The Comparative Advantage of Upland Cotton Production in Texas

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ABSTRACT

This paper uses Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) to explore the relative yield, scale and overall advantage of upland cotton production by comparing different states of the U.S. and different districts of Texas. The study reveals that the comparative advantage in main upland cotton varies significantly across the U.S. and Texas.

KEYWORDS: **Comparative Advantage, Cotton.**

Texas leads the nation in cotton production and produces about 25 percent of the nation's cotton. Cotton is the top cash crop in Texas, generating $1.6 billion annually for farmers. The crop has a statewide economic impact of $5.2 billion, including money generated by supporting industries associated with harvesting, transporting, processing, and marketing cotton. Cotton ranks third behind the beef and nursery industries, making up 8 percent of all of the state's agricultural cash receipts, according to Texas Agricultural Statistics in 2003 (NASS, 2005).

In 2004, Texas cotton producers harvested a record 7.5 million bales on approximately 5.8 million acres. The previous record crop was in 1949 when 6 million bales were produced on 20 million acres. Upland cotton, the most common type of cotton grown, accounted for over 99 percent of the production (NASS, 2005). Modern technology played a major role in the record crop. Productivity in cotton production increased dramatically over the past few decades. Increased use of fertilizers, improved pest management, and improved cultivars have contributed to the enhancement. Currently, cotton production is facing challenges, such as increasing costs of production, shortage of irrigation water, and increased public concern on the negative impacts of agricultural production on the environment.

When comparing Texas cotton production to other cotton production regions in the nation, there are significant differences in yield and production costs. Many factors, such as weather, water, soil, topography, labor and other input costs, management practices, etc., have contributed to the disparities among different regions. The primary objective of this study is to evaluate the comparative advantage of upland cotton production in U.S. and in Texas.

Several previous studies have evaluated the comparative advantage in agricultural production. Pearson and Meyer (1973) evaluated comparative advantages of the four main coffee growing countries in Africa. The focus of the study was to calculate the domestic resource cost per unit of foreign exchange earned or saved (DRC). The study found that Uganda, Ethiopia, and Tanzania all had strong comparative advantages in coffee production with very little deviation among each country's respective indices. The Ivory Coast was found to be reasonably weaker in competition compared to the other three countries. External factors for this country were the primary reason for its disadvantage. This study was one of the first to attempt to tackle the complexity of comparative advantages among regions or countries. Its scope was relatively small, and resulted in a need for more data collection among a larger scope of producing regions.

Zhong et al. (2000) studied the comparative advantages in grain production across different regions of China. Several indicators, which includes: Net Social Profitability (NSP), Domestic Resource Cost (DRC) which are both used to measure price advantages or disadvantages, and Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregated Advantage Index (AAI) were used in the study. The study found that advantages in main grain crops were varied across different regions in China, and there is a potential to improve grain production efficiency in China through the reallocation of natural resources and restructuring of the grain sector. The study concluded that China can still compete with the rest of the world in grain production even if as a whole, the country was at a disadvantage in a particular crop production.

These are the earlier studies about the advantage in a specific crop production. However, there is no research that has studied the comparative advantage in cotton production.

MATERIALS AND METHODS

This study employs a set of indicators, which include the Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) to measure the relative yield and scale advantage of upland cotton production in Texas.

EAI is an indication of how efficiently a crop grows in one specific region. It is calculated by using the relative yield of one crop in one region related to the average yield of all crops in the same region to the yield of same crop in the nation related to the average yield of all crops in the nation. EAI can be expressed following:

$$EAI_{ij} = \frac{\mathrm{Y_{ij}} / \mathrm{Y_i}}{\mathrm{Y_{nj}} / \mathrm{Y_n}} \qquad (1)$$

where, EAI_{ij} represents the Efficiency Advantage Index of the *j*th crop growing in the *i*th region; Y_{ij} is the yield of the *j*th crop in the *i*th region; Y_i represents the average yield of all crops in the *i*th region; Y_{nj} is the national average yield of the *j*th crop; and Y_n is the national average yield of all crops. If $EAI_{ij} > 1$, then the yield of the *j*th crop in the *i*th region, relative to all other crops' yield growing in the same region is higher than that of the national average. It can be interpreted as in the *i*th region; there is a yield or an efficiency advantage in growing the *j*th crop. If $EAI_{ij} < 1$, then the yield of the *j*th crop in the *i*th region, relative to all other crops' yield growing in the same region, is lower than that of the national average. It can be interpreted as in the *i*th region; there is no yield or efficiency advantage in growing the *i*th crop. By assuming a competitive market structure and no significant barriers for technology diffusion and adoption in agricultural production in the country, the EAI_{ij} can be taken as an indicator of relative efficiency due to natural resource endowments and other local economic, social and cultural factors.

The SAI indicates the extent of concentration of a certain crop growing in a region, relative to that ratio of same crop growing in the nation. It can be expressed as following.

$$SAI_{ij} = \frac{S_{ij}/S_i}{S_{nj}/S_n} \tag{2}$$

where, SAI_{ij} is the Scale Advantage Index of the *j*th crop in the *i*th region; S_{ij} represents the planted area of the *j*th crop in the *i*th region; S_i is the total planted area of all crops in the *i*th region; S_{nj} is the total planted area of the *j*th crop in the nation; and S_n represents the total planted area of all crops in the nation. If $SAI_{ij} > 1$, it implies the degree of concentration of the *j*th crop growing in the *i*th region is higher than average concentration ratio in the nation. It also indicates that producers in the *i*th region prefer to grow more *j*th crop, compared to other producers in the nation. If $SAI_{ij} < 1$, the degree of concentration of the *j*th crop growing in the *i*th region is lower than that average ratio in the nation. It indicates that producers in the *i*th region prefer to grow less *j*th crop, compared to other producers in the nation.

Assuming a competitive market structure and that producer can quickly adjust the crop mix by responding to the market price and cost changes, the concentration level is determined by economic factors or the profit level of certain crop growth in the region. For example, a low value of SAI implies producers do not want to increase the share of that crop production in the region because it is less profitable or restricted by natural (or other) conditions, while a high value of SAI implies producers want to increase the share of that crop production in the region.

The AAI is an aggregate indication of the overall comparative advantage of a certain crop in one region relative to the national average. It can be calculated as the geometric average of the EAI and SAI.

$$AAI_{ij} = \sqrt{EAI_{ij} * SAI_{ij}} \tag{3}$$

If $AAI_{ij} > 1$, then the *j*th crop in the *i*th region is considered to have a overall comparative advantage over the national average while $AAI_{ij} < 1$ indicates *j*th crop in the *i*th region does not have a overall comparative advantage over the national average.

The crop that will be studied in this research is upland cotton. The 2003 cotton and other crops' yields and production data are used in calculating the three indices. The primary source of data for this study is from the National Agricultural Statistics Service (NASS) at the United States Department of Agriculture (USDA), which include states' data in the United States and districts' data in Texas.

RESULTS AND DISCUSSIONS

1. Comparative advantage in upland cotton in the United States

Table 1 shows the summary of the calculation of comparative advantages for upland cotton in states of the United States. There are 13 major states that grew over 13 million acres of upland cotton in 2003. Texas leads the nation in upland cotton production, which accounted for over 43% of the production in 2003. Georgia ranked second in the nation and accounted for 10.01% of the production. There are 5 states (Texas, Georgia, Mississippi, Arkansas, and North Carolina) where the planted acres exceed 5% of the national total and hence these are referred to as major producing states. California led the nation in average yield per acre (1317 pounds per acre) in 2003. Arizona ranked second with an average yield of 1239 pounds per acre. The average yield of Texas upland ranked last in the nation at 478 pounds per acre, compared to 723 pounds per acre average in the nation.

Using the formula (1) to (3) above, Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) were calculated for 13 states and listed in Table 1.

Table 1. Comparative Advantage of Upland Cotton Production in Different States.

States	Share of Planted Acres (%)	Yield (lbs/acre)	EAI	SAI	AAI
Alabama (AL)	4.05	772	1.03	1.68	1.32
Arizona (AZ)	1.66	1239	0.95	1.90	1.35
Arkansas (AR)	7.55	916	0.88	0.81	0.84
Califonia (CA)	4.23	1317	1.46	0.90	1.14
Georgia (GA)	10.01	785	1.22	2.30	1.68
Louisiana (LA)	4.05	967	0.99	1.16	1.07
Mississippi (MS)	8.55	934	0.91	1.70	1.25
Missouri (MO)	3.08	862	1.02	0.19	0.44
North Carolina (NC)	6.24	646	1.10	1.17	1.13
Oklahoma (OK)	1.39	616	1.18	0.11	0.36
South Caralina (SC)	1.70	718	1.21	0.83	1.00
Tennessee (TN)	4.32	806	0.85	0.75	0.80
Texas (TX)	43.16	478	0.65	1.54	1.00
US	100.00	723	1.00	1.00	1.00

Figure 1 lists the Efficiency Advantage Index (EAI) of upland cotton production among 13 production states in 2003. It can be seen that California had the highest efficiency in producing upland cotton with an EAI of 1.46. Georgia ranked second with EAI 1.22. Texas had the lowest efficiency (EAI equals 0.65) in producing upland cotton, comparing to other states in the nation. This is because most cotton produced in Texas was dry-land cotton, which has a relatively low yield.

Figure 2 lists the Scale Advantage Index (SAI) of upland cotton production among 13 production states in the nation in 2003. Georgia led the nation with highest scale advantage, i.e., SAI equals 2.30. Other states that had scale advantages were Arizona 1.90, Mississippi 1.70, Alabama 1.68, Texas 1.54, North Carolina 1.17, and Louisiana 1.16. For the rest of seven states the scale efficiency was less than 1. In Missouri and Oklahoma, the EAI was only 0.19 and 0.11, respectively, which means both states had relatively small scale upland cotton production. Most of the cotton production practices in these states were similar to other southern states.

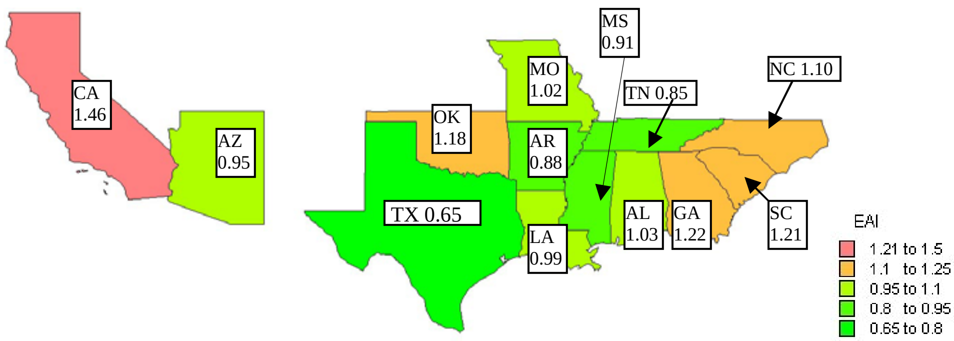

Figure 1. The Efficiency Advantage Index (EAI) of Upland Cotton Production among Major Production States, 2003.

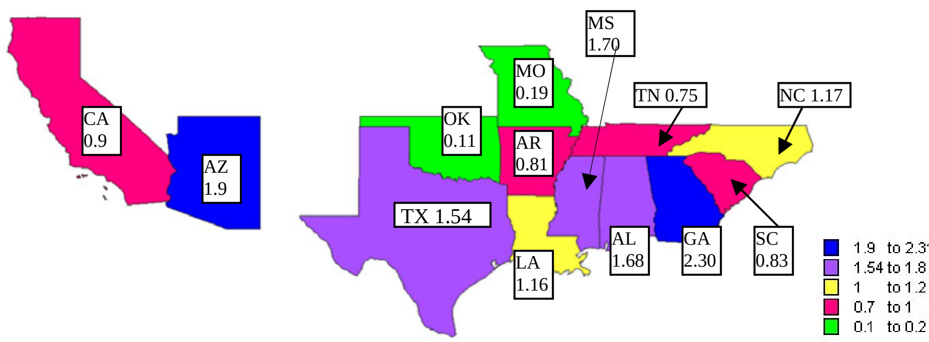

Figure 2. The Scale Advantage Index (SAI) of Upland Cotton Production among Major Production States, 2003.

Figure 3 indicates the Aggregate Advantage Index (AAI) of upland cotton production among the thirteen production states. Georgia has the highest overall efficiency in producing upland cotton compared to other states in 2003 with AAI equals 1.69. Other states that led the nation in AAI were Arizona 1.35, Alabama 1.32, California 1.14, North Carolina 1.23, Mississippi 1.25, Louisiana 1.07, South Carolina 1.00 and Texas 1.00. Only four states did not have any aggregate advantage in upland cotton production, Arkansas 0.84, Tennessee 0.80, Missouri 0.44, and Oklahoma 0.36. All these states are located in the northern portions of the cotton production belt.

In addition, Alabama, Georgia, and North Carolina had both efficiency and scale advantages in upland cotton production, with EAI, SAI and AAI values exceeded one. Arizona, Louisiana, Mississippi, and Texas had scale advantages, with SAI and AAI values greater than one. Among five major upland cotton production states (with production accounting for more than five percent of nation's production: Texas, Georgia, Mississippi, Arkansas, and North Carolina) in 2003, only Arkansas did not have overall comparative advantages**.**

Texas had scale advantage in 2003 (its planted acres accounted for 43.16 % of the nation), but it has no advantage in efficiency. Likewise, Texas' aggregate advantage index was close to one. When considering a combination of all factors, Georgia, Mississippi, North Carolina, and Alabama had strong comparative advantages in growing upland cotton. Arizona and Louisiana also had comparative advantages in the upland cotton production, but their low values of EAI and AAI indicated that these two states may have stronger comparative advantage for other crops. Missouri, Oklahoma, and South Carolina had comparative advantage in producing upland cotton, but the low values of SAI indicated that the expandability of upland cotton production is questionable in the three states.

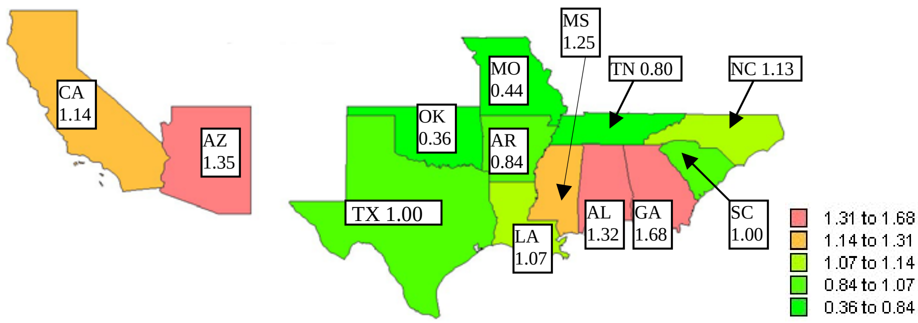

Figure 3. The Aggregate Advantage Index (AAI) of Upland Cotton Production among Major Production States, 2003.

2. Comparative advantage in upland cotton in districts of Texas

Texas is the largest cotton producing state in the country accounting for 43.16% of the total planted acreage in 2003. There are eight Agricultural Statistical Districts in Texas that produced upland cotton in 2003 (Figure 4). The Southern High Plains (District 1-S), located in the lower west side of the panhandle, led the state accounting for 52.34% of state's upland production. The Northern High Plains (District 1-N), located in the northern part of the panhandle, accounted for 15.81% of the state's upland cotton production. The Northern Low Plains (District 2-N) and Southern Low Plains (District 2-S) accounted for 7.36% and 8.91% of the state's production, respectively. The Blacklands (District 4) and Edwards Plateau (District 7) had relatively smaller production scale and produced 2.19% and 2.90%, respectively. There was also some cotton production in south Texas. The South Coastal Bend (District 8) produced 6.62% of state's upland cotton, whereas the Lower Valley (District 10-South) produced about 3.38% of the state's upland cotton.

Using equations (1) to (3), EAI, SAI, and AAI values are calculated for upland cotton for Texas districts and presented in Table 2. District 2-S led the state in efficiency in producing upland cotton with an EAI 1.91. Districts 8-S and 10-S had an EAI 1.67 and 1.58, respectively. The remaining five districts had EAI between 0.4 and 0.88, which indicated no efficiency advantage in upland cotton production.

Seven out of eight districts in Texas (except District 4) had scale advantage in upland cotton production. District 1-S led the state with SAI equals 4.33. This was followed by District 8-S with an SAI of 3.06.

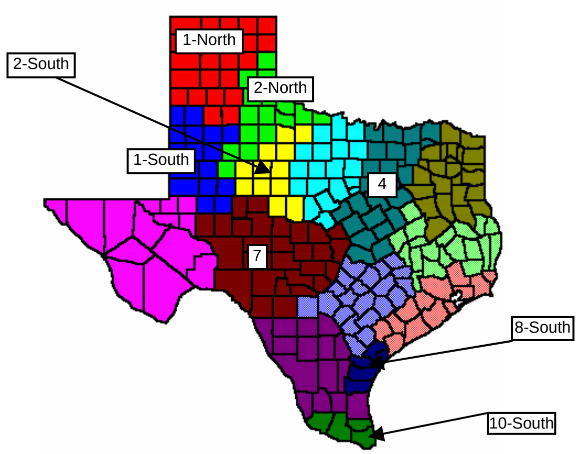

Figure 4. Texas Agricultural Statistical Districts (NASS)

Six out of eight districts in Texas with AAI greater than 1, indicates overall advantage in upland cotton production. District 8-S led the state with an AAI of 2.27. Followed by District 2-S with an AAI of 1.82. There were only two districts with AAI less than 1, i.e., District 1-N with AAI 0.98 and District 4 with AAI 0.39.

Overall, Districts 2-S, 8-S, and 10-S had the efficiency, scale and overall comparative advantages in upland cotton production. Districts 1-S, 2-N, 7, and 10-S had scale and overall advantages. District 1-N had only scale advantage. District 7 is the only district in Texas without any advantage in upland cotton production.

Table 2. Comparative Advantage of Upland Cotton Production in Different Districts in Texas, 2003.

	Share of Planted Acres (%)	Yield (lbs/acre)	EAI	SAI	AAI
District 1-N	15.81	687	0.87	1.10	0.98
District 1-S	52.34	402	0.66	4.33	1.70
District 2-N	7.36	335	0.72	2.13	1.24
District 2-S	8.91	343	1.91	1.72	1.82
District 4	2.19	240	0.40	0.38	0.39
District 7	2.90	449	0.83	1.48	1.11
District 8-S	6.62	783	1.67	3.06	2.27
District 10-S	3.87	607	1.58	1.86	1.72
Texas	100.00	478	0.65	1.54	1.00

CONCLUSIONS

This study provides a comparative advantage analysis of upland cotton production in U.S. and Texas in 2003. The analysis indicates that the comparative advantages in upland cotton production varied significantly across the United States and in Texas in 2003. There exists great potential to improve resource allocation and to increase upland cotton production through the restructuring of upland cotton production. As cotton producers are facing more and more competition from producers around the world, the research provides policy makers and producers more information to make their decisions on what and where to produce the upland cotton in the U.S. and the state of Texas in the future.

Since the data for this research only covered one year, 2003, the calculated results only reflected the upland cotton production in that year which may have a lot uncontrollable factors, such as rainfall, temperature, and etc. that may cause the variability of these indices. So, more research needs to be performed to study advantage changes in the long-run.

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