Free Trade and a Case of Local Tomato Production

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This note looks at the time series evidence of the effect of NAFTA on Alabama tomato production using data up to the start of NAFTA to predict the trend in its absence. The time series is stationary with a constant mean and variance. An autoregressive model with one lag makes the forecast verified by impact analysis. The average yearly production loss over the 8 NAFTA years is estimated to be 85 thousand cwt, worth over $2 million at the average price implying total lost revenue of over $17 million. There is also evidence that imports and peso depreciation lower Alabama production.

Studies of the North American Free Trade Agreement (NAFTA) have examined aggregate industries at the national level and the present paper looks at the time series evidence of the effect of NAFTA on Alabama tomato production. US vegetable growers are facing import competition from Mexico with tomato production declining as summarized by Rossen and Adcock (1999) and Skorburg (2002). The US International Trade Commission documents increased tomato imports, decreased domestic production, but stable prices during NAFTA (ITC, 1999).

The present study examines the history of tomato production in Alabama and estimates time series models of NAFTA. An autoregressive model forecasts tomato production from the start of NAFTA. The technique uses data up to the start of NAFTA and the difference between forecasts and outputs are attributed to NAFTA. Intervention analysis verifies the results. The effects of imports and the exchange rate on Alabama tomato production are also examined.

Tomato protection and shipping costs

The US is maintaining tariffs on tomato imports during NAFTA and an anti-dumping case filed with the ITC against Mexico in 2000 resulted in a temporary price floor, and a tomato quota system persists. Such protection might not last indefinitely as other industries push for fuller implementation of NAFTA. Exports of horticulture to Mexico are expanding (USDA, 1998) leading to a conflict of interests even within such a narrow industry. Malaga, Williams, and Fuller (2001) discuss the increased competition in vegetable trade between Mexico and the US.

Fresh vegetables are the largest agricultural export category of Mexico. About 20% of US tomato consumption is imported and Mexico accounts for almost all of these imports. Tomato imports are about 20% of total fruit and vegetable imports from Mexico. During NAFTA, US imports of Mexican tomatoes doubled and tomato acreage in Alabama decreased over 60% (USDA, 2003). Estimated annual revenue from tomato production in Alabama remains over $6 million but had been over twice that much in the early 1990s.

Increased imports have been attributed to the peso devaluation, the recession in Mexico, good weather in Mexico, poor weather in Florida, and technological improvement in Mexico (USDA, 2003). The 1994 peso devaluation made Mexican tomatoes substantially cheaper, over 70% cheaper in nominal terms, and the economic crisis in Mexico likely increased excess supply. During 1994 and 1995, tropical storm Gordon damaged crops in Florida but Mexico had good weather and the following Southeast season was delayed by cold rainy weather.

Mexican tomato growers are producing vine ripe extended shelf life (VRESL) tomatoes that do not grow well in the Southeast because rain can make them crack on the vine. VRESL tomatoes last a week longer than mature green tomatoes, reducing waste and marketing costs. The US market has become segmented with higher prices for VRESL tomatoes (USDA, 2001). Jonas (2001) suggests Mexican producers have unfair advantages, including lack of grading, lax environmental regulations, and child labor. Opponents of NAFTA want to "level the playing field" across countries, ironically a goal of NAFTA with internationally verified environmental and labor standards.

The US has two tomato tariff seasons. A tariff of $0.039/lb is levied between from March to mid July and from September to mid November, a 17% tariff for Alabama growers given the average price of $0.23 at the farm in 2000. For the rest of the year, the tariff is $0.028 or 12%. With NAFTA, tariffs on Mexican tomatoes from mid July through August and from September to mid November were phased out over 5 years ending in 1999 and remaining tariffs are scheduled to disappear by 2004. A binding quota of 210,000 metric tons has been imposed but is scheduled to expire in 2003. For detail see Brunke (2002).

Shipping costs for Mexican tomatoes are higher than the tariff. An estimate from the Center for Agricultural Business (2003) puts the cost of delivery of a truckload of 20 tons of Mexican tomatoes to Atlanta at $2500, $125/ton or $0.06/lb, almost double the highest tariff. Including the highest tariff and transport costs, Mexican tomatoes would have to cost less than $0.12 to compete with the $0.23 average price in Alabama. Under threat of protection, a minimum import price of $0.45/kg was set in 1995 (*Rural Migration News*, 1996). The tomato industry has lobbied for a quota, suggesting increased production capacity in Mexico is more of a threat than lost tariff protection. The steady price of tomatoes may also reflect the increased quality of Mexican tomatoes as well as the segmented market for VRESL tomatoes.

A look at the Alabama tomato market since 1960

Revenue from Alabama horticulture declined during NAFTA after steadily increasing from 1975 to 1990, evidence of the negative impact of import competition. Figure 1 shows the history of tomato production, revenue, and average price in Alabama starting in 1960, scaled to unit value in 2000. Production grew steadily during the 1960s before a period of high variation up to 1983. From then until 1992, tomato production increased at a high rate before the NAFTA decline of over 60%. The average real price of tomatoes has been fairly stable since the mid 1970s as discussed by Brunke (2002). Revenue generally increased between 1985 and 1991 but has since declined over 70% following the output decline.

There is no apparent time trend with production apparently random around its mean of 375. The average production in the pre NAFTA period is 394, evidence of the negative impact of NAFTA.

Figure 1. Alabama tomato trends

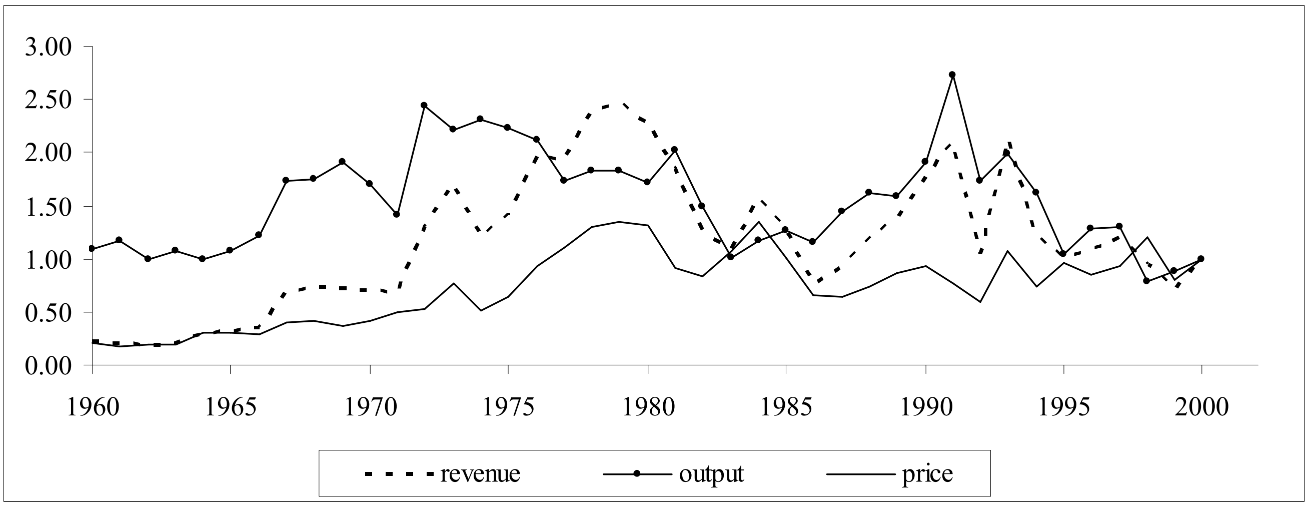

Figure 2 illustrates the economics behind the trends in Figure 1. Alabama growers reduced supply anticipating increased imports and reduced profits. Meanwhile, the quota froze imports. The reduced supply along with the quota kept the price of tomatoes high even with the lower tariff. Expiration of the quota will reduce the quantity produced in Alabama as prices fall toward the Mexican level plus transport costs. The average Alabama farm price in 2000 was $0.23. Chern and Just (1978) estimate the price elasticity of supply to be about unit value, and eliminating the 17% tariff can be expected to lower output by perhaps 15%. Even further decreases in output can be anticipated as growers reduce supply and shift to other crops.

Figure 2. Falling supply and a quota

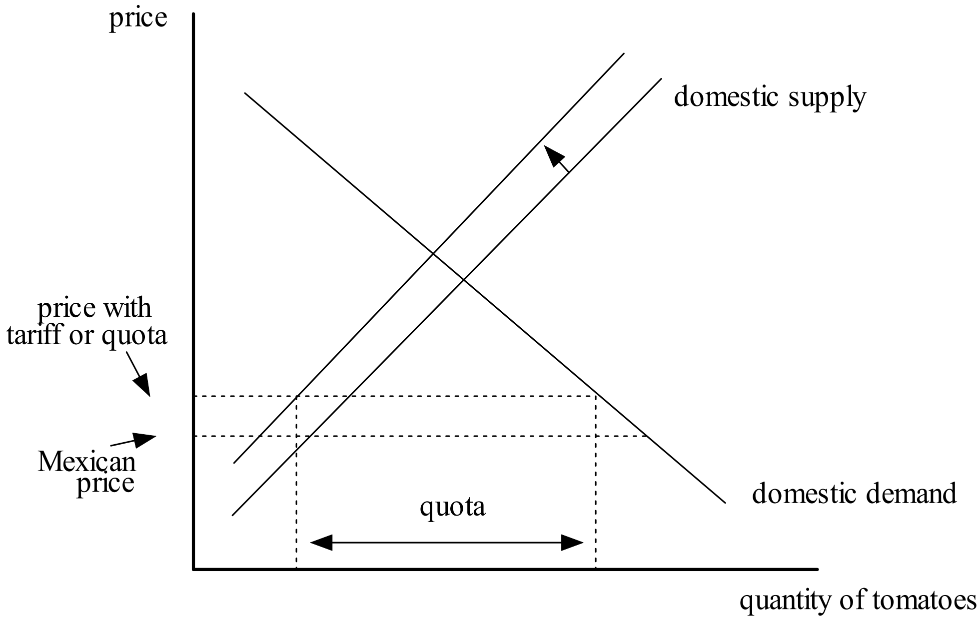

Table 1 presents estimates of various time trends with production x_t a function of time. In the linear time trend

$$x_t = a_0 + a_1 t + \varepsilon_t, \quad (1)$$

the coefficient a_1 is insignificant and the estimate does not explain any of the output variation for the entire period. Estimates are also reported for the pre NAFTA period, 1960-1992. There is a positive and significant linear time trend in the output level x_t and growth rate $\ln x_t$ and a negative time trend in the change in growth rates $d\ln x_t$, but very little of output variation is explained and DW statistics indicate negative autocorrelation. Adding the NAFTA years eliminates the weak positive time trend during the pre NAFTA years.

Table 1. Time trends of outputs (*5%, **10%)

	Entire period			**Pre NAFTA**		
	x_t	$\ln x_t$	$d\ln x_t$	x_t	$\ln x_t$	$d\ln x_t$
a_0	386*	5.92*	.06	332*	5.76*	.04
t	-.50	-.002	-.003	3.64**	0.01**	-.002
adj R^2	-.023	-.021	.006	.069	.089	.028
DW	0.59	0.51	2.42	0.71	0.58	2.20

Time series analysis of Alabama tomato production

Basic statistics reveal the negative impact of NAFTA. During the pre NAFTA period, the mean of tomato production is 394, standard deviation 112, minimum 242, maximum 660, skew 0.38, and kurtosis 2.3, indicating a normal distribution with no skew and slightly high kurtosis. For the entire sample the mean is lower at 375, SD higher at 115, the minimum falls to 192, and the skew increases to 0.43. Including the NAFTA years lowers the mean, increases the spread, and shifts the skew left indicating increased tendency to produce below the mean.

Define the difference between production and its average μ as $n_t \equiv x_t - \mu$. Estimating

$$n_t = a_0 + a_1 t + \varepsilon_t \qquad (2)$$

for both the entire and the pre NAFTA period, the null hypotheses that $a_0 = a_1 = 0$ cannot be rejected (t-statistics 0.55 and 0.14). There is no trend in n_t implying $n_t = \varepsilon_t$, making n_t a random walk around its mean of 0 and suggesting the production series $x_t = n_t + \mu$ is a random walk. In the estimated time trend of the difference in production

$$\Delta x_t = a_0 + a_1 t + \varepsilon_t, \qquad (3)$$

the coefficients are insignificant. It follows that $\Delta x_t = \varepsilon_t$ and $x_t = x_{t-1} + \varepsilon_t$. Output x_t this year is output last year x_{t-1} plus some white noise as verified by Figure 1.

Theoretically, production during a given year would have to depend to some extent on production the previous year with its established facilities, input supply chains, experienced workers, distribution networks, and accustomed buyers. It makes theoretical sense to begin a time series estimate of production with the linear autoregressive model

$$x_t = a_0 + a_1 x_{t-1} + \varepsilon_t, \qquad (4)$$

where a_0 and a_1 are parameters to be estimated.

This AR(1) autoregressive model with one lag has a stochastic error term ε_t with zero mean and constant variance. If $a_0 > 0$ and $0 < a_1 < 1$ in (4), the model converges monotonically to a long run steady state value of $a_0/(1 - a_1)$. Such dynamic stability would make predictions beyond the sample more reliable as developed by Enders (1995).

The question arises whether output from the previous year x_{t-2} might also be included in an AR(2) model. Further, moving average (MA) models provide an alternative time series structure based on a linear function of the series of random error terms $x_t = \Sigma_{i=0}b_i\varepsilon_{t-i}$ with production depending on model error in previous years. ARIMA analysis reveals the present data to be AR(1) with higher order AR terms and MA coefficients insignificant. The Akaike information criterion (AIC) and Schwartz Bayesian criterion (SBC) for the AR(1) model is smaller than those for higher order AR, MA, and ARIMA models. Both the AIC and SBC select an AR(1) model for the data.

As a formal test of stability, Dickey-Fuller unit root stability tests are reported in Table 2. Critical values depend on the form of the model estimated. Without the time trend, the 10% critical value for the t-statistic is -2.60 and with the time trend it is -3.18. In each case, the null hypothesis of a unit root process cannot be rejected, supporting the AR(1) specification. This evidence of stability favors a deterministic model and makes predictions beyond the pre NAFTA period reliable.

Table 2. Dickey-Fuller tests

	Entire period			**Pre NAFTA**		
x_{t-1}	-0.72	-2.55	-2.55	-0.36	-2.57	-2.55
a_0		2.44	2.53		2.56	2.37
t			-0.83			0.44
adj R^2	.012	.124	.117	.028	.154	.130
DW	2.49	2.18	2.22	2.24	2.03	2.00

The predicting model

The autoregressive model (4) is reported in the first column of Table 3. Estimates including second differences in an AR(2) model are included for comparison,

$$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + \varepsilon_t. \qquad (5)$$

In every case, coefficients for x_{t-2} are insignificant.

Table 3. Autoregressive models

	entire period				**pre NAFTA period**			
a_0	113*	98.6**	133*	125*	138*	128*	133*	123**
x_{t-1}	0.70*	0.61*	0.70*	0.59*	0.66*	0.56*	0.64*	0.55*
x_{t-2}	0.13		0.15		0.13		0.13	
t			-0.95	-1.24			0.75	0.59
adj R^2	.473	.457	.469	.458	.437	.405	.421	.385
h	-0.86	0	-1.05	-	-0.13	-	0	-

Given the focus on prediction, a time trend is included. Coefficient estimates are partial derivatives and the time trend captures the influence of smooth changes in supply or demand. Table 3 includes models with a time trend

$$x_t = a_0 + \Sigma_i a_i x_{t-i} + a_3 t + \varepsilon_t, \qquad (6)$$

but the time trends are insignificant.

The Durbin-Watson h statistic tests for autocorrelation when there is a lagged dependent variable. Its critical value at the 5% level is 1.96 and a higher absolute value rejects the null hypothesis of no autocorrelation. The h statistics that can be calculated indicate the null hypothesis cannot be rejected. For three of the models, the h statistic cannot be calculated.

As a further test of autocorrelation, an AR model of the error series ε_t is estimated. For instance, in the AR(1) model with no time trend,

$$\varepsilon_t = x_t - a_0 - a_1 x_{t-1}. \qquad (7)$$

A test of autocorrelation is whether the lagged error ε_{t-1} has any influence on ε_t in regressions including variables in the model. This is the essence of autocorrelation, serial dependence of error terms. In every model, the coefficients of ε_{t-1} are insignificant. There is no autocorrelation in the AR models and estimates are unbiased.

The time series model assumes homoskedasticity, constant variance across time. If variance is time dependent, including an estimated variance for each year would improve predictability. Time dependent variance is examined in an autoregressive conditional heteroskedastic or ARCH model. Error terms are derived using estimates in (7) for the pre NAFTA period,

$$\varepsilon_t = x_t - (a_0 + a_1 x_{t-1}) = x_t - (138 + 0.66 x_{t-1}). \tag{8}$$

The ARCH model estimates a linear relationship between the square of ε_t and its lags. In estimates of ARCH models up to 8 lags,

$$\varepsilon_t^2 = b_0 + b_1 \varepsilon_{t-1}^2 + b_2 \varepsilon_{t-2}^2 + \ldots , \tag{9}$$

all coefficients are insignificant. The constant term b_0 is the square of the estimated variance and estimated variances are less than 29% of the forecasted outputs. The ARCH model does not contribute to prediction.

The AR(1) model used to project production beyond the pre NAFTA period from Table 3 is

$$x_t = 138 + 0.66 x_{t-1}. \tag{10}$$

Explanatory power is reasonably high, coefficient estimates are unbiased, and the model is stable. The pre NAFTA series in (7) converges monotonically to its long run output of 406, just above the mean value of 394.

Estimated lost tomato production in Alabama

To predict tomato production using the AR(1) model in (10), output for the last pre NAFTA year 1992 is used in (7) to predict output for 1993. The projection for 1994 is then calculated using the forecast for 1993, and so on. Using the single year of output x_{1992} to start the series is not reliable because of yearly variation, and the average for the previous 10 years (378) is used to start the rolling forecasts. Projected and actual outputs for the NAFTA years are in Table 4. Projected output is higher than actual output except for 1993, the difference suggesting lost production due to NAFTA.

Table 4. Estimated lost tomato production

Year	Projected	Actual	Difference
1993	387	480	93
1994	394	392	-2
1995	398	252	-146
1996	401	312	-89
1997	402	315	-87
1998	404	192	-212
1999	404	215	-189
2000	405	242	-163

Average yearly production loss due to NAFTA over these 8 years is 85 thousand cwt, worth about \$2.13 million at the period's average price of \$0.25/lb for total lost revenue of over \$16.8 million. Using error terms from the NAFTA years in the estimated model over the entire period $x_t = 113 + 0.70x_{t-1}$ results in estimated average yearly loss of 51 cwt, about half as much. Lost revenue does not imply economic losses given associated costs of production and the switch of growers to other crops, although the decline in Alabama horticulture revenue suggests the industry as a whole has suffered during NAFTA.

Intervention analysis also examines the effect of NAFTA with the use of a dummy variable in the model

$$x_t = a_0 + a_1x_{t-1} + a_2N_t + \varepsilon_t, \tag{11}$$

where $N_t = 0$ before NAFTA and $N_t = 1$ during NAFTA. In (11) the effect of NAFTA would be immediate. The short term impact is reflected by a_2 and the long term effect by $a_2/(1- a_1)$. Results are in Table 5. The effect of NAFTA is insignificant (t = -1.54) and the residuals are white noise (pr > ChiSq = 0.22). Nevertheless for comparison, the short run impact for the model is a reduction of 51.4, a 13% output reduction from the average of 394 before NAFTA. The long term effect is a reduction of 149 = -51.4/(1 - 0.66), a 38% reduction. These estimates flank the 22% reduction of 85 thousand cwt in the AR model.

Table 5. Effect of NAFTA on tomato production (*5%, **10%)

	Immediate effect	Progressive effect
a_0	140*	147*
X_{t-1}	0.66*	0.64*
N_t	-51.4	-63.8**
R^2	.52	0.53

An alternative intervention analysis assumes that the effect of NAFTA was not complete the first year, 50% effective the second year, and completely effective after that. With the two yearly production seasons, the effect of NAFTA on the 1993 season may not be complete making this model plausible. Let N_t be the intervention variable as in (11), $N_t = 0$ pre NAFTA, $N_t = 0.50$ in 1993, and $N_t = 1$ the following years. Results in Table 5 indicate the effect of NAFTA is significant at the 10% level and residuals are white noise (pr > ChiSq = 0.24). The short term effect is a reduction of 64 and the long term effect is a reduction of 167. This model suggests that NAFTA has a significant negative impact on tomato production in Alabama and that the lost production in the long term may be larger than revealed by the AR model.

Imports into the US from Mexico since 1970 are included to gauge whether US imports have had an impact on the Alabama industry,

$$x_t = a_0 + a_1x_{t-1} + a_2m_t + \varepsilon_t. \tag{12}$$

Results in Table 6 suggest that imports have a negative impact on production. There is no autocorrelation, verified by examining estimates of error and lagged error terms. Regarding the size of the import impact, the elasticity of production with respect to US imports at the mean values of output (402) and imports (645,838) is $(\delta x_t/\delta m_t)(m_t/x_t) = -.00012 \times (645{,}838/402) = -0.2$. Every 1% increase in US imports lowers Alabama tomato production 0.2%. This elasticity is small but in 1995 alone imports increased over 100% implying a negative impact of 20% on Alabama production.

Table 6. The direct effect of US imports

a_0	298*
x_{t-1}	0.43*
M_t	-.00012*
R^2	.451

Peso depreciation, a fall in the exchange rate $e_t \equiv \$/\text{peso}$, makes Mexican tomatoes cheaper in the US. The exchange rate e_t is added as an exogenous variable to the AR(1) model for the period since 1970 when the nominal agricultural exchange rate is reported by the USDA,

$$x_t = a_0 + a_1 x_{t-1} + a_2 e_t + \varepsilon_t. \qquad (12)$$

In Table 7, the Durbin h statistic reveals autocorrelation is not a problem. The elasticity of output with respect to the exchange rate is 0.1 at the means, not large but from 1970 until 2000 the peso fell by a factor of over 700. In 1995 alone, the peso fell by 74% implying a 7.4% reduction in Alabama tomato output. Exchange rate changes may not translate directly into price changes given that growers in Mexico may do business in dollars. Chern and Just (1978) estimated price elasticities of supply that range from 0.5 to 1.0, larger than the present exchange rate elasticity. In estimates including both imports and the exchange rate, neither is significant.

Table 7. The direct effect of the exchange rate

a_0	214*
x_{t-1}	0.51*
e_t	10.3**
R^2	.440
h	-0.19

Conclusion

Alabama tomato growers have decreased production due to import competition during NAFTA. Revenue losses are estimated at over $2 million per year. There are two options for the local industry. One is the historical option of lobbying for protection or injunctive relief according to dumping and material injury procedures. Exemptions to NAFTA will become more difficult, however, and fruits and vegetables have never been highly protected. With gains for agricultural exporters, not to mention manufacturing and services, protection for individual products promises to become increasingly costly. A more reasonable option is to differentiate products, moving into higher quality production. For tomatoes, there might be demand for high quality, vine fresh, and organic produce.

The Free Trade Area of the Americas (FTAA) would extend free trade to the entire western hemisphere and the US is committed to FTAA at least in principle. Major agricultural producers Brazil, Argentina, and Chile will provide more competition. NAFTA, FTAA, and the WTO are pushing countries to abandon protection and agricultural support. In Chinese, the word “crisis” is has two parts, “dangerous” and “opportunity.” Facing increased import competition, US agricultural industries have to take advantage of their dangerous opportunity.

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