Demand for Organic Fluid Milk across Marketing Channels

Xianghong Li, Hikaru Hanawa Peterson, and Tian Xia

Organic food products, which have been sold traditionally at natural food stores, have become increasingly available through mass marketing channels. This study estimated an almost ideal demand system (AIDS) model using 2008–2010 retail scanner data to examine consumer demand for organic fluid milk products sold at conventional and natural marketing channels. Asymmetric cross-price elasticities were found suggesting relative stickiness in demand to switch from organic milk to conventional milk and from natural stores to food, drug, and mass merchandiser stores. More generally, demands shifting toward products with higher expenditure elasticities in a differentiated market can be explained by relative budget shares and expenditure elasticities.

Key Words: AIDS model, food, drug, and mass merchandiser stores, marketing channel, natural food stores, organic fluid milk, scanner data

The organic market in the United States continues to expand. Annual growth of organic food sales dropped to 5.1 percent in 2009 after many years of double-digit annual growth, but it has since rebounded. Organic food sales marked another 11 percent rise in 2015 and reached $39.7 billion, almost accounting for 5 percent of the total food market (Organic Trade Association (OTA) 2016). Younger generations, who grew up with organic items as an established part of their food and beverage choices (Roberts 2015), are expected to support the market's continued growth.

Organic dairy has long been regarded as a "gateway" food category for organic consumption (Oberholtzer, Dimitri, and Greene 2005). Sometimes used as a loss leader to attract organic shoppers (Maltby 2013), organic dairy constitutes the second largest segment of the organic food market, with its sales accounting for 15 percent of organic food sales and about 6 percent of all dairy products (OTA

Xianghong Li, Extension Associate, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, USA. Hikaru Hanawa Peterson, Professor, Department of Applied Economics, University of Minnesota, St. Paul, Minnesota, USA. Tian Xia, Associate Professor, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, USA. *Correspondence: Hikaru Hanawa Peterson, Department of Applied Economics, University of Minnesota, St. Paul, Minnesota, USA, Email hhp@umn.edu*

Senior authorship is shared by Li, Peterson, and Xia. The authors are grateful for constructive comments from two anonymous reviewers. This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2007-04505.

The views expressed are the authors' and do not necessarily represent the policies or views of any sponsoring agencies.

Agricultural and Resource Economics Review 47/3 (December 2018) 505–532

2011). Specifically, approximately 2.6 billion pounds of organic fluid milk products were sold in 2016, accounting for 5.5 percent of the total fluid milk product sales and marking a 143 percent increase from 2006, while overall fluid milk product sales dropped by 12 percent over the same period (Agricultural Marketing Service-U.S. Department of Agriculture (AMS-USDA) 2017).

The high penetration rate is accompanied by a distinct change in organic food retailing. In the 1990s, organic foods were primarily sold through natural food stores, including national chains such as Whole Foods Market and Trader Joe's, independent natural grocery stores, and food cooperatives. Since 2000, more than half of organic foods have been sold through conventional food stores, including supermarkets, drug stores, and mass merchandisers (Dimitri and Greene 2002). In 2010, the shares of organic foods sold through conventional and natural food stores were 54 percent and 39 percent, respectively (OTA 2010). Organic milk is currently available in most retail food outlets, and supermarkets have long been the primary retail outlet for both organic and conventional milk.

The impacts of the expansion of organic food across different marketing channels on consumer demand are not clear. Most consumers shop for food items at multiple store outlets, and their behavior naturally varies across outlets (Fox, Montgomery, and Lodish 2004, Bond, Thilmany, and Bond 2006). With all types of stores carrying organic food products, consumers shop for organic products in different marketing channels. According to a study by the OTA, almost nine out of ten seasoned organic shoppers visit two or more stores during a week (OTA 2013). Product offerings also differ across retail outlet types; SPINS reports 69 percent of milk sold in natural stores was certified organic in 2013 (SPINS 2013), while the organic share was much lower in mainstream supermarkets. Whether demand for organic products is the same across marketing channels or not is an empirical question. Any differences we may find could suggest that where consumers shop is important for understanding the changes in the organic and other value-added food sectors, and in consumer food choices and their health-related consequences.

To the best of our knowledge, there have been no studies on the potential impacts of changes in marketing channels on organic food demand, most likely due to the lack of a suitable dataset. In this paper, we estimate demand for organic and nonorganic fluid milk products at conventional and natural marketing channels using a dataset that combines retail-level scanner data from food, drug, and mass merchandiser (FDM) stores and natural food stores.

While most published studies on demand for organic milk examined the period of the market's development in the 1990s and early 2000s, the data set analyzed in this paper spans from 2008 to 2010. Indeed, the organic milk market continued to evolve during the rapid expansion of the overall organic market in the 2000s. Fueled somewhat by the establishment of the National Organic Standards in 2002, demand growth for organic milk has remained robust except for a brief slowing during the economic recession. The increased availability at retail outlets has also likely affected consumer demand for organic milk. In the meantime, organic milk supply has continued to expand. The herd of certified organic dairy cows was reportedly more than 254,700 in 2011, marking an increase of over 420 percent from 2001 (USDA Economic Research Service 2013). Yet, supply of organic milk has not been able to keep pace with increasing demand to date (Neuman 2011).

Cross-price relationships among organic and conventional fluid milk products were of particular interest, and the analysis accounted for various fat content and different types of stores. A review of the literature, discussed in detail below, reveals one surprisingly consistent finding pertaining to the cross-price relationship between organic and nonorganic foods, namely that the demand for organic products is estimated to be more elastic with respect to conventional prices than the demand for conventional products with respect to organic prices. The extant literature offers no rigorous explanation for this relationship. In this study, we turn to the Slutsky equation for an analytical explanation and show that asymmetric cross-price relationships are expected among demands for differentiated products, where demand shifts toward products with higher expenditure elasticities; i.e., toward more luxurious products and away from products with lower expenditure elasticities. Our empirical analysis finds a similar asymmetric cross-price relationship in the 2008–2010 milk market. We test our empirical findings against the hypothesized relationships and find that the hypotheses hold for the majority of cases. Our results highlight the importance of retail store choice in understanding consumer food demand.

Previous Literature

The availability of scanner data that distinguish organic products has enabled researchers to build and estimate demand systems that include organic and nonorganic versions of products. Among studies examining milk demand, demand systems were specified to include organic along with conventional products, often with additional considerations regarding whether items were private-labeled or branded (Glaser and Thompson 2000, Jonas and Roosen 2008, Schröck 2012, Chen, Saghaian, and Zheng 2016) or other features of interest such as the rBST content (Dhar and Foltz 2005), flavor (Choi and Wohlgenant 2012), and fat content (Chang et al. 2011, Choi and Wohlgenant 2012). With the exception of Chang et al. (2011) and Chen, Saghaian, and Zheng (2016), the studies used data from before 2005. Most studies also focused on a regional rather than national market; Dhar and Foltz (2005) used data from 12 cities, whereas Chang et al. (2011) used data in central Ohio. Of the studies on U.S. consumers, only two used nationwide scanner data (Glaser and Thompson 2000, Chen, Saghaian, and Zheng 2016).

Past U.S. studies have found that organic milk demand was more own-price elastic than conventional milk demand (Glaser and Thompson 2000, Dhar and Foltz 2005, Jonas and Roosen 2008, Alviola and Capps 2010, Chen, Saghaian, and Zheng 2016), which is contrary to two European studies (Monier et al. 2009, Schröck 2012). The studies that disaggregated products by fat content found mixed results (Chang et al. 2011, Choi and Wohlgenant 2012). Most of the studies also reported that organic milk demand, at least for a subset of products, was less expenditure-elastic than its conventional counterpart (Dhar and Foltz 2005, Jonas and Roosen 2008, Chang et al. 2011, Chen, Saghaian, and Zheng 2016).

In contrast to these mixed results, a striking consensus was found among all six studies that report cross-price elasticities between organic and conventional milk demands (Glaser and Thompson 2000, Dhar and Foltz 2005, Jonas and Roosen 2008, Alviola and Capps 2010, Chang et al. 2011, Chen, Saghaian, and Zheng 2016). Cross-price elasticity of organic products with respect to conventional prices was greater than the cross-price elasticity of conventional products with respect to organic prices, suggesting that consumers have a greater tendency to switch to organic from conventional than the reverse. Dhar and Foltz (2005), Alviola and Capps (2010), and Chen, Saghaian, and Zheng (2016) speculated on the reason for asymmetry as "the difficulty or unwillingness of consumers to switch back from a high-quality product to a relatively lower-quality product, even if there are notable price changes" (Alviola and Capps 2010, p. 385). We explain below that such relationships can be expected between any products with different expenditure elasticities, particularly when one of the products has newly entered the market with small expenditure shares.

Past studies suggest that consumer shopping behavior for milk likely varied across retail formats and was influenced by store characteristics and household demographics. Retail formats vary not only by the product assortment they offer but also by price. Dong and Stewart (2012) examined a household's choice of milk shopping across seven FDM store types, including grocery stores, drug stores, and mass merchandisers, and found that the probability of shopping at a particular store type was affected by prices at other store types. The demographic profile of consumers was distinct across store formats, and income was found to be the most prominent demographic associated with store choice (Carpenter and Moore 2006, Hansen and Singh 2009, Dong and Stewart 2012). In particular, high-end and specialty grocery stores had attracted higher-income households (Carpenter and Moore 2006, Hansen and Singh 2009).

Buying behavior toward organics also differs across store formats. Thompson and Kidwell (1998) compared in-store data from a specialty grocer and a food cooperative, and found consumers at the cooperative were much more likely to purchase organic. Using household scanner data, Hsieh and Stiegert (2011) found that high-end shoppers bought more organics, and organic shoppers as a whole were less price-sensitive than other shoppers.

Conceptual Framework

Basic demand relationships attribute the asymmetry in the cross-price elasticities of demand to the magnitudes and directions of the effects caused by the differences in the income elasticities and in the budget shares of two products. Regarding demand for a normal good, a price increase of its substitute causes a positive substitution effect and a negative income effect. Because the substitution effects between the two products have the same magnitude based on the Shephard's lemma, an asymmetry in the cross-price effects on demand occurs when either the income elasticities or budget shares differ between the two products. For example, if one product has a smaller income elasticity than the other, the price increase of its substitute will cause a smaller negative income effect on its demand, such that the net effect on demand will be larger. Similarly, if one product has a smaller budget share, its total demand increase in response to a price increase of its substitute will be greater in percentage terms. The case when the products are complements is analogous, except the negative substitution effect from a price increase of a complement augments the income effect. The product with a greater income inelasticity, therefore, will respond with a greater negative cross-price effect. The conditions for asymmetric relationships can be stated in terms of relative income elasticities and budget shares. The detailed derivation is included in the appendix.

Prevailing asymmetry in cross-price elasticities of demand implies a few behavioral predictions. Demand for one good is more responsive to the price of the other good than the other way around. Thus, once the demand shifts to the first good, it will take proportionally larger price changes for the demand to shift back to the second good. Over time, we would expect to see some stickiness in demand.

Despite claims that they have become a mainstream category, organic products remain differentiated from conventional products for consumers. Organic fluid milk products constituted 2 to 5 percent of total U.S. fluid milk products sales during 2006 to 2016 (AMS-USDA, multiple years). Thus, we would expect that the budget shares for organic fluid milk on average are smaller than those for conventional fluid milk at all marketing channels. Previous studies have shown organic and conventional products may have different expenditure elasticity, and many studies found demand for organic products to be less expenditure-elastic than conventional products (Dhar and Foltz 2005, Jonas and Roosen 2008, Chang et al. 2011, Chen, Saghaian, and Zheng 2016). Hence, the above conceptual discussion would suggest an asymmetric demand pattern between organic and conventional products, where changes in demand for organic products in response to price changes in conventional products are likely to be greater than changes in demand for conventional products caused by changes in organic prices, once consumers have included organic products in their bundle.

Marketing channels are also considered here as a means of product differentiation. The FDM channel accounts for a larger share for most conventional food products than the natural retail channel. The rapidly increased availability of organic products at FDM stores during the 2000s has increased its share of organic food products. In particular, 76 percent of organic fluid milk, half and half, and cream products were sold through the conventional channels in 2005, when the shares of all organic product sales through the conventional and natural channels were 46 percent and 48 percent, respectively (Budgar 2006, Dimitri and Venezia 2007). Thus, the budget shares at natural stores in the aggregate for both conventional and organic fluid milk products are likely smaller than those at FDM stores. If demands for comparable products at natural channels are similarly or less expenditure-elastic at natural stores than at FDM stores, and if products at the two marketing channels are substitutes, we would expect an asymmetric demand relationship between products sold at the FDM and natural channels, where demand changes at the natural channel in response to price changes at the FDM channel are greater than demand changes at the FDM channel in response to price changes at the natural channel.

In sum, we consider the following hypotheses about the market demand for differentiated fluid milk products:

Hypothesis 1: *Among fluid milk products sold through the FDM channel, demand for an organic product will increase more in response to a marginal rise in the price of a conventional product than demand for a conventional product would in response to a marginal increase in the organic product price.*

Hypothesis 2: *Demand for fluid milk products sold at natural stores will increase more in response to a marginal increase in the price at the FDM stores than demand for fluid milk products at FDM stores would in response to a marginal rise in the price at the natural stores.*

In addition, we examine the demand relationships among organic and conventional fluid milk products sold at natural stores, similar to Hypothesis 1, and the existence of asymmetric demand responses between various fluid milk products with different fat contents. The asymmetric cross-price patterns would depend on how budget shares and estimated expenditure elasticities compare, and whether or not two goods are substitutes or complements.

Data

Our dataset uniquely combined both Nielsen and SPINS weekly retail-level scanner data from April 2008 through April 2010 to examine the effects across marketing channels. The Nielsen retail scanner data have been widely used to study demand for food products; however, its scanner data include only sales from FDM stores (excluding Walmart) and exclude sales from natural product stores, which is a critical channel for examining organic product demand. The SPINS data, on the other hand, provide information on food products sold through the natural products supermarket channel in the United States by collecting scanner-based sales data from store registers on all UPC-coded products from participating natural products supermarket retailers.[1] The SPINS information has been the predominant source of information on the natural and organic industry in industry trade publications and mainstream media such as Mintel, New Hope 360, Natural Foods Merchandiser, Nutrition Business Journal, and the Wall Street Journal, even though the SPINS database does not include information of Whole Foods Market and Trader Joe's (SPINS 2014).

The Nielsen data were available for all fluid milk products in the refrigerated section. Our SPINS data included the top 100 fluid milk products sold through the natural retailers, which accounted for, on average, 80.6 percent of the total fluid milk sales in their records. To more accurately represent the relationship between fluid milk products at natural stores and those at FDM stores in the following analyses, the SPINS sales data were adjusted by the recorded share of the total amount. That is, the SPINS sales data were scaled up by a factor of approximately 1.24.[2] Only the data for 64-ounce (half gallon), nonflavored fluid milk products were considered, which is how the majority of organic fluid milk is sold. The products were grouped by fat content.

The average market shares of 64-ounce fluid milk products in our sample are shown in Table 1. The share of organic milk is much greater in this dataset than those used in the previous studies. Organic fluid milk accounted for an average of 17.4 percent of total fluid milk sales, with the weekly share increasing steadily from about 16 percent in 2008 to over 18 percent in 2010. In contrast, a half-gallon container of organic milk across all fat content levels registered 3.1 percent of the supermarket milk sales in 1999 (Glaser and Thompson 2000), and the average organic milk market share of the 12-city data used by Dhar and Foltz (2005) increased from 0.12 percent in 1997 to 0.80 percent in 2002.

The variation in market share of organic fluid milk products across fat content was distinct from that of nonorganic products. Fat-free products constituted the highest market share (5.67 percent = 5.31 percent at FDM stores + 0.36

[1] Natural products supermarket channel by SPINS includes full-format stores grossing $2 million or more in annual sales with at least 50 percent of sales from natural/organic products. These stores include co-ops, associations, independents, and large regional chains, such as Sprouts Farmers Market, Earth Fare, Natural Grocers, and National Co + op Grocers.

[2] Scaling resulted in no qualitative differences in results. Results from unscaled data are available from the authors upon request.

Table 1. Average Market Shares of 64-ounce Fluid Milk Products[a]

Outlet/	Organic		Conventional	
Fat Content	FDM[b] Stores (%)	Natural Stores (%)	FDM Stores (%)	Natural Stores (%)
Fat-free (skim)	5.31	0.36	21.32	0.05
1% (low fat)	2.73	0.33	13.64	0.04
2% (reduced fat)	4.35	0.32	27.50	0.06
Whole	3.55	0.40	20.01	0.01

[a]Sales at Walmart, Whole Foods Market, and Trader Joe's are not included in the dataset. The numbers do not sum to 100 due to the rounding error.
[b]FDM stands for food, drug, and mass merchandisers.

percent at natural stores) among organic fluid milk, whereas among conventional fluid milk, reduced-fat (2 percent milk fat) products marked the highest share of 27.6 percent. When 1% and 2% milk fat products were combined, their market share was the largest across fat content for both organic and conventional products, followed by that of fat-free products. Distribution of sales for different retail channels revealed that FDM stores were the main outlets of fluid milk, both conventional and organic, accounting for 98.4 percent of the total sales. Sales of organic fluid milk at natural stores were about 9 percent of those at the FDM stores. The conventional fluid milk sales were higher than the organic fluid milk sales at FDM stores. At natural channel, however, the sales of organic fluid milk dominated. Weekly market shares of fluid milk products were more variable in the natural outlets than in the FDM stores.

Average prices, calculated by dividing the weekly sales by quantity sold, of most 64-ounce fluid milk products were higher at natural stores than at FDM stores (Table 2). The exception was organic 1% and 2% milk. Over the sample period, the prices of conventional fluid milk products at both marketing channels decreased, while the prices of organic fluid milk at FDM stores remained relatively stable, and the prices of organic fluid milk at natural channels slightly rose. Within the respective category of organic and conventional, the prices varied by fat content. At the natural channel, products with higher fat content were generally priced higher for both organic and conventional fluid milk products. Such patterns were also observed for organic fluid milk products at the FDM channel. In contrast, among conventional products at the FDM channel, the average price of fat-free fluid milk was the highest.

Organic fluid milk products maintained large price premiums over conventional products for all fat content at both marketing channels except for whole milk at natural stores (Table 2). During our sample period, the

Table 2. Average Prices of 64-ounce Fluid Milk Products ($/half gallon)

Outlet/	Organic		Conventional	
Fat Content	FDM[a] Stores	Natural Stores	FDM Stores	Natural Stores
Fat-free (skim)	3.61	3.62	2.33	2.46
1% (low fat)	3.86	3.67	2.22	2.43
2% (reduced fat)	3.95	3.63	2.16	2.83
Whole	3.95	4.01	2.19	4.21

[a]FDM stands for food, drug, and mass merchandisers.
Note: When 1%&2% milk fat products were combined, the average prices at FDM and natural stores, respectively, for organic products were $3.91 and $3.65 per half gallon, and for conventional products were $2.18 and $2.65 per half gallon.

price premium of organic fluid milk at FDM stores ranged from 55 percent to 80 percent depending on the fat content, which is slightly higher than the 1999 numbers of 50 percent to 72 percent reported by Glaser and Thompson (2000). Price premiums at natural stores were smaller than those at FDM stores, ranging from −5 percent for whole milk to 51 percent for low fat milk. The seemingly anomalous value for whole milk most likely has resulted from the limited number of whole milk products in the acquired SPINS data.

Empirical Specification

A demand system of fluid milk differentiated by marketing channels and whether or not it was organic was specified using the almost ideal demand system (AIDS; Deaton and Muellbauer 1980), assuming that fluid milk consumption is weakly separable from consumption of other beverages and other dairy products. Both organic and conventional fluid milk were further decomposed into products with different fat content to examine possible substitution patterns among milk with various fat contents. To reduce the degree of complexity, low- and reduced-fat (1% and 2% milk fat) milk were combined and labeled as “1%&2%.” Conventional whole milk in the natural channel was excluded from the analysis due to the extremely low number of products and their unseemly prices.

The AIDS demand system consisting of 11 goods was specified as follows:[3]

[3] A quadratic AIDS model (Banks, Blundell, and Lewbel 1997) was also estimated, and the results were very similar to the results from the linear AIDS model. In particular, the quadratic terms were not statistically significant at the 5 percent level.

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log P_{jt} + \beta_i \log\left(\frac{X_t}{P_t}\right) + \delta_i T_{it} + \sum_{k=1}^{3} \varphi_{ik} D_{kt} + \varepsilon_{it},$$

where $i, j =$ {organic fat-free, organic 1%&2%, and organic whole milk at FDM stores; conventional fat-free, conventional 1%&2%, and conventional whole milk at FDM stores; organic fat-free, organic 1%&2%, and organic whole milk at natural stores; conventional fat-free and 1%&2%, milk at natural stores}. w_{it} is the share of product i in total milk expenditure in week t and was computed by dividing the sales of product i by the total milk expenditure X_t. T is the time trend; D_k is the quarterly dummy to account for seasonality; α is the intercept; γ, β, δ, and φ are parameters; and ε is the error term. P_{jt} is the weighted price ($ per half gallon) of product j, which is calculated as the sales divided by the corresponding quantity.

Following Eales and Unnevehr (1988), we defined the price index P_t as

$$\log P_t = \sum_{j=1}^{n} w_{jt-1} \log P_{jt}.$$

The lagged terms, w_{jt-1}, instead of w_{jt}, were used to address simultaneity problems. The homogeneity and symmetry conditions were imposed. To deal with the potential endogeneity of the expenditure X_t, we treated the expenditure as endogenous and used the generalized instrumental variable method. The variable $\log X_t$ was treated as a function of a set of variables including the logarithms of the Food Costs of Market Basket under the USDA Thrifty Food Plan for Family of 2 and Family of 4, a time trend, logarithm of expenditure from the previous week, and logarithm of the corn price. The predicted value of $\log X_t$ based on the auxiliary equation was used in the estimation of the demand system.[4] At beginning, the Durbin-Watson and Godfrey tests suggested that autocorrelation existed. Once we first-differenced the observations, the test results showed that autocorrelation was no longer significant. The demand system was estimated using iterative seemingly unrelated regression. Based on the estimation results and calculated elasticities, we tested Hypotheses 1 and 2 about the market demand for various differentiated fluid milk products sold through different marketing channels.

[4] A joint estimation of the $\log X_t$ equation and the demand system using the FIML estimator can be beneficial. However, given the dimension of the 11-equation demand system, we estimate the $\log X_t$ equation first and then the demand system to reduce the estimation and computation complexity in our analysis.

Estimation Results

Expenditure Elasticities

The expenditure and price elasticities were calculated using estimated parameters at the sample means and are presented in Table 3.[5] The statistical significance of the elasticity estimates was determined by a Wald test. All expenditure elasticities were statistically significant at the 1 percent level.[6]

The expenditure elasticities indicate that fluid milk products at FDM stores including organic products would not be considered as luxury goods during the sample period. Organic fat-free fluid milk at FDM stores had the highest expenditure elasticities among FDM fluid milk products, but it was not significantly different from 1 at the 5 percent significance level. Such results could be attributed to wide acceptance of organic fluid milk after almost two decades of its market development.

In contrast, organic fluid milk products at natural stores were still considered luxury products. The expenditure elasticities for all fluid milk products at natural stores were also larger than their FDM store counterparts. When a consumer's total milk expenditure increases, demand for fluid milk products at natural stores would increase relatively more, all else equal. The expenditure elasticity estimates reported here are mostly comparable to results from previous studies, which range from 0.42 to 1.60 (Gould 1996, Glaser and Thompson 2000, Dhar and Foltz 2005, Jonas and Roosen 2008, Chang et al. 2011, Choi and Wohgenant 2012, Davis et al. 2012, Schröck 2012, Chen, Saghaian, and Zheng 2016, Chen, Liu, and Rabinowitz 2017).

Within each fluid milk product group at a given marketing channel, the expenditure elasticities were inversely related to the fat content, except for organic products at natural stores. In response to an increase in total fluid milk expenditure, therefore, quantities demanded for fat-free and 1%&2%, fluid milk products would increase more than that for whole milk products, holding everything else constant.

[5] The elasticities of demand for good i with respect to price j are calculated as:

$$e_{ij} = \frac{\gamma_{ij} - \beta_i w_j}{w_i} - d_{ij}$$

where d_{ij} equals 1 when $i = j$, and 0 otherwise. The expenditure elasticity for good i is calculated as:

$$e_{iX} = 1 + \frac{\beta_i}{w_i}$$

[6] The computed Chi-square statistics ranged from 25.41 to 1004.03, where the critical value with 1 degree of freedom at the 5 percent significance level is 3.84.

Table 3. Estimated Expenditure and Own-Price Elasticities for 64-ounce Fluid Milk Products

	Expenditure Elasticity	Own-Price Elasticities	
		Compensated	Uncompensated
FDM Stores			
Organic			
Fat-free milk	1.140***	−1.405***	−1.465***
1%&2% milk	0.785***	−1.290***	−1.345***
Whole milk	0.558***	−1.180***	−1.200***
Conventional			
Fat-free milk	1.128***	−0.610***	−0.851***
1%&2% milk	1.075***	−0.762***	−1.204***
Whole milk	0.786***	−1.141***	−1.298***
Natural Stores			
Organic			
Fat-free milk	1.596***	−1.736***	−1.742***
1%&2% milk	1.737***	−1.249***	−1.260***
Whole milk	1.094***	−0.630***	−0.634***
Conventional			
Fat-free milk	1.623***	−0.855***	−0.856***
1%&2% milk	1.337***	−1.310***	−1.311***

Statistical significance at the 1 percent, 5 percent, and 10 percent levels are indicated by ***, **, and *, respectively.

Own-price Elasticities

All compensated and uncompensated own-price elasticities were statistically significant at the 1 percent level (Table 3). The uncompensated elasticities for organic fluid milk products at FDM stores and all fluid milk products at natural stores were only slightly greater in absolute magnitude than the compensated ones, indicating small income impacts. This result is not surprising because organic milk consumption is commonly perceived to be associated with groups of the population with higher income, and stereotypical shoppers at natural stores are likely income-inelastic. On the contrary, greater differences between the two sets of own-price elasticities were found for conventional fluid milk products at the FDM channel, indicating that changes in income still play a relatively more important role in demand for conventional milk than for organic milk.

Demand for all organic fluid milk products except whole milk at natural stores were own-price elastic, suggesting that lowering the price would likely lead to an increase in sales for these products. Organic fat-free products were the most sensitive to own-price changes, with uncompensated elasticity of −1.47 at the FDM and −1.74 at the natural channels, respectively. The demand for organic whole milk at the natural channel, however, was much less responsive to changes in price, with an elasticity of −0.63. Our estimates of own-price elasticities of demand for organic fluid milk were similar to those in the existing studies that examined data since the 2000s, ranging from −0.83 to −4.08 (Dhar and Foltz 2005, Alviola and Capps 2010, Chang et al. 2011, Choi and Wohgenant 2012, Chen, Saghaian, and Zheng 2016), and notably smaller than those estimated from data before 2000, ranging from −3.67 to −9.73 (Glaser and Thompson 2000). This historical progression suggests that organic products have indeed become much more mainstream. As expected, estimated elasticities using national data were greater in absolute terms than those using recent but regional data, ranging from −0.83 to −0.94 (Chang et al. 2011).

Conventional fluid milk products at FDM stores with lower fat content were less responsive to own-price changes than their organic counterparts by fat content in both compensated and uncompensated terms. This finding seems to be consistent with the results in previous studies. In the literature, the majority of own-price elasticity estimates of conventional milk range between −0.51 and −1.61 (Gould 1996, Dhar and Foltz 2005, Jonas and Roosen 2008, Monier et al. 2009, Alviola and Capps 2010, Chang et al. 2011, Schröck 2012, Chen, Saghaian, and Zheng 2016, Copeland 2016, Chen, Liu, and Rabinowitz 2017), which are smaller than most estimates for organic milk noted earlier (−0.83 to −4.08). The uncompensated demand for conventional fat-free products was own-price inelastic. In contrast to organic products, where demand for fat-free fluid milk was the most elastic, demand for fat-free fluid milk was the most inelastic among conventional products at both marketing channels.

Cross-price Elasticities

Table 4 reports the uncompensated cross-price elasticities based on the AIDS model results. Each element of the table corresponds to the change in demand for the row product, given the change in price of the column product.

Substitution effects dominated the relationship among products within the FDM channel (upper left quadrant). Conventional 1%&2%, and whole fluid milk products were substitutes. Substitution effects among different types of conventional fluid milk products were also found in previous literature (e.g., Gould 1996, Davis et al. 2012, Chen, Saghaian, and Zheng 2016, Chen, Liu, and Rabinowitz 2017). Several organic and conventional products at FDM stores were substitutes, indicating a certain level of competitiveness between organic and conventional fluid milk. Conventional 1%&2% and conventional whole milk were respective substitutes to their organic counterparts with same fat content. Conventional 1%&2% milk was also a

Table 4. Estimated Uncompensated Cross-Price Elasticities for 64-ounce Fluid Milk Products

	FDM Stores						Natural Stores				
	Organic			Conventional			Organic			Conventional	
	Fat-free	1%&2%	Whole	Fat-free	1%&2%	Whole	Fat-free	1%&2%	Whole	Fat-free	1%&2%
FDM Stores											
Organic											
Fat-free	−1.465***	0.084	0.021	−0.095	0.461***	−0.166	−0.007	0.062*	0.002	−0.018**	−0.018
1%&2%	0.081	−1.345***	0.033	−0.266*	0.492***	0.100	0.014	0.038	−0.012	0.021**	0.060***
Whole	0.063	0.081	−1.200***	0.063**	0.207	0.324*	0.084	−0.079	−0.025	0.000	−0.077***
Conventional											
Fat-free	−0.023	−0.113**	−0.010	−0.851***	−0.177	0.038	−0.004	−0.003	0.017	−0.004	0.000
1%&2%	0.063***	0.064***	0.000	−0.080	−1.204***	0.090**	−0.002	0.001	−0.008	0.001	0.000
Whole	−0.025	0.035	0.049*	0.114	0.305***	−1.298***	0.014	0.015	0.005	0.001	−0.001
Natural Stores											
Organic											
Fat-free	−0.131	0.222	0.794	−0.346	−0.460	0.605	−1.742***	−0.463**	0.058	−0.069	−0.065
1%&2%	0.470*	0.344	−0.471	−0.214	−0.217	0.272	−0.256**	−1.260***	−0.367***	−0.032	−0.005
Whole	0.027	−0.235	−0.239	0.892	−0.792	0.197	0.054	−0.590***	−0.634***	0.119**	0.107
Conventional											
Fat-free	−1.765**	2.614**	−0.045	−1.808	0.744	0.108	−0.456	−0.386	0.877**	−0.856***	−0.650**
1%&2%	−0.955	4.172***	−2.750***	0.031	−0.005	−0.335	−0.232	−0.030	0.430	−0.354***	−1.311***

Statistical significance at the 1 percent, 5 percent, and 10 percent levels are indicated by ***, **, and *, respectively.

substitute to organic fat-free milk. Other studies reported similar substitution effects between organic and conventional fluid milk products (e.g., Jonas and Roosen 2008, Alviola and Capps 2010, Chen, Saghaian, and Zheng 2016). In contrast, conventional fat-free milk and organic 1%&2% milk were complements. Cross-price elasticities within the organic product group at FDM stores were not statistically significant, indicating consumers were not willing to switch from one organic product to other organic products.

Regardless of whether organic and conventional fluid milk were substitutes or complements, the price change of a conventional product always led to a larger change in the quantity demanded for the related organic products compared with the change in demand for the conventional product resulting from the price change of the organic product. For example, a 1 percent increase in conventional 1%&2% milk price would result in a 0.49 percent increase in the demand for organic 1%&2% milk. On the other hand, a 1 percent rise in the price of organic 1%&2% milk would lead to a much smaller increase (0.06 percent) in the demand for conventional 1%&2% milk.

In the natural channel (lower right quadrant), complementary relationships prevailed within respective product groups. Organic 1%&2% milk was a complement to both organic fat-free milk and organic whole milk. Conventional fat-free milk and conventional 1%&2% milk were also complements. Within each product group, the price change of fat-free milk will cause a smaller change in demand for 1%&2% milk than vice versa. Between the product groups, conventional fat-free milk and organic whole milk were the only pair showing a statistically significant relationship with a positive cross-price elasticity.

Estimation results also suggested impacts across marketing channels (off-diagonal quadrants). Within the organic products at the two marketing channels, organic 1%&2% milk at natural channel and organic fat-free milk at FDM stores were substitutes. Several substituting relationships were also observed between conventional and organic product groups across the two marketing channels. Organic 1%&2% milk at FDM stores were substitutes for both conventional fat-free and 1%&2% products at natural stores, with much greater responses in demand for products at natural channels to changes in the prices of the products at FDM stores than vice versa. For example, a 1 percent increase in the price of organic 1%&2% milk at FDM stores would cause the demand for conventional 1%&2% milk at natural stores to rise by 4.17 percent, significantly greater than the reverse effect of 0.06 percent. In addition, organic fat-free milk at FDM stores and conventional fat-free milk at natural stores, and organic whole milk at FDM stores and conventional 1%&2% milk at natural stores were shown to be complements, again with a larger impact on demand for conventional products at natural stores in response to a price change in the respective organic product at FDM stores. Notably, no statistically significant relationships were found among demands for conventional fluid milk products sold through the two channels.

The existence of the relationship between the two marketing channels indicates relatively low degree of loyalty of shopping for specific products at a given retail outlet. When relative prices at an outlet change, consumers appear to respond with relative ease buying fluid milk products from a different venue. The cross-price demand relationships were asymmetric, with more elastic responses in the demand for conventional products at natural stores than the demand for organic products at FDM stores. That is, shoppers at natural stores would adjust their purchases of conventional products when organic prices at FDM outlets change, while demand for organic products at FDM stores stay relatively constant to changes in conventional product prices at natural stores. The observation would also be consistent with the case that when shoppers have decided to shop at natural stores, they are less likely to switch back to FDM stores even if prices at FDM stores decline. These implications align with the findings from a survey of U.S. dairy consumers that shoppers who primarily shop at natural stores identified store value and whether or not a product mix could reflect their own lifestyle and values as important factors in deciding where to shop, while price was not as important of a factor than the sample average shopper (Peterson and Li 2013).

Hypothesis Testing

The robustness of the asymmetry of cross-price relationships was tested by Wald tests. The test results are reported in Table 5, where in each row, (1) a pair of products are listed along with (2) their estimated Hicksian relationship, (3) the expenditure elasticities and (4) budget shares for each product, (5) whether or not the condition for asymmetric relationship (appendix) is met, (6) the hypothesized direction of the asymmetry, (7) the comparison of the estimated cross-price elasticities, and (8) the p-value for the significance of their differences.[7] The results for the case where products were aggregated across fat content (rows 1–2 and 11–14) were based on a four-product demand system using the AIDS model: organic and conventional products at FDM and natural stores.[8] At the disaggregated level, all pairs of products that differed in one attribute (for example, organic products sold at FDM stores that differ in fat content) are reported. For product pairs that differ in two attributes, only the pairs with statistically significant estimates of cross-price elasticities are included in the table. Magnitudes of the expenditure elasticities and budget shares were first statistically compared to see if the conditions for the asymmetric relationship held. The asymmetry between the two products was then statistically tested. The testing results show that the empirical results were consistent with analytical predictions.

[7] The hypotheses with respect to both unit change and percentage change of a price were tested. In the interest of space, only the elasticity results are reported in Table 5.

[8] The estimation results for the aggregated system are available from the authors upon request.

Table 5. Asymmetric Patterns in Estimated Cross-Price Elasticities

1		2	3			4			5	6	7			8
64-ounce Fluid Milk Products		Estimated Hicksian Relationship	Expenditure Elasticities			Budget Shares			Meets Sufficient Conditions	H_0	Asymmetry in Cross-price Elasticities			p-value
i	*j*		e_{iX}		e_{jX}	w_i		w_j			e_{ij}		e_{ji}	
Organic vs. conventional														
Aggregated across fat content														
1 Org-FDM	Conv-FDM	Subst.	0.849	<	1.019	0.159	<	0.825	Y	>	0.431	>	0.056	0.000
2 Org-natural	Conv-natural	Subst.	1.563	>	1.514	0.014	>	0.002	Y	<	0.006	<	0.056	0.835
At FDM														
3 Org-fat-free	Conv-fat-free	Subst.	1.140	>	1.128	0.053	<	0.213	N		0.095	>	0.023	0.646
4 Org-1%&2%	Conv-1%&2%	Subst.	0.785	<	1.075	0.071	<	0.411	Y	>	0.492	>	0.064	0.000
5 Org-whole	Conv-whole	Subst.	0.558	<	0.786	0.035	<	0.200	Y	>	0.324	>	0.049	0.021
6 Org-fat-free	Conv-1%&2%	Subst.	1.140	>	1.075	0.053	<	0.411	N		0.461	>	0.063	0.000
7 Org-1%&2%	Conv-fat-free	Compl.	0.785	<	1.128	0.071	<	0.213	N		0.266	>	0.113	0.084
At natural channel														
8 Org-fat-free	Conv-fat-free	Compl.	1.596	<	1.623	0.004	>	0.001	Y	<	0.069	<	0.456	0.188
9 Org-1%&2%	Conv-1%&2%	Compl.	1.737	>	1.337	0.007	>	0.001	N		0.005	<	0.030	0.928
10 Org-whole	Conv-fat-free	Subst.	1.094	<	1.623	0.004	>	0.001	N		0.119	<	0.877	0.044
Natural vs. FDM stores														
Aggregated across fat content														
11 Org-natural	Org-FDM	Subst.	1.563	>	0.849	0.014	<	0.159	N		0.137	>	0.022	0.659
12 Conv-natural	Conv-FDM	Subst.	1.514	>	1.019	0.002	<	0.825	N		0.360	>	0.000	0.038
13 Conv-natural	Org-FDM	Subst.	1.514	>	0.849	0.002	<	0.159	N		0.563	>	0.006	0.659

Continued

Table 5. Continued

1		2	3			4			5	6	7			8
64-ounce Fluid Milk Products		Estimated Hicksian Relationship	Expenditure Elasticities			Budget Shares			Meets Sufficient Conditions	H_0	Asymmetry in Cross-price Elasticities			p-value
i	j		e_{iX}		e_{jX}	w_i		w_j			e_{ij}		e_{ji}	
14 Org-natural	Conv-FDM	Subst.	1.563	>	1.019	0.014	<	0.825	N		−0.098	<	0.006	0.505
Within organic milk														
15 Fat-free-natural	Fat-free-FDM	Compl.	1.596	>	1.140	0.004	<	0.053	Y	>	0.131	>	0.007	0.765
16 1%&2%-natural	1%&2%-FDM	Subst.	1.737	>	0.785	0.007	<	0.071	N		0.344	>	0.038	0.379
17 Whole-natural	Whole-FDM	Compl.	1.094	>	0.558	0.004	<	0.035	Y	>	0.239	>	0.025	0.652
18 1%&2%-natural	Fat-free-FDM	Subst.	1.737	>	1.140	0.007	<	0.053	N		0.470	>	0.062	0.113
Within conventional milk														
19 Fat-free-natural	Fat-free-FDM	Compl.	1.623	>	1.128	0.001	<	0.213	Y	>	1.808	>	0.004	0.143
20 1%&2%-natural	1%&2%-FDM	Subst.	1.337	>	1.075	0.001	<	0.411	N		0.005	>	0.000	0.995
Between organic and conventional														
21 Conv-fat-free-natural	Org-fat-free-FDM	Compl.	1.623	>	1.140	0.001	<	0.053	Y	>	1.745	>	0.018	0.038
22 Conv-fat-free-natural	Org-1%&2%-FDM	Subst.	1.623	>	0.785	0.001	<	0.071	N		2.614	>	0.021	0.031
23 Conv-1%&2%-natural	Org-1%&2%-FDM	Subst.	1.337	>	0.785	0.001	<	0.071	N		4.172	>	0.060	0.000
24 Conv-1%&2%-natural	Org-whole-FDM	Compl.	1.337	>	0.558	0.001	<	0.035	Y	>	2.750	>	0.077	0.005
25 Org-whole-natural	Conv-fat-free-FDM	Subst.	1.094	>	1.075	0.004	<	0.213	N		0.892	>	0.017	0.133
Across fat content														
Organic milk at FDM														

26 Fat-free	1%&2%	Subst.	1.140	>	0.785	0.053	<	0.071	N		0.084	>	0.081	0.946
27 Fat-free	Whole	Subst.	1.140	>	0.558	0.053	>	0.035	Y	<	0.021	<	0.063	0.478
28 1%&2%	Whole	Subst.	0.785	>	0.558	0.071	>	0.035	Y	<	0.033	<	0.081	0.697
Conventional milk at FDM														
29 Fat-free	1%&2%	Subst.	1.128	>	1.075	0.213	<	0.411	N		0.177	>	0.080	0.103
30 Fat-free	Whole	Subst.	1.128	>	0.786	0.213	>	0.200	Y	<	0.038	<	0.114	0.120
31 1%&2%	Whole	Subst.	1.075	>	0.786	0.411	>	0.200	Y	<	0.090	<	0.305	0.000
Organic milk at natural stores														
32 Fat-free	1%&2%	Compl.	1.596	<	1.737	0.004	<	0.007	N		0.463	>	0.256	0.027
33 1%&2%	Whole	Compl.	1.737	>	1.094	0.007	>	0.004	N		0.367	<	0.590	0.010
Conventional milk at natural stores														
34 Fat-free	1%&2%	Compl.	1.623	>	1.337	0.001	<	0.001	Y	>	0.650	>	0.354	0.007

The first section of Table 5 (rows 1, 3–7) provides robust support for Hypothesis 1, suggesting that consumers who have purchased organic fluid milk products at the FDM stores are less likely to switch back to conventional fluid milk. At FDM stores, both the budget share and expenditure elasticity of organic products were smaller than those of conventional products in the aggregate, and the asymmetry in cross-price elasticities was statistically significant at the 5 percent level (row 1). The relative magnitudes of cross-price effects in several previous studies also imply asymmetric consumption pattern between organic and conventional milk (Glaser and Thompson 2000, Dhar and Foltz 2005, Jonas and Roosen 2008, Alviola and Capps 2010, Chang et al. 2011, Chen, Saghaian, and Zheng 2016). In addition, rows 4 and 5 of Table 5 show that there are similar asymmetry results for 1%&2% and whole milk products.

At natural stores, this tendency for consumers to stay with organic fluid milk could not be statistically inferred. Most cross-price elasticities were not statistically different between the pairs at the 5 percent level (rows 2, 8–10). The evidence, however, was consistent with the analytical predictions. The asymmetry prevailed in the opposite direction with organic products accounting for a larger budget share and being more expenditure elastic than conventional products at natural channels (rows 2, 8).

Hypothesis 2, suggesting the relative stickiness in demand at natural stores compared with FDM stores, was also supported by the test results. From the section on "Natural vs. FDM Stores" in Table 5 (rows 11–25), demands for fluid milk products at natural stores were more elastic with respect to price changes at FDM stores than demands for products at FDM stores with respect to price changes at natural stores (column 7). The smaller budget share of the products at natural stores underlay the stickiness in preferences for natural stores over FDM stores, even if demand at natural stores was more expenditure-elastic than at FDM stores. That is, for many cases, the condition for asymmetry is not met (column 5). Regardless, the tendency of shoppers at natural stores to continue shopping for them at natural stores instead of switching to FDM stores was statistically significant at the aggregated level (row 12). The results also suggest that consumers of conventional fluid milk products at natural stores are less likely to switch their selections to organic products at FDM stores (rows 21, 23).

The last section of Table 5 reports the results for pairs of fluid milk products with different fat content. At the natural outlet, the tendency for consumers to stay with fat-free products over 1%&2% products was observed (rows 32 and 34). In contrast, the results suggest consumers tend to maintain their demand for whole milk and not switching to products with lower fat content (rows 31 and 33).

Robustness of the Findings

The caveats noted about the linear approximate AIDS model (e.g., Buse 1994, Moschini 1995, Alston, Chalfant, and Piggott 2001) call for a robustness check of the parameter estimates. Thus, the Rotterdam demand system of 11 fluid milk products was estimated using similar steps as the AIDS model estimation including imposing the homogeneity and symmetry conditions, and using the generalized instrumental variable method to address the potential endogeneity of the expenditure.[9] The estimated expenditure elasticities and own-price elasticities were statistically significant and very similar to those from the AIDS model. The magnitude of the estimated cross-price elasticities were very close to those of the AIDS model and these elasticities had the same signs, indicating the same relationships for each product pair. The asymmetric pattern of these elasticities were same as those of the AIDS model. The results also showed stickiness of consumers to organic products over conventional products and to products at natural stores over products at FDM stores.

Concluding Discussion

Consumer demand for organic products has continued to evolve with developments of the organic food market. This study used a dataset that combined Nielsen and SPINS data to look at demands for organic and conventional fluid milk products across a more comprehensive spectrum of marketing outlets. The results showed that consumers differentiated fluid milk products by multiple attributes, including fat content, whether products were organic or conventional, and where the products were sold. Our work also illustrated the relative stickiness in demand to switch from organic fluid milk to conventional fluid milk and from natural stores to FDM stores, which was predictable from budget shares and estimated expenditure. The expected asymmetric demand patterns should be empirically validated in analyses of demands in other differentiated product markets.

The asymmetric transmission patterns between organic and conventional fluid milk products have been reflected by the continuously expanding demand for organic products. Such asymmetry also suggests the possibility of further increasing the price of organic products and premium over conventional products without jeopardizing its market penetration. In June 2010, the National Organic Program updated the pasture rule to ensure that the standards regarding access to pasture were enforceable. Greater enforcement implies higher average costs of producing organic milk. Meanwhile, closing the grazing loophole could ease consumers' concerns over organic milk and increase the demand for organic milk. Research findings such as the one that reports organic milk containing significantly higher omega-3 acid (Benbrook et al. 2013) could further boost the demand for organic milk, thus further increasing the premium. Our results suggest that

[9] The full set of results based on the Rotterdam model is available from the authors.

the impacts of increasing premium will depend on whether the price changes are universal or limited to certain marketing channels and/or to products with certain fat contents. Because of consumers' reluctance to move away from organic fluid milk products, the demand for them would continue to be strong even the prices would increase, and the organic fluid milk industry might still gain.

The asymmetry in cross-price relationships also suggests stickiness in consumers' demand regarding milk of varying fat content. While rising obesity around the world has prompted discussion about policy options for inducing switches to food with lower fat content, a "fat tax" experiment in Denmark failed in 2001. Our analysis suggests that a fat tax in the United States would similarly be ineffective. For example, a 5 percent tax imposed on all whole milk would decrease demand, but by small amounts; demand for organic whole milk at natural stores and conventional and organic whole milk at FDM stores would decrease by 3.17 percent, 6.48 percent, and 5.99 percent, respectively. On the other hand, demand for milk with lower fat content would be largely unaffected, because of the relative stickiness of whole milk to lower-fat milk products.

The distribution system of organic food has changed in the past few decades, making organic fluid milk more available across all marketing channels. Our findings clearly demonstrate that demand for the same fluid milk products at conventional and natural marketing channels is distinct. It is also likely that demands vary across different outlets within the conventional and natural outlets. The relationship between two products could be reverse at different marketing channels. For instance, the cross-price elasticity for organic 1%&2% milk and organic fat-free milk was positive and insignificant at FDM stores but negative and significant at natural stores. Therefore, marketing channels should be taken into consideration in product demand analysis. Needless to say, FDM and natural stores should be managed differently. The same marketing strategies would yield different outcomes at different marketing channels. More broadly, our findings suggest future studies to inform policy on consumer food choices and their health-related consequences should consider changes in food retailing and consumers' store choices.

References

Alviola, P.A. IV, and O. Capps Jr. 2010. "Household Demand Analysis of Organic and Conventional Fluid Milk in the United States based on the 2004 Nielsen Homescan Panel." *Agribusiness* 26: 369–388.

Alston, J.M., J.A. Chalfant, and N.E. Piggott. 2001. "Incorporating Demand Shifters in the Almost Ideal Demand System." *Economics Letters* 70(1): 73–78.

Banks, J., R. Blundell, and A. Lewbel. 1997. "Quadratic Engel Curves and Consumer Demand." *The Review of Economics and Statistics* 79: 527–539.

Benbrook, C.M., G. Butler, M.A. Latif, C. Leifert, and D.R. Davis. 2013. "Organic Production Enhances Milk Nutritional Quality by Shifting Fatty Acid Composition: A United States–

Wide, 18-Month Study." *PLoS One* 8(12): e82429. Available at https://doi.org/10.1371/journal.pone.0082429.

Bond, J.K., D. Thilmany, and C.A. Bond. 2006. "Direct Marketing of Fresh Produce: Understanding Consumer Purchasing Decisions." *Choices* 21: 229–235.

Budgar, L. 2006. "Convenience and Health Drive Natural Food Sales." *The Natural Foods Merchandiser*, 36: 38–39.

Buse, A. 1994. "Evaluating the Linearized Almost Ideal Demand System." *American Journal of Agricultural Economics* 76(4): 781–793.

Carpenter, J.M., and M. Moore. 2006. "Consumer Demographics, Store Attributes, and Retail Format Choice in the US Grocery Market." *International Journal of Retail and Distribution Management* 34: 434–452.

Chang, C., N.H. Hooker, E. Jones, and A. Sam. 2011. "Organic and Conventional Milk Purchase Behaviors in Central Ohio." *Agribusiness* 27: 311–326.

Chen, B., S.H. Saghaian, and Y. Zheng. 2016. "Organic Labeling, Private Label, and US Household Demand for Fluid Milk." SSRN paper. Available at https://doi.org/10.2139/ssrn.2876119.

Chen, X., Y. Liu, and A.N. Rabinowitz. 2017. "Private Labels Competition, Retail Pricing and Bargaining Power: The Case of Fluid Milk Market." Selected Paper at the Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama.

Choi, H.J., and M. Wohlgenant. 2012. "Demand Analysis of Fluid Milk with Different Attributes." Selected Paper at the Agricultural & Applied Economics Association Annual Meeting, Seattle, WA.

Copeland, A.M. 2016. "*Consumer Demand for Conventional Fluid Milk and Selected Dairy Alternative Beverages in the United States*." Master's thesis, Department of Agricultural Economics, Texas A & M University, College Station, TX.

Davis, C.G., D. Dong, D. Blayney, S.T. Yen, and R. Stillman. 2012. "U.S. Fluid Milk Demand: A Disaggregated Approach." *International Food and Agribusiness Management Review* 15: 25–50.

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

Dhar, T., and J.D. Foltz. 2005. "Milk by Any Other Name … Consumer Benefits from Labeled Milk." *American Journal of Agricultural Economics* 87: 214–228.

Dimitri, C., and C. Greene. 2002. *Recent Growth Patterns in the U.S. Organic Foods Market.* Agricultural Information Bulletin No. 777, U.S. Department of Agriculture, Economics Research Service, Washington, DC, September.

Dimitri, C., and K.M. Venezia. 2007. "Retail and Consumer Aspects of the Organic Milk Market." *Outlook* No. (LDPM-155-01), U.S. Department of Agriculture, Economics Research Service, Washington, DC, May.

Dong, D., and H. Stewart. 2012. "Modeling a Household's Choice among Food Store Types." *American Journal of Agricultural Economics* 94: 702–717.

Eales, J.S. and L.J. Unnevehr. 1988. "Demand for Beef and Chicken Products: Separability and Structural Change." *American Journal of Agricultural Economics* 70: 521–532.

Fox, E.J., A.L. Montgomery, and L.M. Lodish. 2004. "Consumer Shopping and Spending across Retail Formats." *The Journal of Business* 77: S25–S60.

Glaser, L.K., and J.D. Thompson. 2000. "Demand for Organic and Conventional Beverage Milk." Paper presented at Western Agricultural Economic Association Annual Meeting, Vancouver, British Columbia.

Gould, B.W. 1996. "Factors Affecting U.S. Demand for Reduced-Fat Fluid Milk." *Journal of Agricultural and Resource Economics* 21: 68–81.

Hansen, K., and V. Singh. 2009. "Market Structure Across Retail Formats." *Marketing Science* 28: 656–673.

Hsieh, M.-F., and K.W. Stiegert. 2011. "Store Format Choice in Organic Food Consumption." *American Journal of Agricultural Economics* 94: 307–313.

Jonas, A., and J. Roosen. 2008. "Demand for Milk Labels in Germany: Organic Milk, Conventional Brands, and Retail Labels." *Agribusiness* 24: 192–206.
Maltby, E. 2013. *Organic Pay and Retail Price Update for November* 2013. Northeast Organic Dairy Producers Alliance. Available at http://www.nodpa.com/payprice_update_11182013.shtml.
Monier, S., D. Hassan, V. Nichèle, and M. Simioni. 2009. "Organic Food Consumption Patterns." *Journal of Agricultural & Food Industrial Organization* 7(2): 1–25.
Moschini, G. 1995. "Units of Measurement and the Stone Index in Demand System Estimation." *American Journal of Agricultural Economics* 77(1): 63–68.
Neuman, W. 2011. "As Supply Dwindles, Organic Milk Gets Popular." *The New York Times*, December 29.
Oberholtzer, L., D. Dimitri, and C. Greene. 2005. "Price Premiums Hold on as U.S. Organic Produce Market Expands." *Outlook* No. (VGS-30801), U.S. Department of Agriculture, Economics Research Service, Washington, DC.
Organic Trade Association. 2010. "2010 Organic Industry Overview." Available at http://www.ota.com/pics/documents/2010OrganicIndustrySurveySummary.pdf.
———. 2011. "2011 Organic Industry Overview." Available at http://www.ota.com/pics/documents/2011OrganicIndustrySurvey.pdf.
———. 2013. "Eight in Ten U.S. Parents Report They Purchase Organic Products." Available at https://www.ota.com/news/press-releases/17124.
———. 2016. "U.S. organic sales post new record of $43.3 billion in 2015." Available at https://www.ota.com/news/press-releases/19031.
Peterson, H.H., and X. Li. 2013. "Retail Outlet Selection and Preferences for Private Labels: The Case of Milk." Selected Paper at the Western Agricultural Economics Association annual meeting, Monterey, CA.
Roberts, W. "Organic Food and Beverage Shoppers – US – March 2015." Retrieved from Mintel database.
Schröck, R. 2012. "The Organic Milk Market in Germany Is Maturing: A Demand System Analysis of Organic and Conventional Fresh Milk Segmented by Consumer Groups." *Agribusiness* 28: 274–292.
SPINS. 2013. "Double Digit Certified Organic Growth." Available at http://www.spins.com/double-digit-growth-for-organic-products.
———. 2014. "SPINS in the News." 2014. Available at http://www.spins.com/news/spins-in-the-news/.
Thompson, G.D., and J. Kidwell. 1998. "Explaining the Choice of Organic Produce: Cosmetic Defects, Prices, and Consumer Preferences." *American Journal of Agricultural Economics* 80: 277–287.
U.S. Department of Agriculture, Agricultural Marketing Service. 2017. Estimated Fluid Milk Products Sales Report, Dairy Programs Market Information Branch, various issues.
U.S. Department of Agriculture, Economic Research Service. 2013. "Table 2. U.S. certified organic farmland acreage, livestock numbers, and farm operations." Available at https://www.ers.usda.gov/data-products/organic-production/.

Appendix: Conditions of Asymmetric Cross-Price Patterns

Let us consider consumer demand for differentiated products of a basic good, where there are n different varieties of the good and the products are normal goods. The uncompensated consumer demand for product i ($i = 1, 2, \ldots, n$) can be represented as $Q_i = f_i(\boldsymbol{P}, X; \boldsymbol{Z})$, where $\boldsymbol{P}$ is a vector of the prices of all n products, X is the total expenditure, and $\boldsymbol{Z}$ is a vector of other demand shifters. The compensated consumer demand for product i is $h_i = h_i(\boldsymbol{P}, U; \boldsymbol{Z})$, where U is the consumer utility. For any two varieties, it is a straightforward exercise to derive and compare how the consumer demand for one product will change in response to a price change of the other product. The results can be summarized as below:

For any two differentiated products (i, j = 1, 2, ..., n), the change in demand for one product in response to a price change of another product is asymmetric under certain conditions. The asymmetry can occur in two forms depending on whether two products are substitutes or complements.

When two products are substitutes:

(1) The demand increase for product i in response to a one-unit price increase of product j is greater than the demand increase for product j in response to a one-unit price increase of product i, if product i has a smaller income elasticity than product j;

(2) The asymmetry of the cross-price effects in terms of percentage changes (i.e., the cross-price elasticities of demand) depends on the magnitudes and directions of the effects caused by two factors: the difference between the income elasticities and the difference between the budget shares of two products.

(a) If product i has a smaller income elasticity than product j, ceteris paribus, the elasticity of demand for product i with respect to the price of product j is greater than the elasticity of demand for product j with respect to the price of product i,

(b) If product i has a smaller budget share than product j, ceteris paribus, the elasticity of demand for product i with respect to the price of product j is greater than the elasticity of demand for product j with respect to the price of product i.

(c) If product i has a smaller (larger) income elasticity and a larger (smaller) budget share than product j, the asymmetry of the cross-price effects in terms of elasticities depends on the relative magnitudes of the two opposite effects caused by the difference between the income elasticities and the difference between the budget shares of two products.

When two products are complements:

(1′) The demand decrease for product i in response to a one-unit price increase of product j is greater than the demand decrease for product j in response to a one-unit price increase of product i, if product i has a larger income elasticity than product j;

(2′) The asymmetry of the cross-price effects in terms of percentage changes (i.e., the cross-price elasticities of demand) depends on the magnitudes and directions of the effects caused by two factors: the difference

between the income elasticities and the difference between the budget shares of two products.

(a) *If product i has a larger income elasticity than product j, the elasticity of demand for product i with respect to the price of product j is greater in absolute terms than the elasticity of demand for product j with respect to the price of product i.*

(b) *If product i has a smaller budget share than product j, the elasticity of demand for product i with respect to the price of product j is greater in absolute terms than the elasticity of demand for product j with respect to the price of product i.*

(c) *If product i has a larger (smaller) income elasticity and a larger (smaller) budget share than product j, the asymmetry of the cross-price effects in terms of elasticities depends on the relative magnitudes of the two opposite effects caused by the difference between the income elasticities and the difference between the budget shares of two products.*

PROOF: First let us define the income elasticities as $e_{iX} = (\partial f_i/\partial X)(X/Q_i)$ because the products under consideration are normal goods, the price elasticities as $e_{ij} = (\partial f_i/\partial P_j)(P_j/Q_i)$, and the budget shares as $w_i = (P_i Q_i/X)$ for $i, j = 1, 2, \ldots, n$.

Two products are substitutes

If product i and j are substitutes,

(A1)
$$\frac{\partial h_i}{\partial P_j} = \frac{\partial h_j}{\partial P_i} > 0.$$

If product i has a smaller income elasticity than product j, we have

(A2)
$$e_{iX} = \frac{\partial f_i}{\partial X}\frac{X}{Q_i} < e_{jX} = \frac{\partial f_j}{\partial X}\frac{X}{Q_j}.$$

Using (A1) and (A2), we find

$$\frac{\partial f_i}{\partial P_j} = \frac{\partial h_i}{\partial P_j} - Q_j\frac{\partial f_i}{\partial X} = \frac{\partial h_j}{\partial P_i} - \frac{Q_i Q_j}{X}\frac{\partial f_i}{\partial X}\frac{X}{Q_i} > \frac{\partial h_j}{\partial P_i} - \frac{Q_i Q_j}{X}\frac{\partial f_j}{\partial X}\frac{X}{Q_j} = \frac{\partial h_j}{\partial P_i} - Q_i\frac{\partial f_j}{\partial X} = \frac{\partial f_j}{\partial P_i}.$$

Thus, the demand increase for product i in response to a one-unit price increase of product j is greater than the demand increase for product j in response to a one-unit price increase of product i, i.e. $(\partial f_i/\partial P_j) > (\partial f_j/\partial P_i)$.

Then, if either product i has a smaller income elasticity ($e_{iX} < e_{jX}$) or product i has a smaller budget share than product j ($w_i = (P_iQ_i/X) < (P_jQ_j/X) = w_j$), we can obtain

$$e_{ij} = \frac{\partial f_i}{\partial P_j}\frac{P_j}{Q_i} = \frac{\partial f_i}{\partial P_j}\frac{P_jQ_j}{X}\frac{X}{Q_iQ_j} > \frac{\partial f_j}{\partial P_i}\frac{P_iQ_i}{X}\frac{X}{Q_iQ_j} = \frac{\partial f_j}{\partial P_i}\frac{P_i}{Q_j} = e_{ji}.$$

Thus, the elasticity of demand for product i with respect to the price of product j is greater than the elasticity of demand for product j with respect to the price of product i, i.e. $e_{ij} > e_{ji}$

If product i has a smaller income elasticity ($e_{iX} < e_{jX}$) and a larger budget share than product j ($w_i = (P_iQ_i/X) > (P_jQ_j/X) = w_j$), we have

(A3) $$e_{ij} - e_{ji} = \left(\frac{\partial f_i}{\partial P_j} - \frac{\partial f_j}{\partial P_i}\right)\frac{P_j}{Q_i} - \frac{\partial f_j}{\partial P_i}\frac{X}{Q_iQ_j}\left(\frac{P_iQ_i}{X} - \frac{P_jQ_j}{X}\right)$$

So, the direction and magnitude of the asymmetry (i.e., the sign and magnitude of $e_{ij} - e_{ji}$) depend on the relative magnitudes of the two terms of the right-hand-side of (A3), which are the two opposite effects caused by the difference in income elasticity and the difference in budget share. A similar analysis applies to the case when product i has a larger income elasticity ($e_{iX} > e_{jX}$) and a smaller budget share than product j ($w_i = (P_iQ_i/X) < (P_jQ_j/X) = w_j$).

Two products are complements

If product i and j are complements,

(A4) $$\frac{\partial h_i}{\partial P_j} = \frac{\partial h_j}{\partial P_i} < 0.$$

If product i has a larger income elasticity than product j, we have

(A5) $$e_{iX} = \frac{\partial f_i}{\partial X}\frac{X}{Q_i} > e_{jX} = \frac{\partial f_j}{\partial X}\frac{X}{Q_j}.$$

Using (A4) and (A5), we find

$$\left|\frac{\partial f_i}{\partial P_j}\right| = \left|\frac{\partial h_i}{\partial P_j} - Q_j\frac{\partial f_i}{\partial X}\right| = \left|\frac{\partial h_j}{\partial P_i} - \frac{Q_iQ_j}{X}\frac{\partial f_i}{\partial X}\frac{X}{Q_i}\right| > \left|\frac{\partial h_j}{\partial P_i} - \frac{Q_iQ_j}{X}\frac{\partial f_j}{\partial X}\frac{X}{Q_j}\right|$$
$$= \left|\frac{\partial h_j}{\partial P_i} - Q_i\frac{\partial f_j}{\partial X}\right| = \left|\frac{\partial f_j}{\partial P_i}\right|.$$

Thus, the demand decrease for product i in response to a one-unit price increase of product j is greater than the demand decrease for product j in response to a one-unit price increase of product i, i.e. $|\partial f_i/\partial P_j| > |\partial f_j/\partial P_i|$.

Then, if either product i has a larger income elasticity ($e_{iX} > e_{jX}$) or product i has a smaller budget share than product j ($w_i = (P_iQ_i/X) < (P_jQ_j/X) = w_j$), we can obtain

$$|e_{ij}| = \left|\frac{\partial f_i}{\partial P_j}\frac{P_j}{Q_i}\right| = \left|\frac{\partial f_i}{\partial P_j}\frac{P_jQ_j}{X}\frac{X}{Q_iQ_j}\right| > \left|\frac{\partial f_j}{\partial P_i}\frac{P_iQ_i}{X}\frac{X}{Q_iQ_j}\right| = \left|\frac{\partial f_j}{\partial P_i}\frac{P_i}{Q_j}\right| = |e_{ji}|.$$

Thus, the elasticity of demand for product i with respect to the price of product j is greater in absolute terms than the elasticity of demand for product j with respect to the price of product i, i.e., $|e_{ij}| > |e_{ji}|$.

If product i has a larger income elasticity ($e_{iX} > e_{jX}$) and product i has a larger budget share than product j ($w_i = (P_iQ_i/X) > (P_jQ_j/X) = w_j$), we have

(A6)
$$|e_{ij}| - |e_{ji}| = \left[\left|\frac{\partial f_i}{\partial P_j}\right| - \left|\frac{\partial f_j}{\partial P_i}\right|\right]\frac{P_j}{Q_i} - \left|\frac{\partial f_j}{\partial P_i}\right|\frac{X}{Q_iQ_j}\left(\frac{P_iQ_i}{X} - \frac{P_jQ_j}{X}\right).$$

So, the direction and magnitude of the asymmetry (i.e., the sign and magnitude of $e_{ij} - e_{ji}$) depend on the relative magnitudes of the two terms of the right-hand side of (A6), which are the two opposite effects caused by the difference in income elasticity and the difference in budget share. A similar analysis applies to the case when product i has a smaller income elasticity ($e_{iX} < e_{jX}$) and a smaller budget share than product j ($w_i = (P_iQ_i/X) < (P_jQ_j/X) = w_j$).