Acreage Allocation Analysis of Florida's Winter Tomato Production

by

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STATEMENT BY AUTHOR

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Dr. Satheesh Aradhyula Date

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Dr. Russel Tronstad Date

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Dedication

I like to dedicate this thesis to the tomato and produce pickers of the world. In particular, to the pickers of the Sinaloa, Mexico region who migrate from southern regions of their country, often with their entire families, to live a nomadic existence subject to the whims of the Sinaloan acreage allocation decision-making process, as well as the socio-cultural and environmental climates.

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Abstract

Ever since the US/Cuban Embargo of 1962, the U.S. winter tomato market has been almost equally shared by Mexican and U.S. producers. The weather requirements of this vegetable are such that during the winter seasons the state of Florida is more or less the sole domestic producer of this crop. This study attempts to explore and identify the factors that influence the acreage allocation of the U.S. winter tomato production. Given the geographical concentration of this crop, this study focuses on four major tomato production regions of Florida. To this end, an annual panel data set is used to probe the regional tomato production dynamics of Florida through the span of 36 years. This analysis accounts for competitive crops, own price, import regime changes, input costs, population pressures, as well as other regional specific variables. The results suggest that there are several regional differences within state production, as well as the presence of structural sensitivity regarding import regulation changes.

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CHAPTER 1

INTRODUCTION

US Winter Tomato Market

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The United States' winter tomato market has a fierce history of foreign rivalry dating back to the early twentieth century. For practical reasons, such as the weather demands of highly the perishable tomatoes and current market structure, this paper focuses on the post- U.S. Cuban Embargo era (after 1962). When Mexico –with its favorable weather conditions and its proximity to the U.S.- as well as the post 1960's government infrastructure investments, became the leading foreign competitor for Florida (Firch and Young, 1968). Currently, Florida and Mexico share approximately 90% of the total U.S. winter tomato market. (See figure 1.1)

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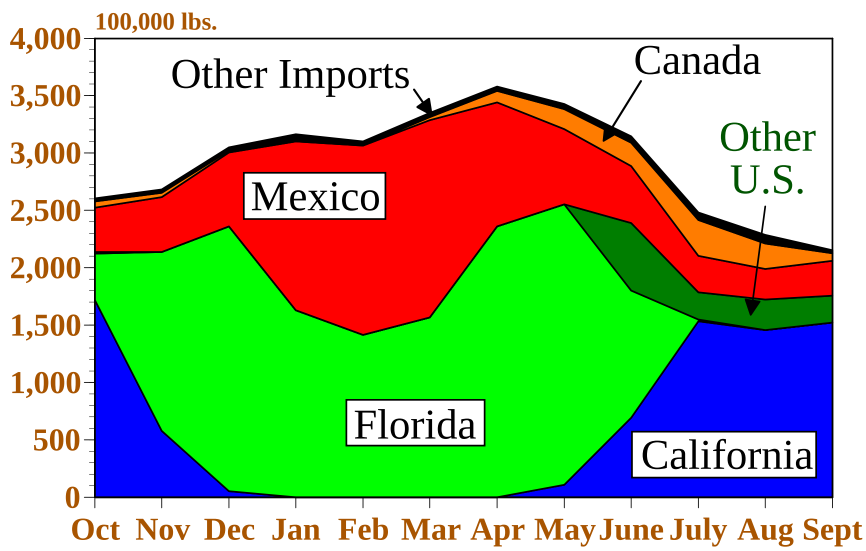

Figure 1.1: Sources of US tomato, average of 1999-01

The protectionist measures for the tomato industry date back to the 1883 Tariff Act, in which a 10% duty tax was levied on all fresh vegetables, including tomatoes. It also continued with other subtle measures such as the 1970-75 Marketing Order Battles and the failed 1978-80 anti-dumping battle. However, these struggles incited Mexican producers to self-impose quotas on their exports during the 1978-79 and 1979-80 marketing years. (Schmitz, Firch, Hillman 1982)

In spite of this web of strategic self-imposed tariffs, quotas, etc., the U.S. official 1951 trade policy instituted a fixed 11% tariff on tomatoes, that has been a constant up to the introduction of the North American Free Trade Agreement (NAFTA). In 1996, two years after the initiation of NAFTA, the U.S. Department of Commerce launched an investigation to see if Mexican tomato farmers were involved in product dumping practices. Yet before the conclusion of the investigation, U. S. and Mexican producers agreed to settle dumping allegations through the Mexico-U.S. Suspension Agreement.

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This agreement does not allow for a certain variety and sizes of Mexican tomato imports to be sold in the U.S. below a fixed "reference" price. This reference price serves as a type of price floor that is activated during the following week of being triggered. Namely, if any variety or size of tomato is sold for lesser value than the reference price, no tomatoes of any variety or size may be sold during the following week for less than this reference price. The dynamic effects of this police are illustrated in figure 1.2, where the relationship between the range of high and low prices appears negatively correlated with abrupt changes in Mexican shipments.

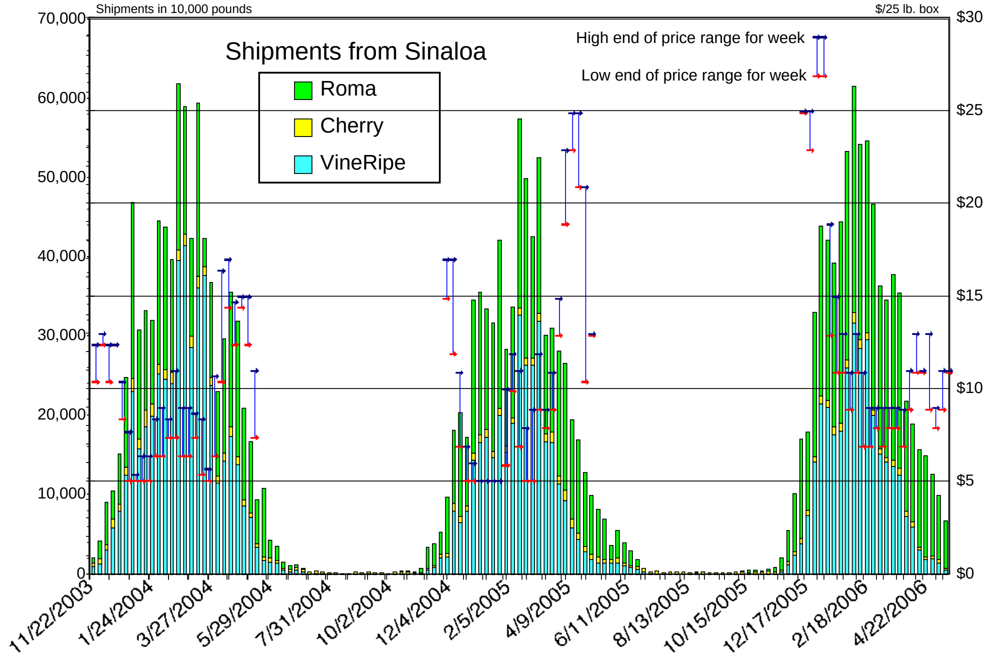

Figure 1.2: Data of Shipments & Prices Illustrated

On November 1, 1996, the first reference price was set at $0.2068 per pound, then on August 21, 1998 it changed to $0.2108 per pound. This agreement was initially negotiated for five years and extended in 2002 while keeping the same 1998 reference price, then, in 2003 the agreement was extended and increased to $0.2169.

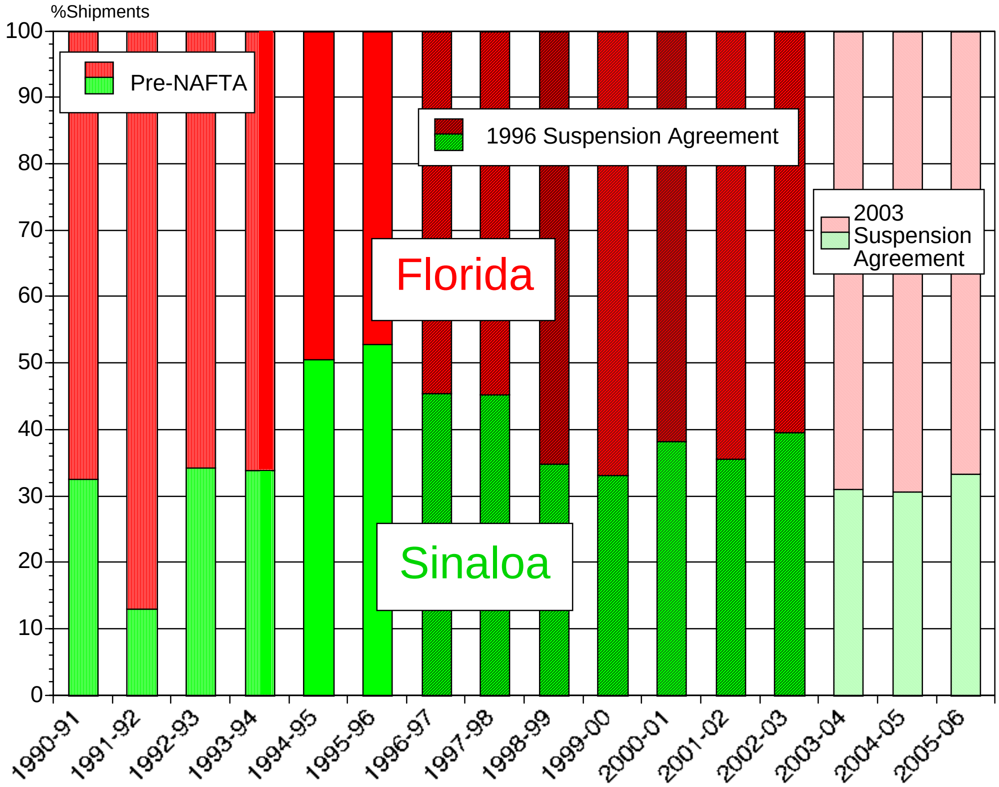

Figure 1.3: Florida and Sinaloa, Mexico's Shipments for 1990 - 06

1.2 Florida's Tomato Production

As seen in figure 1.3, tomato production in Florida is widely spread out throughout the entire state. The major producing regions are Dade, East Coast, Palmetto-Ruskin, North, West, and Southwest. The later being the biggest producer. From 1962 to present, these regions have more or less accounted for the bulk of tomato production in Florida, except for the West, a new production region in 1979.

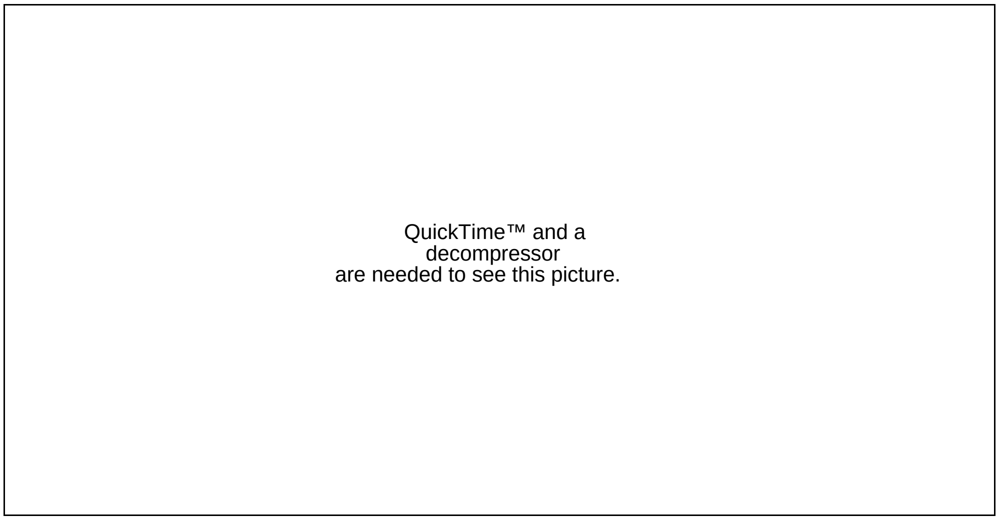

Figure 1.4: Florida's Principal Tomato Producing Region [*]

The planting seasons are from August to March. Planting intensity has an almost bell shape pattern, except for Palmetto-Ruskin, which is very active at the start and end of the season, but takes a flat dive from September to December, as shown in figure 1.4. For this figure, we can see the regions do not appear to have a crop rotation behavior. The average weekly temperature amongst these regions is highly correlated and with a low degree of variance, except for Palmetto –Ruskin from December thru February, Palmetto-Ruskin has a significant temperature drop compared to the other regions (see figure 1.5). Florida has had a long history of hurricanes that have mainly affected the southern cone of the peninsula. Five hurricanes took place during the period of our observations: Betsy-September 1965, Agnes-June 1972, Frederic-September 1979, and Andrew-August 1992; but as seen in figure 3.1, plantings for theses particular years do not appear to be significantly affected. An explanation for this could be that four out of the five hurricanes

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[*] This map is from the 1990 Florida Vegetable Report.

affected Florida in either August or September, which are the beginning of the winter tomato seasons and planting acreage is just starting. Not only is a small amount of acreage planted, but the fact that this tragedy may happen at the beginning of the planting season allows for replanting to occur.

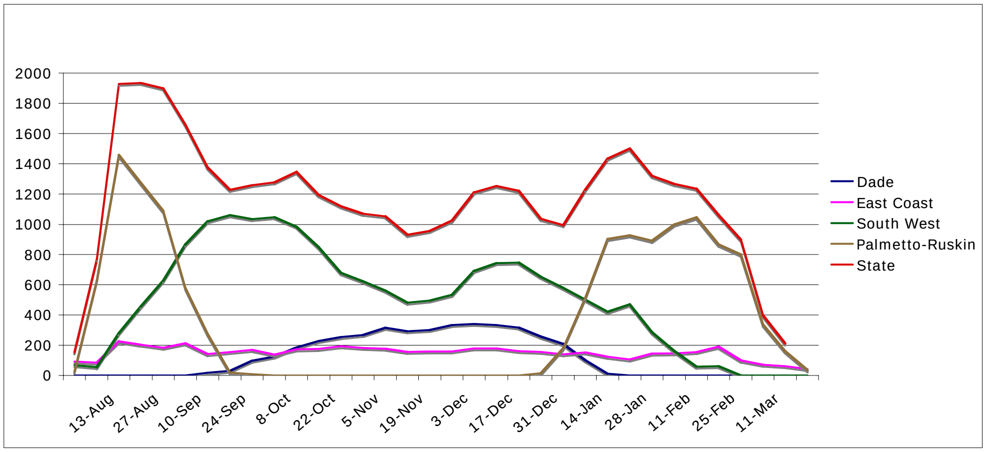

Figure 1.5: Average Weekly Plantings By Region for the periods 1993-01

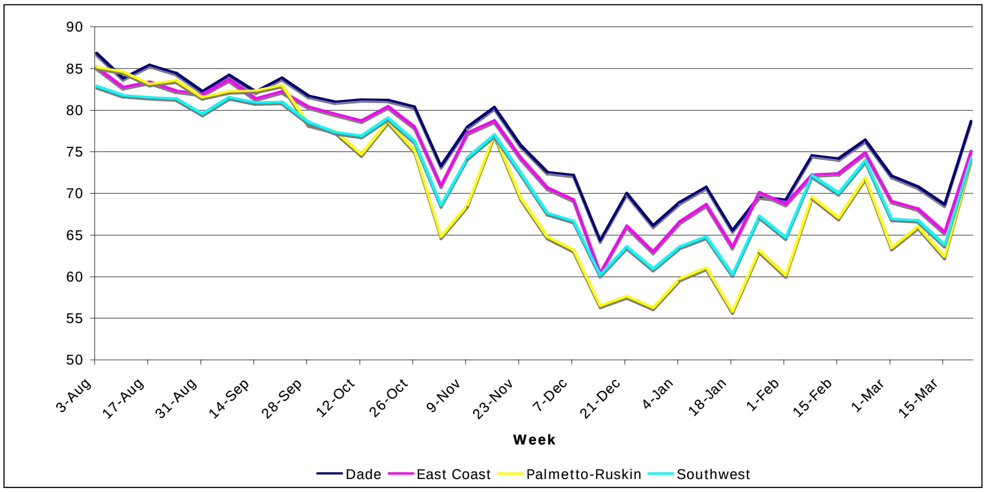

Figure 1.6: Average Weekly Temperature of Florida's Major Tomato Producing Regions, 2003

Figure 1.2 indicates that Floridian tomato production may be highly sensitive to US-Mexican trade agreements. Namely, the graph illustrates an almost 18% market gain for Mexican producers after the implementation of NAFTA in 1994; the 1996 Suspension Agreement seems to have reduced that gain by roughly 10%, which alludes to a possible market structure regime change.

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Statement of Purpose

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This paper attempts to isolate and identify factors that influence the U.S. winter tomato market, more specifically the Floridian tomato production. A panel data set that spans from 1962 to 1999 for four tomato producing regions of Florida is used for this aim. The approach not only observes the influence of regional specific factors, but also the behavioral effects of each tomato producing region, by observing the performance of the other major producing regions. Although the acreage allocation literature has explored multiple approaches of this nature, few have explored the particular regional-specific aspects of the Floridian winter tomato market.

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Thesis Organization

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This paper first examines the tomato acreage allocation literature in the context of the U.S. winter market. It will also examine theoretical frameworks for assessing the regional dynamic aspects of the winter tomato acreage allocation. The data are then explained and analyzed, followed by a statistical summary and a discussion of the results

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and limitations. Finally, empirical results are presented along with the possible policy implications.

CHAPTER 2

LITERATURE REVIEW

2.1 Historic Overview of the U.S. Winter Tomato Market

2.1.1 Foreign Competition

As previously mentioned, the post-Cuban embargo U.S. winter tomato market has been overwhelmingly dominated by U.S. and Mexican producers, specifically Floridian and Sinaloan. To put the foreign competitor's potential in context, it might suffice to mention that the state of Sinaloa's official symbol is a red delicious tomato. An extensive study of the winter vegetable export industry of Northern Mexico, which primarily includes Sinaloa, by Robert S. Firch and Robert A. Young in 1968, details the industry's historical development. They find that tomatoes are the state's dominant vegetable and that the

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"dry, warm winter weather of the coastal valleys of Sinaloa are well suited for vegetable production. Governmental investments in vast irrigation projects have made available considerable additional adapted land and water resources. Improved transportation and communication networks have made possible the rapid delivery of quality vegetables to the U.S. markets. Unemployment and underemployment of the work force assure ample labor supplies, while private credit sources in the U.S. have been tapped for financing."

This stance of international producer rivalry and Mexican presence in the U.S. market, along with cooperation between Mexican producers and U.S. creditors and wholesalers has very much maintained its presence in the current situation.

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2.1.2 The Great Tomato Wars

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To understand the U.S. winter tomato market is important to examine various forms of international rent-seeking activities by producers in both importing and exporting nations. In a 1987 paper, Maury Bredhl, Andrew Schmitz, and Jimmye S. Hilman provide an extensive economic and political framework for the analysis of the market's rent-seeking potential, which includes both the unilateral and collusive import/export scenarios. They explore the various historical attempts at these activities and give reasons for the failures. Their findings show that until 1987 "Florida producers have been unable to increase their rents through lobbying for U.S. initiated quotas and/or tariff protection." In addition, they suggest that for reasons drawn from standard export cartel theory, the import/export cartel may be impossible to sustain.

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For recent years, a winter tomato rent-seeking analysis has yet to be fully examined, but an ongoing study by Satheesh Aradhyula, Gary Thompson, and Russell Tronstad of the University of Arizona has focused on the later portion of this market, namely, the post-NAFTA dynamics of the winter tomato market. Their analysis explores the 1996 US suspension agreement, along with the November 1st, 2003 renewal.

2.2 Acreage Allocation Analysis

The acreage allocation literature has a long and vast history of different methods and topics of analysis. Prior studies have primarily focused in developing models which estimate price vs. the traditional cobweb method of lagging these, using a variety of tools, such as, rational expectation models (e.g. Shokwiler and Emerson (1982)), contracting theories (e.g. Chern (1976)), and others. Most recent studies have turned their attention towards the impacts of various government intervention programs, such as crop insurance programs, farm aid programs, import-export regimes, and others. This study follows the latter category by not only exploring the acreage response to domestic competition, but also the import regime sensitivity.

The tomato acreage allocation analysis has been the subject of a wide range of studies (Zepp (1979), Fu et al. (1986), Huang et al.(1996), Hamming (1979)). While some of these have focused on the over all tomato market, none have narrowed the attention to the regional effects of the winter tomato production. As mentioned in the introduction, this study uses data for the post-1962 Cuban Embargo to probe into the factors that affect the current production. The importance of this is highlighted by Zepp (1979), namely, Zepp explores the impact of the Cuban potential producer by using a spatial price and quantity equilibrium model, and comparing the results to the current winter tomato’s price and equilibrium. The study concludes that given a new Caribbean-area supplier, at the Cuban importing level of pre-1961 shipments, their presence would be of about 2% of 1979 market. Since their presence would be mostly felt during the midwinter, the effects would be detrimental to both U.S. and Mexican producers, but due to the fact that the latter’s highest export volume is largest during the midwinter months, when new Caribbean-area supplies would be expected to arrive, Mexican imports would then be expected to be the most affected. This is not to say that Floridian producers would not be worsened, but since they would be expected to have their highest volume before and after the expected

Caribbean shipments, the impact would weigh less on them. Leaving the U.S. consumers with an increase in supply that would slightly make them better off.

A more holistic approach toward regional acreage allocation was studied by Hamming (1979). This study proposes a model for quarterly response modeling, while appraising the usefulness of mixed estimation. Eleven southeast U.S. regions are considered, which embody total U.S. production during the four quarters to explain quarterly and regional acreage plantings of fresh tomatoes. All regions are estimated by pure and mixed least squares, the later demonstrating a feasible alternative to pure regression in the estimation of relations if prior information is available that can be properly append into a linear probability model.

The literature does not show the use of panel data for assessing the factors that influence acreage allocation of tomatoes. There is, however, the use of this type of panel data in other supply response modeling research. Thijssen (1992) used an incomplete annual panel data set for 1970 to 1982, to estimate the supply response and input demand of Dutch dairy farms. The study found a Hausman test that favored the use of a fixed effects model. Both fixed and random effects models were estimated and presented, along with the respective elasticities. Some of the methodology from this study was taken into consideration, safe the fact that the current study uses a balanced data set, and the random effects model was no longer pursued after the Hausman test favored a fixed effects approach.

CHAPTER 3

EMPIRICAL MODELS AND DATA

3.1 Empirical Model

To explore the factors influencing acreage allocation of winter tomatoes in Florida, a panel data set was assembled to provide a more holistic and efficient analysis. Namely, having four tomato producing regions and 36 years, this approach not only observes the influence of specific regional factors, but also the behavioral effects of each region by observing the performance of the others. (See table 3.1)

Table 3.1: Summary Statistics of Panel Data

Variable	Description	Units	Mean	Std Dev	Minimum	Maximum
Year	Year	Annual	1980.5	11	1962	1999
ToP	Tomato Area Plantings	Acres	11763.88	8019.81	0	38970
ToPr	Avg. Annual FL Tomato Price	$ / 25 lb Cartons	89.32	37.95	27.12	148.4
ToH	Tomato Area Harvest	Acres	11436.45	7690.55	0	35480
CuP	Cucumber Area Plantings	Acres	4012.83	2470.22	650	17450
CuH	Cucumber Area Harvest	Acres	3006.4	2433.07	154.95	10900
PepP	Pepper Area Plantings	Acres	5332.05	3132.64	650	21300
PepH	Pepper Area Harvest	Acres	4978.85	2953.49	450	20300
FW	Avg. FL Ag. Wage	$ / week	56.96	29.51	18.24	117.21
Fpop	FL Tomato Producing Region Population	People	1321151	1423408	112432.6	5415348
TT	Time Trend	Integers	19.5	11	1	38

The fact that Floridian tomato is primarily produced in the winter seasons, and tomato in this state has been produced in almost the same major tomato regions throughout the entire period of interest, makes the study of winter Floridian tomato a good candidate for a panel data approach. As illustrated by Hsaio (2003), there are several advantages and drawback of using panel data, the major gains include: an increase in degrees of freedom by reducing the gap between information and requirements, a reduction in collinearity amongst independent variables, a reduction in estimation bias such as omitted variable bias and simultaneous bias (in this paper the former is dealt with by using dummy variables to capture the regional-invariant variables), as well as providing the micro foundations for aggregate data analysis. Thus, the basic model considered for this study is the following:

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$$y_{it} = \alpha + \mathbf{b}'\mathbf{x}_{it} + \varepsilon_i + u_{it}, \qquad i = 1,\ldots N \quad t = 1,\ldots,T, \qquad 3.1$$

where, y_{it} is annual tomato plantings in area for region i in year t, $\mathbf{x}_{it}$ is a vector of explanatory variables, N represents the number of tomato producing regions of Florida and T the annual observation, $\mathbf{b}'$ is a 1 x K vector of constants, the error term u_{it} represents the effects of the omitted variables that are particular to both the regional units and time periods, and ε_i is the individual region effect.

The particular specification of ε_i marks the difference between implementing a fixed or random effects model. The former treats the individual region effects as a fixed but unknown constant that differs across regions, while the other specification assumes that

ε_i is a random variable, drawn from an identically distributed normal set. One way to test for the proper specification is to implement a Hausman Test, but given the fact that the number of regions considered is only four, and that all data is coming the State of Florida, a effects model specification was utilized for estimating this model.

Using a least-squares dummy-variable approach, detailed in Hsaio (2003), the basic model below will follow from equation 3.1,

$$y_{it} = \alpha_i + \mathbf{b}'\mathbf{x}_{it} + u_{it} \qquad i = 1,\ldots N, \quad t = 1,\ldots,T, \qquad 3.3$$

where α_i is now a 1x1 scalar constant representing the particular effects of i^{th} region.

Based on the above, the following three fixed effects models are proposed:

$$ToP_{it} = \alpha + \beta_{io}D\mathrm{Re}_i + \beta_1 ToH_{it-1} + \beta_2 To\mathrm{Pr}_{t-1} + \beta_3 CuH_{it-1} + \beta_4 PepH_{it-1} + \beta_5 FW_{t-1} + \beta_6 FPop_{t-1} + \beta_7 Dref_t + \beta_8 DPNAFTARP_t + u_{it} \qquad 3.4$$

i = 1,…,4,

t = 1,…,36,

$$ToP_{it} = \alpha + \beta_{io}D\mathrm{Re}_i + \beta_1 ToP_{it-1} + \beta_2 To\mathrm{Pr}_{t-1} + \beta_3 CuP_{it-1} + \beta_4 PepP_{it-1} + \beta_5 FW_{t-1} + \beta_6 FPop_{t-1} + \beta_7 Dref_t + \beta_8 DPNAFTARP_t + u_{it} \qquad 3.5$$

i = 1,…,4,

t = 1,…,36,

$$ToP_{it} = \alpha + \beta_{io} D\mathrm{Re}_i + \beta_1 ToHP_{it-1} + \beta_2 To\mathrm{Pr}_{t-1} + \beta_3 CuHP_{it-1} + \beta_4 PepHP_{it-1} + \beta_5 FW_{t-1} + \beta_6 FPop_{t-1} + \beta_7 Dref_t + \beta_8 DPNAFTARP_t + u_{it} \qquad 3.6$$

i = 1,…,4,

t = 1,…,36,

where ToP_{it} are the annual tomato plantings for region i and time t, $D\mathrm{Re}_i$ is a dummy variable for region i, excluding Region IV in order to avoid the dummy variable trap, ToH_{it-1} is the annual tomato harvested area for region i and time t-1, ToP_{it-1} is the annual tomato planted area for region i and time t-1, $To\mathrm{Pr}_{t-1}$ is the Florida state average free on board (fob) real price for 25lb tomato cartons, for time t-1, CuH_{it-1} is the annual cucumber harvested area for county i and time t-1, CuP_{it-1} is the annual cucumber planted area for region i and time t-1, $CuHP_{it-1}$ is the ratio of annual cucumber harvested area and planted area for region i and time t-1, $PepHP_{it-1}$ is the ratio of annual pepper harvested area and planted area for region i and time t-1, $PepP_{it-1}$ is the annual pepper planted area for region i and time t-1, $PepH_{it-1}$ is the annual pepper harvest for region i and time t-1, FW_{t-1} is the annual real wages of Florida vegetable and melons for time t-1, $FPop_{t-1}$ is the annual Floridian population of the major tomato producing regions for time t-1, $Dref_t$ is a dummy variable that takes 1 if the US-Mexico Suspension Agreement (USMSA) is active (1996-99) and 0 otherwise for time t, and $DPNAFTARP_t$ is a dummy variable that takes 1 if the NAFTA is active and USMSA is not (1994-95) and 0 otherwise for time t.

The difference between three models is that model 3.4 uses lagged area harvested for tomatoes, cucumbers, and peppers, on the right hand side (RHS) of the equation, and model 3.5 uses lagged area plantings on the RHS of the equation, for the three crops, and model 3.6 uses the lagged ratio of area harvested to area plantings on the RHS of the equation for the three crops.

3.2 THE DATA

3.2.1 Plantings, Harvest, Production, and Yield

The Florida Agricultural Statistics Service has been producing an annual Vegetable Summary Report for the State of Florida since 1929. These reports contain detail coverage on the principal vegetable producing counties and regions, and are made possible by estimating services of the Department of Food and Resource Economics, University of Florida. Although the reports date back to 1929, the sub-state level data used in this paper was discontinued in the year 2000 due to federal budget cuts, and hence the ability to extend the regional analysis to the present day. Tomato plantings data for the years 1976 and 1986 was not available for the specific regions, but only at the state level. To resolve this, regional plantings data for the two missing years were estimated using the preceding and following regional breakdowns to weight the current annual data state datum.

The data starts in 1962, the year following the implementation of the US embargo against Cuba. This selection of start year was made based on the fact that Cuba was a significant player in the US winter tomato market and its absence since the embargo has been a permanent market disruption. Therefore, this study choose to obviate it and start with the most recent factors that influence the most current acreage allocation production.

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The Florida Vegetable Summary Reports had data for 25 crops, but due to seasonal and regional considerations only tomato, cucumber, and peppers were collected for this state. Other crops, such as snap bean and sweet corn were also considered, but this region could not be matched with those for tomatoes.

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The data for tomato, cucumber, and pepper were reported by their principal producing regions, which were not exactly composed in the same manner, but using the tomato's principal producing regions (Region I - Dade and East Coast, Region II - Southwest, Region III - North Central and Palmetto-Ruskin, and Region IV - North and West), a common grouping method was used to fit the cucumber and pepper producing regions into these four partitions.

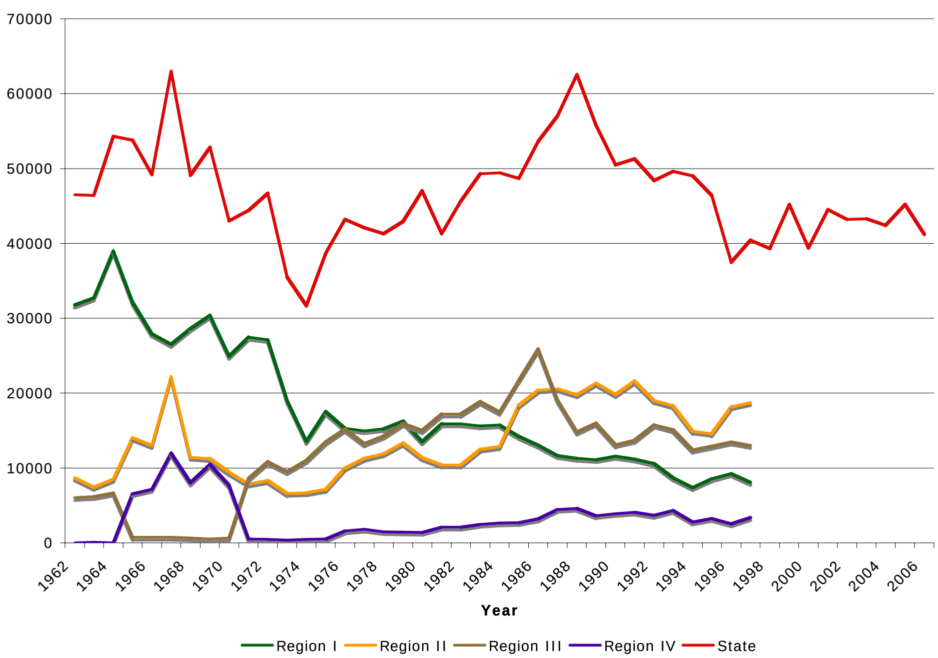

Figure 3.1: Annual Tomato Plantings By Region in Florida, for 1962 - 06

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are needed to see this picture.

Figure 3.2: Map of Florida's Tomato Producing Region

Annual data on plantings, harvest, yield, and production were collected for these three vegetables for the four producing regions of Florida. The units for plantings and harvested were very much consistent in terms of acres throughout the entire sample. Yet the most common and current units for yield and production varied significantly in their estimated packaging bundle, and thus were all converted to their respective most recent common unit's estimated net weight unit, namely, 25 lb carton tomatoes, 28 lb bushel peppers, and 55 lb bushel cucumbers.

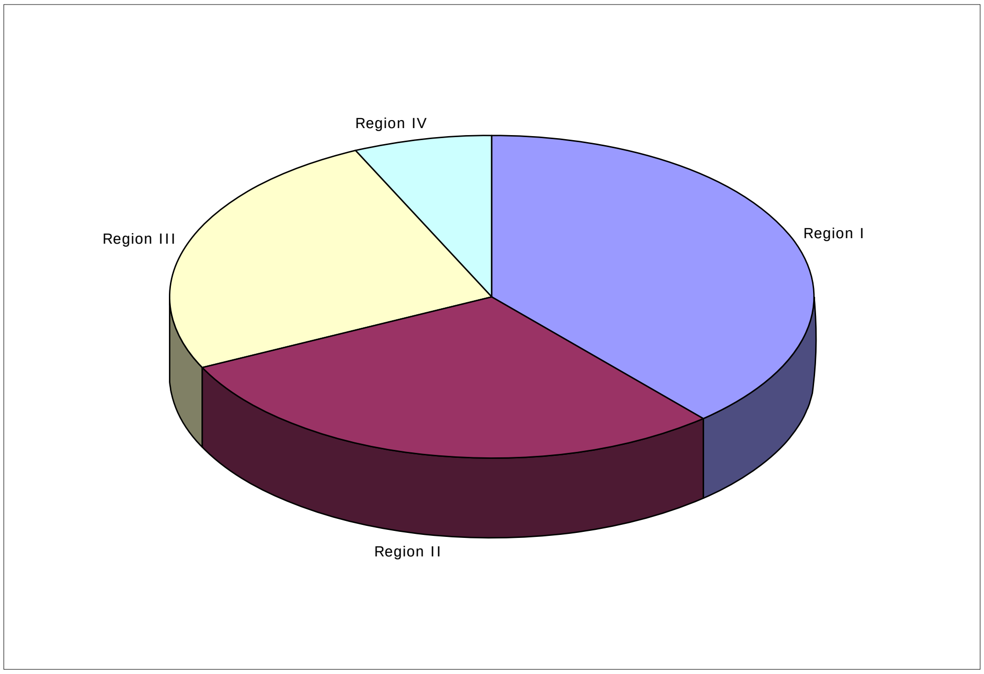

Figure 3.3: Annual Average Tomato Plantings by Region for 1962 to 1999

Definitions and explanations of the Vegetable Summary Reports:

Planted acreage is defined as total acreage planted during the entire plantings season, 'namely, from August to March.' Acreage lost and replanted to the same crop in the same crop in time for harvest in the same quarter is counted only once. Acreage harvested and planted again to the same crop is counted twice.

Harvested acreage is the acreage partially or completely harvested. Those acres that were lost before or at maturity through natural or economic causes are not included.

Yield is the average production per harvested acre of merchantable quality harvested and sold or utilized for human consumption.

Production is the quantity actually harvested and sold or utilized for human consumption.

3.2.2 Wage and PPI

The wage rate represents a proxy for the average annual real weekly wage for producing vegetables and melons in Florida. The data were taken from the Bureau of Labor Statistics (BLS). BLS started collecting such detailed data in 1975 and therefore there were 14 observations missing. To resolve this matter, the missing values were estimated by regressing the industrial wages of Florida on the agricultural wages. The significant parameters of this regression were then used to fit the industrial wages into the missing agricultural data.

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To deflate wages and prices, the U.S. producer price index (PPI) for fresh and dry vegetables was used. These data were also collected from the BLS database.

3.2.3 Population

Population estimates of all the counties at any given period of the sample that have ever hosted a principal tomato producing region were collected from the United States Bureau of the Census. These estimates come from an interpolation of the Population of Counties by Decennial Census.

The counties were grouped as follows:

Region I: Broward, Dade, Martin, Osceola, Palm Beach, and St. Lucie.

Region II: Charlotte, Collier, Glades, Hendry, and Lee.

Region III: De Soto, Hardee, Hillsborough, Manatee, and Sarasota.

Region IV: Gadsden, Holmes, Jackson, Marion, Sumter, and Suwannee.

Weather Proxy

The weather proxy was to estimate the tomato yield equations of tables 4.2, B.2, and C.2. It was constructed from the residuals of regressing cucumber yield on time trend and cucumber price. Cucumber is a crop that is typically planted near tomato plantings and approximately in the same season.

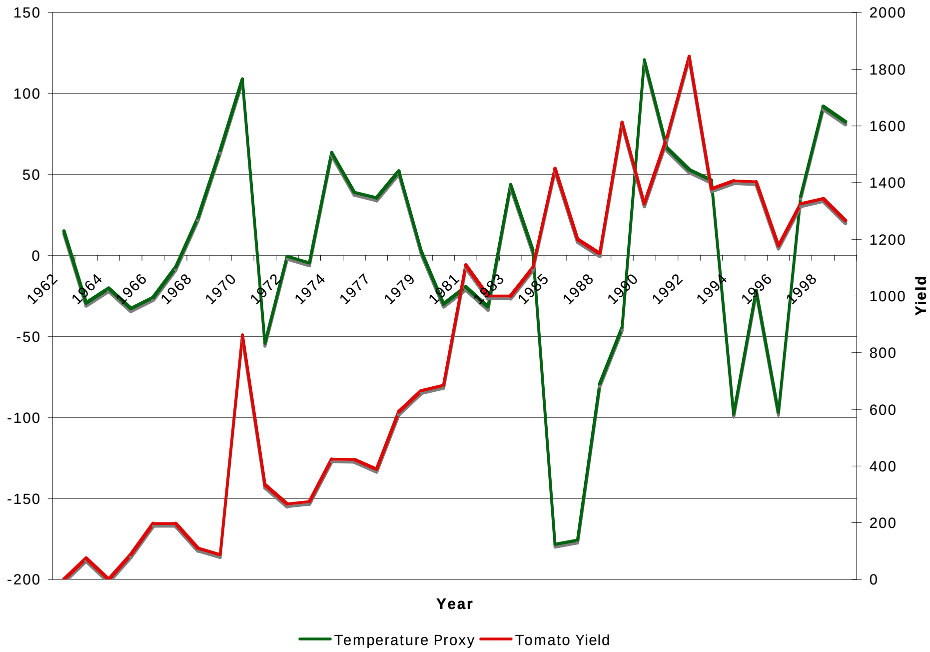

Figure 3.4: Tomato Yield and Weather Proxy for Region IV, 1962 - 1999

3.2.5 Tomato, Cucumber, and Pepper Prices

The tomato, cucumber, and pepper prices are the mean annual f.o.b. of all state shipping points of Florida. They were initially collected in units of dollars per hundredweight (cwt), but converted to match the most common unit of their respective vegetable. That is, tomato price was converted to dollars per 25lb cartons, cucumber prices became dollars per 55lb bushels, and pepper prices became dollars per 28lb bushels.

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3.2.6 Data Manipulation

3.2.6.1 Missing Values

The data were missing the 1973 Region IV harvest and plantings of peppers, as well as the harvest and plantings for all vegetables and all regions for 1976 and 1986. To resolve this, the missing regional values were estimated using annual state level data. The previous and former regional breakdowns for each vegetable were used to infer the current year's regional data from state level data. For example:

1976Region I $\approx$ 1976State *[(1977 Region I / 1977State)/2 + ((1975Region I / 1975State)/2]

By inspecting the summary statistics on table 3.1, we may see that the data contain no outliers, and that the sample size of each variable reveals a balanced data that is ready for statistical analysis.

CHAPTER 4 EMPIRICAL RESULTS

Table 4.1 shows the results of five fixed effects regressions of the proposed models 3.4, 3.5, and 3.6. Model 1 details the results of equation 3.5, model 2 is based on model 1, but excludes the insignificant variables, model 3 regresses equation 3.5, model 4 is based on model 3, but filters out the insignificant variables, and finally, model 5 show the results of estimating equation 3.6.

The majority of variables are very robust throughout these models, having only a minor variations in significance level, but overall very consistent. The estimated signs of almost all coefficients were as expected, except for some insignificant estimates. The R-Squares are 0.88 for models # 1 and # 2, 0.89 for models # 3 and # 4, and 0.66 for model # 5.

4.1 Area Harvested and Area Planted

As expected, the estimate of lagged tomato harvest showed a significant and positive association with tomato plantings. According to the fixed effect results of models 3 and 4, the results of lagged tomato harvest were robustly significant at a 5% level of significance. Estimates were approximately 0.88 in both models and the elasticities for both models were 0.9. Of the competitive crops, only lagged area cucumber was significant at 5% significance, with an elasticity of -0.152 for model # 1 and -0.146. By focusing on model 4, we may observe that the absolute value of the elasticity of lagged cucumber area harvested is bigger than lagged tomato area harvested, but have opposite sign. Namely, tomato plantings seem to be more sensitive to the lagged competitive crop area harvest then to the lagged own area harvested.

Table 4.1: Estimated Acres Planted Equations for Florida Tomatoes

Independent Variable	Expected Sign	Model 1 Estimate	Model 2 Estimate	Model 3 Estimate	Model 4 Estimate	Model 5 Estimate
Intercept	+	660.878 (662.9)	466.365 (595.4)	1744.422** (728.5)	1761.454** (703.2)	25436.23* (8992.5)
$ToPr_{t-1}$		0.542* (0.154) [0.004]	0.528* (0.147) [0.004]	0.548* (0.152) [0.004]	0.561* (0.146) [0.004]	0.374 (0.267) [0.003]
ToP_{t-1}	+	0.862* (0.047)	0.862* (0.038)			
ToH_{t-1}				0.881* (0.049) [0.856]	0.892* (0.04) [0.867]	
$ToHP_{t-1}$	+					-8498.05 (7497.9) [-0.704]
CuP_{t-1}		-0.081 (0.138) [-0.028]				
CuH_{t-1}	+			-0.594** (0.232) [-0.152]	-0.57* (0.211) [-0.146]	
$CuHP_{t-1}$						-30365.2* (6501.3) [-1.907]
$PepP_{t-1}$	–	-0.092 (0.124) [-0.042]				
$PepH_{t-1}$				0.032 (0.131) [0.014]		

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. Tomato planted area is the dependent variable in all models. Figures in parenthesis are estimated standard errors and computed elasticities are reported in brackets.

Table 4.1: Continued

Independent Variable	Expected Sign	Model 1 Estimate	Model 2 Estimate	Model 3 Estimate	Model 4 Estimate	Model 5 Estimate
$PepHP_{t-1}$	–					11491.11*** (6635.9) [0.91]
FW_{t-1}		-0.924* (0.28)	-0.929* (0.235)	-1.005* (0.276)	-1.046* (0.235)	0.521 (0.452)
$Fpop_{t-1}$	–	-0.00004 (0.001)		-0.0002 (0.001)		-0.007* (0.001)
Dref		3303.825** (1532.6)	3701.423* (1325.2)	3334.998** (1508.2)	3514.642* (1313.8)	-4527.17*** (2454.9)
DPNAFTARP	–	1981.845 (1301.4)	2191.215*** (1233.6)	1551.321 (1286.1)	1648.204 (1226.9)	-2445.48 (2191.4)
DRe I		2230.237 (2362)	1525.595*** (860.5)	1529.398 (2341.8)	926.975 (870.2)	13310.26* (5029.6)
DRe II	–	2823.665** (1139.8)	1893.916* (740.6)	4039.879* (1248.8)	3980.871* (1125.2)	11870.24* (1133.1)
DRe III		2030.08*** (1115.5)	1326.225*** (721.6)	3242.8* (1234.1)	3050.096* (1028.4)	14800.9* (1308.3)
Sample Size		112	112	112	112	112
R-Square		0.88	0.88	0.89	0.89	0.66

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. Tomato planted area is the dependent variable in all models. Figures in parenthesis are estimated standard errors and computed elasticities are reported in brackets.

Given that tomato area plantings and area harvested are highly correlated, the results of plantings were, as expected, almost identically robust in models #1 and #2, and almost identical to tomato lagged area harvested.

Lagged tomato area Plantings were robustly significant in models #1 and #2 with a 1% significance level, and estimates of 0.86 each. The competitive crop area plantings were both insignificant.

Model 5, the model estimating area tomato plantings using the ratio of area tomato harvested to area tomato plantings, did not seem to have a significant explanatory presence. That is, in spite of being the model with more significant variables, some of the crucial dependent variables were insignificant, for example, lagged real wage, as well as the lagged ratio of area tomato harvested to area tomato plantings were insignificant. This model also had a lower R-Square then the other four models. However, the ratio of cucumber area harvest to cucumber area plantings was significant at a 5% significance level and with proper sign, but lagged pepper harvested over lagged pepper plantings was significant at a 10% significance level, but failed to have the proper sign.

4.2 Own Price

Real lagged tomato price had the proper sign and was robustly significant throughout the first four models, but insignificant in model 5. The parameter estimate in models # 1 to # 4 was of about 0.5 and the corresponding elasticity was of approximately 0.4 in models # 1 to # 4, and 0.3 for model # 5. The interpretation of these results indicate that an increase in lagged annual average Florida fob price of 55lb tomato crates is highly associated with an increase in current tomato area plantings.

4.3 Input Costs

Florida's lagged agricultural wage for vegetables and melons was used to proxy input costs for this study. Labor typically accounts for almost 80% of production costs for vegetables. The results show that the lagged agricultural wage has a robustly significant negative association with tomato plantings. The estimate for all models was approximately -1 for models # 1 to # 4, except model # 5. These results indicate that an increase in lagged annual Florida agricultural wage is associated with a decrease in current tomato plantings.

4.4 Population Influence

As a population pressure proxy, the lagged tomato producing region populations were taken into consideration. The results of these were insignificant for all models, except for model 5. The estimate in model 5 was -0.007, with a 1% level of significance. The negative sign in this result may be due to the fact that the urban development pressures crowded out land usually used for tomato plantings or overwhelmed any positive expected effects associated with an increase in the availability of labor.

4.5 Regional Effects

Only two of the four regions (regions II and III), one of them being part of the intercept, were robustly significantly different than region IV "the intercept," at a 10% level of significance. These two regions, which account for 54% of the historical tomato area plantings, are very close to each other, on the tip of the southern Floridian peninsula, where as Region I is in the east coast.

4.6 Structural Changes

One of the most interesting results of this study came from the structural change sensitivity of tomato plantings to the implementation of U.S.-Mexico Suspension Agreement. Only one of the two structural change dummy variables exploring these changes, Dref (Reference Price Dummy), was robustly significant at 10% level of significance in all models. Dref is a dummy variable that takes 1 for years in which a reference price, or price floor, was implemented to regulate Mexican tomato imports, and 0 otherwise. Namely, this variable observes the influence of the reference price on Floridian tomato area plantings, that is, the import regime of 1996-present. The insignificant dummy variable, the Post-NAFTA-Pre-Reference Dummy, takes 1 for the union of the post-NAFTA, pre-reference price period, namely 1994-95.

As we may observe from figure 4.1, during the reference price regime, vine ripe and roma tomato varieties were often binding (reaching the price floor) during the winter tomato seasonal weeks. Namely, the combined number of bindings of both varieties exceeds the 20th count out of 32 seasonal weeks. Hence, the reference price has been very active in our sample, which is corroborated by the positive and robust and result of Dref dummy. Part of the effect may be visually seen in figure 4.2.

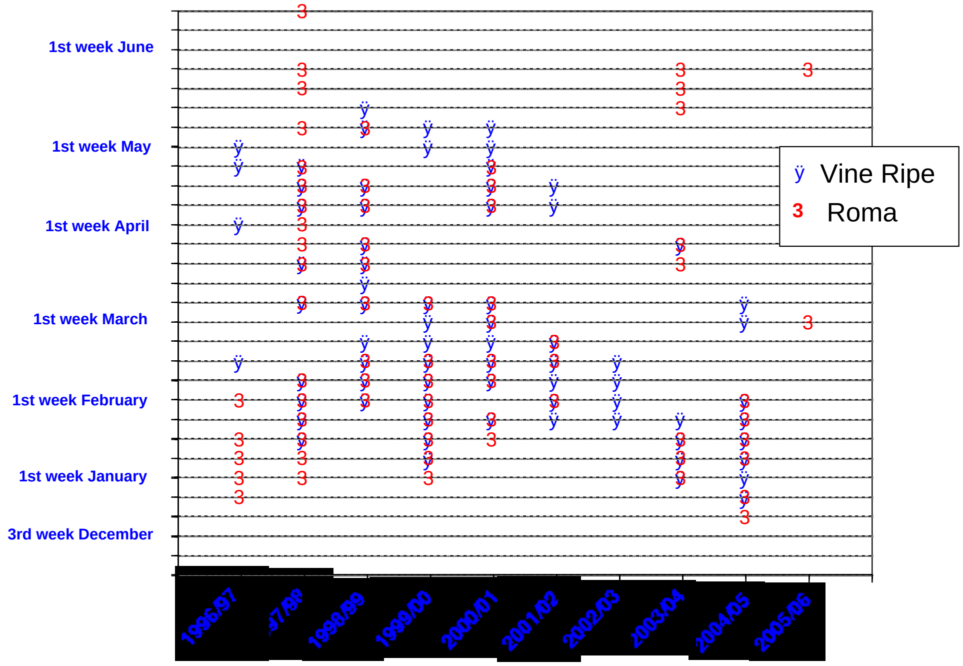

Figure 4.1 Weeks by Season of Binding Tomato Prices

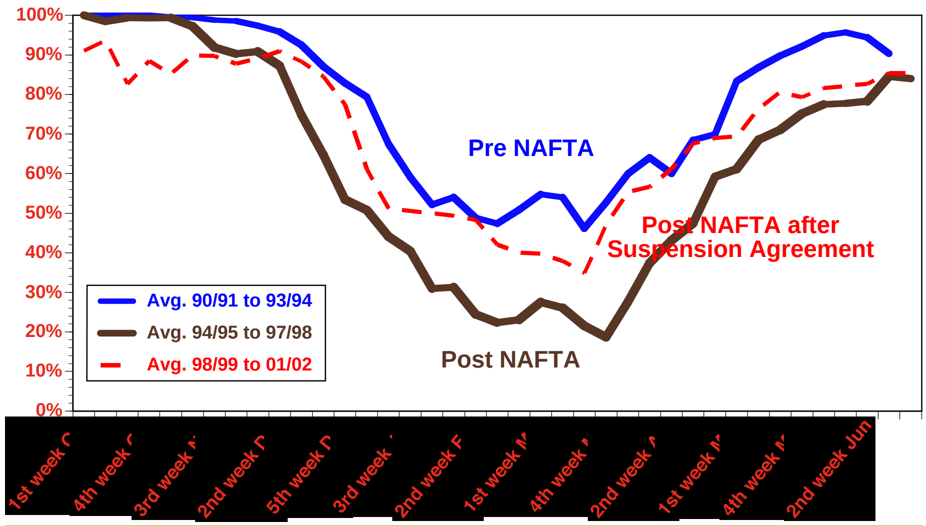

Figure 4.2 Market Share of Florida (Remainder Nogales)

Table 4.2: Estimated Yield for Florida Tomatoes, Panel Data

Dependent Variable	Expected Sign	Estimate
Intercept		-127.182* (42.946)
Time Trend	+	51.125* (5.708)
Real Tomato Price	+	0.039* (0.009)
Weather Proxy	+	0.052** (0.021)
Real Wage	-	-0.069* (0.012)
Region I		8.274 (44.444)
Region II		53.012 (39.342)
Region III		118.889* (39.345)
Sample Size		152
R-Square		0.90

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. Tomato yield is the dependent variable. Figures in parenthesis are estimated standard errors.

Shown in table 4.2 are the estimates of Florida tomato yield, where the results of a fixed effects model show the most import variables significant to a 5% level of significance, with an R-Squared of 0.90, and proper expected signs for all variables. These results reinforce the results in table 4.1, namely, that tomato yield is sensitive to input costs, own price, and weather. That is, the notion that tomato area decision-making process is associated with rational reactions to both market as well as weather changes.

CHAPTER 5

Summary and Conclusions

Using a balanced annual panel data set, the study probed some of the major factors that influence tomato area plantings of winter Floridian production. To this end, data was collected for competitive crop's area harvest and area plantings, own price, major tomato producing regional populations of Florida, and input cost (Florida Ag. Wage). The data came from the four major tomato producing regions of Florida **-** which given the structure of the U.S. winter tomato market, the data virtually translate into the major factors that may explain the U.S. winter tomato production.

A Hausman Test favored the use of a fixed effects model vs. random effects model, and five fixed effects models were estimated using the factors previously mentioned, which alluded to the following conclusions, policy and further research recommendations.

Conclusions:

- Adjusting for area specific effects, and other important factors, the statistical findings show that tomato area plantings are highly sensitive to the U.S.-Mexico Suspension Agreement. Namely, the results indicate that there is a significant positive association between U.S. winter tomato market share (illustrated in figure 4.2) and the implementation of Mexican tomato importing barriers.

- Regarding population pressures, the results are not very robust, safe for model 5 which indicates that lagged increases in populations of the major tomato producing regions are associated with a slight decrease in tomato area plantings.
- Increases in lagged state agricultural wages are robustly associated with a decrease tomato area plantings.
- Tomatoes have a big presence in the Floridian winter season, but the results seem to indicate significant competitive crop sensitivity.

Policy Recommendations and Further Research:

The study found evidence for governmental import regime sensitivity, but did not probe into the welfare effects of the U.S.-Mexico Suspension Agreement, a task that would make for an interesting extension of this study. Never the less, the results indicate that if the government finds it proper to increase the Floridian tomato area plantings, it would be highly probable to do so by restricting the Mexican winter tomato imports.

APPENDIX A

Regional Summary Statistics

Table A.1: Regional Summary Statistics

Variable	Mean	Std Dev	Minimum	Maximum
Region 1 tomato plantings in acres	18,157.36	8,564.06	7,400.00	38,970.00
Region 1 tomato harvest in acres	17,567.78	7,850.66	7,400.00	35,480.00
Region 1 tomato yield in 25lb cartons	872.31	536.83	96.46	1,812.00
Region 1 tomato production in 1000 cartons	11,317.88	5,188.58	3,060.88	21,395.00
Region 2 tomato plantings in acres	13,675.28	4,947.74	6,610.00	22,180.00
Region 2 tomato harvest in acres	13,388.19	4,911.91	6,550.00	21,850.00
Region 2 tomato yield in 25lb cartons	859.46	456.07	85.42	1,516.00
Region 2 tomato production in 1000 cartons	12,818.55	9,409.87	683.5	32,286.00
Region 3 tomato plantings in acres	11,875.28	6,445.81	525	25,850.00
Region 3 tomato harvest in acres	11,738.47	6,350.98	340	24,350.00
Region 3 tomato yield in 25lb cartons	932.95	545.76	109.38	1,895.00
Region 3 tomato production in 1000 cartons	13,534.57	9,181.30	85.94	26,122.00
Region 4 tomato plantings in acres	3,272.92	2,891.29	0	12,000.00
Region 4 tomato harvest in acres	3,167.78	2,680.63	0	11,760.00
Region 4 tomato yield in 25lb cartons	814.58	557.98	0	1,846.00
Region 4 tomato production in 1000 cartons	2,576.41	2,242.42	0	7,199.00
Region 1 pepper plantings in acres	6,178.47	1,867.37	2,500.00	8,950.00
Region 1 pepper harvest in acres	5,732.92	1,824.19	2,300.00	8,860.00
Region 1 pepper yield in 28lb bushels	683.91	360.18	239	1,641.00
Region 1 pepper production in 1000 bushels	4,194.64	2,496.51	820.5	10,116.00
Region 2 pepper plantings in acres	7,815.00	2,159.63	720	12,000.00
Region 2 pepper harvest in acres	7,330.83	2,096.35	450	11,400.00
Region 2 pepper yield in 28lb bushels	592.09	291.42	140	1,351.00
Region 2 pepper production in 1000 bushels	4,555.73	2,576.04	63	9,706.00
Region 3 pepper plantings in acres	5,795.14	3,018.33	2,750.00	21,300.00
Region 3 pepper harvest in acres	5,490.97	2,878.10	2,750.00	20,300.00
Region 3 pepper yield in 28lb bushels	361.32	138.27	223.5	760
Region 3 pepper production in 1000 bushels	2,103.24	1,922.16	1,129.40	12,130.00
Region 4 pepper plantings in acres	1,486.43	419.94	650	2,150.00
Region 4 pepper harvest in acres	1,394.57	403.94	500	2,070.00
Region 4 pepper yield in 28lb bushels	319.16	138.46	98	600
Region 4 pepper production in 1000 bushels	427.64	177.75	165	780
Region 1 cucumber plantings in acres	3,666.81	2,850.39	1,250.00	17,450.00

Table A.1: Continued

Variable	Mean	Std Dev	Minimum	Maximum
Region 1 cucumber harvest in acres	379.5	167.88	154.95	867.31
Region 1 cucumber yield in 55lb bushel	1,367.88	1,469.05	309.9	8,391.73
Region 1 cucumber production in 1000 bushels	1,293.27	1,388.92	293	7,934.00
Region 2 cucumber plantings in acres	5,759.58	1,992.62	2,050.00	9,800.00
Region 2 cucumber harvest in acres	5,355.00	1,836.58	2,000.00	9,400.00
Region 2 cucumber yield in 55lb bushel	368.14	164.52	107.88	761.54
Region 2 cucumber production in 1000 bushels	1,825.11	1,071.54	635.67	7,162.69
Region 3 cucumber plantings in acres	5,163.19	1,431.80	2,750.00	11,500.00
Region 3 cucumber harvest in acres	4,885.42	1,337.08	2,750.00	10,900.00
Region 3 cucumber yield in 55lb bushel	375.4	164.01	236.39	999.17
Region 3 cucumber production in 1000 bushels	1,787.75	798.59	1,194.56	5,358.00
Region 4 cucumber plantings in acres	1,492.36	421.45	650	2,150.00
Region 4 cucumber harvest in acres	1,398.89	404.77	500	2,070.00
Region 4 cucumber yield in 55lb bushel	334.31	159.12	103.65	825
Region 4 cucumber production in 1000 bushels	450.38	196.68	174.52	927.67
Mean annual wages for vegetables and melons	57.88	29.54	21.09	117.21
Region 1 population of all major tomato producing counties	3,492,004	1,150,293	1,726,088	5,415,348
Region 2 population of all major tomato producing counties	428,009	243,089	112,433	863,337
Region 3 population of all major tomato producing counties	1,080,889	330,601	601,472	1,624,672
Region 4 population of all major tomato producing counties	282,715	90,941	170,743	450,731
US PPI for Fresh & Dry Vegetables	87.83	34.4	35.7	144.4
Mean of state annual tomatoes prices in $ / cartons	88.51	38.99	27.12	148.4
Mean of state annual pepper prices in $ / bushel	47.87	19.39	18.03	88.54
Mean of state annual cucumber prices in $ / bushel	45.73	17.72	20.32	74.28

APPENDIX B

State Statistical Analysis

Table B.1 OLS Regressions of State Level Floridian Data on State Area Tomato Plantings.

Independent Variable	Expected Sign	OLS 1962-2006 Estimates	OLS 1962-1999 Estimates
Intercept		17553.21 (9737.119)	25239.51 (17576.4)
Lag-Tom Price	+	-0.1103514 (0.4293681)	0.6688961 (1.07633)
Lag-Tom Area Harvested	+	0.5979937* (0.1485035)	0.5888949* (0.1662733)
Lag-Cu Area Harvested	-	-0.3709599 (0.416558)	-0.2860305 (0.4708731)
Lag-Pep Area Harvested	-	0.8759631 (0.6625555)	0.8945477 (0.8209201)
Lag Real FL Ag. Wage	-	0.1477125 (0.1609491)	0.2388974 (2.259149)
Lag-Pop of FL Tom Prod Regions		-0.0006518 (0.000889)	-0.0022994 (0.0024274)
D-Reference Price	+	-4354.841 (4598.675)	-4461.633 (11060.25)
D-Post NAFTA, Pre-Ref	-	424.4943 (4540.755)	2194.141 (7373.214)

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. FL tomato area planted is the dependent variable. Figures in parenthesis are estimated standard errors.

Table B.2: Estimated Yield for Florida Tomatoes, State Level Data

Dependent Variable	Expected Sign	OLS 1962-99 Estimate	OLS 1962-06 Estimate
Intercept		122.972* (15.165)	131.929* (12.448)
Time Trend	+	7.23* (2.627)	5.402* (1.394)
Real Tomato Price	+	0.006 (0.004)	0.004*** (0.003)
Weather Proxy	+	0.386 (0.276)	0.171 (0.183)
Real Wage	-	-0.011*** (0.005)	-0.003* (0.001)
Sample Size		38	45
R-Squared		0.8	0.82

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. Tomato yield is the dependent variable. Figures in parenthesis are estimated standard errors.

APPENDIX C

SUR Model

Table C.1 Seemingly Unrelated Regression of The Four Major Tomato Producing Regions of Floridian on Regional Tomato Area Plantings.

Independent Variable	Expected Sign	RegionI Estimates	Region II Estimates	Region III Estimates	Region IV Estimates
Intercept		21440.52** (9851.4)	8590.955* (2923.572)	-12673.4** (6089.917)	4659.238 (5372.553)
Lag-Tom Price	+	0.005145 (0.500098)	-0.32788 (0.553971)	-0.49107 (0.461233)	0.001741 (0.397617)
Lag-Tom Area Harvested	+	0.59509* (0.161369)	0.530613* (0.121281)	0.588027* (0.134049)	0.574842* (0.108133)
Lag-Cu Area Harvested	-	-2.52878 (7.300566)	-1.03088* (0.338656)	1.043847 (0.765619)	-3.73516 (3.300884)
Lag-Pep Area Harvested	-	0.548372*** (0.30878)	-0.05624 (0.184725)	-0.97408* (0.35709)	2.471429 (3.208703)
Lag Real FL Ag. Wage	-	1.004581 (1.046261)	-0.61831 (1.076506)	-0.14538 (1.011287)	0.011023 (0.77307)
Lag-Pop of FL Tom Prod Reg		-0.00635*** (0.003473)	0.02767 (0.018303)	0.022906** (0.010832)	-0.00502 (0.032712)
D-Reference Price	+	-2482.92 (4734.069)	-4867.28 (4660.612)	-6702.24 (5223.758)	-272.425 (3293.861)
D-Post NAFTA, Pre-Ref	-	488.4018 (3138.109)	-449.623 (3330.275)	1523.53 (3150.568)	43.13478 (2238.511)

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. FL tomato area planted is the dependent variable. Figures in parenthesis are estimated standard errors.

Table C.2: Estimated Yield for Major Tomato Producing Regions of Florida by Region

Independent Variable	Expected Sign	Region 1 Estimate	Region 1 Estimate	Region 1 Estimate	Region 1 Estimate
Intercept		-86.286 (62.333)	-33.634 (52.87)	40.505 (76.386)	-158.878** (70.451)
Time Trend	+	45.616* (10.181)	56.227* (8.688)	47.568* (12.767)	38.171* (11.617)
Real Tomato Price	+	0.049* (0.016)	0.056* (0.015)	-0.024 (0.018)	0.065* (0.018)
Weather Proxy	+	0.063* (0.021)	0.101* (0.249)	-0.663*** (0.35)	-0.594*** (0.315)
Real Wage	-	-0.065* (0.02)	-0.12* (0.018)	0.028 (0.031)	-0.063** (0.024)
Sample Size		38	38	38	38
R-Squared		0.92	0.92	0.91	0.91

Note: * Significant at 1% level of significance, ** significant at 5% level of significance, *** significant at 10% level of significance. Tomato yield is the dependent variable. Figures in parenthesis are estimated standard errors.

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