Medium-Term Projections of Lemon Acreage and Production

by

Roger Fox and Kenneth Rabyat

Medium-term projections of California-Arizona lemon acreage and production are made using a three equation econometric model. Model projections of acreage compare favorably with existing "committee" projections. Projection errors for production however, are about the same from both approaches. The lemon model represents only the beginning of what could be a major projections system for the California-Arizona citrus industry.
Medium-Term Projections of Lemon Acreage and Production
by Roger Fox and Kenneth Ribyat*

The nature of citrus production is such that medium-term projections of acreage can be made with a fair degree of confidence. The perennial nature of the crop and the lag of five to six years between planting and associated changes in output mean that current bearing and nonbearing acreage are key determinants of bearing acreage three to five years in the future (French and Matthews). Estimating removals of existing acreage is the most difficult factor in making medium-term projections of acreage (Rausser).

Medium-term projections of production are complicated by stochastic variations in yield due primarily to weather. Rausser, in his study of the California-Arizona orange industry, developed a complete five equation supply model consisting of behavioral equations for plantings, removals and yield, and identities for output and bearing acreage. The estimation of Rausser's model, both for oranges and other citrus types, was frustrated by lack of data, especially relating to removals (Ribyat; Matthews, Womack, and Huang).

An alternative model of acreage and production is presented in this paper. The model can be estimated with available data and gives good economic and statistical results. Furthermore,

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it is easily manipulated to give medium-term projections of acreage and production. Projections based on the model are compared with existing "committee" projections published by the California-Arizona Citrus League.

The Model

A three-equation aggregate model was specified with behavioral equations for yield and bearing acreage, and an identity for output. The model, in its most simplified form, is:

\[
Q_t = BA_t \cdot Y_t \quad (1)
\]
\[
Y_t = f(A_t, T_t, W_t) \quad (2)
\]
\[
BA_t = f(P_t, PA_t) \quad (3)
\]

where:

- \(Q_t\) = total output of lemons in season \(t\)
- \(BA_t\) = bearing acreage of lemons in season \(t\)
- \(Y_t\) = average yield of lemons in season \(t\)
- \(A_t\) = age distribution of the lemon tree population in season \(t\)
- \(T_t\) = level of technology employed
- \(W_t\) = weather variable
- \(P_t\) = expected long-run profits of lemons
- \(PA_t\) = expected long-run profits of alternative activities
The omission of separate equations for plantings and removals is an obvious limitation of the model when compared to Rausser's more complete specification. The bearing acreage equation must capture the net effects of plantings and removals, effects that are associated with different time dimensions (removals have an immediate impact while the influence of plantings is delayed). This compromise was made in anticipation of data problems and because of the lack of success with reduced-form estimation of a more complete model (Ribyat).

Alternative specifications of the yield and bearing acreage equations for citrus and other perennial crops have been offered (French and Matthews; Rausser). However, in all previous cases, as with the present model, estimation required the use of proxy variables and other simplifying alterations.

**Estimation of the Model**

Estimation of the bearing acreage equation required the consideration of a number of proxies for the unobservable expected values of the independent variables $P_t$ and $PA_t$. Consistent with previous studies and logic, various lagged price and revenue variables were used to represent expected profits (see Ribyat, pp. 64-69 for details). Since there were no compelling reasons for choosing among functional forms of the equation, several commonly used alternatives were tried. Of the various estimated equations for bearing acreage, the one that was most consistent with economic logic and also gave excellent statistical results was:
\[ B_{At} = 11.74 + 0.06 \text{TRL}_{t-7} - 0.33 \text{TRO}_{t-7} \]
\[ (1.74) \quad (-12.29) \]
\[ + 0.06 \text{QEL}_{t-6} + 0.06 \text{NA}_{t-5} \]
\[ (2.28) \quad (6.49) \]

(4)

where all variables are in logs and

\[ B_{At} = \text{bearing acreage of California-Arizona lemons (acres)} \]
\[ \text{TRL}_{t-7} = \text{3-year moving average of real total revenue per acre of California-Arizona lemons at farm-level prices ($/acre).} \]
\[ \text{TRO}_{t-7} = \text{3-year moving average of real total revenue per acre of California-Arizona oranges at farm-level prices ($/acre).} \]
\[ \text{QEL}_{t-6} = \text{2-year moving average of total fresh exports of California-Arizona lemons (1000's of cartons)} \]
\[ \text{NA}_{t-5} = \text{nonbearing acres of California-Arizona lemons (acres)} \]
\[ t-k = \text{a lag of } k \text{ years} \]

Figures in parentheses are the t-statistics.

Data are for the period 1953-54 through 1977-78. However, because of the lags and moving averages, \( n = 17 \). Real revenues were determined by adjusting current prices with the GNP implicit price deflator.

The \( R^2 \), corrected for the log form of the dependent variable, is 0.994, and the standard error of the estimate, also corrected, is 767. The revenue variable for lemons (\( \text{TRL}_{t-7} \)) has the expected sign and is significant at a 90% level of confidence (one-tailed t-test). The remaining variables have the expected signs and are significant at a 97.5% level of confidence. The Durbin-Watson statistic does not indicate problems of multicollinearity.
inclusion of revenue and nonbearing acreage as independent variables is consistent with economic theory and the nature of citrus production. The use of fresh exports as an independent variable was based on the special role of exports in influencing producer decisions, especially in the past 15 years.

The lack of appropriate data on technology (T) and the age distribution of lemon trees (A) necessitated the introduction of a trend variable (TD) in the estimated yield equation. The coefficient of TD thus reflects the net effects of technology and age distribution as well as other unspecified variables. The trend variable presents obvious deficiencies in explaining changes in structure.

The estimated yield equation is:

\[ Y_t = 523 + 54.9 \text{TD} - 113 \text{W}_t \]

(3.52) (-4.33) (5)

where

\( Y_t \) = average yield in season \( t \) (cartons/acre)

TD = trend in log form

\( W_t \) = dummy variable with adverse weather conditions = 1 and non-adverse conditions = 0.

Figures in parentheses are the \( t \)-statistics. Data are for the period 1953-54 through 1977-78, thus \( n = 24 \).

The coefficients of TD and \( W \) are significant at the 99\% level. The \( R^2 \) for Equation 5 is 0.54. Part of the reason for the low \( R^2 \) is that the effects of exceptionally good weather conditions
are not captured. Neither is it possible to differentiate between more and less severe seasons. However, for the purposes of projection the degree to which yearly fluctuations are explained is not as important as an accurate representation of the trend in yield.

Historical estimates of production were derived from the identity

$$\hat{Q}_t = \hat{BA}_t \cdot \hat{Y}_t$$

where $\hat{BA}_t$ and $\hat{Y}_t$ were obtained from Equations 4 and 5. A regression was run with reported (actual) production as the dependent variable and estimated production ($\hat{Q}_t$) as the independent variable. Seventy-seven percent of the variation in actual output was explained by the estimated production.

**Projections**

Since all the independent variables in Equation 4 are lagged at least five years, it was possible to project bearing acreage for five years using available data. Trends in yield were estimated with Equation 5, assuming non-adverse weather conditions (i.e., $W_t = 0$). Production was forecast using the above identity. The results are shown in Table 1. The downward trends in acreage and production reflect poor returns for lemons in the mid-1970's. The decrease in bearing acreage, which started in 1978-79, reverses a ten year period of steady expansion in the California-Arizona lemon industry. The model did an excellent job in tracking previous changes in bearing
Table 1.

Projections of Bearing Acreage, Yield, and Production of California-Arizona Lemons, 1978-79 through 1982-83

<table>
<thead>
<tr>
<th>Season</th>
<th>Bearing Acreage (acres) (1)</th>
<th>Yield (1000 ctns./acre) (2)</th>
<th>Production (1000 cartons) (1) x (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978-79</td>
<td>76,001</td>
<td>0.702</td>
<td>53,353</td>
</tr>
<tr>
<td>1979-80</td>
<td>75,531</td>
<td>0.704</td>
<td>53,174</td>
</tr>
<tr>
<td>1980-81</td>
<td>72,853</td>
<td>0.706</td>
<td>51,434</td>
</tr>
<tr>
<td>1981-82</td>
<td>71,582</td>
<td>0.708</td>
<td>50,680</td>
</tr>
<tr>
<td>1982-83</td>
<td>68,180</td>
<td>0.710</td>
<td>48,408</td>
</tr>
</tbody>
</table>

Source: Ribyat, p. 72
acreage, including a major turning point in 1967-68, and it appears to have been successful in predicting the more recent turning point (Figure 1).

**Comparison with CACL Projections**

The California-Arizona Citrus League (CACL) sponsors a yearly meeting to make acreage and production projections for the season five years in the future. Projections are made on the basis of judgement and consensus of individuals familiar with the industry. In addition to lemons, projections are made for navel and valencia oranges, winter and summer grapefruit, and tangerine types. CACL projections were first made in 1971 for the 1976-77 season, and were based on data through the 1970-71 season (CACL).

Table 2 lists the CACL lemon projections for the seasons 1976-77 through 1982-83 and the projections made from the model developed in this paper. In order for comparisons to be valid, the model projections were based on a data base similar to what was available at the time CACL made its projections. Thus, to make projections for the 1976-77 season, Equations 4 and 5 were reestimated with data through the 1970-71 season. Subsequent projections were made by expanding the data base by one year and rerunning the equations.

The model and CACL projections are compared with actual acreage and production through 1978-79, the most recent season.

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1/ In recent years, three levels of production (high, low, and mid) are projected by CACL. Comparisons of production in Table 2 are based on the "mid" level projections.
Figure 1. Estimated and Actual Bearing Acreage of California-Arizona Lemons, 1962-63 through 1982-83.
Table 2.
Comparison of 5-Year Lemon Projections by the Model and CACL with Actuals, 1976-77 through 1982-83

<table>
<thead>
<tr>
<th>Season</th>
<th>Years of Data Base for Projections</th>
<th>Bearing Acreage (acres)</th>
<th>Model Projections</th>
<th>CACL Projections</th>
<th>Actual</th>
<th>Production (1000 ctns.)</th>
<th>Model</th>
<th>CACL</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model Projections</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976-77</td>
<td>1954-1971</td>
<td>78,905</td>
<td>(9.1)</td>
<td>71,000</td>
<td>72,307</td>
<td>680</td>
<td>53,655</td>
<td>43,000</td>
<td>51,091</td>
</tr>
<tr>
<td>1977-78</td>
<td>1954-1972</td>
<td>74,124</td>
<td>(1.2)</td>
<td>83,500</td>
<td>73,258</td>
<td>691</td>
<td>51,220</td>
<td>53,500</td>
<td>52,078</td>
</tr>
<tr>
<td>1978-79</td>
<td>1954-1973</td>
<td>75,986</td>
<td>(-0.6)</td>
<td>87,500</td>
<td>76,423</td>
<td>689</td>
<td>52,354</td>
<td>47,000</td>
<td>39,112</td>
</tr>
<tr>
<td>1979-80</td>
<td>1954-1974</td>
<td>75,986</td>
<td>(-0.1)</td>
<td>87,500</td>
<td>75,937</td>
<td>714</td>
<td>54,254</td>
<td>53,250</td>
<td>41,442</td>
</tr>
<tr>
<td>1980-81</td>
<td>1954-1975</td>
<td>72,962</td>
<td></td>
<td>82,000</td>
<td>n.a.</td>
<td>709</td>
<td>51,730</td>
<td>52,000</td>
<td>n.a.</td>
</tr>
<tr>
<td>1982-83</td>
<td>1954-1977</td>
<td>68,180</td>
<td></td>
<td>70,000</td>
<td>n.a.</td>
<td>710</td>
<td>48,408</td>
<td>45,900</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

a/ Values in parentheses are percentage errors from actual values.

b/ n.a. denotes data not available.

c/ 1979-80 figure for actual production is an estimate by the Lemon Administrative Committee.

Source: Ribiyan, p. 77
for which data are available. Except for the 1976-77 season, the model projections of acreage are quite close to the actual figures. The mean absolute percentage error for the four seasons 1976-77 through 1979-80 is 2.8 for the model projections of acreage and 8.2 for the CACL projections. Based on these results, the model clearly outperforms the more informal method used by CACL.

As expected, neither approach yielded consistently good projections of production. The short crops in 1978-79 and 1979-80 resulted in large projection errors. Overall the model and the CACL projections of production had similar mean absolute errors: 17.8% for the model and 16.8% for CACL.

**Conclusions**

The objectives of this paper are modest in comparison with the longer run projections of French and Bressler in their study of the lemon cycle. However, experience has shown that longer projections, even for perennial crops, can be subject to very large errors, due primarily to unforeseen structural changes in the market. The opening of the Japanese market to lemon imports shortly after French and Bressler published their study, essentially reversed most of their projections (Heimpel). Limiting the projection period to five years should result in more accurate forecasts and at the same time provide useful information to planners and decision makers in the citrus industry.
However, much work remains to be done. For the lemon model, improvements in the yield equation would result in more accurate projections of production and allow for reasonable estimates of upper and lower bounds associated with variations in weather. For the purposes of CACL, similar models need to be developed for the other citrus types: navel and valencia oranges, summer and winter grapefruit, and tangerines. Furthermore, CACL makes projections for three producing districts within California and Arizona. Consequently, until more econometric work is completed, the lemon model presented in this paper represents only the beginning of what could be a major projections system for the California-Arizona citrus industry.

References


