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Forecasting the Demand for Frozen Potatoes



Y. Gao,
J. F. Guenther

Table of Contents

Study Methods	3
Explanatory Variables	3
Data Considerations	4
Estimation Methods	5
Results	5
The U.S. Retail Market	5
The U.S. Food Service Market	5
The Japanese Market	6
The Rest of the World	6
Statistical Tests	7
Forecasts of Explanatory Variables	8
Year 2000 Forecast	8
Discussion	9
References	10

The authors —

Yanqing Gao, research associate;

J. F. Guenther, professor,

Department of Agricultural Economics and Rural Sociology,

University of Idaho, Moscow.

Forecasting the Demand for Frozen Potatoes

Several decades ago, meals prepared at home were the primary market for the U.S. potato industry. Today, the frozen potato market is as large as the fresh potato market, and 85 percent of frozen potatoes are consumed away from home. The popularity of fast food restaurants has fueled much of the increase in frozen french fries and other frozen potato products consumption.

The export market is another source of growth. The fast food industry has grown rapidly overseas. During the 1980s, the number of fast food restaurants in Japan increased 10 to 21 percent annually (Potato Board 1990). Many of the more than 4,000 Japanese fast food restaurants, including U.S. franchises such as McDonald's and Burger King, feature frozen french fries as a top selling menu item.

Price volatility is one factor that has not changed in the potato industry. Relatively small supply increases have caused potato prices to decrease to levels well below production costs. The main reason is the inelastic potato demand discussed years ago by Gray et al. (1954), Simmons (1962), and Hee (1967), and confirmed by more recent research (Jones and Ward 1989; Guenther et al. 1991b).

One concern in the potato industry is that supply not expand more rapidly than demand. In order to avoid too rapid expansion and unprofitable prices, understanding

potato demand is important. Therefore, an analysis of the global market for U.S. frozen potatoes was conducted in 1991. The specific objective was to forecast the demand for U.S. frozen potatoes in the year 2000.

STUDY METHODS Markets

The market for U.S. frozen potato products was divided into four segments: (1) the domestic retail market, (2) the domestic food service market, (3) Japan, and (4) the rest of the world (ROW). In 1990, the domestic retail market accounted for about 13 percent of sales, the domestic food service market 80 percent, the Japanese market 5 percent, and the ROW 2 percent.

Explanatory Variables

Economic theory traditionally focuses on four factors that can shift the demand for a product: (1) population, (2) consumer income, (3) prices of other goods, and (4) tastes and preferences (Tomek and Robinson 1990). Demand equations were developed for the domestic and Japanese markets using variables to represent the four demand shifters.

The population demand shifter was incorporated into the models by dividing frozen potato quantities and consumer income by population. Per capita consumption of frozen potatoes was the dependent variable in each equation. Per capita income was an explanatory variable representing two of the four demand shifters. The sign of the per capita income coefficient was expected to be positive, depicting an income-normal good.

The price-of-other-goods demand shifter was included in the domestic

equations by including both a substitute and a complement. The substitute was fresh potatoes. As fresh potato prices increase, consumers would be expected to substitute frozen for fresh potatoes. The sign of the coefficient was expected to be positive. Hamburger price was included in the domestic equations to represent a complement. Since many consumers eat hamburgers and french fries together, an increase in hamburger price was expected to negatively impact demand for frozen potatoes. In order to include the influence of the prices of other goods and services, all monetary variables were deflated by the consumer price index.

The tastes-and-preferences demand shifter was represented by four types of variables:

■ **The percentage of women in the labor force.** It was assumed that as more women work outside the home, they would have less time to prepare meals and would prefer more convenient foods. Since processed potatoes are more convenient to prepare than fresh potatoes, the sign of this variable was expected to be positive.

■ **The percentage of homes with microwave ovens.** Microwave ovens have made it more convenient to bake fresh potatoes. Guenther et al. (1991a) found that microwave oven ownership increased the demand for fresh potatoes at the expense of frozen potatoes. The sign of this variable was expected to be negative.

■ **Advertising.** Advertising is designed to shift consumer tastes and preferences. Two types of advertising variables were included in the domestic models: (1) brand advertising expenditures by frozen potato processors, and (2) generic advertising expenditures by the National Potato

Board and state potato commissions. This type of advertising is called generic as it is for potatoes in general rather than for a particular brand or type of product. The sign of both variables was expected to be positive.

■ **A dummy variable representing the quarter, or season, of the year.** Retail consumer demand for frozen potato products may be different in the winter than in the summer. Due to data limitations, this variable could only be included in the domestic retail market.

Data Considerations

The United States Department of Agriculture (USDA) does not provide frozen potato data segmented into retail and food service sectors. In order to study the two markets separately, we purchased U.S. retail frozen potato price and quantity data from Nielsen Marketing Research, of Chicago. Food service consumption data were estimated by subtracting retail consumption from total consumption, using figures from the USDA (Putnam and Allshouse 1991). Since the USDA data were only available on an annual basis, a quarterly model for the food service market could not be developed.

Generic and frozen potato advertising data were purchased from Leading National Advertisers, of New York. The data consisted of quarterly advertising expenditures for potatoes through six media: magazine, newspaper supplements, network television, spot television, network radio, and outdoor. Aggregated advertising data assumes that consumers have the same response to advertisement expenditures regardless of how it is spent. Generic advertising data included expenditures by the National Potato Promotion Board, Idaho Potato Commission, Washington State Potato Commission, Maine Potato Board, Michigan Potato

Commission, and other state potato associations. Frozen potato advertising expenditures included brand advertising by Carnation, Ore-Ida, Simplot, and other potato processors.

Federal government sources provided other data used in the domestic models. The U.S. Department of Labor provided data on the consumer price index, the fresh potato price index, the hamburger meat price index, and the percentage of women in the labor force. U.S. Department of Commerce publications provided data on population, disposable consumer income, and the percentage of households with microwave ovens.

The USDA Foreign Agricultural Service (FAS) served as the main source of data for the export markets, listing export quantities and values to Japan and the rest of the world. Japanese population and gross domestic product (GDP) were obtained from the International Monetary Fund (IMF). Japan's consumer price index and the exchange rate of Japanese yen with U.S. dollars were obtained from the U.S. Department of Commerce.

This combination of public and private data sources could not provide all the necessary data. The income variable for the Japanese market is per capita GDP rather than per capita disposable income, which was used for the U.S. domestic market. Also, price data for frozen potatoes in the U.S. food service market were not available, which makes the distinction between food service demand different from retail demand. This problem has been well explored in a previous study by Guenther et al. (1991b).

The data set is limited to the period 1970 to 1989 for the U.S. domestic market, and 1978 to 1990 for the international market. Quarterly data were used for the U.S. retail market and the Japanese market, while annual

data were used for the U.S. food service market and the rest of the world.

Estimation Methods

Demand equations for the domestic markets and the Japanese market were estimated using ordinary least squares (OLS) or generalized least squares (GLS) procedures. The Durbin-Watson statistic was calculated to detect serial correlation problems. The Glejser test was used to check for heteroskedasticity. Correlation between explanatory variables was analyzed to detect multicollinearity problems.

The ROW demand was modeled as a simple linear function of time. Since there are many countries included in ROW, developing explanatory variables to represent the four demand shifters was not feasible within the constraints of the study's resources.

RESULTS

The U.S. Retail Market

The U.S. retail market for frozen potato products accounts for about 15 percent of the domestic market share. The equation for the U.S. retail market shows that all coefficients have the anticipated signs (table 1). Demand for frozen potatoes increases as prices for frozen potato products fall. Increased consumer income increases demand. When hamburger prices increase, demand for frozen potatoes declines. When fresh potato prices increase, demand for frozen products will increase.

■ The percentage of women in the labor force positively impacts demand. Since women prepare meals in most households, easy-to-prepare frozen potato products are in higher demand when more women are in the labor force.

■ The percentage of households using microwave ovens negatively impacts demand. One reason is that many consumers may not have been aware of microwavable frozen potato products. Another reason may be the poor quality of microwavable frozen potato products. The crispness that consumers expect in french fries is difficult to produce in the microwave (Valentino 1988). As a result, consumers tend to substitute fresh potatoes for the frozen products once they purchase microwave ovens.

■ Brand advertising by frozen potato processors is apparently effective in stimulating retail market demand. While generic advertising focuses on stimulating the total potato demand, individual processors may be more interested in increasing their market share than increasing the total market demand. Therefore, the actual effects of brand advertising for individual potato processors can be even greater than what this study indicates.

Seasonality is visible in frozen potato consumption patterns in the U.S. retail market; frozen potato products sales are highest in the winter and lowest in the summer. This may be offset by different seasonal patterns in the food service market.

The U. S. Food Service Market

The food-away-from-home market, or food service market, accounts for about 85 percent of the domestic frozen potato market share. This includes restaurants, as well as child care centers, nursing homes, schools, military services, hospitals, prisons, and other institutions. Away-from-home food spending in the United States has been increasing, rising from 34 percent of total food expenditure in 1970 to 46 percent in 1989 (fig. 1).

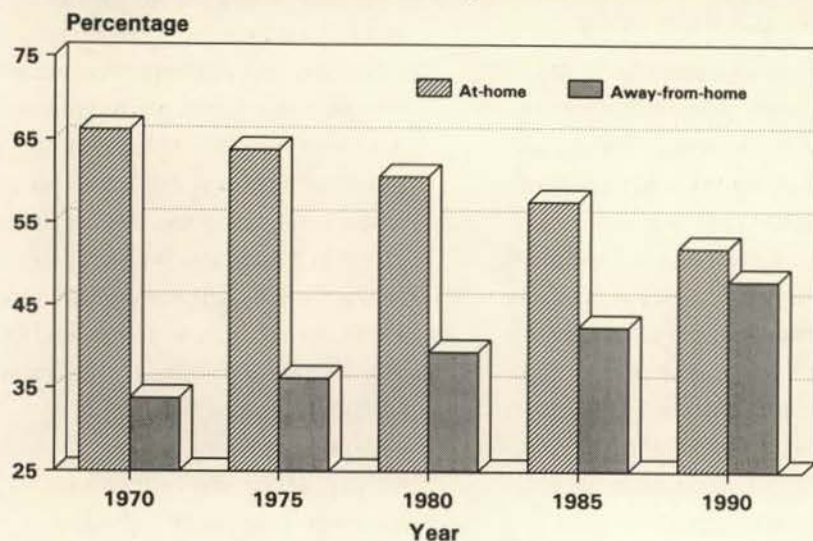
■ Variables that affect the food service market are similar to those for the retail market (table 1). Consumer

Table 1. Estimated equations for U.S. frozen potato demand.

Explanatory variables	Domestic retail (lb / capita)	Domestic food service (lb / capita)	Japanese market (lb / capita)	ROW (1,000 mt)
Constant	0.48 (3.3) ¹	-18.49 (-3.2)	-0.73 (-4.5)	-5.494 (-6.0)
Year				12.30 (6.0)
Retail price	-0.67 (-4.9)			
Export price			-0.26 (-1.6)	
Consumer income	0.005 (2.4)	4.50 (7.2)	0.50 (11.0)	
Hamburger price	-0.068 (-1.8)	-9.38 (-4.9)		
Fresh potato price	0.14 (6.1)	1.73 (1.1)		
Women in labor force	0.007 (1.8)			
Microwave ovens	-0.003 (-6.2)	-0.134 (-5.0)		
Advertising-frozen	3.09 (3.9)			
Advertising-generic		172.5 (3.3)		
Winter (Q1)	0.09 (11.8)			
Spring (Q2)	0.053 (5.1)			
Summer (Q3)	-0.028 (-2.5)			
Exchange rate			-0.0003 (-1.9)	
R ²	0.84	0.94	0.96	0.90

* *t*-values are in parentheses

Fig. 1. At-home and away-from-home food sales.



income has a significant, positive impact on away-from-home frozen potato consumption. Increased income enables consumers to expand their purchases of food away from home, boosting sales of frozen potatoes in the food service market.

- Hamburger price has a negative effect on the demand for frozen potatoes since these two products are complementary. The positive coefficient for fresh potato price indicates that they compete with frozen products in both the retail and food service markets. When the price of fresh potatoes falls, the demand for frozen potatoes is reduced as consumers substitute fresh for the frozen products at home as well as away from home.

- As in the retail market, the percentage of households using microwave ovens shows a negative effect on demand for frozen potato products in the food service market. If consumers eat more fresh potatoes prepared in microwave ovens at home, they are likely to consume less frozen potatoes in the food service market.

- Frozen potato demand in the U.S. food service market responds positively to generic advertising.

Advertising expenditures on frozen potatoes, however, do not seem to significantly impact food service market consumption. Brand advertising is probably not as effective on institutional buyers as it is on final consumers in the retail market.

The Japanese Market

Export markets show growth in frozen potato consumption as well. U.S. frozen potato exports grew 693 percent, from 24,085 metric tons in 1978 to 190,948 metric tons in 1990 (fig. 2). Japan is the driving force behind this significant increase. Japan has been the largest single-country foreign market for U.S. agricultural exports since 1963. The U.S. share of the Japanese frozen potato market has grown from 28.5 percent to 72 percent in 1988, and is estimated to be at nearly 80 percent in 1991 (Squires 1986).

- Japan's booming economy and high per capita income have significantly increased the demand for U.S. frozen potatoes (table 1). As income increases, the Japanese people travel more and become exposed to western foods and lifestyle. The high per capita income allows them to buy more

service-added products offering convenience, rather than raw products requiring a lot of preparation.

- The currency exchange rate has a negative effect on the frozen potato consumption. When the U.S. dollar depreciates against the Japanese yen, the effective price of U.S. frozen potatoes becomes cheaper for Japanese importers. This causes them to increase their U.S. frozen potato imports, perhaps at the expense of competing exporters.

The Rest of the World

While Japanese demand has been leveling off, the import demand from the rest of the world shows continued strong growth (fig. 2). In 1990, U.S. frozen potato exports to Asia accounted for 81 percent of the total export market. Out of the top 10 markets for U.S. frozen potato exports, eight are Asian Pacific Rim nations (table 2).

After Japan, Hong Kong, Singapore, and Taiwan have led the U.S. frozen potato export market. South Korea is another market with great potential. These four newly industrialized countries are called the Four Little Dragons: they are small in size, but economically powerful. In recent years, these countries show economic growth at the highest rates in the world. Their booming economies, import liberalization, exchange rate fluctuations, a general trend toward western lifestyle and foods, growing tourism, and increasing promotion efforts by the U.S. potato industry all account for the expansion of U.S. frozen potato exports to these Asian Pacific Rim nations.

Japan is the well-developed, first tier market for U.S. frozen potato exports, and the Four Little Dragons make up the second tier. The third tier consists of other Asian Pacific Rim nations that

are not yet significant in terms of trade volume, but have grown rapidly in recent years. These countries include the Philippines, Malaysia, Indonesia, Thailand, and the People's Republic of China. They all have future development potential because of similarities with the Four Little Dragons.

To assess the demand from the rest of the world, which takes a small market share and includes numerous countries, we performed trend analysis rather than attempting to establish an econometric model for each country. Based on the 1978 to 1990 period, a simple linear regression using time as the only explanatory variable does not show a very high coefficient of determination (R^2). Figure 2 displays a turning point in U.S. frozen potato exports to the rest of the world in 1985. This is the year the U.S. dollar reached its peak and began depreciating against the currencies of major trading partners, including Japan. The devaluation lowered the price of U.S. food products and sharpened the competitive edge of U.S. frozen potato exports in the world market in following years. Asia's emergence as the dominant regional market for U.S. agricultural products further stimulated U.S. frozen potato exports in the late 1980s.

Table 2. Top 10 markets for U.S. frozen potato exports.

Country	Quantity (metric tons)			% Change
	1980	1985	1989	1980-1989
Japan	26,546	51,925	112,252	323
Hong Kong	2,590	4,011	14,937	477
Singapore	895	2,636	7,150	699
Taiwan	0	74	5,916	
Bahamas	481	111	4,422	819
Malaysia	199	1,007	3,976	1,898
Canada	2,284	3,782	2,774	21
South Korea	108	599	2,769	2,464
Philippines	25	0	2,593	10,272
Indonesia	249	284	1,235	396
Rest of the World	4,972	1,718	6,774	36
Total	38,349	66,147	164,798	330

Source: *Horticulture Products Review*, March 1990.

In order to more accurately capture the demand trend from the rest of the world, the data set was divided into two parts: 1978 to 1984 and 1985 to 1990. Two separate regressions were run for the two periods. Both t -statistics and R^2 were improved by splitting the data set. The recent trend line from 1985 to 1989 is used in this study to project the demand from the rest of the world in the year 2000. It should be noted that future structural

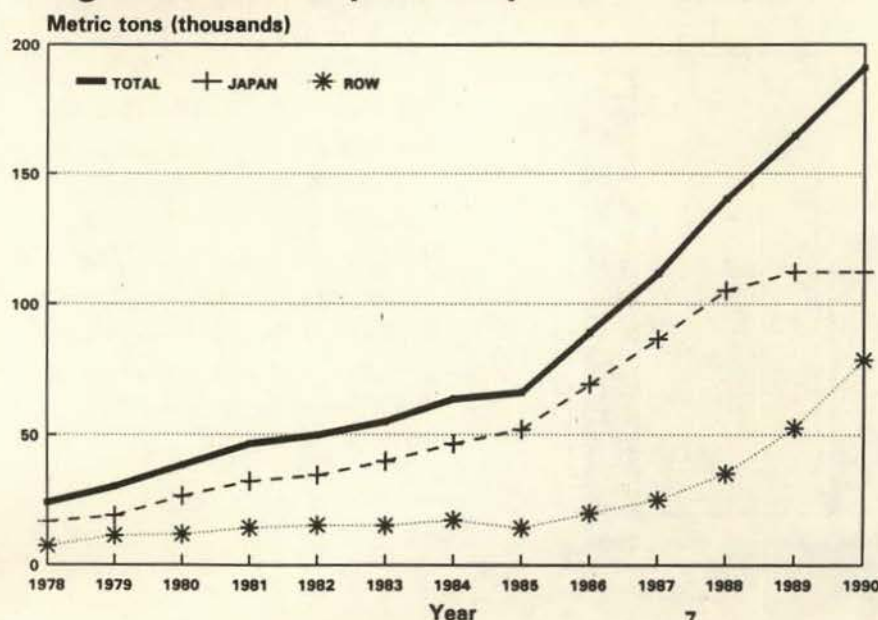
changes could alter the slope of the 1985 to 1990 trend line.

Statistical Tests

Equations were tested for problems with serial correlation, heteroskedasticity, and multicollinearity. A serial correlation problem in the U.S. retail equation was solved by transforming the variables using a modified Cochrane-Orcutt method. A Durbin-Watson statistic of 2.11 for the generalized least squares (GLS) model indicates that the serial correlation problem was solved.

Multicollinearity was present in both the U.S. retail and U.S. food service equations. The percentage of women in the labor force and the percentage of households using microwave ovens are highly correlated with per capita disposable income. This, however, will not affect the usefulness of the model for making accurate forecasts outside the sample, if the interrelationships among the explanatory variables follow the same pattern in the forecast period as in the sample period (Judge et al. 1988). Since the goal was to forecast demand in 2000, and the

Fig. 2. U.S. frozen potato exports.



interrelationships among the variables influencing the frozen potato demand in the sample period are likely to continue into the future, remedial action was not taken.

In the equation for Japan, a weighted least squares (WLS) regression based on transformed data was tested to alleviate problems with serial correlation and heteroskedasticity. However, the R^2 was reduced from 0.96 in the OLS model to 0.39 in the WLS model. Since a high correlation coefficient is generally accepted as a more important criterion than low standard errors in forecasting (Koutsoyiannis 1977), the OLS model was adopted despite the presence of heteroskedasticity.

Forecasts of Explanatory Variables

To forecast frozen potato demand, we used forecasted values for the explanatory variables in the year 2000. These forecasts were obtained from the following methods, in order of preference: (1) government forecasts, (2) functions of time, and (3) average value or last observation.

The U.S. Department of Commerce Statistical Abstract of the United States provided forecasts of U.S. population and the percentage of women in the

labor force in 2000. Japanese population projections were provided in the Japanese Bureau of Statistics Japan Statistical Yearbook. Government estimates for other explanatory variables were not found.

Income, consumer price index, price of frozen potatoes, fresh potato price index, and hamburger price index were estimated from simple linear trends. The R^2 for all these trend models were more than 0.75, indicating a satisfactory goodness of fit.

The microwave oven variable graphically shows a S-shaped growth pattern, and was estimated by using the logistic growth function

$$Pt = K/[1 + e^{-(a+bt)}]$$

where Pt is the percentage of households that use microwave ovens in year t , K is the ceiling value, which is set at 98 percent, t is the time variable, a is a constant that positions the data curve on the time scale and b is the rate of growth coefficient. The R^2 for this model was 0.99.

three explanatory variables — For generic advertising, brand advertising, and currency exchange rate — time analysis did not provide a satisfactory forecasting tool. Therefore, average 1970 to 1989 deflated values of advertising expenditures (both generic

and frozen) were used as the 2000 estimates. Since many economic factors influence yen/dollar exchange rates fluctuation, the exchange rates for 2000 are assumed to be the same as 1990.

Year 2000 Forecast

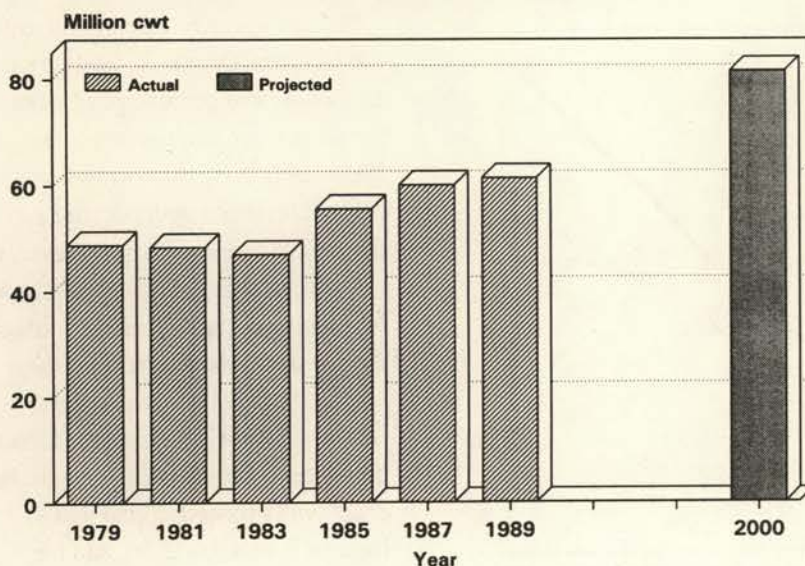
Forecasts for the year 2000 were developed in a three-step process. First, the demand equations were estimated. Second, values for the explanatory variables were forecasted. Third, these values were plugged into the equations to calculate the forecast.

Estimates show that the total demand for U.S. frozen potato products will reach 81.5 million cwt at the forecasted price level in year 2000, a 33 percent increase from 1989 (fig. 3). The domestic retail market is forecasted to increase 4 percent, from 9.71 million cwt in 1989 to 10.1 million cwt in 2000. The food service market is expected to expand 33 percent, from 47.98 million cwt in 1989 to 64.02 million cwt in 2000.

The export market is expected to double its 1989 size by the year 2000. U.S. frozen potato product exports to Japan are projected to increase to 3.2 million cwt in 2000, a 30 percent growth from the 2.47 million cwt in 1989. Frozen potato exports to the rest of the world are forecasted to grow 264 percent, from 1.16 million cwt in 1989 to 4.22 million cwt in 2000.

This study projects that by the year 2000 the foreign market will account for 9 percent of the total demand for U.S. frozen potatoes, compared to 7 percent in 1990. Clearly, the U.S. frozen potato market will still be dominated by domestic consumption, especially in the food service market, even though foreign demand will grow faster than domestic demand (fig. 4).

Fig. 3. Total frozen potato demand.



DISCUSSION

Price, income, and cross-price elasticities were estimated to provide additional demand analysis information (table 3). The own-price elasticity confirms that the demand for frozen potatoes is inelastic in both the U.S. and the Japanese markets. The high-income elasticity in the Japanese market and the U.S. food service market suggest that economic growth can boost the demand for frozen potato products.

We conducted sensitivity analysis on the three variables for which we used the least desirable projection methods. The change from the baseline forecast for the lowest and highest observations of the variables were:

- Frozen advertising, -2.6 percent and +2.9 percent changes in U.S. retail demand;
- Generic advertising, -6.5 percent and +5.5 percent changes in U.S. food service demand; and
- Exchange rate, -6.6 percent and +0.3 percent changes in Japanese demand.

More reliable estimates of these variables could improve forecast accuracy, but not by a large amount in terms of total frozen potato demand.

Table 3. Price, income, and cross price elasticities estimated at mean values.

	Domestic retail	Domestic food service	Japanese market
Own-price	-0.49		-0.23
Income	0.56	2.80	3.40
Cross price-hamburger	-0.08	-0.66	
Cross price-fresh potatoes	0.16	0.12	

Other factors that could impact the demand for U.S. frozen potatoes were not included in the econometric models because of statistical problems and/or data availability problems. Among the variables that were hypothesized as important but not included were: household size, age composition of the population, advertising expenditures for dehydrated potatoes, TEA (Targeted Export Assistance) expenditures, number of western style restaurants in Japan, and the number of Japanese people travelling abroad. If data and statistical problems are solved, further studies can assess the relationship between demand for frozen potatoes and some of these variables.

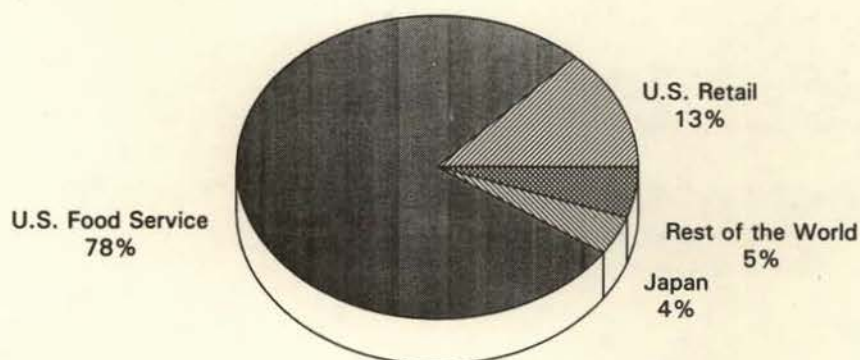
The microwave oven variable has negative coefficients in both the U.S.

retail and U.S. food service markets. Product development, advertising, and education may change that situation. If the industry develops new frozen potato products or improves the quality of microwavable french fries, the microwave oven variable might positively influence frozen potato demand. Consequently, domestic demand could grow faster than forecasted.

New markets for U.S. frozen potatoes are emerging as the worldwide economic situation changes. Many markets other than Japan warrant closer observation and detailed study. The Four Little Dragons are clearly worth further development. The third-tier markets also present future opportunities to the frozen potato industry.

The U.S. frozen potato industry will be increasingly involved in global markets. Exports will grow more rapidly, in percentage terms, than the domestic market. The domestic market, however, will continue to dominate in the year 2000 and beyond. The total market for U.S. frozen potatoes is expected to grow about 3 percent per year. If frozen potato supply grows more rapidly than demand, prices will decline.

Fig. 4. Projected market share, year 2000.



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