STRUCTURAL CHANGES IN U.S. COTTON SUPPLY RELATIONSHIPS

Donna Mitchell
John R. C. Robinson
Texas AgriLife Extension Service
Dept. of Agricultural Economics, Texas A&M University
College Station, Texas

Abstract

This paper is part of a larger project in involving spatial equilibrium modeling of U.S. cotton supply/demand flows. The U.S. is the third-largest producer of cotton in the world and, in recent years, has produced about 20 percent of the world's annual supply. This paper represents results from (1) econometric estimates of regional supply functions of U.S. cotton, (2) test results for structural changes in the U.S. cotton supply relationships, and (3) comparisons to more commonly used elasticities used for policy analysis, e.g., by FAPRI, aggregate supply/demand estimates.

Introduction

Texas is the number one cotton producing state in the United States. The U.S. is the third-largest producer of cotton in the world and, in recent years, has produced about 20 percent of the world's annual supply (USDA ERS, 1996). About one quarter of U. S. production is marketed to domestic mills for processing, while the remaining three quarters are shipped to international markets that are located throughout the world, but primarily in Asia (Robinson and McCorkle). Therefore, a significant majority of both U.S. and Texas cotton production is dependent on foreign markets that can only be accessed with long-haul transportation services. It follows that U.S. competitiveness in these distant foreign markets is partially influenced by the efficiency of the transportation and logistics network that links gins and compresses in U.S. production regions to foreign destination markets via inter-modal transfer facilities and the truck, rail and ship modes. Further, because the U.S. is the leading importer of textile products, the U.S. mills who are the buyers of one-third of U.S. cotton production, are in keen competition with foreign mills (Robinson, 2006). Therefore, transporting cotton to domestic mills in an efficient and timely manner is critical to enhance these processors' competitiveness. With volatile transportation costs, industries and manufactures may reduce outsourcing, increasing the amount of products made in the U.S. (Rohter).

The information presented in this paper will be developed into an economic model of the U.S. cotton transportation system. This tool will be used to conduct policy analysis to guide industry leaders and policy makers. For example, if the new farm bill and subsequent USDA regulations further alter the current system of storage cost reimbursement for loan cotton, this would have potential impacts on the flow of cotton (i.e., at least on the seasonal pattern of shipments). The objective of this project is to 1) econometrically estimate supply functions for the United States to be applied later to a spatial equilibrium model and 2) estimate structural changes in the United States cotton industry.

Methods and Procedures

Study Regions

To estimate U.S. cotton supply functions, homogeneous regions must be identified within the United States based on cotton production, cotton prices, corn production, and corn prices. The USDA's former statistical mapping system divided U.S. cotton production into four regions. The USDA's Southwest region included Arizona and California. The Southern Plains region included Oklahoma, and Texas. The Delta region included Arkansas, Louisiana, Mississippi, Missouri and Tennessee, and the Southeast region included Alabama, Georgia, North Carolina, and South Carolina (USDA ERS, 2007).

This paper has defines five regions for the United States very similar to the USDA regions described above. Region One includes North Carolina, Tennessee, and Virginia. Region Two includes Alabama Florida, Georgia and South Carolina. Region Three includes Arkansas, Louisiana, Mississippi, and Missouri. Region Four includes Kansas, Oklahoma, and Texas. Region Five includes Arizona, California, and New Mexico. These regional specifications were chosen for this paper because they appeared to better delineate different cotton production systems.

Model Specification and Data Development

A dual equation model was used to econometrically estimate United States cotton supply for the five U.S. regions established above. Equations 1 and 2 were defined as follows:

1.) $Yield_{t,r} = f(\Pr iceCotton_{t-1,} Yield_{t-1}, Weather_t)$

2.) $Acres_{t,r} = f(\Pr iceCotton_{t-1}, Acres_{t-1}, Policy_t, \Pr iceCompetingCrops_{t-1}, NetExpenses_{t-1})$

Regional cotton yield (Equation 1) was estimated as a function of a lagged price of cotton, lagged yield, and weather variables. Data from NASS estimates of regional yield and cotton price were used from 1979 to 2006 to represent lagged yield and the lagged price of cotton (USDA NASS, 1979-2007). The data for cotton yield and price was obtained by averaging the yield and price data from NASS for the states included in each respective region.

Weather is obviously an important variable determining for crop yield and production. For cotton, the key weather influences are soil moisture and temperatures at particular points in the planting/growing season. To explain variations in yield, we would ideally collect data on soil moisture at planting and various plant growth stages. However, such data are not available in an aggregate study. Previous research has employed rainfall and temperature data series from weather stations to represent the wider region. However, in this paper we approximated regional weather effects by simply indicating the occurrence of El Nino/La Nina phenomenon . ENSO (El Nino/Southern Oscillation) represents abnormal changes in the atmosphere due to oceanic events causing subsurface temperatures to change resulting in effects in weather patterns throughout the world, redistributing rain, causing floods, and droughts. The Southern Oscillation refers to an oscillation of subsurface temperatures. El Nino and La Nina are two extreme phases of the ENSO climate cycle (NOAA, 2001). El Nino occurs when there is an irregular warming of subsurface temperatures from Peru to Ecuador to the Pacific. Past El Nino occurrences were recorded in 1951, 1953, 1957-1958, 1965, 1969, 1972-1973, 1976, 1982-1983, 1986-1987, 1991-1992, 1994 and 1997 (Thomas, 2001).

The effects of El Nino results in less rain and mild conditions across the Northern United States and causes an increase in rain across the Southern part of the United States (Pena, 2008). La Nina represents a cooling of subsurface temperatures and was recorded in 1950, 1954, 1964, 1970, 1973, 1975, 1988, and 1995 (NOAA, 2001). La Nina causes warmer conditions and less rain across the Southern United States and more rainy conditions across the Northern United States (Pena, 2008). We would expect that El Nino conditions would generally result in more moisture and higher cotton yields in the relatively drier regions such as Region Four (Texas, Oklahoma, and Kansas). We would also expect La Nina years to result in more drought conditions and lower yields, *ceteris paribus*.

Harvested acres (Equation 2) was estimated as a function of lagged price of cotton, lagged acres, policy variables, lagged prices of competing crops and net expenses. Data for the lagged price of cotton, lagged acres, lagged price of corn and lagged price of soybean were taken from NASS Quickstats for the years 1979 to 2006 (USDA NASS, 1979-2007). Again, the data for acres and price was an average of the data for the individual states included in each region. The policy variables used were reflected as dummy variables for the years following the implementation of the 1981, 1985, 1990, 1996, 2002 farm bills. The USDA's Historic and Old Format Production Regional Cost and Return Data contain cotton farm budgets from 1975 to 1996. The cash expenses from the budget sheet were used to represent our Net Expenses for our regressions. The cash expense includes seed, fertilizer, chemicals, custom operations, fuel, lube and electricity, repairs, hired labor, ginning, and other variable expenses calculated from 1979 to 1996 (USDA ERS, 2008). Years 1997 to 2007 were forecasted numbers. Region One and Region Two regressions contain cash expense data from the Southeast. The regression for Region Three contains cash expense data from the USDA Delta region and Region Four contains cash expense data from the USDA Southern Plains region. The regression for Region Five contains cash expense data from The USDA Southwest region.

Equations 1 and 2 were estimated separately using ordinary least squares.

Results and Discussion

The regression for Yield in Region One has an F-Test of 1.971 and an R^2 of .255 and an $Rbar^2$ of .126. Yield t-1 is the significant variable. The elasticity at the mean for yield in Region One is .013. The F-test for Acres in Region One is 19.841 and has an R^2 of .921 and $Rbar^2$ of .875, which is a good fit. Significant variables are the 1990 and 1996 farm bills. The elasticity at the mean for Acres is .429. The total elasticity of supply in Region One is .442.

The regression for Yield in Region Two has an F-test of .496 and has an R^2 of .079 and an $Rbar^2$ of 0. The intercept shows to be the significant variable. The elasticity at the mean is .062. The regression for Acres in Region Two has an F-test of 25.217 and an R^2 of .937 and an $Rbar^2$ of 0.9. Lagged Price of Cotton and Lagged Acres are the significant variables. The elasticity at the mean is .675 giving a total elasticity of supply of .737.

The regression for Yield in Region Three shows an F-Test of 3.941 and an R^2 of .407 and $Rbar^2$ of .304. The elasticity at the mean is a -.213, so we will exclude the lagged price of cotton variable. This gives a significant variable of lagged yield. The regression for Acres shows an F-Test of 5.408 and has an R^2 of .761 and .620. There are no significant variables. The elasticity at the mean is .143.

The regression for Yield in Region Four shows an F-Test of 7.033 and has a R^2 of .550 and an $Rbar^2$ of .472. Lagged Yield is the significant variable. The elasticity at the mean is .028. The regression for Acres has an F-Test of 15.866 and has an R^2 of .903 and an $Rbar^2$ of .846. The significant variables include the intercept, and all of the policy variables. The elasticity at the mean for Acres is .262. The total elasticity of supply for Region Four is 0.29.

The regression for Yield in Region Five shows an F-Test of 9.802 and has an R^2 of .630 and an $Rbar^2$ of .566. The intercept, lagged yield, and the La Nina weather variable are significant. The elasticity at the mean is -.147. Since the elasticity at the mean is negative, we will take lagged cotton price out of the model which changes the F-Test to 12.413 and changes the R^2 to .608 and $Rbar^2$ of .559. The regression for Acres has an F-Test of 23.984 and has an R^2 of .923 and an $Rbar^2$ of .885. The significant variables are the intercept, lagged cotton and all of the policy variables. The elasticity at the mean for Acres is .645.

Table 1. Yield and Acres Regression Results.

Regression Results			
Region	**F-Test**	**R^2**	**$Rbar^2$**
Region 1:			
Yield	1.971	0.255	0.126
Acres	19.841	0.921	0.875
Region 2:			
Yield	0.496	0.079	0
Acres	25.217	0.937	0.9
Region 3:			
Yield	3.941	0.407	0.304
Acres	5.408	0.761	0.620
Region 4:			
Yield	7.033	0.550	0.472
Acres	15.866	0.903	0.846
Region 5:			
Yield	9.802	0.630	0.566
Acres	23.984	0.923	0.885

Table 1 shows the regression results for yield and acres in the five U.S. regions. In Regions One, Two, and Three the R^2 and $Rbar^2$ are very low for yield, suggesting a very poor fit. Region Four and Five have an R^2 and $Rbar^2$ that is comparatively better, but still low. The yield regression in Region Five has the best R^2 with a 0.630. The low R^2 numbers for Yield may be due to an unexplained variable that was not included in this regression. The regressions for Acres in Region One, Two, Four, Five have a very high R^2 and $Rbar^2$, suggesting very good fits. Region Three has an R^2 and $Rbar^2$ for Acres that is comparatively lower than the results from the other regions, but is still a good fit. The R^2 confirms that Acres is explained by the price, acreage, policy, and expense variables used in this regression.

Table 2. Yield Parameter Results

Econometric Parameter Estimation for Yield					
	Intercept	Cotton Price t-1	Yield t-1	El Nino	La Nina
Region 1:					
Beta	359.556	14.488	**0.447**	-21.546	-141.676
T-Test	1.396	0.051	2.136	-0.380	-1.342
P-Value	0.176	0.960	0.044	0.708	0.193
Region 2:					
Beta	**578.547**	65.504	0.011	17.322	-114.821
T-Test	2.809	0.301	.053	.340	-1.234
P-Value	.010	.766	.958	.737	.230
Region 3:					
Beta	480.053	-271.844	**.563**	32.954	-110.372
T-Test	1.838	-1.002	2.740	.612	-1.090
P-Value	.079	.327	.012	.546	.287
Region 4:					
Beta	127.607	22.292	**.755**	-54.262	-161.584
T-Test	.775	.103	4.041	-1.219	-2.004
P-Value	.446	.919	.001	.235	.057
Region 5:					
Beta	**634.506**	-251.801	**.583**	-49.457	**--164.483**
T-Test	2.171	-1.174	3.184	-1.377	-2.438
P-Value	.040	.252	.004	.182	.023

Table 2 shows the parameter results for Yield in each of the five regions. The beta, t-test and p-value are shown above. In Region One, Three, and Four lagged yield was the only significant value. In Region Two, the intercept was significant, and in Region Five, the intercept, lagged yield and the La Nina weather variable were significant.

Table 3. Acre Parameter Results

Econometric Parameter Estimation for Acres											
	Intercept	Cotton Price t-1	1981 Farm Bill	1985 FB	1990 FB	1996 FB	2002 FB	Acres t-1	Price Corn t-1	Price Soybeans t-1	Net Expenses
R1:											
Beta	137.767	245.606	-23.8	26.054	**164.690**	**220.781**	224.293	0.337	-46.58	-13.914	0.071
T-Test	0.472	1.302	-0.41	0.382	2.261	2.317	1.987	1.738	-0.802	-0.458	0.060
P-Value	0.643	0.210	0.682	0.707	0.037	0.033	0.063	0.100	0.434	0.653	0.953
R2:											
Beta	120.47	**424.77**	**0.781**	29.614	6.272	86.644	114.06	109.95	-81.20	-6.584	-0.321
T-Test	0.411	2.382	4.092	0.487	0.092	1.219	1.074	0.888	-1.251	-0.208	-0.278
P-Value	0.686	0.029	0.001	0.633	0.928	0.239	0.298	0.387	0.228	0.838	0.784
R3:											
Beta	470.56	181.08	-0.146	-167.94	-164.03	22.812	-203.03	-324.00	-146.9	22.830	1.942
T-Test	1.406	0.618	-0.472	-1.682	-1.470	0.142	-0.877	-1.069	-1.633	0.557	1.309
P-Value	0.178	0.545	0.643	0.111	0.160	0.889	0.392	0.300	0.121	0.585	0.208
R4:											
Beta	**3897.5**	886.67	-0.097	**-2328.2**	**-2706.6**	**-2629.5**	**-2955.4**	**-2838.6**	-456.5	86.930	4.191
T-Test	5.037	1.253	-0.868	-6.683	-5.555	-4.418	-3.647	-3.006	-1.908	0.943	0.696
P-Value	0.000	0.227	0.397	0.000	0.000	0.000	0.002	0.008	0.073	0.359	0.496
R5:											
Beta	**992.445**	**453.739**	-0.090	**-134.0**	**-229.70**	**-217.57**	**-290.93**	**-365.60**	-58.68	-0.706	**992.445**
T-Test	3.377	3.031	-0.531	-2.425	-2.915	-2.443	-2.339	-2.454	-1.498	-1.157	3.377
P-Value	0.003	0.007	0.602	0.026	0.009	0.025	0.031	0.025	0.151	0.262	0.003

Table 3 shows the parameter results for Acres in each of the five regions. The beta, t-test, and p-value are shown above. In Region One, the 1990 and 1996 farm bills were significant. In Region Two, lagged cotton price and the 1981 farm bill was significant. In Region Three, no variables were significant, and in Region Four, the intercept and all farm bills were significant. In Region Five, the intercept, lagged cotton price, 1985 to 2002 farm bills and the La Nina weather variable were significant.

Table 4. Regional U.S. Cotton Supply Elasticities, and Comparison with FAPRI Elasticities.

Cotton Elasticity of Supply Results				
Region	Yield Elasticity	Acreage Elasticity	Total Elasticity of Supply	FAPRI Elasticity
Region 1	0.013	0.429	0.442	0.076
Region 2	.062	.675	0.737	0.076
Region 3	---	.143	0.143	.131
Region 4	0.028	0.262	0.29	0.459
Region 5	---	.645	0.645	.670

Table 4 shows the yield and acreage elasticity results. The total elasticity of supply is obtained by adding the yield and acreage elasticities. For comparison purposes, FAPRI elasticity results for 2008 to 2017 are also shown in Table 2 (FAPRI, 2009). The Southeast region, which corresponds to our estimated elasticities in Regions One and Two, has a cotton elasticity of 0.076. FAPRI's Delta region, corresponds to our Region Three and has a cotton supply elasticity of .131. FAPRI's Southern Plains region, which compares to our Region Four, has a cotton elasticity of .459, while FAPRI's Far West region, which compares to our Region Five has a cotton supply elasticity of 0.670. The estimated elasticity results from this paper are very close to FAPRI generated results in Region Three and Five. The results in Region One and Two are very different from the FAPRI elasticities.

From the results in this dual equation model, we can conclude that the regression on Acres is explained very well by the variables used, but the regression on Yield is poorly explained. The regressions on Yield in all five regions did not have good fits. This may be due to model misspecification with an explanatory variable unaccounted for in the regression. One hypothesis is that boll weevil eradication adoption (not explicitly accounted for in the yield model) should be a significant determinant of cotton yield. Another possible improvement would be from including an explicit variable (or proxy) indicating the extent of adoption of newer, more productive cotton varieties. Lastly, Region Five had the only significant weather variable suggesting that ENSO did not sufficiently capture weather effects. In Region Four, one reason for the lack of significance of ENSO variables is the extent and influence of irrigated cotton acreage in Texas. The next step is to gather different weather data to re-estimate the yield regressions.

References

FAPRI Iowa State University. *Elasticities Database*. 2009. Retrieved on December 15, 2008 from http://www.fapri.iastate.edu/tools/elasticity.aspx.

NOAA. 2001. *Answers to La Nina Frequently Asked Questions*. Retrieved on November, 11, 2008 from http://www.elnino.noaa.gov/lanina_new_ faq.html?loc=interstitialskip.

Pena, Jose G. *The Continuing Drought in Southwest Texas Will Make 2008 a Difficult Year for Agriculture And Require Special Planning for 2009*. Ag Eco News. Vol. 24, Issue 31. December 2008.

Robinson, J.R.C, J. Park, S. Fuller. *Cotton Transportation and Logistics: A Dynamic System*. 2006. Accessed 11/20/08 at http://agecon2.tamu.edu/people/faculty/robinson-john/.

Robinson, J. R. C. and D. A. McCorkle. 2006. *Trends and Prospects for Texas Cotton*. *Texas: Connecting the Old West to the New East.* Cotton Outlook. May, 2006. http://agecon2.tamu.edu/people/faculty/robinson-john/Cotlookarticle.pdf accessed 11/20/08.

Thomas, Ray G. *ENSO Learning Module*. 2000. Retrieved on November 11, 2008 from http://ess.geology.ufl.edu/usra_esse/El_Nino.html

USDA ERS. *Old Production Regions*. Oct. 2007. Accessed 12-17-2008 from: http://www.ers.usda.gov/Data/CostsAndReturns/oldregions.htm#cotton

USDA ERS. *Commodity Costs and Returns: U.S. and Regional Cost and Return Data*. Nov. 2008. Accessed on 12-17-2008 from: http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm

USDA ERS. Summary of Report: Cotton Acreage Gains of Past Decade. July 1996. Accessed on August 15, 2008 from: http://www.ers.usda.gov/Publications/Summaries/cotton.htm

USDA National Agricultural Statistics Service. 1979. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1980. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1981. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1982. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1983. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1984. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1985. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1986. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1987. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1988. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1989. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1990. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/.

---. 1991. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1992. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1993. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1994. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1995. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1996. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1997. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1998. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 1999. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2000. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2001. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2002. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2003. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2004. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2005. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2006. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/

---. 2007. *Texas Data-Crops*. Retrieved December 1,2008 from. http://www.nass.usda.gov/QuickStats/