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# Apple Price and Production Forecasts for Maine and the United States

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An econometric model of U.S. and Maine apple production and prices was estimated with ordinary least squares multiple regression. A Gauss-Seidel solution technique was used to examine the equation system goodness of fit and to forecast endogenous variable values. Results indicate that supply expansion in the U.S. and Maine will continue, but Maine's slower rate of increase will erode its market share. Apple prices for the U.S. and Maine are predicted to decline in real terms by the year 2000 if inflation rates exceed 3 percent annually during the period 1982 to 2000.

Apples are the second most important crop in Maine as measured by gross producer receipts. The average size of the 1980 to 1982 apple crops was 84.5 million pounds with a farm level value of almost 13 million dollars (U.S.D.A.). However, the apple industry generates additional income which is shared by processors, equipment and chemical dealers, handlers, year-round and harvest labor. Maine is an important regional supplier of apples contributing approximately 25 percent to total New England production. Nationally, however, Maine's share of total production is about one percent. Thus its annual and long-term economic prospects are greatly influenced by the national apple situation.

The U.S. apple industry is in a transitional period marked primarily by the rapid adoption of size-controlled apple trees, often referred to as dwarf or semi-dwarf trees, which are replacing standard-size trees. The size-controlled trees have the following advantages over standard seedling trees: their smaller size permits more intensive planting, resulting in more bearing surface per acre and higher average apple yields; the small trees on clonal rootstocks result in earlier fruit bearing; the small tree size permits better spray penetration, better air movement and greater light penetration leading to improved fruit quality; the small size and tendency for less vegetative growth result in reduced labor requirements for pruning, brush removal, thinning and harvesting (Downy et al.). These advantages re-

sult in higher production per unit of land area, reduced variable costs and earlier returns on investment compared to the standard seedling trees.

Recent large increases in actual and potential apple production have heightened industry concern regarding possible lower prices and net returns (O'Rourke). These concerns seem at least partly justified since average production for the years 1974 to 1976 was 6,860.8 million pounds in the U.S. and 75 million pounds in Maine. In contrast, average production for the period 1980 to 1982 was 8,264.1 and 84.7 million pounds, respectively, in the U.S. and Maine. These production changes represent increases of 21 and 13 percent in less than a decade for the U.S. and Maine, respectively (U.S.D.A.). An important contributing factor to these increases was the adoption of size-controlled apple trees. For instance, in Maine the number of semi-dwarf trees expanded from 25,000 to 132,000 between 1965 and 1976 (NECLRS). By 1980 an additional 74,000 plantings brought the total number of semi-dwarf trees to 206,000. In contrast, the number of standard trees exhibited a downward trend, totalling 256,000 in 1970 and 178,000 in 1980. Continued rapid growth in size-controlled tree plantings may result in U.S. apple supply increasing faster than demand lowering prices and net producer returns. It is the purpose of this paper to forecast annual apple production and prices for Maine and the U.S. to the year 2000. An econometric model, which explicitly incorporates the rate of size-controlled tree adoption by orchardists, is utilized.

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## The Apple Industry Model

The formulation and estimation of econometric perennial crop models is in general more difficult and complex than for annual crops. The modeling difficulty arises in the supply analysis where complex time lags and producer expectations may exist. The unique features of perennial crops are: the longer gestation period between planting and the first commercially marketable output; an extended period of production from the initial input or investment decision; a gradual deterioration of the productive capacity of the plant as it ages (French and Matthews). A correctly specified apple crop supply response model should take into account: new plantings; the time lag between planting and commercial production; producer expectations; the stock of mature trees and their yields; and annual tree removals.

The model in this paper consists of two regional supply response equations, a national demand equation, a market clearing equilibrium condition, and a price linkage equation. Separate supply response equations were estimated for Maine and all other U.S. production (total U.S. production less Maine production, termed other production). The model is recursive and the recursive structure begins with Maine and other production estimated as functions of lagged endogenous and current and lagged exogenous variables. Maine was isolated as a separate production area since one objective of this model is to estimate future Maine apple production and prices. A market clearing condition equated U.S. total apple supply (Maine production plus other production) with the U.S. total demand for apples to determine a national average apple price. A single, price-dependent U.S. apple demand equation was estimated. Included as an explanatory variable in this equation is the endogenous variable  $USDEMAND_t$  (put on a per capita basis by dividing by the exogenous population) which has been previously explained in the recursive structure and the market clearing condition. The national average price is used as an independent variable in a price linkage equation to predict Maine apple price. Since the other region annually produces roughly 99 percent of U.S. production, a separate price linkage equation was not used as it was assumed that the other region apple price equaled the U.S. apple price.

The recursive structure has implications for

equation estimation. The conditions for a recursive model are that of a triangular endogenous variable structure and that the residual covariances between equations vanish in the limit (see for example Johnston, pp. 377–378). If these conditions are met, then ordinary least squares is an appropriate equation estimation technique. The apple model meets the first condition of a triangular endogenous variable structure beginning with the regional production equations being functions of predetermined variables. The second condition of vanishing contemporaneous residual covariances can never be known for certain ahead of time. In general if the residuals to the structural equations can be thought of as primarily capturing the effects of excluded variables (variables not explicitly included in the equations) residuals from two structural equations are likely to be uncorrelated if the excluded variables from each equation constitute disjoint sets. We have invoked such an assumption in estimating these equations and have employed ordinary least squares in estimating those structural equations requiring estimation.

## The Estimated Supply Response Equations

New apple plantings are assumed to be a function of producers' long run price expectations. It is likely that several past years prices are used when long-run price expectations are formed. The resulting plantings will be composed of both standard and dwarf (hereafter used to refer to all size-controlled trees) trees which will have disparate effects on production due to their different biological time lags between planting and first commercial production. New apple production in a given year was assumed to be a function of past price expectations and the mix of rootstock types planted. Since adequate data were not available on yearly apple tree plantings, new production (the result of recent plantings) was modeled using a price expectations variable lagged two different lengths to account for the different biological properties of the two tree types. Price expectations are hypothesized to be formed using a weighted average of past prices. The weights were hypothesized to follow an increasing then decreasing pattern similar to the "inverted V" of DeLeeuw.

Due to the shorter time lag between planting and first commercial harvest for the dwarf trees than for the standard trees, one would

expect a shorter distributed lag. In 1960 the ratio of dwarfing rootstocks planted to total plantings was approximately 1:9, however, by 1980 this ratio was 9:1 (NECLRS). To capture the dynamics of orchardists' adoption of dwarfing rootstocks, the two price expectation variables were weighted by a rate of dwarf tree adoption variable. The rate of dwarf tree adoption, designated  $R$ , was calculated from the most recent available fruit tree surveys by interpolating tree age distribution data and then estimating annual plantings by rootstock type.<sup>1</sup> The rate of dwarf tree adoption was defined as the number of dwarf trees planted in a year divided by total plantings for that year.

The estimated apple production equation for the other region is as follows:

$$\begin{aligned}
 (1) \quad OPROD_t = & 21948.6 + 28269.2WPEVSTD_{t-9} \\
 & (0.6695) \quad (5.7053) \\
 & + 22410.7WPEVDWF_{t-6} \\
 & (5.4645) \\
 & - 0.4OLDTREES_{t-40} + 0.74OSTOCK_{t-6} \\
 & (-1.9552) \quad (2.3301) \\
 F \text{ RATIO} = & 127.11 \\
 R^2 = & .97 \\
 OPROD_{MEAN} = & 128,999 \text{ thousand bushels} \\
 OPROD \text{ STD DEVIATION} = & 22,846 \text{ thousand bushels} \\
 \text{MODEL STANDARD ERROR} = & 3,999.4 \text{ thousand bushels} \\
 & (t\text{-statistics are in parentheses})
 \end{aligned}$$

where:

$OPROD_t$  = a three-year moving average of apple production in the other region, in thousands of bushels, in year  $t$ .

$WPEVDWF_{t-6}$  = weighted price expectation variable for dwarf trees, lagged six years. Price used was undeflated U.S. average annual price per bushel for apples, all methods of sale. The weight equaled  $R$  lagged six years.

$WPEVSTD_{t-9}$  = weighted price expectation variable for standard plantings, lagged nine years. Price used was undeflated U.S. average annual price per bushel for apples, all methods of sale. The weight equaled  $(1 - R)$  lagged nine years.

$OLDTREES_t$  = the number of trees forty years old in year  $t$ , times a trend variable where 1960 = 17; 1961 = 18, etc.<sup>2</sup>

$OSTOCK_{t-6}$  = a five-year moving average of U.S. less Maine apple production lagged six years.<sup>3</sup>

The signs of the coefficients in (1) agree with a priori expectations. The standard deviation of the dependent variable equaled 22,846 thousand bushels while the model standard error equaled 3,994.4 thousand bushels. Equation (1) and its Maine counterpart were estimated with ordinary least squares using time series data for 1944 to 1982. A test for autocorrelation using the chi-square statistic on a contingency table as discussed in Maddala [p. 88] showed no statistically significant autocorrelation. Overall, the statistical properties of this equation are judged to be acceptable.

Production data for the variables  $OPROD_t$  and  $OSTOCK_{t-6}$  were expressed as three and five-year moving averages, respectively, to reduce the annual effects of weather fluctuations and to capture the long-term trends in production. The variable  $WPEVSTD_{t-9}$  is the standard tree price expectation variable weighted by one minus the rate of dwarf tree adoption, lagged nine periods. The price expectation variable is a weighted average of five past annual farm level prices where the shape of this distributed lag was determined with the method developed by DeLeeuw. The variable  $WPEVDWF_{t-6}$  is an analogous variable for the dwarf trees except the weighting is with the rate of dwarf adoption variable. The price ex-

<sup>1</sup> Fruit tree surveys are available for most states except Washington and California. Plots of the annual rate of adoption of dwarf trees for all states for which data was available showed New York State (NYCRS) to be a "typical" adopter, and so its rate of adoption curve was assumed to be representative of the entire apple industry. The rate of adoption curve was found to follow the classic logistic growth function described by Griliches.

<sup>2</sup> Data for the  $OLDTREES$  variable came from various agricultural censuses. Starting with the census of 1920, annual non-bearing tree members were estimated by interpolation between census years. It was assumed that it took ten years for trees to come into bearing; therefore, it was assumed one-tenth of the non-bearing trees were planted in that year. Trees planted in 1921 were, therefore, forty years old in 1960 (year 17 of the data series).

<sup>3</sup>  $OSTOCK$  was lagged six years so that only production coming from trees at least six years old would be accounted for.

pectation variable for the dwarf trees is lagged only six years as that is approximately how long it takes the dwarf trees to begin commercial production. The rate of dwarf tree adoption variable,  $R$ , was used to weight the two price expectation variables and ranged between .175 in 1960 to .966 in 1981. When mostly standard sized trees were being planted  $R$  was low and a higher weight  $(1 - R)$  was on the standard price expectations variable. Attempts to incorporate costs into the supply response equation were unsuccessful.

The variable  $OSTOCK_{t-6}$  is a five year moving average of other apple production lagged six years and was included to represent the existing stock of trees. The variable  $OLDTREES_{t-40}$  is the estimated number of trees forty years old in year  $t$  multiplied by a time trend variable. This variable is a proxy for production reduction due to the replacement and abandonment of old trees. The estimated number of trees was multiplied by the time trend to account for the fact that over time trees have become more productive.

The Maine apple production equation estimated with ordinary least squares is as follows:

$$(2) \quad MEPROD_t = 1297.8 + 110.1MEPEV_{t-6} + 0.2006 MESTOCK_{t-6}$$

(12.9322) (3.3745)  
(3.5532)

$$F \text{ RATIO} = 20.46$$

$$R^2 = .66$$

$$MEPROD_{MEAN} = 1562.9 \text{ thousand bushels}$$

$$MEPROD \text{ STD DEVIATION} = 473.8 \text{ thousand bushels}$$

$$\text{MODEL STANDARD ERROR} = 91.2 \text{ thousand bushels}$$

(t-statistics are in parentheses)

$MEPROD_t$  = a three-year moving average of total Maine apple production in year  $t$ , 1,000 bushel basis.

$MEPEV_{t-6}$  = expected Maine nominal price of apples at the farm level, annual average of all methods of sale, dollars per bushel, lagged six years.

$MESTOCK_{t-6}$  = a five-year moving average of total Maine apple production lagged six years.

The variable  $MEPROD_t$  equaled a three-

year moving average of total Maine apple production in thousands of bushels. The variable  $MEPEV_{t-6}$  is the Maine price expectation which equaled a five-year weighted average of the Maine apple price lagged six years. The weights were determined by the method of DeLeeuw. The variable  $MESTOCK_{t-6}$  equaled a five-year moving average of Maine apple production lagged six years and represented the stock of trees in Maine.

All of the coefficients are of the expected magnitude and sign. The standard deviation of the dependent variable equaled 473.8 thousand bushels while the model standard error equaled 91.2 thousand bushels. Attempts to incorporate the rate of adoption of dwarf trees into the Maine supply response model was statistically unsuccessful. Thus, only one lagged price variable, which had the correct sign and significance, was included. Also, a proxy variable representing tree removals was omitted because of an insignificant t-statistic. A contingency table of the residuals resulted in a statistically insignificant chi-square value suggesting no autocorrelation.

#### United States Demand Equation

The U.S. apple demand equation (normalized on price) was estimated as a function of per capita apple consumption, per capita disposable income and a dummy variable. This equation is a composite of domestic fresh, processed, and net export demand. Both nominal and deflated models were estimated with nominal prices producing the best statistical results. Attempts to include the quantities of substitute products were unsuccessful as evidenced by either a lack of significance or the wrong sign on the coefficients. The dummy variable is included to account for the abrupt increase in nominal disposable income and apple prices that occurred in 1973 and persists to the present. The oil shocks and rapid inflation of the seventies is responsible for this shift. Evidence of the intercept shift was found by examining a plot of U.S. apple price and per capita disposable income. The resulting equation is interpreted in the following way: for a given  $PCAPPLES_t$  and nominal income in any year, nominal price will be 1.018 higher in years 1973 or later than if it is 1972 or earlier. Alternatively, for a given nominal price and income in any year,  $PCAPPLES_t$  will be 173.72 (i.e.  $1.018/.00586$ ) higher if the year is 1973 or later than if it is 1972 or earlier.

This is consistent with regarding the dummy variable as primarily capturing effects of higher nominal prices of all goods and services in years following 1972. These goods and services, as a class, are gross substitutes for apples. The intercept value in the price dependent demand equation for the 1960 to 1972 period is 4.967 and for 1973 to 1981 is 5.985 (4.967 plus the 1.018 coefficient on the dummy variable).

The final form of the estimated U.S. demand for apples is:

$$(3) \text{ USPRICE}_t = 4.967 - .00586(\text{USDEMAND}_t/\text{POP}_t) \\ (6.3431) \quad (-4.6707) \\ + 0.412\text{PCDI}_t + 1.018\text{DUMMY}_t \\ (6.1527) \quad (4.114)$$

$$F \text{ RATIO} = 103.65$$

$$R^2 = .95$$

$$\text{USPRICE}_{\text{MEAN}} = 2.58 \text{ dollars per bushel}$$

$$\text{USPRICE STD DEVIATION} = 1.12 \text{ dollars per bushel}$$

$$\text{MODEL STANDARD ERROR} = 0.29 \text{ dollars per bushel}$$

$$(t\text{-statistics are in parentheses})$$

where:

$\text{USDEMAND}_t/\text{POP}_t$  = U.S. apple supply in thousands of bushels in year  $t$  divided by U.S. population in millions in year  $t$ ;

$\text{PCDI}_t$  = U.S. per capita nominal disposable income, in billions of dollars per million population, in year  $t$ ;

$\text{DUMMY}_t$  = a dummy variable, where 1960 to 1972 equal zero and 1973 to 1981 equal 1;

$\text{USPRICE}_t$  = U.S. annual average price of apples all methods of sale, in dollars per bushel.

All of the coefficients are of the correct sign and have  $t$ -statistics which are significant at the 99 percent level. Equation (3) was estimated with ordinary least squares using time series data for 1960 to 1981.

Price and income flexibilities are calculated at their mean values. Price flexibilities for agricultural products at the farm level are expected to be negative and greater than one. Income flexibilities for normal goods are positive and less than or equal to one. The flexibility of nominal U.S. apple prices with respect to per capita apple consumption is  $-1.59$ . The flexibility of the U.S. nominal apple price with respect to per capita disposable income is  $0.64$ . Both flexibilities are consistent with a priori expectations based on economic theory.

The equation is consistent with a priori expectations of the sign and magnitudes of the estimated coefficients in terms of both statistical significance and size of the flexibilities. The Durbin-Watson  $d$ -statistic of  $1.31$  was in the indeterminant region. A chi-square analysis of a contingency table of the expected signs of the residuals showed no statistically significant autocorrelation.

#### *Market Clearing Institutional Rule*

A condition of the model required that in each time period the quantity of apples produced equaled the quantity of apples consumed. Using previously established notation this condition is:

$$(4) \text{ USDEMAND}_t = \text{OPROD}_t + \text{MEPROD}_t$$

This equation requires no estimation but insures the determination of a price which clears the market in each period.

#### *The Price Mapping Equation*

The U.S. apple industry model is recursive as production in a given year is determined by past prices and production. The intersection of the supply and demand functions yields a U.S. apple price. While the other region's supply response function includes as an explanatory variable U.S. price, the Maine supply response function uses Maine price as an explanatory variable. Maine apple producers are price takers as they produce only about one percent of total U.S. apple production. It was assumed that there exists a stable relationship between U.S. and Maine apple prices. Therefore an equation to link U.S. and Maine prices was estimated. Because a larger share of Maine apple production goes into fresh uses, the price of Maine produced apples will be higher than for the U.S. as a whole.

Maine prices are regressed against U.S. apple prices with the following result:

$$(5) \text{ MEPRICE}_t = .1527 + 1.1849 \text{USPRICE}_t \\ (.5175) \quad (13.1072)$$

F RATIO = 171.8

$R^2 = .90$

$\text{MEPRICE}_{\text{MEAN}} = 5.28$  dollars per bushel  
 $\text{MEPRICE STD DEVIATION} = 1.08$  dollars per bushel

MODEL STANDARD ERROR = .48 dollars per bushel

(t-statistics are in parentheses)

where:

$\text{MEPRICE}_t$  = Maine annual average apple prices for all methods of sale in dollars per bushel in year  $t$

$\text{USPRICE}_t$  = U.S. annual average apple price for all methods of sale, in dollars per bushel in year  $t$ .

Equation (5) was estimated using time series data for 1960 to 1981. The coefficient on the USPRICE variable is positive and its t-statistic is significant at the 99 percent level. The positive relationship is consistent with the fact that relatively more apples are sold fresh in Maine than in the U.S. and fresh apples receive a higher price than apples for other uses.

#### Equation System Goodness of Fit

The equation system goodness of fit refers to how closely the complete model estimates correspond to actual data. The equation system goodness of fit measures used in this study were calculated as part of a Gauss-Seidel solution procedure written at Washington State University. The Gauss-Seidel is an iterative technique for finding the value of endogenous variables in recursive and simultaneous systems of equations. Three measures of goodness of fit each calculated by two options of the Gauss-Seidel procedure will be evaluated. The two options of the Gauss-Seidel procedure differ in their method of calculating the solution values. Option 1 calculated current values of the endogenous variables by using historical values of the exogenous variables and previously calculated solution values of the lagged endogenous variables. Goodness of fit measures are then calculated using historical and solution values of the endogenous

variables. Option 2 works in the same manner except that historical values are used in the lagged endogenous variables rather than model-generated solution values.

The three measures of goodness of fit to be calculated for each endogenous variable under each option are:

1. mean absolute percent error

$$\frac{1}{n} \sum_{t=1}^n |\hat{Y}_t - Y_t| \cdot 100/Y_t$$

2. squared correlation between  $Y_t$  and  $\hat{Y}_t$
3. Theil's U-statistic

$U =$

$$\sqrt{\frac{\sum_{t=1}^n [(\hat{Y}_t - \hat{Y}_{t-1}) - (Y_t - Y_{t-1})]^2}{\sum_{t=1}^n (Y_t - Y_{t-1})^2}}$$

where:

$\hat{Y}_t$  = the current endogenous variable solution;

$Y_t$  = actual endogenous variable value.

The mean absolute percent error expresses the absolute value of each forecast error as a percent of the actual value of the variable. These percentages are then averaged to determine the mean absolute percent error. This measure has a lower bound of zero and, in general, the closer it is to zero, the better the model approximates the actual values of the endogenous variables.

The squared correlation between  $Y_t$  and  $\hat{Y}_t$  is a measure of the linear association between actual and solution values for the endogenous variables. Its value will range from zero to one where a value of one corresponds to a perfect linear relationship. The closer this value is to one, the better the goodness of fit.

The final measure is the Theil U-statistic which ranges from zero to infinity. The smaller the value of the U-statistic the better the forecasting performance of the model. For instance, if  $\hat{Y}_t$  happened to equal  $Y_t$  for every observation, the U-statistic would equal zero. The Maine forecast of using  $Y_{t-1}$  as a prediction of  $Y_t$  would produce a U-statistic of 1.

Table 1 lists the Gauss-Seidel measures of goodness of fit for Options 1 and 2. Option 1, the use of past predicted values for lagged endogenous variables, is a more rigorous test of the forecasting ability of the model than is the use of actual lagged values (Option 2). Option 1 corresponds to the procedure that will be used to make predictions into the future where solution values from previous pe-

**Table 1. Equation System Measures of Goodness of Fit Under Options 1 and 2**

Option	Variables	Mean Absolute Percent Error	Y vs. $\hat{Y}$ Squared Correlation	Theil-U Statistic
1	MEPRICE	11.51	.89	.86
	USPRICE	10.94	.87	.90
	OPROD	2.73	.92	.79
	MEPROD	4.43	.63	.95
	USPROD	2.71	.92	.79
	USDEMAND	2.71	.92	.79
2	MEPRICE	11.10	.90	.87
	USPRICE	11.26	.86	.93
	OPROD	3.17	.87	.92
	MEPROD	4.53	.59	.96
	USPROD	3.13	.87	.91
	USDEMAND	3.13	.87	.91

riods are used to generate the next period's predicted value.

Under Option 1 the equations explaining quantities (OPROD, MEPROD, USPROD) perform very well with a range of 2.71 to 4.34 mean absolute percent error. The squared correlation between  $Y$  and  $\hat{Y}$  for Option 1 ranges from .63 for the Maine production variable to .92 for OPROD. Only one variable is lower than .87 under Option 1. Option 2 results show a slight improvement in the Maine price variable when historical data are used as lagged endogenous variables. All other variables show a decline in squared correlation compared to Option 1. All Theil U-statistics are less than one under both options. Option 1 results range from .79 for USPROD and OPROD to .95 for the Maine apple production variable. Under Option 2, the U-statistics range from .87 for MEPRICE to .96 for MEPROD. Based on the summary statistics reported and discussed above the overall model was judged as satisfactory.

#### *Forecasting Procedure and Data*

The apple industry model contains three exogenous variables, OLDTREES, PCDI and  $R$  for which future values must be found. The number of trees planted forty years ago requires no forecasts since the length of its lag is greater than the length of the forecast period.

Per capita disposable income, PCDI, is a composite of nominal disposable income and population. Disposable income and population are determined independently of each other and are forecasted separately before being expressed as a ratio for use in the model simula-

tions. Future population levels were obtained from the Bureau of the Census based upon 1980 Census data. These forecasts were the Bureau's most likely population projections. Years for which projections were not provided were estimated by linear interpolation between years for which values were available.

The rate of size-controlled tree adoption,  $R$ , was assumed to be .97 throughout the forecast period. The rate of adoption has a theoretical ceiling of 1.00, but it is assumed that a small percentage of orchardists will continue to plant some standard trees. Future levels of per capita disposable income were determined by dividing an estimated total U.S. disposable income by the Bureau of Census estimates of U.S. population. The nominal U.S. disposable income forecasts were determined by extrapolating the historic pattern with a time trend equation.

The stock of trees variables for the other region and Maine are composed of lagged values of the endogenous variables for other region and Maine production, respectively. Thus, they are predetermined within the model. The dummy variable was set equal to one throughout the forecast period, as it was assumed that the shift in the general price level would persist.

Initial values for the lagged endogenous variables are required by the Gauss-Siedel solution procedures for calculating forecasts (Option 1). Due to the long lags in the apple supply response equations, the following data had to be provided: U.S. apple prices for 1968 to 1981; Maine apple prices from 1972 to 1981; other region and Maine apple production from 1972 to 1981; and the rate of dwarf tree adoption from 1976 to 1981. From 1982 onward,

Option 1 uses previously calculated solution values for the lagged endogenous variables.

### Forecast Results

Table 2 presents the endogenous variable forecasts for the 1981 to 2000 forecast period. United States production is predicted to increase from 183,095,000 bushels in 1981 to 401,005,000 bushels in 2000. This 119 percent increase results from an unbroken trend of increased annual production. The identical large increases in production through 1989 exhibited in the other forecasts are also present in this result. In contrast, however, from 1993 to 2000 annual production is predicted to grow at a noticeably higher rate. U.S. price ranges from \$4.45 (1982 actual) to \$7.59 per bushel in 2000. Prices trend upward with no declines with the exception of actual 1982 price.

Maine apple production exhibits an increase from 2,038 (1,000 bushel) units in 1981 to 2,622 units in 2000, a 28.7 percent increase. Maine apple prices show a continuous upward trend with the exception of actual 1982 price of \$5.80 per bushel. Prices range from \$5.80 per bushel in 1982 to \$9.14 in 2000.

### Conclusions

The apple supply and price situation will continue the trends of the last decade. One would not expect the continued production increases to be consumed solely on the domestic market. Recently U.S. net exports (exports minus imports) of apples have increased. Between 1977 and 1981 U.S. exports, U.S. net exports, and U.S. net exports as a percent of U.S. production have more than doubled. In 1981, U.S. net exports equaled 6.4 percent of U.S. production (U.S.D.A.). Maine's rate of production expansion which is slower than that of the other region will result in an erosion of its market share. In 1982, Maine's production accounted for about 1.1 percent of total U.S. production; however, its share is projected to be 0.65 percent in the year 2000.

Large forecasted increases in apple production will mean a larger supply of apples on the fresh market as this is the preferred outlet of most producers. Recent large increases in production have come primarily from Washington State and other western producing regions. Although the model does not predict production at a disaggregated level, based on historical data it is reasonable to assume that the largest part of new production will origi-

**Table 2. Endogenous Variable Values: 1981–2000 Forecast**

Year	Endogenous Variables				
	USPRICE	USPROD	OPROD	MEPRICE	MEPROD
	(\$ per bu.)	(000 bu.)	(000 bu.)	(\$ per bu.)	(000 bu.)
1981 (actual)	(5.00)	(183,095)	(181,057)	(6.96)	(2,038)
1981	4.99	180,989	178,924	6.06	2,065
1982 (actual)	(4.45)	(182,900)	(180,783)	(5.80)	(2,117)
1982	5.00	197,827	195,745	6.08	2,082
1983	5.18	208,552	206,450	6.29	2,102
1984	5.41	217,381	215,236	6.56	2,145
1985	5.51	230,901	228,745	6.68	2,156
1986	5.65	242,693	240,532	6.85	2,161
1987	5.77	255,632	253,371	6.98	2,261
1988	5.94	266,010	263,741	7.19	2,269
1989	6.28	269,204	266,859	7.59	2,345
1990	6.52	276,412	274,066	7.88	2,346
1991	6.63	288,782	286,430	8.01	2,352
1992	6.71	302,972	300,616	8.10	2,356
1993	6.72	319,546	317,183	8.12	2,363
1994	6.80	333,439	331,069	8.21	2,370
1995	6.95	344,054	341,566	8.38	2,488
1996	7.11	353,854	351,358	8.58	2,496
1997	7.28	363,417	360,913	8.78	2,504
1998	7.43	373,857	371,350	8.96	2,507
1999	7.53	386,578	384,067	9.07	2,511
2000	7.59	401,004	398,382	9.14	2,622

nate from the West and be comprised of varieties such as Delicious which are not well suited to Maine growing conditions. Therefore, Maine, which sells 83 percent of its crop on the fresh market, could be at a disadvantage if its major variety, McIntosh, becomes a minor variety nationally. Maine producers must thus find new market outlets and engage in product promotion to develop a preference for Maine-grown apples. There is a market order in Maine that contributes to a regional effort to promote varieties grown in New England and New York State. The feasibility of further expanding promotional activities and establishing alternative outlets should be examined.

Forecast results suggest that U.S. and Maine apple prices would only increase in real terms if low levels of inflation persist. For instance, annual inflation rates of 2.5 and 3.0 percent throughout the forecast period would result in a constant real price in the year 2000 for Maine and the U.S., respectively. Since it is likely that inflation will exceed the 2.5 to 3.0 percent range, real apple prices can be expected to decline. This implies that Maine and other U.S. orchardists must continue to adopt the latest available technology and utilize a high degree of management skill to keep production and processing costs low.

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