Methodology for Trend Analysis and Projection Of Production, Market Shares, and Consumption*

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Introduction

Food processing and marketing firms must continually analyze alternative product marketing strategies in view of the intensely competitive environment of the industry. Rural, agriculturally dependent communities with concentrated production of various crops frequently turn to expansion of food processing and marketing for increased employment and value adding economic activity. Formulation of product marketing strategies by firms and rural economic development efforts face the same problems of identifying crops, products, and areas in which to expand.

Identification of trends in crop acreage and consumption of important agricultural products in defined geographic regions is valuable for firm planning and overall industry outlook purposes. Numerous single commodity analyses have been performed using econometric and mathematical programming techniques. Examples of single industry studies include Greig's mathematical programming model of the U.S. sweet corn industry and French and Willett's econometric model of the nation's asparagus industry. Shortcomings of these studies is lack of comparability among the results across commodities. Extensive data is also required for initial model construction and subsequent use in industry simulations.

Application of uniform and systematic methods of analysis across the spectrum of crops and processing activities in a region yields mean-

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ingful relationships and comparisons concerning acreage, processing, marketing and consumption trends. The purpose of this research is to describe a systematic method of analyzing consumption trends and market shares which does not require excessive collection and maintenance of data and complex modeling techniques.

Objectives

The objective of this research report is to describe methods for analyzing consumption trends and regional market shares. The methodology is first presented and discussed in general form. Subsequently, the techniques are applied to the consumption and market shares of Washington asparagus.

These techniques were developed to gain insight concerning relative rates of expansion in various types of fruit and vegetable processing in Washington in the year 2010, [Worley and Folwell]. The methodology and results of this research are based upon relatively few variables. This permits the methods to be replicated for other regions and crops which may be of particular interest to persons representing many different food industries.

Although these techniques are relatively straight forward in nature, there is much sophistication incorporated into the projection methods via the income and population forecasts utilized. Forecasts of U.S. income and population made by the United States Department of Commerce are incorporated into the methodology. These forecasts are based on a complex set of assumptions concerning future economic and population growth in the United States which are further explained in the text of this paper.

Domestic Consumption Per Capita

U.S. domestic market demand projections were accomplished in two steps. First, per capita consumption functions were statistically estimated for each product form (fresh, canned, frozen, etc.). The per capita consumption function estimated for each product form was one of the following three functional forms:

$$(1) \qquad C_{i,t} = \hat{\beta}_{1,i}\, Y_t$$

$$(2) \qquad C_{i,t} = \hat{\beta}_{0,i} + \hat{\beta}_{1,i}\, Y_t + \hat{\beta}_{2,i}\, T_t$$

$$(3) \qquad C_{i,t} = \hat{\beta}_{1,i}\, Y_t + \hat{\beta}_{2,i}\, T_t$$

where:

$C_{i,t}$ = per capita consumption of the i^{th} commodity form in the t^{th} year;

Y_t = per capita personal income year t in constant 1982 dollars;

T_t = time trend measured in years, 1980, 1981, etc.; and

$\hat{\beta}_i$ = the ordinary least-squares estimators of the intercept and slope coefficients for the i^{th} commodity form.

A consumption function was estimated using historical data from 1980-1989 for each product form. Selection of functional form (with or without an intercept) and the specification of the equation (with or without a trend variable) was based upon statistical considerations (significance), economic considerations (signs), as well as the predicted value for the year 2010, given trends in the historical data.

Thus, the projected per capita consumption levels are based upon a continuation of past trends with income and/or time being the primary variables in the consumption formulas. The data requirements are minimal with per capita consumption for each product form and a U.S. income series being the only required data. The estimation technique is the simplest among those in inferential statistics which allows for hypotheses testing and tests of statistical significance.

The estimated per capita consumption functions were evaluated for the year 2010 using projected per capita personal income for 2010. The income level in 2010 was adopted from projections by the U.S. Department of Commerce Bureau of Economic Analysis (USDC-BEA). The projected 2010 per capita income was $16,693 measured in 1982 dollars.

The income projections by the USDC-BEA are based on assumptions of continuance of past economic relationships with no major policy changes. Consequently, these are essentially the same assumptions underlying the consumption functions. Gross national product (GNP) was projected based on projections of population, labor-force, employment, and GNP per employee. The population projections were based mainly on the work of the U.S. Department of Commerce Bureau of the Census (USDC-BC), and the labor force projections were based mainly on the work of the U.S. Department of Commerce Bureau of Labor Statistics. The GNP projections were in general the basis of the derivation of other national measures, including total personal income by component and both employment and earnings by industry.

Aggregate U.S. Consumption

The 2010 per capita consumption estimates were used in conjunction with projected 2010 population levels as published by the USDC-BC to determine aggregate U.S. consumption. The USDC-BC uses a cohort-component model to make such population projections. The basic data used to generate the projected population levels included a base-year population, projected fertility rates, projected survival rates, future net immigration statistics, and under count rates from the 1980 census. The projections include a low, middle, and high series of estimates for U.S. population. The USDC-BC describes these estimates as:

> . . . The lowest series assumes low fertility, low life expectancy, and low net immigration; while the highest series assumes high fertility, high life expectancy, and high net immigration. These series provide the widest range around the middle series (which is based upon the middle assumption for each component) in terms of future total population size, but do not necessarily represent the extreme range for any particular population subgroup.

The total U.S. population estimates for 2010 by USDC-BC using these assumptions were:

Low:	264,193,000
Middle:	282,575,000
High:	305,882,000

These population levels were multiplied by the projected 2010 per capita consumption estimates to project total U.S. consumption in 2010 for the three population levels of the various commodity forms.

Net Foreign Demand

Import and export data as identified by the Harmonized Commodity Description and Coding System were compiled for the calendar years 1989 and 1990 [Foreign Agricultural Trade of the United States]. The data for specific products were aggregated by product form (fresh, canned, frozen) to achieve compatibility with the domestic consumption product forms. The data were reported on a product weight basis and were converted to fresh or farm weight by using factors published by USDA [Stat. Bulletin 616].

Trade data for calendar years 1989 and 1990 were averaged and used to calculate net foreign trade as a percentage of total 1990 domestic consumption for each product form. This percentage was assumed unchanged in the future and was used as an adjustment factor to the previously estimated 2010 domestic consumption to account for the effect of net foreign trade. Total U.S. output was assumed equal to aggregate domestic consumption adjusted for the percentage of consumption represented by foreign supply or demand.

Market Shares Determination

Estimated market shares for a selected study area were obtained through trend analysis of historical acreage data using regression techniques. The market shares for the study market area were specified as linear functions of time:

$$MS_t = \alpha_{0,i,j} + \alpha_{1,i,j} T_t$$

Where MS_t is market share and is defined as the percent of U.S. acreage grown in the study area in year t, T is the time trend measured in years; $\alpha_{0,i,j}$ and $\alpha_{1,i,j}$ are the ordinary least-squares estimators; i and j denote the i^{th} commodity form and

j^{th} market area, and t is the year. The market shares measure: 1) the percentage of total U.S. acreage of the i^{th} commodity grown in a selected state, and 2) the percentage of total state acreage of the i^{th} commodity grown in the study area. The regression equations were estimated using historical acreage data from 1980 through 1990. An advantage of using this simple model for projections is that the market share for the state and the rest of the United States will always add up to 100 percent, which insures gains in market share in the selected state are offset by losses in the other states.

Market Shares Applied to Projected U.S. Production

The market shares projections for 2010 were applied to the previously calculated net U.S. output projections to determine the production of each commodity in a selected state and study area. These were then compared to the derived level of production in 1990 for the selected state and study area to determine the magnitude of change over the 20-year period.

The procedure was to first calculate the state's share of the net U.S. production and then use the resulting state total to calculate the study area's share of state production. The same market share was used for all forms of product. This assumes that each state and the study area produce the same proportion of each product form of the commodity. These projections were compared to 1990 production levels calculated the same way except using 1990 market shares and net U.S. production. Thus, comparability between a base year, 1990, and the 2010 projections was maintained.

Example Application: Washington Asparagus

The historical per capita asparagus consumption data summarized in Table 1 was first regressed on income and time variables as described previously. The results of these OLS regressions are presented in Table 2 for each product form of asparagus. The regression was not completed for frozen asparagus since the historical consumption of this product remained unchanged over the ten-year period of 1980-89.

These estimated consumption functions were then used to predict the per capita levels of consumption in 2010 by evaluation at projected 2010 income and time. Column one of Table 3 reports these estimated 2010 per capita consumption levels. Per capita asparagus consumption trends are negative for canned, flat for frozen, and slightly positive for fresh product. The regression equations of fresh and canned were used to project the per capita consumption of these product forms in 2010, while the historical average for frozen was used as the per capita projection for that product form. The per capita estimates of consumption were then multiplied by the three estimates of population to estimate aggregate U.S. consumption levels for 2010 reported in Table 3.

Table 4 shows the average net level of foreign trade in asparagus by product form, the percentage of 1990 U.S. consumption, and the resulting adjustment factor. U.S. aggregate consumption was adjusted using this factor which resulted in the projected asparagus production shown in Table 5. Net trade for fresh and frozen asparagus is negative; the United States is a net importer of these forms. The United States is a relatively small net exporter of canned asparagus with quantities averaging 1.3 percent of domestic consumption during 1989 and 1990.

Acreage data used for the trend regression is shown in Table 6. The estimated trend in market share coefficients indicates that Washington's share of U.S. acreage in increasing. Washington's share of U.S. acreage has expanded during the 1980-1990 period by an estimated 0.3 percent per year. Projecting this rate of increase to year 2010 results in an expected share of 38.8 percent of all U.S. acres to be grown in Washington, increasing from the 32.7 percent share in 1990.

Applying the estimated 2010 market shares to the estimated U.S. production levels in 2010 provides the projected level of output in Washington in 2010 shown in Table 7. These projections are then divided by the 1990 levels yielding the expansion ratios shown in Table 7.

Table 1

U.S. Per Capita Asparagus Consumption By Form Of Product, 1980-89

Product Form	Pounds Per Capita			
	Mean	Std. Deviation	Range	
			Low	*High*
Fresh	.47	0.1252	.30	.60
Canned	.32	0.0422	.30	.40
Frozen	.10	0.0000	.10	.10

Source: USDA Vegetables and Specialties

Table 2

Ordinary Least Squares Estimates
Of Asparagus Consumption Function Coefficients By Product Form

Product Form	Intercept	Income	Time	Residual Mean Square
Fresh		.0000385 (15.37)[1]		.009577
Canned	94.604 (5.88)[1]	.0001522 (4.78)[1]	-.048455 (-5.83)[1]	.000276
Frozen		*regression not possible*		

[1]Student t values at the 95% level of confidence.

Table 3

Estimated 2010 Per Capita And Total U.S. Consumption By Population Level

Product Form	2010 Per Capita	2010 Total U. S. Consumption		
		Low	Middle	High
	lbs	*farm weight equivalent (million lbs)*		
Fresh	0.64	169.1	180.8	195.8
Canned	0.25	66.0	70.6	76.5
Frozen	0.10	26.4	28.3	30.6

Table 4

Net U.S. Trade Of Asparagus By Product Form (Exports-Imports) Averaged For 1989 and 1990

Product Form	Average Net Trade	Average as % of 1990 Consumption	Adjustment Factor[1]
		million lbs farm weight equivalent	
Fresh	-3.788	2.53	0.9747
Canned	0.995	1.33	1.0133
Frozen	-1.135	4.55	0.9545

[1]Adjustment factor to adjust aggregate U.S. consumption to total U.S. production.

Table 5

U.S. Asparagus Production Projected In 2010 By Population Level

Product Form	Adjustment Factor	Population Level		
		Low	Medium	High
			---- *million pounds* ----	
Fresh	0.9747	164.800	176.266	190.805
Canned	1.0133	66.928	71.584	77.489
Frozen	0.9545	25.216	26.971	29.196

Table 6

U.S. and Washington Asparagus Acreage and
Share of U.S. Acreage in Washington State, 1980-1990

Year	Washington	United States	WA/US
	----- *000 acres* ------		
1980	22.20	87.95	.2524
1981	23.70	81.99	.2891
1982	28.40	84.64	.3355
1983	29.30	87.29	.3357
1984	29.00	89.93	.3225
1985	29.00	91.45	.3171
1986	30.00	96.18	.3119
1987	31.00	99.84	.3105
1988	32.00	100.91	.3171
1989	32.00	98.51	.3248
1990	30.00	95.60	.3138
Estimated time coefficient:			.00304
Projected 2010 share of U.S. in WA:			.388

Table 7

Washington Asparagus Production Projected in 2010 and
The Expansion Ratio Relative to 1990 at Three Population Levels

		2010 Projected			Expansion Ratio		
	1990	*Low*	*Med*	*High*	*Low*	*Med*	*High*
	million pounds farm weight						
Fresh	45.760	63.942	68.391	74.032	1.397	1.495	1.618
Canned	23.787	25.968	27.775	30.066	1.092	1.168	1.264
Frozen	7.469	9.784	10.465	11.328	1.310	1.401	1.517

Data for the last three years indicate that 69 and 31 percent of Washington asparagus is grown for processing and fresh use, respectively [WA Agri-Facts]. This dependency on processing coupled with the forgoing trends suggest that the asparagus processing industry in the state will continue at about its present size. The likelihood of expanded canning activity seems especially slight, given the declining per capita consumption and relatively low volume of net exports.

Summary and Conclusions

Relative magnitudes of change between current and projected production, processing and consumption levels can be consistently measured using the described methodology. These methods provide results which identify those crops and processing activities which have potential for expansion in a state and intra-state regions. The methodology was applied to only one region of the state and to only one commodity. Applications to other specified study areas could yield regional expansion rates for comparison within a state.

References

Chase, Robert A., *Washington State's Preserved Fruit and Vegetable Industry: An Economic Assessment - Draft Highlights*, School of Business, University of Washington, Seattle, June 1992.

Folwell, R. J. and B. G. Swanson, The Economic Importance of the Food Industry in Washington, *Washington's Land & People*, College of Agriculture and Home Economics, Washington State University, Vol. 4, No. 1, Spring 1990.

Food Processing: The Pacific Northwest's Industrial Powerhouse, *Pacific Northwest Executive*, School of Business, University of Washington, Seattle, Vol. 6, No. 3, July 1990.

French, Ben C. and Lois Schertz Willett. *An Econometric Model of the U.S. Asparagus Industry*. California Agricultural Experiment Station, Giannini Research Report Number 340, September 1989.

Greig, Smith. *Interregional Competition in Processing of Frozen Sweet Corn with Emphasis on the Northwest's Competitive Position*. Agricultural Research Center, Washington State University, Research Bulletin XB0947, 1986.

U.S. Department of Agriculture, *Conversion Factors and Weights and Measures*, Economics, Statistics, and Cooperative Service, Statistical Bulletin No. 616, Washington, D.C., 1979.

_____, *Foreign Agricultural Trade of the United States - Calendar Year 1990 Supplement*, Economic Research Service, Washington, D.C., November 1991.

_____, *Vegetables and Specialties Situation and Outlook Yearbook*, Economic research Service, TVS-255, December,1991.

U.S. Department of Commerce, *BEA Regional Projections to 2040 - Volume 1: States*, Bureau of Economic Analysis, Washington, D.C., June 1990.

_____, *Projections of the Population of the United States, by Age, Sex, and Race: 1988 to 2080*, Bureau of the Census, Series P-25, No. 1018, Washington, D.C., 1989.

Washington Agricultural Statistics Service, *Washington Agri-Facts*, Washington State Department of Agriculture, Olympia, Washington.

Worley, T. and R. Folwell, *Food Processing Industry in the Prosser Area: Recent Trends and Future Prospects*, Department of Agricultural Economics, Washington State University, Pullman, April 1992.