EXAMINATION OF THE DEMAND FOR YOGURT BY BRAND, 2009-2011

A Thesis

by

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ABSTRACT

Per capita consumption of yogurt in the United States has increased dramatically over the last 40 years. Yogurt was named one of the most popular foods over the last ten years. This increase in growth partially can be attributed to an increasingly health-conscious population. In order to provide an in-depth analysis of the yogurt industry as a whole by brand, this study uses weekly point-of-sale information from Nielsen for five major yogurt brands over the period January 2009 to December 2011. During this period, the most dominant brands in the yogurt industry were Dannon, Yoplait, Stonyfield, Private Label, and Chobani. Chobani entered the market in 2009 as the first Greek yogurt brand.

Single-equation regression demand models and a seemingly unrelated regression (SUR) demand systems model were constructed to provide own-price, cross-price, and expenditure elasticities of demand for yogurt by brand. These models also identified the impacts of income, the Great Recession, seasonality, and habit formulation for each of the five brands. The drivers of demand in the single-equation models were own-price, habit formulation, tastes and preferences, seasonality, and Christmas. The SUR model takes into account correlation of the error terms as well as the incorporation of the homogeneity restriction on the own-price, cross-price, and income elasticities. Additionally, the SUR model was used to re-examine some of the results from the single-equation models since the latter were at odds with conventional economic theory. Similar to the single-equation models, own-price, income, tastes and preferences, seasonality, and Christmas were found as drivers in the SUR model. Cross-price effects were not found to be a significant driver of demand for the respective yogurt brands in both models. To analyze the performance of the models, metrics such as R-Squared, Adjusted R-Squared, standard error of the regression (SER), and Durbin-Watson (DW) statistics were used. The SUR model performed better for the Chobani, Stonyfield, and Private Label brands, while the single-equation models performed better for the Dannon and Yoplait brands.

Using ex-post forecasting, single-equation and SUR models were evaluated to determine their ability to generate accurate forecasts. The last thirteen weeks of 2011 were withheld to test the forecast performance of the respective models. Metrics such as root mean squared error (RMSE), mean absolute error (MAE), mean absolute percent error (MAPE), bias proportions, variance proportions, and covariance proportions were used to assess the ability of the single-equation and SUR models to generate accurate predictions. Forecast accuracy was better for the Chobani, Yoplait, and Private Label brands when using the SUR model, but forecast accuracy was better for the Dannon and Stonyfield brands when using the single-equation model.

The analysis provides a view of the yogurt industry from 2009 to 2011 in the United States. To date, there is not much research dealing with the demand for yogurt by brand. This examination of the yogurt industry will benefit analysts and manufacturers of these major yogurt brands as well as improve their understanding of the driving forces of demand for yogurt. In particular, the estimated own-price elasticities will help manufacturers maximize their revenues, with appropriate pricing strategies.

DEDICATION

I would like to dedicate this work to my mom and dad. I couldn't have made it to where I am now without their encouragement, support, and love. You have picked me up through my struggles and celebrated with me through my accomplishments. Thank you for always being there for me and pushing me to be my very best. I appreciate all you have done for me to get to this point. I am so blessed to have the both of you as my parents.

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The data analyzed in Chapter 3 was provided by Professor Capps. The model development and data analysis depicted in Chapters 4-6 were conducted in part by Professor Capps and Nima Khodakarami of the Department of Agricultural Economics.

All other work conducted for the thesis was completed by the student independently.

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CHAPTER I
INTRODUCTION

Background

In recent years, there has been a rise in the demand for yogurt throughout the United States. From 1975 through 2013, yogurt per capita consumption increased from 2.0 pounds to 14.9 pounds, while milk per capita consumption steadily declined (USDA, 2016). The revenue for the industry in 2015 was approximately $4.9 billion (Isakowitz, 2015). Greek yogurt makes up roughly 36% of the yogurt industry (Isakowitz, 2015). With a population that is becoming increasingly health conscious, yogurt has become a staple dairy choice. It has been recognized for its digestive health benefits, for strengthening of the immune system, as a preventative for osteoporosis, and for the ability to reduce risk of high blood pressure (WEBMD Weight Loss Clinic, 2008). It is expected that by 2020, yogurt sales will amount to $5.7 billion (Isakowitz, 2015).

The NPD Group provides market information and the ability to track sales in different industries. According to the NPD Group, yogurt has become one of the most popular foods over the last ten years (Bizzozero, 2014). Yet, there is a lack of consumer demand analysis in the extant literature concerning the product. The increase in demand for yogurt could be attributed to a more health-conscious population as previously mentioned, a shift towards easily prepared foods that can be eaten at home, or possibly other factors.

This thesis will examine national yogurt brands over the period 2009-2011. The time period was selected in order to capture the yogurt market before the Greek yogurt phenomenon. During this period, primarily non-Greek yogurt was featured with the exception of Chobani. In particular, attention will be centered on prominent national brands of yogurt, namely Dannon, Yoplait, Stonyfield, and Chobani. Hence, the focus is to provide an in-depth analysis of the yogurt industry as a whole by brand. This type of analysis has not been done on the industry to date, at least in the public domain.

Literature Review

Hovhannisy and Bozic (2013) studied market power in the U.S. yogurt industry. Data on yogurt sales and unit values (2009-2011) were weekly product-level scanner data from Information Resources Incorporated (IRI). Five U.S. metropolitan areas were examined for the analysis. Attention was centered on brands (not specified), in particular national brand one (NB1), national brand two (NB2), and store brand (SB) as well as fat content (skim and whole). Inverse demand functions were estimated for the respective products. The study was subsequently extended to consider aspects of empirical industrial organization by utilizing conjectural variations (CV).

Additionally, Hovhannisy and Bozic (2013) developed supply functions by modelling a range of possible equilibrium outcomes obtained by equating marginal revenue and marginal cost (CV approach). "This method allows one to gauge competition without imposing ad hoc game-theoretical structures on firm's market interactions." They found that retailers were exploiting strong consumer preferences for national brand (NB) yogurt, whereas store brand(SB) yogurt remained relatively less important from a retail profitability perspective. The estimates of own-price elasticities across the five cities and the three brands ranged from -0.014 to -0.076. Consequently, the demand for yogurt by brand was found to be highly inelastic over the period 2009-2011, coincidentally the same time period in this thesis.

Davis (2010) used Nielsen Homescan data to investigate a three-equation translog demand system for refrigerated yogurt, frozen yogurt, and drinkable yogurt. Yogurt consumption was analyzed based on price, income, and demographic factors. Demographic factors that were used consisted of presence of children, marriage, and female head of household employment. But these factors had little impact on consumption. The drivers of demand in yogurt were price and income. The own-price elasticities showed that the respective yogurt products were sensitive to changes in retail prices and income. The own-price elasticity of refrigerated yogurt found in this study was -1.012, higher than other studies in the literature to (Boehm and Babb -0.51 (1975); Veeman and Peng -0.81 (1997)). The own-price elasticity of frozen yogurt found in this

study was -2.026. Drinkable yogurt's own-price elasticity was found to be -1.103. Consequently, Davis that the demand for refrigerated yogurt, frozen yogurt, and drinkable yogurt to be elastic.

Villas-Boas (2004) analyzed the relationships between retailers and manufacturers in the U.S. yogurt market in a certain Midwestern city. The demand analysis used store-level scanner data for quantity and price of the products. Villas-Boas focused on the yogurt industry because it was one of the largest dairy categories in retail. "Dannon and General Mills (Yoplait) together account for almost 62 percent of total U.S. yogurt sales, private label brands from retail stores are in third place with 15 percent of the market" (Villas-Boas, 2004). She discovered that double marginalization did not occur through the yogurt market. Villas-Boas states that "Double marginalization occurs when the upstream and downstream markets are not perfectly competitive and the product is traded with a uniform wholesale price." Double marginalization causes markups on top of markups which are bad for the customer but may also lower prices for the firms. There are multiple manufacturers in this market which allows for the retailers to have some bargaining power.

Di Giacomo (2008) "analyzed price-cost margins in specific industries avoiding the use of accounting data as proxies for relevant demand and cost parameters." It was assumed that the demand structure for yogurt can be properly described by a nested logit model, accounting for both endogeneity and heterogeneity issues within a panel data framework. This model was then applied to aggregate market data. The data covered a 14-month period from September 2001 to October 2002 including information on monthly sales and average prices for a large number of Italian yogurt brands. The analysis centered attention on six yogurt segments: (1) children, (2) probiotic, (3) drinkable, (4) mixing, (5) whole milk, and (6) light. The own-price elasticities of these six segments were: children (-2.636), probiotic (-2.333), drinkable (-0.799), mixing (-2.179), whole milk (-1.637), and light (-1.746). Own-price elasticities also were estimated for the major Italian yogurt brands: Danone (-2.026), Parmalat (-1.817),

Muller (-1.601), and Yomo (-2.121). The brands with higher average prices resulted in a higher own-price elasticities.

Bonanno (2009) considered the demand for functional products in the Italian yogurt market. A nested logit model was estimated using scanner data of conventional and functional yogurts. Market data from January 2004 to December 2006 were used. The purpose was to provide a framework to evaluate the impacts of price and health-related characteristics on the success of functional products. The results showed that different levels of differentiation existed among functional and conventional products. Drinkable functional yogurts emerged as a successful differentiated sub-category. Additionally, it was also concluded that health-related characteristics of consumers have a major role in the impact of success of functional products. The own-price elasticities for conventional yogurt ranged from -3.079 to -5.842, and the cross-price elasticities ranged from 0.182 to 2.263. The own-price elasticity for functional yogurt ranged from -4.472 to -7.495 and the cross-price elasticities ranged from 0.587 to 4.689.

Table 1 summarizes the own-price elasticities reported according to the literature review. This information is useful in comparing our results to past research. The aforementioned papers discussed research that has already been conducted on the yogurt industry. Although these papers provided important insights into the industry, they are lacking in various respects. In the existing literature, there are only a handful of studies that deal with the demand of yogurt in the United States. The difference in these studies and this one is that here we look at yogurt in the United States by brand. In addition, these papers did not deal with forecast ability of their empirical models. Overall, there is a lack in research on the demand of yogurt in the United States.

Table 1. Summary of Own-Price Elasticities from the Literature Review

Author(s)	Own-Price Elasticity	Method	Data Type	Publication Year
Hovhannisy and Bozic	-0.014 to -0.076	CV approach	Weekly data 2009-2011	2013
Davis	-1.012 (refrigerated); -2.026 (frozen); -1.103 (drinkable)	Translog demand system	2005 Panel data	2010
Veeman and Peng	-0.81	AIDS	Quarterly data from 1984 to 1993	1997
Boehm and Babb	-0.51	N/A	N/A	1975
Di Giacomo	-2.026 (Danone); -1.817 (Parmalat); -1.601 (Muller); -2.121 (Yomo)	Nested logit model	Monthly data from 2001-2002	2008
Bonanno	-3.079 to -5.842 (conventional); -4.472 to -7.495 (functional)	Nested logit model	Monthly data from 2004-2006	2009

Objectives

To fill the research void, the specific objectives of the thesis are to: (1) provide a historical perspective on the yogurt market; (2) provide own-price, cross-price, and expenditure elasticities of demand for yogurt by brand; (3) identify the impacts of income, recession, and seasonality on the demand for yogurt by brand; (4) identify the degree of habit formulation; and (5) forecast future quantities of yogurt by brand. This work then allows the examination of the sensitivity of consumers to own-price changes by brand, changes in competitor prices, changes in consumer income, recession, and seasonality. The brands analyzed include Yoplait, Dannon, Chobani, Stonyfield, and Private Label. These brands are the key players in the yogurt industry. Private label refers to store brands as opposed to national brands.

Scope

The scope of the analysis is the entire U.S. yogurt market from 2009 to 2011. Weekly data using point-of-sale information from Nielson for five of the major yogurt manufacturers are utilized. The time period was selected due to data availability and to limit the focus on Greek yogurt.

This analysis is organized as follows. Chapter 2 will discuss the historical perspective of the yogurt market in the United States. Chapter 3 will present descriptive data from Nielsen concerning yogurt brands. Model development will be addressed in Chapter 4. Chapter 5 will discuss the estimation of the demand models. Chapter 6 will analyze the forecast performance of the respective empirical models. Chapter 7 will provide concluding remarks and address any limitations.

CHAPTER II
HISTORICAL PERSPECTIVE OF THE YOGURT MARKET

To satisfy one of the objectives, this section provides a historical perspective on the market for non-Greek and Greek yogurt. Background on each specific brand and the market as a whole is provided.

Yogurt has been consumed since 500 B.C. in places like India, Iran, and Turkey. Today, it is consumed across the world with heavy influence in the western hemisphere. It was introduced to the United States in the 20th century in the form of tablets used to help people with digestive intolerance. Over time, there have been major changes to the manufacturing of the product. Most yogurt today is made "by pasteurizing milk, enriching it with powder milk to boost its protein and calcium content, then heating it to 43 degrees Celsius and adding two types of bacteria: *Streptococcus thermophiles* and *Lactobacillus bulgaricus*" (Down to Earth, 2013). Fruit jam was added in 1933, fruit yogurts emerged in 1937, and blended yogurts came into play in 1963. Consumption of yogurt in the United States has increased 400% over the past thirty years. This increasing trend in yogurt consumption is not just a domestic phenomenon but a global one as well. In addition, medical researchers are looking into the use of yogurt as edible vaccines. The bacteria in yogurt is able to carry pathogens to the intestine to assist the immune system. Simply put, yogurt is gaining market share globally vis-à-vis other products. Finally, the use of yogurt may find a niche in medicine.

Yoplait

The company started in 1964 in France, when 100,000 French farmers merged their regional dairy co-ops. In 1965, two men named Yola and Coplait joined the co-op and introduced a new, special way to make yogurt. Their names created the brand name Yoplait. Fresh fruit was added to the yogurt in 1967 (Yoplait, "Where It All Began"). Since the brand started, 11 different types of yogurt have been created, with more than 85 flavors. The yogurt made its way to Canada and the United States in 1971. In 2011, General Mills purchased 51% of the company, while the rest remains with the French cooperative. Yoplait has been a supporter of breast cancer awareness. It started campaigns called Save Lids to Save Lives and the Race for the Cure. Their involvement in the community has helped promote the brand. As of 2011, Yoplait had a market share of around 24%.

Chobani

Chobani, a privately-held company, produces and sells Greek yogurts. The company was founded by Hamdi Ulukaya, a Turkish immigrant now residing in New York. Once settled in New York, Ulukaya decided to start a yogurt company after he discovered how unsatisfactory yogurt was in the United States. In 2005, he purchased a closed yogurt plant in upstate New York. Chobani started selling its all natural Greek yogurts in 2007. Ulukaya was approached by established yogurt companies like Dannon asking him to sell his company to them. Chobani produces about 2.2 million cases of yogurt a week and has over $1 billion in sales. Initially, the company comprised 0.2% of the yogurt market in the United States, but in 2011 it made up 29% of the market share for yogurt. Ulukaya says that his yogurt has been so successful compared to other yogurt companies because his products are not high in sugar, coloring, and preservatives (Chobani, "Chobani History"). Chobani is a privately-held company that has made a huge impact on the yogurt industry. It has become one of the fastest growing businesses in the United States.

Dannon

Dannon was founded in 1942 by Daniel Carasso. In the early years of the company, most of the product market was confined to the New York area. Once the company added strawberry fruit on the bottom, the brand expanded. It appealed to health enthusiasts and dieters. The company expanded westward into Ohio. Iconic athletes were used to promote their product across the United States. In 1988, Dannon Light was available in stores and later on yogurt blended fruit was added as well. Activia, which launched in 2006, made more than $100 million in net sales in the first year. As of today, Dannon has seven different yogurts that come in a variety of flavors. As of April 2016, Dannon has pledged to commit to bringing the three flagship brands (Dannon, Oikos, and Danimals) towards the use of more natural and non-GMO ingredients (Dannon, 2016). Starting in December 2017, the company also will place a label on any of their products that contain GMOs. In 2011, Dannon had a market share of 27%.

Stonyfield

Stonyfield was founded in 1983 by Samuel Kaymen and Gary Hirshberg on a small New Hampshire farm. They sold yogurt without the use of toxic pesticides or chemical fertilizers. Today the company sells organic yogurts, soy yogurts, frozen yogurts, milk, and cream. There are no pesticides, artificial hormones, antibiotics, or GMOs used in the making of Stonyfield products. The company has pioneered planet-friendly business practices such as making yogurt cups from plants and making their own renewable energy. In 2011, Stonyfield had a market share of 5%.

Private Label

Private Label represents the generic brand of yogurt found in most grocery stores. The success of private label store brands rests on lower prices and consumer loyalty. In 2011, private label or store brands had a market share of about 15%.

CHAPTER III
DATA FROM NIELSEN CONCERNING YOGURT BRANDS

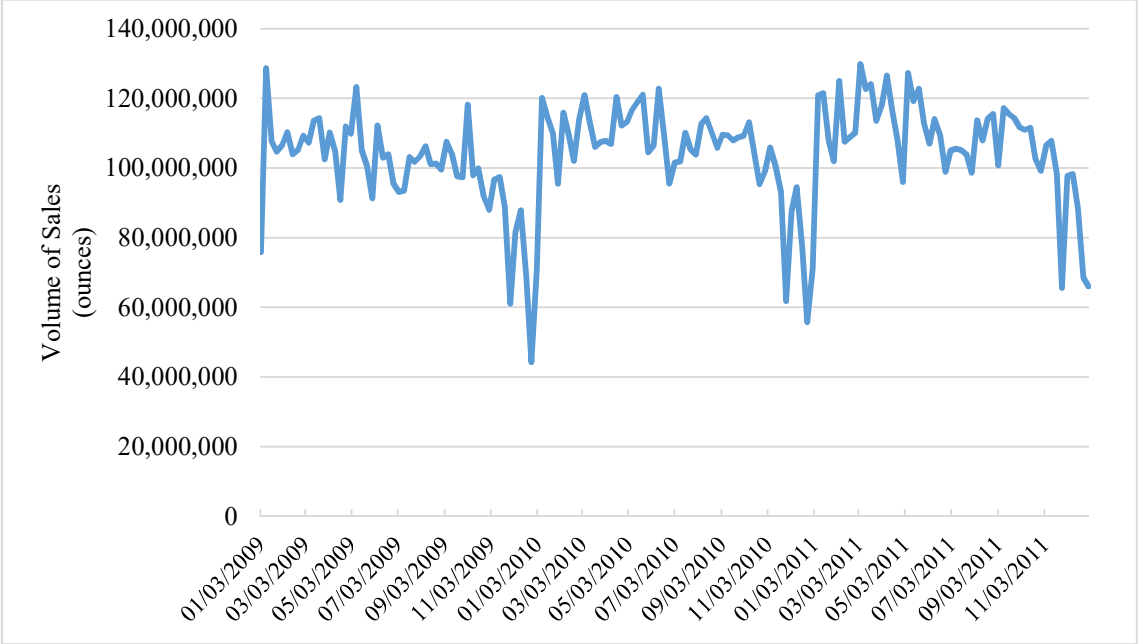
To complete the second objective, data from a third-party vendor, Nielsen, were used over the period 2009 to 2011.The primary reasons to analyze this period are twofold: (1) except for Chobani, this period captures primarily non-Greek yogurt; and (2) data for 2012 and beyond were not available to the Agribusiness, Food, and Consumer Economics Research Center (AFCERC). The data correspond to weekly time-series totaling 157 weeks. From this information, descriptive information and figures are provided concerning weekly sales volume across the entire industry, weekly sales volume of yogurt by brand, market share from 2009-2011, weekly brand prices per ounce, and weekly dollar sales of yogurt by brand..

As seen in Figure 1, weekly total volume sales for the yogurt category ranged from 40 million ounces to 140 million ounces. It is apparent that there seems to be seasonal buying patterns for yogurt. From December to January every year, there is a notable decline in overall sales of yogurt.

Figure 2 represents the sales volume by brand from 2009-2011. We can conclude that during the winter sales for almost all of the brands there was a decrease relative to other quarters. Chobani and Stonyfield were newer to the market during this time frame, which is indicated by their relatively low sales volume. As Greek yogurt became more popular, Chobani's sales volume increased. However, Stonyfield, an organic yogurt, had no notable sales growth.

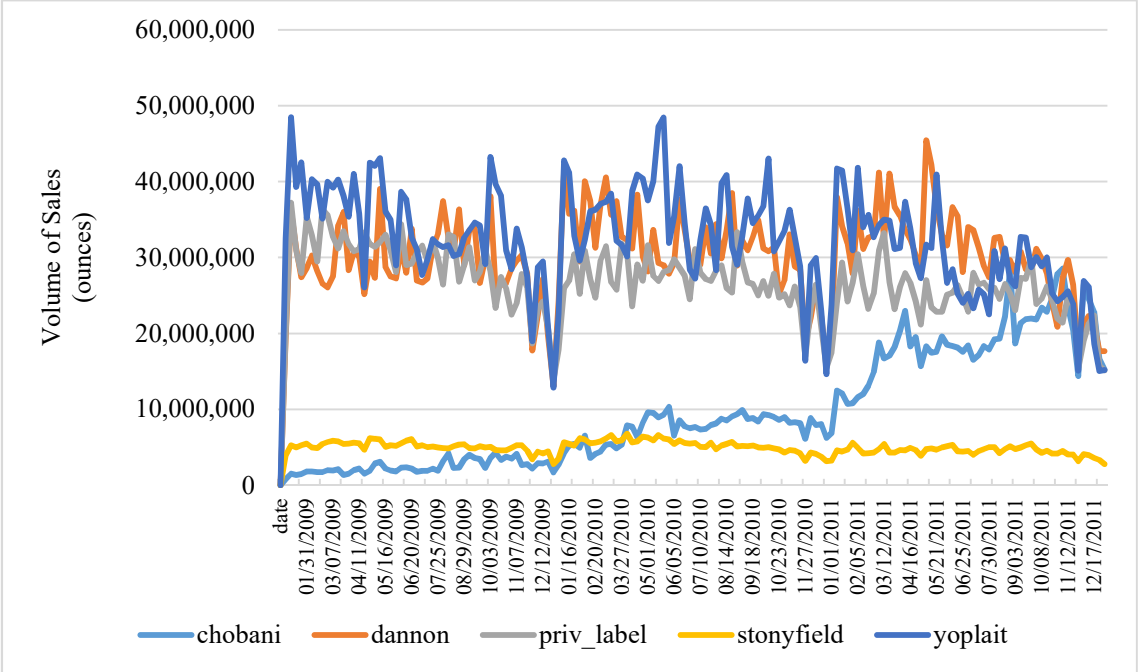
Figure 3 shows the market share by dollar sales for all of the brands in 2009. Since Chobani had just recently entered the market, the market share is at a low 5%. Chobani was the only brand to solely produce Greek yogurt. The other brands were mainly non-Greek during this time period. Yoplait and Dannon were the leaders of the industry followed closely by Private Label or store brands.

Figure 1. Weekly Sales Volume Across the Yogurt Industry from 2009 to 2011



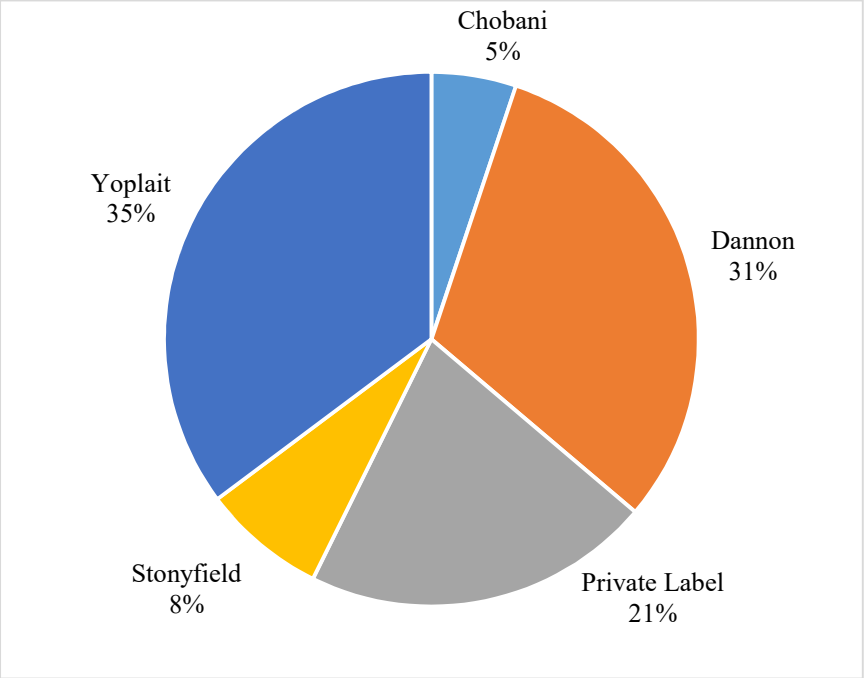
Source: Nielsen Homescan data 2009-2011

Figure 2. Weekly Sales Volume of Yogurt by Brand from 2009 to 2011



Source: Nielsen Homescan data 2009-2011

Figure 3. Market Share in 2009 by Dollar Sales of Yogurt Brands in the United States

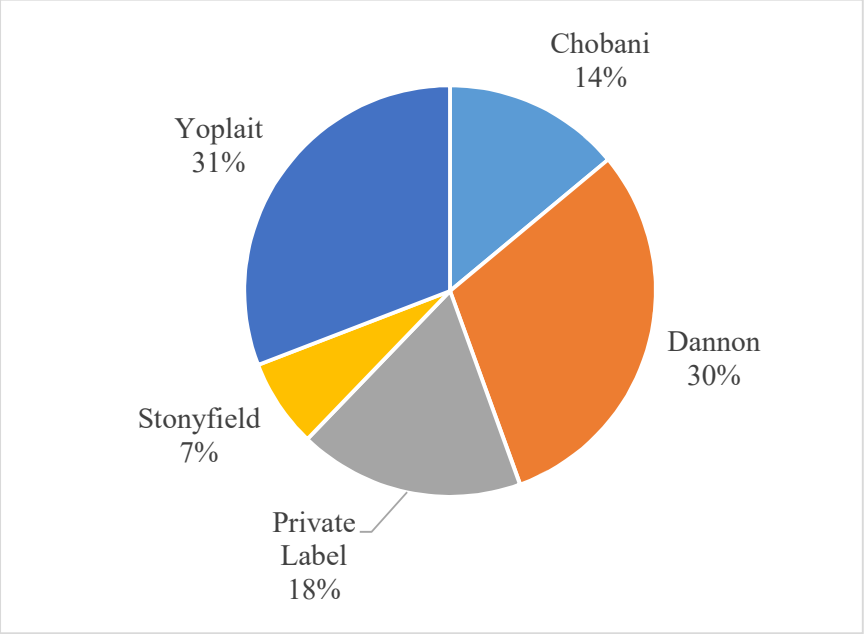


Source: Nielsen Homescan data 2009-2011

Figure 4 shows Chobani gaining more of the market share in terms of dollar sales. All of the other four brands lost market share in 2010 because of Chobani's growth. The most affected was Yoplait with a 4% decrease in market share.

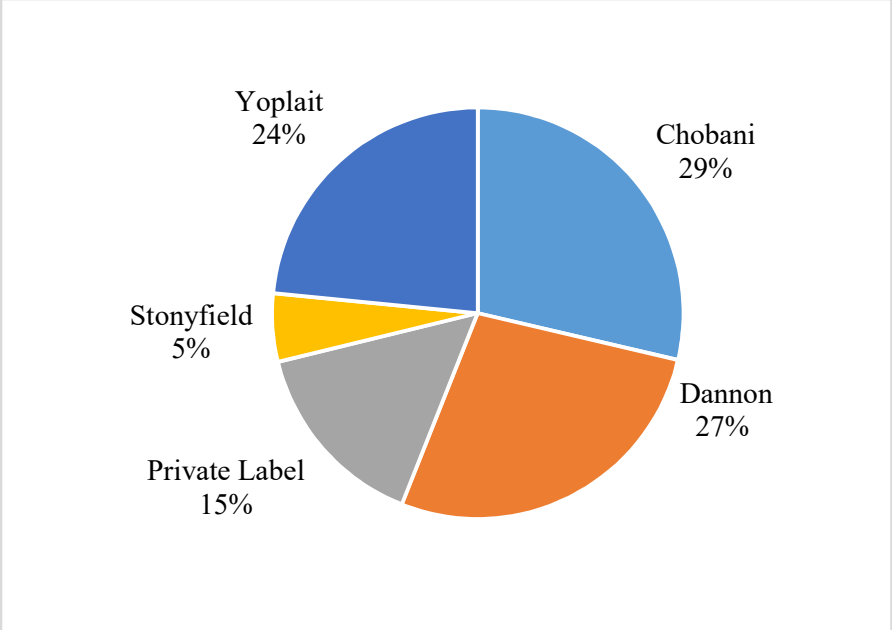
Figure 5 shows the market share of each brand of yogurt in 2011. Chobani increased its market share to 29%. The other four brands suffered a loss in market share in 2011 compared to earlier periods. Yoplait's market share decreased from 31% to 24%, making it the brand most affected by the presence of Chobani. In 2011, Chobani became the leader of the yogurt industry in the United States with 29% of the sales. In order to compete with Chobani's Greek yogurt, the other brands started to manufacture their own Greek yogurts in an effort to regain market share.

Figure 4. Market Share in 2010 by Dollar Sales of Yogurt in the United States



Source: Nielsen Homescan data 2009-2011

Figure 5. Market Share in 2011 by Dollar Sales of Yogurt in the United States



Source: Nielsen Homescan data 2009-2011

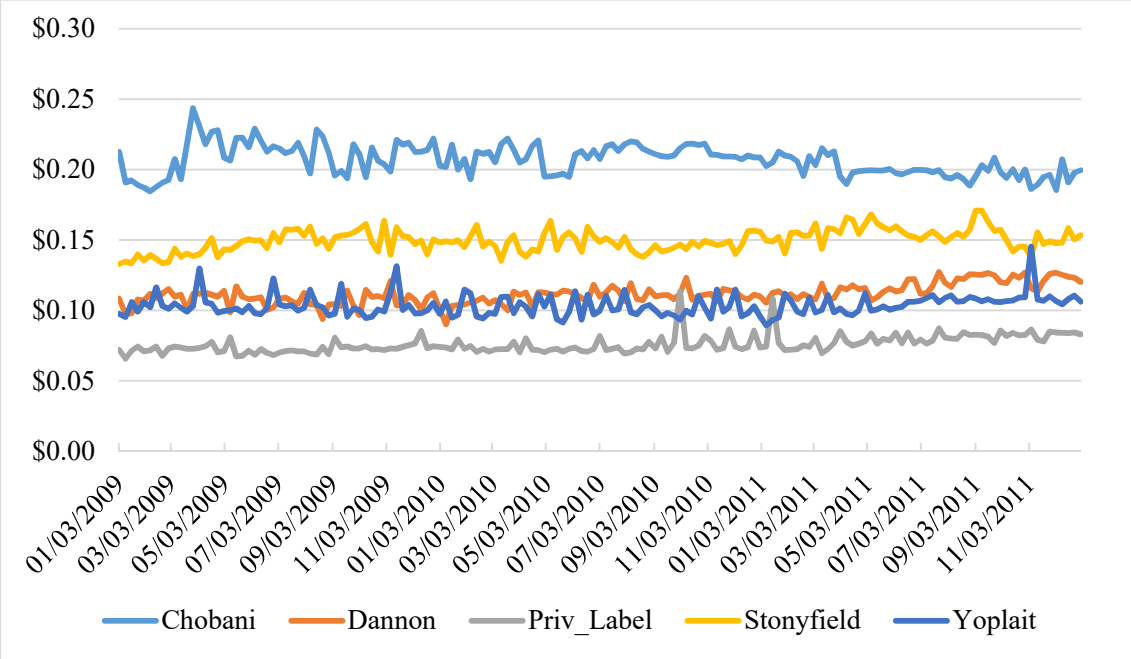
Looking at the time period from 2009-2011, Chobani increased sizably mostly at the expense of Yoplait. Chobani entered the market at a time when Greek yogurt was not popular. Over time, consumers realized the health benefits and other perks of Greek yogurt over non-Greek yogurt. From 2009 to 2011, Chobani increased its market share from 5% to 29%. Yoplait's market share from 2009 to 2011 decreased from 35% to 24%. Dannon's market share decreased only from 31% to 27% over this time period. Private Label's market share fell from 21% to 15% over the time period 2009 to 2011. Stonyfield's market share decreased from 8% to 5% over this time period. The introduction of Chobani to the market affected some brands more than others. Yoplait was the brand that was most affected by Chobani entering the market.

Figure 6 illustrates the price per ounce of yogurt by brand. Yoplait and Dannon historically have been the leaders in the yogurt industry. As seen in the Figure 6, the prices of these two brands remain relatively constant. Chobani has the highest price per ounce because the yogurt they manufacture is only Greek which is more costly to produce. Stonyfield has a higher cost per ounce as well because of its focus on organic attributes. Consumers have to pay a premium for the Stonyfield brand because of higher production costs due to the attention on organic ingredients. The minimum price per ounce from 2009 to 2011 is $0.07 while the highest is $0.24.

Figure 7 shows the weekly dollar sales of yogurt by brand from 2009 to 2011. Chobani and Stonyfield are the lowest in dollar sales because of different reasons. Chobani was a relatively new company in 2009 and grew significantly. As shown in Figure 7, Chobani had the highest dollar sales at the end of 2011.

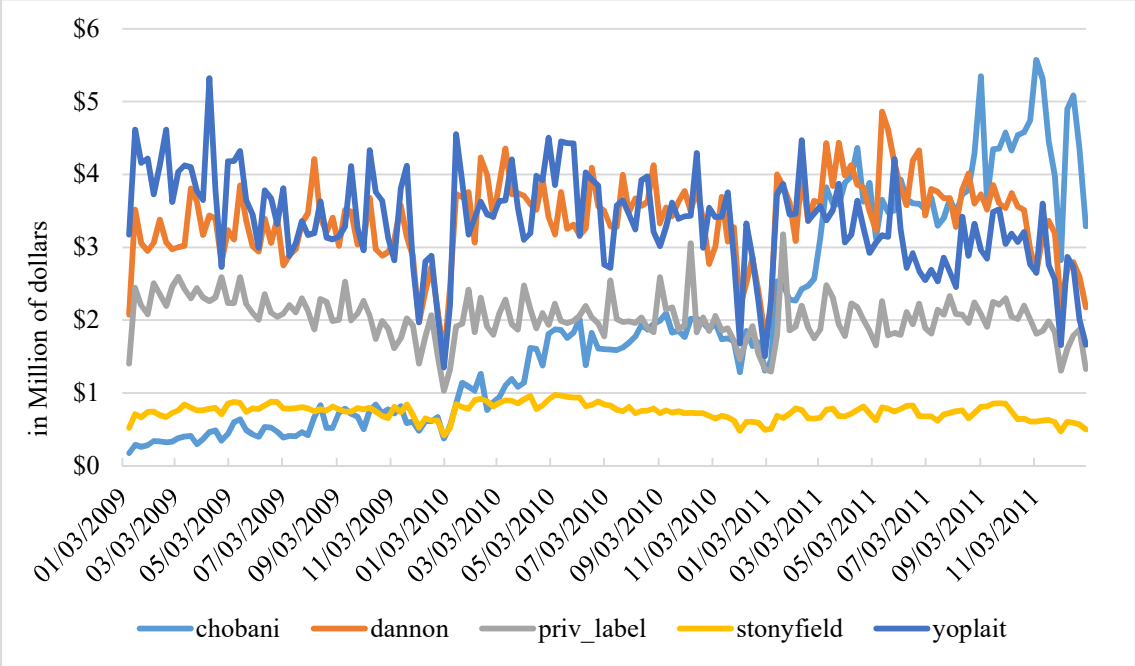
The magnitudes of dollar sales across these yogurt brands have a wide range. As seen in Table 2, in 2009 Chobani's median weekly sales in dollars was $482,064. Dannon's median sales in dollars was $3,081,753. Private Label's median weekly sales in dollars was $2,117,137. Stonyfield's median weekly sales in dollars was $763,021. Yoplait's median weekly sales in dollars was $3,635,232. Chobani's median weekly sales in dollars in 2009 were much less than Dannon, Private Label, and Yoplait since Chobani was just being introduced into the yogurt market. Stonyfield, the organic yogurt

Figure 6. Weekly Price per Ounces of Yogurt by Brand from 2009 to 2011



Source: Nielsen Homescan data 2009-2011

Figure 7. Weekly Dollar Sales of Yogurt by Brand from 2009 to 2011



Source: Nielsen Homescan data 2009-2011

Table 2. Mean, Median, Minimum, Maximum and Standard Deviation of Yogurt Brands for Weekly Dollars Sales from 2009 to 2011

	2009 Weekly Sales in Dollars				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	$512,103	$3,103,472	$2,109,208	$747,726	$3,517,232
Median	$482,064	$3,081,753	$2,117,136	$763,021	$3,635,231
Minimum	$175,359	$1,469,672	$1,029,535	$419,378	$1,351,819
Maximum	$840,943	$4,212,527	$2,595,823	$880,997	$5,324,083
Standard Deviation	$167,669	$472,163	$318,810	$89,891	$699,917

	2010 Weekly Sales in Dollars				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	$1,568,344	$3,427,378	$1,991,953	$781,791	$3,464,185
Median	$1,693,825	$3,509,339	$1,954,718	$785,961	$3,453,160
Minimum	$547,860	$1,793,134	$1,324,020	$479,736	$1,506,571
Maximum	$2,091,856	$4,354,184	$3,053,179	$975,021	$4,554,643
Standard Deviation	$381,243	$506,202	$291,365	$121,403	$641,573

	2011 Weekly Sales in Dollars				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	$3,716,666	$3,549,324	$1,970,170	$695,060	$3,040,884
Median	$3,656,199	$3,621,999	$1,944,243	$688,418	$3,066,371
Minimum	$1,436,477	$2,127,031	$1,256,618	$425,572	$1,611,737
Maximum	$5,574,208	$4,859,358	$3,178,555	$859,513	$4,470,876
Standard Deviation	$844,005	$607,194	$312,725	$99,165	$577,133

Source: Nielsen Homescan data 2009-2011

manufacturer in the market, only had slightly higher sales in dollars in 2009 than Chobani despite not being a startup company. At the end of 2011, the only brand that had major changes in dollar sales was Chobani. Chobani's median weekly sales in dollars in 2011 was $3,656,200. Over the 2009 to 2011 period, Chobani increased its

weekly sales in by 658%. The rest of the brands did not fluctuate much through this time weekly period.As seen in Table 3, Chobani had the most change in weekly volume sales from 2009 to 2011. Chobani's median weekly volume sales in 2009 was the least at with 2,194,507 ounces. Dannon's median weekly volume sales in 2009 was 28,575,557 ounces. Private Label's median weekly volume sales was 30,270,943 ounces. Stonyfield had the second least amount of median weekly volume sales in 2009 with 5,134,478 ounces. Yoplait had the most weekly volume sales in 2009 with a median of 34,026,542. In 2011, Chobani's median weekly volume sales increased to 18,340,062 .Dannon's median weekly volume sales increased to 31,119,976. Private label's median weekly volume sales decreased to 25,013,927. Stonyfield's median weekly volume sales decreased to 4,575,543. Yoplait's median weekly volume sales also decreased to 28,837,686. Chobani's median weekly volume sales changed the most over the time period. Since it was a new company in 2009, the sales were relatively low until consumers built loyalty to the brand.

In Table 4, it is clear that Chobani and Stonyfield have the highest price per ounce in 2009. Chobani and Stonyfield incur higher production costs due to their methods of production involving Greek and organic attributes, respectively. The price per ounce may fluctuate throughout the time period because of changes in the market, competition, price changes in inputs, and other factors.

Table 3. Mean, Median, Minimum, Maximum and Standard Deviation of Yogurt Brands for Weekly Volume Sales from 2009 to 2011 (ounces)

	2009 Weekly Volume Sales				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	2,446,536	28,978,762	29,133,389	5,100,691	34,034,634
Median	2,194,507	28,575,551	30,270,943	5,134,478	34,026,542
Minimum	825,438	13,082,910	13,827,092	2,786,161	12,849,046
Maximum	4,323,846	39,020,218	37,226,265	6,205,523	48,461,660
Standard Deviation	841,036	4,920,896	4,643,403	625,457	6,459,962

	2010 Weekly Volume Sales				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	7,462,836	31,352,355	26,663,144	5,301,979	34,110,221
Median	8,007,726	31,195,034	26,901,173	5,435,508	34,401,869
Minimum	2,703,852	16,144,147	15,509,232	3,166,943	14,630,892
Maximum	10,348,336	41,504,697	33,337,785	6,783,778	48,444,606
Standard Deviation	1,819,541	5,157,510	3,509,241	822,886	6,508,915

	2011 Weekly Volume Sales				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	18,726,907	30,458,587	24,615,590	4,500,348	29,088,055
Median	18,340,062	31,119,976	25,013,927	4,575,543	28,837,686
Minimum	6,883,550	17,504,985	15,133,230	2,775,346	15,062,158
Maximum	28,527,398	45,431,639	33,227,309	5,607,929	41,805,174
Standard Deviation	4,575,712	6,135,004	3,577,500	581,235	6,177,854

Source: Nielsen Homescan data 2009-2011

Table 4. Mean, Median, Minimum, Maximum and Standard Deviation of Yogurt Brands in Weekly Prices per Ounce from 2009 to 2011

	2009 Weekly $/Ounce				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	0.21	0.11	0.07	0.15	0.10
Median	0.21	0.11	0.07	0.15	0.10
Minimum	0.18	0.09	0.07	0.13	0.09
Maximum	0.24	0.12	0.09	0.16	0.13
Standard Deviation	0.013	0.005	0.003	0.008	0.008

	2010 Weekly $/Ounce				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	0.21	0.11	0.07	0.15	0.10
Median	0.21	0.11	0.07	0.15	0.10
Minimum	0.19	0.09	0.07	0.14	0.09
Maximum	0.22	0.12	0.11	0.16	0.11
Standard Deviation	0.007	0.005	0.007	0.006	0.007

	2011 Weekly $/Ounce				
	Chobani	Dannon	Private Label	Stonyfield	Yoplait
Mean	0.20	0.12	0.08	0.15	0.11
Median	0.20	0.12	0.08	0.15	0.11
Minimum	0.19	0.11	0.07	0.14	0.09
Maximum	0.22	0.13	0.11	0.17	0.15
Standard Deviation	0.007	0.007	0.006	0.007	0.008

Source: Nielsen Homescan data 2009-2011

CHAPTER IV
MODEL DEVELOPMENT

To accomplish objectives 2-4, single-equation regression demand models and a seemingly unrelated regression (SUR) demand systems model were constructed. The use of the SUR model allows the examination of the interdependencies of demand among major yogurt brands for the period 2009 to 2011.

In the respective models, the dependent variable relates to per capita consumption (volume) of yogurt. The explanatory variables relate to own-price, prices of other yogurt brands, income, seasonality, Christmas holiday, the Great Recession, inertia or habit persistence, and tastes and preferences. Own-price is included as an explanatory variable because we expect that the price of the product will inversely affect demand. The own-price elasticity is expected to be negative and relatively elastic given the availability of alternative brands. The prices of the other brands are included as explanatory variables to capture the substitutability and/or complementarity among brands. We would expect that the cross-price elasticities would be positive suggesting that the yogurt brands are substitutes. That said, cross-price elasticities may be negative because consumers may be buying Greek and non-Greek yogurt together. Income is expected to be a driver of demand since we expect that yogurt brands to be normal goods with income elasticities between 0 and 1. Seasonality is included in the explanatory variable set to allow for the potential seasonal nature of yogurt consumption. Because yogurt consumption fluctuates noticeably around Christmas, we capture this situation through the use of a dummy variable. The Great Recession is included as an explanatory variable because recessions can greatly affect demand of certain goods. The Great Recession occurred in the first six months of 2009. A lag of the dependent variable is included as an explanatory variable to account for habit persistence or inertia in consumption. The coefficient of this variable is expected to be positive and between 0 and 1. Trend and trend squared are included as explanatory variables as proxies to account for tastes and preferences such as movement toward Greek yogurt and healthier

living. Advertising, often a driver of demand, is notably absent from the explanatory variables because the information was not available to us.

A seemingly unrelated regression demand systems model is constructed to take into account potential correlation of the error terms as well as to improve a restriction pertaining to demand theory, namely homogeneity. SUR looks at all brands together. The sum of the own-price, cross-price, and income elasticities are set to zero during estimation to insure the homogeneity condition.

Mathematically, the respective equations may be expressed as follows:

Single-equation Models by Brand

$$\ln q_{it} = a_{i0} + \sum_{j=1}^{5} a_{ij} \ln price_{it} + a_{i6} \ln income_{it}$$
$$+ a_{i7} \ln q_{it-1} + a_{i8}\, Gre\_Recession_t + a_{i9}\, Christmas_t$$
$$+ a_{i1}\, Q_{1t} + a_{i11} Q_{2t} + a_{i12} Q_{3t} + a_{i13} trend_t$$
$$+ a_{i14} trend_t^2 + e_{it}, \text{ where}$$

$q_{it} = per\ capita\ \ volume\ sales\ of\ yogurt\ brand\ i\ in\ time\ period\ t$

$p_{it} = real\ price\ of\ yogurt\ brand\ i\ in\ time\ period\ t$

$income_t = real\ per\ capita\ income\ in\ time\ period\ G$

$q_{it-1} = \ one - period\ lag\ of\ q_{it}$

$Great\_Recession_t = dummy\ variable\ associated\ with\ the\ Great\ Recession$
$(if\ recession, or\ otherwise)$

$Christmas_t = dummy\ variable\ associated\ with\ Christmas$
$(if\ Christmas, or\ otherwise)$

$Q_{1t}, Q_{2t}, Q_{3t} = dummy\ variables\ to\ capture\ seasonality.$
$Q_{1t}\ refers\ to\ January\ through\ March, Q_{2t}\ refers\ to\ April\ through\ June, and$
$Q_{3t}\ refers\ to\ July\ through\ September,$
$The\ base\ or\ reference\ period\ is\ the\ fourth\ quarter, October\ through\ December.$

$Trend_t = 0\ for\ the\ first\ observation, 1\ for\ the\ second\ observation, 2\ for\ the\ third$
$observation, etc.$

$Trend_t^2 = 0\ for\ the\ first\ observation, 1\ for\ the\ second\ observation, 4\ for\ the\ third$
$observation, etc.$

Data for monthly U.S. population values were used to place volume and income on a per capita basis. Data pertaining to monthly consumer price index values were used to adjust for inflation of the prices and income explanatory variables in the model. Logarithmic transformations of volumes, prices, and incomes were made. As such the estimated coefficients associated with prices and income are own-price, cross-price, and income elasticities.

In the SUR model, we restrict $\sum_{j=1}^{5} a_{ij} + a_{i6}$ to be zero to insure homogeneity in each equation. The subscript i refers to the respective brands in question.

CHAPTER V
ESTIMATION OF DEMAND MODELS

This section describes the estimation results of the single-equation models as well as the SUR model. Ordinary Least Squares (OLS) is used to estimate the single-equation demand models and Joint Generalized Least Squares (JGLS) is used to estimate the SUR model. To ascertain statistical significance of the estimated coefficients, we adopt a level of significance of 0.05. Any estimated coefficient with p-values less than 0.05 are deemed to be statistically different from zero.

Results Using Single-Equation Demand Models

Metric of Model Performance

Various goodness-of-fit measures describe the performance of the respective model. In this analysis, we use the following metrics: (1) goodness-of-fit, R2 and R2 (adjusted R2 needs the line above); (2) standard error of the regression; and (3) Durbin-Watson (DW) statistics. The R-Squared is known as the coefficient of determination. It is calculated by dividing the explained variation from the model by the total variation to be explained. The R-Squared is always a number between 0 and 1. If the coefficient of determination is equal to 1, then the model explains all the variability of the response data around its mean. A higher R-Squared means that the model fits the data better. The adjusted R-Squared is generally a better measure of how well the model performs. It adjusts for the number of variables in a model and the number of observations. Adjusted R-Squared values are always lower than or equal to R-Squared values. The standard error of the regression is also a measure of model performance. Smaller values are better for the standard error of the regression because that indicates that the observations are closer to the fitted line (Frost, 1970). The last measure of model performance used in this analysis was the Durbin-Watson statistic. It is a test statistic which detects the presence of autocorrelation in the residuals. If autocorrelation is present, then the standard errors of the estimated coefficients are biased. The Durbin-Watson test reports a

test statistic between 0 and 4. A DW statistic of 2 means that there is no autocorrelation. A Durbin-Watson test statistic of 0 to 2 is indicative of positive correlation, common in time-series data. A DW of 2 to 4 is indicative of negative autocorrelation.

Table 5 shows the goodness-of-fit measures for the yogurt brands. The Chobani model has an adjusted R-Squared of 0.971, meaning that 97.1% of the variation in the dependent variable is explained by the set of independent variables. The Chobani model has a standard error regression (SER) of 0.149. The Durbin-Watson Statistic for the Chobani model is 1.65 which is close to 2 showing that there is no significant positive correlation in the residuals. For the Dannon model, the adjusted R-Squared measure was 0.675. The SER measure for the model was low at 0.113 and the DW statistic was 1.928, indicative of no serial correlation. For the Yoplait model, the adjusted R-squared was 0.742. The SER for the model was 0.085 and the DW statistic was close to 2 (no correlation) at 1.916. The model for Stonyfield had the lowest adjusted R-Squared value, 0.608. The SER for this model was 0.151, and the DW statistic was 1.913, again meaning the absence of serial correlation. The Private Label model had the second lowest adjusted R-Squared value at 0.662. The SER for the model was 0.104 and the Durbin-Watson Statistic was 2.106 which again shows the absence of any serial correlation pattern in the residuals. Bottom line, the goodness-of-fit measures range from 0.608 (Stoneyfield) to 0.971 (Chobani), and the SER measures range from 0.085 (Yoplait) to 0.151 (Stoneyfield). The DW statistics for the respective set of single-equation models indicate the absence of any systematic pattern in the residuals.

Own-Price Elasticities

The own-price elasticity of demand is a measure of the percentage change in the quantity demanded attributed to a one percent change in the price, holding all other factors constant. To reflect the inverse relation of price and quantity in demand analysis, the estimated own-price elasticities are expected to be negative. As seen in Table 6, Chobani's own-price elasticity of -1.766 indicates that the demand for this brand is elastic meaning that the percentage change in quantity demanded for Chobani is

relatively responsive to percentage changes in price. A 1% increase in price will lead to a 1.766% decrease in quantity purchased. Dannon's own-price elasticity of demand is similar to that of Chobani at -1.424. The demand for national brand Dannon is elastic as well. A 1% increase in price will lead to a 1.424% decrease in quantity demanded for Dannon yogurt. Yoplait has an own-price elasticity of demand of -0.406. Unlike Chobani and Dannon, the own-price elasticity of Yoplait is less than one in absolute value. With a 1% increase in price, there will be a 0.406% decrease in the change in quantity demanded for Yoplait. Hence, the demand for Yoplait is inelastic. Stonyfield's own-price elasticity also is inelastic at -0.792. A 1% increase in price will give rise to a 0.792% decrease in quantity demanded of Stonyfield. Private Label has an own price elasticity of -0.128 which was not statistically different from zero at the 5% level of significance. The statistically insignificant own-price elasticity means that consumers are not sensitive to price changes in the Private Label brand. The consumers may also realize that despite price fluctuations in the Private Label brand, it will always be the cheapest option. All other factors invariant, brands that have own-price elasticities that are elastic (Chobani and Dannon) should increase firm revenues by decreasing prices. Yoplait and Stonyfield should increase revenues by increasing prices due to the fact that their own-price elasticities are inelastic. The nature of price responsiveness then is quite important when dealing with various pricing strategies.

Cross-Price Elasticities

The cross-price elasticity of demand measures how responsive the quantity demanded for a good is to the change in the price of another good. Cross-price elasticities can be either negative or positive. If the value is positive, then the two goods in question are substitutes meaning one is bought in place of the other. A negative cross-price elasticity shows that the two goods are complements meaning that they are bought together. Only two out of the twenty cross-price elasticities were found to be statistically significant in the single-equation models. As shown in Table 7, Stonyfield is a complement to Chobani with a cross price elasticity of -0.794. With a 1% increase in

price of Stonyfield, the quantity demanded for Chobani will decrease by 0.794%. Private Label is a complement to Stonyfield with a cross-price elasticity of -0.225. If the price of Private Label or store brand yogurt increases by 1% then the quantity demanded for Stonyfield would decrease by 0.225%. On the basis of the cross-price elasticities, prices of other yogurt brands in general do not significantly affect the demand for a particular yogurt brand over the time period 2009 to 2011. This finding is at odds with our hypothesis that the yogurt brands are substitutes.

Income Elasticities

The income elasticity of demand measures the responsiveness of the quantity demanded of a good to the change in the income of the people who demand that good. A positive income elasticity is associated with a normal good meaning that an increase in income would lead to a rise in the quantity demanded for this good. If the income elasticity is less than one, the good is considered a necessary good. Goods for which the income elasticity is greater than one are considered to be luxury goods. Only one out of the five brands had statistically significant income elasticity, as seen in Table 8. Stonyfield has an income elasticity of -4.061 showing that it is an inferior good meaning as income rises, consumers buy less of this good. In the respective demand models, the estimated income elasticities are at odds with conventional economic reasoning. This issue will be re-examined with the use of the SUR model.

Estimated Coefficients Associated with Other Demand Factors

From Table 9, we can see that the impact of the Great Recession was not statistically significant for any of the five brands. A dummy variable was used to indicate when the Great Recession was present throughout the data set. The Great Recession was present in this data set from 1/03/2009 to 6/27/2009, the first six months of 2009. The Great Recession did not impact the demand for yogurt. Chobani is the only brand that had a significant linear trend. Chobani introduced Greek yogurt to the industry and experienced notable growth in volume sales. Trend and Trend^2 are proxy

variables for tastes and preferences The Christmas holiday is statistically significant for all five of the brands. These results show that yogurt is not being purchased as much during the /Christmas holiday season. Q1, Q2, and Q3 are all significant factors in this model meaning that seasonality is in play. Q4 has significantly less sales than the rest of the quarters. Depending on the brand, volume sales are higher by 14% to 20% during the first quarter relative to the fourth quarter; higher by 12% to 23% during the second quarter relative to the fourth quarter; and higher by 12% to 20% during the third quarter relative to the fourth quarter. The lagged dependent variable is significant for all of the five brands, meaning that habit persistence in present when consumers are buying these yogurt brands.

Table 5. Model Performance Metrics by Yogurt Brand Using the Single-Equation Model

	Chobani	Dannon	Yoplait	Stonyfield	Private Label
R-Squared	0.974	0.705	0.765	0.643	0.692
Adjusted R-Squared	0.971	0.675	0.742	0.608	0.662
S.E. of Regression	0.149	0.113	0.085	0.151	0.104
Durbin-Watson Stat	1.65	1.928	1.916	1.913	2.106

Table 6. Own-Price Elasticities by Yogurt Brand Using the Single-Equation Model

BRAND	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Own-Price Elasticity	**-1.766** (0.0000)	**-1.424** (0.0000)	**-.406** (0.0335)	**-.792** (0.0000)	-.128 (0.3562)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Table 7. Cross-Price Elasticities by Yogurt Brand Using the Single-Equation Model

	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Chobani	**-1.766** (0.0000)	.457 (0.1073)	-.037 (0.8452)	**-.794** (0.0082)	-.058 (0.7708)
Dannon	-.281 (0.2031)	**-1.424** (0.0000)	-.132 (0.3540)	-.044 (0.8444)	-.077 (0.6096)
Yoplait	-.506 (0.0835)	-.204 (0.4685)	**-.406** (0.0335)	-.585 (0.0525)	-.162 (0.4189)
Stonyfield	-.184 (0.2656)	.082 (0.6168)	-.014 (0.9014)	**-.792** (0.0000)	**-.225** (0.0483)
Private Label	-.057 (0.7815)	.054 (0.7881)	.026 (0.8446)	-.104 (0.6169)	-.128 (0.3562)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Table 8. Income Elasticities by Yogurt Brand Using the Single-Equation Model

BRAND	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Income Elasticity	0.476 (0.8469)	-1.362 (0.4710)	0.114 (0.9637)	**-4.061** (0.0061)	0.991 (0.5659)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Table 9. Estimated Coefficients Associated with Other Demand Factors Using the Single-Equation Model

	Great Recession	Trend	Trend Squared	Christmas	Q1	Q2	Q3	Lagged dependent variable
Chobani	-0.049 (0.6468)	**0.018** (0.0000)	**-4.46E-05** (0.0013)	**-0.404** (0.0000)	**0.161** (0.0002)	**0.231** (0.0000)	**0.144** (0.0002)	**0.321** (0.0000)
Dannon	0.062 (0.4443)	0.003 (0.1505)	-1.13E-05 (0.2617)	**-0.397** (0.0000)	**0.209** (0.0000)	**0.193** (0.0000)	**0.197** (0.0000)	**0.226** (0.0003)
Yoplait	0.111 (0.3014)	0.004 (0.1617)	**-2.99E-05** (0.0287)	**-0.513** (0.0000)	**0.144** (0.0011)	**0.125** (0.0062)	**0.119** (0.0020)	**0.283** (0.0001)
Stonyfield	0.05 (0.4114)	0.002 (0.1757)	-1.37E-.5 (0.0791)	**-0.229** (0.0000)	**0.151** (0.0000)	**0.184** (0.0000)	**0.146** (0.0000)	**0.348** (0.0000)
Private Label	0.052 (0.4840)	-0.001 (0.5439)	-1.48E-06 (0.8731)	**-0.386** (0.0000)	**0.153** (0.0000)	**0.119** (0.0003)	**0.156** (0.0000)	**0.175** (0.0133)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Results Using the Seemingly Unrelated Regression (SUR) Model

Metrics of Model Performance

Table 10 shows the model performance metrics associated with the demand systems specification. For the Chobani equation, the adjusted R-Squared, the SER and the Durbin-Watson statistic were 0.974, 0.142, and 1.79, respectively. All of these measurements show that the model performed well for Chobani. The SUR model for Chobani performed slightly better when looking at goodness-of-fit than the single-equation model. For the Dannon equation, the adjusted R-Squared, the SER, and the Durbin-Watson statistic were 0.661, 0.115, and 1.918, respectively. The SUR model for Dannon performed very closely to the single-equation model. In the SUR analysis for Yoplait, the adjusted R-Squared, the SER, and the Durbin-Watson statistic were0.591, 0.153, and 1.729, respectively. After comparing the results to the single-equation model for Yoplait, it is evident that the single-equation model performed better than the SUR model based on the goodness-of-fit measures. In the SUR analysis for Stonyfield, the adjusted R-Squared, the SER, and the Durbin-Watson statistic were0.729, 0.087, and 1.749, respectively. The SUR model performed better than the single-equation model for Stonyfield based on goodness-of-fit measures. The model performance metrics for the SUR model for Private Label brand are very close to those of the single-equation model for the Private Label brand.

Own-Price Elasticities

In the SUR model, four out of the five own-price elasticities were statistically significant, as exhibited in Table 11. Chobani and Dannon both have own-price elasticities in the elastic range. Consumers are sensitive to price changes for these brands. Yoplait and Stonyfield have inelastic own-price elasticities, and consequently consumers of these brands are less responsive to changes in price of the goods. Private Label is the only brand that does not have a statistically significant own-price elasticity, at least at the five percent level of significance. This own-price elasticity for Private Label however, is statistically significant at the ten percent level of significance. The

SUR results correspond to the single-equation results for the own-price elasticities for the yogurt brands. When comparing with the literature, Di Giacomo (2008) had similar own-price elasticities for the Italian market. He mentioned that the higher-priced brands had higher own-price elasticities which correlates by and large with what was found in our results.

Cross-Price Elasticities

Only seven out of the twenty five cross-price elasticities were statistically significant based on the SUR model (Table 12). Stonyfield and Chobani serve as a gross complement to Yoplait with cross-price elasticities of -0.603 and -0.618 respectively. Consumers might be buying these products together since Stonyfield is an organic yogurt, while Chobani is a Greek yogurt. During this time period, Yoplait was for the most part a conventional yogurt brand. Chobani and Private Label are considered a gross complement to Stonyfield with cross-price elasticities of -0.417 and -0.279 respectively. Consumers are buying Chobani and Stonyfield brands together possibly because they are wanting organic and Greek yogurt at the same time. At the same time, consumers buy Stonyfield (organic) and Private Label (least-cost alternative) together. Chobani is a gross complement to Dannon with cross-price elasticity of -0.55. Dannon, however, is considered a gross substitute for Chobani with cross-price elasticity of 0.501. Stonyfield is considered a gross complement to Chobani with a cross-price elasticity of -0.699.

Income Elasticities

As exhibited in Table 13, four out of the five income elasticities for the brands were found to be statistically significant. Since all of the income elasticities are greater than zero, all of the brands are considered normal goods. Private Label is the only brand that does not have a statistically significant income elasticity. Hence, the demand for Private Label does not greatly depend on fluctuations in consumer income. Yoplait, Stonyfield, Dannon, and Chobani are all considered luxury goods meaning since their

respective income elasticities exceed one. The income elasticities gleaned from the SUR analysis are quite different from those generated by the single-equation models.

Estimated Coefficients Associated with Other Demand Factors

Table 14 shows the results for other factors that affect the demand for these yogurt brands. The Great Recession is not statistically significant at the five percent level which compares with the results for the single-equation models. Trend was only statistically significant for Chobani which compares with the single-equation results. This result makes sense since Chobani was introduced in the beginning of the data set then had a dramatic increase in demand from 2009 to 2011. Trend squared was found statistically significant for all of the five yogurt brands. Similar to Trend, Trend squared also accounts for tastes and preference factors that we might not have accounted for. For the single-equation results, Trend squared was significant for Chobani and Yoplait. The Christmas holiday was statistically significant for Chobani and Yoplait. For the single-equation results, Christmas was statistically significant for all five of the yogurt brands. Q1, Q2, and Q3 were all found statistically significant across all five brands showing that there is seasonality present in yogurt demand. These results compare with the results from the single-equation models as well. The coefficients associated with the lag of the dependent variable which accounts for habit persistence was only statistically significant for Private Label brand. In the single-equation results, these coefficients were statistically significant for all of the five brands. Unlike the single-equation models, serial correlation was present for Chobani, Stonyfield, and Dannon in the SUR model. Corrections for serial correlation were mad with a first-order autoregressive process of the residuals.

Table 10. Model Performance Metrics by Yogurt Brand Using the SUR Model

	Chobani	Dannon	Yoplait	Stonyfield	Private Label
R-Squared	0.976	0.692	0.628	0.754	0.694
Adjusted R-Squared	0.974	0.661	0.591	0.729	0.663
S.E. of Regression	0.142	0.115	0.153	0.087	0.103
Durbin-Watson Stat	1.790	1.918	1.729	1.749	2.031

Table 11. Own-Price Elasticities by Yogurt Brand Using the SUR Model

BRAND	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Own-Price Elasticity	**-2.642** (0.0000)	**-1.428** (0.0000)	**-0.365** (0.0342)	**-0.860** (0.0000)	-0.188 (0.1343)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-vales are in parentheses.

Table 12. Cross-Price Elasticities by Yogurt Brand Using the SUR Model

	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Chobani	**-2.642** (0.0000)	**0.501** (0.0334)	0.088 (0.5523)	**-0.699** (0.0081)	-0.141 (0.3539)
Dannon	**-0.55** (0.0169)	**-1.428** (0.0000)	-0.185 (0.1437)	-0.042 (0.8459)	-0.131 (0.3164)
Yoplait	**-0.618** (0.0331)	-0.15 (0.5672)	**-0.365** (0.0342)	**-0.603** (0.0348)	-0.245 (0.1708)
Stonyfield	**-.417** (0.0125)	-0.102 (0.4607)	0.019 (0.8234)	**-0.860** (0.0000)	**-0.279** (0.0017)
Private Label	-0.106 (0.5564)	-0.006 (0.9738)	0.005 (0.9694)	-0.088 (0.6357)	-0.188 (0.1343)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Table 13. Income Elasticities by Yogurt Brand Using the SUR Model

BRAND	Chobani	Dannon	Yoplait	Stonyfield	Private Label
Income Elasticity	**2.893** (0.0000)	**2.336** (0.0000)	**1.981** (0.0011)	**1.639** (0.0000)	0.383 (0.3264)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

Table 14. Estimated Coefficients Associated with Other Demand Factors Using the SUR Model

	Great Recession	Trend	Trend Squared	Christmas	Q1	Q2	Q3	Lagged Depen-dent Variable	Serial Correla-tion AR (1)
Chobani	-0.067 (0.5674)	**-7.09E-05 (0.0003)**	**-0.245 (0.0005)**	**0.029 (0.0000)**	**0.269 (0.0001)**	**0.327 (0.0000)**	**0.203 (0.0002)**	-0.072 (0.2481)	0.534 (0.0000)
Dannon	-0.027 (0.7231)	-1.57E-05 (0.2059)	**-0.28 (0.0000)**	0.002 (0.2858)	**0.254 (0.0000)**	**0.224 (0.0000)**	**0.208 (0.0000)**	0.045 (0.5440)	0.330 (0.0008)
Yoplait	0.088 (0.3428)	0.004 (0.1338)	**-3.65E-05 (0.0196)**	**-0.421 (0.0000)**	**0.159 (0.0061)**	**0.1340 (0.0119)**	**0.102 (0.0315)**	0.149 (0.2408)	0.085 (0.5692)
Stonyfield	-0.082 (0.3106)	-1.63E-05 (0.2538)	**-0.116 (0.0043)**	0.000 (0.9232)	**0.278 (0.0000)**	**0.267 (0.0000)**	**0.192 (0.0000)**	-0.114 (0.0802)	**0.642 (0.0000)**
Private Label	0.066 (0.2036)	-4.18E-06 (0.6085)	**-0.334 (0.0000)**	-0.000 (0.8620)	**0.123 (0.0002)**	**0.093 (0.0036)**	**0.124 (0.0001)**	**0.300 (0.0056)**	-0.165 (0.2159)

Note: Numbers in bold font are statistically significant at α=0.05 level. P-values are in parentheses.

CHAPTER VI
FORECAST PERFORMANCE

We assessed the ability of the single-equation models and the SUR model to generate accurate forecasts. We conducted ex-post forecast evaluations of the models. The last 13 weeks of 2011 were withheld to examine forecast performance. Metrics that were used in this ex-post forecast evaluation include root mean squared error (RMSE), mean absolute error (MAE), mean absolute percent error (MAPE), bias proportion, variance proportion, and covariance proportions of per capita volumes for each of the respective brands.

The Root Mean Square Error is a commonly used measure of the difference between values predicted by a model and the values that were actually observed. The difference between the predicted values (F_t) and the actual values (A_t) are called the residuals, given by F_t - A_t.

1) RMSE = Root Mean Squared Error

   MSE = Mean Squared Error $= \frac{1}{M}\sum_{t=1}^{M} (F_t - A_t)^2$

   RMSE = $(\text{MSE})^{\frac{1}{2}}$

   The mean absolute error is an average of the absolute errors.

2) MAE = Mean Absolute Error

   $$\frac{1}{M}\sum_{t=1}^{M} |F_t - A_t|$$

   Mean absolute percent error expresses accuracy as a percentage. The lower the MAPE the better the forecast accuracy.

3) MAPE = Mean Absolute Percent Error

   $$\frac{1}{M}\sum_{t=1}^{M} \left|\frac{F_t - A_t}{A_t}\right| x\ 100$$

The bias Proportion is an indication of systematic error. It tells how far the mean of the forecasted values is from the mean of the actual series. The variance proportion

tells how far the variation of the forecasted values is from the variation of the actual series. The covariance proportion summarizes the remaining forecasting errors (EViews).

The bias proportion, the variance proportion, and the covariance proportion result from a decomposition of the MSE. As such, these proportions much sum to one. If the forecast is "good", the bias and variance proportions should be small so that most of the bias should be concentrated on the covariance proportion (EViews).

Decomposition of MSE is as follows:

Mean (or bias) proportion = $U_m = \frac{(\bar{F} - \bar{A})^2}{MSE}$

Variance proportion = $U_s = \frac{(S_F - S_A)^2}{MSE}$

Covariance proportion = $U_C = \frac{2(1-r)S_F S_A}{MSE}$

$U_m + U_s + U_c = 1$

With this decomposition,

U_m Measure of bias - unequal central tendencies of the actual and forecasted values

$(\bar{F} - \bar{A})^2$

U_s Measure of unequal variation - squared difference between standard deviations, both actual and forecasted

$(S_F - S_A)^2$

U_c Measure of incomplete covariation - correlation coefficient r between actual and forecasted values

$2(1-r)S_F S_A$

$$U_m = \frac{(\bar{F} - \bar{A})^2}{MSE}; \quad U_s = \frac{(S_F - S_A)^2}{MSE}; \quad U_C = \frac{2(1-r)S_F S_A}{MSE}$$

$U_m + U_s + U_c = 1$

U_c – nonsystematic random error, cannot be avoided.

$U_m, U_s -$ represent systematic errors that should be avoided.

$U_m \rightarrow 0$ as $\bar{F} = \bar{A}$; if U_m large, then average predicted value deviates substantially from average realized value.

$U_s \rightarrow 0$ as $S_F = S_A$; U_s indicates ability of the model to replicate the degree of variability; if U_s large, then the actual series fluctuated considerably but the simulated series shows little fluctuation or vice versa.

$U_c \rightarrow 0$ as r=1; can never hope that forecasters will be able to predict so that all points are located on the straight line of perfect forecasts.

$U_c \rightarrow$ remaining error after deviations from average values and deviations in variabilities have been accounted for.

From Tables 15 and 16, we can conclude which models are better for each yogurt brand. On the basis of the RMSE, MAE, and MAPE metrics, Chobani, Yoplait, and Private Label have better forecast accuracy when using the SUR model. Dannon and Stonyfield have better forecast accuracy results when using the single-equation model. The bias proportion for both of the Chobani models is high because the forecasts underestimate the actual values since Chobani took off so fast from 2009 to 2011. In particular, the MAPEs for the respective models range from 8.28 to 22.78, very good results for consumer products.

As seen in Table 17, the off diagonal elements are different from zero meaning that the SUR model provides better estimates statistically than the single-equation model.

Table 15. Single-Equation Model Forecasting Results

	RMSE	MAE	MAPE	Bias Proportion	Variance Proportion	Covariance Proportion
Chobani	5,856,105	5,282,790	22.78	0.634	0.142	0.224
Yoplait	3,951,978	3,616,287	16.75	0.0210	0.182	0.608
Dannon	3,192,057	2,782,061	12.79	0.000	0.193	0.807
Stonyfield	372,849	301,392	8.28	0.117	0.063	0.820
Private Label	3,315,495	2,874,466	14.23	0.112	0.246	0.642

Table 16. Seemingly Unrelated Regression (SUR) Model Forecasting Results

	RMSE	MAE	MAPE	Bias Proportion	Variance Proportion	Covariance Proportion
Chobani	5,515,622	5,020,783	22.04	0.508	0.172	0.320
Yoplait	3,752,005	3,292,723	15.88	0.059	0.292	0.649
Dannon	3,498,787	2,957,101	13.32	0.000	0.325	0.674
Stonyfield	388,833	321,960	8.95	0.053	0.403	0.545
Private Label	2,937,586	2,477,529	12.36	0.071	0.283	0.646

Table 17. Residual Correlation Matrix

	LOG(YOPLAIT_ VOLUME/POP_ THOUSANDS)	LOG(STONY FIELD_VOLUME/ POP_ THOUSANDS)	LOG(PRIV_LABEL_ VOLUME/ POP_ THOUSANDS)	LOG(DANNON_ VOLUME/ POP_THOUSANDS)	LOG(CHOBANI_ VOLUME/ POP_THOUSANDS)
LOG(YOPLAIT_ VOLUME/ POP_THOUSANDS)	1	0.530	0.354	0.597	0.538
LOG(STONYFIELD_ VOLUME/POP_THOUSANDS)	0.530	1	0.460	0.436	0.531
LOG(PRIV_LABEL_ VOLUME/POP_THOUSANDS)	0.354	0.460	1	0.400	0.379
LOG(DANNON_ VOLUME/ POP_THOUSANDS)	0.597	0.436	0.400	1	0.477
LOG(CHOBANI_ VOLUME/ POP_THOUSANDS)	0.538	0.531	0.379	0.477	1

CHAPTER VII
CONCLUSIONS AND LIMITATIONS

This analysis provides a view of the yogurt industry by brand from 2009-2011 in the United States. To date, not much research dealing with the demand for yogurt by brand exists in the economic literature. As such, this thesis adds to the store of knowledge about demand relationships for yogurt at brand level. Additionally, this research helps analysts and manufacturers of these major yogurt brands improve their understanding of the underlying forces which affect the demand for yogurt. Further, this research ascertains the ability of major yogurt brands to use this information to increase their revenue.

Looking at own-price elasticities, across the respective models Chobani and Dannon are quite price sensitive compared to other brands. The own-price elasticities for these brands are in the elastic range in absolute value. The demands for Yoplait and Stonyfield are considered inelastic since their own-price elasticities are less than 1.These two brands are less sensitive to changes in own-price compared for other brands. Consumers are not at all sensitive to changes in price in the case of private label or store brand. Based on the own-price elasticities alone, appropriate pricing strategies with the goal of maximizing revenue would be to lower prices of Chobani and Dannon and to raise prices of Yoplait, Stonyfield, and store brands.

The cross-price elasticities for the most part not statistically significant. Where significance occurred, Stonyfield is a complement for Chobani and Private Label is a complement for Stonyfield based on the single-equation model. We are assuming that consumers are buying these brands together in order to get a bundle of either Greek/organic or conventional/organic. Using the SUR model, there were more statistically significant cross-price elasticities than those from the single-equation model. Chobani and Stonyfield are considered complements for Yoplait. Chobani is a complement for Stonyfield. Chobani is also a complement for Dannon. Dannon is a

substitute for Chobani while Stonyfield is a complement to Chobani. Noticeably absent was the presence of substitutability among the respective brands.

Looking at the results for income elasticities, the single-equation models produce results counter to expectation due to the non-imposition of homogeneity restriction. Using the SUR model, the income elasticities provide results consistent with economic theory. Yoplait, Stonyfield, Dannon, and Chobani are all considered luxury goods, while Private Label or store brand yogurt is a necessity.

We evaluated the forecast performance of both the single-equation models and the SUR model using various established metrics such as RMSE, MAE, MAPE, as well as bias, variance, and covariance proportions. Chobani, Yoplait, and Private Label all have better forecast accuracy when using the SUR model. Dannon and Stonyfield have better forecast accuracy result when using the single-equation model. We expected that the SUR model would have much better results than the single-equation models, which was not the case for the Dannon and Stonyfield brands. Both single-equation model and the SUR model were very close in terms of forecast accuracy. After looking at the residual correlation matrix for the SUR model, the off- diagonal elements are quite different from zero. This result provides additional support of the SUR model over the single-equation models.

The thesis has several limitations. For this analysis, the data from Nielsen was only available until 2011. As such, aside from Chobani, this analysis fails to take into account the period of the Greek yogurt phenomenon. Because the data are not reflective of current market conditions, the thesis addresses in reality the demand for non-Greek yogurt with the exception of the Chobani brand. If the data set were to go beyond 2011, we would most likely see the market flooded with Greek yogurts because of their popularity. Consequently, the thesis does not address the Greek yogurt industry. Another limitation is the lack of detailed time-series information on branded advertising. Advertising and promotions may play a major role in assessing the demand for these products. Despite these limitations, this thesis provides much detail by brand that was not previously published in the extant literature.

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