A Practical Approach to Forecasting Winter-Fresh Tomato Markets

by

Shannon Reid Hamm and Neilson Conklin

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Commodity analysts in industry, government, and universities have long used their knowledge of institutional, biological, and physical as well as economic factors affecting commodity markets to forecast prices. Years of experience and observation lie behind these intuitive and usually undocumented models. On the other hand, more "scientific" econometric and time series models generally lack the flexibility to cope with the institutional, biological, and environmental complications which the everyday forecaster faces. The distance between "artful" and "scientific" forecasters has widened in agricultural economics, as the rapid development of new quantitative methods has left commodity analysts behind, and left little time for the more theoretical analysts to absorb the realities of commodity markets.

But microcomputers and interactive software may help agricultural economists narrow the gap between "artful" and "scientific" forecasting. Spreadsheets and easy-to-use statistical software provide commodity analysts with the flexibility to develop and modify quantitative models rapidily to meet the changing conditions of markets. The winter fresh tomato forecasting system presented in this paper is one example of how new technology is being used to bridge the gap between "artful" and "scientific" forecasting.

One of the most important fresh-market vegetables, in both value and consumption, is tomatoes. U.S. tomato production, valued at $658 million in 1985, grew at an average annual rate of 3.5 percent over the past 10 years (Figure 1), mainly in response to stronger demand. Fresh tomato consumption grew over the same period at an average annual rate of 2 percent. Florida produces about 90 percent of the U.S. fresh-market tomatoes supplied between late October and early June. Florida's fresh-market tomatoes were valued at $371 million in 1985, making them Florida's most important vegetable crop. Because tomatoes are a major fresh-market vegetable, tomato prices are heavily weighted in the grower and retail price indices for vegetables. Thus, winter fresh-market tomato price forecasts are an important input into the forecasting of aggregate indicators, like farm income and the CPI for food.

The objective of this paper is to present a flexible and practical model which can provide accurate and timely forecasts for use in USDA's Outlook and Situation program. To meet this goal the forecasting system for Florida prices was developed using spreadsheet software for microcomputers.

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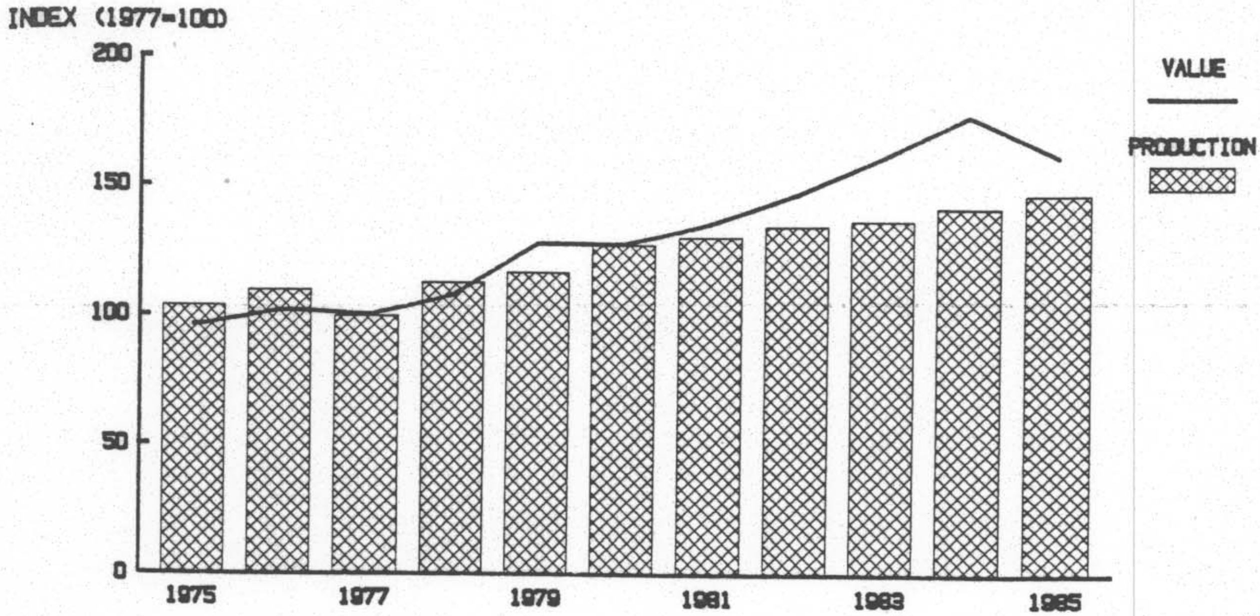
Figure 1. U.S. Tomato production and value



Forecasting prices for fresh-market tomatoes presents somewhat different problems than forecasting storeable commodity prices. Fresh-market tomatoes are subject to seasonal shifts in the location of production and to adverse weather conditions. Because tomato market conditions change rapidly, a useful forecasting model must be able to provide forecasts at frequent intervals. Although a daily model might be desirable, weekly f.o.b. price and shipment data from the USDA Agricultural Marketing Service (AMS) are the best data currently available.

Purely econometric models for this type of high frequency forecasting can be cumbersome, while time series models, conditioned on past performance, often fail to reflect fundamental shifts in supply and demand. Integrating econometric and time series models may provide a more practical approach to forecasting the winter fresh tomato market. The tomato forecasting system described in this paper uses a weekly econometric equation to reflect the underlying price dependant relationship between shipments and prices plus a simple seasonal equation to forecast weekly shipments.

TOMATO MARKETS AND PRICES

Price analysis models for fresh-market tomatoes have been developed by many agricultural economists over the years. The purposes of the studies varied from parameter estimation (Lopez, Van Sickle and Alvarado) to price discovery analysis (Bohall, Jesse and Machado, and Shonkwiler). Published price forecasting models for fresh produce are not as common, though Epperson, Fu, and Mizelle recently reported on a weekly retail price forecasting model for Georgia peaches. This model uses current prices, quantity shipped, USDA production estimates, and weekly dummy variables to forecast prices up to 3 weeks in advance.

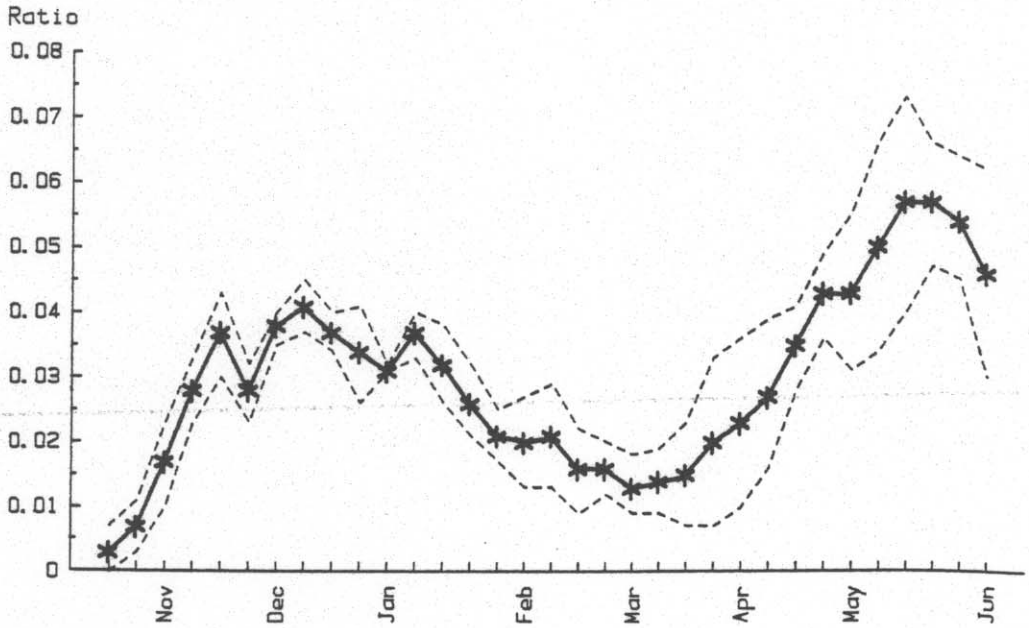
Tomato prices in Florida during the winter season are characterized by high variability and the risk of sudden price increases due to the geographical concentration of supply and the possibility of freezes. As the sole domestic supplier, Florida producers risk devastating losses due to freezes, while retailers and consumers bear the risk of higher prices and/or inadequate supplies. The effects of freezing weather on winter tomato markets are fresh in everyone's mind since the Florida industry has experienced freezes in every season since 1981/82.

Grower prices rise immediately after a freeze damages the crop. The level and rate of price increase depend upon the amount of tomatoes in the marketing channels and the degree of salvage harvesting. Following a freeze, growers face a choice of either replanting vegetable acreage, as it was previously planted, or reallocating among various crops. The acreage reallocation for tomatoes varies with the timing of the freeze. For example, following the freeze in late January 1985, Florida growers replanted more acreage in tomatoes for the spring harvest--normally the peak season. The resulting bulge in tomato acreage subsequently increased production and lowered prices.

Shipments of winter fresh-market vegetables are technically related to harvested acreage which in turns depends on the number of acres planted, and the number of times a field is picked. However, the variation in shipments is primarily due to the seasonal shifts in acreage planted, with harvest occuring about 9 weeks later. Florida tomato acreage is allocated unevenly throughout their October to June season, with the largest amount in the spring period. Thus, shipments peak between April and June. They are seasonally low from February through March (Figure 2). But since every season since 1981 has experienced a freeze, the average seasonal pattern from 1981/82 to 1984/85 reflects a "freeze season" shipment pattern. The stability of this seasonal pattern is evident from the narrow zone of irregularity (+ or - one standard deviation) around the mean in Figure 2. Notice that the zone widens during the peak shipment months of April, May and June, when the change in weekly shipments is greater.

Because tomatoes are perishable and weekly supplies are tied to the number of acres planted about 9 weeks prior, prices will rise or fall to a level which clears the market. However, planting schedules and weather shocks are not the only factors affecting tomato prices. Although fresh tomatoes are perishable, mature green tomatoes can be held in storage for 2-3 weeks.

Figure 2. Seasonal variation in Florida tomato shipments, 1981-85 1/



/ Seasonal pattern is a ratio calculated as he current week's shipment to season hipment total.

Bohall (1972) reported that this helped to smooth price fluctuations, and he used the ratio of the current week's shipments to the previous two week's average shipments as a proxy variable for stocks. While changes in income and population are relatively constant through a single winter tomato season, shifts in demand at the f.o.b. shipper level occur as a result of transportation problems, changes in the quantities of substitutes, and holiday food buying habits.

THE TOMATO PRICE FORECASTING SYSTEM

The tomato price forecasting system consists of two simple equations, one describing the seasonal behavior of winter tomato shipments, and the other relating weekly tomato prices to shipments, stocks, and past prices. Equation (1), below, specifies weekly shipments as a linear function of seasonal behavior, represented by a ratio of current shipments to 33-week season total shipments. Because the winter fresh tomato season time series is discontinuous, the seasonal factors used in this analysis are based on season totals rather than on the standard centered moving average method (Foote and Fox). Thus, the seasonal factor used in this analysis may be interpreted as the proportion of season's total shipments in a particular week. Slope and intercept dummy variable were added to the equation to control for a shift in the seasonal pattern during the 1984/85 season.

Equation (2) specifies the price of tomatoes this week as a function of last week's price, last week's stocks, and current shipments. The stocks variable is simply the ratio of last week's shipments to the average shipments of the two previous weeks.

(1) $F_t = B_o + B_1\ DF_t + B_2\ SF_t - B_3\ D_t + V_t$
(2) $P_t = a_o + a_1\ P_{t-1} + a_2\ S_{t-1} + a_3\ F_t + U_t$

Where

F_t = the weekly quantity of tomatoes shipped in 1,000 cwt, week t;

DF_t = the seasonal slope shifter for shipments, 1 = 1984/85 season, 0 = otherwise;

SF_t = the seasonal index for shipments between October and June, week t;

D_t = the seasonal intercept shifter for shipments, 1 = for 1984/85 season, 0 = for all other seasons;

P_t = the weekly f.o.b. price per 25 pound carton of Florida tomatoes between October through June, week t; and

S_{t-1} = the previous week's ratio of shipments to the average two previous week's shipments;

While substitutes for Florida tomatoes should explicitly be included in this model, problems were encountered using Mexican tomato shipments as a variable. Mexico is Florida's primary competitor in the winter fresh tomato market (Zepp and Simons) and earlier studies (Bohall, Van Sickle and Alvarado) have found strong negative relationships (both lagged and contemporaneous) between Florida tomato prices and Mexican shipments. However, a regression line of these two variables for the 1981/82 to 1984/85 seasons reveal an upward sloping relationship between Florida prices and Mexican shipments (Figure 3). Thus Mexican shipments were not explicitly included in the model through they are implicitly.

One possible explanation for the perverse sign is that the high prices following freezes (which occurred during each of the seasons in this analysis) triggered the increased movement of Mexican vine ripe tomatoes. Thus, the model may be identifying a supply relationship for Mexico, rather than a price dependant demand relationship for Florida tomatoes. An alternative explanation is that Florida and Mexican tomatoes have increased their seasonal complementarity due to the frequency of freezes and the seasonal decline in Florida supplies during the high risk freeze period (Figure 4).

The price data used in estimating the seasonal shipment and price equations were obtained from the Annual Florida Tomato Committee (FTC) reports for the 1981/82 through the 1984/85 seasons and the shipment data were taken from the Agricultural Marketing Service's (AMS) Weekly Shipments and Arrivals publications. Equations (1) and (2) were estimated on an IBM microcomputer by

Figure 3. Florida's f.o.b. tomato prices and Mexican shipments, 1981-85

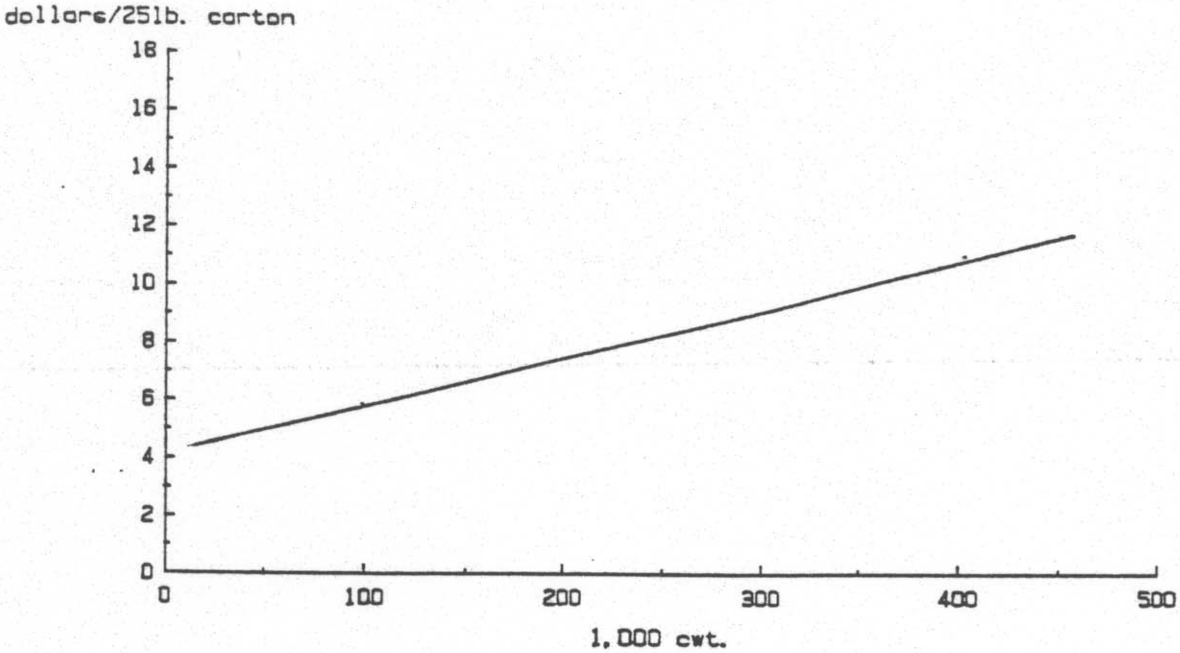
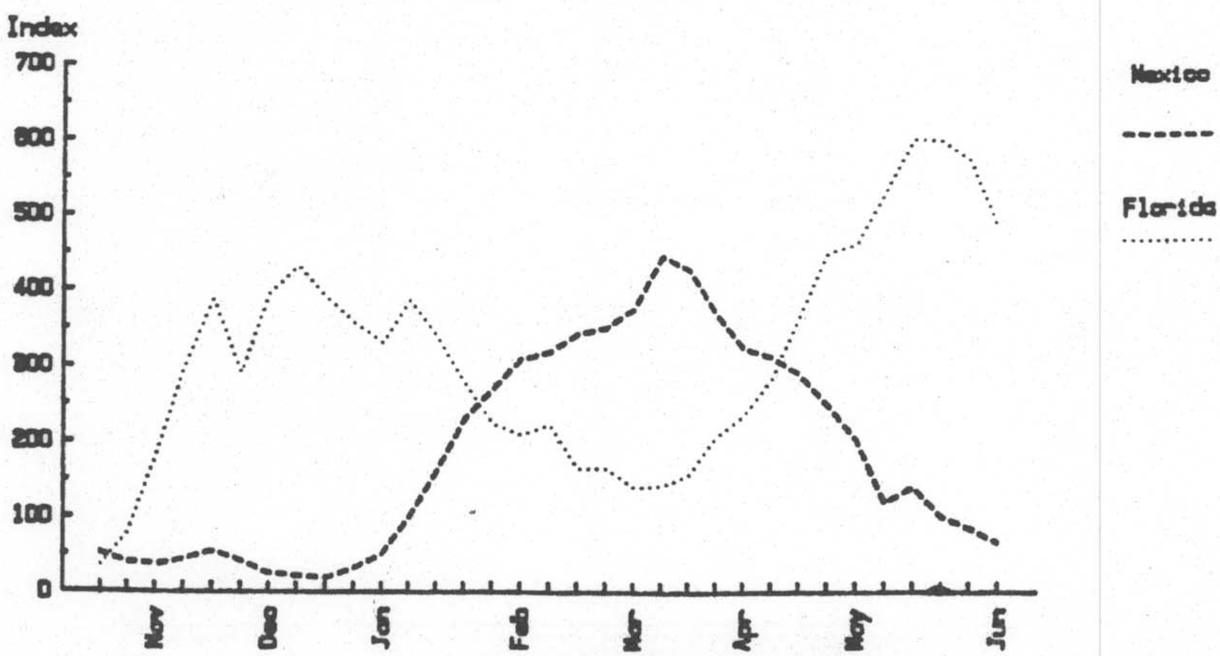


Figure 4. Seasonal relationship between Florida and Mexican shipments, 1981-85



ordinary least squares (OLS) procedures using Time Series Processor (TSP). TSP is an interactive econometric program which supports data exchange with spreadsheet programs like Lotus 123.

RESULTS OF FORECASTING MODELS

The estimated coefficients for both forecasting equations, shown in Table 1, have large t ratios, with the exception of the intercept shift dummy variable in the shipments equation. All of the coefficients had the expected signs. The high R^2, .99, for the shipment model was expected as the equation is tautological and merely serves as a mechanical way of translating an average seasonal pattern into shipment levels.

Table 1. Regression analysis for winter fresh-market Florida tomatoes 1/

Variable	Price model	Shipment model
	Coefficients	
P_{t-1}	.716 (12.808)	
F	-.004 (-3.55)	
S_{t-1}	-.508 (-3.131)	
SF		10143.461 (336.063)
DSF		1542.911 (32.002)
D		-1.44 (-.819)
R^2	.79	.99
Durbin's-h statistic	.549	
DW statistic		1.42
Theil's inequality coefficient	.0903	.0052
Observations	133	135

1/ The t-values are listed in parentheses below the parameter estimates for each variable.

The price equation explains about 80 percent of the variation in the f.o.b. tomato prices. Equations which predict at frequent intervals often fit less well than quarterly or annual equations, because of higher "noise" levels in the data. Because of the lagged dependant variable in the price equation Durbin's h statistic was used to check for autocorrelation (Pyndick and Rubinfeld). At the 5 percent level, the critical value of h is 1.645. Therefore, because the calculated h is 0.549, the null hypothesis of no autocorrelation cannot be rejected and is therefore accepted.

Although the price model is not structural, a price flexibility can be computed using the estimated coefficient on the shipment variable. The price flexibility computed at the means for winter fresh-market tomatoes is -0.168 (Table 2). If instead of using the average price and shipment values (see Appendix table A), the sample extremes are used, then the price flexibility ranges from -0.007 at high prices and low quantities, to -1.07 at low prices and high quantites. These flexibilities fall within the range of those previously reported by Nuckton (1980). Thus, depending on the time of the season, the price flexibility of tomatoes varies (Table 2), and it is possible to estimate the impact of a freeze on the f.o.b. tomato price using these flexibilities.

OUT OF SAMPLE PERFORMANCE

Although no single standard test exists for forecasting performance, the ability of the model to predict can be measured by goodness-of-fit criteria like Theil's inequality coefficient or the root mean square error. Appendix tables B and C contain the descriptive statistics and root mean square error for the out of sample test. The forecasts are made by using one step ahead estimates. To forecast 1985-86 prices, the out of sample shipments are estimated using the 4 year average weekly ratio in the seasonal shipment equation. Then, the current week's forecast shipment is then applied to the price dependent equation. The stocks variable is also derived from the estimated shipments.

Table 2. Weekly f.o.b. price flexibilities for Florida winter fresh-market tomatoes, 1981-85.

Season	Price flexibility
late October-December	-.255
January-April	-.107
January-early June	-.149
late October-early June	-.168

Table 3. Out of sample forecast error for winter fresh-market Florida tomato models

Variable	1985/86 Price	1985/86 Shipment
Correlation between actual and predicted	0.67	0.83
Theil's inequality coefficient U	.118	.226
Theil's bias coefficient U_m	0.173	0.101
Theil's variance coefficient U_s	0.032	0.352
Observations	21	23

The out of sample price and shipment forecasts are better than a naive no change forecast, since the Theil's inequality coefficient is significantly less than 1 for both forecasts (Table 3). However, the price's model forecast is biased upward (U_m is close to 0.2). This upward bias is due to the existence of freezing weather in the estimated seasonal shipments. The data used to estimate the price and shipment equations are influenced by freezes in every season. However, the 1985/86 season used in the forecasting test did not include a severe freeze, although freezing temperatures were registered in late February and early March. Clearly a better way needs to be found for incorporating a freeze effect into the model, instead of implicitly incorporating them from seasonal shipment patterns.

Shipments during a nonfreeze season, such as 1985/86, are likely to be higher than during a freeze season (Figure 5). The out of sample seasonal shipment pattern is very similiar to the sample period early in the season, when the chance of a freeze is very small. However, the difference between the two patterns widens during the critical period for freezes. The historical seasonal shipment pattern lowers the estimated shipment level due to freeze influences. Since the estimated seasonal pattern deviates below the out of sample pattern, the resulting price forecast will necessarily be higher (Figure 6). Since the seasonal shipment pattern is being used to forecast prices one week ahead, an adjustment to this low pattern can be applied to raise the estimated level. A three week average error ratio of the actual shipment to the seasonally estimated shipment level was computed and added to this week's estimated level.

Figure 5. Out of sample test of Florida tomato shipments, 1985-86

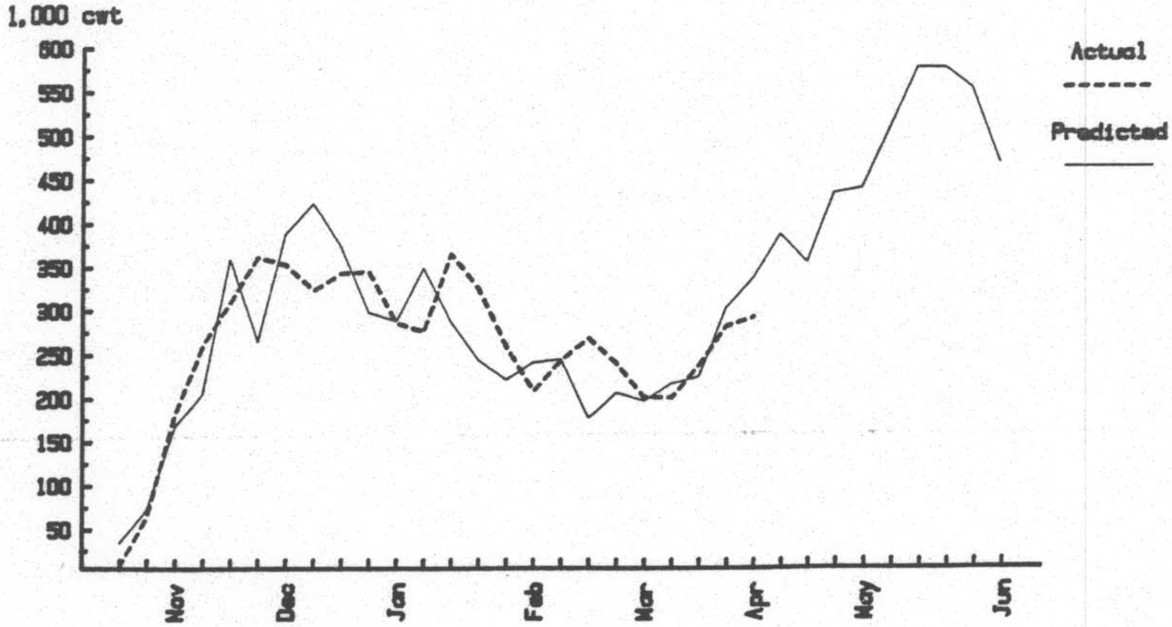
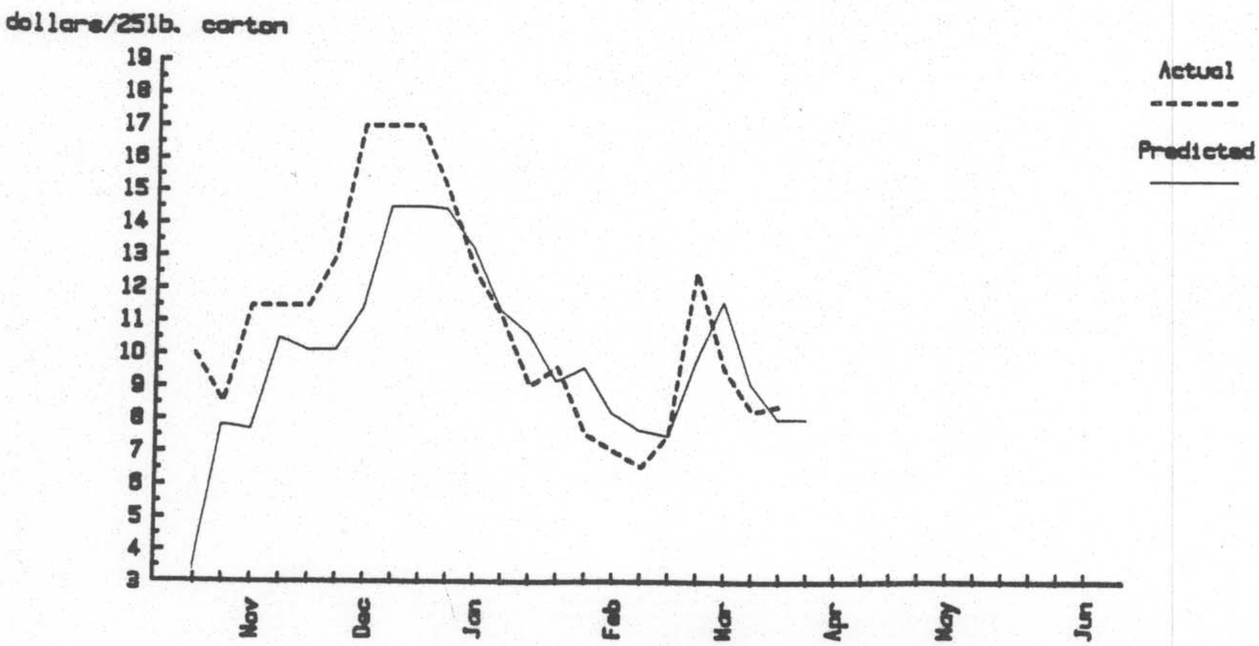


Figure 6. Out of sample test of Florida tomato prices, 1985-86



SUMMARY

A weekly tomato price forecasting system is currently being used by ERS vegetable analysts. Because it is easy to update and run on a microcomputer spreadsheet, it provides timely forecasts for use in the vegetable outlook and situation program, and as an input to forecasts of aggregates like farm income and the fresh vegetable grower price index. Although the model needs further development and refining, it is already a useful tool.

By implementing the model on spreadsheet software, the commodity analyst keeps the flexibility of testing the impact of changes in shipment patterns or freezes on winter-fresh tomato prices. Thus, the commodity analyst is able to combine "artful" analysis with better quantitative estimates of economic behavior. As a new generation of commodity analysts develop more forecasting applications for personal computers, the gap between "artful" and "scientific" in commodity price forecasting will continue to narrow.

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Appendix table A. Descriptive statistics for tomato price and shipment models

Variable 1/	Mean	Standard Deviation	Maximum	Minimum
		--Price model--		
P(actual)	7.452	3.081	15.220	3.23
P_{t-1}	8.464	3.071	15.220	3.23
F	337.669	167.750	867.000	26.000
S_{t-1}	1.255	.842	7.273	0.450
P(resid)	-3.848E-08	1.449	4.612	-5.462
P(fitted)	7.452	2.719	14.405	2.872
		--Shipment model--		
SF	.032	.015	.074	.002

1/ Variables are the same as defined by models. P(resid) is the residual of the tomato price model. P(fitted)is the predicted tomato price using the OLS estimates.

Appendix table B. Descriptive statistics for Florida tomato out of sample model

Variable 1/	Mean	Standard Deviation	Maximum	Minimum
P	11.298	3.245	17.000	6.500
P_{t-1}	11.348	3.215	17.000	6.500
S_{t-1}	1.267	.933	5.010	.710
F	284.750	54.069	366.000	201.000
P(fitted)	10.491	2.257	14.457	7.557
P(resid)	14.47E-09	1.894	3.846	2.420
		--Shipment model--		
SF	.032	.015	.074	.002

1/ Variables are the same as defined by models. P(resid) is the residual of the tomato price model. P(fitted)is the predicted tomato price using the OLS estimates.

Appendix Table C. 1985/86 f.o.b. tomato price out of sample errors

Week	Predicted	Actual	Error
	-Dollars/25lb carton-		
1	NA	NA	NA
2	NA	NA	NA
3	3.37	10.00	-6.63
4	7.83	8.50	-.60
5	7.67	-11.50	-3.82
6	10.50	11.50	-.96
7	10.10	11.50	-1.35
8	10.10	13.00	-2.87
9	11.40	17.00	-5.54
10	14.50	17.00	-2.85
11	14.50	17.00	-2.43
12	14.40	15.00	-.55
13	13.20	12.50	.73
14	11.30	11.10	.28
15	10.60	9.00	1.61
16	9.15	9.60	-.44
17	9.59	7.50	2.10
18	8.17	7.00	1.18
19	7.63	6.50	1.13
20	7.44	9.75	-2.31
21	9.76	12.50	-2.73
22	11.60	9.50	2.14
23	9.06	9.00	.87
Root mean Square Error			2.60