Effect of Climate Change on Supply Response of Florida Citrus Crops 1980-2010

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Abstract

A supply response model for the highest valued citrus commodities in Florida is specified to analyze the impact of climate change on acreage and yield responses. Preliminary results suggest that temperature has an impact on the acreage and yield responses whereas precipitation did not have any impact.

Keywords: acreage response, climate change, error-correction model, supply response, yield response

JEL Classification: Q11, Q54

Introduction

Citrus industry in Florida includes the growing of fresh oranges and grapefruits. In terms of production, Florida accounts of 63 percents of total citrus production with 165.9 million boxes of citrus (USDA NASS, 2011). Most of the citrus production has been expanding in the last recent years. Prices, climate, and weather and others factors have an impact on citrus supply sector. Meanwhile, there are concerns about the impact of climate change on agriculture and many studies examined the climate variables on U.S crop yields and suitability of land for crop production (Adams et al.1990). Studies differ on the principle of the impact of climate on agriculture, for example, Deshenes and Greenstone (2007) highlighted that agriculture in the United States has benefited so far from the climate change; however Shelenker et al. (2006) justified the opposite. Quantifying the supply response of citrus in Florida is imperative to prevent the prices instability in order to form more an informed market.

Several studies estimated the supply response through two components: acreage and yield responses (Choi and Helmberger, 1993; Houck and Gallagher, 1976). In those studies, they estimated the impact of crop prices on corn yields. On the other hand, Huang et al (2010) added the climate variables in the analysis by estimating the impact of climate variable, technology and crop prices on crop yield and crop acreage in the US. Moreover, Boussiois et al (2012) estimated the impact of weather on Grain supply response in Kansas.

The purpose of this paper is to undertake a comprehensive analysis of the impact of potential climate change on supply response of highest valued citrus commodities in Florida using panel data methods from 1980-2010. Specifically, this paper estimates the yield and acreage responses of fresh oranges to output prices and to changes in climate and technology over time.

Most of the literature estimated the supply response for the following crops such wheat, soybean, corn, however up to my knowledge; no literature estimated the effect of climate change on the supply response of fresh oranges and grapefruits.

Literature Review

In the early studies, Shaw (1964) argued that there is no correlation between crop yield and climate factors. However this concept has changed through the development of the literature. Choi and Helmberger (1993) investigated the sensitivity of corn, wheat and soybean yields to price changes using time series from 1964 to1998. Thompson et al. (2005) studied the impact of the U.S. Department of Commerce suspension agreement which governs imports of fresh tomatoes from Mexico.

Inspiring by Choi and Helmberger (1993) paper, Huang et al (2010) rejected that hypothesis by developing a crop yield using a county level panel data. The yield model is a function of climate conditions, economics environment, technical progress, and farm land use changes. The results show that the high temperature will lead to a reduction in yields of wheat, corn and soybean while more precipitation on wheat yields are inclusive, however changes in precipitation could result to increase or decrease wheat yields. In addition, Asner (2003) justified this outcome by proving that one degree increase in growing season temperature leads to a decrease in corn and soybean yields.

From the methodology prospect, in the earliest studies, research estimated the effect of climate on agricultural crops by using the production function or hedonic approach. However, the drawback of the first method relies on the fact that the estimates do no account for the full range of compensatory responses to changes in weather made by profit-maximizing farmers.

In addition, the hedonic approach estimates the effect of climate on land value. However it would confound climate with other factors and the sign and magnitude of the resulting omitted variables bias is unknown. Deshenes and Greenstone (2007) proposed a new strategy to estimate the impact of climate change on the agricultural crops profit by exploiting the random year-to year variation in temperature and precipitation.

Moreover, Alston et al. (2012) developed a supply response in the Australian orange growing industry to analyze the impact of the price changes received by growers on tree numbers and production of oranges. Other literatures focused on modeling the perennial crop supply.

Method

Fresh Oranges and Grapefruits Acreage Model:

Following Choi and Helmburger (1993) and Huang (2010) models, the general form of Fresh Oranges and Grapefruits acreage:

$$Acreage_i = f\{PX_{t-i}, A_{t-i}, Climate_i, T_i, \varepsilon_i \} \quad (1)$$

Where $PX_{t-i}, A_{t-i}, Climate_i$, $and\ T_i$ are the independent variables sets representing the lagged own-price, lagged acreage, climate conditions, technology, and a constant. The climate variable includes the yearly mean temperatures and the yearly precipitation for the state of Florida. Time trends measure the progress of technology and describe any change in acreage due to unobservable factors that might change over time. A linear log model for estimation is implanted for an ease of interpretation (Choi and Helmburger, 1993; Deshenes and Greenstone, 2007).

Fresh orange Yield Model

The general form of fresh oranges yield model can be written as:

$$Yield_i = f\{PX_{t-i}, W_t, F_t, Climate_i, T_i\ , \varepsilon_i\ \} \quad (2)$$

Where $PX_{t-i}, W_t, F_t, Climate_i, T_i$ are the independent variables sets representing the own- price, wage rate, fertilizer price index, climate conditions, technical progress, and a constant. According to Thomspon et al (2005), the majority of supply response models for agricultural commodities are dependent on fixed lag structure in order to allow predicting the supply response.

Traboulsi et al. (2013) developed a strategy to solve the nonstationary time-series problem. A stationary time-series data constant mean, constant variance, and the covariance between two periods relies on the gap between the periods (Charemza and Deadman, 1992, p.118). The first step is to test the dependent variable for a unit root (if a time series is nonstationary) using the augmented Duckey-Fuller test (ADF). If data is stationary, the model is estimated with ordinary least squares (OLS) or with the Prais-Winsten transformation for first-order autocorrelation of the error term. A log likelihood ratio tests is performed to choose between the two estimators.

On the other hand, if the data is nonstationary, a test for conintegration is conducted: if this test is rejected, the model by the first difference is estimated, if the test is failed to reject, the model by error correction model (ECM) is estimated. It is to be noted that ordinary least square estimate captures the long-run relationships of the variables and the ECM captures the short-run dynamics (Traboulsi et al, 2013).

Table 1 presents the ADF test results for all the dependent variables. The results show a reject of unit root and thus non-stationary of the dependent cannot be rejected.

Table 1. Augmented Dickey Fuller Tests Results for Dependent Variables

	Acreage			Yield		
Crops	Test statistic	5% critical value	# of observations	Test statistic	5% critical value	# of observations
Fresh Oranges, 1980-2010	-0.987	-2.986	30	-3.681	-2.986	30
Grapefruits, 1980-2010	1.776	-2.986	30	-4.552	-2.986	30

Data and Descriptive Statistics

1980-2010 Annual Data on fresh oranges acreage (acres) and yield (short tons per acre) measures are obtained from the USDA National Agricultural Statistic Service (USDA/NASS). In addition, the prices of fresh orange and grapefruit are also obtained from NASS. The mean temperature and the level of precipitation data are obtained from the National Oceanic and Atmospheric Administration (NOAA).

Fertilizers Index prices data are obtained from Economic Research Statistic (ERS).

Results

The results of ordinary least squares (OLS) for acreage (fresh oranges and grapefruits) are presented in table 2.

Table 2. Conintegration Regression and Ordinary Least Squares Results

Explanatory variables	Fresh Oranges 1980-2010	Grapefruits 1980-2010
	Acreage	
Log own price, lagged	.171***	.047**
	(.037)	(.046)
Log acreage, lagged	.981***	1.046***
	(.048)	(.060)
Log Temperature	2.202**	-.892
	(.820)	(1.069)
Log Precipitation	-0.003	-.101
	(.065)	(.089)
Constant	-9.543**	4.147
	(3.492)	(4.532)
Time Trend	.002	-.002
	(.001)	(.002)

***indicates significance at .01; **indicates significance at .05; *indicates significance at .10

The ADF results for the residuals are reported in table 3. This test helps to indicating whether to estimate the model by ECM or first difference. If the test statistic is larger than the 5% level, then the unit root in the residuals is rejected and we can predict that the residual is stationary.

Table 3. Augmented Dickey Fuller Tests Results for Residuals of Cointegration Regression

	Acreage			Yield		
Crops	Test statistic	5% critical value	# of observa-tions	Test statistic	5% critical value	# of observa-tions
Fresh Oranges, 1980-2010	-6.345*	-2.989	20	n/a	n/a	n/a
Grapefruits, 1980-2010	-4.422*	-2.989	25	n/a	n/a	n/a

*Test indicates stationary residual indicating error correction mechanism is appropriate

Acreage and Yield Response

The long run own-price acreage elasticities of fresh oranges and grapefruits are positives and significant at 5% and 10% respectively. These elasticities show that 1% increase in price, fresh

oranges and grapefruits acreage will increase .17% and .05% respectively. The fresh oranges and grapefruits elasticities with lagged own-acreage are positive and statistically significant at least 5%. In other words, 1% increase in the own-acreage in the prior period will lead to increase of acreage in the current period by .98% and 1.05% for fresh oranges and grapefruits respectively. To measure the effect of climate change on acreage, the temperature has a positive effect on fresh oranges acreage. The results show that 1% increase in temperature will result an increase of fresh oranges acreage by 2.2%. On the other hand, precipitation didn't have any effect on fresh oranges and grapefruits acreages in the long run.

Table 3 presents the results of the short-run elasticities of acreage that are obtained from the ECM regressions. The short-run own-price acreage elasticitiy for fresh oranges is positive and statistically significant while that for grapefruits is not. It shows that the short run price adjustment for acreage of fresh oranges is .12%. The short-run elasticities of acreage with respect to the acreage change in the previous period acreage allocated to the crops are positives and statistically significant for fresh oranges and grapefruit. Fresh oranges acreage has the largest response. In addition, temperature has a positive effect on fresh oranges acreage. The results show that 1% increase in temperature, it will lead to 1.1% increase in fresh oranges acreage while it didn't have any effect on grapefruits acreage. None of the precipitations and time trends are statistically significant. The coefficient of the error correction model is negative and significant. It indicates that fresh oranges acreage returns to equilibrium immediately.

Table 3. Error Correction Model and First Differenced Model Results

Explanatory variables	Fresh Oranges 1980-2010	Grapefruits 1980-2010
	Acreage	
ΔLog own price, lagged	.117***	-0.025
	(.026)	(.026)
ΔLog acreage, lagged	1.068***	.607*
	(.151)	(.345)
ΔLog Temperature	1.079**	-.353
	(.466)	(.693)
ΔLog Precipitation	0.021	-0.051
	(.034)	(.060)
Constant	.004	-.014
	(.005)	(.015)
Residual, lagged	-1.134***	-.006
	(.395)	(.398)

The yield response equations for fresh oranges and grapefruits are presented in table 4. The coefficients of fresh oranges are mostly insignificant. The fertilizer price index is negative and statistically significant. All the coefficients of grapefruit yield response are significant except the precipitation. The own-price and time trend coefficients are positive, while the wages, fertilizer price index, coefficients are negative and significantly different from zero statistically. In addition, the coefficient of temperature for grapefruit yield per acre is negative and statistically significant indicating that 1%increase in temperature will decrease yield per acre by 2.9%.

Table 4. Prais-Winsten Autocorrelation

Explanatory variables	Fresh Oranges 1980-2010	Grapefruits 1980-2010
	Yield	
Log own price, lagged	.068	.118*
	(.109)	(.057)
Wages	3.863	-15.228*
	(10.473)	(8.627)
Log Fertilizer price	-.772**	-.983***
	(.307)	(.294)
Log Temperature	-1.331	-2.907*
	(1.994)	(1.584)
Log Precipitation	.192	.239
	(.217)	(.179)
Time Trend	.025	.0041***
	(.016)	(.0122)

Constant	13.521	22.776***
	(8.846)	(7.079)

***indicates significance at .01; **indicates significance at .05; *indicates significance at .10

Conclusion

This study estimated the effect of climate change on fresh oranges and grapefruits in the state of Florida by conducting an econometric analysis using a state level data from 1980 to 2010. The supply response is estimated by analyzing the acreage and the yield responses of fresh oranges and grapefruits using Prais-Winsten when appropriate and ECM otherwise.

The own-price responds positively on the fresh oranges acreage and grapefruits yield responses. Temperature has a positive impact on the acreage response of fresh oranges, whereas a negative on the grapefruits yield. An increase of global temperature will lead to an increase in fresh orange acreage. However, there was no significant impact of precipitation on the supply response.

Results of this study have important implication on the supply response of citrus production in Florida. It contributes to the estimation of the long run and short relationship in acreage and yield for fresh oranges and grapefruits. Moreover, it shows the importance of climate change on agricultural supply and how temperature can play a role in production shifting.

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