THE COMPARATIVE ADVANTAGE OF UPLAND COTTON PRODUCTION IN TEXAS
Xiaoling (Sherry) Yu, Mark Yu and Frank Ewell
Tarleton State University
Stephenville, TX

Abstract
By using Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI), this paper explores the comparative advantage of upland cotton production by comparing different states of the United States and different districts of Texas. The study reveals that the comparative advantage in main upland cotton varies significantly across the United States and Texas.

Introduction
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. Modern technology played a major role in the record crop. In recent decades, productivity in cotton production increased dramatically. Increased uses 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 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 Texas.

Materials And Methods
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 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:

\[
EAI_{ij} = \frac{Y_{ij}}{Y_i} \frac{Y_i}{Y_n} = \frac{Y_{ij}}{Y_n}
\]

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.

$$SAI_{ij} = \frac{S_{ij}/S_i}{S_{nj}/S_n}$$ (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 $SAI$.

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

If $AAI_{ij} > 1$, then 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.

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 US and districts’ data in Texas.

### Results And Discussion

1. **Comparative advantage in upland cotton in the United States**

   Table 1 is a 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 Aggregated Advantage Index (AAI) were calculated for 13 states and listed in Table 1.

**Table 1. Comparative Advantage of Upland Cotton Production in Different States, 2003.**

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

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 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.

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

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.

2. Comparative advantage in upland cotton in districts of Texas
Texas is the largest cotton producing state in the US accounting for 43.16% of the total planted acreage of total upland cotton in the nation. 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 accounted for 52.34% of the production. Northern High Plains (District 1-N), located in the most northern part of the panhandle, accounted for 15.81% of the state’s upland cotton production. 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 each. Blacklands (District 4) and Edwards Plateau (District 7) had relatively smaller production scale and produced 2.19% and 2.90% each. There was also some cotton production in south Texas. South Coastal Bend (District 8) produced 6.62% of state’s upland cotton. Lower Valley (District 10-South) produced about 3.38% of state’s upland cotton.

Figure 4. Texas Agricultural Statistical Districts (NASS)

Using equations (1) to (3), Table 2 is a summary of the calculation of comparative advantages for upland cotton in different districts in Texas. District 2-S led the state in efficiency in producing upland cotton with EAI 1.91. Districts 8-S and 10-S had an EAI 1.67 and 1.58, respectively. The remaining four 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.

Six out of eight districts in Texas with AAI greater than 1, indicates overall advantage in upland cotton production. District 2-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.
Upland Cotton Yield | Planted (%) | EAI | SAI | AAI  
--- | --- | --- | --- | ---  
District 1-N | 687 | 15.81 | 0.87 | 1.1 | 0.979  
District 1-S | 402 | 52.34 | 0.66 | 4.33 | 1.695  
District 2-N | 335 | 7.36 | 0.72 | 2.13 | 1.237  
District 2-S | 343 | 8.91 | 1.91 | 1.72 | 1.815  
District 4 | 240 | 2.19 | 0.4 | 0.38 | 0.389  
District 7 | 449 | 2.90 | 0.83 | 1.48 | 1.11  
District 8-S | 783 | 6.62 | 1.67 | 3.06 | 2.265  
District 10-S | 607 | 3.87 | 1.58 | 1.86 | 1.715  
Texas | 478 | 100 | 0.65 | 1.54 | 1  

Conclusions

The above analysis indicates that the comparative advantages in upland cotton production varied significantly across US and Texas in 2003. It implies that there exists great potential to improve resource allocation and to increase upland cotton production through restructuring of upland cotton production.

This analysis also indicates that some states in the nation may still have comparative advantage for upland cotton production. This implies that detailed analyses at state or lower level are needed when projecting the nation’s upland cotton trade flow.

In addition, more information 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 information of state comparative advantages, measured among main upland cotton among states and Texas. Further studies are needed to evaluate more crops and to take a closer analysis of each state. 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 of the restructuring.

Such restructuring, if realized, will certainly have major implications in the U.S.’s trade. Even though the U.S. as a whole is at a disadvantage in upland cotton, some states still have a comparative advantage in growing upland cotton.

References


