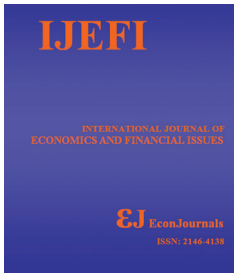

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Strategic Price Response in the Differentiated U.S. Yogurt Market

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ABSTRACT

Pricing decision is the most important decision made by food manufacturers. Although products are offered at regular prices most of the time, they are periodically offered at discounted prices to boost sales. In a differentiated product market, how brands respond to each other's price change is not addressed very often empirically. This paper studies a strategic price response to perceive how brands response to each other's prices in the U.S. differentiated yogurt market. This paper also estimates the frequency of price promotion to answer the question of whether private labels go on price promotion less or more frequently than main national brands. Vector autoregressive estimates suggest that the price pattern of yogurt brands is systematic and there is a strategic decision in setting prices. Granger-causality test shows that both Yoplait and private labels alter prices of other brands by having a significant impact on their pricing decision. Results of the impulse response functions confirm that Yoplait with the highest market share is the price leader in the yogurt market where all brands respond significantly to Yoplait's price shock up to 5 weeks following an impulse. The Markov-switching regression shows that private labels go on price promotion as frequently as national brands.

Keywords: Yogurt, Strategic Price, Granger-causality, Impulse Response, Markov-switching
JEL Classifications: C32, C33, D22, L11

1. INTRODUCTION

Pricing decision is the most important decision made by food manufacturers since it affects the competitiveness of a brand in the marketplace. It also affects brands' sales volumes and therefore brands' profit margins. Marketing literature suggests that the retail price of a brand is mainly affected by the demand for the brand (Pesendorfer, 2001; Nijs et al., 2007; Dhar and Ray, 2002; Boscagli, 2019), wholesale prices and the pricing history of the brand (Krishna et al., 2001; Nijs et al., 2007), and retail competition and store traffic (Chintagunta, 2002). The saturated distribution channel made food manufacturers to follow competitive pricing strategies in the market. In the same way, retailers vary the price of their products to get a higher margin and to stay competitive.

Weekly price reduction, offering products at discounted prices periodically, is considered the most common type of marketing tactic among a large variety of promotional offers. Weekly price reduction will naturally boost short term sales. Mulhern and Padgett (1995) find a positive correlation between regular price and promotion purchasing level where over three-fourths of shoppers who identify the promotion as a reason for visiting the store purchased one or more items at a regular price. In addition to the type of promotion, the distribution channels' strategic marketing decision also addresses the timing, frequency, and depth of the promotions (Kumar and Pereira, 1997).

Estimating strategic price response in a differentiated market would prevent food distributors from costly misreading of pricing signals (Vicker and Davies, 2000; Vorley, 2006)[1]. Despite the importance of the price war topic in industrial organization, a rather limited number of empirical studies have been done in the

1 To read more about price wars, see Garda and Marn (1993).

food industry. Recent reports from the ERS USDA analyses the relationship between private label and national brand product prices and in-store promotions for two major US grocery store chains (Volpe, 2011). It is shown that retailers "promote private label products strategically in response to national brand pricing promotions to protect private label market" (Volpe, 2011). Authors found a great deal of variation in pricing promotions in the retailers' response across supermarket departments.

Bontemps et al. (2008) study relationships between national brand prices and the development of private labels. A positive correlation (89%) is revealed between brand prices and purchases of private labels. This relationship stays significant even if product quality is removed. Further studies show that perceived risk, quality and price are important to the private label brands consumers (Glynn and Chen, 2008). Furthermore, researchers found that store brands not only benefit from the strength of the retailers' brand, but they also contribute, in a reciprocal way, to the improvement of the retailer image (Kremer and Viot, 2012).

This paper follows Vicker and Davies (2000) considering existing investigations (Tirole, 1988; Volpe, 2011) on dynamic pricing games. Therefore, the main objective of this study is two-fold: first to empirically estimate strategic price response in a differentiated yogurt market to see if prices of brands are set systematically and second, predict the duration of two price states, regular and promotional, for main brands to see if private labels go on price promotion as frequent as national brands. Yogurt is chosen because this fast-growing market made $7.7 billion in 2015 based on Nielsen-measured retail channels where the main competitors are Chobani, Dannon, Yoplait, and private labels.

Although little empirical work exists on studying price response among brands, economists have shown both theoretically and empirically that brand pricing is systematic where brands respond strategically to each other's prices. Table 1 is a subset of data taken from one retail store in Atlanta, GA that supports this theory. Chobani is advertised on price promotion during the week of January 09, 2011. Then, the week after, all products are offered at a reduced price. Steenkamp et al. (2005) showed that retaliation with price promotion to price-promotion attacks is the most common reaction by brands to a competitive attack. It also can be noticed, from Table 1, the two states of prices, regular and promotional, where all products are sold at the regular price more than half of the times during these 5 weeks.

Empirical research based on theories behind the temporary price reduction (Varian, 1980; Blattberg et al., 1981; Jeuland and Narasimhan, 1985; Pashigian, 1988; Volpe, 2011) investigated the effects of price promotion on brand sales and substitution (Kumar and Leone, 1988), sales and consumption (Assuncao and Meyer, 1993), factors affecting consumers' attitudes toward promoted brands (Liu and Wang, 2008), category-demand (Nijs et al., 2001), brand loyalty and switching behavior (Huang et al., 2006), and search behavior and purchase intention (Manzur et al., 2013). However, the model of sales proposed by Varian (1980) showed that firms held price promotion randomly, Berck et al. (2008) strongly rejected this hypothesis by showing that price promotion is systematic. Berck et al. (2008) showed that Minute Maid has the price leadership in the U.S. orange juice market rather than the largest brand of Tropicana. We would expect that Yoplait with the highest market share has price leadership in the U.S. yogurt market. Therefore, the first approach of this study will test the hypothesis of whether the price pattern of a yogurt brand is set strategically and then find the brand that leads the market.

By contrast, less attention has been paid to the prediction of price promotion frequency of differentiated products. Park and Gupta (2011) investigated the timing of price reduction for a firm's price promotional strategies by showing that the reduction in price offered during the high purchasing period would increase sales more than that offered during the low purchasing period. It can be expected that private labels go on price reduction less frequently than national brands since it is not profitable for a product to go on price promotion while it is already sold at price close to marginal cost. Recent studies show that private labels are promoted regularly (Abril and Rodriguez-Cánovas, 2016; Olbrich and Jansen, 2014). Raju et al. (1990) conclude the opposite that national brands go on price promotion less frequently than private labels since the former have more loyal consumers and it is not profitable for these brands to go on price reduction because they would lose more revenue from their large number of loyal consumers compared to private labels[2]. The second approach of this paper would test the hypothesis of whether brands go on price promotion equally frequency. National brands are expected to have a larger price promotion depth compared to private labels since they are offered at higher margins. Then, a shorter price promotion period is expected for national brands since it is not profitable for firms to have longer durations (Carlson et al., 2007). Therefore, national

2 This controversy can be answered based on the theory of demand that price relationship is governed by the price elasticity which is decreasing the price will increase the revenue when demand is elastic and vice versa.

Table 1: Weekly price promotions observed in a single store in philadelphia

Product	Non organic non fat strawberry yogurt											
Brand	Chobani			Dannon			Yoplait			Private label		
Week	Price (6oz)	Promo.	Feature Ad size	Price (6oz)	Promo.	Feature Ad size	Price (6oz)	Promo.	Feature Ad size	Price (6oz)	Promo.	Feature Ad size
02 January 2011	1.48	No	No	1.05	No	No	0.92	No	No	0.57	No	No
09 January 2011	1.44	Yes	No	1.11	No	No	0.78	No	No	0.58	No	No
16 January 2011	1.06	Yes	Medium	0.92	Yes	Large	0.84	Yes	No	0.51	Yes	No
23 January 2011	1.5	No	No	0.95	Yes	Medium	0.93	No	No	0.76	No	No
30 January 2011	1.5	No	No	0.94	No	No	0.92	Yes	No	0.5	Yes	No

Source: IRI (2011)

brands should have a smaller frequency of price promotion than private labels. In this paper, we test this hypothesis.

Vector autoregressive (VAR) models are used to study the properties of brand prices and test the hypothesis of whether prices are set systematically. The evidence of price leadership is tested using Granger causality tests. Then, impulse response functions are used as an alternative to price leadership tests and to study the brand's price response to their rival's price shock. Finally, Markov's-switching regressions are used to predict the price promotion frequency of main yogurt brands. In the next section, the model is introduced followed by a brief data description. Then, the main findings of the study are discussed and finally, the conclusion of this paper is presented.

2. MODEL

The first approach of this study is to estimate how the prices of different brands respond to each other's price strategy. For this purpose VAR models are used. Because VAR models represent the correlations among a set of variables, they are often used to analyze aspects of the relationships between the variables of interest (Lütkepohl, 2005). VAR is chosen because it is suited to analyze the transmission of idiosyncratic price shocks across brands, which is the impulse response function. Impulse response function allows for the evaluation of the interactions between the variables of a system (Koop et al., 1996). To describe the dynamic interrelationship among price of brands p, consider the m-dimensional reduced form VAR of order k represented by the following system of linear equations that was first introduced by Holtz-Eakin et al. (1988):

$$p_{it} = \delta_i(k)\mathrm{P}_{t-1} + u_{it} \quad (1)$$

i=1,…, N, t=1,…,T

where the subscribe i represents Chobani, Dannon, Yoplait, and private label, respectively; p is the price; P_t is the stacked version of p_{it}, i.e., $P_t = (p_{1t}, p_{2t}, p_{3t}, p_{4t})'$; δ_j are (4×4) coefficient matrices to be estimated, u_{it} is a (4×1) vector of unobservable or white noise with zero means, $E[u_{it}] = 0$, and contemporaneous covariance matrix, $E[u'_{it}u_{it}=\Sigma]$, where the covariance matrix Σ is assumed to be nonsingular. In the estimation of these price series, seemingly unrelated regression (SUR) models are preferred to ordinary least-squares (OLS). Since regressions have identical regressors, the equations should be estimated separately by OLS (Greene, 2008), i.e., the standard VAR estimation by OLS is the same as SUR (Kmenta, 1986).

The evidence of price leadership can be addressed using a price response test or what is known as a Granger causality test. Granger (1969) has defined the concept of causality that is a cause that occurs before the effect where if a variable x affects a variable y, the former should help to improve the predictions of the latter. This test regresses the price of brand one, $p_{1,t}$, on its lagged values of itself, $p_{1,t-1}$, and other brands' prices, $p_{2,t-1}, p_{3,t-1}, p_{4,t-1}$. Significant parameters estimated of other brands' lagged prices mean they explain some of the variance of p_1 which is not explained by its lagged values and therefore p_2, p_3, p_4 are Granger-cause p_1. The mathematical representation of price response for the first brand of Chobani, for example, is[3]:

$$p_{1,t} = \alpha_1 p_{1,t-1} + \beta_1 p_{2,t-1} + \beta_2 p_{3,t-1} + \beta_3 p_{4,t-1} + u_{1,t} \quad (2)$$

The Wald statistics for the joint hypothesis is:

$$\beta_1 = \beta_2 = \beta_3 = 0 \quad (3)$$

Where the null hypothesis is that the price of other brands does affect the price of the first brand where this restriction can be tested based on a simple F-test based on the result of a simple OLS estimate.

The price response test does not show the degree of the response in the price of a brand resulting from a change in the price of other brands. Therefore, impulse response functions can be used as an alternative way of characterizing strategic price response and addressing price leadership with a VAR model. The impulse response function is used because it represents the mechanism through which shock spread over time.

Markov's structure is used to identify the states of a brand price, which are the states of price promotion and regular price in the yogurt market. The Markov process is a particular type of stochastic process characterized in such a way that the outcome of an endogenous variable at time t only depends on the outcome of that variable at time $t-1$, and is independent of the outcome of the variable at time before $t-1$ (Mellor, 1984). Consider the evolution of a price series p_t, where t= 1, 2,... T, is characterized by two states s_t, where s_t is 1 if the price is in state of price promotion and 2 otherwise, as in the model below:

$$\mathrm{P}_t = \mu_{s_t} + \sum_{i=1}^{k} \varnothing_{i,s_t}(\mathrm{P}_{t-i} - \mu_{s_{t-i}}) + \varepsilon_{s_t} \quad (4)$$

Where P_t is the dependent variable at time t representing the price of Chobani, Dannon, Yoplait, and private label, respectively; μ_{s_t} is the state-dependent intercept equals μ_1 when $s_t = 1$ and μ_2 when $s_t = 2$; $\varnothing_{i,s_t}$ is the i^{th} AR term in state s_t; and is the *i.i.d.* normal error with mean 0 and state-dependence variance $\sigma^2_{s_t}$; and μ_{s_t}, $\varnothing_{i,s_t}$, and $\sigma^2_{s_t}$ are parameters to be estimated. Based on the lower value of Schwarz's Bayesian information criterion (SBIC) test statistics, the price of each brand is lagged two periods, $k = 2$.

However, in the case of using average prices for brands, we never know in which state the price is, i.e., states are unobserved. Markov switching regression model allows the parameters to vary over the unobserved states where states are drawn randomly every period. Although it is not possible to know with certainty in which state the price lies, the Markov process estimates the probabilities of being in each state in addition to the transition probabilities. The transition probabilities can be estimated where

3 See the *model selection* subsection under the *Results* section to know why only one lag is used.

the current realization of the state depends only on the immediate past (Hamilton, 1989):

$$P=\begin{bmatrix}\Pr(s_t=1|s_{t-1}=1) & \Pr(s_t=2|s_{t-1}=1)\\ \Pr(s_t=1|s_{t-1}=2) & \Pr(s_t=2|s_{t-1}=2)\end{bmatrix}=\begin{bmatrix}p_{11} & p_{12}\\ p_{21} & p_{22}\end{bmatrix} \quad (5)$$

Where p_{ij} is the probability of transitioning from state i to state j. For example, p_{12} denotes the probability of a brand transitioning to a regular price in the next week given that a brand is on price promotion in the current week.

If we let D_i denote the duration of state i, then the expected duration is (Noel, 2007):

$$E[D_i]=\frac{1}{1-p_{ii}} \quad (6)$$

3. DATA

Data used in this study is a weekly[4] scanner-level data of yogurt purchases from 206 grocery stores that belong to 19 chains in 25 cities collected by the Information Resource Inc. (IRI) during 2009-2011. The data provides information for each product at the Universal Product Code (UPC) level, unit sales, dollars paid, feature, and store and market identifier. Data is complemented with information about the product characteristics including brand name and volume equivalent also provided by IRI. This paper only uses brands that have the highest market shares which are Chobani, Dannon, Yoplait, and private labels. Some stores do not provide information about all brands and their complete price series due to data errors or because that store did not carry that brand that week. Consequently, the sample is restricted to only those stores that have complete price series for all yogurt brands which 11 stores in 4 cities[5]. After dropping observations with key explanatory variables missing, the sample size is 858. The summary statistics of the average yogurt price are shown in Table 2. Figure 1 demonstrates the observed sequence of 78 weeks of retail average prices for main yogurt brands. The average prices ($/6oz) are 1.24, 0.88, 0.75, and 0.54 for Chobani, Dannon, Yoplait, and private labels, respectively where the price of a brand never exceeds its rival. Also, all series tend to move together.

4. RESULTS

Before beginning the analysis, the original brand prices are subjected to the standard tests for stationarity by plotting the average price of brands. Visual representation of the prices, as shown in Figure 1, suggest that all prices are stationary. More formally, a price trend is tested for all brands by regressing the price of each brand on a constant and a time trend. Although the estimated trend coefficients are statistically significant at 5% level, they are very small in magnitude[6]. As a result, as claimed by Berck et al. (2008), it could be concluded that the trend in prices has no economical or statistical meaningful explanation and the variation in prices should be due to something else rather than a stable change in prices. In the second step, data are tested for the unit root using an augmented Dickey-Fuller test. Data need to be stationary, i.e., means variances and covariances should not depend on time, for the econometric procedure to have the appropriate statistical properties (Adkins and Hill, 2011). We reject the unit root null hypothesis that there is a unit root for the price series at the 1% level for all brands concluding that there is a stationary in price series as shown in Table 3. Notice that the dependent variables are the difference in prices for each brand while the independent variables are the first lag of the brand price.

4.1. Model Selection

The analysis continues by choosing the optimal lag order for first-to third-order VARs using the first four lags of the brand's prices as instruments to improve efficiency. For model selection, we follow consistent moment and model selection criteria proposed by Andrews and Lu (2001) which are equivalent to the

4 We do not have complete price series for all weeks where the dataset only provides information for the first 26 weeks of each year.

5 Cities are Atlanta, GA; Boston, MA; Hartford, CT; New England, ME. Someone would expect sales of a given national brand to be correlated across retailers in a city or region, but not for private labels. Berck, et al. (2008) showed that prices of orange juice private labels are correlated at the chain level and the market (city) level.

6 For example, the trend coefficient for Yoplait is 0.0002.

Table 2: Summary statistics of average yogurt price

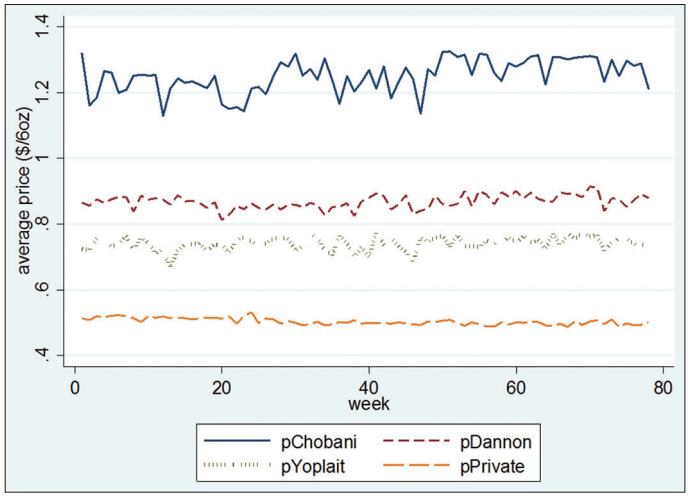
Variable	Mean	Std. dev.	Min	Max
Chobani	1.248	0.131	1.007	1.69
Dannon	0.882	0.076	0.718	1.102
Yoplait	0.752	0.079	0.588	0.925
Private label	0.541	0.095	0.273	0.787

Table 3: The Dicky-fuller test

Dependent variable: D.Price	Chobani	Dannon	Yoplait	Private
Lagged value of price	−0.366	−0.175	−0.635	−0.079
	(0.026)	(0.020)	(0.033)	(0.013)
Constant	0.455	0.155	0.478	0.043
	(0.033)	(0.017)	(0.025)	(0.007)
Wald Chi-square	195.37	80.01	374.41	37.67
P-value	0.00	0.00	0.00	0.00

Dependent variable: D.Price; Independent Variable: L.Price. Numbers in parenthesis are standard errors

Figure 1: Observed average retail price for main brands of yogurt



Akaike information criteria (AIC) (Akaike, 1969), the Bayesian information criteria (BIC) (Schwarz, 1978; Risannen, 1978; Akaike, 1977), and the Hannan-Quinn information criteria (HQIC) (Hannan and Quinn, 1979). Results in Table 4 show that the first-order VAR is the preferred model since it has the smallest MBIC and MQIC. It can be noticed that MAIC is the largest for the first order which does not support the test that the first order is the preferred model. Andrews and Lu (2001) showed that MAIC is the best procedure when the sample size is small, but when the sample size increases, it reflects the inconsistency of this procedure and as a result, it does not perform as well as the other two procedures. Therefore, the first-order VAR model (1-week lag) is used based on MBIC and MQIC.

4.2. VAR

The results of both the price and log price are quantitatively similar. As a result, the price is used in the VAR models and results are presented in Table 5. It can be noticed that almost all estimated coefficients are statistically significant at 5% level, suggesting that brands' price patterns are systematic (Berck et al., 2008). In the Chobani price reaction function, for example, the parameter estimated on one-period lagged own price is positive and statistically significant. The price of Chobani is sensitive to other's brand pricing. The null hypothesis that all estimated coefficients of lagged prices are equal to zero was rejected using likelihood ratio tests. This means the brands' prices are not explained as random variation about a constant term and as a result prices of brands are not random.

4.3. Granger Causality Tests

VAR system estimates for each brand are used to investigate Granger tests which test the hypothesis that past prices of a given brand and its rivals cause the present price of a brand. The null hypothesis of this statistical test is that the excluded variable does not Granger-cause equation variable. In other words, if we reject the null hypothesis that the VAR coefficients for Dannon, Yoplait, and private labels, for example, in the equation for Chobani are zero using a likelihood ratio test, then we say the price of these brands Granger-cause price of Chobani. By looking at Table 6 we can notice that the null hypothesis is rejected at the 5% level for the equation of Chobani meaning that the price of each of Dannon, Yoplait, and private labels Granger-cause the price of Chobani, but the price of Chobani does not Granger-cause the price of Dannon. The prices of Yoplait and private labels are also Granger-cause the price of Dannon. In the same way, the price of all brands Granger-cause the price of Yoplait, while the price of Dannon does not Granger-cause the price of private label. Granger test provides whether the price of one brand helps in predicting the price of another brand, i.e. the price pattern of one brand is followed by the price pattern of another brand, but it does not present the magnitude of the response. Besides, the evidence of price leadership in the yogurt market cannot be addressed using these mutual results of Granger-causality. Following Vicker and Davies (2000), a brand is considered a price leader if its price change makes a significant change in the prices of all competitor brands. As a result, impulse-response functions are used to predict the change in the price of a given brand over time as a result of a price shock of other brands, and as an alternative way to address the price leadership brand in the yogurt market.

4.4. Impulse-response Functions

Impulse responses are computed over a 5-week horizon for each VAR and results are shown graphically in Figure 2 to get a visual impression of the dynamic interrelationships within the system. Notice that the shaded areas show the bootstrap-generated confidence bounds. As mentioned earlier, the impulse response function is preferred to other price reaction function, the Granger-causality test, because it represents the mechanism through which the response to a shock is distributed through

Table 4: VAR selection order

Lag	CD	J	J P-value	MBIC	MAIC	MQIC
1	0.975	176.182	1.56E-16	−139.29	80.182	−4.572
2	0.980	132.947	2.90E-14	−77.366	68.947	12.444
3	0.979	81.264	9.84E-11	−23.893	49.264	21.012

VAR: Vector autoregressive

Table 5: VAR results

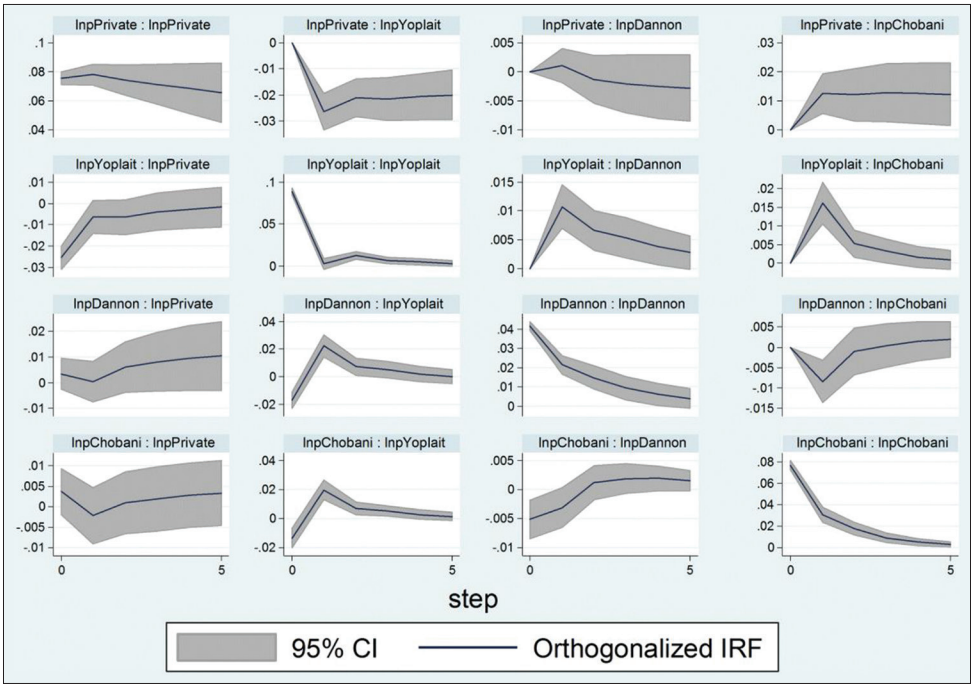
Variables	Coefficients	Std. err.	z	P>z
pChobani				
pChobani L1.	0.316	0.054	5.88	0.00
pDannon L1.	−0.247	0.096	−2.56	0.01
pYoplait L1.	0.273	0.055	4.96	0.00
pPrivate L1.	0.292	0.086	3.37	0.001
pDannon				
pChobani L1.	0.017	0.015	1.15	0.249
pDannon L1.	0.622	0.048	12.83	0.00
pYoplait L1.	0.164	0.022	7.41	0.00
pPrivate L1.	0.055	0.026	2.08	0.038
pYoplait				
pChobani L1.	0.164	0.024	6.72	0.00
pDannon L1.	0.597	0.075	7.95	0.00
pYoplait L1.	0.102	0.039	2.65	0.008
pPrivate L1.	−0.22	0.048	−4.59	0.00
pPrivate				
pChobani L1.	−0.026	0.01	−2.44	0.015
pDannon L1.	−0.006	0.036	−0.18	0.86
pYoplait L1.	0.117	0.02	5.7	0.00
pPrivate L1.	0.98	0.025	39.1	0.00

VAR: Vector autoregressive

Table 6: Price response (Granger-causality) test

Equation	Excluded	Chi-square	df	Prob>Chi-square
pChobani				
	pDannon	6.565	1	0.01
	pYoplait	24.565	1	0.00
	pPrivate	11.373	1	0.001
	All	49.098	3	0.00
pDannon				
	pChobani	1.33	1	0.249
	pYoplait	54.868	1	0.00
	pPrivate	4.313	1	0.038
	All	56.578	3	0.00
pYoplait				
	pChobani	45.158	1	0.00
	pDannon	63.193	1	0.00
	pPrivate	21.106	1	0.00
	All	101.771	3	0.00
pPrivate label				
	pChobani	5.944	1	0.015
	pDannon	0.031	1	0.86
	pYoplait	32.45	1	0.00
	All	44.684	3	0.00

Figure 2: Impulse-response functions



several periods. The response takes account of changes throughout the system (Berck et al., 2008) i.e., it takes into account all the feedback effects among brands. For example, if Chobani price changes Dannon price and Dannon price changes Yoplait price, this indirect price change will appear in the impulse-responses. Log of prices are used for estimation. Therefore, responses can be interpreted as percentage changes to Cholesky one-standard deviation upward shock to the price of impulse. Following Berck et al. (2008), effects are tested using asymptotic standard errors to check whether responses are statistically significantly different than zero.

The initial response of Yoplait's price to the price shock of Chobani is positive while it is negative for the price of Dannon for 2 weeks following the shock of Chobani. Yoplait responded positively to the price shock of Dannon while Chobani responded negatively for 5 weeks following the price shock of Dannon. Dannon responded positively to the price shock of private label while Yoplait responded negatively. Yoplait is the only brand that made all competitors to respond significantly to its price shock which supports the hypothesis that all brands appeared to follow Yoplait's lead. One-standard deviation shock in the price of Yoplait made the price of Chobani to be responded by a 1.6% increase a week later while the highest response in the price of Dannon appeared a week later by a 1.1% increase. Private label responded negatively during the 5 weeks following the price shock of Yoplait. Concerning own price shocks, all brands reacted strongly but fell to an equilibrium path within 5 weeks, except private label.

4.5. The Switching Probabilities and Stages Duration

As shown in the model section, a more complex Markov-switching regression model is specified that includes the lagged values of the brand prices and allows its coefficients to switch as well. As shown in Table 7, the output indicates that the lagged prices do not significantly affect brand prices in price promotion state, state 1, but most of the coefficients on the lagged prices in the state of regular price, state 2, are significant. For all of the price series, the estimate for the constant term is higher in regular price state than in priced promotion state. Results from the within-regime regression are used to estimate the switching probabilities for all brands, and then to derive the duration of each state as reported in Table 7.

For Chobani, the likelihood of a brand being on price promotion next week given a brand on price promotion this week is 30% while the likelihood of a brand being on price promotion next week given a brand on a regular price this week is 29%. The regular price of Chobani lasts 3 weeks, on average, followed by 1 week of price promotion. The likelihood of a Dannon being on price promotion next week given a brand on a regular price this week is 21% while the likelihood of a brand being on price promotion next week given a brand on a price promotion this week is 30%. The average regular price of Dannon lasts 5 weeks followed by 1 week of price promotion.

For Yoplait, the likelihood of a brand being on price promotion next week given a brand on a regular price this week is 13% while the likelihood of a brand being on price promotion next week given a brand on a price promotion this week is 43%. The average regular price of Yoplait lasts 8 weeks followed by 2 weeks of price promotion. Finally, for private label, the likelihood of a brand being on price promotion next week given a brand on regular price this week is 29% while the likelihood of a brand being on regular price next week given a brand on a regular price this week is 71%. The regular price of private label lasts 3 weeks, on average, followed by 1 week of price promotion.

By looking at the expected price state duration estimated by Markov-switching regression, considering 52 weeks in a year, Dannon has the lowest frequency of weeks on price promotion, 8 weeks, followed by Yoplait, 10 weeks, and finally by Chobani,

Table 7: Markov switching regression, switching probabilities, and stage duration

Variable	Chobani	Dannon	Yoplait	Private label
Markov switching regression				
State 1				
Price lagged (1)	0.978***	0.121	−0.337	−0.01
	(0.195)	(0.3)	(0.246)	(0.213)
Price lagged (2)	−0.094	0.451	0.677**	0.341
	(0.215)	(0.278)	(0.337)	(0.256)
Constant	1.21***	0.843***	0.708***	0.493***
	(0.015)	(0.006)	(0.004)	(0.001)
State 2				
Price lagged (1)	0.34**	0.382***	−0.074	0.722***
	(0.144)	(0.147)	(0.151)	(0.143)
Price lagged (2)	0.44***	0.485***	0.275*	0.296**
	(0.159)	(0.151)	(0.155)	(0.137)
Constant	1.277***	0.88***	0.748***	0.504***
	(0.014)	(0.007)	(0.002)	(0.002)
Price transition probabilities				
p11				
Promotion to promotion	0.301***	0.30**	0.434***	0.302
	(0.107)	(0.124)	(0.156)	(0.191)
p12				
Promotion to regular	0.70***	0.70***	0.566***	0.70***
	(0.107)	(0.124)	(0.156)	(0.191)
p21				
Regular to promotion	0.293***	0.205***	0.126**	0.293***
	(0.073)	(0.06)	(0.06)	(0.077)
p22				
Regular to regular	0.707***	0.79***	0.873***	0.706***
	(0.073)	(0.06)	(0.06)	(0.077)
Price expected duration				
State 1				
Promotion	1.431***	1.43***	1.766***	1.432***
	(0.219)	(0.255)	(0.488)	(0.392)
State 2				
Regular	3.41***	4.88***	7.92**	3.407***
	(0.851)	(1.44)	(3.802)	(0.897)

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

13 weeks. Although private label has a little higher frequency of weeks on price promotion, 13 weeks, compared to Dannon and Yoplait, it has an equal frequency of price promotion as Chobani. Therefore, we can conclude that the private labels go on price promotion as frequently as national brands which this finding is consistent with most recent studies.

5. CONCLUSION

The significance of parameters estimated using VAR models suggests that the price patterns of brands are systematic and there is a specific brand that leads the market. Yoplait and private labels have the largest effect on the prices of Dannon and Chobani which each of Yoplait and private labels Granger-cause the price of Dannon and Chobani.

The granger-causality test has not determined which brand is the price leader in the yogurt market. Therefore, impulse response functions are used to show the degree of the response in the price of a specific brand resulting from a one-standard deviation shock in the price of other brands. Although all brands respond to each other's price impulse, the magnitude of the response is small. Results showed that the impulse in the price of private label does not make a significant response in the price of Dannon, while all brand response to the price impulse of Yoplait significantly. This supports the hypothesis that Yoplait with the highest market share is the price leader in the yogurt market.

The Markov-switching regression is used to determine whether a previous price condition of a particular brand can predict its future price promotion condition as the second main objective of this paper. The within-regime regression provides a transaction from the current condition of the brands' price to the future condition of the brand's price in terms of probabilities. Results showed that the probability of brands being on price promotion next week given brands on price promotion this week is larger than the probability of brands being on price promotion next week given brands on a regular price this week. Results also showed that private labels go on price promotion as frequently as major national brands in the yogurt market. Therefore, the hypothesis that national brands should have a smaller frequency of price promotion than private labels is rejected.

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