STRUCTURAL CHANGES IN U.S. COTTON SUPPLY

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Abstract

Recent droughts have caused policy makers to implement water use restrictions in some areas, causing shifts out of irrigated cotton production. With the passage of the 2014 Farm Bill, cotton lint is no longer considered a program crop, and producers will now have to rely on using additional crop insurance for protection. Low cotton prices coupled with lack of domestic policies could negatively impact the amount of acreage dedicated to cotton production. Cotton supply functions were estimated to determine if structural changes exist.

Introduction

The U.S. is the third-largest producer of cotton in the world following China and India and the world's largest exporter (USDA ERS, 2014). U.S. cotton production is obviously influenced by both technological improvements and natural phenomenon (i.e., weather). Of particular note have been boll weevil eradication programs, adoption of new varieties, and recent ENSO-related weather patterns including both extreme droughts (circa 2011) and optimal moisture (circa 2007, 2010). These influences have been hypothesized to be interactive supply shifters, but their effects have not been separated and quantified (e.g., McCorkle et al., 2010). Besides productivity influences, there have been other variables affecting U.S. cotton production. Recent droughts have caused policy makers to implement water use restrictions in some areas, causing shifts out of irrigated cotton production. With the passage of the 2014 Farm Bill, cotton lint is no longer considered a program crop, and producers will now have to rely on using additional crop insurance for protection. Low cotton prices coupled with lack of domestic policies could negatively impact the amount of acreage dedicated to cotton production.

The objective of this paper is to develop regional cotton supply functions by econometrically estimating yield and acreage equations. The results will be tested for structural changes in U.S. cotton supply relationships.

Materials and Methods

This paper has defined five cotton producing regions for the United States very similar to the USDA Farm Resource Regions (USDA ERS, 2000). Regional specifications were chosen for this paper to better delineate different cotton production systems. Figure 1 is a map of the regions. 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.

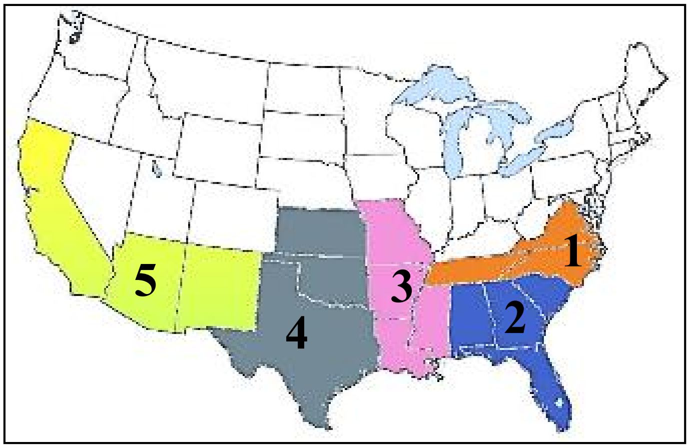

Figure 1. Map of Region

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 are defined as follows:

1.) $Yield_{t,r} = f(Yield_{t-1}, BWE, Variety_t, Weather_t)$

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

Regional cotton yield (Equation 1) was estimated as a function of a lagged cotton yield, a boll weevil eradication indicator variable, varietal adoption, and weather variables. Harvested acres (Equation 2) was estimated as a function of lagged acres, lagged price of cotton, policy variables, lagged prices of competing crops, and lagged net expenses.

Data from NASS estimates of yield, crop prices, and acreage were used from 1980 to 2014 (USDA NASS, 1980-2014). The data was averaged for each state included in each respective region. Figures 2-11 provide the historical cotton yield and acreage for each region. The USDA's Historic and Old Format Production Regional Cost and Return Data contain cotton farm budgets from 1975 to 1996. Net expenses from the budget sheets were used in the regressions. The cash expenses include seed, fertilizer, chemicals, custom operations, fuel, lube and electricity, repairs, hired labor, ginning, and other variable expenses (USDA ERS, 2008). Data from 1980 to 1996 were used from the USDA budgets and 1997 to 2014 were forecasted numbers. Region One and Region Two regressions contain net expense data from the Southeast. The regression for Region Three contains net expense data from the USDA Delta region and Region Four contains net expense data from the USDA Southern Plains region. The regression for Region Five contains data from the USDA Southwest region.

Weather is obviously an important variable determining for crop yield and production. For cotton, the key weather influences are soil moisture and temperature 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. Rainfall and temperature data from weather stations will be used to represent the wider region. We will also approximate 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. El Niño and La Nina will be represented by a dummy variable.

Historical weather station observations were collected from NOAA (NCDC Data Online, 2015). Monthly averages for May, June, and July for precipitation (PRCP), and average daily temperature was used in the yield regressions. In Region One, weather station observations for Brownsville, TN, Roanoke Rapids, NC, and Norfolk, VA were averaged to derive monthly estimates. In Region Two, weather station observations for Huntsville, AL, Tallahassee, FL, Albany, GA, and Columbia, SC were averaged to form monthly estimates. Region Three included observations from Jackson, MS, Little Rock, AR, and Springfield, MO. Weather data from Lubbock, TX was used in Region Four. Region Five included weather station data from Bakersfield and Fresno CA. Climate variability was included in the analysis through the use of dummy variables to represent El Nino and La Nina events in the yield and acreage regressions.

The effect of cotton seed varieties were also used to estimate yield with data collected from the Agricultural Marketing Service (AMS) *Cotton Varieties Planted* publications from 1999-2015. The time series data used in this project's regressions include the percentages of newer varieties that have contribute to recent increases in yield. Variety information for 2010, 2013, and 2014 were missing, so those values were imputed. The AMS has four growth areas: the Southeast (which includes Alabama, Florida, Georgia, North Carolina, South Carolina, and Virginia), South Central (which includes Arkansas, Louisiana, Mississippi, Missouri, and Tennessee), Southwest (which includes Texas, Oklahoma, and Kansas) and the West (which includes Arizona, California, and New Mexico).

Region One and Region Two use the AMS data from the Southeast. The most popular variety from these regions that has made a significant impact on yield is the Deltapine Boll Guard/Round-up Ready strains that emerged in 2003 and phased out in 2010. The AMS data for the South Central was used to calculate the percentages in Region 3. The Deltapine Boll Guard/ Round-up Ready (B/RR) varieties were most used in this region beginning in 1999 and ending in 2009. The AMS Southwest region was used in Region Four to determine the effect of the popular Fibermax strain. AMS has variety data for Fibermax starting in 2001 and continues to be used. The AMS west growth region is used in Region Five. The variety captured in the regression for this region is Deltapine Boll Guard/ Round-up Ready, which began use in 2000 and lasted until 2010.

A dummy variable was used to represent the effect of boll weevil eradication on yield and acreage in each region. Boll weevil eradication began in 1987 in Regions One, Two, and Five, 2008 in Region Three, and 1994 in Region Four. The policy variables were dummy variables for the years following the implementation of the 1981, 1985, 1990, 1996, 2002, and 2008 farm bills.

Results and Discussion

Parameter estimates of the yield and acreage regressions are shown in Tables 1 and 2. The regression measures of fit are shown in Table 3. Final yield regressions were a function of lagged yield, BWE, crop varieties, precipitation and temperature. El Niño and La Nina was removed from the regressions for possible correlations with the weather variables. Final acreage regressions were a function of lagged cotton acreage, lagged cotton price, lagged prices of soybeans and corn, lagged net expenses, and policy variables.

The region one yield regression had lagged yield, crop variety, July rainfall, and July precipitation as significant variables with an R^2 of 0.73. In the region one acreage regression, lagged cotton acreage, lag cotton price, lag soybean price, and the 1990, 2002, 2008 farm bills were significant with an R^2 of 0.89. The region two regression on yield had no significant variables and the lagged price of cotton, lagged price of soybeans and the 2008 farm bill had significant impacts on acreage. The R^2 for yield and acreage were 0.32 and 0.94, respectively. Region three BWE, July rainfall and July temperatures had significant impact on yield and the lagged price of soybeans was significant on acreage. The R^2 for each equation was 0.77 and 0.82. In region 4, BWE, crop varieties, and July temperature had significant impacts on yield. These results provide some of the first evidence of separate effects of BWE, varietal and weather influences. The yield regression had an R^2 of 0.97. In the region four acreage regression, lagged acreage, lagged corn prices, and all farm bill dummies had significant impacts. The regression had an R^2 of 0.61. Region five BWE, variety, and June temperatures had significant impacts on yield and the lagged price of cotton and all policy variables were significant for acreage. The R^2 of the yield and acreage regressions were 0.85 and 0.90, respectively.

Table 1. Regional Yield Results

	Intercept	**Lag Yield**	**BWE**	**Variety**	**May PRCP**	**May AVG**	**June PRCP**	**June AVG**	**July PRCP**	**July AVG**
Region 1:										
Beta	-471.70	**0.36**	-12.03	**2.54**	-0.6	4.4	10.85	5.69	**41.84**	**-1.15**
S.E.	842.01	0.15	60.39	0.84	10.47	8.86	12.82	10.73	12.53	0.32
T-test	-0.56	2.45	-0.2	3.01	-0.06	0.5	0.85	0.53	3.34	-3.6
Region 2:										
Beta	519.42	0.21	19.81	0.76	9.04	14.92	7.34	17.57	0.35	-31.28
S.E.	1770.76	0.19	62.71	1.01	14.87	12.03	10.38	14.80	11.50	20.25
t-test	0.29	1.11	0.32	0.75	0.61	1.24	0.71	1.19	0.03	-1.54
Region 3:										
Beta	2769.53	0.22	**210.78**	2.57	-13.86	12.04	-9.03	2.77	**-31.61**	**-37.55**
S.E.	1388.11	0.18	78.69	1.28	11.82	8.49	13.56	12.17	13.90	11.03
t-test	2.00	1.19	2.68	2.01	-1.17	1.42	-0.67	0.23	-2.27	-3.40
Region 4:										
Beta	1251.20	0.05	**106.57**	**5.07**	2.77	2.54	-6.99	2.55	7.91	**-16.22**
S.E.	725.71	0.17	30.84	1.45	7.26	5.39	10.71	6.54	9.32	7.62
t-test	1.72	0.29	3.46	3.49	0.38	0.47	-0.65	0.39	0.85	-2.13
Region 5:										
Beta	126.20	0.11	**103.32**	**11.59**	-5.21	4.36	0.65	**15.07**	-75.94	-8.94
S.E.	677.75	0.21	35.53	3.12	4.23	6.22	4.60	5.66	54.23	5.29
t-test	0.19	0.53	2.91	3.72	-1.23	0.70	0.14	2.66	-1.40	-1.69

Table 2. Regional Acreage Results

	Intercept	**Lag Cotton Acreage**	**Lag Cotton Price**	**Lag Price Corn**	**Lag Price Soybeans**	**Lag Net Expenses**	**1981 FB**	**1985 FB**	**1990 FB**	**1996 FB**	**2002 FB**	**2008 FB**
Region 1:												
Beta	545.96	**0.44**	**1001.09**	0.00	**-103.56**	-1.06	-7.25	136.04	449.05	**608.65**	**675.69**	**823.62**
S.E.	461.24	0.18	447.42	0.00	30.99	1.98	211.20	217.29	234.18	277.64	302.04	273.06
t-test	1.18	2.51	2.24	0.00	-3.34	-0.54	-0.03	0.63	1.92	2.19	2.24	3.02
Region 2:												
Beta	2329.69	**0.70**	**1363.80**	-93.55	**-194.35**	-3.96	370.74	-96.01	-83.35	193.91	208.78	**686.08**
S.E.	998.98	0.14	433.97	106.92	73.13	2.66	259.26	252.89	306.58	365.76	346.14	304.33
t-test	2.33	5.10	3.14	-0.87	-2.66	-1.49	1.43	-0.38	-0.27	0.53	0.60	2.25
Region 3:												
Beta	**2985.60**	199.80	1615.14	0.00	**-242.86**	1.41	-825.41	-444.47	419.39	-4.23	-163.69	-723.45
S.E.	1274.34	1026.12	968.98	0.00	98.72	4.23	870.69	835.49	941.56	1070.63	1073.58	1166.34
t-test	2.34	0.19	1.67	0.00	-2.46	0.33	-0.95	-0.53	0.45	0.00	-0.15	-0.62
Region 4:												
Beta	**10476.45**	**-0.37**	1360.07	**-679.93**	0.00	12.61	**-4389.25**	**-5138.38**	**-4744.75**	**-6156.97**	**-5761.50**	**-5811.72**
S.E.	1955.51	0.16	1862.98	242.22	0.00	12.92	982.22	1187.56	1397.32	1839.55	2010.47	2327.64
t-test	5.36	-2.31	0.73	-2.81	0.00	0.98	-4.47	-4.33	-3.40	-3.35	-2.87	-2.50
Region 5:												
Beta	**2697.02**	0.03	**858.67**	-106.29	0.00	-1.69	**-436.67**	**-627.58**	**-623.70**	**-932.12**	**-1093.53**	**-1245.71**
S.E.	737.82	0.16	324.38	60.31	0.00	1.37	195.05	226.70	240.89	296.73	375.11	402.22
t-test	3.66	0.19	2.65	-1.76	0.00	-1.23	-2.24	-2.77	-2.59	-3.14	-2.92	-3.10

Table 3. Yield and Acreage Regression Measures of Fit

	R^2	**$Rbar^2$**
Region 1:		
Yield	0.726	0.623
Acreage	0.887	0.838
Region 2:		
Yield	0.321	0.066
Acreage	0.941	0.911
Region 3:		
Yield	0.767	0.680
Acreage	0.824	0.747
Region 4:		
Yield	0.968	0.826
Acreage	0.614	0.446
Region 5:		
Yield	0.851	0.773
Acreage	0.940	0.915

Summary

Increasing drought and low cotton prices, coupled with a lack of policy support, may cause farmers to face limitations in their crop choice. To extend cotton production, this research has Conversion to dryland is a likely outcome in some areas of the Southern Great Plains, causing farmers to switch to sorghum, wheat, and integrated livestock systems. We have created cotton supply functions to identify long-term shifts in cotton production. Our results have shown that some models have better fit and performance than others. The regressions on acreage had higher R^2 than the yield regressions. Region 2 yield had a poor fit with an R^2 of 0.321. Region 4 acreage performed the worst with an R^2 of 0.614. Region 4 yield had the best yield performance with an R^2 of 0.968. This research will help to identify key variables in cotton supply by separating out the effects of boll weevil eradication, cotton varieties, and weather.

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