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Working Paper Series

FSWP2007-01

DEMAND FOR ORGANIC AND CONVENTIONAL POTATOES

Ming-Feng Hsieh

University of Wisconsin-Madison

Paul D. Mitchell

University of Wisconsin-Madison

Kyle W. Stiegert

University of Wisconsin-Madison

We investigate pricing and demand issues for four fresh potato categories (russet, red, white, and minor colored), organic fresh potatoes, and two processed potato categories (frozen/refrigerated and dehydrated) using a nonlinear generalized almost ideal demand system (GAIDS) that is closed under unit scaling (CUUS). We identify five major findings. First, we found little evidence for potato demand differences among the four U.S. regions in our study (east, west, north, and south). Second, increased consumer preferences for organic food consumption have caused price declines for red, russet and minor colored potatoes while organic potato prices rose significantly. Third, white potatoes emerged from the study as apparently the non-organic category most able to compete in an increasingly organically-oriented market. Fourth, potatoes as an aggregate commodity are inferior good, with perhaps the exception being the minor colored potatoes. Fifth, the potato market competes with other carbohydrate groups. In particular, we find strong statistical support that lower bread or frozen vegetables prices implying reduced system expenditures on potatoes and for dehydrated potato demand being sensitive to competing carbohydrate prices.

Keywords: carbohydrate, closed under unit scaling (CUUS), demographic demand factors, generalized almost ideal demand system (GAIDS), organic, potato, vegetable.

**Food System Research Group
University of Wisconsin-Madison
<http://www.aae.wisc.edu/fsrg/>**

February 2007

Corresponding author: **Kyle W. Stiegert**
kwstiegert@wisc.edu

This research was supported by a USDA grant to the Food System Research Group,
University of Wisconsin, Madison.

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Authors are listed alphabetically; senior authorship is not assigned.

Hsieh is a Research Assistant, Mitchell is an Assistant Professor and Stiegert is an
Associate Professor, all with the Department of Agricultural and Applied Economics,
University of Wisconsin-Madison. The authors would like to thank Brian Gould for
numerous comments that assisted in the development of the research and Mac Johnson of
the U.S. Potato Board for supplying key data used for this study.

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Contents

	Page
INTRODUCTION	5
A MODIFIED GAIDS MODEL WITH PRICE AND EXPENDITURE EQUATIONS	7
DATA DESCRIPTION	10
ESTIMATION AND RESULTS	11
CONCLUDING REMARKS	15
REFERENCES	17
REVIEWER'S APPENDIX	28

Tables and Figures

TABLE 1. DESCRIPTIVE STATISTICS OF VARIABLES USED FOR ESTIMATION	19
TABLE 2. NONLINEAR GAIDS PARAMETER ESTIMATES FOR EXPENDITURE SHARE EQUATIONS	20
TABLE 3. NONLINEAR GAIDS PARAMETER ESTIMATES FOR PRICE EQUATIONS	21
TABLE 4. NONLINEAR GAIDS PARAMETER ESTIMATES OF EXPENDITURE EQUATION: LN(E)	22
TABLE 5. UNCOMPENSATED OWN AND CROSS-PRICE ELASTICITIES	23
TABLE 6. EXPENDITURE, INCOME, AND OTHER CROSS-PRICE ELASTICITIES	24
FIGURE 1. ORGANIC FOOD SALES AND PENETRATION RATES IN THE U.S., 1997-2005	25
FIGURE 2. AVERAGE U.S. POTATO CONSUMPTION PATTERN, 2000-2005	26
FIGURE 3. CONSUMPTION TREND ON ORGANIC POTATOES IN THE U.S., 2000-2005	27
TABLE A. COMPENSATED OWN AND CROSS-PRICE ELASTICITIES	30

Demand for Organic and Conventional Potatoes

INTRODUCTION

The U.S. organic food industry grew at nearly 20% annually over the past decade. The Organic Trade Association (2006) reports that sales of organic foods reached \$13.8 billion in 2005 and accounted for 2.5% of total U.S. food sales (Figure 1). Sales of organic foods through natural food channels such as Whole Foods Market and Wild Oats increased through much of the 1990s and peaked at 68% of total organic sales in 1995. By 2005, the market share of natural food channels had dropped to 47% of sales with conventional food retailers taking larger chunks of the growing market. Indeed, conventional retailers had increased their share from 33% in 1995 to about 46% in 2005. The transition of organic food distribution is expected to continue, as Wal-Mart, the nation's largest grocer, and Target have announced a major move into marketing organic foods (Pollan, 2006; Mitchell, 2006). These and other retailers will put downward pressure on organic food prices and help make them accessible and affordable to tens of millions of Americans who are currently not part of this market.

As the trend toward increased organic food sales continues, understanding the market impacts on competing food groups will subsequently grow in importance. Organic foods and beverages are available in nearly every category of food sold in the U.S. However, fresh fruits and vegetables are the most frequently purchased category of organic foods,¹ accounting for 39% of total organic food sales (Organic Trade Association, 2006). Non-dairy beverages and bread/grains are the second and third most popular categories. Among fresh vegetables, the top organic purchases are lettuce, tomato, broccoli, onion, and potato. Organic price premiums vary by vegetable, with the largest organic premiums typically for potatoes (Zhang, et al., 2006). From 1999-2003, the average organic potato price was 75% higher than the conventional potato aggregate price, compared to price premiums of 20%-30% for other organic vegetables (Dimitri and Greene, 2002).

This paper investigates pricing and demand issues characterizing current U.S. food at home (FAH) market for potatoes. Because potatoes are not a homogeneous good, we constructed a demand system with a category for fresh organic potatoes, four categories of conventional fresh potatoes (russet, white, red, minor-colored), and separate categories for frozen/refrigerated potatoes and for dehydrated potatoes. Organic and conventional potato growers, processors, and retailers would benefit from an improved understanding of the own and cross-price elasticities among the various types of potato products, as well as the effect of demographic factors,

¹ Based on survey results, 73% of organic food purchasers make at least one purchase of a fruit or vegetable per store visit (Whole Foods Market, 2004).

seasonality, regional differences, and supply shocks. For this purpose, we estimate a nonlinear generalized almost ideal demand system (GAIDS), modified to satisfy the closed under unit scaling (CUUS) property by appropriately handling external demand shifters (Alston, Chalfant and Piggott, 2001). We structure the model not only to evaluate the traditional competitive position of organic potatoes via own- and cross-price elasticities, but also included a set of variables to capture the effects of the aggregate organic market on the demand and pricing of each potato category.

Demand systems analysis typically operates under the assumptions of expenditure and price exogeneity. If either (or both) of these assumptions does not hold, estimated parameters are biased and inconsistent. Group expenditure may be endogenous when household expenditure allocations are correlated between the goods of interest and other goods outside the group. This is likely the case for our study, because demand for potatoes is correlated with the consumption of other carbohydrate products and vegetables (Richards, Kagan and Gao, 1997; Zhang, et al., 2006). Because expenditure data for carbohydrate products without potatoes were not available for our study, a comprehensive demand system including all carbohydrate products was not feasible. To correct for probable simultaneity bias on the expenditure side, we add an expenditure equation that includes as instruments price indexes of carbohydrate products (rice, pasta, and breads) and fresh and processed vegetables.

Regarding price endogeneity, Richards, Kagan and Gao (1997) failed to reject price exogeneity in their potato demand study. However, their data were aggregated into broad carbohydrate categories (potatoes, rice, bread, etc.) and their test results are not overly surprising, given the intra-store separation of these items in most supermarkets. In our study, the potential for significant strategic pricing behavior among the different potato categories exists. Similarly, Dhar, Chavas and Gould (2003) found expenditure and price endogeneity in a narrow, disaggregated and differentiated product group (branded soft-drinks). Thus, to address these issues, in addition to the expenditure equation, we add a price equation for each category and introduce instruments from a set of demographic translating variables and from factors outside the system but related to potato production, storage and processing costs.

Demand analysis of potatoes is rather sparse.² Gao, Richards and Kagan (1997) developed a latent variable model to examine unobservable taste factors that might have occurred in different time periods, using two surveys collecting data on broad complex carbohydrate food categories (potato, bread, rice, pasta and corn). Their key finding shows that taste factors between the two surveys had a profound impact on the demand for carbohydrates. While all own-price elasticities were negative and significant in both survey years, 14 of the 20 cross-price elasticities in both

² See Richards, Kagan and Gao (1997) for review of the literature prior to 1995.

periods suggested carbohydrate groups were complements and the six positive cross-price elasticities were insignificant in the latter survey period.

Richards, Kagan and Gao (1997) used an LA/AIDS specification to investigate the effect of relative prices, expenditures, and a set of socioeconomic variables on starchy staple foods, including fresh and frozen potatoes, rice, pasta, and breads, in a complex carbohydrate demand system. Using data from 1970 to 1991, they found an own-price Marshallian elasticity of -0.48 for fresh potato while frozen potatoes exhibited positive own-price elasticity of 0.51 . Estimated uncompensated cross-price elasticities were mostly negative and ranged from -6.46 to 0.055 , once again suggesting evidence of complementarities among these product lines. As the authors point out, these complementary relationships suggest complex carbohydrates may be “companions in the diets of consumers” (p. 63), though they do not suggest that these items are purchased at the same time. Ideally, estimating substitution and complementarity is best conducted using transaction level data. Our current study comes only part-way in this regard. Our data remain quite aggregated, but we break out five fresh and two processed potato categories, consider quarterly consumption periods, and allow regional differences in consumption patterns.

The paper is organized as follows. Section 2 presents the modified GAIDS model. Section 3 contains an overview of the data used in this study. Section 4 contains a discussion of the estimation process, regression results, estimated elasticities, and key findings. Section 5 provides a summary, conclusions and directions for future research.

A MODIFIED GAIDS MODEL WITH PRICE AND EXPENDITURE EQUATIONS

The AIDS model, originally suggested by Deaton and Muellbauer (1980), has been widely applied to empirical demand studies. The model is, however, not consistent with the closed under unit scaling (CUUS) property when incorporating demand shifters in the traditional way. Parameter estimates, and thus elasticities, from an AIDS model with demand shifters change depending on the units chosen for measuring quantities. Following a solution suggested by Alston, Chalfant and Piggott (2001), we build on the GAIDS model first derived by Bollino (1987). The core of the GAIDS model is characterized by the following expenditure share equations:

$$(1) \quad w_i = \frac{p_i c_i}{E} + \frac{E^*}{E} \left[\alpha_i + \sum_{j=1}^N \gamma_{ij} \ln(p_j) + \beta_i \ln(E^*/P_A) \right], \quad i = 1, \dots, N,$$

where w_i represents the share of good i out of group expenditure (E), p_i is the retail price of good i , c_i denotes the pre-committed quantity of good i , $E^* = E - \sum_{j=1}^N p_j c_j$ denotes

supernumerary expenditure, α, γ , and β are parameters, and P_A is the price index for the group of goods

$$(2) \quad \ln(P_A) = \delta + \sum_{i=1}^N \alpha_i \ln(p_i) + \frac{1}{2} \sum_{j=1}^N \sum_{k=1}^N \gamma_{jk} \ln(p_j) \ln(p_k).$$

Satisfying homogeneity, adding-up, and symmetry requires these parameter restrictions:

$$(3) \quad \sum_{i=1}^N \alpha_i = 1, \quad \sum_{i=1}^N \beta_i = 0, \quad \sum_{i=1}^N \gamma_{ij} = 0 \quad \forall j, \quad \gamma_{ij} = \gamma_{ji} \quad \forall i \neq j.$$

Besides prices and expenditure, demographic and/or socioeconomic variables are often included in demand equations. To maintain the CUUS property, these demand shifters (Z_1, \dots, Z_M) are incorporated to GAIDS model by making each pre-committed quantity a linear function of these shifters:

$$(4) \quad c_i = c_{0i} + \sum_{m=1}^M \lambda_{mi} Z_m, \quad i = 1, \dots, N.$$

The resulting share equations become:

$$(5) \quad w_i = \frac{p_i (c_{0i} + \sum_{m=1}^M \lambda_{mi} Z_m)}{E} + \frac{E^*}{E} \left[\alpha_i + \sum_{j=1}^N \gamma_{ij} \ln(p_j) + \beta_i \ln(E^*/P_A) \right], \quad i = 1, \dots, N.$$

Finally, because expenditure shares must sum to one, one of the share equations is omitted from estimation and its parameters recovered using the restrictions reported in equations (3).

As discussed earlier, price and expenditure endogeneity problems can arise in demand estimation. The standard procedure for correcting simultaneity bias involves replacing prices and expenditure in the share equations by predicted values obtained from the additional price and expenditure equations. The price equations used in this study are

$$(6) \quad p_i = \theta_{0i} + \sum_{m=1}^M \theta_{Zim} Z_m + \sum_{l=1}^L \theta_{Xil} X_l,$$

where $\{Z_m\}$ represents a set of demand shifters, and $\{X_l\}$ represents a set of supply shifters thought to affect good i 's production costs, and the θ 's are parameters. The expenditure equation is represented as a function of per capita income Y , the group price index P_A defined by equation (2), prices of relevant goods outside the group ($P_B = \{p_{Bk}\}$), and a general food price index P_C . For convenience, we assume a double logarithmic form:

$$(7) \quad \ln(E) = d_0 + d_Y \ln(Y) + d_A \ln(P_A) + \sum_{k=1}^K d_{Bk} \ln(p_{Bk}) + d_C \ln(P_C).$$

Given the parameters estimated from the system of regression equations specified by (5), (6), and (7), the associated elasticities can be calculated (derivations available on request). Each expenditure elasticity is

$$(8) \quad \eta_i^E = \frac{\partial q_i}{\partial E} \frac{E}{q_i} = (1 - c_i/q_i)(E/E^*) + \beta_i/w_i.$$

Because aggregate income Y is in the expenditure equation, an income elasticity is available:

$$(9) \quad \eta_i = \frac{\partial q_i}{\partial Y} \frac{Y}{q_i} = d_Y \eta_i^E = d_Y \left[(1 - c_i/q_i)(E/E^*) + \beta_i/w_i \right].$$

The expenditure and income elasticities are the same when $d_Y = 1$, i.e., when the expenditure elasticity of each category is unity.³ Similarly, we use the expenditure equation to estimate impacts on the demand of each potato category from the prices of goods outside the system such as the complex carbohydrates. Specifically, the Marshallian price elasticity for a price change of outside good k is

$$(10) \quad \varepsilon_{ik}^O = \frac{\partial q_i}{\partial p_k} \frac{p_k}{q_i} = d_{Bk} \eta_i^E = d_{Bk} \left[(1 - c_i/q_i)(E/E^*) + \beta_i/w_i \right].$$

The inclusion of an expenditure equation adds complexity to the traditional AIDS price elasticity formulas. In particular, the Marshallian (uncompensated) price elasticity is

$$(11) \quad \varepsilon_{ij} = (\gamma_{ij}/w_i)(E^*/E) - \left[(\beta_i/w_i)(E/E^*) - d_A((1 - c_i/q_i)(E/E^*) + \beta_i/w_i) \right] \\ \times (\alpha_j + \sum_k \gamma_{jk} \ln(p_k)) - ((1 - c_i/q_i)(E/E^*) + \beta_i/w_i)(p_j c_j/E) - \Phi_{ij},$$

where Φ_{ij} equals $1 - c_i/q_i$ if $i = j$, and 0 otherwise. Note that the Marshallian price elasticity formulas reduce to those reported by Thompson (2004) for the AIDS model when $c_i = c_j = 0, \forall i, j$ and thus $E = E^*$. Also, the price elasticity formulas further reduce to the traditional AIDS formulas if, along with the previous conditions, $d_Y = 1$ and $d_A = 0$.⁴

³ The addition of the group expenditure equation allows for the elasticity of group expenditure with respect to income to be flexible, which leads to the distinction between expenditure and income elasticities.

⁴ Hicksian (compensated) elasticities are derived by applying the Slutsky equation: $\varepsilon_{ij}^H = \varepsilon_{ij} + \eta_i w_j$. Estimated Hicksian elasticities for this study are available from the authors.

DATA DESCRIPTION

At-home consumption data for fresh organic and conventional potatoes and processed potato products were drawn from AC Nielson supermarket sales data. Available data were at an aggregate level for four regions in the United States from 2000 to 2005, for a total of 96 quarterly observations (4 regions with 24 quarters) for each potato category. Specifically, fresh potatoes included organic and four conventional types: russet, white, red, and minor colored potatoes (e.g., yellow, purple, blue). Processed potatoes were grouped into two categories: frozen/refrigerated and dehydrated potatoes. Based on the USDA's 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII), about 55% of the U.S. potato crop was used for food consumed at home. Over 80% of fresh, dehydrated, and canned potatoes, plus potato chips, were sold through retailers and consumed at home. On the contrary, frozen potatoes, especially frozen French fries, are sold mainly for away-from-home consumption.⁵ Figure 2 shows the typical composition of U.S. potato consumption. Potato chips are a large group of processed potatoes consumed at home that are not included in this study due to data availability. However, this exclusion can be justified on the grounds that potato chips belong more appropriately to a snack food group rather than a close substitute for other potato products. In sum, the data used in our analysis represent the majority of demand for fresh and processed potatoes consumed at home.

Table 1 presents descriptive statistics for the data used for estimation. The mean value of expenditure on all potato varieties across the U.S. is \$2.28 per capita each quarter. The largest share of consumer expenditure is russet potato with over 30% market share. The combined expenditure share of the two processed potato products is over 50% of the food away from home (FAH) market. Obviously, processed potatoes implicitly contain less raw potato input in their total cost structure and are probably less price responsive to quantity or farm level cost factors. Potato consumption patterns differ considerably across regions. Average per capita consumption is lowest in the western region and highest in the eastern region. Compared to conventional potatoes, consumers spent very little on organic potatoes. The U.S. average share of expenditure spent on organic potatoes was only 0.12%. Even in the eastern region, which has the highest spending share, it is only over 0.21% on average. However, the consumption on organic potatoes has grown rapidly over time. As shown in Figure 3, by the fourth quarter of 2005, consumption of organic potatoes in the eastern region had increased to 0.52% of total expenditure on potatoes. Among the four seasons, we observe a consistent tendency for increased consumption of fresh rather than processed potatoes in the fourth quarter.

⁵ CSFII data show that fast food establishments account for 67% of the frozen French fry market, followed by a 13% share for restaurants.

A set of demand shifters was selected to control for demand effects from factors other than prices and expenditures. Included is a time trend, a collection of regional and seasonal dummy variables, selected socio-demographic variables for age, race, and workforce participation, and a set of interaction terms linking the aggregate trend in organic consumption with regional dummies. The organic consumption trend was measured by the penetration rate of organic foods relative to total food sales in the U.S., based on the Organic Trade Association's (2006) Manufacturer Survey. These data proxy the growing interest in organic foods due to perhaps taste, health, environmental, or other preferential concerns. Because this proxy variable was collected at the national level, the trend is interacted with regional dummies to allow for varying responses among regions. Socio-demographic variables are from the annual *Statistical Abstract of the United States* (U.S. Census Bureau).

In the price equation, we included as instruments previously described demand shifters, as well as a set of supply shifters. For fresh conventional potatoes, the average U.S. potato yield (cwt/acre) reported in *Potato Statistics* (USDA/ERS) capture supply effects and a set of farm-paid price indexes from *Agricultural Prices* (USDA/NASS) are used to represent potato production costs. Farm-paid price indexes include those for farm labor, automobiles and trucks, storage, fertilizer, chemical inputs, and the ninety-day T-bill rate. For organic potatoes, we dropped the fertilizer and chemical price indexes, since organic production uses little or no such inputs, and added a machinery price index and organic potato acreage to capture supply effects. Manufacturer processing costs are instrumented by a labor and a service price index in food manufacturing, plus price indexes for storage, transportation, and energy, and the ninety-day T-bill rate obtained from the U.S. Bureau of Labor Statistics' (BLS) *Producer Price Indexes* (USD/L/BLS).

The instruments used in the expenditure equation include median household income in each region Y , the group price index P_A , the prices of carbohydrate substitutes P_{Bk} , and a price index for general food. The selected relevant goods used in the study are "starchy staple" foods, including rice, pasta, and breads, as well as fresh and frozen vegetables as reported in the *Consumer Price Index* (USD/L/BLS).

Data series only available on an annual basis (e.g., organic trend, socio-demographic and income variables) were converted to quarterly series using SAS's PROC EXPAND, which fits cubic splines to non-missing values to form continuous approximations. Quarterly BLS price indexes were available, but only at a national level. These price indexes were assigned to all regions, assuming no significant difference in supply costs across the country.

ESTIMATION AND RESULTS

The full GAIDS consists of 14 equations: six budget share equations, seven price equations, and one expenditure equation. The system was estimated using SAS in two steps. First, predicted

values of each price equation (6) were estimated using OLS. The second step is an iterative process. Using predicted prices from the first stage, expenditure equation (7) was estimated to predict system expenditure, then, after replacing actual prices and expenditure with their predicted values, the expenditure and share equations were estimated jointly by iterative seemingly unrelated regression (ITSUR) with the restriction that the parameters δ , α and γ in the group price index P_A be the same for all share equations and the expenditure equation.

Generalized Durbin-Watson tests indicated serial correlation among the error terms, so we modified the regression system using an autoregressive (AR) error processes for several equations. Following test results, an AR(1) process is used for the russet and white potato price equations and an AR(4) process for the expenditure equation. For the share equations, an AR(1) is used for organic potatoes, an AR(4) for white and red potatoes, and an AR(2) for russet, minor colored and frozen/refrigerated potatoes.

Tables 2-4 report nonlinear GAIDS parameter estimates for the share equations, the price equations, and the expenditure equation, respectively. The nonlinear GAIDS provides a fairly good fit, as about a half of the parameter estimates are significant at a 5% or better level of significance.⁶ Results generally fit theoretical expectations, though some parameter estimates have incorrect signs. Also, the organic price equation has relatively low explanatory power, probably due to unobservable demand shocks, such as changes in demand preferences for organic produce over time.

Table 2 reports parameter estimates for the GAIDS share equations. We discuss price components later in the context of the elasticities, but other findings warrant discussion here. The time trend was insignificant for all potato categories except dehydrated, which apparently lost market share through the 2000~2005 study period due to factors not associated with any included variables.

Examining the three demographic variables, race was not statistically important in explaining changes for any potato category market share. However, though not conclusive, russet potato demand may have increased as the percent of Caucasians increased in the market. As the percentage of young people (< 25 years) increased, the frozen/refrigerated potato market share increased and the dehydrated potato share decreased. As participation of women in the workforce increased, important market share gains were found for russet, white and red potatoes. These findings suggest a demographic profile of the market and may provide useful information for potato market boards, branded processors, and other industry participants developing promotional campaigns.

⁶ The R^2 values reported in Table 2 from ITSUR are not bounded by zero and one and cannot be reliably used as goodness-of-fit measures to compare models in GLS estimation (Greene, 2003).

Of the 21 regional dummies, only one was statistically significant. If regional differences are present, we could not identify them under our aggregation scheme. We also included regional dummies in an interaction term with the growing share of organic food sales throughout the nation. While more statistical significance is noted in this group of parameters (8 of 28), the variation was mainly across potato categories and not across regions. For example, three of four interaction terms for both white and dehydrated potatoes were significant, but parameter estimates for both categories were in a tight range (1.46-1.71 and 0.61-0.68, respectively). Thus, while we found that a growing demand for organic foods did influence the demand for certain potato categories, the effect did not differ greatly across regions. A possible exception is the russet potato category—the eastern region russet potato demand had a large and positive demand shift explained by the growing trend in organic food demand. Overall, it appears white and dehydrated potatoes have benefited from the emergence of organic foods. Interestingly, only one of the interaction parameters in the organic potato category was statistically significant and all were close to zero.

Table 3 reports parameter estimates and standard errors for the price equations, as well as providing information about demographic, seasonal, and production factors that explain potato prices. In terms of demographic effects, the percentage of young people (< 25 years) had a negative effect on most prices, except organic and frozen/refrigerated potatoes, but the only significant effects were negative effects on the prices of red, minor colored and dehydrated potatoes. Race as the percentage of Caucasian in the population only had a significant (and positive) effect on the price of red potatoes, while women's workforce participation rate significantly decreased the price for white potatoes and increased the price for organic potatoes.

Interestingly, based on results for the interaction variables for the organic trend and regional dummies, the increasing trend for organic food had a downward effect on all fresh non-organic potato prices—all 16 coefficients were negative and 11 were significant. Furthermore, results for the same interaction variables were statistically significant and explained higher organic potato prices in all four regions. Though results in Table 2 show that the upward trend in organic food consumption did not change the market share of organic potatoes, results in Table 3 show that organic and non-organic fresh potato prices were impacted by this same trend in organic food demand.

Interaction terms in the price equations also provide an interesting story regarding white potatoes. In Table 3, white potato prices were negatively impacted by the trend in organic consumption, but none of the coefficients were significant. Recalling from Table 2 that the market share of white potatoes grew as organic food consumption increased, white potatoes may be emerging as a potentially strong substitute for organic potatoes and may be a conventional potato product that competes well with the emerging organic market.

The average U.S. potato yield had a negative and statistically significant effect on retail prices for non-organic fresh potatoes, but no statistical impact on explaining either processed potato prices or fresh organic potatoes. Several farm cost variables explained fresh potato prices, which suggests that potato markets do respond to production costs. Fertilizer and chemical price indices were significant, but of the incorrect sign—higher production costs led to lower potato prices. This may suggest that larger potato farmers are indifferent to these input prices and/or that acreage shifts into potato production to reduce total chemical input usage in other crops.

Table 4 presents the parameter estimates for the expenditure equation. The double log structure allows interpretation of the parameters as elasticities. Three of the price variables were significant. As the price of bread or frozen vegetables increased by 1%, consumers increased their expenditures on potatoes by about 1.5% and 1.8% respectively. Also, when the aggregate potato price index (P_A) rose by 1%, total expenditures rose by only 0.4%, suggesting a negative quantity response. When income rose by 1%, expenditures on potatoes declined by 0.4%, implying that, in the aggregate, potatoes are in inferior good.

Table 5 reports uncompensated price elasticities. All own-price elasticity estimates are negative, with the white, red and minor colored potato estimates statistically significant. In the fresh market, the demand for minor colored potatoes was the most price-elastic (-2.80) followed by red and then white potatoes. Organic and white potatoes have nearly identical own-price elasticities. Zhang, et al. (2006) found an own price elasticity of -1.11 for organic potatoes using scanner data between 1999 and 2003, while our estimates imply a statistically insignificant elasticity of -0.58. The two processed potato own-price elasticities were also insignificant.

Based on the cross-price elasticities, strong substitution relationships exist among three fresh categories: organic, minor colored and white. Not surprisingly, the cross-price elasticities show white potatoes to be the only statistically significant substitute category for organic and confirm our earlier findings that these are strong substitutes. Quantities demanded of organic potatoes are shown to be very sensitive to the price of white potatoes, reflecting their substitutability and the small market share of organic potatoes. Similar statistically strong findings occurred for the cross-price relationship between white potatoes and minor colored potatoes. Though not significant, the cross price relationship between minor colored and organic potatoes displayed the same pattern – a 1% price increase for minor colored potatoes generated almost a 2% increase in the organic potato quantity demanded. Overall, the prices of white and minor colored potatoes independently and jointly have the potential to dramatically shift the market share of organics. As a result, organic producers, processors and retailers should pay close attention to pricing among this trio of products.

Table 6 reports elasticities for changes in expenditures, income, and carbohydrate, vegetable and food prices. The first two columns report elasticity estimates for changes in system expenditures and aggregate income. Increasing system expenditures leads to statistically significant and

magnified increases in the quantity of white and dehydrated potatoes (cross-price elasticities exceed 1.0). The elasticity of russet potato demand was positive and significant, but slightly below 1.0. No other expenditure elasticities were significant. Elasticities for national income are quite interesting. As previously discussed, because the estimate of d_y in the expenditure equation was negative and significant, the aggregate potato complex acts as a set of inferior goods. However, this does not imply that all potato categories are inferior, which was borne out in our results. Income elasticities for russet, white and dehydrated potatoes were all negative and statistically significant. Not surprising, dehydrated potatoes were the most sensitive to income increases. The only superior (but insignificant) potato category was minor colored, which are the most expensive conventional fresh potato.

The last five columns of Table 6 present the demand responsiveness of potatoes with respect to price changes of outside goods: rice, pasta, breads, fresh and processed vegetables, and food in general. We found statistical support implying that bread and processed vegetables act as substitutes to russet, white and dehydrated potatoes. No elasticity for any other potato category was statistically significant.

CONCLUDING REMARKS

We investigated pricing and demand issues characterizing the U.S. food away from home (FAH) market for potatoes. We developed a demand system incorporating five fresh potato categories and two processed potato categories. Four of the fresh categories were conventionally produced potato varieties (russet, white, red, minor colored) and the fifth category was organically grown potatoes. The two processed potato categories are frozen/refrigerated potatoes and dehydrated potatoes. We estimated a nonlinear Generalized Almost Ideal Demand System (GAIDS) under the assumptions of price and expenditure endogeneity. The GAIDS model was modified following Alston, Chalfant and Piggott (2001) to satisfy the closed under unit scaling (CUUS) property, which is appropriate when including demographic, seasonal, regional and similar demand shifters.

Five major findings are drawn from this study. First, we did not find much evidence that potato demand was different across the four U.S. regions in our study (east, west, north and south). In the share equations, only one of the 21 stand-alone regional dummies was significant. Regional dummies were also included in the price equations. Some significant price activity was noted for red potatoes, with decreases in the eastern and central regions and increases in the southern region. Only one other coefficient in this group of 21 was significant.

For both the price and share equations, each regional dummy was interacted with the share of organic food sales to determine if prices and/or demand for the various potato categories in different regions reacted differently to the emerging organic food industry. Our second major finding is that changing consumer tastes for organic food demand did significantly impact retail

prices for fresh potatoes. The magnitude of statistically significant price declines was highest for red and russet potatoes, with smaller declines for minor colored. White potato prices declined, but not with statistical significance. Prices of organic potatoes rose significantly as a result of the general upward trend in organic demand. With respect to the demand system market shares, white potato and dehydrated potato market shares increased in response to organic trends.

Third, several findings arose with regard to the white potato market. The market share of white potatoes was the only conventional fresh market potato to respond positively to the upward trend in organic demand and it did so without a corresponding price decline. In terms of uncompensated own and cross price elasticities, we found that both organic potatoes and minor colored potatoes had only one statistically significant substitution relationship – with white potatoes. Finally, when system expenditures rise, the share of white potatoes is statistically shown to be the only fresh market potato to gain in market share. Thus, it appears that white potatoes, despite their low price profile, compete effectively with the more expensive minor colored and organic potatoes. White potatoes seem positioned to gain in market share relative to other conventional fresh market potatoes in the emerging organic-oriented marketplace.

The fourth finding arose from the expenditure equation and from the system expenditure and national income effects on the demand for each potato category. We found that, for the potato complex as a whole, increasing the overall potato price index by 1% led to only a 0.4% increase in expenditures, which implies that aggregate potato demand can be viewed as inelastic, which is not surprising given that only two of the seven categories (minor colored and dehydrated) had elastic own-price elasticities. Thus, at least in an aggregate average sense, retail potato prices will remain quite sensitive to available supplies. Expenditure effects on market shares of each category are quite mixed. As system expenditures expand, we found no statistical support for making claims about category winners or losers. However, white potatoes and dehydrated potatoes seem to do better than russet and organic potatoes, and substantially better than red, minor colored, and frozen/ refrigerated potatoes. In terms of income effects, we found strong statistical support that russet, white, and dehydrated potatoes are inferior goods. Potato marketing boards may want to incorporate such findings into their promotional campaigns aimed at improving the potato's market image.

Our fifth major finding is that competing carbohydrate groups do significantly impact the potato market. We found strong statistical support for lower bread or frozen vegetables prices leading to a reduction in system expenditures on potatoes. Both rice/pasta and fresh vegetables prices were not statistically important in explaining expenditures. In terms of category effects, dehydrated potatoes are overwhelmingly most sensitive to competing carbohydrate prices, but not frozen/refrigerated, organic, minor colored and red potatoes. Surprisingly, the prices of fresh vegetables (which are usually sold in close store proximity to fresh potatoes) had no influence on potato category market shares.

REFERENCES

- Alston, J. M., J. A. Chalfant, and N. E. Piggott. "Incorporating Demand Shifters in the Almost Ideal Demand System." *Economics Letters* 70(2001): 73-78.
- Bollino, C. A. "GAIDS: A Generalised Version of the Almost Ideal Demand System." *Economics Letters* 23(1987): 199-202.
- Deaton, A., and J. Muellbauer. *Economics and Consumer Behavior*. Cambridge: Cambridge University Press, 1980.
- Dhar, T., J.-P. Chavas, and B. W. Gould. "An Empirical Assessment of Endogeneity Issues in Demand Analysis for Differentiated Products." *American Journal of Agricultural Economics* 85(2003): 605-617.
- Dimitri, C., and C. Greene. "Recent Growth Patterns in the U.S. Organic Foods Market." Rep. No. AIB777, Economic Research Service, USDA, Washington, DC, 2002.
- Gao, X. M., T. J. Richards, and A. Kagan. "A Latent Variable Model of Consumer Taste Determination and Taste Change For Complex Carbohydrates." *Applied Economics* 29(1997).
- Mitchell, D. "Retailers Push Wholesalers for More Organics." *The Packer* November 27.
- Organic Trade Association. "The OTA 2006 Manufacturer Survey Overview." Organic Trade Association, Greenfield, MA, 2006.
- Pollan, M. "Mass Natural." *The New York Times* June 4, 2006.
- Richards, T. J., A. Kagan, and X. M. Gao. "Factors Influencing Changes in Potato and Potato Substitute Demand." *Agricultural and Resource Economics Review* 26(1997): 52-66.
- Thompson, W. "Using Elasticities from an Almost Ideal Demand System? Watch Out for Group Expenditure!" *American Journal of Agricultural Economics* 86(2004): 1108-1116.
- U.S. Census Bureau. *Statistical Abstract of the United States*. U.S. Census Bureau, Administrative and Customer Services Division, Statistical Compendia Branch. Online, 2000-05. Available at <http://www.census.gov/compendia/statab/>. [Accessed September, 2006].
- USDA/ERS. *Potato Statistics*. U.S. Department of Agriculture, Economic Research Service. Online, 2002. Available at <http://usda.mannlib.cornell.edu/data-sets/specialty/91011/>. [Accessed September, 2006].
- USDA/NASS. *Agricultural Prices*. U.S. Department of Agriculture, Economics, Statistics, and Market Information System. Online, 2000-05. Available at <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1002>. [Accessed September, 2006].

USDL/BLS. *Consumer Price Indexes*. U.S. Department of Labor, Bureau of Labor Statistics. Online, 2000-05. Available at <http://www.bls.gov/cpi/>. [Accessed September, 2006].

USDL/BLS. *Producer Price Indexes*. U.S. Department of Labor, Bureau of Labor Statistics. Online, 2000-05. Available at <http://www.bls.gov/ppi/>. [Accessed September, 2006].

Whole Foods Market. "Organic Foods Continue to Grow in Popularity According to Whole Foods Market Survey." *Whole Foods Market Reports* October 21, 2004.

Zhang, F., et al. "National Demand for Fresh Organic and Conventional Vegetables: Scanner Data Evidence." Selected Paper: The American Agricultural Economics Association Annual Meeting, Long Beach, CA, July 23-26, 2006. Available at <http://agecon.lib.umn.edu/>.

Table 1. Descriptive Statistics of Variables Used for Estimation

	mean values	-- mean values (by region) --				-- mean values (by quarter) --			
variables	United States*	East Central	South	West		Q1	Q2	Q3	Q4
potato expenditure (\$)	2.28 (0.50)	2.69	2.46	2.36	1.59	2.34	2.21	2.16	2.40
(as % of income)	0.0048 (0.0012)	0.0052	0.0053	0.0053	0.0033	0.0050	0.0047	0.0045	0.0049
<u>expenditure shares (%)</u>									
russet	32.25 (5.58)	28.52	30.23	35.57	34.67	31.45	31.93	31.74	33.87
red	8.43 (2.60)	10.66	9.04	9.29	4.74	7.71	8.89	9.33	7.80
white	5.98 (3.90)	11.66	2.77	6.91	2.60	5.48	5.52	6.89	6.05
minor colored	2.32 (1.56)	3.33	1.58	2.76	1.60	2.36	2.01	2.19	2.73
organic	0.12 (0.13)	0.21	0.04	0.06	0.17	0.11	0.08	0.14	0.16
frozen & refrigerated	38.63 (6.14)	35.01	42.12	34.94	42.45	40.41	40.00	37.90	36.21
dehydrated	12.26 (2.46)	10.60	14.21	10.46	13.78	12.49	11.57	11.82	13.19
<u>prices (\$/lb)</u>									
russet	0.33 (0.0815)	0.43	0.30	0.34	0.26	0.32	0.33	0.36	0.32
red	0.54 (0.0939)	0.65	0.46	0.53	0.54	0.51	0.55	0.58	0.53
white	0.34 (0.0718)	0.37	0.27	0.37	0.35	0.31	0.37	0.35	0.32
minor colored	0.61 (0.0906)	0.70	0.56	0.56	0.63	0.57	0.64	0.65	0.59
organic	0.72 (0.1670)	0.78	0.76	0.72	0.62	0.71	0.75	0.73	0.68
frozen & refrigerated	1.12 (0.0856)	1.24	1.07	1.03	1.13	1.12	1.13	1.11	1.11
dehydrated	2.96 (0.3442)	2.90	2.95	2.58	3.42	2.94	3.01	3.03	2.86
<hr/>									
Mean Values of Explanatory Variables (Unite States)*									
<i>mean of annual values across regions</i>					<u>Farm paid price indexes (base year 1999-2000)</u>				
age (% below 25)	36.30	(1.40)	<i>mean of national values across quarters</i>						
race (% white)	81.25	(3.28)	labor				109.55	(6.24)	
women participation rate (%)	61.32	(2.48)	autos & trucks				97.35	(1.92)	
median income (\$)	48410	(5132)	fertilizer				116.21	(18.18)	
average yield (c.w.t./acre)	111769	(170301)	chemical				100.09	(0.76)	
organic acreages (acre)	1597	(2335)							
3-month t-bill rate (%)	2.78	(1.78)	<u>Producer price indexes (base year 1999-2000)</u>						
<u>Consumer price indexes (base year 1999-2000)</u>					<i>mean of national values across quarters</i>				
<i>mean of national values across quarters</i>			storage				101.60	(0.80)	
rice & pasta	105.21	(3.71)	machinery				109.61	(7.99)	
bread	108.81	(5.91)	transport				106.84	(6.44)	
fresh vegetables	112.34	(8.96)	energy				122.30	(21.19)	
frozen vegetables	107.93	(4.51)	labor (food manufacturing)				106.23	(3.69)	
food	106.45	(4.66)	service (food manufacturing)				103.04	(2.48)	

* Values in parenthesis are standard deviations.

Table 2. Nonlinear GAIDS Parameter Estimates for Expenditure Share Equations

	russet	white	red	minor colored	organic	frozen & refrigerated	dehydrated
constant (c_0)	-316.53 <i>183.60</i>	-45.3277 <i>54.2219</i>	-32.5858 <i>27.7644</i>	-2.6194 <i>19.3897</i>	1.5072 <i>1.3089</i>	-7.5098 <i>19.0652</i>	27.3009 <i>26.9471</i>
time trend	-1.5350 <i>3.7326</i>	-2.2609 <i>1.3539</i>	1.1236 <i>0.6417</i>	0.0258 <i>0.4875</i>	-0.0563 <i>0.0335</i>	-0.8504 <i>0.6014</i>	-1.4650 * <i>0.6190</i>
age (% below 25)	-0.8188 <i>0.6951</i>	-0.1261 <i>0.2686</i>	-0.1124 <i>0.1127</i>	0.0938 <i>0.0706</i>	0.0039 <i>0.0054</i>	0.2464 ** <i>0.0799</i>	-0.2422 * <i>0.1141</i>
race (% white)	3.7973 <i>2.3475</i>	0.4697 <i>0.7092</i>	0.4045 <i>0.3565</i>	-0.0470 <i>0.2517</i>	-0.0238 <i>0.0168</i>	-0.0356 <i>0.2415</i>	-0.2343 <i>0.3456</i>
women participation rate	0.5666 ** <i>0.2096</i>	0.1545 * <i>0.0739</i>	0.0764 * <i>0.0348</i>	0.0434 <i>0.0260</i>	0.0039 <i>0.0023</i>	-0.0056 <i>0.0293</i>	0.0125 <i>0.0398</i>
dummy: east	-6.0831 <i>3.9932</i>	0.0632 <i>1.4604</i>	-0.6779 <i>0.6276</i>	0.4982 <i>0.4102</i>	0.0398 <i>0.0299</i>	1.0542 * <i>0.4110</i>	-0.7636 <i>0.6165</i>
dummy: central	-19.4092 <i>10.8381</i>	-2.4409 <i>3.3417</i>	-2.2175 <i>1.6609</i>	0.0851 <i>1.1691</i>	0.1098 <i>0.0787</i>	0.6322 <i>1.1118</i>	0.7968 <i>1.5976</i>
dummy: south	17.8046 <i>10.4808</i>	2.7588 <i>3.1049</i>	1.8209 <i>1.5824</i>	-0.0156 <i>1.1095</i>	-0.0849 <i>0.0742</i>	0.4461 <i>1.0894</i>	-1.5118 <i>1.5442</i>
dummy: season2	0.4129 ** <i>0.1023</i>	-0.0482 <i>0.0347</i>	0.1005 ** <i>0.0168</i>	0.0127 <i>0.0132</i>	-0.0026 * <i>0.0010</i>	-0.0902 ** <i>0.0145</i>	-0.0389 ** <i>0.0142</i>
dummy: season3	0.4383 ** <i>0.1152</i>	0.1072 ** <i>0.0363</i>	0.1414 ** <i>0.0184</i>	0.0257 <i>0.0135</i>	-0.0003 <i>0.0008</i>	-0.1481 ** <i>0.0131</i>	-0.0158 <i>0.0159</i>
dummy: season4	0.1227 <i>0.1041</i>	0.0572 <i>0.0349</i>	-0.0434 * <i>0.0172</i>	-0.0035 <i>0.0129</i>	0.0004 <i>0.0009</i>	-0.0790 ** <i>0.0146</i>	0.0636 ** <i>0.0149</i>
organic trend * east	3.7563 * <i>1.6577</i>	1.7165 ** <i>0.6039</i>	-0.3280 <i>0.3349</i>	0.0886 <i>0.2417</i>	0.0281 <i>0.0145</i>	0.5843 <i>0.3275</i>	0.6829 ** <i>0.2554</i>
organic trend * central	1.4392 <i>1.6815</i>	1.1669 <i>0.6062</i>	-0.4406 <i>0.3093</i>	0.2097 <i>0.2279</i>	0.0299 <i>0.0159</i>	0.6677 * <i>0.3098</i>	0.4977 <i>0.2748</i>
organic trend * south	3.0128 <i>1.7053</i>	1.5289 * <i>0.6338</i>	-0.3157 <i>0.3304</i>	0.2013 <i>0.2467</i>	0.0308 <i>0.0168</i>	0.4432 <i>0.3251</i>	0.6830 * <i>0.2861</i>
organic trend * west	2.3258 <i>1.7589</i>	1.4692 * <i>0.6521</i>	-0.4372 <i>0.3264</i>	0.1384 <i>0.2438</i>	0.0348 * <i>0.0163</i>	0.5073 <i>0.3161</i>	0.6106 * <i>0.2969</i>
constant (α)	0.5230 ** <i>0.1233</i>	0.2024 ** <i>0.0621</i>	0.2050 * <i>0.0880</i>	0.0270 <i>0.0573</i>	0.0019 <i>0.0046</i>	0.3459 <i>0.3101</i>	-0.3053 <i>0.2771</i>
ln(p_russet)	0.1314 ** <i>0.0434</i>	-0.0401 <i>0.0267</i>	0.0902 * <i>0.0411</i>	-0.0063 <i>0.0277</i>	-0.0029 <i>0.0022</i>	-0.6844 ** <i>0.1387</i>	0.5122 ** <i>0.1256</i>
ln(p_red)	0.0902 * <i>0.0411</i>	0.0273 <i>0.0194</i>	-0.1224 * <i>0.0591</i>	-0.0113 <i>0.0228</i>	-0.0016 <i>0.0023</i>	0.4316 ** <i>0.1277</i>	-0.4137 ** <i>0.1224</i>
ln(p_white)	-0.0401 <i>0.0267</i>	0.0774 ** <i>0.0255</i>	0.0273 <i>0.0194</i>	0.0479 ** <i>0.0177</i>	0.0038 * <i>0.0018</i>	-0.1415 <i>0.1027</i>	0.0253 <i>0.0957</i>
ln(p_minor colored)	-0.0063 <i>0.0277</i>	0.0479 ** <i>0.0177</i>	-0.0113 <i>0.0228</i>	-0.0718 <i>0.0409</i>	0.0025 <i>0.0031</i>	-0.0324 <i>0.1010</i>	0.0713 <i>0.1034</i>
ln(p_organic)	-0.0029 <i>0.0022</i>	0.0038 * <i>0.0018</i>	-0.0016 <i>0.0023</i>	0.0025 <i>0.0031</i>	0.0000 <i>0.0023</i>	-0.0011 <i>0.0078</i>	-0.0006 <i>0.0083</i>
ln(p_frozen & refrigerated)	-0.6844 ** <i>0.1387</i>	-0.1415 <i>0.1027</i>	0.4316 ** <i>0.1277</i>	-0.0324 <i>0.1010</i>	-0.0011 <i>0.0078</i>	-1.8805 ** <i>0.2854</i>	2.3084 ** <i>0.3453</i>
ln(p_dehydrated)	0.5122 ** <i>0.1256</i>	0.0253 <i>0.0957</i>	-0.4137 ** <i>0.1224</i>	0.0713 <i>0.1034</i>	-0.0006 <i>0.0083</i>	2.3084 ** <i>0.3453</i>	-2.5029 ** <i>0.4098</i>
ln(E/P _A)	-0.1303 ** <i>0.0390</i>	0.0031 <i>0.0278</i>	0.0602 <i>0.0311</i>	-0.0286 <i>0.0319</i>	0.0001 <i>0.0024</i>	-0.7332 ** <i>0.0617</i>	0.8285 ** <i>0.0734</i>
number of observation	96	96	96	96	96	96	96
R-square	-0.534	0.911	0.435	0.466	0.814	0.978	-
Durbin-Watson Statistics	1.954	1.690	1.958	2.165	2.072	1.862	-

Note: Estimates are in bold; standard errors are in italics. Single and double asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.

Table 3. Nonlinear GAIDS Parameter Estimates for Price Equations

	russet	white	red	minor colored	organic	frozen & refrigerated	dehydrated
constant	-1.5127 <i>16.9967</i>	-23.7392 <i>26.7038</i>	-74.0484 * <i>29.8497</i>	8.8668 <i>30.6206</i>	-41.7126 <i>79.7312</i>	6.5500 <i>18.0072</i>	-65.7977 <i>44.0361</i>
time trend	1.5203 ** <i>0.5248</i>	0.7068 <i>0.6209</i>	2.4070 ** <i>0.6616</i>	0.8535 <i>0.6787</i>	-1.5745 <i>1.9496</i>	-0.1492 <i>0.3493</i>	1.3804 <i>0.8542</i>
age (% below 25)	-0.0385 <i>0.0350</i>	-0.0502 <i>0.0620</i>	-0.1642 * <i>0.0736</i>	-0.2201 ** <i>0.0755</i>	0.0648 <i>0.2153</i>	0.0466 <i>0.0472</i>	-0.2427 * <i>0.1153</i>
race (% white)	0.0857 <i>0.2089</i>	0.3712 <i>0.3289</i>	1.0528 ** <i>0.3668</i>	0.0081 <i>0.3763</i>	0.3320 <i>1.0079</i>	-0.0885 <i>0.2245</i>	0.8489 <i>0.5490</i>
women participation rate	0.0078 <i>0.0125</i>	-0.0523* <i>0.0213</i>	-0.0387 <i>0.0252</i>	0.0389 <i>0.0259</i>	0.1732 ** <i>0.0649</i>	0.0086 <i>0.0158</i>	0.0112 <i>0.0386</i>
dummy: east	-0.1495 <i>0.2352</i>	-0.5449 <i>0.3999</i>	-1.3668 ** <i>0.4593</i>	-0.7369 <i>0.4712</i>	0.3984 <i>1.4052</i>	0.4266 <i>0.2906</i>	-2.0335 ** <i>0.7106</i>
dummy: central	-0.4656 <i>0.9507</i>	-1.6420 <i>1.5008</i>	-4.8283 ** <i>1.6756</i>	-0.4470 <i>1.7189</i>	-2.4157 <i>4.6251</i>	0.4823 <i>1.0270</i>	-4.5894 <i>2.5114</i>
dummy: south	0.3612 <i>0.9541</i>	1.5114 <i>1.4968</i>	4.4716 ** <i>1.6727</i>	-0.3608 <i>1.7159</i>	1.7068 <i>4.5193</i>	-0.4068 <i>1.0221</i>	2.8141 <i>2.4995</i>
dummy: season2	0.0203 <i>0.0163</i>	0.0773** <i>0.0209</i>	0.0292 <i>0.0219</i>	0.0854 ** <i>0.0225</i>	0.0340 <i>0.0600</i>	0.0103 <i>0.0104</i>	0.0252 <i>0.0254</i>
dummy: season3	-0.0153 <i>0.0324</i>	-0.0069 <i>0.0411</i>	-0.0249 <i>0.0434</i>	0.0105 <i>0.0445</i>	0.0253 <i>0.0905</i>	0.0011 <i>0.0086</i>	0.0459 * <i>0.0210</i>
dummy: season4	0.4317 ** <i>0.0747</i>	0.4768** <i>0.0909</i>	0.3750 ** <i>0.0958</i>	0.4675 ** <i>0.0982</i>	0.1063 <i>0.2742</i>	-0.0064 <i>0.0713</i>	-0.1753 <i>0.1745</i>
organic trend * east	-0.7724 ** <i>0.2307</i>	-0.2516 <i>0.2330</i>	-0.7022 ** <i>0.2354</i>	-0.5964 * <i>0.2415</i>	1.7229 ** <i>0.5696</i>	0.0287 <i>0.1419</i>	-0.3863 <i>0.3470</i>
organic trend * central	-0.8416 ** <i>0.2417</i>	-0.4186 <i>0.2534</i>	-1.1225 ** <i>0.2599</i>	-0.6481 * <i>0.2666</i>	2.0079 ** <i>0.6641</i>	0.0400 <i>0.1406</i>	-0.6917 * <i>0.3439</i>
organic trend * south	-0.8095 ** <i>0.2392</i>	-0.4129 <i>0.2489</i>	-1.0121 ** <i>0.2544</i>	-0.5018 <i>0.2610</i>	2.0619 ** <i>0.6493</i>	0.0835 <i>0.1385</i>	-0.6167 <i>0.3387</i>
organic trend * west	-0.8592 ** <i>0.2436</i>	-0.4112 <i>0.2572</i>	-1.0692 ** <i>0.2644</i>	-0.5782 * <i>0.2712</i>	1.4696 * <i>0.6743</i>	0.0908 <i>0.1419</i>	-0.6379 <i>0.3470</i>
average yield	-1.2E-06 ** <i>2.0E-07</i>	-1.3E-06** <i>2.4E-07</i>	-1.1E-06 ** <i>2.5E-07</i>	-1.3E-06 ** <i>2.6E-07</i>	-4.1E-07 <i>6.5E-07</i>	1.9E-08 <i>1.7E-07</i>	5.7E-08 <i>4.2E-07</i>
farm labor price index	0.0037 <i>0.0031</i>	0.0089* <i>0.0040</i>	0.0076 <i>0.0042</i>	0.0086 <i>0.0043</i>	0.0019 <i>0.0119</i>		
autos trucks price index	-0.0444 ** <i>0.0094</i>	-0.0539** <i>0.0118</i>	-0.0683 ** <i>0.0126</i>	-0.0558 ** <i>0.0130</i>	0.0036 <i>0.0317</i>		
storage price index	0.0303 <i>0.0160</i>	0.0639** <i>0.0202</i>	0.0699 ** <i>0.0214</i>	0.0593 ** <i>0.0220</i>	0.0144 <i>0.0606</i>	-0.0178 <i>0.0128</i>	0.0602 <i>0.0313</i>
3-month t-bill rate	0.0663 ** <i>0.0135</i>	0.0644** <i>0.0159</i>	0.1003 ** <i>0.0170</i>	0.0681 ** <i>0.0174</i>	-0.0030 <i>0.0192</i>	0.0026 <i>0.0070</i>	-0.0316 <i>0.0171</i>
fertilizer price index	-0.0060 ** <i>0.0011</i>	-0.0051** <i>0.0013</i>	-0.0066 ** <i>0.0014</i>	-0.0053 ** <i>0.0014</i>			
chemical price index	-0.0199 ** <i>0.0069</i>	-0.0234** <i>0.0085</i>	-0.0234 * <i>0.0089</i>	-0.0336 ** <i>0.0092</i>			
machinery price index					-0.0204 <i>0.0173</i>		
organic acreage					0.0001 * <i>0.0000</i>		
transportation price index						-0.0021 <i>0.0030</i>	0.0048 <i>0.0074</i>
energy price index						-0.0005 <i>0.0005</i>	-0.0006 <i>0.0012</i>
labor (food manufacturing)						0.0016 <i>0.0028</i>	0.0116 <i>0.0069</i>
service (food manufacturing)						0.0124 <i>0.0108</i>	0.0152 <i>0.0264</i>
Observation	96	96	96	96	96	96	96
Adjusted R-square	0.942	0.818	0.851	0.832	0.655	0.926	0.973
Durbin-Watson Statistics	2.037	2.069	2.099	1.967	2.214	2.372	2.122

Note: Estimates are in bold; standard errors are in italics. Single and double asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.

Table 4. Nonlinear GAIDS Parameter Estimates of Expenditure Equation: $\ln(E)$

Variable	Coefficients
Constant	1.1171 <i>1.7491</i>
$\ln(\text{Income})$	-0.4131 * <i>0.1743</i>
$\ln(P_A)$	0.3877 ** <i>0.0547</i>
$\ln(P_{\text{rice-pasta}})$	-1.0498 <i>0.6267</i>
$\ln(P_{\text{bread}})$	1.5163 ** <i>0.3275</i>
$\ln(P_{\text{fresh vegetables}})$	-0.0272 <i>0.0907</i>
$\ln(P_{\text{frozen vegetables}})$	1.7954 ** <i>0.4499</i>
$\ln(P_{\text{food}})$	-1.1430 <i>0.5872</i>
Observations	96
Adjusted R-square	0.715
Durbin-Watson Statistic	2.013

Note: Estimates are in bold; standard errors are in italics.
 Single and double asterisks (*) denote statistical
 significance at the 5% and 1% levels, respectively.

Table 5. Uncompensated Own and Cross-Price Elasticities

	russet	white	red	minor colored	organic	frozen & refrigerated	dehydrated
russet	-0.1148 <i>0.2348</i>	0.0394 <i>0.0874</i>	-0.0120 <i>0.0927</i>	0.0312 <i>0.0746</i>	-0.0091 <i>0.0063</i>	0.6718 <i>0.5932</i>	-1.0841 <i>0.7031</i>
white	0.2129 <i>0.3499</i>	-0.6511* <i>0.2800</i>	-0.0541 <i>0.2889</i>	0.7979** <i>0.3098</i>	0.0597 <i>0.0343</i>	1.3301 <i>0.7255</i>	-3.1161** <i>0.8507</i>
red	0.5227 <i>0.3096</i>	0.2529 <i>0.1808</i>	-0.8830** <i>0.3050</i>	-0.1980 <i>0.2391</i>	-0.0190 <i>0.0257</i>	3.0036* <i>1.1579</i>	-2.9048* <i>1.1199</i>
minor colored	0.3075 <i>0.8260</i>	2.0032** <i>0.6582</i>	-0.4954 <i>0.8852</i>	-2.8098** <i>1.3887</i>	0.1038 <i>0.1258</i>	0.6951 <i>2.2990</i>	1.0763 <i>2.4971</i>
organic	-2.1500 <i>1.1702</i>	3.0663* <i>1.4678</i>	-1.4325 <i>1.8253</i>	1.9621 <i>2.3648</i>	-0.5752 <i>0.7376</i>	-0.1091 <i>2.9493</i>	-1.2164 <i>3.4757</i>
frozen & refrigerated	-0.0007 <i>0.6581</i>	-0.0801 <i>0.1396</i>	0.5771* <i>0.2219</i>	0.1098 <i>0.1288</i>	-0.0026 <i>0.0088</i>	-0.0003 <i>2.5525</i>	-0.5529 <i>2.4197</i>
dehydrated	-0.0985 <i>2.5805</i>	-0.1422 <i>0.5356</i>	-2.5686** <i>0.8664</i>	-0.0585 <i>0.4518</i>	-0.0073 <i>0.0325</i>	2.7135 <i>9.3935</i>	-3.0796 <i>9.0744</i>

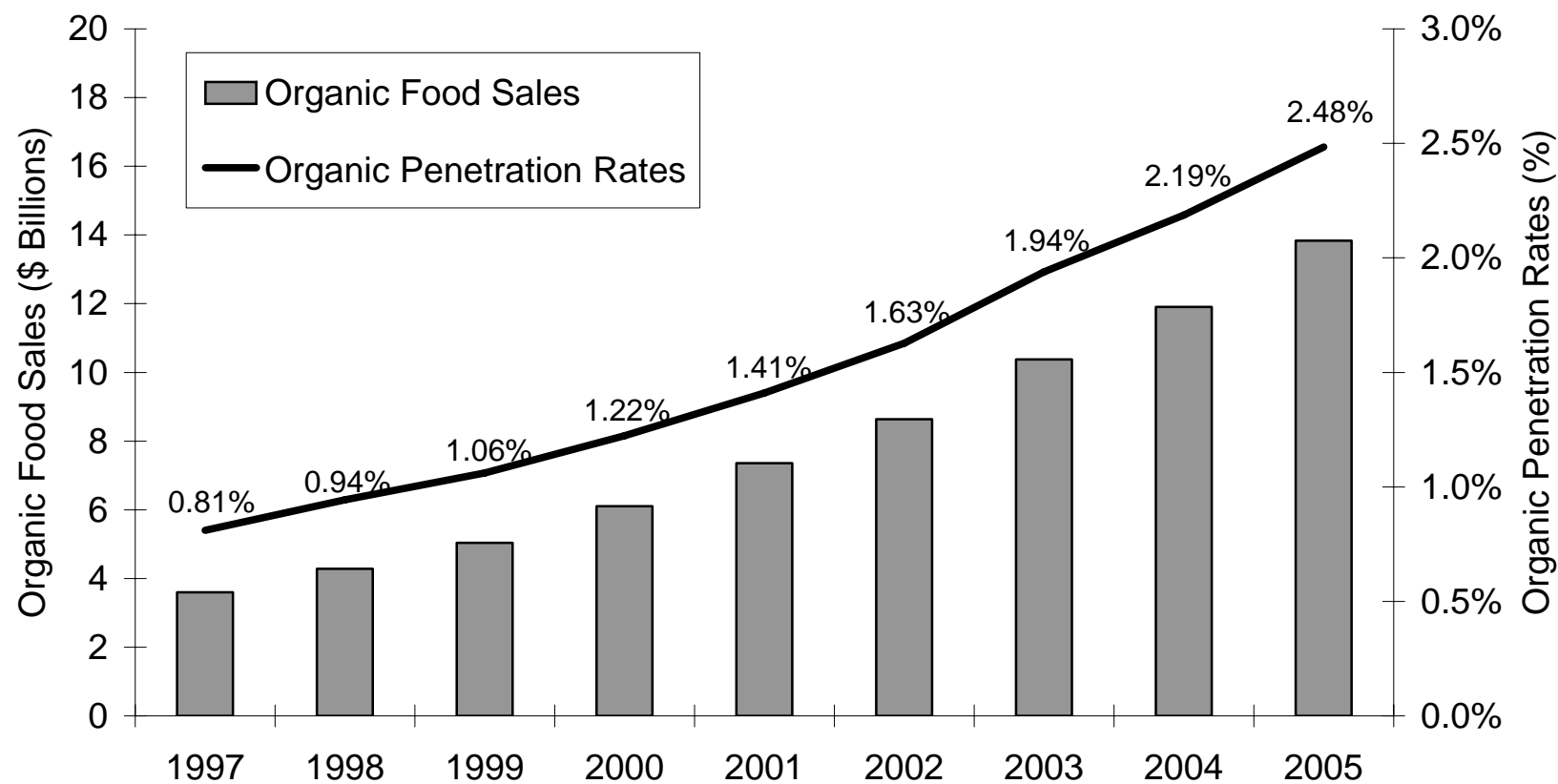
Note: Elasticity estimates (evaluated at sample means) are in bold; standard errors are in italics. Columns represent 1 percentage change in prices; rows represent the percentage change in quantity demanded. Single and double asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.

Table 6. Expenditure, Income, and Other Cross-Price Elasticities

	expenditure	income	rice-pasta	bread	fresh vegetables	processed vegetables	food
russet	0.8220 ** <i>0.2407</i>	-0.3396* <i>0.1692</i>	-0.8630 <i>0.5715</i>	1.2465 ** <i>0.4539</i>	-0.0224 <i>0.0751</i>	1.4759 * <i>0.5756</i>	-0.9396 <i>0.5607</i>
white	2.3146 ** <i>0.5155</i>	-0.9562* <i>0.4275</i>	-2.4300 <i>1.5345</i>	3.5098 ** <i>1.0212</i>	-0.0630 <i>0.2096</i>	4.1557 ** <i>1.3436</i>	-2.6456 <i>1.4942</i>
red	0.2940 <i>0.3306</i>	-0.1215 <i>0.1529</i>	-0.3086 <i>0.4105</i>	0.4458 <i>0.5234</i>	-0.0080 <i>0.0284</i>	0.5278 <i>0.6255</i>	-0.3360 <i>0.4089</i>
minor colored	-1.3103 <i>1.1081</i>	0.5413 <i>0.4872</i>	1.3756 <i>1.3376</i>	-1.9869 <i>1.6400</i>	0.0357 <i>0.1205</i>	-2.3526 <i>1.9917</i>	1.4977 <i>1.4893</i>
organic	0.7300 <i>1.5183</i>	-0.3016 <i>0.6413</i>	-0.7664 <i>1.6758</i>	1.1069 <i>2.3258</i>	-0.0199 <i>0.0779</i>	1.3107 <i>2.7634</i>	-0.8344 <i>1.7931</i>
frozen & refrigerated	0.1153 <i>0.1154</i>	-0.0476 <i>0.0500</i>	-0.1211 <i>0.1321</i>	0.1749 <i>0.1744</i>	-0.0031 <i>0.0109</i>	0.2070 <i>0.2102</i>	-0.1318 <i>0.1489</i>
dehydrated	4.5899 ** <i>0.8690</i>	-1.8962* <i>0.8951</i>	-4.8186 <i>3.0293</i>	6.9600 ** <i>1.9922</i>	-0.1250 <i>0.4163</i>	8.2409 ** <i>2.5367</i>	-5.2463 <i>2.8612</i>

Note: Elasticity estimates (evaluated at sample means) are in bold; standard errors are in italics. Columns represent 1 percentage change in expenditure, income, and prices (columns 3-7); rows represent the percentage change in quantity demanded. Single and double asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.

Figure 1. Organic Food Sales and Penetration Rates in the U.S., 1997-2005



Source: OTA's 2006 Manufacturer Survey, annual Nutrition Business Journal Surveys of Manufacturers, SPINS, etc.

Figure 2. Average U.S. Potato Consumption Pattern, 2000-2005

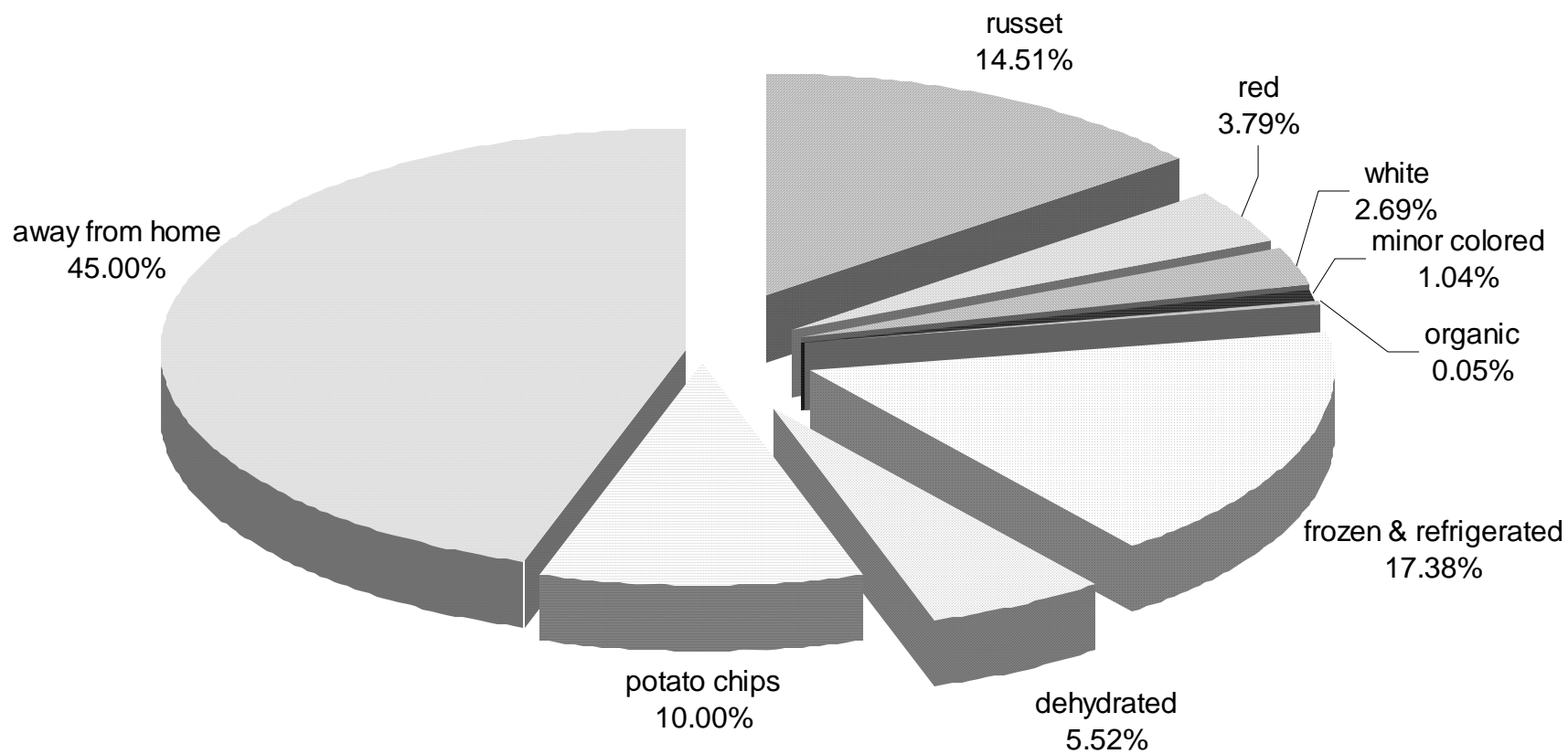
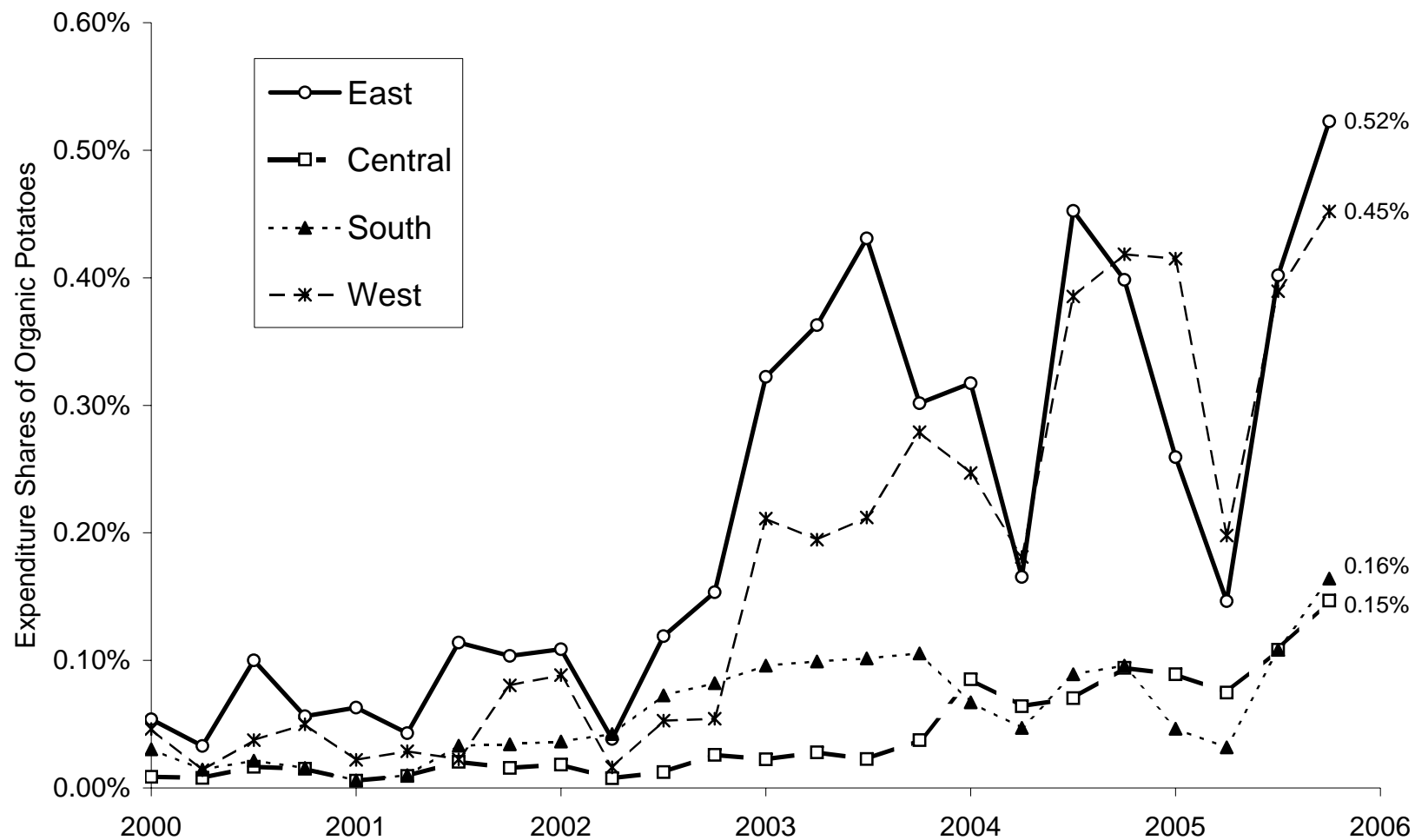


Figure 3. Consumption Trend on Organic Potatoes in the U.S., 2000-2005



REVIEWER'S APPENDIX

Derivation of Elasticities

Given the expenditure share equation of GAIDS specified by (1), the corresponding expression for the quantity of the i th good is given by:

$$(A.1) \quad q_i = c_i + (E^*/p_i) \left[\alpha_i + \sum_k \gamma_{ik} \ln(p_k) + \beta_i \ln(E^*) - \beta_i \ln(P_A) \right],$$

where

$$(A.2a) \quad E^* = E - \sum_k p_k c_k,$$

$$(A.2b) \quad \ln(P_A) = \delta + \sum_i \alpha_i \ln(p_i) + \frac{1}{2} \sum_j \sum_k \gamma_{jk} \ln(p_j) \ln(p_k).$$

Expenditure and Income Elasticity

The derivative of (A.1) with respect to the group expenditure equals:

$$(A.3) \quad \partial q_i / \partial E = (q_i - c_i) / E^* + \beta_i / p_i.$$

Multiplying (A.3) by E/q_i yields the expenditure elasticity:

$$(A.4) \quad \eta_i^E = (1 - c_i/q_i) (E/E^*) + \beta_i/w_i.$$

While restricting $c_i = 0, \forall i$, GAIDS reduces to AIDS and (A.4) becomes the traditional formula for expenditure elasticity: $\eta_i^E = 1 + \beta_i/w_i$.

With the additional expenditure equation, it allows for the elasticity of group expenditure with respect to income to be flexible. Specifically, $\partial E / \partial Y$ equals $d_Y E/Y$ as given the specification of (7). The income elasticity is thus:

$$(A.5) \quad \eta_i = d_Y \eta_i^E = d_Y \left[(1 - c_i/q_i) (E/E^*) + \beta_i/w_i \right].$$

Price Elasticities

Given that specifications of (A.2a) and (A.2b), along with the addition of group expenditure equation (7), the derivative $\partial E^* / \partial p_j$ is equal to $\partial E / \partial p_j - c_j$, or, after plugging in

$$\partial E / \partial p_j = d_A (E/P_A) (\partial P_A / \partial p_j) \text{ and } \partial P_A / \partial p_j = (P_A/p_j) \left(\alpha_j + \sum_k \gamma_{jk} \ln(p_k) \right),$$

$$(A.6) \quad \partial E^* / \partial p_j = d_A (E/p_j) \left(\alpha_j + \sum_k \gamma_{jk} \ln(p_k) \right) - c_j.$$

The derivative of (A.1) with respect to the price of another good j in the group is:

$$(A.7) \quad \partial q_i / \partial p_j = (E^*/p_i p_j) \gamma_{ij} + (w_i E/p_i - c_i) \left(d_A E/E^* p_j \right) \left(\alpha_j + \sum_k \gamma_{jk} \ln(p_k) \right)$$

$$+ (E^*/p_i p_j) \beta_i (d_A E/E^* - 1) (\alpha_j + \sum_k \gamma_{jk} \ln(p_k)) \\ - ((w_i E/p_i - c_i)/E^* + \beta_i/p_i) c_j$$

The Marshallian (uncompensated) cross-price elasticity formula is thus given by:

$$(A.8) \quad \varepsilon_{ij} = (\gamma_{ij}/w_i) (E^*/E) - [(\beta_i/w_i) (E/E^*) - d_A ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i)] \\ \times (\alpha_j + \sum_k \gamma_{jk} \ln(p_k)) - ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i) (p_j c_j/E).$$

This is a relatively complex formula if compared to the one obtained in AIDS, due to the inclusion of the pre-committed quantity in GAIDS. It is easy to confirm that when $c_i = c_j = 0, \forall i, j$ and therefore $E = E^*$, the formula reduces to the one obtained in Thompson (2004) for AIDS: $\varepsilon_{ij} = \gamma_{ij}/w_i - [(\beta_i/w_i) - d_A (1 + \beta_i/w_i)] (\alpha_j + \sum_k \gamma_{jk} \ln(p_k))$.

The own-price elasticity is similar, but with one additional item, $-(1 - c_i/q_i)$. That is, the formula for own-price elasticity is:

$$(A.9) \quad \varepsilon_{ii} = (\gamma_{ii}/w_i) (E^*/E) - [(\beta_i/w_i) (E/E^*) - d_A ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i)] \\ \times (\alpha_i + \sum_k \gamma_{ik} \ln(p_k)) - ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i) (p_i c_i/E) - (1 - c_i/q_i).$$

Hicksian or compensated elasticities can be derived by applying the Slutsky equation:

$\varepsilon_{ij}^H = \varepsilon_{ij} + \eta_i w_j$. Taking together with (A.5) and (A.8), the cross-price compensated elasticity formula is:

$$(A.10) \quad \varepsilon_{ij}^H = (\gamma_{ij}/w_i) (E^*/E) - [(\beta_i/w_i) (E/E^*) - d_A ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i)] \\ \times (\alpha_j + \sum_k \gamma_{jk} \ln(p_k)) - ((1 - c_i/q_i) (E/E^*) + \beta_i/w_i) (p_j c_j/E) - \Phi_{ij} \\ + w_j d_Y [(1 - c_i/q_i) (E/E^*) + \beta_i/w_i],$$

where Φ_{ij} equals $1 - c_i/q_i$ if $i = j$, but 0 otherwise. Finally, the uncompensated cross-price elasticity with respect to price of an outside good k is

$$(A.11) \quad \varepsilon_{ik}^O = d_{Bk} \eta_i^E = d_{Bk} [(1 - c_i/q_i) (E/E^*) + \beta_i/w_i].$$

Using equations (A.9) and (A.10), the compensated demand elasticities were calculated as below:

Table A. Compensated Own and Cross-Price Elasticities

	russet	white	red	minor colored	organic	frozen & refrigerated	dehydrated
russet	-0.2243	0.0191	-0.0406	0.0233	-0.0095	0.5406	-1.1258
	<i>0.2497</i>	<i>0.0906</i>	<i>0.0967</i>	<i>0.0749</i>	<i>0.0063</i>	<i>0.5945</i>	<i>0.7045</i>
white	-0.0955	-0.7083*	-0.1347	0.7757 *	0.0586	0.9607	-3.2334 **
	<i>0.3969</i>	<i>0.2803</i>	<i>0.2952</i>	<i>0.3094</i>	<i>0.0343</i>	<i>0.7117</i>	<i>0.8641</i>
red	0.4836	0.2456	-0.8932 **	-0.2008	-0.0192	2.9567 *	-2.9197 *
	<i>0.3145</i>	<i>0.1813</i>	<i>0.3082</i>	<i>0.2390</i>	<i>0.0257</i>	<i>1.1463</i>	<i>1.1259</i>
minor colored	0.4821	2.0356**	-0.4498	-2.7973 **	0.1044	0.9043	1.1427
	<i>0.8462</i>	<i>0.6627</i>	<i>0.8943</i>	<i>1.3879</i>	<i>0.1258</i>	<i>2.2818</i>	<i>2.5158</i>
organic	-2.2472	3.0483**	-1.4579	1.9551	-0.5756	-0.2256	-1.2534
	<i>1.2027</i>	<i>1.4663</i>	<i>1.8370</i>	<i>2.3630</i>	<i>0.7377</i>	<i>2.8694</i>	<i>3.5179</i>
frozen & refrigerated	-0.0160	-0.0830	0.5731 *	0.1087	-0.0027	-0.0187	-0.5588
	<i>0.6631</i>	<i>0.1408</i>	<i>0.2209</i>	<i>0.1288</i>	<i>0.0088</i>	<i>2.5590</i>	<i>2.4179</i>
dehydrated	-0.7100	-0.2557	-2.7284 **	-0.1025	-0.0096	1.9810	-3.3121
	<i>2.5252</i>	<i>0.5343</i>	<i>0.8850</i>	<i>0.4489</i>	<i>0.0325</i>	<i>9.3141</i>	<i>9.1052</i>

Note: Elasticity estimates, evaluated at sample means, are in bold; standard errors are in italics. Columns represent 1 percentage change in prices; rows represent the percentage change in quantity demanded. Single and double asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.