Phi(z'_{ih}\hat{\varphi}_i)w_{ih}(\mathbf{p}_h, m_h; \psi) + \delta_i \emptyset(z'_{ih}\hat{\varphi}_i) + \varepsilon_{ih} \qquad (12)$$

with seemingly unrelated regression (SUR) where $\varepsilon_{ih} = w_{ih} - E(w_{ih} \mid \mathbf{p}_h, m_h, z_h)$

Expenditure elasticities are derived by differentiating the budget share equations with respect to ln *m*. Expressions are simplified using the intermediate results following Banks *et al.* (1997):

$$\mu_i \equiv \frac{\partial E(w_i)}{\partial \ln m} = \Phi(z'_i\hat{\varphi}_i)\frac{\partial w_i}{\partial \ln m} = [\Phi(z'_i\hat{\varphi}_i)].\beta_i + \frac{2\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\} \qquad (13)$$

$$e_i = 1 + \frac{\mu_i}{w_i} \qquad (14)$$

Marshallian or uncompensated price elasticities are derived by differentiating the budget share equations with respect to ln p_j. Using expression μ_{ij} , the formula for the Marshallian price elasticities can be written as:

$$\mu_{ij} \equiv \frac{\partial E(w_i)}{\partial \ln p_j} = \Phi(z'_i\hat{\varphi}_i)\frac{\partial w_i}{\partial \ln p_j}$$

[5] Notice that the dependent variable is the positive expenditure share while the explanatory variables are sociodemographic exogenous variables of households that affects the purchase decision in addition to the brands' prices.

$$= [\Phi(z_i'\hat{\varphi}_i)].\gamma_{ij} - \mu_i \left[\alpha_j + \sum_{l=1}^{K} \gamma_{jl} \ln p_l\right] - \frac{\lambda_i \beta_j}{b(\mathbf{p})} \left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 \quad (15)$$

$$e_{ij}^{u} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \quad (16)$$

where δ_{ij} is the Kronecker delta equals 1 if $i = j$ and 0 otherwise.

Using the Slutsky equation, the Hicksian or compensated price elasticities are calculated:

$$e_{ij}^{c} = e_{ij}^{u} + w_j e_i \quad (17)$$

Data

Data used in this study are the household's purchases of yogurt from 27 retailers collected by the Information Resource Inc. (IRI). The data is a weekly scanner-level dataset at the chain level in the city of Eau Claire in Wisconsin and the city of Pittsfield in Massachusetts for the period 1998-2011. Scanner data are able to capture consumers' dynamic behavior and reflect consumers' real purchased choices (Swait and Andrew, 2003; Chang *et al*., 2010).

The data provides information for each product at the Universal Product Code (UPC) level, dollar sales, volume sales, retailer, and weeks. Information on product characteristics are obtained from the product category dataset, which contains information on brand, volume equivalent, flavor, fat content, and organic information. Using volume equivalent information, volume sales are converted to a product quantity and then retail prices are obtained from quantity and dollar sales information.

Using UPC codes, 136 types of yogurt are obtained. These types were characterized by product characteristics such as brand, flavor, and fat content. Aggregating products using product characteristics may yield inconsistent results due to researchers' different opinion on grouping (Heng, 2015). In addition to that, the large number of products makes the estimation difficult. As a result, choices are made at the manufacturer level. This study focuses on brands with the highest market shares which are Yoplait, Dannon, and Chobani respectively, in addition to the private label which comes in the fourth place. For the second approach, yogurt is divided between Greek and non-Greek yogurt. Table 1 presents the summary statistics of yogurt groups.

Data is complemented with a college dummy variable equals 1 if household head has a college degree and above, in addition to a child dummy if they have children in order to take into account the consumers' demographic information. Income of the household and the family size are also used as an instrumental variables to deal with the endogeneity bias caused by the expenditure on yogurt. These information is also obtained from the panel demographics dataset provided by IRI for the actual yogurt consumers, which are 5142 households, who made purchases during the year of 2008-2011. Table 2 presents the summary statistics of household demographic variables.

Results

Demand Parameter Estimates

Table 3 reports the estimation results from the first step probit models to interpret the demographic and price effects on yogurt purchases in terms of probabilities. Even though, probit models are estimated to compute the probability and the cumulative density values, this step is also aimed to show that the buying decision does not occur randomly, and to determine the variables that predict it. As mentioned in the model section, the dependent variable in the probit model is a binary variable taking a value of one if positive purchase occurs by households for a specific group and zero otherwise; while the explanatory variables are: the household income, a dummy variable for households with a college degree, a dummy variable for a presence of children in a household, and log of prices. Households with a college degree are more likely to purchase Chobani and Dannon brands rather than Yoplait and the private label. Having a college degree will increase the probability of buying a Greek yogurt in general. Families with children in the household tend to purchase Dannon and Yoplait which have lower prices compared to Chobani. This is also confirmed by the demand for non-Greek yogurt by households with children. An increase in income will increase the demand on branded yogurt and also the demand for Greek style yogurt which have higher prices compared to the private label and non-Greek yogurt respectively. In general, the effect of an increase in price of the product will decrease the probability that households buy the given product where most parameters related to own prices are negative and significant The statistical significance of φ_i's indicate that the additional information provided by the probability density values explains a significant part of the variation in the budget shares.

Parameter estimates from the nonlinear AIDS demand system are presented in tables 4 and 5. The budget equation for the private label and the Greek yogurt were dropped during estimation for each case to avoid singularity of the variance-covariance matrix when all groups are included and then parameters of the deleted equations are recovered using the theoretical restrictions. The significance of estimated coefficients of λ's allow us to choose easily between the original AIDS and the quadratic AIDS model. The null hypothesis that λ_i is zero in the budget share equation is rejected for the private label at the brand level estimation. As a result the quadratic AIDS model is preferred for the demand estimation at the brand level. However, at the style level, this hypothesis is failed to be rejected, providing no evidence in support of the quadratic AIDS model. As a result, the original AIDS model is recommended for demand estimation at the style level.

Elasticities

Elasticities are used to interpret the effect of yogurt price and household income on yogurt purchases. An examination of the expenditure elasticities are shown in the last column of tables 6 and 7 where all the estimates, except the Private label, are statistically significant. The positive sign of estimated expenditure elasticities indicate that all these groups can be considered as normal goods. At the brand level, demand for Chobani is more than unitary elastic which makes this brand as a luxury good. A 1% increase in the household income will increase household expenditure on Dannon and Yoplait by 1.09% and 1.08%, respectively. Demand on a new brand, Chobani will substantially increase by 1.52% as an income of a household increases by 1%. Parameter estimates with respect to the private label is not statistically significant. At the style level, demand is almost unitary elastic where an expenditure elasticity for the non-Greek and Greek yogurt will increase by 1.01% and 1.02% respectively as the income of a household increases by 1%.

Tables 6 and 7 also reports uncompensated and compensated price elasticity estimates evaluated at the sample means along with the associated standard errors. Most estimates are statistically significant. At the brand level, Dannon has the lowest uncompensated own-price elasticity (-0.42) followed by the elastic demand of Yoplait (-1.55). The inelastic demand of Dannon reveals the popularity of this brand among yogurt consumers. Danone comes in 84 different flavors where strawberry, blueberry and vanilla are the most popular flavors respectively (IRI, 2011). Chobani with the highest price among branded yogurt has the highest uncompensated own-price elasticity (-6.57). One possible reason why Chobani elasticity is of greater magnitude compared to other branded yogurt is the fact that Chobani was a new brand at that time and it was not very popular nationally and it was only offered at 16 different flavors. Although, the private label was expected to have the highest uncompensated own-price elasticity despite its lowest price, its price elasticity (-2.91) is not very high compared to Chobani. At the style level, almost all elasticity estimates are statistically significant with uncompensated own-price elasticity of -1.08 for non-Greek and -1.47 for Greek yogurt. The Greek yogurt has the highest price elasticity because it was at the beginning of its popularity at that time which was mainly offered by Chobani. Villas-Boas (2007) found an average elastic own-price elasticity of -5.48, -5.65 and -6.15 for Dannon, Yoplait, and the private label respectively using Berry Levinsohn Pakes (BLP) model. Mehta *et al*., (2010) found inelastic demand of -0.6, -0.66, and -0.85 for Dannon, Yoplait and the private label respectively using an integrated framework proposed by Hanemann model. Our elasticities estimated are -0.42, -1.55, and -2.91 for Dannon, Yoplait and the private label respectively using QUAIDS model. It can be said that our estimates are not consistent with the elastic demand of the first study and inelastic demand of the second study. One possible reason is that each study peruses different market during different period. Our study investigates the yogurt market after a change in market competition by the introduction of Chobani in 2005.

Relationships among yogurt groups are also identified by estimated compensated cross-price elasticities. Most cross-price elasticities are positive and significant, indicating yogurt groups are substitutes, but the substitution among groups is asymmetric. An increase in the price of Chobani will increase the demand of Dannon, Yoplait and the private label substantially while an increase in the price of Dannon will not increase the demand of Chobani. In the same way, an increase in the price of Dannon will increase the demand of Yoplait while an increase in the price of Yoplait will not increase the demand of Dannon. At the style level, the substitution among groups is symmetric. An increase in the price of the non-Greek yogurt will increase the demand of Greek yogurt and also an increase in the price of Greek yogurt will increase the demand of the non-Greek yogurt, in a higher magnitude. The stickiness in consumer behavior, once they have bought the Greek style yogurt they are unwilling to switch back to the non-Greek yogurt, was expected but this result shows that consumers are very price sensitive and price really matters in consumers' utility rather than the yogurt style!

Meta-Analysis

Meta-analysis has been widely used in marketing, economics and psychology and refers to the statistical analysis of empirical research results (Stanley, 2001). In this study, meta-analysis is used to synthesize the factors that determine the estimated own-price elasticities for Non-Greek and Greek yogurt. We think since elasticities are functions of cdf's and the latter are functions of demographics, prices and market shares, it would be interesting to analyze the variation in elasticities at the style level by regressing demographics, prices and yogurt style market shares on estimated own-price elasticities to asses factors that are most influential in elasticities estimation.

The variation of uncompensated own-price elasticities by individuals' demographics for non-Greek and Greek yogurt are shown in figures 1 to 3. Figures show that the estimated own-price elasticities are all negative and that they approximate a normal distribution for non-Greek yogurt consumers. The negative responds to price tends to become less pronounced as households get a college degree while it tends to be stronger for households without children. Not surprisingly, when the own-price elasticities are broke down by income categories, it is clear that lower income households have a greater tendency toward negative respond.

In order to determine the impact of explanatory variables on the magnitude of change in price elasticities, the latter are expressed as an absolute values. More specifically:

$$Elasticity = \alpha_0 + \alpha_1 Share + \alpha_2 College + \alpha_3 Children + \alpha_4 Income + \alpha_5 NGPrice + \alpha_6 GPrice + \varepsilon \quad (18)$$

Results from the meta-regression for both non-Greek and Greek yogurt are reported in table 8. Market share has a negative and statistically significant impact on the magnitude of price elasticities for both non-Greek and Greek yogurt explaining diminishing consumers' price sensitivity as the market power of the product increases. For non-Greek yogurt, households with a college degree are less price sensitive while for Greek yogurt the effect is not statistically significant compared to households without a college degree. Households who have children are more price sensitive for non-Greek yogurt but not for the Greek yogurt. For non-Greek yogurt, lower-income households are shown to be more price sensitive while for Greek yogurt they are less price sensitive compared to higher-income households. With respect to the effect of products' price, an increase in the price of both non-Greek and Greek yogurt increases the price sensitivity of non-Greek yogurt consumers. Although, the price of Greek yogurt increases the price sensitivity of Greek yogurt consumers, the price of non-Greek yogurt diminishes the price sensitivity of Greek yogurt consumers.

Conclusion

The brand of yogurt considers an important attribute affecting consumers purchasing decisions. In the last decade, there is also a growth of Greek style yogurt in the U.S. yogurt market. The main objective of this study is to investigate the price sensitivity of yogurt by estimating the demand elasticities at the brand level, and at the style level in the yogurt market. This study is motivated by the study of Villas-Boas (2007) where author investigates a high elastic demand for major players in the yogurt market. This paper seeks to investigate the change in demand elasticities after the introduction of one of the recent most popular brand of Chobani and also the change in consumer preferences towards the Greek style yogurt. The analysis employed retails scanner sales data for Massachusetts and Wisconsin retail chain, and demographic characteristics from IRI. Results indicate that demand for a new brand of Chobani is substantially elastic compared to other main brands of Dannon and Yoplait. On average, at the style level, groups have the same magnitude with respect to the expenditure elasticity, while higher uncompensated own-price elasticity for the Greek style yogurt.

The demand estimates provide intuition to policy makers who regulate the U.S. dairy market. Any regulation that might lead to increase the price of milk would affect the yogurt market revenues due to a change in product production costs. This information can also be used by retailers to increase their sales. As noted, demand for Chobani and the private label is highly elastic. This will give a chance to retailers to increase their sale by decreasing the price. Grouping yogurt brands based on style between Greek and non-Greek will also provide insights to retailers to maximize overall profit from all brands. Finally, retailers can target consumers using their demographic information to increase sales as each group of individuals have different preferences for each yogurt brand or type. Meta-analysis, that considers the main contribution of this paper, provides very interesting results that might be used by chains to utilize micro-marketing strategies. For example the difference in price sensitivity between low-income and high-income households suggests that retailers can have area-specific pricing.

Unfortunately, IRI provides only the demographic information for two states of Massachusetts and Wisconsin which is a big data limitation of this study. This limitation provides an interesting direction for future research to widen the geographical scope of yogurt demand study to the entire U.S. market. Another extension of this study would be assuming different supply models like the widely used Bertrand-Nash pricing model, a leader follower (Stackelberg) framework, or a joint-profit maximization (monopoly) game, to provide the market power each brand has in the yogurt market. Yoplait maker General Mills has launched a new “French-style” yogurt called “Oui” in July 2017 which would a very interesting topic for future studies to analyze the effect of this new product’s introduction to the yogurt market.

References

Banks, J., Blundell, R., and Lewbel, A. (1997). “Quadratic Engel Curves and Consumer Demand.” *The Review of Economics and Statistics* 79(4): 527-539.

Blayney, D.P. (2010). “Milk Utilization Patterns in the U.S. Presentation to the Dairy Industry Advisory Committee.” Retrieved from: http://www.fsa.usda.gov/Internet/FSA_File/1_3_utiliz_blayney.pdf

Blundell, R.W., Pashardes, P., and Weber, G. (1993). “What Do We Learn About Consumer Demand Patterns from Micro Data.” *American Economic Review* 83(3): 570-597.

Boehm, T. W. (1975). “The Household Demand for Major Dairy Products in the Southern Region.” *Southern Journal of Agricultural Economics,* 7(2): 187-196.

Bopape, L.E. (2006) “The Influence of Demand Model Selection on Household Welfare Estimates: An Application to South African Food Expenditures” A PhD Dissertation, Michigan State University.

Boynton, R.D., and Novakovic, A.M. (2013) “Industry Evaluations of the Status and Prospects for the Burgeoning New York Greek-Style Yogurt Industry.” Program on dairy markets and Policy Research Paper Series, Research paper number RP13-01.

Cembalo, L., Caracciolo, F., and Pomarici, E. (2014). “Drinking Cheaply: The Demand for Basic Wine in Italy.” *Australian Journal of Agricultural and Resource Economics*, 58(3): 374-391.

Chang, J. B., Lusk, J.L., and Norwood, F.B. (2010). “The Price of Happy Hens: A Hedonic Analysis of Retail Egg Prices.” *Journal of Agricultural and Resource Economics*, 35(3): 406-423.

Davis, C. G., Dong, D., Blayney, D., and Owens, A. (2010a). "An Analysis of U.S. Household Dairy Demand." TB-1928, U.S. Department of Agriculture, Economic Research Service, December 2010.

Davis, C.G., Blayney, D., Muhammad, A., Yen, S.T., and Cooper, J. (2010b). "A Cross-Sectional Analysis of U.S. Yogurt Demand." *Journal of Food Distribution Research,* 41(2): 36-45.

Davis, C.G., Yen, S.T., Dong, D., and Blayney, D.P. (2011). "Assessing Economic and Demographic Factors that Influence United States Dairy Demand." *Journal of Dairy Science* 94(7): 3715-3723.

Deaton, A. (1997). "The Analysis of Household Surveys-A Microeconometric Approach to Development Policy". Baltimore: The Johns Hopkins University Press.

Deaton, A.S., and Muellbauer, J. (1980). "An Almost Ideal Demand System." *American Economic Review,* 70: 312-326.

Dhar, T., Chavas, J.P., and Gould, B.W. (2003). "An Empirical Assessment of Endogeneity Issues in Demand Analysis for Differentiated Products." *American Journal of Agricultural Economics* 85(3): 605-617.

Hanemann, M.W. (1984). "Discrete/Continuous Models of Consumer Demand." *Econometrica,* 52(3): 541-561.

Heng, Y. (2015). "Three Essays on Differentiated Products and Heterogeneous Consumer Preferences: The Case of Table Eggs." Ph.D. Dissertation. Department of Agricultural Economics, College of Agriculture, Kansas State University. Retrieved from: https://krex.k-state.edu/dspace/bitstream/handle/2097/18993/YanHeng2015.pdf?sequence=2

Hovhannisyan, V., and Bozic, M. (2013). "A Benefit-Function Approach to Studying Market Power: An Application to the U.S. Yogurt Market." *Journal of Agricultural and Resource Economics,* 38(2):159-173.

Hovhannisyan, V. and Khachatryan, H. (2017). "Ornamental Plants in the United States: An Econometric Analysis of a Household-Level Demand System." *Agribusiness: An International Journal,* 33(2): 226-241.

Lambert, R., Larue, B., Yelou, C., and Criner, G. (2006). "Fish and Meat Demand in Canada: Regional Differences and Weak Separability." Agribusiness: An International Journal, 22(2): 175-199.

Lewbel, A. (1991). "The Rank of Demand Systems: Theory and Nonparametric Estimation." *Econometrica* 59(3): 711-730.

Maynard, L.J., and Veeramani, V.N. (2003). “Price Sensitivities for U.S. Frozen Dairy Products.” *Journal of Agriculture and Applied Economics*, 35(3): 599-609.

Mehta, N., Chen, X., and Narasimham, O. (2010). “Examining Demand Elasticities in Hanemann’s Framework: A Theoretical and Empirical Analysis.” *Marketing Science,* 29(3): 422-437.

Pollak, R.A., and Wales, T.J. (1978). “Estimation of Complete Demand Systems from Household Budget Data: The Linear and Quadratic Expenditure Systems.” *American Economic Review* 68(3): 348-359.

Shonkwiler, J.S., and Yen, S.T. (1999). “Two-Step Estimation of a Censored System of Equations.” *American Journal of Agricultural Economics* 81(4): 972-982.

Stanley, T.D. (2001). “Wheat from Chaff: Meta-Analysis as Quantitative Literature Review.” *Journal of Economic Perspectives*, 15(3): 131–150.
Swait, J. and Andrews, R.L. (2003). “Enriching Scanner Panel Models with Choice Experiments.” *Marketing Science*, 22(4): 442-460.

Thompson, W. (2004). “Using Elasticities from an Almost Ideal Demand System? Watch Out for Group Expenditure!” *American Journal of Agricultural Economics* 86(4) 1108-1116.

U.S. Department of Agriculture. (2016). National Agricultural Statistics Service. Dairy Products: Per Capita Consumption. Retrieved from: https://www.ers.usda.gov/data-products/dairy-data/dairy-data/#Data files

Villas-Boas, S.B. (2007). “Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data.” *The Review of Economic Studies*, 74: 625-652.

Xiong, B., Sumner, D., and Matthews, W. (2014). “A New Market for an Old Food: The U.S. Demand for Olive Oil.” *Agricultural Economics* 45:107-118.

Table 1 Summary Statistics of Yogurt

Variables	Chobani	Dannon	Yoplait	Private Label	Greek yogurt	Non-Greek yogurt
Retail prices ($/6 oz)						
	1.197	0.724	0.674	0.492	1.219	0.672
	(0.171)	(0.249)	(0.215)	(0.129)	(0.26)	(0.22)
Quantity consumed by HH (oz)						
	4.310	26.4	41.047	4.174	5.636	81.684
	(18.440)	(47.32)	(64.99)	(19.245)	(20.672)	(103.675)
Customers HH (%)						
	32.65	83.06	91.17	32.54	42.53	99.44
Market share (%)						
	6.58	30.86	57.07	5.49	7.48	92.52

Note: Numbers in parentheses are standard deviations.

Table 2 Summary Statistics of Households

Variable	Mean	Std. Dev.	Min	Max
College	0.170	0.375	0	1
Children	0.204	0.403	0	1
Family size	2.388	1.243	1	8
Income*	7.201	3.253	1	12

* in (10,000)

Table 3 First Stage Probit Estimation

Variables	Chobani	Dannon	Yoplait	Private	Non-Greek yogurt	Greek yogurt
College	0.230***	0.155***	-0.060	0.057	-0.207	0.218***
	(0.050)	(0.058)	(0.069)	(0.049)	(0.159)	(0.047)
Child	-0.172	0.162***	0.654***	-0.020	0.467**	0.01
	(0.047)	(0.055)	(0.085)	(0.046)	(0.239)	(0.044)
Income	0.043***	0.025***	0.022***	0.012**	-0.006	0.041***
	(0.005)	(0.006)	(0.007)	(0.005)	(0.02)	(0.005)
In P_1	-1.156***	-0.600***	0.391	-2.319***	-0.421	1.159***
	(0.199)	(0.244)	(0.305)	(0.214)	(0.316)	(0.084)
In P_2	0.640***	-0.272***	-0.307***	-0.395***	-0.58	-0.275**
	(0.083)	(0.097)	(0.107)	(0.081)	(0.479)	(0.141)
In P_3	1.090***	0.397***	-0.333**	0.401***		
	(0.098)	(0.099)	(0.134)	(0.093)		
In P_4	0.939***	0.425***	-0.392***	0.587***		
	(0.098)	(0.113)	(0.130)	(0.095)		
Constant	-0.774***	1.277***	1.169***	2.029***	3.505***	-0.886***
	(0.243)	(0.296)	(0.371)	(0.259)	(0.616)	(0.173)

Note: Numbers in parentheses are standard deviations. ***, ** and * indicate significant at 1%, 5% and 10% respectively.

Table 4. Parameter Estimates from the Nonlinear AIDS Demand System (Brand Level)

Parameters	Coefficients	Standard Errors	z	P>z
α_1	-0.188	0.086	-2.18	0.029
α_2	0.226	0.081	2.79	0.005
α_3	0.699	0.076	9.16	0.00
α_4	0.263	0.092	2.87	0.004
β_1	-0.123	0.077	-1.6	0.11
β_2	-0.093	0.070	-1.33	0.184
β_3	0.129	0.066	1.97	0.049
β_4	0.087	0.062	1.4	0.161
γ_{11}	-0.471	0.056	-8.44	0.00
γ_{12}	0.072	0.024	2.96	0.003
γ_{13}	0.251	0.031	7.97	0.00
γ_{14}	0.148	0.030	4.94	0.00
γ_{21}	0.072	0.024	2.96	0.003
γ_{22}	0.081	0.023	3.43	0.001
γ_{23}	-0.034	0.020	-1.7	0.089
γ_{24}	-0.118	0.021	-5.58	0.00
γ_{31}	0.251	0.031	7.97	0.00
γ_{32}	-0.034	0.020	-1.7	0.089
γ_{33}	-0.154	0.026	-5.88	0.00
γ_{34}	-0.063	0.017	-3.58	0.00
γ_{41}	0.148	0.030	4.94	0.00
γ_{42}	-0.118	0.021	-5.58	0.00
γ_{43}	-0.063	0.017	-3.58	0.00
γ_{44}	0.033	0.025	1.28	0.199
δ_{11}	0.128	0.017	7.59	0.00
δ_{12}	0.008	0.016	0.5	0.617
δ_{13}	-0.073	0.015	-4.91	0.00
δ_{14}	-0.063	0.013	-4.8	0.00
δ_{21}	0.009	0.020	0.43	0.669
δ_{22}	-0.051	0.020	-2.56	0.011
δ_{23}	0.022	0.021	1.08	0.278
δ_{24}	0.020	0.023	0.88	0.378
δ_{31}	0.025	0.003	8.21	0.00
δ_{32}	0.005	0.003	1.81	0.07
δ_{33}	-0.015	0.002	-6.56	0.00
δ_{34}	-0.015	0.003	-5.61	0.00
λ_1	0.022	0.027	0.82	0.413
λ_2	0.035	0.027	1.31	0.19
λ_3	-0.012	0.025	-0.49	0.626
λ_4	-0.045	0.023	-1.99	0.047
$\emptyset_1$	0.276	0.041	6.74	0.00
$\emptyset_2$	-0.300	0.106	-2.83	0.005

$\emptyset_3$	0.117	0.124	0.94	0.348
$\emptyset_4$	-0.093	0.164	-0.57	0.57

Table 5. Parameter Estimates from the Nonlinear AIDS Demand System (Style Level)

Parameters	Coefficients	Standard Errors	z	P>z
α_1	1.043	0.037	28.56	0.00
α_2	-0.043	0.037	-1.17	0.243
β_1	0.018	0.039	0.45	0.65
β_2	-0.018	0.039	-0.45	0.65
γ_{11}	-0.057	0.012	-4.93	0.00
γ_{12}	0.057	0.012	4.93	0.00
γ_{21}	0.057	0.012	4.93	0.00
γ_{22}	-0.057	0.012	-4.93	0.00
δ_{11}	-0.010	0.011	-0.9	0.366
δ_{12}	0.010	0.011	0.9	0.366
δ_{21}	-0.042	0.011	-3.93	0.00
δ_{22}	0.042	0.011	3.93	0.00
δ_{31}	-0.006	0.002	-4.07	0.00
δ_{32}	0.006	0.002	4.07	0.00
λ_1	-0.011	0.015	-0.71	0.48
λ_2	0.011	0.015	0.71	0.48
$\emptyset_1$	-3.813	0.566	-6.74	0.00
$\emptyset_2$	3.813	0.566	6.74	0.00

Table 6. Own-Price, Cross-Price, and Expenditure Elasticities Estimates (Brand Level)

	Price Elasticities				Expenditure Elasticity
Uncompensated	Chobani	Dannon	Yoplait	Private	
Chobani	**-6.57*****	3.183***	6.192***	4.302***	1.522**
	(1.832)	(1.048)	(0.737)	(0.984)	(0.8)
Dannon	0.391	**-0.427****	0.326***	-0.017	1.099***
	(0.288)	(0.182)	(0.107)	(0.167)	(0.212)
Yoplait	0.241	-0.312***	**-1.55*****	-0.361***	1.086***
	(0.18)	(0.11)	(0.061)	(0.093)	(0.148)
Private	2.415	-5.689***	-5.276***	**-2.912****	-0.972
	(2.096)	(1.465)	(1.021)	(1.342)	(0.903)
Compensated	Chobani	Dannon	Yoplait	Private	
Chobani	**-6.47*****	3.707***	7.027***	4.365***	
	(1.79)	(0.844)	(0.634)	(0.96)	
Dannon	0.463*	**-0.049**	0.929***	0.027	
	(0.275)	(0.124)	(0.112)	(0.16)	
Yoplait	0.312*	0.061	**-0.954*****	-0.316***	
	(0.171)	(0.07)	(0.076)	(0.087)	
Private	2.351	-6.024***	-5.809***	**-2.952****	
	(2.046)	(1.269)	(0.914)	(1.319)	

Note: Bold numbers are own-price elasticities. Standard errors are in parentheses. ***, ** and * indicate significant at 1%, 5%, and 10% respectively.

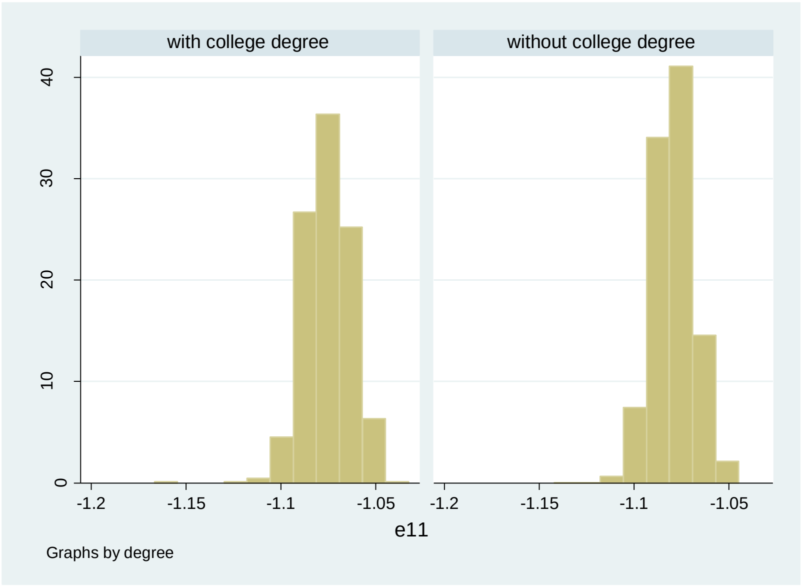
Table 7. Own-Price, Cross-Price, and Expenditure Elasticities Estimates (Style Level)

	Price Elasticities		Expenditure Elasticity
Uncompensated	Non-Greek	Greek	
Non-Greek	**-1.086*****	0.043	1.014***
	(0.039)	(0.045)	(0.043)
Greek	0.943***	**-1.475*****	1.023***
	(0.431)	(0.501)	(0.091)
Compensated	Non-Greek	Greek	
Non-Greek	**-0.157*****	0.128***	
	(0.013)	(0.042)	
Greek	1.881***	**-1.389*****	
	(0.357)	(0.494)	

Note: Bold numbers are own-price elasticities. Standard errors are in parentheses. *** and ** indicate significant at 1% and 5% respectively.

Figure 1. Distribution of Uncompensated Own-Price Elasticity by College Degree.

Non-Greek Yogurt Consumers



Greek Yogurt Consumers

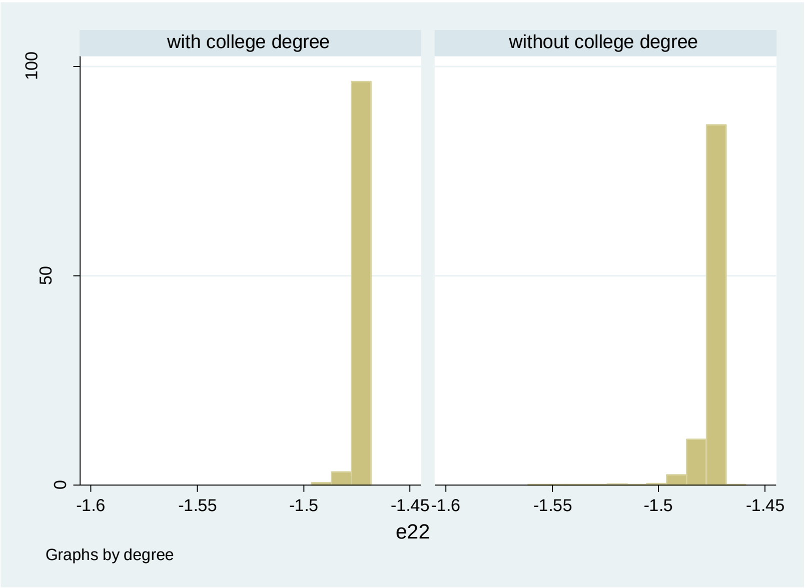
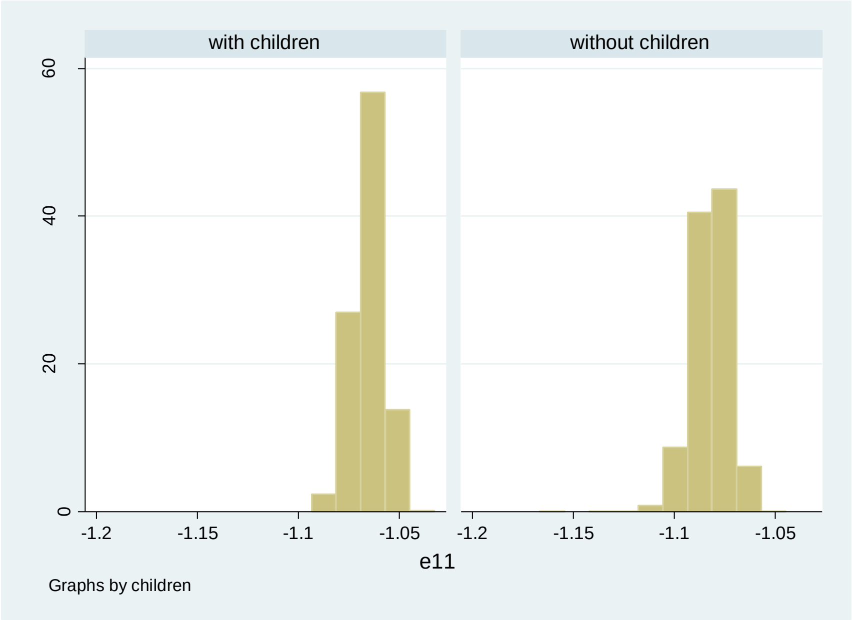


Figure 2. Distribution of Uncompensated Own-Price Elasticity by Child Groups

Non-Greek Yogurt Consumers



Greek Yogurt Consumers

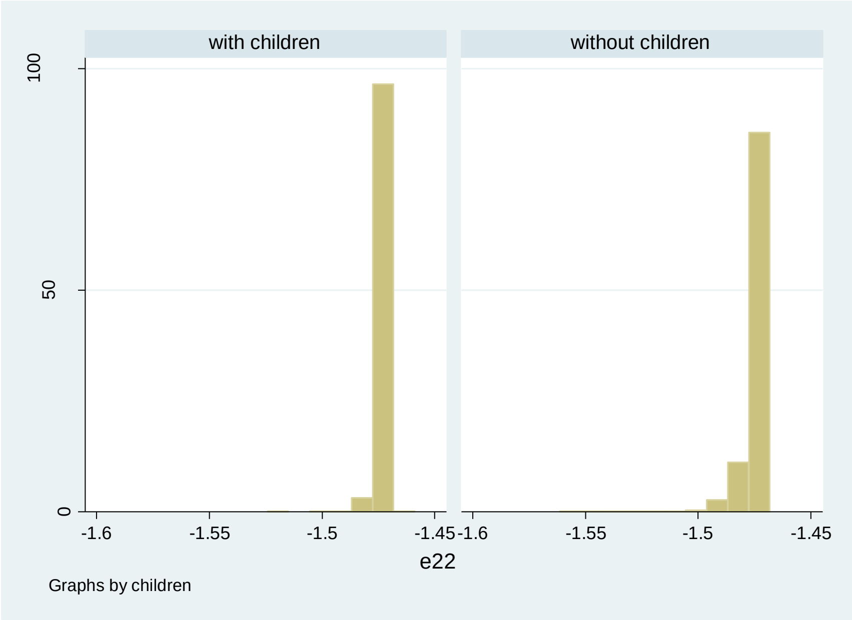
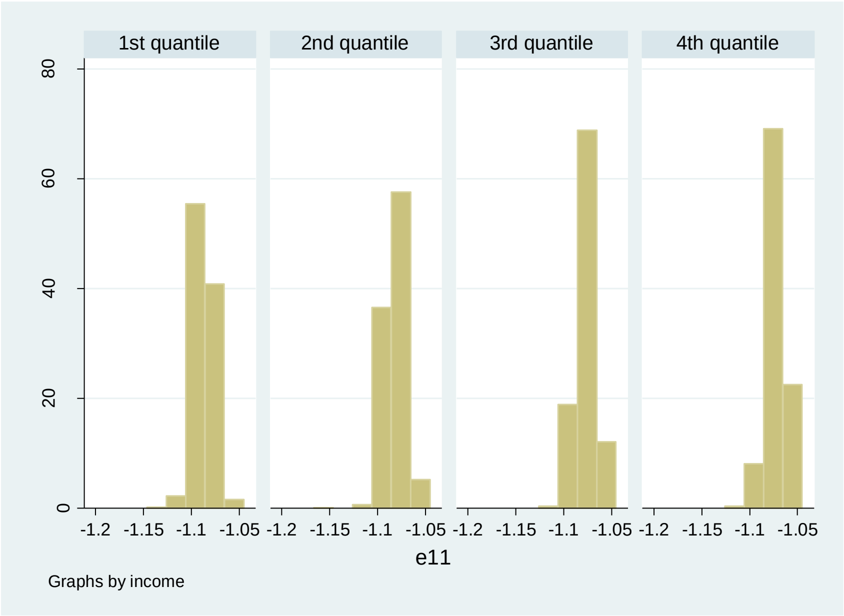


Figure 3. Distribution of Uncompensated Own-Price Elasticity by Income Groups

Non-Greek Yogurt Consumers



Greek Yogurt Consumers

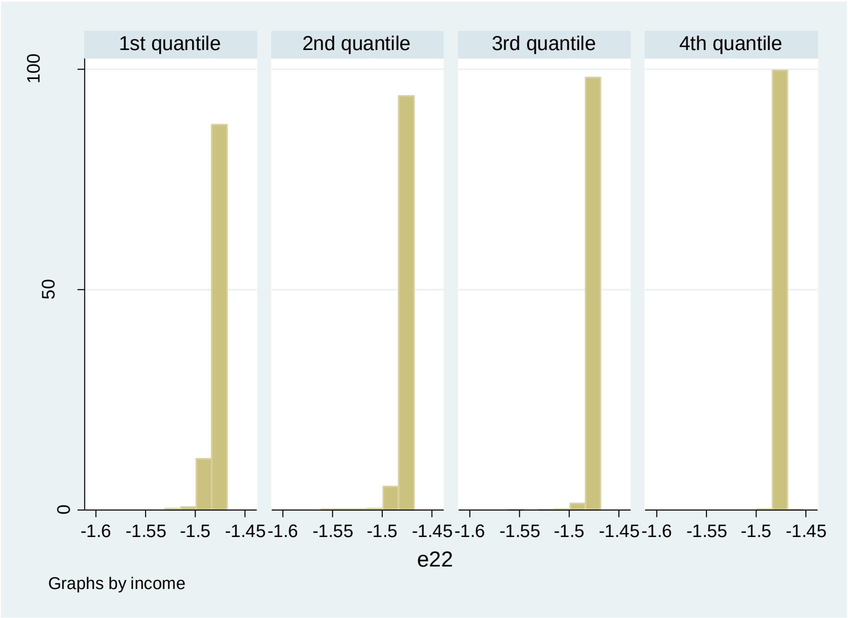


Table 8. Meta-Analysis Parameter Estimates for Non-Greek and Greek Yogurt Price Elasticities

Variable	Non-Greek	Greek
Market Share	-0.129**	-0.042**
	(0.004)	(0.000)
College	-0.006**	-0.0001
	(0.000)	(0.000)
Children	-0.011**	-0.0001
	(0.000)	(0.000)
Income	0.01**	-0.0002**
	(0.000)	(0.000)
Price non-Greek	0.005**	-0.0002*
	(0.000)	(0.000)
Price Greek	0.014**	0.001**
	(0.000)	(0.000)
Constant	1.175**	1.532**
	(0.004)	(0.000)

Standard errors are in parentheses.
** and * indicate significant at 1% and 5% respectively.