1999 AAEA Annual Meeting in Nashville, TN
Selected Paper

A Regional Econometric Model of U.S. Apple Production

by

Jutta Roosen
478 A Heady Hall
Department of Economics
Iowa State University
Ames, IA 50011-1070

Phone: (515) 294-2038
Fax: (515) 294-0221
email: jutta@iastate.edu

Subject Code 18 (Econometrics)

Abstract: A four-region econometric model of U.S. apple production and consumption is developed. Technical progress has benefited growers in the Northwest the most, but prices there are much lower in comparison to other regions. Estimated elasticities are used to estimate national and regional welfare impacts of pesticide cancellations.

Copyright 1999 by Jutta Roosen. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

The author would like to thank David Hennessy, Vickie McCracken, Bruce Babcock, Alicia Carriquiry, Joe Herriges, and Catherine Kling for comments on earlier drafts of this paper.

Introduction

Estimation of economic surplus changes that are caused by technology shifts requires knowledge of demand and supply elasticities in the markets in questions. Because apple production systems are very heterogeneous across the United States, growers' abilities to respond to technology changes and market forces differ widely. To capture the dispersion of responses, estimates of elasticities are needed for the different grower groups. To this end, a model of U.S. apple production was estimated at a regional level.

Several econometric models of the U.S. apple industry exist in the literature, but none of them provides regional elasticity estimates that are suitable for our modeling effort of assessing regional impacts of technology changes. Willett (1993) estimates an econometric model of the apple industry with a focus on the demand side. Supply is estimated at the aggregated U.S. level. Baumes and Conway (1984) also estimate a model at the aggregated U.S. level. Their model does not allow for the analysis of regional effects. Hossain (1993) and Chaudry (1988) estimate regional models of the U.S. apple industry. Supply is considered to be fixed in any given period and the model is not useful for the estimation of short-run or long-run production impacts because growers can only adjust to price changes by reallocating fruit from fresh to processed consumption.

In general it can be said that, although several models of the apple industry exist, most of them are dated and interest is mostly focused on short-term allocation decisions or structural changes in product demand. None of these models is appropriate for the modeling of regional impacts of technology shifts because supply is usually taken as given. The results in this paper show that production adjustments differ across regions and that this heterogeneity ought to be acknowledged when conducting welfare assessments of technology changes in the apple industry.

The Model

The structural model is organized into five components: supply, allocation, pricing, demand, and net imports. We divide the United States into four apple production regions, the Northwest (NW), the Southwest (SW), the Central (C), and the East (E), as described in table 1, and for each region the total supply and the allocation between markets for fresh and processed utilization are modeled. The demand

and net import equations on the other hand are set at the aggregated U.S. level. To link the regional supply components with the demand component, regional pricing equations are introduced that translate U.S. level prices into regional prices. For space consideration, we describe the specification of each model component concurrently with the results. But before doing so, we outline the estimation procedure.

Estimation

The model is estimated via three stage least squares using data from 1971-97. Data has been obtained from several statistical publications (USDA Agricultural Statistics; USDA Foreign Agricultural Trade of the United States; USDA ERS/CED; Johnson; U.S. President). Table 1 gives some production statistics for the four regions. The estimated model is presented in table 2 and the numbers in parentheses report t-values for the parameter estimates. Variable definitions are given in table 3. The R^2 values suggest a good fit and the Durbin-Watson statistics either reject the presence of first-order autocorrelation or are inconclusive.

Supply

In each production region, supply decisions for a crop are divided into a decision about bearing acreage and a decision about planned yields. Following French, King, and Minami, we model the bearing acreage in its first difference as a function of past input and output prices, $IPP3_t$ and $PAj3_t$, where *j* = NW, SW, C, E denotes the respective region and t is the time subscript. Yield per acre, Yj_t, is modeled as a function of expected price and a time trend, *T*, that captures changes in the production technology. Specifically, price expectations are modeled as adaptive expectations and approximated by a three-year moving average of past average prices received, $PAj3_{t-1}$. Total production for a region, $QPTj_t$, is the product of yield and bearing acreage.

The parameter to the price variable in the acreage equation is positive in all regions and it is significant in the Central and in the East. For the yield equation, the price variable is significant in all regions except the Central. The parameter to the time trend is larger in the Northwest than in all other regions showing that the Northwest has benefited more from technological progress in the apple industry than any other region. After accounting for market changes, average yields increased by 698 lb./acre/year in the Northwest, compared with 229 lb./acre/year in the Southwest, 250 lb./acre/year in the Central, and 113 lb./acre/year in the East.

Allocation

The allocation equation estimates the amount of apples sold in the market for fresh apples, $QPFj_t$. Explanatory variables include the price premium paid for fresh apples, i.e. the difference of prices paid for fresh and process apples, $PFj_t - PPj_t$, and total production in the current year, $QPTj_t$. The coefficient to $QPTj_t$ indicates the share of total production above average total production allocated to fresh consumption, while the coefficient to $PFj_t - PPj_t$ measures the change of fresh utilization due to price incentives. Produce allocated to the processing market is defined as the difference between total and fresh production.

In all regions the allocation equations indicate that if total production increases, a smaller than average share of total production is allocated to fresh utilization, i.e., the average share of fresh production in the Northwest is 73.2% and 66% of an increase in total production are marketed as fresh. For the Southwest these percentages are 38.5% and 35.4%, for the Central they are 50.6% and 49.3%, and for the East they are 43.4% and 17.3%. Also, the premium paid in the fresh market significantly influences the allocation decision.

Net Imports

Net imports for fresh and processed apples are modeled as a function of the U.S. price for the respective product, PF_t and PP_t, and the quantities of U.S. fresh and processed production, QPF_t and QPP_t. In addition, the per-unit values of net imports, PIF_t and PIP_t, are included; they are calculated as the value of net imports and exports over the respective total quantity.

It is found that the home price level is significant in the determination of net imports of both fresh and processed apples. The per-unit value of imports, on the other hand, is significant in the fresh market but not so in the processed market. Low quantities of home production increase net imports, i.e., increase imports and/or lower exports. Net imports respond more to home production in the processing sector than they do in the fresh sector. Both imports for fresh apples and processing apples increase over time but imports in the processing sector are increasing at a faster absolute rate. In fact, net imports are negative for fresh apples and positive for processed apples so that our model predicts a decreasing trade surplus in the fresh apple market and an increasing trade deficit in the processed apple markets given recent price and home production levels.

The estimates indicate that imports of processed apples are much more responsive to changes in the home market than it is the case for the fresh market. Both the responsiveness to the U.S. price level and the responsiveness to the quantity of home production are larger.

Demand

Regional production of fresh and processed apples is aggregated to the U.S. level at which the demand system estimates apple consumption per person in the form of inverse demand functions. The per capita quantities of consumption of fresh apples, QUF_t, and consumption of an alternative fresh fruit, e.g., fresh oranges, enters the estimation of the inverse demand for fresh apples, as do per capita personal food consumption expenditures, $PCEDC_t$. A time trend is also included. Alternative fruits are considered to measure substitution effects or changes in taste parameters. The demand for processing apples is specified as a function of processed apple consumption, QUP_t, consumption of an alternative processed fruit, e.g., orange juice, and personal food consumption expenditures.

The demand equations show that demand for fresh and processed apples is decreasing in prices and increasing in income. The income coefficient is larger in the demand for fresh apples than for processed apples. Fresh oranges were used as the alternative fruits in the equation for fresh demand and orange juice as the alternative in the equation for processed demand. Other fruits such as fresh bananas, canned pears, and canned peaches were tested as additional or alternative substitutes but failed to improve the estimation. Fresh oranges serve as substitutes for fresh apples. However, orange juice serves a complement of processed apples. Since increased apple juice consumption is the primary cause for the increased consumption of processed apples in general, we conclude that orange juice measures a change in taste towards higher juice consumption, a result that is also found in Willet.

Pricing

To link the regional supply sectors of the model to the national demand sector, regional fresh and processing prices are modeled as a linear function of the average U.S. price. Using linear pricing equation jointly with the inverse demand equations, we restrict the differences in the regional demand equations to linear transformations of a common national demand function. For the Northwest, we can conclude that prices are more variable in the Northwest than in the other regions because the multiplicative term is greater than one, and for the Southwest prices for fresh apples are less variable than they are in other regions.

Elasticity Estimation

Elasticities are calculated at the means of the data for first-year impacts (short run) and fifth-year impacts (long run). Given the structure of the model, the elasticities for the first year after an exogenous change in output price can only include yield and allocation changes, while at a five-year lag acreage might adjust as well. For the demand and net import equations the model is static, hence elasticities are the same for all years. A non-parametric bootstrap was used to determine the statistical significance of the elasticity estimates and asterisks mark the elasticities that are significant at the 0.1 level.

Table 4 gives the estimated elasticities. On the supply side, they measure total supply responses, i.e. the concurrent adjustment of fresh and processed production in each region following a change in the U.S. price level. Supply responses are inelastic to price changes in the short run. The technology of apple production allows only for slow adjustments because newly planted orchards take several years to come into full bearing and yields can only be adjusted to a very limited extent. Although technology constrains growers to a relatively inelastic response in total production, they can also adjust by reallocating production between the fresh and processing sector if relative prices change.

The cross elasticities of supply are negative in all regions in the short run. The increase in average price due to the increase in the price for fresh or processed apples will induce an increase in yield and acreage. The change in relative prices will in addition cause the reallocation of crop to the utilization for which prices increase, and this reallocation outweighs the increase in total production in the short run. Turning to the long-run elasticities, the cross-price elasticity of processed production with respect to fresh price turns positive in the Northwest and Southwest, as now, given the increase in fresh price, total production will increase so much that both fresh and processed production increases.

Own-price demand elasticities for fresh and processing apples are -0.37 and -0.70, respectively, and the overall demand elasticity with respect to an increase in average price is -0.55. The demand for apples responds relatively inelastically to changes in prices. The income elasticity is 1.2 for fresh apples and 2.6 for processed apples.

Policy Application

We utilize the estimated elasticities to estimate the economic impacts of pesticide cancellations scenarios at the regional level. We employ a partial-equilibrium framework of apple supply and demand and shock the marginal cost function of the producers that use the pesticide in a way as described in Lichtenberg, Parker, and Zilberman. Approximating the shift in the marginal cost function (supply function) by a linear shift allows us to estimate the producer and consumer surplus changes in the market.

Data to estimate the shift in the supply function are obtained in expert opinion surveys conducted as part of a USDA-NAPIAP project. The results show that regional distribution effects are important to consider, not only because of differences in the marginal cost impacts across regions, but also because of growers heterogeneity in responding to changes in the market environment. A simulation study that analyzes economic impacts for the case where the marginal cost function is equally distorted in all regions shows that growers in the East will lose most in relative terms of regional revenue from apple production whereas growers in the Midwest are relatively least impacted.

Looking at the results for some pesticides, a ban on simazine causes growers in the West lose $3.7 mill. in terms of producer surplus because their production technology is severely impacted. Growers in other regions, however, would benefit because their cost increases are outweighted by price increases that are caused by the reduced supply from western regions. Consumer bear a large share of the resulting surplus losses and total losses are estimated at $8 mill. Looking for instance at a hypothetical ban on egosterol biosynthesis inhibitors, a group of fungicides, shows that marginal cost impacts are more homogeneous across the United States, and all regions but the Central would suffer economic surplus losses. Given the large share of western state in total production they still would suffer most of the impact with a producer surplus loss of $1.6 mill. Total losses are estimated at $4.7 mill.

Conclusion

Elasticity estimates are obtained for supply and demand responses to price changes in the markets for fresh and processed apples. Supply elasticities are obtained for four production regions, and differences in growers' ability to respond to market changes are evident in these estimates. The resulting elasticity estimates are employed in the analysis of regional impacts that result from hypothetical changes in pesticide availability.

Table 1. Production Regions, 1997 [a]

Region	States	Bearing Acreage (000 ac)	Total Prod. (mill. lb.)	Fresh Prod. (mill. lb.)	Avg. Price (c/lb.)	Fresh Price (c/lb.)	Proc. Price (c/lb.)
NW	Washington, Oregon, Idaho	170.3	5,270.0	3,762.0	16.7	21.7	4.1
SW	Arizona, California, Colorado, Utah, New Mexico	50.5	1,091.0	440.0	16.6	32.4	6.4
C	Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, Tennessee, Wisconsin	92.6	1,413.1	1,050.1	13.2	20.3	7.3
E	Delaware, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, West Virginia,	140.6	2,627.0	574.9	13.5	24.9	8.3
U.S.		**454.0**	**10,401.1**	**5,827.1**	**15.4**	**23.0**	**6.4**

[a] Numbers might not add up due to rounding.

Table 2. Estimation Results

<u>Supply Sector</u>		
Northwest		
$\Delta ABNW_t =$	$-0.124 + 20.540\ PANW3_{t-3}/IPP3_{t-3} + 11.000\ D867$	$R^2 = 0.497$
	$(-0.059)\ \ (1.491)\ \ \ \ \ \ (8.951)$	$DW = 1.276$
$ABNW_t =$	$ABNW_{t-1} + \Delta ABNW_t$	
$YNW_t =$	$7.192 + 0.674\ PANW3_{t-1} + 0.698\ T$	$R^2 = 0.523$
	$(2.054)\ \ (4.426)\ \ \ \ \ \ (8.805)$	$DW = 1.695$
$QPTNW_t =$	$ABNW_t * YNW_t$	
Southwest		
$\Delta ABSW_t =$	$-2.821 + 22.290\ PASW3_{t-3}/IPP3_{t-3} + 4.834\ D879$	$R^2 = 0.471$
	$(-1.497)\ \ (1.521)\ \ \ \ \ \ (6.782)$	$DW = 2.312$
$ABSW_t =$	$ABSW_{t-1} + \Delta ABSW_t$	
$YSW_t =$	$-0.165 + 1.065\ PASW3_{t-1} + 0.229\ T$	$R^2 = 0.513$
	$(-0.083)\ \ (8.818)\ \ \ \ \ \ (6.398)$	$DW = 2.400$
$QPTSW_t =$	$ABSW_t * YSW_t$	
Central		
$\Delta ABC_t =$	$-7.926 + 37.948\ PAC3_{t-3}/IPP3_{t-3} + 3.952\ D81$	$R^2 = 0.433$
	$(-3.883)\ \ (2.883)\ \ \ \ \ \ (6.965)$	$DW = 1.324$
$ABC_t =$	$ABC_{t-1} + \Delta ABC_t$	
$YC_t =$	$9.906 + 0.050\ PAC3_{t-1} + 0.250\ T - 4.730\ D967$	$R^2 = 0.316$
	$(3.227)\ \ (0.340)\ \ \ \ \ \ (3.907)\ \ (-5.026)$	$DW = 2.383$
$QPTC_t =$	$ABC_t * YC_t$	
East		
$\Delta ABE_t =$	$-11.659 + 79.046\ PAE3_{t-3}/IPP3_{t-3}$	$R^2 = 0.363$
	$(-4.911)\ \ (4.231)$	$DW = 1.851$
$ABE_t =$	$ABE_{t-1} + \Delta ABE_t$	
$YE_t =$	$13.567 + 0.071\ PAE3_{t-1} + 0.113\ T$	$R^2 = 0.350$
	$(10.405)\ \ (1.081)\ \ \ \ \ \ (4.087)$	$DW = 1.841$
$QPTE_t =$	$ABE_t * YE_t$	
<u>Allocation</u>		
Northwest		
$QPFNW_t =$	$-0.808 + 16.419\ (PFNW_t - PPNW_t) + 0.661\ QPTNW_t$	$R^2 = 0.975$
	$(-0.007)\ \ (2.033)\ \ \ \ \ \ (44.637)$	$DW = 2.437$
$QPPNW_t =$	$QPTNW_t - QPFNW_t$	
Southwest		
$QPFSW_t =$	$-128.253 + 8.251\ (PFSW_t - PFSW_t) + 0.354\ QPTSW_t$	$R^2 = 0.878$
	$(-5.086)\ \ (5.414)\ \ \ \ \ \ (12.127)$	$DW = 1.931$
$QPPSW_t =$	$QPTSW_t - QPFSW_t$	

Table 2 (continued)

Central

$QPFC_t = -357.647 + 28.488\,(PFC_t - PPC_t) + 0.493\,QPTC_t$ $R^2 = 0.693$
(-3.366) (6.960) (9.603) DW = 2.372

$QPPC_t = QPTC_t - QPFC_t$

East

$QPFE_t = 242.384 + 34.544\,(PFE_t - PPE_t) + 0.173\,QPTE_t$ $R^2 = 0.627$
(2.336) (7.491) (4.652) DW = 1.730

$QPPE_t = QPTE_t - QPFE_t$

Regional Price Determination

Northwest

$PFNW_t = -4.596 + 1.197\,PF_t$ $R^2 = 0.881$
(-3.125) (17.833) DW = 1.794

$PPNW_t = -4.923 + 1.535\,PP_t$ $R^2 = 0.764$
(-5.376) (15.205) DW = 1.557

$PANW_t = (QPFNW_t * PFNW_t + QPPNW_t * PPNW_t)/ QPTNW_t$

Southwest

$PFSW_t = 15.260 + 0.460\,PF_t + 4.617\,D86$ $R^2 = 0.533$
(5.809) (4.123) (5.970) DW = 2.133

$PPSW_t = -2.758 + 1.364\,PP_t$ $R^2 = 0.702$
(-2.673) (11.862) DW = 1.931

$PASW_t = (QPFSW_t * PFSW_t + QPPSW_t * PPSW_t)/ QPTSW_t$

Central

$PFC_t = 1.794 + 0.916\,PF_t$ $R^2 = 0.718$
(0.875) (9.990) DW = 1.826

$PPC_t = 2.024 + 0.814\,PP_t$ $R^2 = 0.832$
(3.414) (12.787) DW = 2.446

$PAC_t = (QPFC_t * PFC_t + QPPC_t * PPC_t)/ QPTC_t$

East

$PFE_t = 0.670 + 1.020\,PF_t$ $R^2 = 0.627$
(0.238) (8.077) DW = 1.270

$PPE_t = 2.731 + 0.688\,PP_t$ $R^2 = 0.872$
(6.398) (15.070) DW = 1.785

$PAE_t = (QPFE_t * PFE_t + QPPE_t * PPE_t)/ QPTE_t$

Aggregation to U.S. Production

$QPF_t = QPFNW_t + QPFSW_t + QPFC_t + QPFE_t$
$QPP_t = QPPNW_t + QPPSW_t + QPPC_t + QPPE_t$

Utilization

$QUF_t = QPF_t/POP_t + NIF_t/POP_t$
$QUP_t = QPP_t/POP_t + NIP_t/POP_t$

Table 2 (continued)

Net Imports		
NIF_t =	3024.12 - 31.320 PF_t - 579.324 PIF_t - 0.632 QPF_t + 23.779 T	R^2 =0.873
	(11.346) (-5.540) (-2.026) (-11.900) (3.688)	DW=0.941
NIP_t =	2855.47 - 100.344 PP_t - 23.190 PIP_t - 0.758 QPP_t + 172.664 T	R^2 =0.870
	(4.803) (-2.369) (-0.094) (-3.827) (9.229)	DW=1.424
Demand		
PF_t =	24.401 - 3.202 QUF_t - 0.059 $QUFO_t$ + 0.021 $PCEDC_t$ - 0.941 T	R^2 =0.650
	(2.281) (-7.947) (-0.514) (4.189) (-4.458)	DW=0.920
PP_t =	-8.667 - 0.540 QUP_t + 0.507 $QUJO_t$ + 0.009 $PCEDC_t$ - 0.316 T	R^2 =0.478
	(-1.155) (-5.989) (2.213) (3.237) (-2.509)	DW=1.747

Table 3. Definition of the Variables

$ABNW_t$	Bearing acreage in Northwest in year t	(000 acres)
$ABSW_t$	Bearing acreage in Southwest in year t	(000 acres)
ABC_t	Bearing acreage in Central in year t	(000 acres)
ABE_t	Bearing acreage in East in year t	(000 acres)
$\Delta ABNW_t$	Change in bearing acreage in Northwest from year t-1 to year t	(000 acres)
$\Delta ABSW_t$	Change in bearing acreage in Southwest from year t-1 to year t	(000 acres)
ΔABC_t	Change in bearing acreage in Central from year t-1 to year t	(000 acres)
ΔABE_t	Change in bearing acreage in East in year t-1 to year t	(000 acres)
YNW_t	Yield/acre in Northwest in year t	(000 lb./acre)
YSW_t	Yield/acre in Southwest in year t	(000 lb./acre)
YC_t	Yield/acre in Central in year t	(000 lb./acre)
YE_t	Yield/acre in East in year t	(000 lb./acre)
$QPTNW_t$	Total production in Northwest in year t	(mill. lb.)
$QPTSW_t$	Total production in Southwest in year t	(mill. lb.)
$QPTC_t$	Total production in Central in year t	(mill. lb.)
$QPTE_t$	Total production in East in year t	(mill. lb.)
$QPFNW_t$	Quantity marketed as fresh in Northwest in year t	(mill. lb.)
$QPFSW_t$	Quantity marketed as fresh in Southwest in year t	(mill. lb.)
$QPFC_t$	Quantity marketed as fresh in Central in year t	(mill. lb.)
$QPFE_t$	Quantity marketed as fresh in East in year t	(mill. lb.)
$QPPNW_t$	Quantity marketed as processed in Northwest in year t	(mill. lb.)
$QPPSW_t$	Quantity marketed as processed in Southwest in year t	(mill. lb.)
$QPPC_t$	Quantity marketed as processed in Central in year t	(mill. lb.)
$QPPE_t$	Quantity marketed as processed in East in year t	(mill. lb.)
QPF_t	U.S. fresh production in year t	(mill. lb.)
QPP_t	U.S. processed production in year t	(mill. lb.)

Table 3 (continued)

$PFNW_t$	Price received by growers for fresh apples in Northwest in year t	(¢/lb.)
$PPNW_t$	Price received by growers for processed apples in Northwest in year t	(¢/lb.)
$PANW_t$	Average price received by growers in Northwest in year t	(¢/lb.)
$PANW3_t$	Three-year average of $PANW_t$ based on periods t-2, t-1, t	(¢/lb.)
$PFSW_t$	Price received by growers for fresh apples in Southwest in year t	(¢/lb.)
$PPSW_t$	Price received by growers for processed apples in Southwest in year t	(¢/lb.)
$PASW_t$	Average price received by growers in Southwest in year t	(¢/lb.)
$PASW3_t$	Three-year average of $PASW_t$ based on periods t-2, t-1, t	(¢/lb.)
PFC_t	Price received by growers for fresh apples in Central in year t	(¢/lb.)
PPC_t	Price received by growers for processed apples in Central in year t	(¢/lb.)
PAC_t	Average price received by growers in Central in year t	(¢/lb.)
$PAC3_t$	Three-year average of PAC_t based on periods t-2, t-1, t	(¢/lb.)
PFE_t	Price received by growers for fresh apples in East in year t	(¢/lb.)
PPE_t	Price received by growers for processed apples in East in year t	(¢/lb.)
PAE_t	Average price received by growers in East in year t	(¢/lb.)
$PAE3_t$	Three-year average of PAE_t based on periods t-2, t-1, t	(¢/lb.)
PF_t	Price received by growers for fresh apples in year t	(¢/lb.)
PP_t	Price received by growers for processed apples in year t	(¢/lb.)
IPP_t	Index of prices paid by farmers in year t	(1977=100)
$IPP3_t$	Three-year moving average (t,…,t-2) of IPP_t	
T	Time index, incremented by 1 each year (1971=1)	
D81	Dummy variable (0 before 1981, 0 otherwise)	
D86	Dummy variable (0 before 1986, 1 otherwise)	
D867	Dummy variable (1 in 1986-87, 0 otherwise)	
D879	Dummy variable (1 in 1987-89, 0 otherwise)	
D967	Dummy variable (1 in 1996-97, 0 otherwise)	
NIF_t	Net imports of fresh apples in year t	(mill. lb.)
NIP_t	Net imports of processing apples (fresh fruit equivalent) in year t	(mill. lb.)
PIF_t	Unit value of fresh net imports in year t	(¢/lb.)
PIP_t	Unit value of juice net imports (fresh fruit equivalent) in year t	(¢/lb.)
POP_t	U.S. Population in year t	(mill.)
QUF_t	Per-capita utilization of fresh apples with net imports in year t	(lb./capita/year)
QUP_t	Per-capita utilization of processed apples with net imports in year t	(lb./capita/year)
$QUFB_t$	Per-capita consumption of fresh bananas in year t	(lb./capita/year)
$QUFO_t$	Per-capita consumption of fresh oranges in year t	(lb./capita/year)
$QUCPP_t$	Per-capita consumption of canned peaches in year t	(lb./capita/year)
$QUCEP_t$	Per-capita consumption of canned pears in year t	(lb./capita/year)
$QUJO_t$	Per-capita consumption of orange juice in year t	(lb./capita/year)
$PCEDC_t$	Private consumption expenditure per person on food in year t	($)

(all prices, including IPP_t, are deflated by the GDP deflator, 1992=100)

Table 4. Elasticities (calculated at means)[a]

		Short Run (Year 1)	Long Run (Year 5)
Northwest			
Fresh Production	$E_{QPFNW,PF}$	0.306	0.623
	$E_{QPFNW,PP}$	-0.059	-0.006
Processed Production	$E_{QPPNW,PF}$	-0.220	0.237*
	$E_{QPPNW,PP}$	0.229*	0.272*
Southwest			
Fresh Production	$E_{QPFSW,PF}$	0.346*	0.540*
	$E_{QPFSW,PP}$	-0.225*	-0.065
Processed Production	$E_{QPPSW,PF}$	-0.055*	0.215*
	$E_{QPPSW,PP}$	0.279*	0.452*
Central			
Fresh Production	$E_{QPFC,PF}$	0.868*	0.981*
	$E_{QPFC,PP}$	-0.288*	-0.269*
Processed Production	$E_{QPPC,PF}$	-0.831	-0.668
	$E_{QPPC,PP}$	0.291	0.295
East			
Fresh Production	$E_{QPFE,PF}$	0.638*	0.708*
	$E_{QPFE,PP}$	-0.162*	-0.157*
Processed Production	$E_{QPPE,PF}$	-0.467	-0.288
	$E_{QPPE,PP}$	0.133	0.180
Consumption			
	$\in_{QPF,PF}$	-0.374	-0.374
	$\in_{QPP,PP}$	-0.701	-0.701
	$\in_{QPT,PA}$	-0.554	-0.554
	$\in_{QPF,PCEDC}$	1.195	1.195
	$\in_{QPP,PCEDC}$	2.591	2.591
	$\in_{QPT,PCEDC}$	1.961	1.961
Import			
	$\in_{NIF,PF}$	-0.609	-0.609
	$\in_{NIP,PP}$	-0.791	-0.791
	$\in_{NIF,QPF}$	-3.276	-3.276
	$\in_{NIP,QPP}$	-3.193	-3.193

[a] The asterisk marks significance at the 10% level.

References

Baumes, Jr. H.S. and R.K. Conway. *An Econometric Model of the U.S. Apple Market.* ERS Staff Report AGES850110. Washington, DC: USDA-ERS-NED, June 1985.

Chaudhry, A.J. *An Econometric Analysis of the U.S. Apple Industry*. Unpublished Ph.D. Dissertation. Washington State University, 1988.

French, B.C., G.A. King, and D.D. Minami. "Planting and Removal Relationships for Perennial Crops: An Application to Cling Peaches." *Amer. J. Agric. Econ.* (May 1985): 215-23.

Hossain, M.D. B. *Market Allocation and the Derived Demand Relationships for U.S. Apples.* Unpublished Ph.D. Dissertation, North Carolina State University, 1993.

Johnson, D.C. *Fruits and Nuts Bearing Acreage, 1947-83.* USDA/NASS Statistical Bulletin Number 761, Washington, DC, December 1987.

Lichtenberg, E, D.D. Parker, and D. Zilberman. "Marginal Analysis of Welfare Costs of Environmental Policies: The Case of Pesticide Regulation." *Amer. J. Agric. Econ.* 70(November 1988): 868-74.

U.S. Department of Agriculture. *Agricultural Statistics*. Washington, DC. Various Years.

U.S. Department of Agriculture. *Foreign Agricultural Trade of the United States: Calendar Year Supplement*. Washington, DC, various years.

U.S. Department of Agriculture. ERS/CED. *Fruit and Tree Nuts Situation and Outlook Report*: *Yearbook.* Washington, DC, various years.

U.S. Department of Agriculture. ERS/CED. *Noncitrus Fruit and Nuts Annual Summary.* Washington, DC, various years.

U.S. President. *Economic Report of the President*. Washington, DC, various years.

Willet, L.S. "The U.S. Apple Industry: Econometric Model and Projections." *Agric. Res. Econ. Rev.* (1993): 138-49.