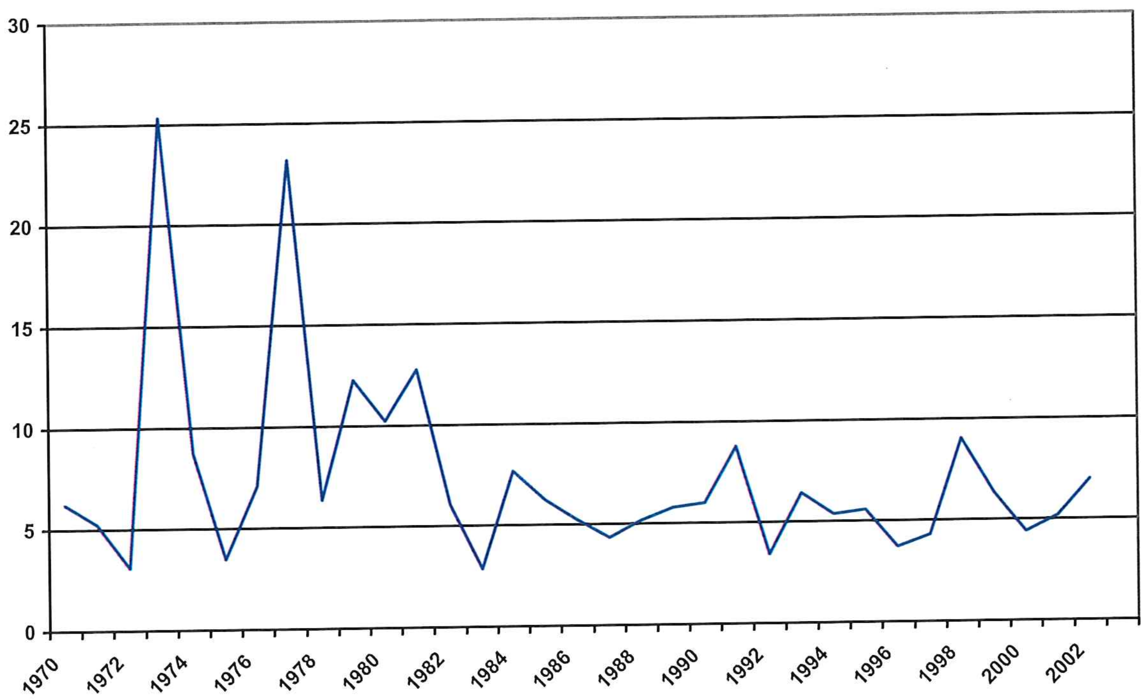

Figure 9A: Standard Deviation of Monthly Alfalfa Price (Real dollars per month, base 1983/4).

Cotton

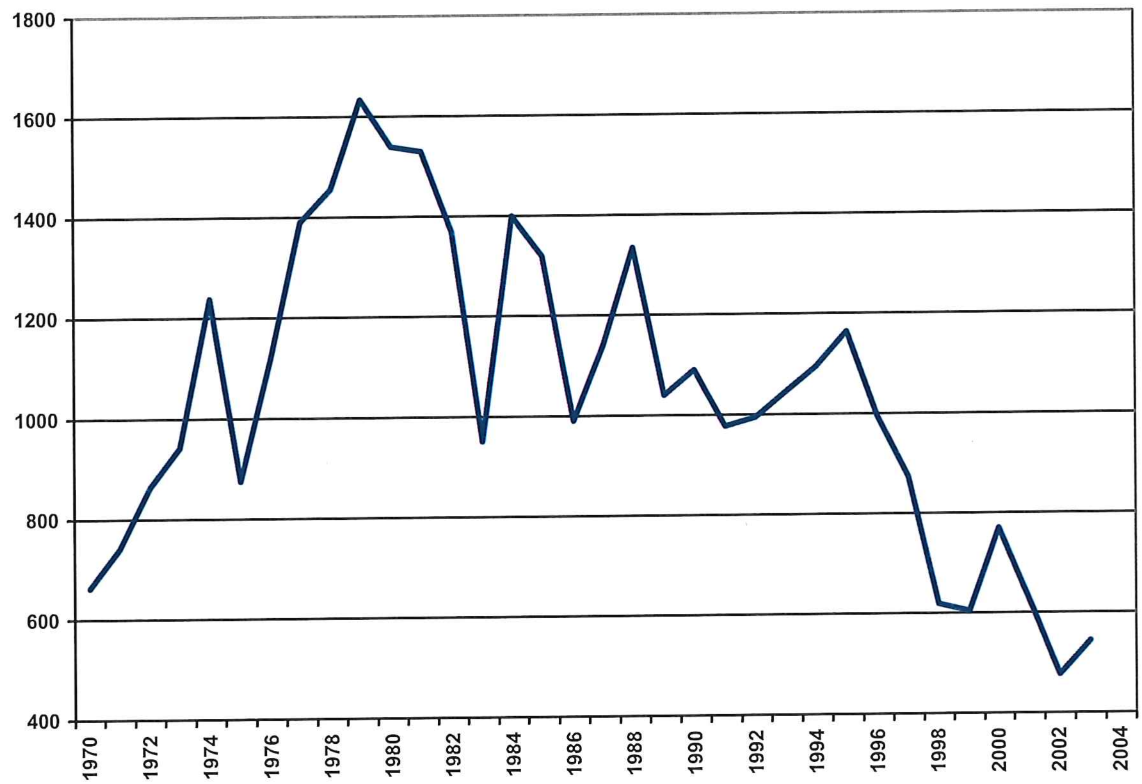

Figure 10A: Cotton Acreage in California (acres/ in thousands).

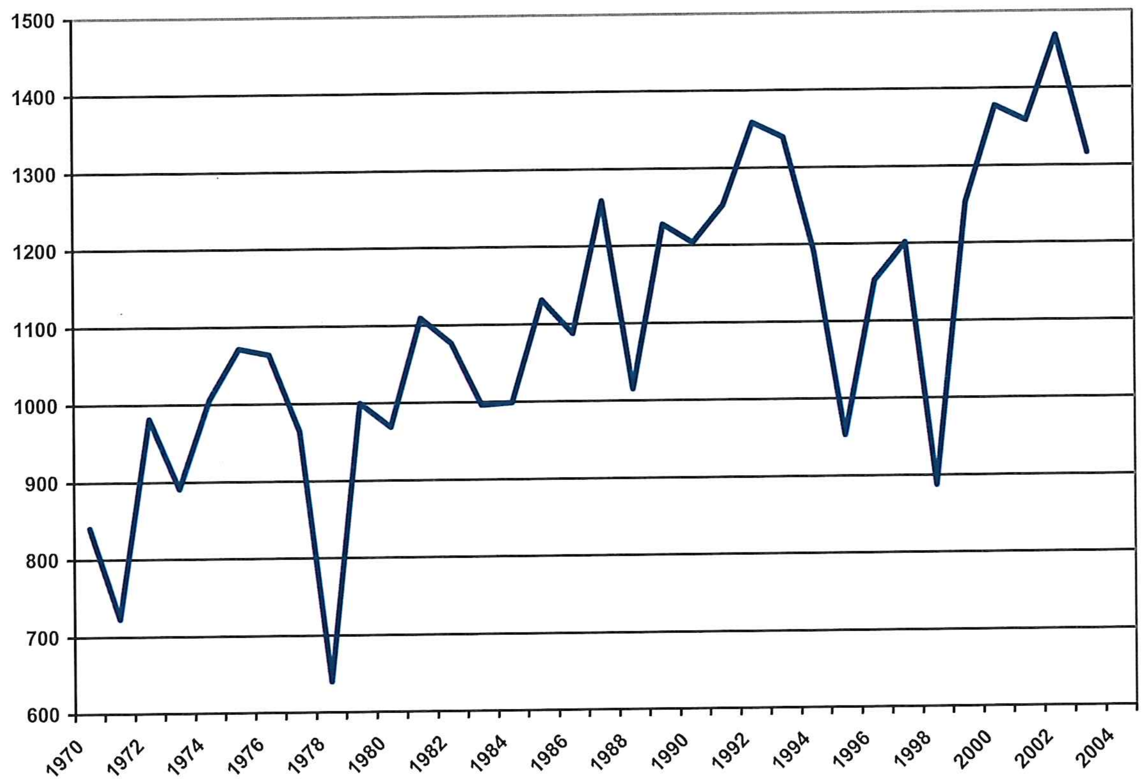

Figure 11A: Cotton Yield in California (pounds).

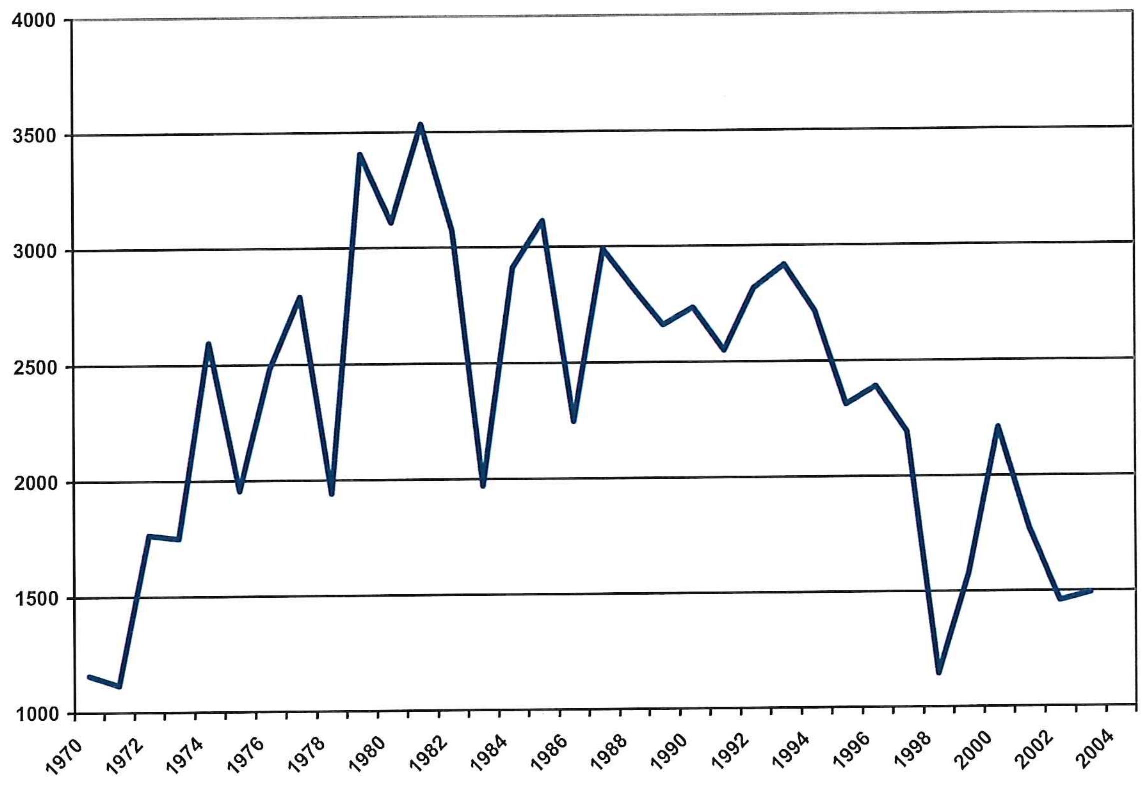

Figure 12A: Cotton Production in California (1000 bales).

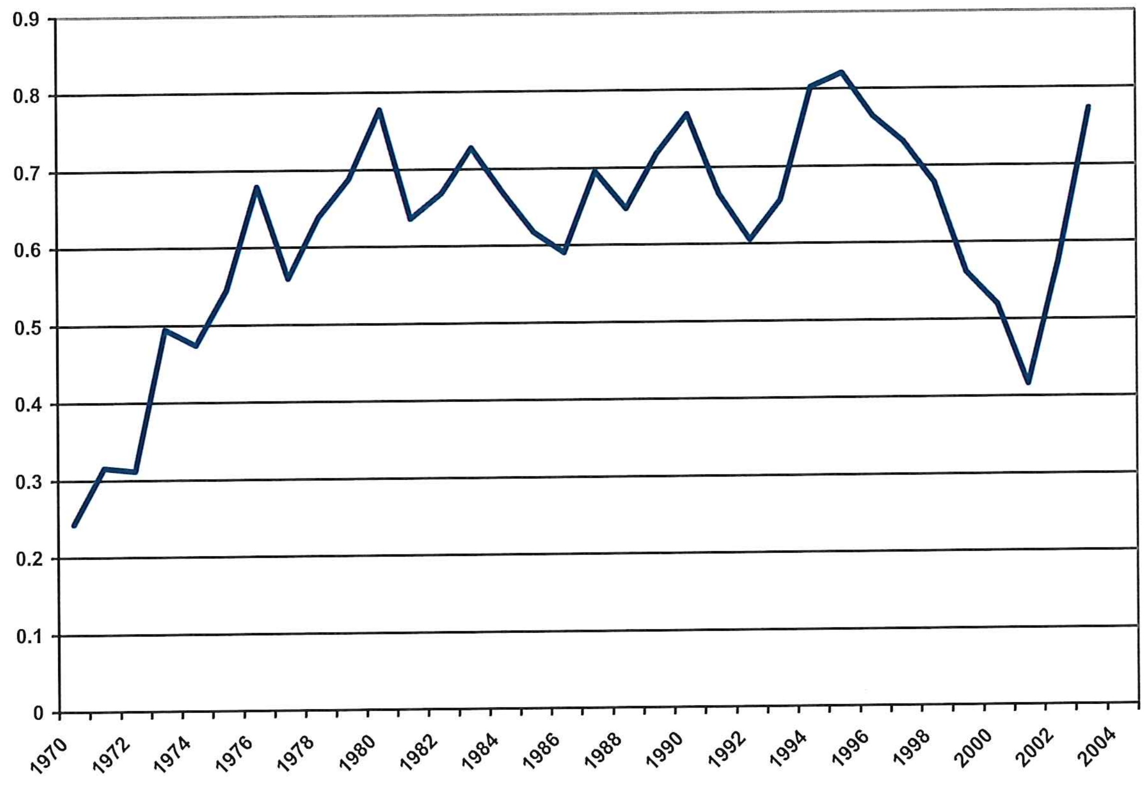

Figure 13A: Nominal Producers' Price in California for Cotton ($/lb).

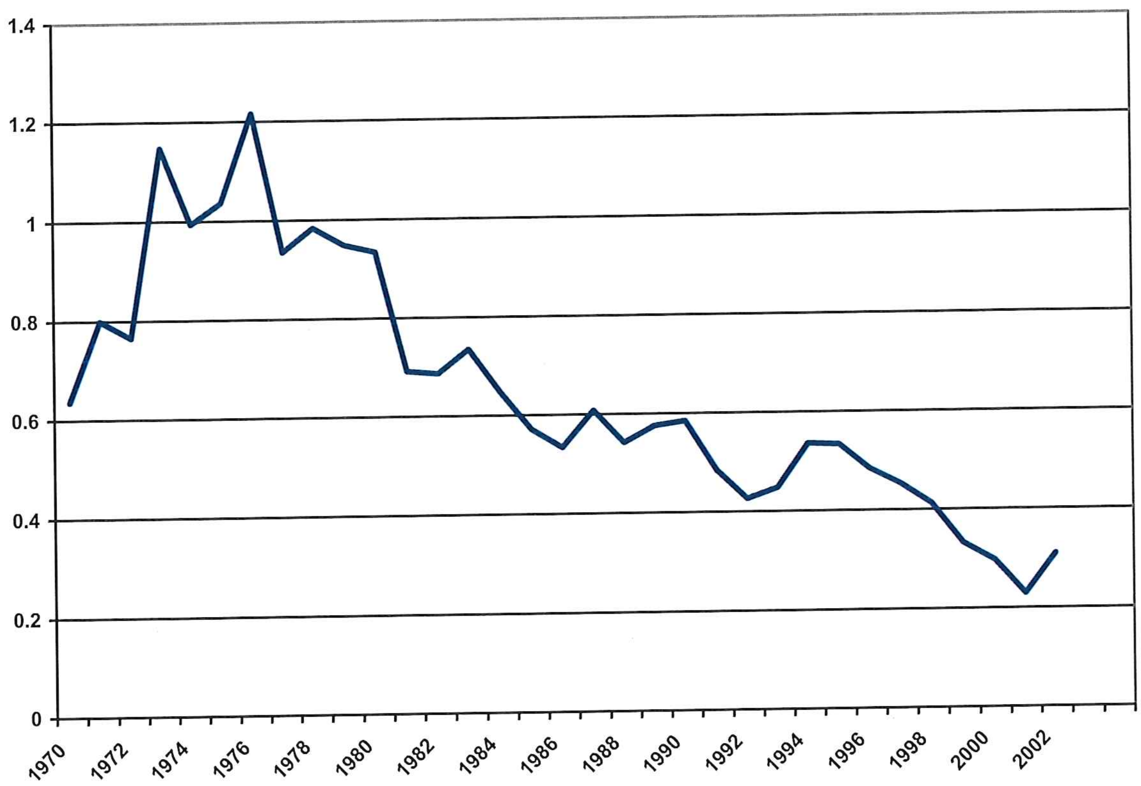

Figure 14A: Real Producers' Price in California for Cotton ($/lb).

RICE

National vs. State Model

California is one of the major producers of rice in the US. The other most important states are Arkansas, Louisiana, Mississippi, Missouri and Texas. The market in California appears to be fully integrated with the southern states, as suggested by an empirical check of the law of one price. This conclusion is hardly surprising, given that rice is a storable and easily transportable commodity. Figure 1 illustrates the law of one price between California and Arkansas.

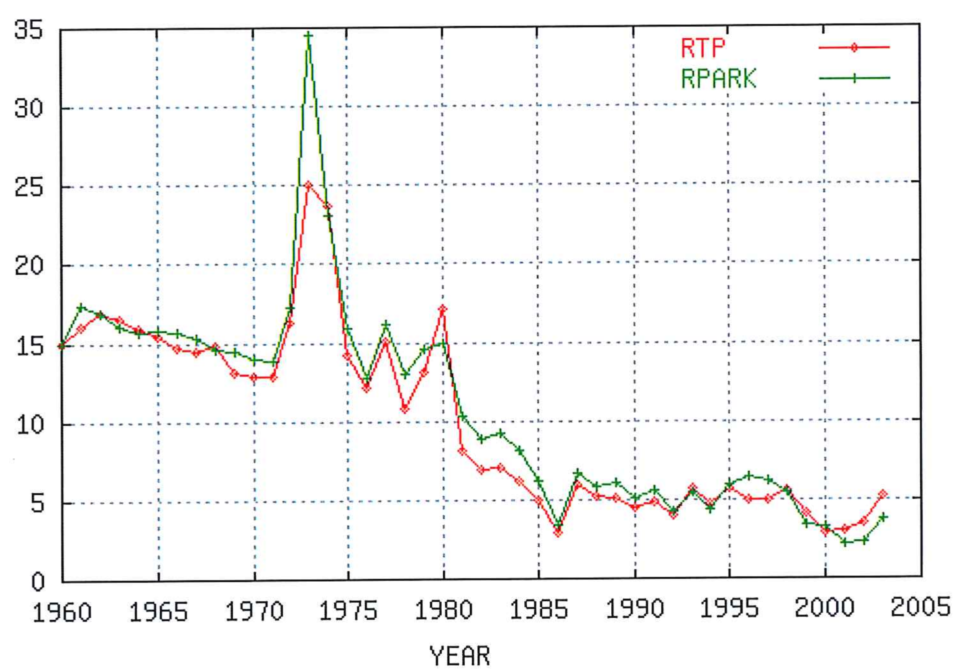

Figure 1: ***Rice grower price (real) in California (RTP) and Arkansas (RPARK)***

(in real dollars per cwt.)

A simple ordinary least squares regression of California rice price on Arkansas price gives an R^2 of 0.939 and an estimated slope coefficient between 0.80 and 0.94 (with a 95% confidence level). Moreover, a simple cointegration test suggests the absence of unit roots in the disturbances. Thus, California price and Arkansas rice prices move together over the long run. Market integration suggests that a US level model can be useful to describe California rice production. In this study, however, we present both national and state models.

The US Market

We estimated two models for the US rice industry. The first one is based on a longer time series, but does not account for policy distortions or trade. The second model considers the influence of policy and trade but data limitations constrain the length of the available time series.

A simplified model

A simplified production model is

$$\ln Q_t = \beta_0 + \beta_1 \ln P_{t-1} + \beta_2 \ln P_{t-2} + \beta_3 t + \beta_4 \ln Q_{t-1} + \beta_5 D_t + \varepsilon_t \quad (1)$$

where Q is the quantity of rice production in tons, P_t is rice price per ton , t is a time trend and D is a binary variable identifying the years 1977 and 1983 (outliers).

Prior to reporting the estimated production function for rice, a brief discussion of some aberrations of the rice market will be explained. Around 1976-77 there was a price collapse that caused producers to rotate to other crops or not plant rice at all. This lead to decreases in rice production. In the early eighties rice prices collapsed again and this caused many growers to forfeit their crop to the government because the price was below the value of the government loan. This was not only the case with rice, but other program crops such as wheat and corn. In an attempt to reduce acreage and sell off the rice that the government had claimed, the government implemented the 50/92 plan. Subsides were directly linked to production. Thus, if a grower did not produce he was not paid. The 50/92 program allowed the grower to produce on 50% of his acreage and receive 92% of the subsidies that he would receive if he had produced on 100% of his land. This reduced production allowed the government to reduce the stocks of commodities that they had to claim in 1981-82. The 50/92 program ran until about 1988. Since then subsidies have been decoupled from production to prevent problems like this from happening again. The 50/92 program was popular in the south, especially in Texas where their production was lower and they had low fixed costs of land, but in California it was only widely used for a few years. Policy variables are incorporated into some of the models below.

The estimated partial adjustment production model for rice, for the time period 1972-2004, is:

$$\ln \hat{Q}_t = \underset{(0.68)}{2.32} + \underset{(0.07)}{0.23} \ln P_{t-1} - \underset{(0.08)}{0.07} \ln P_{t-2} + \underset{(0.00)}{0.02} t + \underset{(0.16)}{0.41} \ln Q_{t-1} - \underset{(0.07)}{0.26} D_t \qquad (2)$$

with $R^2 = 0.896$ and $n = 33$. The Durbin h test did not indicate problems with autocorrelation. The coefficient on lagged production is positive and significant. This indicates that there is some adjustment each year in the production of rice. By removing the lags, i.e., by assuming $Q_t = Q_{t-1}$, the long-run price elasticity of production is 0.27 which is inelastic and significant, but indicates that rice producers do respond to price changes. The estimated coefficient on the time trend variable is 0.02 and significant indicating a positive trend over time. The estimated coefficient on the dummy variable is negative (coefficient = -0.26) and significant for the outlier years as expected.

Figure 2 describes the fit of the regression (in logarithmic scale--the original series is in 000 cwt).

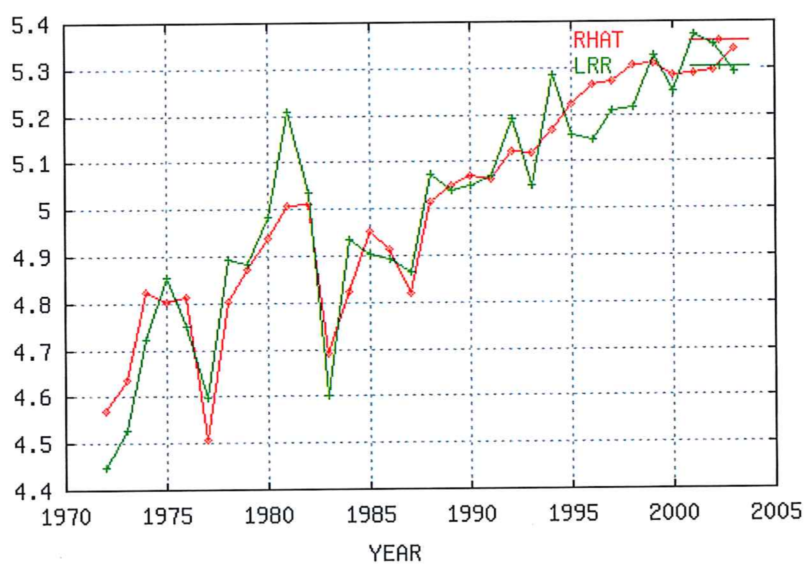

Figure 2: ***US rice production actual (LRR) and estimated (RHAT)***

(logarithmic scale)

Domestic Demand for Rice

The US domestic demand equation for rice is:

$$\ln PC_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln PCINC_t + \beta_3 \ln CPI_t + \varepsilon_t \quad (3)$$

where PC represents domestic consumption in pounds per capita, P denotes rice price per cwt, $PCINC$ represents per capita income in dollars per capita, and CPI is the consumer price index.

The estimated domestic demand function for rice, corrected for first-order autocorrelation, is:

$$\underset{(1.16)}{\ln \hat{PC}_t = -4.51} - \underset{(0.05)}{0.08 \ln P_t} + \underset{(0.25)}{0.74 \ln PCINC_t} - \underset{(0.29)}{1.47 \ln CPI_t} \quad (4)$$

with $R^2 = 0.93$ and n = 34. The results of the simple model suggest that rice consumption is price inelastic (estimated own-price elasticity of -0.08), however, it is not significantly different from zero (p-value = 0.09). Domestic consumption of rice is positively related to income with a statistically significant (p-value = 0.0000) estimated income elasticity of 1.56. The estimated autocorrelation coefficient was 0.57 with an asymptotic t-ratio of 4.07 and after the correlation the Durbin-Watson statistic did not indicate any problems with autocorrelation.

The single equation estimates may be inefficient, given that errors may be correlated across equations. To overcome this problem we estimated a seemingly unrelated regression (SUR) production-consumption system for rice based on the simplified model specification. The results are:

$$\underset{(0.07)}{\ln \hat{Q}_t = 11.21} + \underset{(0.03)}{0.14 \ln EP_t} + \underset{(0.002)}{0.02t} - \underset{(0.07)}{0.19 D_t} \quad \text{(production equation)} \quad (5)$$

$$\underset{(2.85)}{\ln \hat{PC}_t = 1.15} - \underset{(0.05)}{0.03 \ln P_t} + \underset{(0.61)}{0.36 \ln PCINC_t} - \underset{(0.61)}{0.32 CPI_t} + \underset{(0.002)}{0.02t} \quad \text{(demand equation)}$$

(6)

where EP represents the expected price of rice (price lagged one time period). The individual equation R^2s are high (0.93 and 0.89; respectively). The estimated own-price elasticity of production is

0.14 and but not significant. The own-price elasticity of demand for rice is -0.03, but it is not significant either. The income elasticity of demand for domestic rice is 0.36 and is also not significant. The explanatory variables were highly collinear which accounts for some of the estimated coefficients being insignificant.

An Alternative Model

An alternative model considers policy and exports. However, due to the short time series (1986-2003), the model must be parsimonious. For a comprehensive and disaggregated treatment of the influence of commodity programs on the rice acreage response to market prices, see McDonald and Sumner.[1]

The least squares estimated production equation is:

$$\ln \hat{Q}_t = \underset{(0.236)}{10.843} + \underset{(0.067)}{0.176} \ln P_{t-1} + \underset{(0.001)}{0.003} PSE_t + \underset{(0.033)}{0.034} t \tag{7}$$

with $R^2 = 0.87$ and $n = 18$. The policy variable, PSE_t, is the OECD percentage producer support estimate for the U.S. that is a comprehensive or aggregate measure of total policy support. The other explanatory variables are as defined above. The estimated policy coefficient is positive with a value of 0.003 and almost significant (p-value = 0.079). The estimated expected price elasticity of production is 0.176 and is significant (p-value = 0.02). The estimated coefficient on the time trend indicates that production has been increasing over time.

Overall the results suggest that public support has a significant and positive effect on production. The fit of the regression is depicted in Figure 3.

---

[1] McDonald and Sumner incorporate detailed rice commodity programs into their approach. Their approach is based on an econometric estimation of a marginal cost curve, some assumptions about the distribution of parameters of their cost function combined with a simulation methodology. Their main policy results indicate that models that do not take into account all the programs' rules produce smaller structural parameters. They cite previous studies that find the acreage elasticites for rice vary from 0.09 to 0.34 which their results indicate are too small.

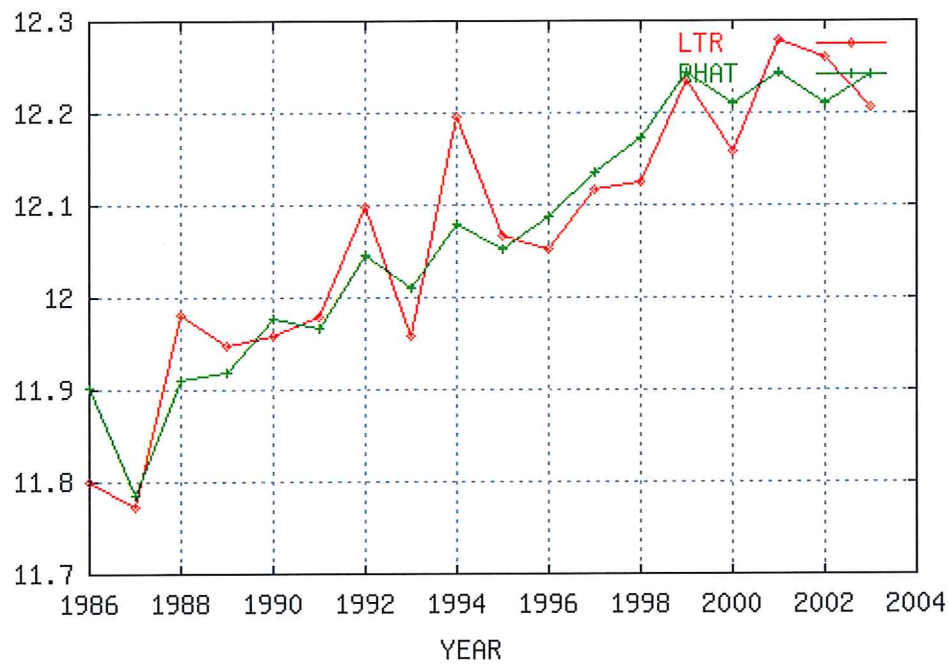

Figure 3: ***US rice production actual (LTR) and estimated (RHAT)***

(in billions of lbs)

Export Demand for Rice

The estimated export equation for rice is:

$$\ln \hat{EX}_t = 31.81 - 0.49 \ln P_{us,t} + 0.91 \ln P_{Thai,t} - 1.99 \ln Inc_{Japan,t} + 0.04t \quad (8)$$
$$(6.52)(0.19) \qquad (0.31) \qquad (0.62) \qquad (0.01)$$

with $R^2 = 0.78$, n = 18, and where EX_t represents US exports of rice in 000 cwt, P_{US} represents the grower price for US rice in \$/cwt, P_{Thai} denotes the price for rice in Thailand (the major competitor in the world market) and Inc_{Japan} represents per capita income in Japan (the major importer of US rice). The estimated results indicate that US exports decrease with US price increases (US price elasticity of exports is -0.49), increase with increases in Thailand rice prices, and have been increasing over time, conditioned on the other variables. The negative sign on per capita income in Japan was not expected.

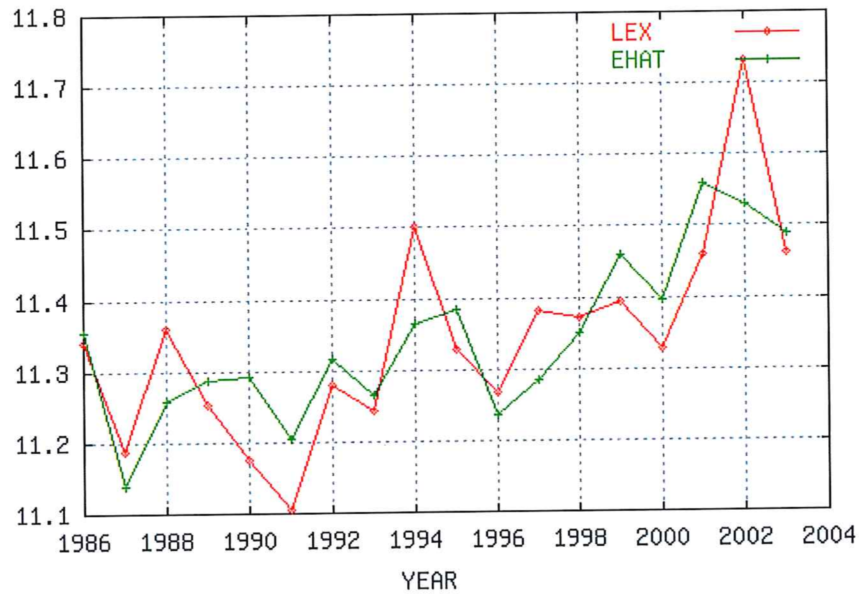

Figure 4: ***US rice export actual (LEX) and estimated (EHAT)***

In order to account for price endogeneity, correlated errors across equations, and to obtain more efficient estimates, we estimated a system of two equations for US rice, under the market clearing assumption. Lagged price was used as the instrumental variable for current price to account for endogeneity of prices. The system was estimated by iterative three stage least squares (3SLS). The estimators have the same asymptotic properties as maximum likelihood estimators. That is, they are consistent, asymptotically normally distributed and efficient. Iterative 3SLS converge to the same value as MLE, but are not equivalent because of a Jacobian term in the likelihood function. The first equation is a production function and the second equation is a demand function. The system results are:

$$\ln \hat{Q}_t = \underset{(1.74)}{8.92} + \underset{(0.39)}{0.45} \ln P_{US,t} + \underset{(0.14)}{0.27} \ln P_{Thai,t} + \underset{(0.01)}{0.01} PSE_t + \underset{(0.02)}{0.06} t \qquad (9)$$

$$\ln \hat{Q}_t = \underset{(3.77)}{2.68} - \underset{(0.17)}{0.36} \ln P_{US,t} + \underset{(0.25)}{0.39} \ln P_{Thai,t} + \underset{(0.21)}{0.33} Inc_t + \underset{(0.49)}{0.34} Inc_{Japan,t} \qquad (10)$$

The fit of the system is depicted graphically in Figure 5 (the R^2 for the first equation is 0.718 and for the second is 0.888).

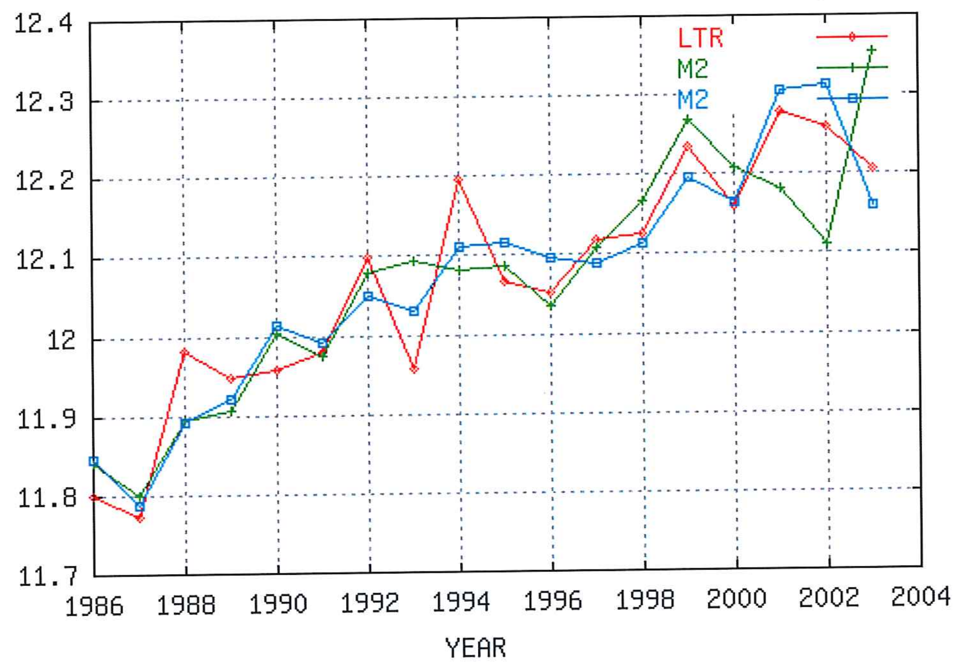

Figure 5: ***Estimation of supply and demand for US rice, under market equilibrium assumption***

The estimated US price expectation (the lag price) elasticity of supply is 0.45 which is also inelastic but is not significant. The estimated coefficient of Thailand price of rice is 0.27 with a t-ratio of about two. The index for price support is positive but not significant. There is also a positive (0.06) and significant time trend in the supply of rice. According to the estimated price coefficient (-0.36), the elasticity of demand of US rice implies that an increase of 1% in price results in a decrease of 0.36% change in the quantity demanded. As the price of Thailand rice increases, the demand for US rice increases, but again the estimated coefficient is not significant. The income elasticity is 0.33 and the estimated coefficient of Japanese income is 0.34 as expected. Both coefficients are not significant, however.

California Market

The estimated production function of California rice is:

$$\ln \hat{Q}_t = \underset{(0.72)}{7.56} + \underset{(0.16)}{0.48} \ln P_{t-1} + \underset{(0.05)}{0.11} Pay_t - \underset{(0.04)}{0.005} Loan_t + \underset{(0.01)}{0.04} t + \underset{(0.52)}{1.21} D_t - \underset{(0.48)}{1.23} D_t * Pay_t \quad (11)$$

with $R^2 = 0.816$, $n = 21$, and where Q denotes California production, P denotes grower price, Pay represents direct payments, $Loans$ are the interest rate on marketing loans and D is a dummy variable identifying the years 1996 and after to account for policy changes.

The estimated own-price elasticity is 0.48 (and significant) which is higher than the corresponding estimated value for US production. Producers respond positively to increases in direct payments and to policy changes occurring after 1996. There is also a positive time trend. Interest rates on marketing loans did not have a significant impact on California production. Figure 6 depicts the fit of the California production model.

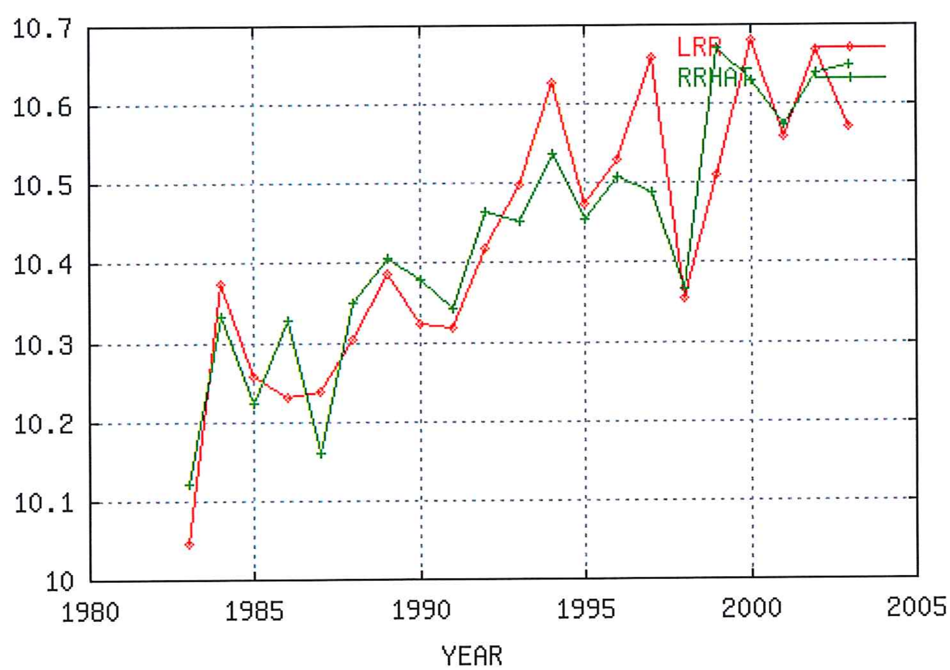

Figure 6: ***California rice production actual (LRR) and estimated (RRHAT)***

Conclusions

Rice producers in California and throughout the United States respond positively to increases in rice prices. The short-run price elasticity of production, based on a partial adjustment model, for the US was estimated to be 0.23. When policy variables were included in the production equation the price elasticity dropped to 0.18 (see eq. 7). Rice producers respond positively to support programs. The production equation was an aggregated one. For a disaggregated approach that estimates how rice producers respond to different support programs, see McDonald and Sumner.

The estimated own-price elasticity of demand for rice was found to be inelastic (-0.140) for a SUR system. The income elasticity for rice was estimated to be 0.74 in a single-equation demand function (eq. 4).

US rice producers export less when the US price increases (estimated elasticity =-0.49). They export more when the Thailand rice price increases (estimated Thailand price elasticity of 0.91) since Thailand is a major competitor in the world market.

References

McDonald, J. and D. Sumner, "The Influence of Commodity Programs on Acreage Response to Market Price: with an Illustration Concerning Rice Policy in the United States", *American Journal of Agricultural Economics*, 85(4): 2003: 857-871.

TOMATOES

Background

The United States is the world's second leading producer of tomatoes, after China. Fresh and processed tomatoes combined accounted for almost $2 billion in cash receipts during the early 2000s. Mexico and Canada are important suppliers of fresh market tomatoes to the United States and Canada is the leading importer of U.S. fresh and processed tomatoes.

The characteristics of tomato consumption are changing. Fresh tomatoes consumption increased by 15% between the early '90s and early 2000s, while the use of processed products declined 9%. Currently, the per capita consumption is 18 pounds per person of fresh tomatoes, and 68 pounds for processed tomatoes (fresh-weight basis).

The U.S. fresh and processing tomato industries consist of separate markets. According to ERS (website) four basic characteristics distinguish the two industries. Tomato varieties are bred specifically to serve the requirements of either the fresh or the processing markets. Processing requires varieties that contain a higher percentage of soluble solids (averaging 5-9 percent) to efficiently make tomato paste, for example.

- Most tomatoes grown for processing are produced under contract between growers and processing firms. Fresh tomatoes are largely produced and sold on the open market.
- Processing tomatoes are machine-harvested while all fresh-market tomatoes are hand-picked.
- Fresh-market tomato prices are higher and more variable than processing tomatoes due to larger production costs and greater market uncertainty

Policy

Tomato production is not covered by price or income support. However, tomato producers may benefit from general, non crop specific-programs such as federal crop insurance, disaster assistance, and western irrigation subsidies. The only federal marketing order in force for tomatoes covers the majority of fresh-market tomatoes produced in Florida between October and June.

With respect to imports, the United Stated negotiated a voluntary price restraint on fresh tomato imports from Mexico starting in 1996. Mexico agreed to set a floor price of $0.21 per pound of tomatoes exported to the United States The effect of the policy was to reduce Mexican exports to the U.S. and there were sizeable fresh tomato diversions (to other importing countries) and diversions into processing; see Baylis and Perloff for more details of this policy.

California Production

California is the second leading producer of fresh tomatoes in the US, after Florida. Figures 1-3 compares fresh tomatoes planted acreage, production and nominal price for US, Florida and California.

California accounts for about 95 percent of the area harvested for processing tomatoes in the United States—up from 79 percent in 1980 and 87 percent in 1990. The other major producers are Texas, Utah, Illinois, Virginia, and Delaware and Florida. In Figure 1, total U.S. fresh tomato acreage has declined over the period 1960 to 2002, but acreage in California and Florida has remained steady. The declined in acreage has come from the states of Texas, Utah, Illinois, Virginia, and Delaware (Lucier). Figures 4-6 illustrates the trends for California and US planted acreage, production and nominal prices for processed tomatoes.

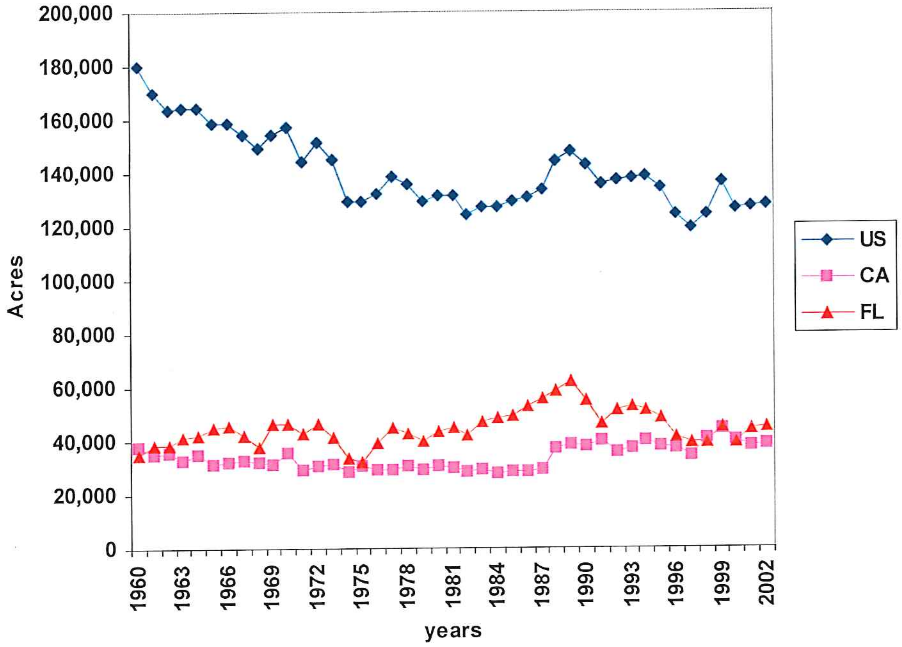

Figure 1: ***Fresh tomato acreage 1960-2002 – (source ERS)***

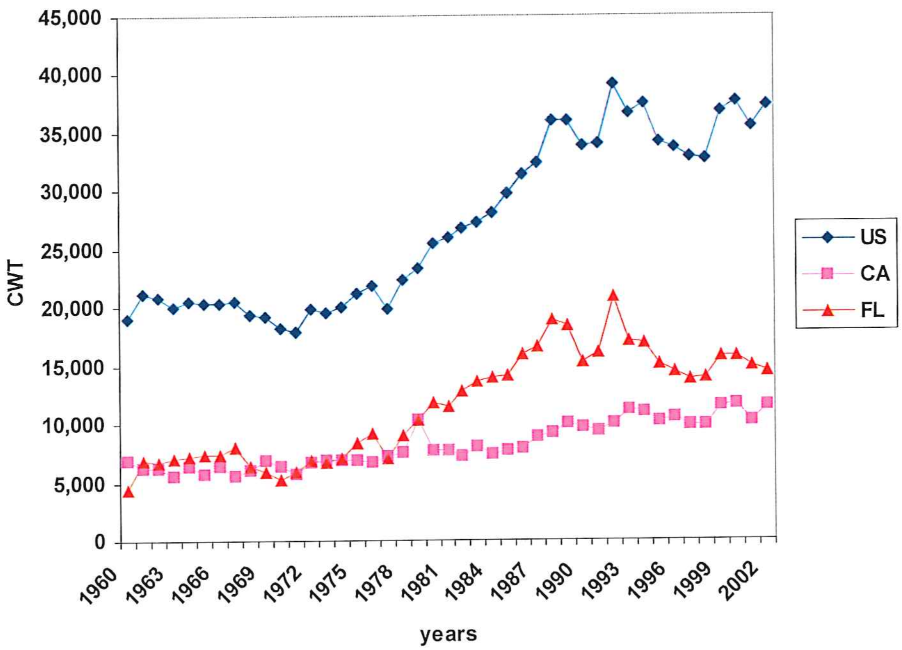

Figure 2: ***Fresh tomato production 1960-2002 – (source ERS)***

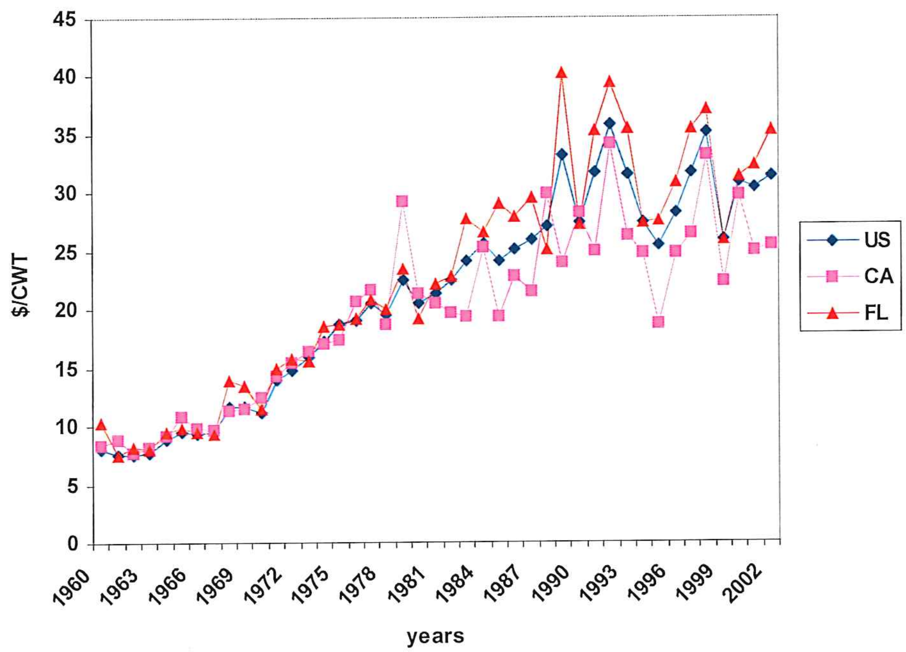

Figure 3a: ***Fresh tomato nominal prices 1960-2002 –(source ERS)***

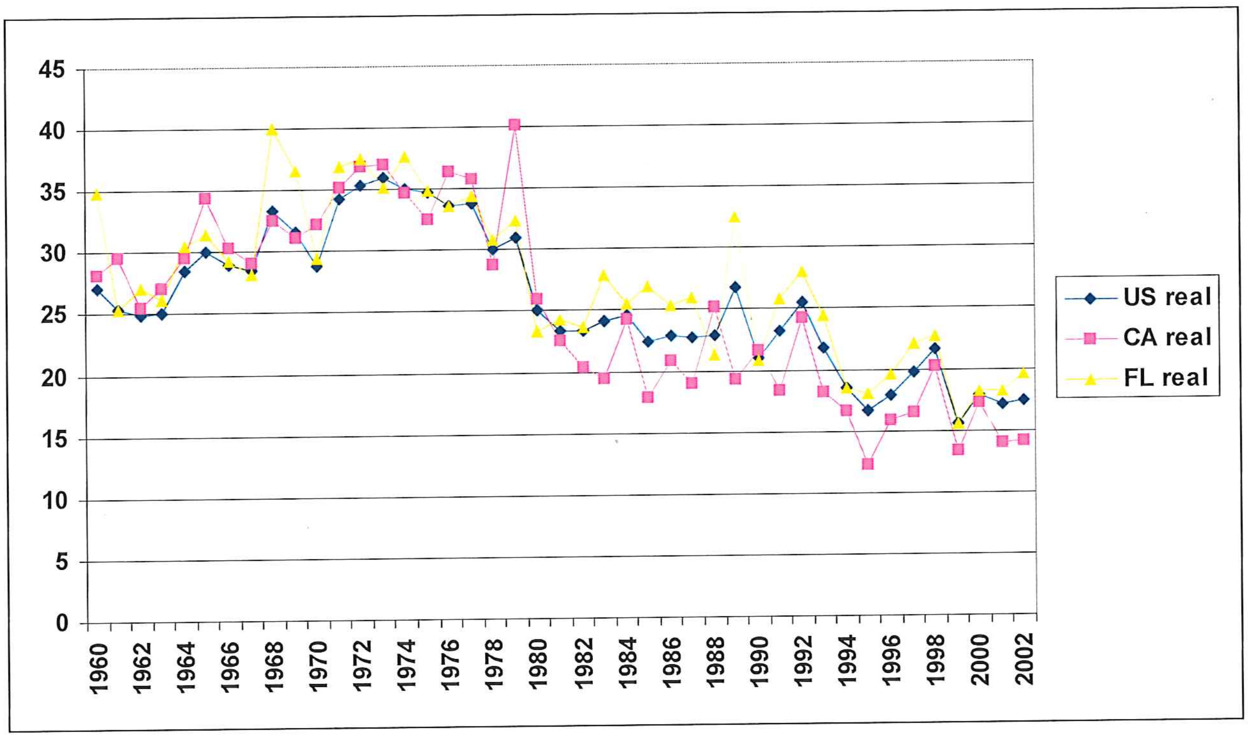

Figure 3b*: Fresh tomato real price 1960-2002 (base 1983-84)*

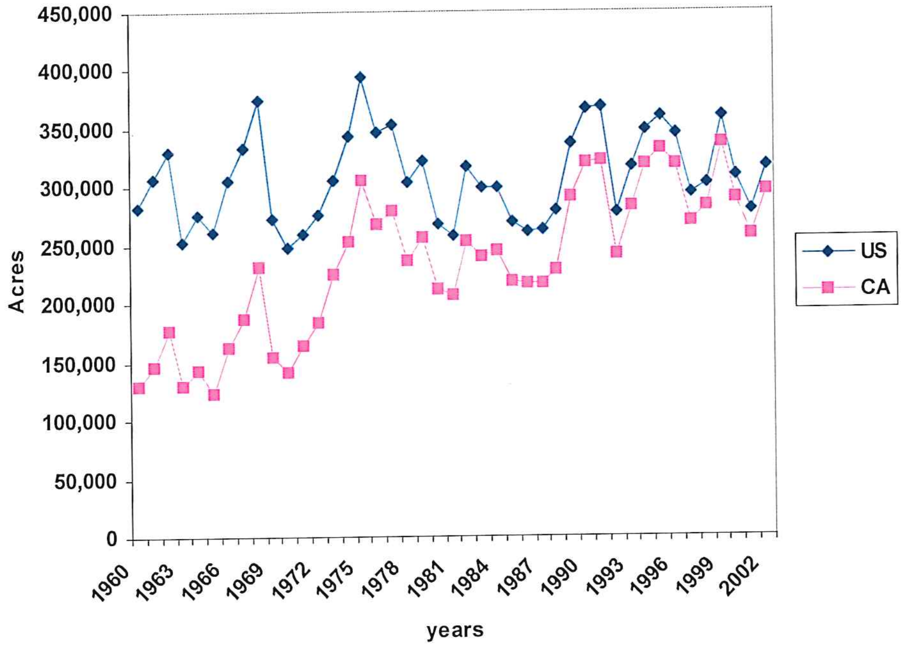

Figure 4: ***Processing tomato acreage 1960-2002 – (source ERS)***

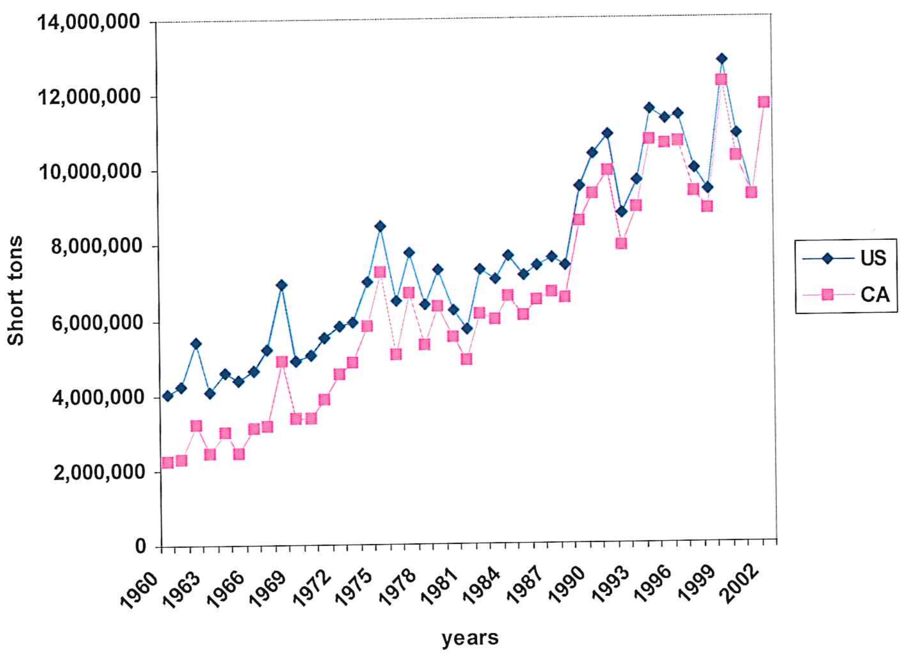

Figure 5: ***Processing tomato production 1960-2002 – (source ERS)***

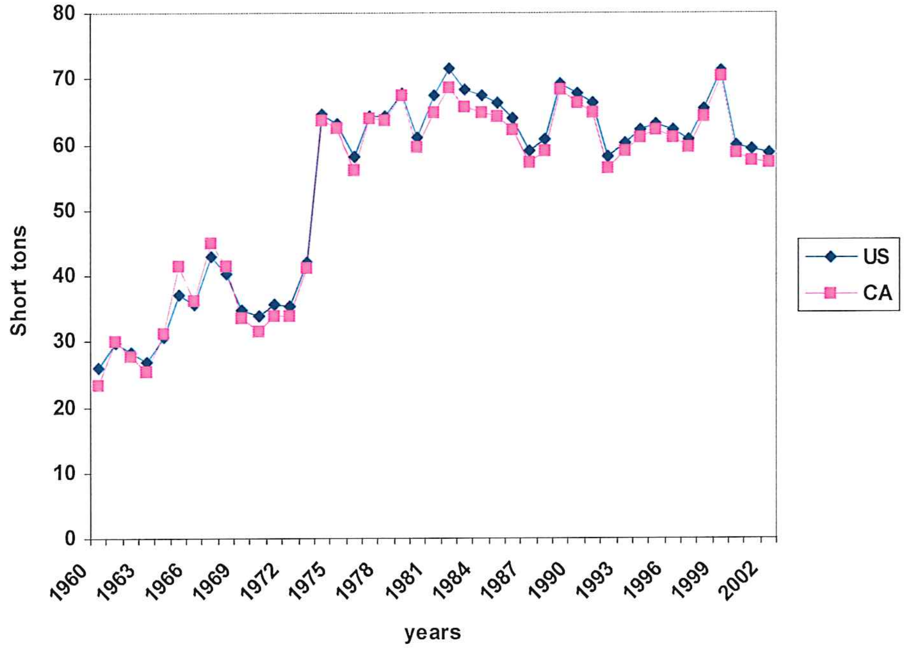

Figure 6: ***Processing tomato nominal prices 1960-2002 ($/ton) – (source ERS)***

Processing Tomatoes

Tomato growing is based on grower-processor contract agreements. The majority of production is traded this way with the spot market playing a marginal role. Most initial processing is by firms that manufacture tomato paste, a raw ingredient. Tomato paste is storable up to 18 months. Downstream firms transform the paste in final consumer products. According to the Food Institute, at the end of the process, raw material (tomatoes and fees) account for 39%-45% of total production cost.

According to the ERS, there was a radical structural change in the processing industry in the late 1980's and early 1990's. A period of relatively high prices in the late 1980s triggered new investments. This finally resulted in excess supply and decreasing prices. As a consequence, many processors went bankrupt and the whole industry was restructured. The current structure is the result of such adjustments.

Estimation

A brief industry description highlights two key points prior to the estimations.

Price expectations. The majority of production is sold under contract. This has two implications: i) producers know (with good approximation) prices when planning production, so we do not need to model expectations; rather we assume perfect information, ii) the actual contract price is unobservable, being industry private information. It is reasonable to assume that the spot market price is correlated with contract price according to the additive error formula:

spot price = contract price + error .

We use the spot price as a proxy for the real contract price. However, since the measurement error is likely to be correlated with the error terms in the production equations (for example in case of unexpected shortage, we expect higher spot prices) we use an instrumental variable (IV) approach. The instrument is the previous year's spot price, which is correlated with the current spot price, but uncorrelated with random shocks in current production.

Structural change. The industry underwent structural changes from the late '80s until the early '90s. Much of the change is likely due to continued expansion in food-service demand, especially for pizza, taco, and other Italian and Mexican foods (Lucier). Increased immigration and changes in America's tastes and preferences have contributed to rising per capita tomato use (Lucier, *et al).* Commercial varieties were developed to expedite packing, shipping, and retailing in the processing market. Mechanical harvesting and bulk handling systems replaced hand harvest of processing tomatoes in the California in the 1960's as the new varieties were introduced. Increases in yields are due to the development of higher yielding hybrid varieties and improved cultural practices such as increases in use of transplanting (Plummer). The hypothesis of structural change was tested on both the supply and demand side.

Acreage

The acreage equation is based on a partial adjustment model:

$$\ln A_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln A_{t-1} + \beta_3 t + \varepsilon_t \qquad (1)$$

where A_t represents acreage at time t in actual acres, P_t represents the spot price of processing tomatoes in \$/cwt, and t is a time trend.

The OLS estimated acreage function for the years 1960-2002 is:

$$\ln \hat{A}_t = \underset{(1.38)}{5.67} + \underset{(0.12)}{0.47} \ln P_t + \underset{(0.13)}{0.32} \ln A_{t-1} + \underset{(0.01)}{0.03} t \qquad (2)$$

with $R^2 = 0.815$, n = 42 and where the numbers in parentheses are standard errors.

The instrumental variable estimated acreage equation is:

$$\ln \hat{A}_t = \underset{(1.39)}{5.67} + \underset{(0.18)}{0.41} \ln P_t + \underset{(0.14)}{0.36} \ln A_{t-1} + \underset{(0.01)}{0.02} t \qquad (3)$$

with $R^2 = 0.814$ and n = 42.

Figures 7 and 8 compare the fits of the two regressions.

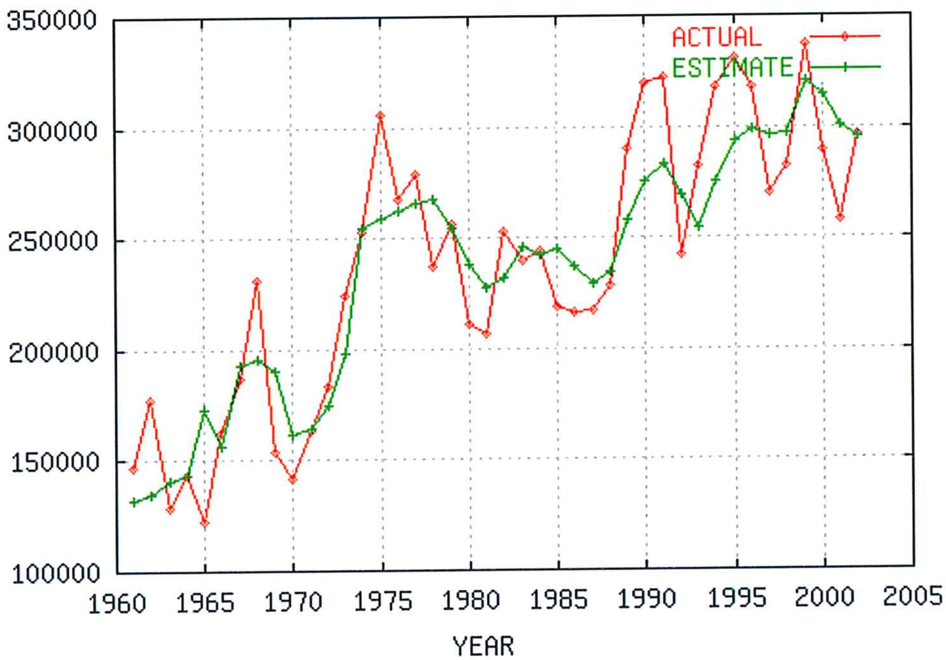

Figure 7: ***OLS estimation of processing tomato acreage (in acres).***

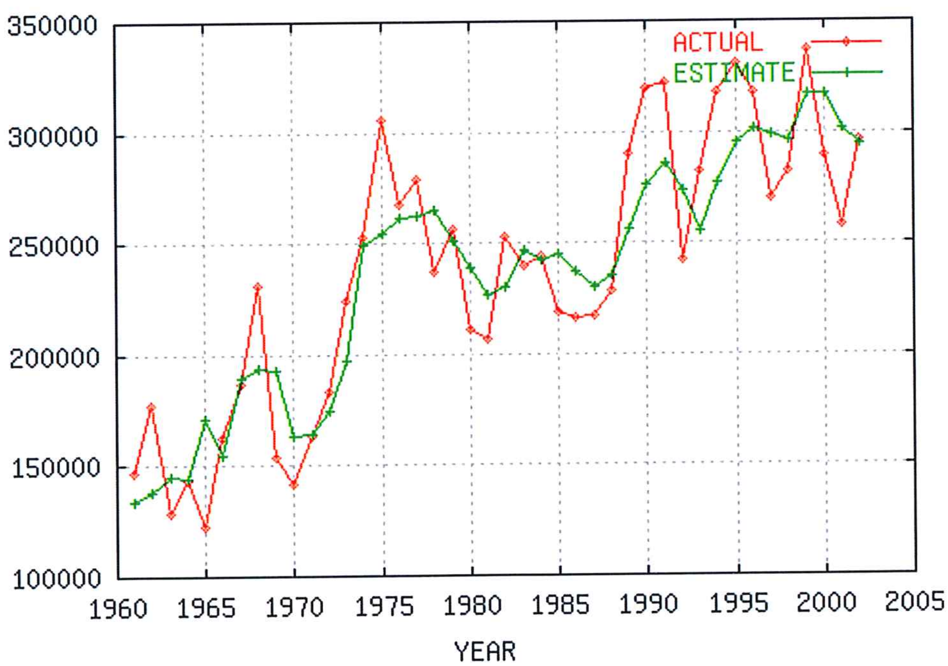

Figure 8: ***IV estimation of processing tomato acreage (in acres).***

The two estimation procedures –OLS and IV- give similar results. According to the partial adjustment model, the IV estimate of the short-run elasticity of acreage with respect to a change in price is 0.41 compared to the OLS estimate of 0.47. The estimate of the long-run price elasticity is 0.64. The coefficients on lagged acreage and the time trend are both positive. All the coefficients are statistically significant from zero.

Structural change

The Chow test confirmed the possibility of a structural break in the late '80s. The estimation of the model for the two periods (before and after 1988) gave the following results:

Dep. Variable: Tomato Acreage	Before 1988		After 1988	
Variable	estimate	std. dev.	estimate	std. dev.
Constant	5.62	1.73	2.20	3.21
Price	0.51	0.15	1.09	0.36
Lag Acreage	0.32	0.16	0.40	0.19
Time Trend	0.02	0.01	0.03	0.01

Table 1. Chow test results for processing tomato acreage function.

By observing the results prior to 1988 and past 1988, almost all of the coefficients are significantly different from zero. Most of the estimated coefficients differ little in magnitudes between the two periods. However, the short-run elasticity of acreage with respect to price is 0.51 before 1988 and 1.09 after 1988. Producers are much more responsive to prices after 1988 regarding their acreage. What explains this difference? Producers are, apparently, more responsive to price changes with the increased use of contracts and other structural changes mentioned above.

Figure 9 depicts the fit of the estimated structural-break model.

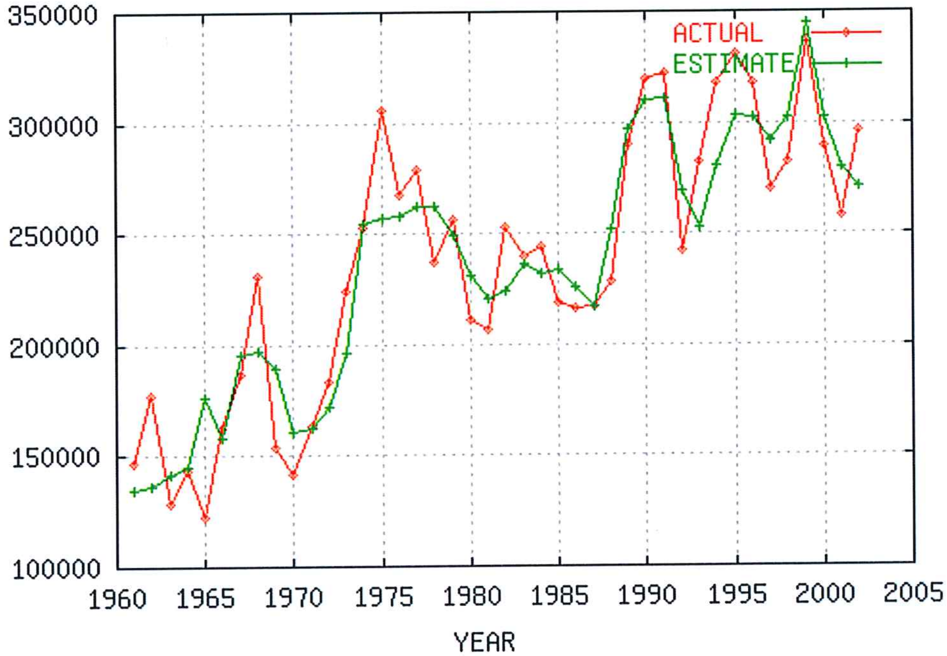

Figure 9: ***Structural break model for processing tomato acreage (in acres)***

Production

The partial adjustment model for processed tomato production is

$$\ln Q_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Q_{t-1} + \beta_3 t + \varepsilon_t \tag{4}$$

where Q_t denotes production at time t in tons, P_t represents real price of processing tomatoes in \$/cwt, and t is a time trend. The OLS estimated production function is

$$\underset{(1.98)}{\ln \hat{Q}_t = 11.00} + \underset{(0.13)}{0.45} \ln P_t + \underset{(0.14)}{0.10} \ln Q_{t-1} + \underset{(0.01)}{0.04t} \tag{5}$$

with $R^2 = 0.92$ and n = 42.

The same model, estimated by using lagged prices as instrumental variables, gave comparable results:

$$\underset{(1.99)}{\ln \hat{Q}_t = 11.03} + \underset{(0.19)}{0.55} \ln P_t + \underset{(0.15)}{0.07} \ln Q_{t-1} + \underset{(0.01)}{0.05t} \tag{6}$$

with $R^2 = 0.91$ and n = 42. The OLS estimate of the own-price elasticity is 0.45 compared to that of 0.55 for the instrumental variables estimate. Both coefficients are significant. Coefficients of lagged acreage are both positive but not significant. And both coefficients on the time trends are positive and significant.

Figures 10 and 11 compare the fit of the two estimations.

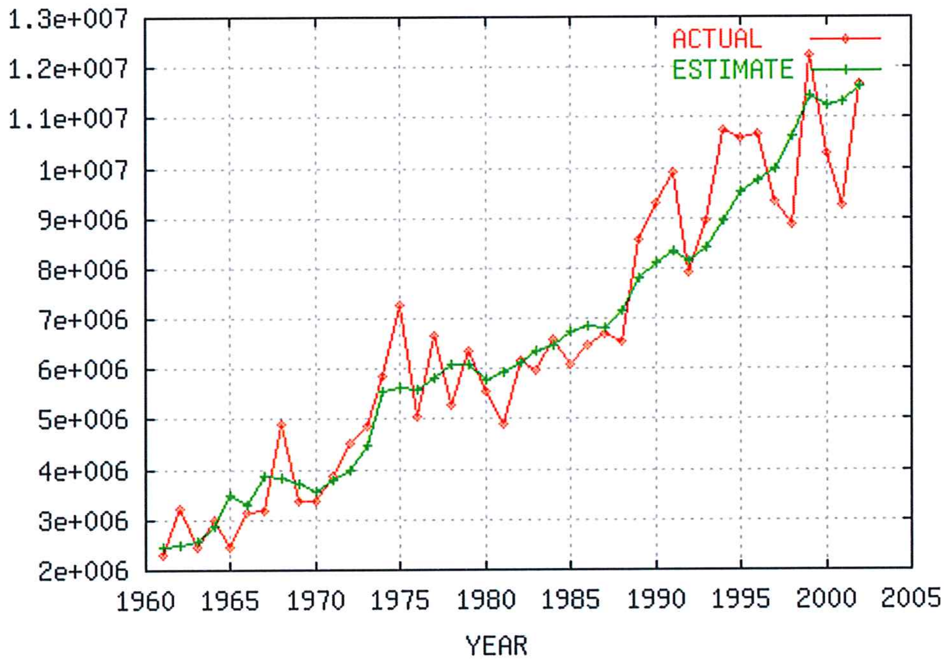

Figure 10: ***Production estimation for processing tomato (OLS) in tons.***

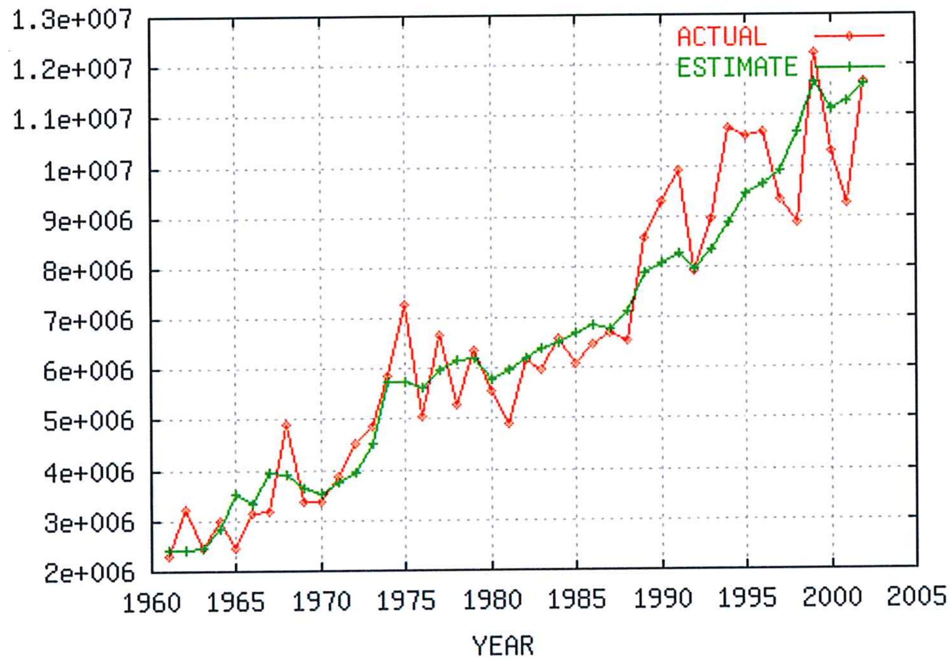

Figure 11: ***Production estimation for processing tomato (IV)in tons.***

Although a Chow test did not reject the null hypothesis of no structural change[1], we present the estimates for the two-period model, to provide a comparison with the acreage model.

Dep. Variable Production in tons	Before 1988		After 1988	
Variable	estimate	std. dev.	estimate	std. dev.
Constant	12.11	2.52	4.89	5.29
Price	0.51	0.17	1.04	0.47
Lag Acreage	0.01	0.19	0.35	0.25
Time Trend	0.05	0.01	0.04	0.01

Table 2. Chow test results for processing tomato production function

[1] The test has a p-value of 0.117.