Factors Influencing Changes in Potato and Potato Substitute Demand

T.J. Richards, A. Kagan, and X.M. Gao

Despite the rapid rise in complex carbohydrate consumption over the last twenty-five years, fresh potato consumption has fallen by over 50%. Fresh potato growers and retailers alike need to know whether these changes reflect consumer responses to changing relative prices or incomes, or whether they are due to changes in consumer tastes. This paper uses a linear approximation almost ideal demand system (LA/AIDS) to investigate the effect of relative prices, expenditures, and a set of socioeconomic variables on complex carbohydrate demand. Estimation results show that the socioeconomic variables explain some of the changes in demand, but a significant amount remains as evidence of a change in consumer tastes.

Americans consume potatoes in one of four forms: fresh or table stock, dehydrated, frozen, and potato chips. Consistent with the trend toward the consumption of high value-added convenience foods in general, per capita consumption of frozen, dehydrated, and chipping potatoes is increasing at the expense of fresh potatoes. In farm-weight terms, consumption of frozen potatoes increased from 7.6 pounds per capita in 1960 to over 52 pounds in 1993, dehydrated potatoes from 4.9 in 1960 to 14.6 pounds in 1993, and potato chip consumption rose 51.8% (USDA/ERS/CED 1993). Once (in 1960) fully 76.4% of domestic potato consumption, by 1993 fresh potatoes constituted only 35.2% of the total utilization, representing a decline from 81 to 46.7 pounds per capita from 1960 to 1993.

Fresh potatoes have lost market share not only to processed potato products but also to other "starchy staple" foods such as rice, pasta, and breads. The trend toward these other low-fat, high-carbohydrate foods and the rise of ethnic food consumption in general (Senauer, Asp, and Kinsey 1991) have led per capita pasta consumption to roughly double from 6.3 pounds in 1967 to 13 pounds in 1992, and rice consumption to rise by 127%, from 7.4 to 16.8 pounds (USDA/ERS/CED 1993). Similarly, wheat flour consumption has risen from 103 pounds per capita in 1970 to almost 130 pounds in 1992.[1] If the movement away from fresh potatoes is due to a change in tastes, and not a response to changing prices or incomes, then generic fresh-potato promotion programs may have a role in reversing this trend.

Growers invest significant amounts in such programs through the National Potato Promotion Board, the Idaho Potato Commission, Washington Potato Commission, and several other state boards (Guenthner, Lin, and Levi 1991). For example, the Idaho Potato Commission's "Grown in Idaho" program uses retail promotions, advertising incentives, and food service support, as well as detailed nutritional information, to help its members develop brand awareness for the Idaho potato. To reverse the trend away from fresh potatoes, these programs must counteract the effects of fundamental economic and demographic forces.

Several studies suggest that these changes are a result of evolving lifestyles, habits, and technology. Jones and Ward (1989) find that increases in the proportion of away-from-home food expenditures spent on fast food and the percentage of women in the workforce both cause frozen potato consumption to rise and fresh consumption to fall. Jones and Choi (1992) find similar results with a model that also shows the positive effect of both branded and generic advertising on the demand for frozen potato products. While the results of Gao and Guenthner (1992) and Guenthner, Lin, and Levi (1991) support the effect of women's participation rate on frozen potato demand, they show a

T.J. Richards is assistant professor, School of Agribusiness and Resource Management, Arizona State University. A. Kagan is professor, School of Agribusiness and Resource Management, Arizona State University. X.M. Gao is senior econometrician, American Express, Phoenix, Arizona.

[1] For the purposes of this study, the consumption of wheat flour is treated as bread consumption, although it is recognized that per capita flour consumption includes flour used for several purposes. Of the varied uses of flour, desserts and other sweets are the largest group of nonstaple products.

negative relationship with microwave use—microwaves are responsible for causing the baked-fresh potato to become a popular convenience food. Similarly, McCracken (1988) shows that households that are likely to place a greater value on their time spent in food preparation consume relatively more frozen and less fresh potatoes than otherwise. Evidence from cross-sectional data by Gao, Wailes, and Cramer (1994) shows that many socioeconomic variables have a significant effect on potato demand relative to rice, bread, and pasta. In particular, if the meal planner is female, potato demand share rises, while the share falls if the female head-of-the-household is employed outside the home. With the exception of Gao, Wailes, and Cramer (1994), all of these studies rely upon ad hoc, single-equation demand models that do not incorporate the restrictions of demand theory. As a result, their findings may be significantly misleading.

The objective of this paper is to determine whether or not changes in the pattern of complex-carbohydrate consumption in the United States can be explained by factors that are associated with changing consumer tastes, and if so, to determine what these factors are. Estimates of the structure of complex-carbohydrate demand are conducted with a linear approximation of Deaton and Muellbauer's Almost Ideal Demand System (LA/AIDS) (1980). The LA/AIDS model incorporates a set of socioeconomic variables designed to proxy the underlying factors determining changes in food demand through the translating method of Pollak and Wales (1981). With this approach, the LA/AIDS parameters are functions of time, convenience, labor force trends, dietary habits, and food preparation methods. This procedure not only tests for structural change but also provides a theoretically sound way to estimate the contribution of each to any change that may have occurred. Eales and Unnevehr's Inverse Almost Ideal Demand system (LA/IAIDS) (1993) provides an alternative method to conduct similar tests under the assumption of quantity exogeneity. Hausman specification tests determine which of the LA/AIDS or LA/IAIDS models is appropriate for the staple carbohydrate data.

The first section of the paper provides a brief discussion of some of the theoretical and empirical issues that arise in estimating and testing demand subject to tastes that change over time. The second section presents the LA/AIDS model and the method of accounting for changes in complex carbohydrate demand. The next section describes the complex-carbohydrate consumption data and estimation methods. A discussion of the system parameters, the implied elasticities, and the results of testing for the determinants of changes in demand follows. Finally, the concluding section compares these results with previous potato demand studies and suggests some implications for potato and potato substitute marketing.

Empirical Analysis of Changes in Demand

Much of the previous research into changing patterns of commodity demand concerns the shift from red meat to poultry consumption during the 1970s. Changes in consumption are usually attributed to changes in relative prices, income levels, or consumer tastes. Because taste is a latent, or unobservable, variable, empirical models of demand often use proxies for taste or preference. If these proxy variables are found to be significant, then a change in taste is implied. This section provides a brief review of the methods that have been used to investigate the impact of factors other than price and expenditure on demand, and proposes a particular approach that applies to the potato problem.

Many of the earlier studies rely on single-equation demand specifications. Nyankori and Miller (1982), Braschler (1983), and Moschini and Meilke (1984) all employ different forms of the single-equation model. Moschini and Meilke (1984) provide only limited support for the changes reported in the earlier studies. Using Canadian data, Atkins, Kerr, and McGivern (1989) and Young (1987) also arrive at differing conclusions with respect to the stability of meat demand.

Concern over the sensitivity of tests for structural change to model specification motivates the demand systems approach taken by a second group of studies. Chavas (1983), Wohlgenant (1985), and Dahlgran (1987) all use different types of demand systems but arrive at a common conclusion that the structure of meat demand had indeed changed. Tegne (1990) adopts a Kalman filter method similar to that of Chavas in finding a change in the structure of alcoholic beverage demand. Chalfant (1987) finds that a combination of the Fourier and AIDS specifications provides a better fit to the data but argues that preliminary tests of meat demand against the weak axiom of revealed preference (WARP) suggest that a structural change need not be considered. This nonparametric approach also fails to support the existence of structural change in Australian and Canadian meat demand (Chalfant and Alston 1988; Alston and Chalfant 1991). Moreover, these authors show that only the Rotterdam model agrees with the conclusions of the WARP.

Despite this support for the Rotterdam specification, most recent studies employ some variant on the AIDS model, or its linear approximation, the LA/AIDS. Moschini and Meilke (1989) reverse their previous conclusions upon applying a time-varying parameterization of the AIDS model to U.S. meat demand data. Chen and Veeman (1991) adopt a "dynamic translating parameter" method to incorporate consumption dynamics in an otherwise static AIDS model to find that Canadian meat demand parameters change over time. Similarly, Reynolds and Goddard (1991) estimate a time path for the meat demand parameters with a linear version of the AIDS model using Moschini and Meilke's method (1989). Gao, Wailes, and Cramer (1994) attempt to address the specification issue in a synthetic model of potato, rice, pasta, and bread demand that nests both the AIDS and Rotterdam models. They find that the AIDS model outperforms all but their full synthetic model. Based upon this evidence, and the theoretical and empirical advantages of the AIDS approach cited by Deaton and Muellbauer (1980), this study employs a linearized version to determine the effect of proxies for consumer tastes and preferences on complex-carbohydrate demand. However, before applying the standard LA/AIDS specification, the following section addresses the issues of price endogeneity, dynamic consumer behavior, and the method of testing for changes in taste.

The LA/AIDS is often subject to criticism for its implicit assumption of price exogeneity—an assumption that may lead to biased parameter estimates if proven false. Thurman (1987) explicitly tests this assumption, finding that production costs determine poultry prices and not the current period's demand. Wahl and Hayes (1990) reach a similar conclusion in a simultaneous LA/AIDS model of Japanese meat expenditure, where they show that the supply curves for all other meats (Wagyu beef, dairy beef, pork, and fish) slope upward, while the price of chicken is exogenous. Eales and Unnevehr (1993) test the exogeneity of meat quantities with an Inverse Almost Ideal Demand System (LA/IAIDS).[2] Finding only the quantity of beef to be exogenous, they were led by tests of structural change in meat demand with this new model to reverse their prior conclusions (Eales and Unnevehr 1988). Clearly, failing to allow for predetermined quantities may confuse changes in supply for changes in demand in annual data. For perishable and seasonal fruits and vegetables, the production cycle is far shorter than one year, so the argument for the simultaneous determination of fresh potato price and quantity is especially strong.

In the case of fresh potatoes, the production cycle is more akin to that of field crops than to other vegetables, as growers plant fully 95% of the crop in the spring for fall harvest. Therefore, supply decisions are made prior to the realization of the current year's market demand—a fact that argues for endogenous fresh potato prices. Furthermore, fresh potatoes are costly to transport, and imports constitute a very low proportion of domestic consumption. However, advances in storage technology and increased off-season production have meant that fresh potatoes are readily available throughout the marketing year (Miranda and Glauber 1993). For fresh potatoes, therefore, arguments can be made for either price or quantity endogeneity. A similar dilemma exists for processed potato products.

Potatoes are processed in order to increase their storability, to differentiate them from other potato products, and to meet the particular needs of foreign consumers. As a result, export markets and storage decisions for frozen potatoes are far more significant than they are for fresh, which argues for predetermined prices. However, the constraint imposed by processing capacity argues in favor of quantity exogeneity. As a result of these opposing forces, the resolution of this debate is an empirical matter. The arguments for simultaneity are less strong for rice, pasta, and bread.

The United States is a significant net exporter of rice. Partly as a result of export enhancement program (EEP) subsidies, 43% of U.S. rice production went to export from 1991 to 1993. Furthermore, domestic stocks over the same period averaged one-sixth of annual production. In annual data, therefore, it is likely that domestic consumption plays only a limited role in the determination of the retail price. The effect of domestic consumption on the price of pasta, however, is a function of the cost and market structures of pasta processors. Although wheat constitutes only about 7% of the final price of pasta, conditions in the durum wheat market represent a significant influence on pasta prices. In 1991, imports of durum were nearly 9% of domestic production, while holdover stocks amounted to over 60%.[3] While this suggests that the supply curve of durum to an individual processor is unlikely to be upward sloping, an oligopo-

[2] The inverse AIDS model is also attributed to Moschini and Vissa (1992).

[3] The share of durum in pasta costs is from Dunham (1993), while the durum import and stock statistics are from USDA (1994). The trade figures refer to the wheat equivalent of flour and other milled products volume.

listic market structure may allow processors to pass other costs along to the consumer. However, recent data show that the four-firm concentration ratio among U.S. macaroni and spaghetti producers is only 42%, and the eight-firm ratio 66%.[4] Thus, pasta processing appears to be sufficiently competitive to expect predetermined prices. In the case of bread, farm products constitute only 6.4% of the retail price, so the behavior of the price is driven by the costs of wheat-milling, bread-baking, and distribution. Although the milling process tends to be dominated by a few large firms, the baking and distribution stages are more likely to be competitive. Although this evidence suggests that rice, pasta, and bread prices are likely to be predetermined, Hausman's specification test provides a more formal justification. In addition to the possible bias introduced by price-endogeneity, Deaton and Muellbauer (1980), Blanciforti and Green (1983), Chen and Veeman (1991), and Bjorndal, Salvanes, and Adreassen (1992) argue that dynamic behavior can lead to violations of the theoretical restrictions of demand theory.

Because staple foods tend to be regular items in consumers' diets, by definition, habit persistence is likely to be a factor in complex-carbohydrate demand. When consumer dynamics are taken into account, such as when habits are slow to change, demand parameters can become unstable. Thus, habit formation can be mistaken for a structural change in demand. Just as people are slow to adopt fundamental changes in their diet, they are slow to learn and adopt methods of food preparation designed to save time. As workers spend longer days on the job, work more overtime hours, and demand more of their leisure time, they are less willing to spend time in food preparation. Therefore, this study tests the significance of habit formation or adjustment costs on the demand for complex-carbohydrate products using the method of Blanciforti and Green, the details of which are given in the description of the empirical model below. The results of this test, and the Hausman test of price or quantity endogeneity, determine the estimated form of the demand system. Allowing the parameters of this model to vary with a set of socioeconomic variables constitutes one way of incorporating tastes and preferences into the model of complex-carbohydrate demand.

Maddala (1977) describes several alternative methods of testing and specifying time-varying parameter models, many of which find application in the meat demand literature. Typically, tests for structural change use some variant on the Chow test, which amounts to a test of the significance of a dummy variable designed to segment the sample into two or more subperiods. Atkins, Kerr, and McGivern (1989) provide an example of this approach. Moschini and Meilke (1989) apply a gradual switching regression model wherein the price, expenditure, and constant parameters follow piecewise paths from time independence to linear functions of time. Reynolds and Goddard (1991) apply a variant of this model to investigate structural changes in Canadian meat demand. Both studies show that this approach is useful in locating the point at which any change occurs. Others, such as Dahlgran (1987), argue that demand parameters are more likely to follow logistic or exponential parameter paths. Furthermore, Gao and Shonkwiler (1991) provide evidence from a structural-latent variable model of meat demand that explicitly treats changing tastes as functions of several exogenous, or "cause," variables. This result suggests that systematic parameter variation need not be determined entirely by a time trend, but may also include socioeconomic, demographic, or other exogenous variables.

Variables of this type are often introduced into demand systems through the translation or scaling methods of Pollak and Wales (1981). Whereas translation allows exogenous variables to shift budget share equations (McGuirk et al. 1995), scaling deflates product prices, thereby changing the slope of each demand curve. Many studies use this approach to explain variations in demand that result from promotion (Green, Carman, and McManus 1991; Chang and Green 1992; Cox 1992; and several others). For example, Cox applies both the translation and scaling techniques to a Rotterdam model of fats and oils demand in determining the effects of promotion. Although scaling is a conceptually preferable method of incorporating factors that are thought to shift demand, this study uses translation because of concerns over degrees of freedom. The following section describes the application of this approach to explain changes in the demand for complex-carbohydrate foods.

Empirical Model of Complex-Carbohydrate Demand

This section begins by presenting the empirical model in a general form, then describes the incorporation of socioeconomic proxies that attempt to

[4] Shipment value concentration ratios are from USDA (ERS/CED 1994).

explain changes in consumer taste. In budget-share form, the linear-approximate version of the AIDS model (LA/AIDS) is:

$$(1)\qquad w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(X/P) + e_i,$$

where w_i is the budget share of good i, $\boldsymbol{X}$ is the total expenditure on all i goods, p_j is the retail price of good j, and $\boldsymbol{P}$ is a Stone index of prices defined as $\log(P) = \sum_i w_i \log p_i$, and e_i is one element of a vector of independent, identically distributed errors. Homogeneity, symmetry, and adding up are imposed upon the system by requiring:

$$(2)\qquad \begin{aligned} &\sum_i \alpha_i = 1; \quad \sum_i \gamma_{ijt} = 0; \quad \sum_i \beta_i = 0; \\ &\sum_j \gamma_{ijt} = 0; \\ &\gamma_{ijt} = \gamma_{jit}. \end{aligned}$$

The Inverse Almost Ideal Demand System (IAIDS) of Eales and Unnevehr (1993) provides an alternative specification to equation (1) that allows for price, rather than quantity, endogeneity. They develop this model in response to a concern that supply changes are responsible for the apparent structural changes found in meat demand. Using Stone's linear approximation to the quantity index, the IAIDS model is:

$$(3)\qquad w_i = \tau_i + \sum_j \psi_{ij} \log q_j + \phi_i \log Q + e_i,$$

where q_j is the per capita consumption of good j, and $\boldsymbol{Q}$ is a Stone's quantity index. Homogeneity, symmetry, and adding up imply restrictions directly analogous to those of the direct LA/AIDS model. Rather than rely solely on the theoretical arguments above to select between equations (1) and (3), specification tests allow the data to determine which is more appropriate.

Specifically, Hausman's general approach (1978) is used to test for the endogeneity of prices and quantities. Thurman (1987), Wahl and Hayes (1990), and Eales and Unnevehr (1993) all describe the application of this test to models of meat demand. Hausman's test relies upon the existence of an estimator that is consistent under both the null and alternative hypotheses but is not asymptotically efficient under the null, and one that is consistent and asymptotically efficient under the null. In the present example, endogeneity of frozen potato, pasta, and bread prices and quantities are in question.

To test the endogeneity of potato prices alone, iterative seemingly unrelated regression (ITSUR) estimates of the system with exogenous fresh and frozen potato prices are compared to three-stage least squares (3SLS) estimates. Under the null hypothesis, ITSUR estimates are consistent and asymptotically efficient, whereas 3SLS estimates are inefficient. When these two sets of estimates are compared, the Hausman test statistic is:

$$(4)\ (\beta_s - \beta_t)'[V(\beta_s) - V(\beta_t)]^{-1}(\beta_s - \beta_t) \sim X^2_q,$$

where q represents the number of parameters associated with the potentially endogenous variables, β_t is the vector of ITSUR parameters with covariance matrix $V(\beta_t)$, and β_s are the 3SLS estimates with covariance matrix $V(\beta_s)$. Rejecting the null hypothesis in the LA/AIDS model indicates that potato prices are likely endogenous. Applying this procedure to the LA/IAIDS model constitutes a test of potato quantity endogeneity. Finally, the same test determines whether pasta and bread prices and/or quantities are endogenous.

Based on the results of these endogeneity tests, the appropriate specification provides a means of determining the factors other than prices and expenditure that cause changes in demand. Modifying this system to include a set of translating variables provides a general varying-parameter specification where demand depends not only upon time, but upon proxies for increasing demand for convenience, increased spending on fast food, and the rising sophistication of food preparation technology. As in Green (1985), incorporating these variables in the LA/AIDS model allows the α_i parameters to vary according to:

$$(5)\qquad \begin{aligned} \alpha_{ij}(Z) = {} & \delta_{0ij} + \delta_{1ij}T + \delta_{2ij}O \\ & + \delta_{3ij}W + \delta_{4ij}M \\ & + \delta_{5ij}F. \end{aligned}$$

However, if the socioeconomic factors enter via a scaling process, the γ_{ij} parameters vary according to:

$$(6)\qquad \begin{aligned} \gamma_{ij}(Z) = {} & \rho_{0ij} + \rho_{1ij}T + \rho_{2ij}O \\ & + \rho_{3ij}W + \rho_{4ij}M \\ & + \rho_{5ij}F, \end{aligned}$$

where T is a time trend, W is the participation rate of women in the work force, M is the number of microwaves in use in the United States, O is the average number of overtime hours worked per week among industrial workers, and F is the total expenditure on fast food in the United States on an annual, per capita basis. Tests for both translating and scaling effects amount to t-tests of the significance of the components of the $\alpha(\mathbf{Z})$ and $\gamma(\mathbf{Z})$ parameter vectors in the full structural form of the LA/AIDS model:[5]

$$(7) \qquad w_i = \alpha_i(Z) + \sum_j \gamma_{ij}(Z)\log p_j + \beta_i \log(X/P) + e_i.$$

Additional restrictions implied by homogeneity, adding up, and symmetry are similar to those in Moschini and Meilke (1989). In fact, this representation encompasses their time-varying parameter model as a special case when the only element of **Z** is some form of time trend. Unfortunately, with only twenty-two observations, the most general form of this model is not estimable. Therefore, the final specification of the model attempts to explain only the variation in the intercept term of each equation as shown in (5) above. Therefore, if a particular δ_{ij} is found to be different from zero, then the hypothesis that the average budget share changes linearly in one of the socioeconomic variables cannot be rejected. This, in turn, implies that demand changes systematically with the appropriate socioeconomic proxy.

It may be the case, however, that changes in demand attributed to these variables may be due to behavioral dynamics on the part of consumers rather than changes in taste. Deaton and Muellbauer (1980) suggest that including lagged budget share values or a time trend in each share equation of the AIDS model removes the serial correlation caused by dynamics in demand. Chen and Veeman (1991) and Blanciforti and Green (1983) use the translating method of Pollak and Wales (1981) to introduce lagged consumption values in an attempt to address this issue. Although this approach causes their models to become consistent with symmetry and homogeneity, the same cannot be said of the complex-carbohydrate system.[6] Others account for habit formation, learning, and contractual obligations through estimating demand systems in first-difference form (Moschini and Meilke 1989; Reynolds and Goddard 1991; Eales and Unnehevr 1993; Alston and Chalfant 1993). As with the lagged-consumption model, estimating the complex-carbohydrate system in first differences leads to violations of both symmetry and homogeneity. The failure of both methods to detect any dynamic behavior means that the price and expenditure elasticities are found with a static model.

Chalfant (1987) and Green and Alston (1990) provide expressions for the uncompensated own and cross-price elasticities for the LA/AIDS model:

$$(8) \qquad \begin{aligned} \epsilon_{ij} &= -\tau_{ij} + (\gamma_{ij} - \beta_i w_j)/w_i, \\ \tau_{ij} &= 1 \textit{ if } i = j, \\ \tau_{ij} &= 0 \textit{ if } i \neq j, \end{aligned}$$

and the expenditure, or scale, elasticity:

$$(9) \qquad E_i = -1 + \beta_i/w_i.$$

Hayes (1992) argues that the LA/AIDS elasticities are, despite the inclusion of exogenous variables, invariant to the translating parameters, whereas the equivalent elasticity expressions for the non-linear AIDS model are not. While the effect of the translating variables on the price elasticities would be of interest, Green and Alston (1990) show that it is not valid to use LA/AIDS estimates to calculate AIDS elasticities.[7] Therefore, this study reports the direct elasticities of demand with respect to the translating variables and not their effect on the slope estimates.

Data and Methods

This study uses annual data from 1970–91 on retail-weight consumption of fresh (w_1) and frozen (w_2) potatoes, rice (w_3), pasta (w_4), and bread (w_5).[8] Per capita potato, rice, pasta, and bread consumption values are from USDA's *Food Consumption, Prices, and Expenditures: 1970–92* (ERS/CED 1993). Retail price data are taken from the 1970–92 volumes of the annual report of the Bureau of Labour Statistics' *Consumer Price Index: Monthly Summary.* Data on the amount of food consumed away from home are found in the *Food Marketing Review* (USDA/ERS/CED 1994), the authors of which provide data on the proportion consumed as fast food for the entire sample period. Total consumer expenditure on foods and beverages, used as an instrumental variable for complex-carbohydrate expenditure, is from the WEFA group database. Overtime hours, the number of microwaves in use, and the participation rate of women in the workforce are all from the *Statistical Abstract of the United States,* published annually by the Department of Commerce. Although potato

[5] Note that the nonlinear price index specification also includes the translating and scaling variables, but the linear approximation version, which this study employs, does not.

[6] Similar improvements are noted by Deaton and Muellbauer (1980) and Anderson and Blundell (1983).

[7] Chang and Green (1992) use LA/AIDS estimates of the translating effects of promotion in calculating AIDS parameter expressions.

[8] As in Gao, Wailes, and Cramer (1994), the bread variable is expressed in terms of wheat flour equivalents. As such, this variable includes many different types of breads and other bakery products.

utilization includes a significant amount of chipping potatoes, it is felt that potato chips belong more appropriately to the "snack food" group and are not seen as a viable substitute for other starchy staple foods. Table 1 provides summary statistics for each of the above variables.

This table suggests that there has been considerable variation among the socioeconomic variables, particularly fast-food expenditure and microwave usage, but provides little information on the underlying trends. On the one hand, while fast-food expenditure and women's participation in the workforce rose steadily over the sample period, microwave usage climbed rapidly at first, reaching a plateau in recent years. Overtime hours, on the other hand, appear to vary with more general economic cycles.[9] Table 1 also shows that a significant change in relative prices has occurred. Whereas rice, pasta, and fresh potato prices rise by roughly 300% in nominal terms, frozen potato and bread prices rise by only about 200%. Based only on price information, therefore, frozen potato and bread consumption should rise relative to the rest.

Instruments for potato supply are selected such that they are predetermined with respect to the endogenous variables in the system and yet remain highly correlated with the explanatory variables. For fresh potatoes and frozen potato products, a U.S. average producer price index developed by Mischen (1994) and the average U.S. potato yield reported in the USDA's *Potato Statistics* (ERS/NASS 1994) are used to represent the cost of potato production. Processing cost instruments include a "food and kindred products" labor wage rate, a fuels and energy price index, and the ninety-day T-bill rate.

The iterated seemingly unrelated regression (ITSUR) procedure in SHAZAM provides parameter estimates for each of the demand systems under the maintained hypothesis of price exogeneity. Preliminary tests reject the null hypothesis of a diagonal variance/covariance matrix, so the ITSUR method represents an improvement in efficiency over single-equation OLS methods. In order to avoid singularity of the design matrix, the bread equation is omitted from the estimation procedure. However, because the iterative seemingly unrelated least squares parameter estimates are invariant to which equation is dropped, estimates of the bread parameters are subsequently recovered by reestimating the system with the pasta equation excluded (Barten 1969).

Tests of homogeneity and symmetry are conducted sequentially. First, the restrictions implied by symmetry of the price-response matrix form a Wald test statistic that is chi-square distributed with the degrees of freedom equal to the number of pairwise constraints. For the LA/AIDS model, the test statistic value is 4.855. At a 5% level of sig-

[9] A reviewer points out that the overtime variable may not be perfectly representative of the general time constraints that all workers feel in times of economic expansion, because it measures only blue-collar overtime. However, by including this variable as defined, we are implicitly assuming that pressures to work overtime are proportional for all workers—blue and white collar alike. Because we have no data on white-collar overtime, there is no way to test the validity of this assumption, but we see no a priori reason why it is likely to be false.

Table 1. Descriptive Statistics for Complex Carbohydrate Data: 1970–91

Variable[a]	N	Mean	Std. Dev.	Minimum	Maximum
Overtime	22	3.373	0.499	2.200	4.100
Fast food	22	11098.000	7106.200	2051.200	23574.000
Women %	22	51.077	5.059	43.300	58.500
Microwave	22	5082.600	4402.200	0.000	12610.000
Prices					
P_{Fresh}	22	0.191	0.079	0.079	0.351
P_{Frozen}	22	0.564	0.171	0.298	0.853
P_{Rice}	22	0.244	0.090	0.106	0.453
P_{Pasta}	22	0.525	0.207	0.226	0.889
P_{Bread}	22	0.465	0.148	0.243	0.710
Quantities					
Q_{Fresh}	22	48.108	3.882	43.987	59.318
Q_{Frozen}	22	20.019	3.529	12.837	25.482
Q_{Rice}	22	10.017	3.365	5.603	16.813
Q_{Pasta}	22	10.536	1.522	7.700	13.600
Q_{Bread}	22	111.951	6.736	102.750	124.880

[a]Variable units are as follows: Overtime = hours per week; fast food = $ millions; women % = percentage; microwave = millions; prices = $ per lb.; quantities = lbs. per capita.

DATA SOURCES: Fast food spending is from USDA (ERS/CED 1994). All prices and quantities are from USDA (ERS/CED 1993). Overtime hours, women's participation rate, and microwave use are from the Department of Commerce (1994).

nificance, the critical chi-square value with six degrees of freedom is 12.59, so the null hypothesis of symmetry cannot be rejected. Based on this result, homogeneity tests proceed with symmetry imposed.

Homogeneity requires the sum of the price parameters for each equation to equal zero. Again, this test forms a Wald statistic that is chi-square distributed. With 10 degrees of freedom, the critical chi-square value for the joint test of homogeneity and symmetry is 18.31. The imposition of homogeneity yields a chi-square statistic value of 15.22, so the null hypothesis cannot be rejected. Therefore, both symmetry and homogeneity are imposed before testing the significance of the socioeconomic variables and interpreting the structural elasticities.

It is assumed that expenditure on the complex-carbohydrate food group is weakly separable from expenditure on other goods, so the demand estimates are, of course, conditional. Moschini, Moro, and Green (1994) and Nayga and Capps (1994) present methods of testing this assumption, but as Green, Carman, and McManus (1991) state, "it is not obvious which of the myriad combinations of groups of commodities would be viable candidates" to test the complex-carbohydrate group against.[10] This is intuitively clear because the group of complex-carbohydrate products considered herein includes such a large proportion of the dietary staples consumed in the United States that consumers have few alternatives for satisfying their nutritional demands for this essential nutrient. Given this fact, it is expected that marginal rates of substitution between goods in the group are not affected by the consumption of products in other groups, or, at least, that they follow a specific pattern (Nayga and Capps 1994).

Nonetheless, LaFrance (1991) argues that least squares estimates of such conditional demand systems will be inconsistent as the group expenditure is endogenous. Moreover, LaFrance argues that standard instrumental variable (IV) methods are inconsistent if the demand functions are nonlinear in group expenditure. However, Edgerton (1993) presents an alternative, more general specification wherein share functions are linear in the log of group expenditure. With the demand system so defined, IV estimates of the conditional demand system are consistent with total expenditure, or its log, included in the set of instruments for the log of group expenditure (Edgerton 1993, p. 144). Consequently, this study applies Edgerton's instrumental variables procedure to account for the potential endogeneity of expenditure. Instruments for group expenditure include all prices and quantities as well as total personal expenditure on food and beverages (Yang and Koo 1994).

Results and Discussion

Of the meat demand studies that explicitly test for price or quantity exogeneity (Thurman 1987; Dahlgran 1987; Wahl and Hayes 1990; Eales and Unnevehr 1993), each finds some degree of support for estimation with an instrumental variables method. As it is not clear a priori that either prices or quantities can confidently be assumed to be exogenous in complex-carbohydrates, similar tests guide model selection in this study. The first Hausman test considers the endogeneity of potato product prices in the LA/AIDS model. As table 2 shows, the null hypothesis that fresh and frozen potato prices are exogenous cannot be rejected. Neither can the null hypothesis of price exogeneity be rejected for pasta and bread prices. However, a Hausman test also fails to reject the exogeneity of potato, pasta, and bread quantities within a LA/IAIDS model. Therefore, either the LA/AIDS or LA/IAIDS models are appropriate specifications of the complex-carbohydrate demand system.

Given these results, estimates of the demand system are obtained with the ITSUR LA/AIDS model. Table 3 shows the structural parameter estimates for each equation.

These results show that the LA/AIDS model provides a relatively good fit to the data as each equation in the system has an R^2 of over 90%, and 40% of the parameter estimates are significant at a 5% level of significance. However, the Durbin-Watson d statistic is inconclusive for each equa-

Table 2. Hausman Tests of Price and Quantity Endogeneity

Variable[a]	Potato Products	Bread	Pasta
Quantity	5.1582	1.6744	1.3200
Price	7.4617	2.0734	5.6605

[a]Critical chi-square at 5% level is 21.0300 for the potato products and 9.4900 for pasta and bread.

[10] Implementing this test requires obtaining price and quantity data on other foods and nonfood products and estimating cross-price elasticities, both with and without separability restrictions, between the various groups. Because a thorough consideration of even a limited set of alternatives is beyond the scope of this paper, and because the limited number of observations would cause the tests to be of very low power, this study does not investigate the separability assumption in detail.

Table 3. LA/AIDS Complex-Carbohydrate Parameter Estimates

Variable	Fresh Potatoes	Frozen Potatoes	Rice	Pasta	Bread
Constant[a]	−0.496	−0.284	−1.010	0.093	2.691
	(−0.875)	(−0.691)	(−2.913)**	(0.425)	(3.478)**
Time	−0.106	0.055	−0.116	0.069	0.097
	(−1.099)	(0.753)	(−1.793)*	(2.046)*	(0.678)
Overtime	−0.004	0.001	−0.009	0.003	0.010
	(−1.113)	(0.422)	(−3.783)**	(1.530)	(1.765)*
Women's	−0.001	0.004	0.002	−0.001	−0.003
participation	(−0.383)	(1.568)	(0.745)	(−1.085)	(−0.601)
Microwaves	0.009	−0.003	−0.0002	−0.005	0.001
	(1.071)	(−0.393)	(−0.386)	(−1.412)	(0.096)
Fast food	0.002	−0.004	0.003	−0.009	−0.005
	(1.215)	(−3.043)**	(2.982)**	(−1.630)	(−0.224)
P_{fresh}	0.073	−0.008	−0.019	−0.010	−0.036
	(4.978)**	(−0.860)	(−2.377)**	(1.903)*	(−2.146)*
P_{frozen}	−0.008	0.220	0.009	−0.006	−0.215
	(−0.860)	(15.990)**	(1.073)	(−0.515)	(−13.300)**
P_{rice}	−0.190	0.009	0.013	0.001	−0.004
	(−2.377)*	(1.073)	(1.422)	(0.256)	(−0.343)
P_{pasta}	−0.010	−0.006	0.001	0.047	−0.032
	(−1.903)*	(−0.515)	(0.256)	(1.860)*	(−1.871)*
P_{bread}	−0.036	−0.215	−0.004	−0.032	0.288
	(−2.136)*	(−13.280)**	(−0.338)	(−1.872)*	(9.175)**
Expenditure	0.148	0.037	0.192	−0.001	−0.375
	(1.517)	(0.527)	(3.215)**	(−0.033)	(−2.815)**
d[b]	1.917	2.193	2.695	2.661	2.230
R^2	0.911	0.978	0.914	0.978	0.937

[a]T-ratios are in parentheses. *indicates significance at the 5% level; **indicates significance at the 1% level.
[b]The d parameter is the Durbin-Watson statistic. At a 5% level of significance, d_L is 0.281 and d_U is 3.057. Values of d within this range cause the Durbin-Watson test to be inconclusive.

tion.[11] Of primary concern, however, is the significance of the translating parameters. If δ_i is significantly different from zero, then the i^{th} translating variable explains some variation in the share equation intercept. After an interpretation of these test results, the implications for budget shares and elasticity estimates follow.

Moschini and Meilke (1989) suggest a particular form of the time trend that yields a Farley-Hinich test for structural change. Essentially, specification of the time trend as t/T binds the time variable on the [0,1] interval. The time parameter estimates in table 3 show that both rice and pasta budget shares change linearly with time—rice decreasing and pasta increasing. Although this result may be surprising given the trends cited in the introduction, it does indicate that some other factor must be responsible for the observed rise in rice consumption over time. This factor appears to be fast-food expenditure. While the usual conception of fast food includes only burgers and fries, the rise of ethnic restaurants has been dramatic and is evidently responsible for the rise in rice consumption.[12] Surprisingly, fast-food expenditure has a negative effect on the consumption of frozen potato products. Given the strength of the own-price effect, this result may be due to fast-food outlets using French fries as key items in budget meal packages. Pasta consumption is also negatively related to fast-food expenditure. Once considered the fast and cheap at-home alternative, spaghetti or macaroni meals appear to be losing budget share to fast-food meals eaten away from the home.

Such consumption trends often follow more general economic cycles. As the costs of laying off and rehiring manufacturing employees to accommodate business cycles rise, the trend has been toward a greater use of overtime hours, especially during the latter stages of boom cycles. As workers put in longer days, their demands for convenience

[11] While SHAZAM provides an exact form of the Durbin-Watson test that removes the possibility of an inconclusive result, this option is available only for single-equation estimation and does not apply to the ITSUR procedure.

[12] A reviewer suggests that this result may be due to bias resulting from the possible endogeneity of fast-food expenditure. Conducting a Hausman test for the endogeneity of fast-food expenditure yields a chi-squared test statistic value of 2.225. At a 5% level, the critical chi-squared value is 9.49. Therefore, this test fails to reject the null hypothesis of fast-food exogeneity.

in food preparation increase. A priori, this creates an expectation that the shares of easier-to-prepare products should rise with overtime hours. Although the advent of the microwave has made fresh-baked potatoes perhaps the simplest to prepare, table 4 shows that both overtime and microwaves have an insignificant effect on fresh potato consumption. Overtime hours do, however, have a significantly negative influence on rice consumption. Perhaps because of the time required in preparation, rice demand falls by 1.4% for each 1% rise in overtime. In contrast, per capita pasta consumption rises with overtime hours, which may imply that when consumers prepare convenient meals at home (as opposed to going out for fast food), they are often pasta based. Besides the traditional pasta meals, a large proportion of the new frozen gourmet dinners use some variety of pasta as their staple element. While wheat flour is rarely part of this type of meal, its role as the basis for many "convenience foods" causes its consumption to rise with overtime hours as well.[13]

Beyond the obvious use in sandwiches and hamburgers, "bread" (as defined here) is used in all products made from wheat flour, including such items as pizzas, burritos, and doughnuts. As these are all convenience foods, their consumption should rise when people have less time to prepare meals (Capps, Tedford, and Havlicek 1985). The logic behind a household production approach to modeling demand provides an explanation for this effect. In a household production framework, convenience is just one of several inputs to the meal production process. When overtime rises, consumers' opportunity cost of meal preparation time rises. Therefore, their demand for convenience attributes within particular foods rises as well. This effect has been shown to be significant in an empirical household production model by Richards, Gao, and Kagan (1996) and in a cross-sectional study using National Food Consumption Survey data by Capps, Tedford, and Havlicek (1985). As the demand for convenience content rises, the demand for foods that embody those characteristics rises as well. This argument also suggests that the consumption of preprepared and frozen potato products should rise with overtime hours; however, this effect is not statistically significant.

A better explanation of the rise in frozen potato share lies in the percentage of women in the workforce. Again reflective of increased demands for convenience in food preparation, the elasticity estimates in table 4 show, at a 10% level of significance, that a 1% rise in participation causes the frozen potato share to rise by 1.4%. Jones and Choi (1992) report similar results in their model of potato demand and promotion, but this study finds that women's participation rate is not a significant influence on the demand for other complex carbohydrates. Contrary to the results of Guenthner, Lin, and Levi (1991), microwave use is not a significant determinant of the demand for any complex-carbohydrate product, so it does not appear to help explain the observed change in budget shares.

While the above evidence shows how changes in the demand for complex carbodyrates are driven to a certain extent by demographic and socioeconomic trends, changes in budget share are, of course, also due to variation in relative prices and expenditure. Analysis of the substitution matrix will make these relationships more explicit.

The uncompensated price and the expenditure elasticities in table 5 are found at the sample mean

[13] Capps, Tedford, and Havlicek (1985) cite a definition of convenience foods by Traub and Odland (1979, p. 862) as "any fully or partially prepared food in which significant preparation time, culinary skills, or energy inputs have been transferred from the homemaker's kitchen to the food processor and distributor."

Table 4. U.S. Complex-Carbohydrate Translation Elasticities: 1970–92

	Estimated Elasticities				
Variable	Fresh Potato	Frozen Potato	Rice	Pasta	Bread
Time[a]	−0.654	0.216	−2.665	0.554	0.057
	(−1.022)	(0.764)	(−1.702)*	(2.089)*	(0.702)
Overtime	−0.165	0.032	−1.392	0.127	0.037
	(−1.024)	(0.426)	(−3.248)**	(1.574)	(1.979)*
Women's participation	−0.737	1.413	3.513	−0.929	−0.165
	(−0.390)	(1.527)	(0.732)	(−1.095)	(−0.617)
Microwaves	0.054	−0.009	−0.051	−0.041	0.007
	(1.015)	(−0.395)	(−0.388)	(−1.434)	(0.094)
Fast food	0.249	−0.302	1.560	−0.155	−0.007
	(1.199)	(−3.047)**	(2.946)**	(−1.635)*	(−0.224)

[a]T-ratios are in parentheses. *indicates significance at the 5% level; **indicates significance at the 1% level.

Table 5. U.S. Uncompensated Complex-Carbohydrate Demand Elasticities: 1970–91

	Estimated Elasticities				
Carbohydrate	Fresh Potato	Frozen Potato	Rice	Pasta	Bread
Fresh potato[a]	−0.484	−0.263	−0.212	−0.182	0.008
	(−2.309)*	(−1.907)*	(−2.621)*	(−2.886)**	(0.174)
Frozen potato	−0.084	0.508	0.055	−0.061	−0.249
	(−0.802)	(5.341)**	(0.869)	(−0.656)	(−6.573)**
Rice	−1.329	−0.610	−0.761	−0.390	0.011
	(−3.171)**	(−1.757)*	(−2.349)*	(−1.927)*	(0.477)
Pasta	−0.145	−0.088	0.020	−0.317	−0.009
	(−1.161)	(−0.597)	(0.244)	(−0.822)	(0.317)
Bread	−0.298	−0.806	−6.457	−0.031	−0.182
	(−2.278)*	(−5.193)**	(−3.482)	(−1.390)	(−1.479)
Expenditure	2.340	1.259	7.355	0.981	0.422
	(2.649)**	(2.558)**	(3.721)**	(1.725)*	(2.055)*

[a]T-ratios are in parentheses. *indicates significance at the 5% level; **indicates significance at the 1% level.

budget shares.[14] Table 6 presents the compensated elasticities. Although the model is restricted to be consistent with homogeneity and symmetry, both restrictions implied by demand theory, frozen potatoes exhibit positive own-price Marshallian elasticities of demand. Jones and Choi (1992) report a similar result in a double-log model of potato demand, but Gao and Guenthner (1992) find an elasticity of −0.63. The fresh potato elasticity of −0.484 is, however, consistent with Miranda and Glauber's short-run price elasticity estimate (1993) for fresh potatoes of −0.52. Using Canadian data, Destorel (1984) finds a negative demand curve for fresh potato disappearance at the wholesale level.

In general, the elasticity estimates of this study tend to be higher than those reported in previous studies. This is perhaps not surprising in that these studies use data from an earlier period (McCracken 1988; Jones and Ward 1989; Gao and Guenthner 1992), and, as more substitutes become available, both the cross- and own-price elasticities of demand are likely to rise. Recent years have seen a proliferation of new products within each of the complex-carbohydrate subgroups—gourmet breads, curly fries, a wide variety of pastas, and premixed rice dishes. While the expected rise in elasticities may be true, it assumes that the products are indeed substitutes.[15]

On the contrary, the cross-price elasticities in

[14] On the suggestion of a reviewer, we also estimated a level version of the Rotterdam model (Gao, Wailes, and Cramer 1994) in order to evaluate the robustness of our elasticity estimates. The resulting elasticities are very similar in pattern of sign and statistical significance to our LA/AIDS estimates, but the Rotterdam elasticities are consistently larger in absolute value than the equivalent LA/AIDS values. However, none of the conclusions drawn from the LA/AIDS results is changed in a qualitative sense upon estimating the Rotterdam model.

[15] The complex-carbohydrate demand system of Gao, Wailes, and Cramer (1994), which they estimate with cross-sectional data from a relatively recent period (1987–88), shows all compensated cross-price elasticities to be positive, whereas several are negative in the current study. The discrepancies between the results of Gao, Wailes, and Cramer (1994) and the results of this study may be due to several factors, including aggregation biases in our data, differences in functional form, and problems with the definition of "consumption" in the USDA data (Nelson 1991).

Table 6. U.S. Compensated Complex-Carbohydrate Demand Elasticities: 1970–91

	Estimated Elasticities				
Carbohydrate	Fresh Potato	Frozen Potato	Rice	Pasta	Bread
Fresh potato[a]	−0.223	−0.086	0.007	0.056	0.283
	(−0.293)	(−1.361)	(−0.083)	(0.948)	(6.816)**
Frozen potato	0.177	0.508	0.275	0.135	0.026
	(0.338)	(4.421)**	(1.419)	(1.021)	(5.250)**
Rice	−1.068	−0.433	−0.541	−0.324	0.286
	(−0.088)	(−3.244)**	(−0.998)	(−2.481)**	(7.031)**
Pasta	0.116	0.089	0.239	−0.251	0.266
	(−1.152)	(2.541)	(0.306)	(−0.737)	(6.013)**
Bread	−0.037	−0.629	−6.237	0.035	−1.545
	(−0.627)	(−5.876)**	(−1.088)	(1.540)	(3.284)**

[a]T-ratios are in parenthesis. *indicates significance at the 5% level; **indicates significance at the 1% level.

table 5 show more evidence of complementarity among the products than substitution. Specifically, these results show the relationship between fresh potato and bread consumption to be asymmetrical—while fresh potatoes substitute for bread, the opposite is not true. It may be the case that the microwaved baked potato is taking the place of many bread-based convenience meals, but when fresh potatoes are consumed, bread also forms part of the meal. Frozen potatoes are also regarded as poor substitutes for the other products. This perhaps reflects a perception among consumers that frozen products are somehow nutritionally inferior to the alternatives. It could also be the case that consumers have been unwilling to accept anything other than French fries as the ubiquitous fast-food side dish.

The cross-price elasticities also provide evidence that rice is a complement to both bread and fresh potato consumption. While this result does not suggest that these products are consumed together, it does indicate that they are companions in the diets of consumers with similar consumption patterns. It is tempting to include these products in a group of "mature" and declining foods, but the expenditure elasticities indicate otherwise.

In particular, table 5 shows rice to be a strong luxury good. Of the other products, fresh and frozen potatoes are also luxury items, while pasta and bread are necessities. Thus, as the total expenditure on complex carbohydrates grows, the share of rice and fresh potatoes in particular should rise at the expense of pasta and bread.

Conclusions

This study attempts to determine whether or not socioeconomic factors are responsible for observed changes in the demand for staple complex carbohydrates. Staple carbohydrates consist of fresh potatoes, frozen potato products, rice, pasta, and bread. Increased demands for convenience and variety in food preparation suggest that, a priori, the elasticities of and relationships among staple food products change over the 1970–91 sample period, and continue to change.

The empirical model employs a demographic translation approach, which is interpreted as a generalization of the time-varying parameter approach of Moschini and Meilke (1989). This method allows the parameters of a LA/AIDS specification of staple carbohydrate demand to vary systematically in response to changes in a set of socioeconomic variables. These variables consist of proxies for changes in food preparation technology, workforce composition, the decline in leisure time, and the rise in fast-food consumption.

Estimates of the effect of these variables on staple carbohydrate demand parameters are obtained with annual retail per capita U.S. consumption data over the period 1970–91. T-tests of the significance of each parameter constitute a variable-by-variable assessment of the impact of socioeconomic trends on the demand for each product.

These tests confirm that the average budget share of each product changes significantly over the sample period for reasons other than variation in relative prices and expenditure. In fact, variations in budget share that are not explained by prices and expenditure are at least partially explained by a set of socioeconomic variables. Because such changes in taste are unobservable, the socioeconomic variables are proxy variables that measure consumers' changing demand for convenience, quality, or health in food consumption. Specifically, the set of proxy variables includes the proportion of women in the workforce, the number of microwave ovens in use, the average number of overtime hours, and the amount of fast-food expenditure in the United States. Together, these variables account for much of the observed changes in complex-carbohydrate demand.

Specifically, the results show that increases in fast-food expenditure tend to cause the consumption of fresh potatoes to rise. While many would expect fast-food spending to explain observed increases in frozen potato consumption, this trend is instead explained by rising total expenditure on complex carbohydrates and the rising proportion of women in the workforce—a proxy variable for the demand for convenience. While rice consumption is trending downward sharply with time, *ceteris paribus,* pasta consumption is rising at a moderate rate. In contrast, rice consumption rises with fast-food expenditure, but pasta consumption falls. The exact opposite effect is true for the effect of overtime hours. Overtime hours are the only significant socioeconomic determinant of changes in the demand for bread, producing a small, yet significantly positive elasticity. Even after controlling for these factors, the elasticities of rice and pasta still vary significantly with time. This is evidence of a pure change in consumer tastes in the sense of Moschini and Meilke (1989).

These results provide valuable information to potato marketing groups in the design of generic promotional programs. Promotions aimed at the restoration of fresh potato market share, for example, would be well advised to educate the public in methods of fresh potato preparation that are simple, fast, and consistent with trends toward more "ethnic" meals (Senauer, Asp, and Kinsey 1991). Microwave-baked fresh potatoes could form the basis of such a campaign. Similar advice to producer groups could result in product and package innovations to restore fresh potato consumption. Prewrapped and seasoned baking potatoes would be one option for a value-added process that capitalizes on the natural convenience of the fresh potato. Some fast-food chains recognize this fact and offer baked potatoes on their menu. Further efforts to promote the adoption of baked potatoes by more chains would allow fresh potatoes to participate in the fastest growing segment of the potato market, possibly gaining back market share in the "backyard" of the frozen potato.

Comparing the results of this paper with previous work suggests that the elasticity of fresh potato demand is falling over time. Consequently, further reductions in fresh potato price through yield increases on the farm or greater efficiencies in distribution will have little effect on the overall demand. Instead, efforts that shift the demand curve for fresh potatoes will provide a higher return the less elastic fresh potato consumption becomes.

References

Anderson, G., and R. Blundell. 1983. "Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada." *Review of Economic Studies* 50:397–410.

Alston, J., and J. Chalfant. 1991. "Can We Take the Con Out of Meat Demand Studies?" *Western Journal of Agricultural Economics* 16:36–48.

______. 1993. "The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." *American Journal of Agricultural Economics* 75:304–13.

Atkins, F.J., W. Kerr, and D.B. McGivern. 1989. "A Note on Structural Change in Canadian Beef Demand." *Canadian Journal of Agricultural Economics* 37:513–24.

Barten, A.P. 1969. "Maximum Likelihood Estimation of a Complete System of Demand Equations." *European Economic Review* 1:7–73.

Bjorndal, T., K.G. Salvanes, and J.H. Andreassen. 1992. "The Demand for Salmon in France: The Effects of Marketing and Structural Change." *Applied Economics* 24:1027–34.

Blanciforti, L., and R. Green. 1983. "An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Commodity Groups." *Review of Economics and Statistics* 65:511–15.

Braschler, C. 1983. "The Changing Demand Structure for Pork and Beef in the 1970s: Implications for the 1980s." *Southern Journal of Agricultural Economics* 15:105–10.

Brown, M.G., and J.-Y. Lee. 1992. "Theoretical Overview of Demand Systems Incorporating Advertising Effects." In *Commodity Advertising and Promotion,* ed. H.W. Kinnucan, S.R. Thompson, and H.-S. Chang. Ames: Iowa State University Press.

Capps, Jr., O., J.R. Tedford, and J. Havlicek, Jr. 1985. "Household Demand for Convenience and Nonconvenience Foods." *American Journal of Agricultural Economics* 67: 862–69.

Chalfant, J. 1987. "A Globally Flexible Almost Ideal Demand System." *Journal of Business and Economic Statistics* 5: 233–42.

Chalfant, J., and J. Alston. 1988. "Accounting for Changes in Tastes." *Journal of Political Economy* 96:391–410.

Chang, H.-S., and R. Green. 1992. "Measuring the Effects of Advertising on Demand Elasticities Using Time Series/Cross-Sectional Data." In *Commodity Advertising and Promotion,* ed. H.W. Kinnucan, S.R. Thompson, and H.-S. Chang. Ames: Iowa State University Press.

Chavas, J.P. 1983. "Structural Change in the Demand for Meat." *American Journal of Agricultural Economics* 65: 148–53.

Chen, P.Y., and M. Veeman. 1991. "An Almost Ideal Demand System Analysis for Meats with Habit Formation and Structural Change." *Canadian Journal of Agricultural Economics* 39:223–35.

Choi, S., and K. Sosin. 1990. "Testing for Structural Changes: The Demand for Meat." *American Journal of Agricultural Economics* 72:228–36.

Cox, T.L. 1992. "A Rotterdam Model Incorporating Advertising Effects: The Case of Canadian Fats and Oils." In *Commodity Adversiting and Promotion,* ed. H.W. Kinnucan, S.R. Thompson, and H.-S. Chang. Ames: Iowa State University Press.

Dahlgran, R.A. 1987. "Complete Flexibility Systems and the Stationarity of U.S. Meat Demands." *Western Journal of Agricultural Economics* 12:152–63.

Davis, B., and H.T. Cardwell III. 1980. "Production and Price Relationships for West Texas and U.S. Spring and Summer Potatoes." Department of Agricultural Economics, College of Agricultural Sciences Publication No. T-1-191. Lubbock, Texas: Texas Tech University.

Deaton, A., and J. Muellbauer. 1980. "An Almost Ideal Demand System." *American Economic Review* 70:312–26.

Destorel, J.J. 1984. "Potato Forecasting Model." Marketing and Economics Branch working paper. Ottawa: Agriculture Canada. August.

Dunham, Denis. 1993. *Food Cost Review.* Washington, D.C.: USDA, Economic Research Service.

Eales, J.S., and L.J. Unnevehr. 1988. "Demand for Beef and Chicken: Separability and Structural Change." *American Journal of Agricultural Economics* 70:521–32.

______. 1993. "Simultaneity and Structural Change in Meat Demand." *American Journal of Agricultural Economics* 75:259–68.

Edgerton, D.L. 1993. "Separable Demand Models." *Journal of Agricultural and Resource Economics* 18:141–46.

Fulponi, L. 1992. "The Almost Ideal Demand System: An Application to Food and Meat Groups for France." *Journal of Agricultural Economics* 40:82–92.

Gao, X.M., and J.S. Shonkwiler. 1991. "Taste Change in Meat Demand—An Application of the MIMIC Model." *Southern Journal of Agricultural Economics* 23:260.

Gao, X.M., E.J. Wailes, and G.L. Cramer. 1994. "A Synthetic Demand System: An Application to U.S. Consumer Demand for Rice and Selected Rice Substitutes." *Review of Agricultural Economics* 16:27–38.

Gao, Y., and J.F. Guenthner. 1992. "Forecasting the Demand for Frozen Potatoes." University of Idaho, College of Agriculture, Agricultural Experiment Station Report no. 755.

Green, R.D. 1985. "Dynamic Utility Functions for Measuring Advertising Responses." In *Proceedings of Research on Effectiveness of Agricultural Commodity Promotion, Seminar.* Arlington, Va.: Farm Foundation and USDA.

Green, R.D., and J. Alston. 1990. "Elasticities in AIDS Models." *American Journal of Agricultural Economics* 72: 442–45.

Green, R.D., H.F. Carman, and K. McManus. 1991. "Some Empirical Methods of Estimating Advertising Effects in Demand Systems: An Application to Dried Fruits." *Western Journal of Agricultural Economics* 16:63–71.

Guenthner, J., B.H. Lin, and A.E. Levi. 1991. "The Influence of Microwave Ovens on the Demand for Fresh and Frozen Potatoes." *Journal of Food Distribution Research* September: 45–52.

Hausman, J. 1978. "Specification Tests in Econometrics." *Econometrica* 46:1251–71.

Hayes, D. 1992. "Discussion: Incorporating Advertising into Demand Systems." In *Commodity Advertising and Promotion,* ed. H.W. Kinnucan, S.R. Thompson, and H.-S. Chang. Ames: Iowa State University Press.

Jones, E., and Y. Choi. 1992. "Advertising of Fresh and Processed Potato Products." In *Commodity Advertising and Promotion,* ed. H.W. Kinnucan, S.R. Thompson, and H.-S. Chang. Ames: Iowa State University Press.

Jones, E., and R.W. Ward. 1989. "Effectiveness of Generic and Brand Advertising on Fresh and Processed Potato Products." *Agribusiness* 5:528–36.

LaFrance, J.T. 1991. "When Is Expenditure 'Exogenous' in Separable Demand Models?" *Western Journal of Agricultural Economics* 16:49–62.

Maddala, G.S. 1977. *Econometrics.* New York: McGraw-Hill.

McCracken, V.A. 1988. *Consumer Demand for Potatoes: At Home and Away From Home.* Research Bulletin XB1000. Pullman: College of Agriculture and Home Economics Research Center, Washington State University.

McGuirk, A., P. Driscoll, J. Alwang, and H. Huang. 1995. "System Misspecification Testing and Structural Change in the Demand for Meats." *Journal of Agricultural and Resource Economics* 20:1–21.

Miranda, M.J., and J.W. Glauber. 1993. "Intraseasonal Demand for Fall Potatoes under Rational Expectations." *American Journal of Agricultural Economics* 75:104–12.

Mischen, P. 1994. "NFAPP Potato Model Baseline Projections." National Food and Agricultural Policy Project. Tempe: Arizona State University.

Moschini, G., and K.D. Meilke. 1984. "Parameter Stability and the U.S. Demand for Beef." *Western Journal of Agricultural Economics* 9:271–82.

______. 1989. "Modeling the Pattern of Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 71:253–61.

Moschini, G., and A. Vissa. 1992. "A Linear Inverse Demand System." *Journal of Agricultural and Resource Economics* 17:294–302.

Moschini, G., D. Moro, and R.D. Green. 1994. "Maintaining and Testing Separability in Demand Systems." *American Journal of Agricultural Economics* 76:61–73.

Nayga, R.M. Jr., and O. Capps, Jr. 1994. "Tests of Weak Separability in Disaggregated Meat Products." *American Journal of Agricultural Economics* 76:800–808.

Nelson, J. 1991. "Quality Variation and Quantity Aggregation in Consumer Demand for Food." *American Journal of Agricultural Economics* 73:1204–12.

Nyankori, J.C.O., and G.H. Miller. 1982. "Some Evidence and Implications of Structural Change in Retail Demand for Meats." *Southern Journal of Agricultural Economics* 14: 65–70.

Pollak, R.A. 1970. "Habit Formation and Dynamic Demand Functions." *Journal of Political Economy* 78:745–63.

Pollak, R.A., and T.J. Wales. 1969. "Estimation of the Linear Expenditure System." *Econometrica* 37:629–750.

______. 1981. "Demographic Variables in Demand Analysis." *Econometrica* 49:533–51.

Reynolds, A., and E. Goddard. 1991. "Structural Change in Canadian Meat Demand." *Canadian Journal of Agricultural Economics* 39:211–22.

Richards, T.J., X.M. Gao, and A. Kagan. 1996. "The Demand for Quality and Convenience: A Household Production Approach." Discussion paper, National Food and Agricultural Policy Project. Arizona State University. June.

Senauer, B., E. Asp, and J. Kinsey. 1991. *Food Trends and the Changing Consumer.* St. Paul, Minn.: Eagan Press.

Tegne, A. 1990. "The Kalman Filter Approach for Testing Structural Change in the Demand for Alcoholic Beverages in the U.S." *Applied Economics* 22:1407–16.

Thurman, W.N. 1987. "The Poultry Market: Demand Stability and Industry Structure." *American Journal of Agricultural Economics* 69:30–37.

Traub, L.G., and D. Odland. 1979. "Convenience Foods versus Home Prepared Foods: Comparative Costs, Yield, and Quality." Agricultural Economics Report no. 429. Washington, D.C.: USDA, ESCS.

U.S. Department of Agriculture. 1994. *Agricultural Statistics, 1993.* Washington, D.C.

U.S. Department of Agriculture, Economic Research Service (ERS), Commodity Economics Division (CED). 1993. *Food Consumption, Prices, and Expenditures: 1970–92.* Washington, D.C.

______. 1994. *Food Marketing Review: 1992–93.* Agricultural Economics Report no. 678. Washington, D.C.

U.S. Department of Agriculture, Economic Research Service (ERS), National Agricultural Statistics Service (NASS). 1994. *Potato Statistics.* Washington, D.C.

U.S. Department of Commerce. 1994. *Statistical Abstract of the United States, 1993.* Washington, D.C.: Government Printing Office.

______. Bureau of Labour Statistics. 1970–92. *Consumer Price Index: Monthly Summary.* Washington, D.C.

Wahl, T.I., and D.J. Hayes. 1990. "Demand System Estimation with Upward Sloping Supply." *Canadian Journal of Agricultural Economics* 38:107–22.

WEFA Group. 1995. *U.S. Macroeconomic Services.* New York.

Wohlgenant, M.K. 1985. "Estimating Cross-Elasticities of Demand for Beef." *Western Journal of Agricultural Economics* 10:322–29.

Xu, X., and M. Veeman. 1995. "Model Choice and Structural Specification for Canadian Meat Consumption: 1967–1992." Paper presented at American Agricultural Economics Association annual meetings, Indianapolis, In., August.

Yang, S.-R., and W.W. Koo. 1994. "Japanese Meat Import Demand Estimation with the Source Differentiated AIDS Model." *Journal of Agricultural and Resource Economics* 19:396–408.

Young, L.J. 1987. "Canadian Meat Demand." Policy Branch Working Paper 10/87. Ottawa: Agriculture Canada. June.