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A PREDICTION MODEL FOR MAINE'S POTATO PRODUCTION

Alan S. Kezis, Michael Hammig, and Marc Ribaudo

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By

Alan S. Kezis, Michael Hammig, and Marc Ribaudo*

INTRODUCTION

The Maine potato industry is one of the most important agricultural industries in the State. Over the period 1975-77, farm cash receipts of the potato industry constituted 28 percent of the State's total agricultural receipts. Maine potato production has traditionally contributed significantly to the Nation's potato crop serving markets ranging throughout the eastern United States. The climate and soil conditions are ideal for production, especially in Aroostook County where the majority of the potato producers are located; however, the growing season is relatively short.

Over the past 15 years there has been a fairly steady decline in potato acreage planted in Maine, while average yields have shown a less well defined downward trend. Total production has, therefore, trended downward over this period. Though the general trend has been downward, both acreage planted and yield have exhibited large fluctuations from year to year. Thus, expectations of total Maine potato production are highly speculative until after the crop has been harvested. For a state whose economy is significantly dependent on the health of the potato industry, a mechanism to forecast the expected level of production with a reasonable degree of accuracy could be a valuable tool for economic analysis and planning. The objective of this study is to develop an econometric model to predict production using selected data which are available well before the crop is harvested.

METHODOLOGY

The econometric tool used to evaluate the postulated factors affecting production and to estimate a prediction equation is ordinary least squares regression (OLS). We postulate that

$$Y = f(X), \tag{1}$$

where Y is an $n \times 1$ matrix of observations on the dependent variable and X is an $n \times k$ matrix of observations on the k explanatory variables.

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The specific case examined in this paper is to define an equation of the form of (1) that relates the dependent variable Q_s (production of Maine potatoes) to a set of variables X that affects that production. Assuming linearity, an estimable relation can be defined as

$$Q_s = B_0 + B_1X_1 + B_2X_2 + \ldots + B_kX_k + u, \tag{2}$$

where B_i, $i = 0$, , k, are regression coefficients and u is a random disturbance term with mean zero and variance σ^2. Equation (2) can be expressed in the matrix form of the general linear model as

$$Q_s = XB + u \tag{3}$$

where B is a *kx1* vector of coefficients and u is an *nx1* vector of random disturbances. Application of the OLS procedure to minimize the sum of squared errors yields:

$$Q_s = Xb + e \tag{4}$$

where b is a kx1 vector of estimates of B and e is an nx1 vector of residuals.

MODEL FORMULATION

The relation used to estimate the quantity of potatoes produced in Maine in a given year was hypothesized as

$$Q_{s,t} = B_0 + B_1PE_t + B_2RT_t + B_3ACPL_{t-1} + B_4TREND_t + u_t \tag{5}$$

where $Q_{s,t}$ is the quantity of potatoes (1,000 cwt.) produced in year t. PE_t is the expected average price per cwt. to be received for the crop grown in year t.[1] RT_t is the perceived risk in producing the crop in year t. $TREND_t$ is a trend variable and $ACPL_{t-1}$ is the acreage planted in the preceding year.

Expected Price

Producers are uncertain as to future product prices and production levels. While producers are uncertain as to specific future prices or the exact quantities they will produce, each individual is able to subjectively assign probabilities that a particular outcome will occur. The existence of time lags between planting and harvesting requires farmers to plant acreage and apply inputs, such as fertilizer, based on anticipated prices to be received for the crop.

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[1] In all cases price data refer to the average yearly potato price per cwt. reported by the Crop Reporting Service, USDA.

In the model presented here, it is assumed that farmers base their price expectations for the current year on the prices received over the past three years. A weighted summation process is used to calculate the expected price, such that the price received for the last crop is weighted more heavily than the prices received for crops grown further in the past.

Expected price is defined as

$$PE_t = \sum_{i=1}^{3} w^i\, P_{t-1} \qquad (6)$$

where PE_t is the price expected to prevail for the crop grown in year t and P_{t-i} is the actual price received for crops grown in years t-i. The weighting factor w is constrained such that

$$\sum_{i=1}^{3} w^i = 1 \qquad (7)$$

Thus, the term w is equal to .544.

Risk

The importance of risk as an influence on producer behavior and the planting decision depend on the producer's predisposition toward risk. If the farmer is risk averse, as is commonly presumed, the amount of acreage planted will be some quantity less than the quantity that would be planted if the producer operated in a risk-free environment.

Definition of risk in an econometric model may take many different forms. In most empirical work, risk is represented by some measure of accuracy with which the price expectation is formed. Thus, as past expectations are compared to past actual prices, the less the difference between expected and actual outcomes, the less the risk, and vice versa.

In the model presented here the risk variable is defined as the square root of the sum of squared differences between actual and expected outcomes over the three previous production periods, relative to the current expectation.

$$RT_t = \frac{\sqrt{\sum_{i=1}^{3} (PE_{t-i} - P_{t-i})^2}}{PE_t} \qquad (8)$$

where RT_t is the level of risk in period t, and $PE_{t-i} - P_{t-i}$ is the difference between actual and expected prices in period t-i. Inclusion of the

current expectation as a divisor in the risk expression serves the purpose of establishing a perspective on the accuracy measure in the numerator. That is, risk is defined as the accuracy of expectation formation relative to the level of expectations. Thus, the same difference between expected and actual prices would imply less risk when current expectations are relatively high than when current expectations are relatively low.

ACRES PLANTED LAST YEAR

The partial adjustment hypothesis provides a logical basis for the inclusion of a lagged planted acreage as an explanatory variable. This variable can be viewed as an explanatory force which captures the influence of a number of fixed factors of production. Such factors include specialized equipment for a particular crop, technical expertise and existing storage facilities. The effect of such forces may induce the farmer to plant a level of acreage which is closely related to the acreage he planted the year before.

TIME

The inclusion of a time or trend element as an explanatory variable permits consideration of additional forces which may not be quantifiable; or may represent the net effect of several variables where the impact of each is too small to warrant its inclusion separately. For the Maine potato industry this may include changes in input prices. Functionally the time variable for this model is the natural logarithm of the last two digits of the crop year.

RESULTS

Equation (5) was estimated using data from the production years 1964-78. The results of the OLS procedure are:

Q_s = 307814.4 + 2748.979(PE) — 8760.963(RT) + 244.067(ACPL1) —
SE   (757.859)   (2192.048)   (53.769)
F(1,10)   13.157   15.974   20.604
                    73002.62(TREND)
                       (11704.249)
                          38.904
Regression F(4,10) = 25.108
R^2 = .909
DW = 2.594

These results indicate that quantity supplied is directly related to expected price and previous acreage planted, and inversely related to risk and time. The negative effect of the trend variable on production could be due to the combined impact of loss of soil through erosion and decreased use of fertilizer inp... due to increasing input prices.

The objective of this exercise was to develop an econometric relation that can be used as a predictor of future production levels of Maine potatoes. The results presented here indicate that the estimated equation can perform that task. The R^2 value implies that the variables included in the model combine to explain about 91 percent of the variation in production. Since values for all explanatory variables are known before the crop is actually produced, projections of future production levels can be obtained using these results. Figure 1 shows the accuracy with which the estimated equation predicts actual production over the period of the data used for estimation.

ELASTICITIES

The estimated short-run elasticities of quantity produced with respect to expected prices and risk can be calculated from the estimated equation. These elasticities indicate the responsiveness of farmers to changes in expected prices and perceived risks.

Since current expected price is explicitly entered in the risk formulation, the elasticity of production with respect to expected price must involve estimated coefficients on the expected price and the risk variables. Given RT as defined in equation (8), let the numerator be represented by SD. The general equation for production now becomes

$$Q_s = B_0 + B_1 PE + B_2 SD/PE + \qquad (9)$$

The elasticity of Q_s with respect to PE is given by

$$\varepsilon_{PE} = \frac{\delta Q_s}{\delta PE} \frac{PE}{Q} = B_1 \frac{PE}{Q_s} - B_2 \frac{SD}{PE\,Q_s} = B_1 \frac{PE}{Q_s} - B_2 \frac{RT}{Q_s} \quad (10)$$

Substituting in the estimated coefficients, and the mean values of PE, Q_s, and RT for the period 1964-78, an elasticity of .45 results. This figure compares closely to the expected price elasticity calculated by Estes (1) for the Maine potato industry of .476.

The elasticity of production with respect to risk can be defined as

$$\varepsilon_{RT} = \frac{\delta Q_s}{\delta RT} \frac{RT}{Q_s} = B_2 \frac{RT}{Q_s} \qquad (11)$$

Substituting the coefficient estimated for risk and the means for RT and Q_s into (11) yields a risk elasticity of −.197. This value com-

pares with a value of −.085 which was also calculated by Estes (2).

In general, the potato supply is price inelastic. Large changes in expected price are necessary to substantially change the quantity produced. Likewise, supply is risk inelastic. Large increases in perceived risk are needed to substantially decrease the quantity of potatoes supplied.

CONCLUSIONS

Using the explanatory variables, expected price, risk, previous acreage planted, and time a reasonably accurate model for the prediction of quantity produced can be derived. This model, however, is only the first step in formulating a comprehensive model for the entire industry. As a supply equation, the model presented here predicts well, but it is too highly aggregated for many purposes. The supply side could be broken down to each type of potato production: tablestock, chips, french fries, and processed. In order to complete an industry model, a demand model must be formulated. Once a demand model is available, the supply and demand sides can be estimated simultaneously and an equilibrium price predicted.

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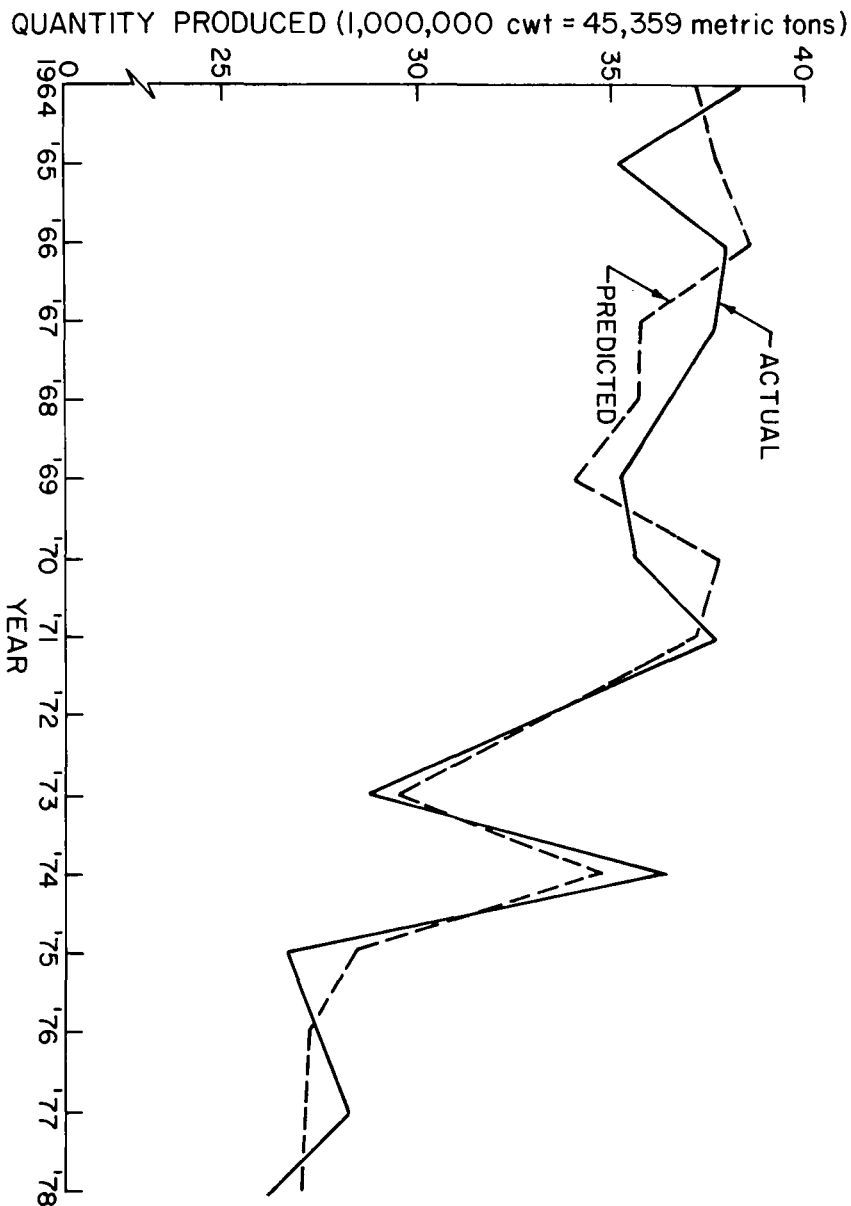
2. Ibid.

Figure 1

Predicted vs. Actual Quantities Produced from 1964 to 1978