# ANALYSIS OF THE COMPARATIVE ADVANTAGE OF TEXAS UPLAND COTTON Zhongna Yang Department of Economics and Management, Tarim University Xinjiang, China Department of Agricultural and Consumer Sciences Tarleton State University Mark Yu Ashley Lovell Department of Agricultural and Consumer Sciences Tarleton State University

## <u>Abstract</u>

By using Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI), the study explores the changes in efficiency, scale and aggregate advantages, among the major U.S. cotton states in upland cotton production and the major crop production in Texas from 1997 to 2016. The study reveals that the Texas Upland Cotton has a significantly greater comparative advantage than other Upland cotton growing areas and states.

### **Introduction**

Cotton is most valuable crop in Texas, generating about 9% of the state's total agricultural receipts and 29% of the nation's cotton revenues (Texas Net State, 2016). On average, Texas grows 5.9 million acres and produces 27.5 billion bales of cotton annually, which represents about 48% of acreage and 47% of production in U.S. Texas cotton statistics reveals that cotton production acreage, total production and yield in the state shows a growing trend for last 20 years. According to USDA Crop Production Report in September 2017, Texas Upland Cotton production totaled 9.30 million bales, which is 15 percent higher than 2016. Yield averaged 757 pounds per acre, compared with 748 pounds in 2016. Acreage harvested, at 5.90 million acres, is up 13 percent from 2016 (NASS, 2017).

Modern technology has played a major role in the crop production. In recent decades, productivity in cotton production has increased dramatically, because of increased uses of fertilizers, improved pest management, improved cultivars, and enhanced irrigation practices. Currently, there are 17 states that planted cotton in U.S.

The objectives of this study are: (1) to evaluate the changes of comparative advantage of upland cotton production in Texas from 1997 to 2016; (2) to compare the comparative advantage among different major crops production in Texas from 1997 to 2016; and (3) to evaluate the compare advantage in major cotton producing state in the 20 years.

#### <u>Methods</u>

This study will use a set of indicators, which include Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) to measure the relative yield, scale, and aggregate advantage of upland cotton production in Texas (Yu et al., 2006; Yin and Huang, 2014).

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 the same crop in the nation related to the average yield of all crops in the nation. It can be expressed following:

$$EAI_{ij} = \frac{Y_{ij}/Y_i}{Y_{nj}/Y_n}$$
(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 all crops. If  $EAI_{ij} > 1$ , 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, relative to all other crops, relative to all other crops' yield or an efficiency advantage in growing the *j*th crop. If  $EAI_{ij} < 1$ , 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, relative to all other crops' yield growing in the same region; so yield growing in the same region, is lower than that of the national average, which 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 limiting 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.

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

where, SAI<sub>ij</sub> is the Scale Advantage Index of the *j*th crop in the *i*th region; S<sub>ij</sub> represents the planted area of the *j*th crop in the *i*th region; S<sub>i</sub> is the total planted area of all crops in the *i*th region; S<sub>nj</sub> is the total planted area of the *j*th crop in the nation; and S<sub>n</sub> represents the total planted area of all crops in the nation. If SAI<sub>ij</sub> > 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<sub>ij</sub> < 1, the degree of concentration of the *j*th crop growing in the *i*th region prefer to grow more *j*th crop, compared to other producers in the nation. If SAI<sub>ij</sub> < 1, the degree of concentration of the *j*th region prefer to grow less *j*th crop, compared to other producers 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.

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

If  $AAI_{ij} > 1$ , the *j*th crop in the *i*th region is considered to have an overall comparative advantage over the national average; while  $AAI_{ij} < 1$  indicates *j*th crop in the *i*th region does not have an overall comparative advantage over the national average (Cui and Zhou, 2013).

The crop that will be studied in this research is upland cotton. The 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 individual state's data in the United States.

#### **Results**

#### Comparative advantage in Texas upland cotton in 1997-2016

Using the formula (1) to (3) above, Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) were calculated for Texas from 1997 to 2016 and presented in Figure 1.

In 2007-2016, the average EAI for Texas upland cotton is 1.02, which indicates Texas cotton production have a relatively small Efficiency Advantage. But EAI ranged from 0.78 to 0.96 (less than 1) from 1996 to 2006, which means Texas did not have efficiency advantage in the time period. EAI ranged (greater than 1) from 1.03 to 1.20 in 2007-2016. The results indicates Texas improves its efficiency in cotton production in the last ten years.



Figure 1. Texas Upland cotton Comparative advantage Trends from 1997 to 2016.

The average SAI is 6.78, which means Texas has a relatively large scale advantage in cotton planting acres. From 1996 to 2006, the EAI ranges from 5.33 to 6.08; while it ranged 6.58 to 8.47 from 2007 to 2016.

AAI is Aggregate Advantage, ranged from 2.13 to 3.16, the average is 2.63. The results indicate that Texas have a large overall advantage in upland cotton production.

Figure 1 indicates that the Scale Advantage (SAI) of Texas cotton production is very large in 1997-2016; Efficiency Advantage (EAI) improved from below national average (1997 to 2006) to above national average (2007 to 2016). As Texas cotton is planted on dry-land, an increase in irrigated acreage and gene technologies, cotton breeding program, improved technologies, which played an important role in improving cotton yield in Texas. Overall, AAI keeps improving and Texas enjoys a large aggregate advantage in cotton production.

# Comparative advantage of major crops produced in Texas in 1997-2016

Texas is largest cotton-producing state in the nation. Other important agricultural products produced in the state are greenhouse and nursery products, corn for grain, hay, wheat, sorghum grain, peanuts, rice, and cane for sugar (Texas Net State, 2016). In order to analyze the comparative advantage of major crops produced in Texas, this study chooses the top 5 valued crops in Texas based on the average percentage in 1997-2016: upland cotton (26.08%), corn (21.75%), hay (12.54%), sorghum (9.23%), and winter wheat (7.08%).

Figure 2 shows the SAI (Scale Advantage Index) of major crops in Texas varied significantly. Cotton exhibits the largest Scale Advantage of the five crops and it is increasing. Sorghum ranks second, with an average value of 4.79, which means sorghum have a relatively large-scale advantage. Both SAI of wheat and hay are greater than 1, and thus have a scale advantage. The SAI for corn is less than 1, which indicates relatively small planting acres and no scale advantage in Texas.



Figure 2. SAI of major crops in Texas in 1997-2016.

Figure 3 shows that the EAI (Efficiency Advantage Index) of the major crops in Texas from 1997 to 2016 was not significant. In 2012, the sorghum reached the highest at 1.76. In 2016, the largest of efficiency advantage is hay at 1.29. Cotton ranked the second at 1.11 in 2014, which is a little higher than 1 and indicates it relative smaller efficiency advantage. Most of cotton in Texas is dry-land cotton and has a relatively low yield. Sorghum ranked the third at 1.07, which showed a little higher efficiency advantages. Both of the EAI of corn and winter wheat are less than 1, which means both crops do not have efficiency advantage and both yields are lower comparing to production in other states. Lack of irrigations plays an important role in explanation.



Figure 3. EAI of major crops in Texas in 1997-2016.

Figure 4 is the Aggregate Advantage of major crops in Texas from 1997 to 2016. It can be seen that cotton have a large aggregate advantage, and its upward trend in 20 years is highly significant. Sorghum ranks second, but from 2012 to 2016, it has a clear down trend, and in 2016, the AAI was 2.12. The AAI for wheat is also greater than 1, while hay is close to 1, which means both crops have an aggregate advantage. The AAI for corn is less than 1 in 20 years, which indicates there is no aggregate advantage in corn production in Texas.



Figure 4. AAI of major crops productions in Texas in 1997-2016.

From the above analysis, the study found that among the five main crops in Texas, the comparative advantage of cotton is the highest, with a clear upward trend. Secondly, sorghum also has a comparative advantage, though in recent years, its comprehensive advantage fluctuates greatly. The comprehensive advantages for wheat and hay are more stable. Overall, corn does not have the comparative advantage.

# Comparative advantage of major cotton-producing states in 1997-2016

There are 17 states produce cotton in the U.S. This study calculates the average percentage of cotton planting acress for 20 years (1997-2016) in 17 states, and the top 5 states are selected for further analysis (Chen and Cao, 2013). The top 5 average percentage of planting acreage are Texas (48.00%), Georgia (10.76%), Mississippi (6.22%), Arkansas (5.92%) and North Carolina (5.21%). Obviously, Texas is the leading state.

Figure 5 shows that scale advantages are significant in five largest cotton producing states. Among them, Georgia has the largest SAI, followed by Texas. The SAI for remaining three states of SAI indicates a clear down trend in recent years, though greater than 1.



Figure 5. SAI of major cotton-producing states in U.S from 1997 to 2016.

Figure 6 is the EAI of major cotton-producing states in U.S in 1997-2016. It can be seen that Texas cotton Efficiency Advantage overall on the rising from 0.84 (1997) to 1.23 (2013). The Efficiency Advantage of Arkansas and Mississippi is >1, but has fluctuated frequently during the past 20 years. However, with an EAI>1, these two states have a higher yield advantage. The EAI of Georgia and North Carolina of <1, first rose and then dropped trend, the states are not significant in Efficiency Advantages.



Figure 6. EAI of major cotton-producing states in U.S from 1997 to 2016.

Figure 7 indicates that the AAI of the major cotton-producing states are all greater than1. The AAI for Georgia and Texas have a clear upward trend, which reach 3.02 and 3.05 respectively in 2016. The AAI of Arkansas and North Carolina ranges from 1.10 (2016) to 1.99 (2002). Mississippi has a larger range of changes in 20 years, with the lowest number of 1.54 in 2009 and the highest point of 2.95 in 2001.



Figure 7. AAI of major cotton-producing states in U.S. in 1997-2016.

From the above analysis, the study found that the five major cotton-producing states in the U.S. have a comparative advantage, with their AAI greater than1 in 1997-2016. Georgia and Texas have a larger comprehensive advantage and show an upward trend. Secondly, the comparative advantage of Mississippi fluctuates frequently. Finally, both Arkansas and North Carolina show a downward trend in recent years.

### **Summary**

The above analysis indicates that Texas upland cotton has a significantly comparative advantage in the United States in the past 20 years. It implies that Texas exists great potential to improve resource allocation and to increase upland cotton production through restructuring of upland cotton production.

This study also analyzes the comparative advantage of major crops produced in Texas from 1997 to 2016. The results show that upland cotton has the largest AAI among major crops. Sorghum also has a larger comparative advantage, but it fluctuates greatly in recent years. The comprehensive advantage for wheat and hay are much stable. Only corn appears to lack a comparative advantage.

When comparing major cotton-producing states in the nation, the study found the comparative advantage of Georgia, Texas, Mississippi, Arkansas, and North Carolina are significant. Some states have a relatively lower yield. But there are numerous factors, such as natural factors, economic factors, social factors, and so on that can impact the yield in cotton production. Therefore, further analysis to identify the factors that affect the cotton production in various regions is warranted.

In addition, additional analysis of state comparative advantages is essential for policy makers and producers to decide the direction and the pace of the restructuring. This study has provided some insight into comparative advantage in major cotton producing states and different primary crops in Texas. Further studies are needed to evaluate more crops and analysis of each state's competitive advantage. More importantly, further studies should reveal regional comparative advantages. Comparative advantage viewed from each region, combined with that viewed from each crop, will provide a clearer picture of the desired directions and impact of such for restructuring.

## **References**

Chen, Z., and L. Cao. 2013. Analysis on the comparative advantages of the main grain crops production in 18 cities of Henan Province. *Journal of Henan Agricultural University*. 47: 351-354.

Cui, Q., and N. Zhou. 2013. Contribution rate of grain production in main producing areas and comparative analysis of regional comparative advantages. *Agricultural Economics and Management*. (2):37-40.

NASS. 2017. National Agricultural Statistics Service, USDA.

Texas Net State. 2016. <u>http://www.netstate.com/economy/texas\_economy.htm</u> (Accessed on December 1, 2017).

Yin, X., and N. Huang. 2014. Comparative analysis of peanut production in Shandong Province. *Agricultural Economics*. 25: 53-54.

Yu, X., M. Yu, and F. Ewell. 2006. The Comparative Advantage of Upland Cotton Production in Texas. *The Texas Journal of Agriculture and Natural Resource*, 19:31-38.