Demand for Organic and Conventional Frozen Vegetables

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Abstract: In this paper, we examine retail sales of organic and conventional frozen vegetables (broccoli, green beans, green peas, and sweet corn) using supermarket scanner data. Descriptive analysis includes comparisons of sales volume, prices, and market shares. Price and expenditure elasticities are estimated using the almost ideal demands system (AIDS).

Key words: organic foods, frozen vegetables, almost ideal demand system.

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The availability of organic foods expanded in the 1990's, partially spurred by the growth of natural-product supermarkets such as Whole Foods and Wild Oats. Mainstream supermarkets also introduced or increased organic product lines in response to retail competition and consumer demand. It is no longer unusual for large-scale supermarkets in metropolitan areas to carry some fresh and/or processed organic products.

Industry sources estimate that distributor sales of organic products grew from $1 billion in 1990 to $3.5 billion in 1996 (Raterman). Recent studies have gathered more detail on the market in 1997 (Scott). One study indicates that organic food sales in natural-product stores totaled $1.96 billion in 1997, with organic produce and frozen foods accounting for $317.8 million and $198.5 million, respectively. Another study reports survey results showing organic produce sales at natural and mainstream grocery stores topped $670 million. Industry experts predict that the organic foods industry will grow to $6 billion by the year 2000 (Brandt).

In this paper, we examine and compare the demand for organic and conventional frozen vegetables using national supermarket scanner data. Price and expenditure elasticities for these frozen vegetables are estimated using the almost ideal demands system (AIDS).

Previous Studies

Most previous studies of the demand for organic foods have measured attitudes rather than actual purchases. As an indication of such attitudes, these studies often elicit willingness to pay for organic or pesticide-free products relative to conventional counterparts. Moreover, these studies have generally focused on fresh produce. Only in the last few years have researchers

broadened their scope of analysis to include other organic foods. Thompson (1998) recently reviewed this highly disparate group of academic and industry studies.

The lack of accessible data on retail sales probably accounts for the emphasis on consumer self reporting. Time series of supermarket scanner data long enough to permit econometric analysis do exist for processed products, but the data are expensive. Data on variable-weight products, such as fresh fruit and vegetables, are limited. Only in the last year or so have firms begun to collect and sell data on variable-weight products and only for selected metropolitan areas.

Frozen Vegetable Use and Supermarket Sales Data

Frozen vegetables, other than potatoes, account for a small portion of the vegetables Americans consume. During the last decade, vegetables used for freezing (excluding potatoes) accounted for about 8% of per capita use on a farm-weight basis (Lucier). Vegetable processors pack frozen vegetables for three markets: retail grocery stores, restaurants and other foodservice firms, and institutional buyers, such as hospitals and prisons. On a volume basis (and excluding repacked bulk frozen products), retail stores received only about one-third of frozen vegetables (excluding potatoes) packed in recent years (*1997 Frozen Food Pack Statistics*).

To examine the retail market for frozen vegetables, we analyzed U.S. monthly supermarket scanner data from AC Nielsen Marketing Research for the period September 1990 to December 1996. The data were collected from approximately 3,000 supermarkets with annual sales of $2 million or more and represent about 83% of the U.S. retail food market, excluding fresh meat and produce. Neilsen uses the industry definition of a supermarket: a grocery store with dairy, produce, fresh meat, package food, and nonfood departments and annual sales of $2

million or more. Sales from health food stores and food cooperatives were not included in the data.

This analysis focused on four categories of processed frozen vegetables: broccoli, green beans, green peas, and sweet corn (excluding corn on the cob). Frozen vegetables used in soups and other prepared foods were not included. We contacted manufacturers listed in the dataset who identified their products as organic or conventional. Not all known organic manufactures appeared in the data, possibly because of their limited size and/or regional scope of operation. Generic and store brands were excluded from the analysis because we could not determine whether they were organic or conventional.

We also organized the data into similar types of frozen vegetables. Based on the characteristics of the organic products in the dataset, we chose the following designations: cut broccoli, regular cut green beans, regular green peas, and regular and golden sweet corn. Thus, we were able to compare market share and retail prices of like products.

Supermarket Sales of Frozen Organic Vegetables

Summary statistics for the frozen vegetables are presented in Table 1. The first organic brands to appear in the data were introduced in September 1990. When viewed on an annual basis, volume sales of organic frozen broccoli, green beans, green peas, and sweet corn increased during the period, particularly in 1995 and 1996. However, organic sales decreased in 1992. On average, during 1991-96, sales of the four organic frozen vegetables increased 58.4% per year in volume and 67.8% in value. Volume sales of conventional frozen vegetables showed no clear trend over the period. From 1991-96, sales growth was either negative or in the single digits. Additional detail about market shares, etc. can be found in Glaser et al.

Table 1. Summary Statistics for Selected Frozen Vegetables[1]

	Broccoli	Sweet Corn	Green Peas	Green Beans
Supermarket Prices		*(Nominal $ per 16 oz. Unit)*		
Average Organic Price				
1991	2.59	2.06	2.51	2.31
1992	2.91	2.38	2.87	2.58
1993	3.28	3.03	3.69	3.28
1994	3.46	3.03	3.89	3.26
1995	3.28	2.86	3.75	3.06
1996	3.11	2.72	3.53	2.88
Average Conventional Price				
1991	1.12	1.09	1.08	1.04
1992	1.10	1.03	1.04	1.00
1993	1.09	1.06	1.04	0.99
1994	1.12	1.10	1.06	1.04
1995	1.14	1.32	1.06	1.04
1996	1.18	1.39	1.07	1.05
Mean[2]				
Organic Price	3.06	2.63	3.31	2.85
Conventional Price	1.12	1.16	1.07	1.03
Organic Premium	172.1%	125.8%	209.7%	175.7%
Standard Deviation				
Organic Price	0.38	0.44	0.61	0.44
Conventional Price	0.02	0.13	0.02	0.03
t-Statistic for Equality of Means	44.54	27.71	31.83	35.86
Supermarket Sales Volume		*(Number of 16 oz. Equivalent Units)*		
Organic				
1991	1,524	7,053	7,685	3,700
1992	1,205	5,158	5,066	2,109
1993	5,329	5,821	8,009	4,506
1994	6,042	16,557	16,851	8,107
1995	11,452	30,418	36,898	12,975
1996	18,906	45,196	58,451	20,010
Conventional				
1991	26,292,928	39,588,597	18,804,061	20,853,172
1992	23,745,119	37,174,631	17,688,540	19,574,812
1993	23,820,420	38,398,153	18,469,051	19,723,856
1994	22,886,923	36,603,594	17,924,991	19,054,879
1995	23,372,042	38,925,663	17,794,938	20,455,993
1996	21,619,154	41,197,350	17,431,506	20,473,956
Total[2]				
Organic	44,878	111,152	133,882	51,687
Conventional	165,693,042	265,795,608	126,436,299	139,322,479
Organic Share	0.03%	0.04%	0.11%	0.04%

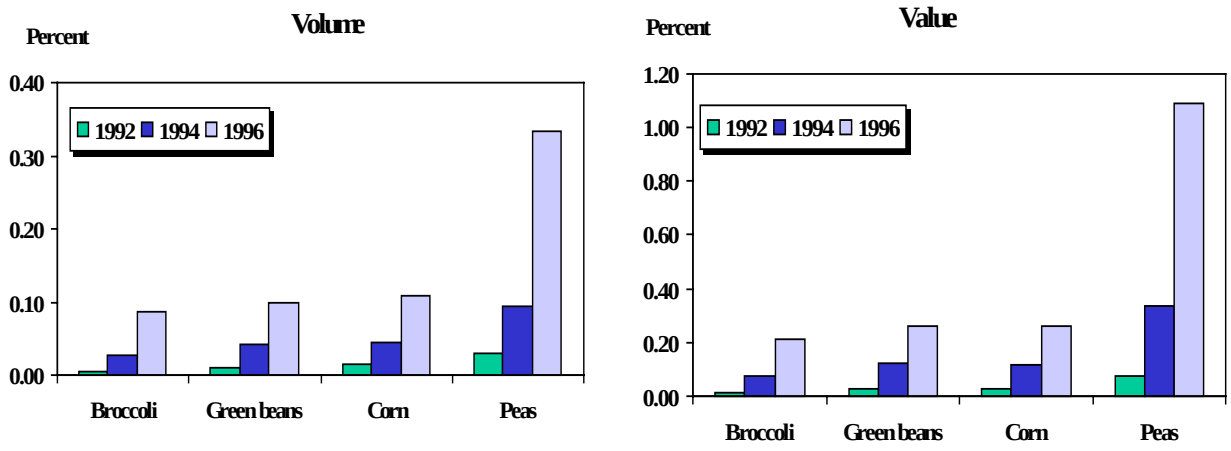
[1] Statistics are for sales from identified manufacturers and of selected types (cut broccoli, regular and golden sweet corn, Regular green peas, and regular cut green beans. [2] For the period September 1990 to December 1996.

Source: AC Nielsen Marketing Research.

Although increases in the sales of organic frozen vegetables have been quite dramatic, supermarket sales of these organic products are dwarfed by sales of their conventional counterparts. Organic frozen vegetables accounted for less than 1% of sales value during the study period. The one exception was green peas, which reached a 1.1% share of sales value in 1996 (Figure 1). All of the other organic vegetables held less than 0.4% of the market when measured in value terms. On a volume basis, organic products accounted for an even smaller part of supermarket sales. In 1996, green peas had the highest volume share at 0.33%, while the rest of the organic vegetables had less than 0.1% each.

Figure 1

Organic Market Share of Supermarket Sales[1]



[1] Based on total sales from products with identified manufacturers and of selected types (cut broccoli, regular and golden corn, regular cut green beans, and regular green peas). Value measured in dollars and volume in pounds.

Source: AC Nielsen Marketing Research.

Small market shares occurred because, even in 1996, frozen organic vegetables were available in only a small percentage of the roughly 3,000 stores from which Neilsen collects data. Availability did increase over the sample period, however. Organic green peas were sold in the highest percentage of stores, reaching 4% in December 1996. Organic sweet corn increased from

1% or less in 1991-94 to 3% in the fall of 1996. Organic broccoli and green beans were sold in 2% of stores during the last few months of 1996.

Organic Price Premia

From September 1990, when data on organic frozen vegetables first appeared in the Nielsen dataset, nominal supermarket prices of organic frozen broccoli, sweet corn, green beans, and green peas generally increased to the end of 1993. Prices leveled off in 1994, declined in 1995, and leveled off again in 1996. In comparison, prices of their conventional counterparts stayed relatively stable over the time period, ranging roughly between $1.00 and $1.40 per pound.

Organic frozen vegetables were appreciably more expensive than their conventional counterparts. In several years, the price premia ranged between 100% and 250% of conventional prices. As with the organic prices, the premia increased until 1993 or 1994 and declined slightly in 1995 and 1996. Since all organic manufacturers are not represented in the data, it is unclear how much of the recent decline in prices is due to increased competition. Lower prices might also reflect lower per-unit production and distribution costs resulting from greater organic output and returns to scale.

The foregoing description of organic frozen vegetables reveals interesting national trends: a small but growing market share, sizable but declining price premia, and limited but expanding availability in mainstream supermarkets. How these trends affect price and expenditure elasticities has not been previously analyzed. We now turn to the estimation of these elasticities.

Econometric Estimation and Inference

For purposes of estimation, the system of frozen vegetables—broccoli, sweet corn, green peas, and green beans—is assumed to be weakly separable from other food products consumed at- and away-from home. The almost ideal demand system (AIDS) was employed to model the system of demand equations, namely

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_t / P_t) \qquad t = 1, 2, \ldots, T \tag{1}$$

where w_{it} denotes the share of the i^{th} frozen vegetable in the t^{th} period ($w_{it} \equiv p_{it} q_{it} / x_t$), p_{jt} and q_{jt} represents the price and quantity of j^{th} frozen vegetable, x_t represents total expenditure on frozen vegetables ($x_t \equiv \sum_j p_{jt} q_{jt}$), and P_t is defined as $\ln P_t = \alpha_0 + \sum_k \gamma_{kt} \ln p_{kt} + \sum_k \sum_\lambda \gamma_{k\lambda} \ln p_{kt} \ln p_{\lambda t}$. If organic and conventional types of all four vegetables were included in a single system, there would be eight goods in (1). The eight-good system was initially considered but some of the cross-price elasticities are of questionable meaning and use; for example, the cross-price elasticity between organic peas and conventional corn seems of limited interest. Instead, each pair of organic and conventional vegetables was included with all other frozen vegetables grouped into a composite commodity, resulting in a three-good system for each vegetable. Because frozen vegetables may be stored for an extended period, an ordinary demand system in which quantities consumed are conditioned by prices was chosen instead of an inverse demand system (Eales et al.).

Both conventional and organic frozen vegetables display pronounced seasonality with month-to-month changes in volume sold in excess of 100% in some cases. Dummies for the months of March and December were included in each share equation to account for seasonal

spikes in sales. A linear trend was also included in each organic share equation to reflect rapid growth in sales.

The nonlinear AIDS model rather than the linear approximation to the AIDS model was estimated because of the deficiencies in using the latter (Hahn). The usual conditions for consistency of the AIDS model with consumer theory were tested and imposed. The conditions are: (i) adding-up, $\sum_i \alpha_i = 1$, $\sum_i \gamma_{ij} = 0$, and $\sum_i \beta_i = 0$; (ii) homogeneity, $\sum_j \gamma_{ij} = 0$; and (iii) symmetry, $\gamma_{ij} = \gamma_{ji}$. Likelihood ratio tests corrected for size (De Boer and Harkema) provided mixed evidence for rejecting all three conditions jointly. The p-values for the χ^2 statistics were: broccoli, 0.00; corn, 0.05; green beans, 0.13, green peas, 0.28. Despite the mixed evidence, the conditions were imposed. Negativity at the sample mean was verified by examining the eigenvalues of $k_{ij}=p_i p_j s_{ij}/x$ (Deaton and Muellbauer). Hypothesis tests failed to reveal any serious evidence of system-wide autocorrelation or non-normal residuals. Given the foregoing test results, the nonlinear AIDS model seems a reasonable specification.

Uncompensated price and expenditure elasticities are presented in Table 2. Own-price response for organic vegetables is much larger at the sample mean than for conventional counterparts: twice as large for broccoli and three times greater for green beans. Organic own-price elasticities ranged from -1.630 to -2.268, indicating that small changes in the prices of organic frozen vegetables elicit very large changes in quantities purchased. Such large own-price response is perhaps not surprising given that organic frozen vegetables were newly introduced items with a thin market share. When elasticities were evaluated at average values for the last 12 months of the sample (1996), own-price elasticities for organic vegetables uniformly declined in absolute value while the own-price elasticities for conventional vegetables remained nearly identical. The decline in own-price response

Table 2. Uncompensated Elasticities and Standard Errors at Sample Mean and 1996 Values

	Mean of Sample (Sept-1990 to Dec-1996)					
	Broccoli			**Corn**		
	Organic	Conventional	Expenditure	Organic	Conventional	Expenditure
Organic[1]	-2.268 *	0.636	1.131 *	-1.630 *	2.437 *	0.778 *
	(0.452)	(0.542)	(0.132)	(0.330)	(0.687)	(0.098)
Conventional	0.535 *	-1.043 *	0.857	0.002 *	-0.102	1.158 *
	(0.002)	(0.566)	(0.712)	(0.001)	(0.061)	(0.048)
	Green Peas			**Green Beans**		
	Organic	Conventional	Expenditure	Organic	Conventional	Expenditure
Organic	-1.906 *	0.446	1.489 *	-2.181 *	0.836	1.123 *
	(0.276)	(2.233)	(0.155)	(0.283)	(2.318)	(0.401)
Conventional	0.001	-0.299	0.892 *	0.001	-0.596 *	1.113 *
	(0.004)	(0.256)	(0.006)	(0.003)	(0.206)	(0.037)
	Mean of 1996 (Jan-1996 to Dec-1996)					
	Broccoli			**Corn**		
	Organic	Conventional	Expenditure	Organic	Conventional	Expenditure
Organic	-1.511 *	0.256	1.053 *	-1.259 *	0.999 *	0.909 *
	(0.182)	(0.798)	(0.053)	(0.136)	(0.283)	(0.040)
Conventional	0.001	-1.048	0.834 *	0.002 *	-0.241 *	1.133 *
	(0.002)	(0.655)	(0.083)	(0.001)	(0.048)	(0.041)
	Green Peas			**Green Beans**		
	Organic	Conventional	Expenditure	Organic	Conventional	Expenditure
Organic	-1.342 *	0.169	1.184 *	-1.509 *	0.360	1.053 *
	(0.104)	(0.842)	(0.058)	(0.122)	(0.999)	(0.173)
Conventional	0.001	-0.213	0.879 *	0.001	-0.592 *	1.114 *
	(0.005)	(0.287)	(0.007)	(0.003)	(0.208)	(0.037)

[1] Standard errors, which were calculated using procedures in Krinsky and Robb, are in parentheses.

* Absolute value of ratio of elasticity to standard error exceeds 1.75.

at the end of the sample period has a number of plausible interpretations. First, as some consumers become more familiar with organic frozen vegetables and expect them to be more widely available, their sensitivity to price changes may become dulled. Purchases of novelty items like newly introduced organic frozen vegetables were likely sensitive to relatively high prices. Second, as nominal prices for organic frozen vegetables began to decline in 1995 and 1996, own-price responses also appear to have moderated.

Most cross-price elasticities had relatively large standard errors. Only the cross-price elasticities for corn and conventional quantity-organic price broccoli are statistically distinguishable

from zero. Perhaps not coincidentally, the price premium for organic corn was appreciably lower (125.8%) than price premiums for the other three organic vegetables (172.1% and higher). Despite large standard errors, there appears to be a tendency toward asymmetry in cross-price responses: changes in organic quantities as conventional prices change are larger than changes in conventional quantities as organic prices change. One interpretation of this asymmetry would be that consumers currently buying conventional vegetables will cross over to organics if relative prices change whereas consumers currently buying organics are much less likely to "revert" to conventional counterparts. The general lack of statistical precision may suggest that cross-over purchases—conventional to organic or the converse—were not widespread as the very small market share of organic vegetables suggests.

If some consumers self select in the sense that they either buy an organic or a conventional frozen vegetable but do not compare relative prices, cross-price elasticities would be small. For those consumers for whom price matters, with organic prices so high relative to conventional counterparts, the extent of "crossing-over" from conventional to organic frozen vegetables was practically nil. A contributing factor to the weak evidence for substitution of organic for conventional frozen vegetables is that the retail venues where newly organic frozen vegetables were first introduced were often separate from mainstream supermarkets where the vast majority of consumers shopped. Even when newly introduced organic food items were available in the same supermarket, they were often not displayed prominently nor advertised extensively, making comparisons between organic and conventional frozen vegetables difficult for all but the most ardent organic shoppers who purposefully sought out such foods.

All but one of the expenditure elasticities have relatively small standard errors. For broccoli and green peas, expenditure elasticities for organic vegetables are larger than for their conventional

counterparts. The converse is true for corn while green bean expenditure elasticities for organic and conventional are virtually the same magnitude. As such, no general pattern regarding expenditure elasticities emerges. The expenditure elasticities of organic vegetables evaluated at the end of the sample period tend towards unity when compared with corresponding elasticities at the sample mean. Although expenditure is not synonymous with disposable income, these expenditure elasticities for organic frozen vegetables seem to suggest that increases in real income may not generate huge gains in organic market shares.

Conclusions

Supermarket sales of conventional frozen broccoli, green beans, green peas, and sweet corn stayed roughly the same or declined slightly from 1991 to 1996, while prices of these products generally stagnated. In contrast, sales of their organic counterparts rose an average 58.4% per year in volume during 1991-96. Despite these impressive gains, for the most part, organic frozen vegetables accounted for less than 1% of supermarket sales in 1996. During September 1990-December 1996, the annual price premia ranged from a low of 125.8% for sweet corn to a high of 209.7% for green peas.

Elasticity estimates suggest that consumers were quite sensitive to own-price changes in organic frozen vegetables, two and three times as sensitive as for their conventional counterparts. But as nominal prices of organics declined in 1995 and 1996, own-price response became less sensitive. The evidence for substitution of organic frozen vegetables for their conventional counterparts is statistically weak; most cross-price elasticities have large standard errors. Yet some asymmetry in substitution between organic and conventional is evident. Increases in

conventional prices induce large increases in organic quantity purchased whereas increases in organic prices bring almost no change in purchases of conventional products.

There are several limitations to our analysis. Because we only have access to national-level scanner data, the influence of income distribution and geographic and demographic factors on the demand for frozen vegetables cannot be examined. In addition, the influence of fresh organic vegetables on the demand for their frozen counterparts was not investigated. Sales information on organic fresh produce is very limited because it is sold in a variety of venues, including farmers markets and direct sales, and sales data on variable weight products are limited. However, as supermarkets increase the use of price-lookup codes for fresh produce, further analysis may be possible. Also, further investigation might examine other processed-product categories.

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