



Impacts of Transportation Infrastructure on the U.S. Cotton Industry

Parr Rosson, Flynn Adcock, Rafael Costa and John Robinson¹

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¹ Rosson is Professor/Extension Economist and Director, Center for North American Studies; Adcock is International Program Coordinator and Assistant Director, Center for North American Studies; Costa is Graduate Research Assistant, Center for North American Studies; and Robinson is Professor/Extension Economist, Texas AgriLife Extension Service. For more information, Please call 979-845-3070 or e-mail prosson@tamu.edu. All are located in the Department of Agricultural Economics, Texas A&M University, College Station, Texas 77843-2124.

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Introduction

The U.S. transportation system, including roads, air, rail, waterways and ports is under constant use and strain. At a recent conference at the University of Virginia it was concluded “Before the onset of the recession, bottlenecks in all transport modes had begun to compromise both the quality of people’s lives and America’s global competitiveness. Today, the transportation system’s deficiencies will almost certainly impede the pace of economic recovery,” (Miller Center of Public Affairs). The U.S. cotton industry operates within these constraints and its competitiveness is linked directly to the efficiency of U.S. and global systems and transportation infrastructure.

Overview

The United States is the world’s third largest cotton producer and the largest exporter, supplying 17 percent of the global cotton production since 2000 and accounting for 38 percent of the world export market (USDA). U.S. cotton production is concentrated in the Southern Plains, Southeast, Delta, and Western regions of the United States with Texas producing 45.3 percent of all U.S. cotton in 2010. Georgia, Arkansas, California, North Carolina and Mississippi each were responsible for producing between five and 12 percent of U.S. cotton production (NASS). The principal markets for U.S. cotton are China, Turkey, Mexico, Indonesia, Pakistan, Thailand and, more recently, Vietnam.

In the last two decades, the U.S. cotton sector has faced a number of challenges as the domestic mill demand has declined and U.S. exports have increased. During the 1990s, for example, domestic mill demand accounted for about fifty percent of available cotton supplies. Due to the decrease in domestic textile production caused by competition from imported textile and apparel products, U.S. mill use dropped to 30 percent for 2000-2005 and has averaged less than 20 percent annually since then. The resulting cotton surplus forced the industry to look for alternative markets. Significant changes in the global market for cotton and cotton-based products, particularly an increase in the global export demand, have provided overseas markets for U.S. cotton. As a result, U.S. cotton exports rose to 17.7 million bales in 2005/06, more than triple levels of a decade earlier, before settling at about 13 million bales in recent years. The emergence of China as the world largest cotton importer has resulted in a strong, but somewhat variable market for U.S. cotton. Currently, about 31 percent of all global cotton exports go to China (USDA). The United States is responsible for about 40 percent of China’s total cotton imports, representing 26 percent of U.S. cotton production.

The global demand for cotton is expected to grow in the future. According to USDA, world cotton mill use reached a record 123.8 million bales in 2006/07, and nearly matched that at 123.3 million bales in 2007/08 (USDA). While world use dropped to 109.9 million bales in 2008/09 due to the global economic downturn, cotton use has recovered to average about 117 million bales for the past two years. China and India have experienced the greatest gains in cotton use since 2000. The continuing increase in world demand for cotton is a good sign for the U.S. cotton industry as it offsets the decline in the domestic mill demand. The United States

continues to be the largest supplier of cotton to the world market and is forecast to account for 41 percent of world trade in 2010/2011.

Because the U.S. cotton industry is highly dependent on foreign markets, it is important for the industry to keep U.S. cotton competitive with foreign suppliers such as India and Uzbekistan. Transportation is one of the major factors that affect the competitive position of U.S. cotton, allowing the delivery of cotton to international markets in a timely, cost effective manner. The increase in U.S. cotton exports has clearly resulted in a shift in trade patterns and logistical requirements. In particular, increasing cotton demand in China and other Asian countries has increased cotton shipments to congested U.S. west coast ports (Fraire *et al.*). This problem was exacerbated during 2008 as Atlantic and Gulf ports became increasingly inaccessible for containerized cotton exports. Outgoing grain and oilseed exports required a greater number of containers and berths at ports. Delta and Southeast cotton shipments to China were increasingly shipped via the West Coast instead of Savannah, which resulted for the first time in a declining futures market basis for Delta/SE cotton relative to Texas cotton. While port congestion has eased since that time due to the global economic downturn, adequate transportation infrastructure that guarantees cotton shipments in a timely, efficient manner will provide a greater level of competitiveness for U.S. cotton exports in the future.

Consequently, the primary objective of this study is to evaluate U.S transportation infrastructure serving the cotton industry. Furthermore, this study will analyze the potential impacts of transportation infrastructure improvements on the U.S. cotton industry, focusing on requirements in Texas, Arkansas and Louisiana. These states were chosen because they are contiguous and, when taken together, account for about half of U.S. cotton production. While production is high in this region, only about one-quarter of U.S. cotton exports are shipped via Texas and Louisiana ports. This is in contrast to the western cotton states of California, Arizona and New Mexico that account for less than ten percent of cotton production. About one-half of U.S. cotton exports, however, are shipped through western seaports. Further, the proximity of Texas, Arkansas, and Louisiana to Mexico merits analysis because of Mexico's prominence as a major market. Finally, improvements and expansion of the Panama Canal are analyzed to assess the impacts on cotton shipping patterns in the United States and globally.

Many of the logistical and infrastructure issues affecting the cotton industry in recent years have related to major producing states. The task of accumulating cotton in this production area for shipment to the Texas-Mexico border, Gulf ports, and western U.S. ports is of major importance to the overall competitiveness of the U.S. cotton industry. Inefficiencies with this process, however, emphasize the need for additional study.

Global container fleet capacity is forecast to increase from 13.2 million twenty-foot equivalent units (TEU) in 2010 to 16.8 million TEU in 2013, placing additional demand on U.S. ports and transportation system infrastructure (ACP 2010). The demand for containers for the export of corn, wheat, oilseeds, and distiller's dry grain (DDG) increased from 306,000 TEU in 2003 to 804,000 TEU in 2008. While this represents a relatively small share of total containers available for U.S. cargo, much of the increased demand occurred at the ports of Savannah and Norfolk. Part of the reason for this was the significant increase in freight rates for bulk cargo during this time period. The situation resulted in a shortage of containers on the East Coast and

led to the increased shipments of cotton to the West Coast for export. Although congestion and container shortages were mitigated somewhat by the recent economic recession, global cargo shipments have recovered and are expected to again strain the U.S. port system.

Trends in U.S. Cotton Exports

U.S. cotton exports grew 128 percent to 16.2 million bales from 2000 to 2006 before beginning a downward trend (figure 1). Following this steady drop, cotton exports stood at 12.0 million bales in 2009 for a three-year drop of 26 percent. However, 2010 U.S. cotton exports were 17.5 percent over 2009 and slightly more than in 2008. A return to higher cotton exports will place additional strain on the transportation system.

The largest export market for U.S. cotton is China, which imported 4.9 million bales of U.S. cotton during 2010, down from 7.6 million bales in 2006. While China has been the largest market for U.S. cotton exports since 2003, it was only the eighth leading market during 2000 and tenth in 2001 (figure 2). Following China are Turkey, at 2.1 million bales during 2010, Mexico (1.4 million bales), Indonesia (704,000 bales), Vietnam (628,000 bales), Thailand (618,000 bales) and Taiwan (469,000 bales). With the exception of Vietnam, which did not register in the top ten until 2007, the others have all been consistently been in the top seven or eight export markets for U.S. cotton. As some markets have grown in importance, others have decreased. Examples of declining markets for U.S. cotton include Japan, Hong Kong, and the EU. India and Pakistan are stronger markets during some years and less important in others. India received 532,000 bales of U.S. cotton in 2003 before averaging 211,000 bales during 2005-2006, while Pakistan received more than 700,000 bales in both 2007 and 2009 but less than 430,000 bales in 2008 and 2010.

While the importance of export markets for U.S. cotton has changed over the years, the importance of U.S. ports has stayed relatively constant. Los Angeles, Savannah, Long Beach, Houston, and Laredo have occupied the top five ports for the export of U.S. cotton for the 2003 to 2010 time period, and usually in that order (figure 3). What has changed is the relative importance of Los Angeles/Long Beach (LA/LB). In 2003, LA/LB accounted for 36 percent of all U.S. cotton exports. While high, it has not been below forty percent since and reached a high of 54 percent (7.4 million bales) in 2008. Savannah remains the number two port for U.S. cotton exports, reaching 3.0 million bales in 2007 before falling to below 2.0 million bales in 2008 and 2009. Savannah narrowly surpassed two million bales in 2010. The exports of cotton through Houston reached a peak of 2.2 million bales in 2005, before declining to an average of 1.6 million bales for the past three years. Exports through Laredo remain fairly constant with a range of 900,000 bales to 1.1 million bales annually for the 2003 to 2010 period. While not currently at its peak, it does illustrate an extremely stable relationship between the United States and Mexico in the cotton market.

U.S. cotton exports have varied by port. For example during 2010, 65 percent of the 1.7 million bales exported from Houston were destined for Turkey (figure 4). This compares to 53 percent for 2003 (figure 5). Turkey has more than doubled as a market for cotton exports from New Orleans as 65 percent of port cotton exports, or 244,000 bales, during 2010. During 2003, only 28 percent of cotton exported through New Orleans went to Turkey.

On the West Coast, China and other East Asian² markets have always been the main markets from LA/LB cotton exports. Still, there has been some shifting as China increased from 31 percent of the cotton exports from LA/LB in 2003 to 53 percent in 2008 before falling to 42 percent in 2009. During 2010, China accounted for 60 percent of LA/LB cotton exports.

Savannah has also experienced changes in destinations for cotton exports. In 2003, 38 percent of cotton exports via Savannah went to China, 33 percent to other East Asia, and 15 percent to Turkey. By 2010, only 23 percent was shipped to China and other East Asia was 29 percent while Turkey grew to 27 percent.

A more pronounced view appears when examining concentration by market regions. The top three market regions for cotton exports through Houston were Turkey, South America, and Pakistan/India and accounted for about 90 percent of cotton exports through Houston during 2009-2010, up from an average of 77 percent in 2003-2004 (figure 6). For New Orleans, this concentration increased from an average of 52 percent in 2003-2004 to 87 percent 2009-2010, while LA/LB increased from 86 percent to 91 percent for the same time period for its two largest cotton export market regions (figures 7 and 8). Only Savannah has maintained a relatively stable concentration for top market regions at 81 percent for the time period (figure 9).

Export Markets by U.S. Port

China has been the leading market for U.S. cotton since 2003 and imported 4.9 million bales during 2010, down significantly from 7.6 million bales in 2006 but up from 2.8 million bales in 2009 (figure 10). LA/LB has been and remains the leading route for these exports, accounting for 4.1 million bales in 2010, down from 5.2 million bales in 2006 but nearly double that of 2009 (figure 11). Due to proximity to the Southeastern U.S. cotton producing region, Savannah has enjoyed prominence as a point of departure for cotton bound for China. In 2006, exports reached 1.3 million bales. More recently, these exports fell to 347,900 bales in 2009 before increasing to 454,650 bales in 2010. Oakland is the other major port accounting for cotton exports to China with 138,240 bales in 2009 and 212,240 bales in 2010. Oakland surpassed Houston as the third most important port for exports to China during 2008.

Turkey is currently the second leading export market for U.S. cotton, importing 2.1 million bales during 2010, down from a peak of 2.7 million bales in 2007 but up from 1.6 million bales in 2008 and 1.8 million bales in 2009 (figure 12). While this represents a decrease of 22 percent from 2007, it is far less than the 35 percent decline in U.S. cotton exports to China from its 2006 record high. Further, both destinations have rebounded from recent lows in 2008 and 2009. Houston has been and remains the leading port for exporting cotton to Turkey, accounting for 938,000 bales in 2009 and 1.1 million bales in 2010 (figure 13). Savannah is the second leading port for cotton exports to Turkey with over 500,000 bales in both 2009 and 2010 with New Orleans next at more than 200,000 bales. During the peak year of 2007, Savannah actually shipped the most cotton to Turkey, however, that was the only time that Houston was not in the leading position.

² East Asia includes Bangladesh, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Vietnam.

The Case of Mexico

The large majority of cotton exports to Mexico cross at land ports of entry. With so much cotton production in Texas and a fully-implemented North America Free Trade Agreement (NAFTA), Texas represents an important source of cotton for Mexico. These shipments have experienced a gradual decline each year since from 2003 through 2009, decreasing from 1.63 million bales to 1.35 million bales (figure 14). In 2010, cotton exports to Mexico were up slightly compared to 1.45 million bales. Laredo is the leading port for U.S. cotton exports to Mexico and accounted for nearly three-quarters of exports in both 2009 and 2010 (figure 15). The only significant change came in the Lower Rio Grande Valley where Hidalgo, which shipped minimal volumes of cotton to Mexico as recently as 2007, accounted for 296,000 bales (22 percent) exported in 2009 and 2010. Brownsville had previously been second, but newer infrastructure and less congestion led shippers to use Hidalgo more for cotton exports.

Most Mexican cotton is produced in the western states of Chihuahua, 870,000 bales in 2008, and Baja California (379,000 bales), with some production in Coahuila (257,000 bales). These three states account for 90 percent of Mexican cotton production. Whether cotton is produced in Mexico or imported from the United States, the destination in Mexico are the mills in the states of Mexico, Hidalgo, and Morelos, all near Mexico City. Mexico produces only about half of its mill use, so cotton imports, 98 percent of which come from the United States, are important.

During conversations with personnel based at six Mexican cotton mills, it was found that all U.S. cotton is shipped via truck and that border crossings are seen as a bottleneck. This may be the best mode of transportation as trains are too slow for the delivery requirements of most mills. The reasons for the bottleneck at the border are familiar and include the need for three transportation companies including drayage firms, two customs agents, and two agricultural departments for inspection of cotton cargo. The need to use all these entities requires time and imports incur additional costs. Several possible solutions were mentioned. First, allow the same transportation company to handle the entire transaction, reduce the need for a second customs agent, and harmonize phytosanitary requirements. This suggestion sounds simple, but there are public and private sector interests which would be resistant to these changes. Second, load containers on flat rail cars and then transfer to truck once past the border. Finally, skip the land borders and ship to Veracruz.

Other Major Markets

Southeast Asian countries of Indonesia, Vietnam, and Thailand have emerged as important markets for U.S. cotton. Taken together, these three countries imported over two million bales of U.S. cotton annually from 2007 to 2009, reaching a peak of 2.7 million bales in 2008 (figure 16). Exports to these countries dropped to 1.9 million bales in 2010. LA/LB is the largest port involved in shipping cotton to the Southeast Asian region, accounting for about 70 percent in 2009 and 2010 while Savannah is second.

U.S. cotton exports to Pakistan are also important, but somewhat erratic. For instance, Pakistan imported 787,000 bales of U.S. cotton during 2007, but exports dropped to 46 percent

in 2008, increased 65 percent in 2009, and then dropped again to 54 percent in 2010 (figure 17). As a result of the 2010 decline, Pakistan fell below Taiwan for the first time since 2006, below South Korea for the first time since 2005, and below Bangladesh and Peru for the first time since 2001 and 2000, respectively. The main port involved in exporting to Pakistan is LA/LB. Houston, Savannah, Charleston, and Oakland have each occupied the second spot during at least one year between 2003 and 2010.

Of particular interest to ports in Texas and Louisiana are the Latin American markets other than Mexico, which combines all countries in Central America, South America, and the Caribbean. As a group, these countries accounted for over one million bales of U.S. cotton exports from 2006-2008 before dropping to 876,000 bales during 2009 (figure 18). Exports returned to 1.1 million bales in 2010. Houston and Freeport combined to account for more than one-half of exports to other Latin America with Gulfport next in importance during 2010. Savannah and New Orleans also ship significant volumes to other Latin America depending on the year. The top individual destinations for U.S. cotton in 2009 and 2010 were Peru, which averaged 288,000 bales, and Colombia, which averaged 241,000 bales (figure 19). El Salvador and Guatemala each imported over 100,000 bales of U.S. cotton in both 2009 and 2010.

The Panama Canal Expansion

One of the major factors affecting the efficiency, distribution and competitiveness of U.S. cotton will be expansion of the Panama Canal. With sea freight the fastest growing mode of transportation, the number and size of vessels that are able to pass through the Canal will increase after the expansion is completed in 2014. This expansion is necessary not only to accommodate growing commerce, but also because post-Panamax vessels are forecast to account for nearly 25 percent of cargo vessel capacity by 2012 and already account for 35 percent of all vessels carrying cargo worldwide (ACP, December 2007).

The new Panama Canal lock system will be equipped to handle vessels up to 12,600 twenty-foot equivalent units (TEU) for containers, compared to a present maximum vessel size of 4,400 TEU. The Canal expansion should relieve U.S. West Coast congestion on routes to Asia and increase potential to increase cotton shipments from the U.S. Gulf and South Atlantic ports to China and other Asian destinations. The *Journal of Commerce* estimates that Gulf port container volume could increase by 20 percent due to Panama Canal expansion. In addition, U.S. ports have experienced a 156% increase in post-Panamax vessel calls over the past five years, increasing the demand for service of larger vessels (U.S. Department of Transportation).

While yet to be verified empirically, it is expected that significant additional volume of U.S. cotton will be shipped via Gulf Coast and East Coast ports to China and the Far East after 2014. This in large part, however, will depend on the expansion of these ports to handle post-Panamax vessels. While East Coast ports such as Savannah, Charleston and Norfolk are in position to benefit initially from the expansion of post-Panamax vessel trade, the amount of additional cargo that may be handled is uncertain until improvements are made in capacity and water depth (U.S. Army Corps of Engineers). Ports along the southern Gulf are positioned to gain longer-term as port facilities are expanded. LA/LB and Oakland can be expected to

continue as a major port in the post-Panamax era well into the future, but at some point may reach capacity limitations and be forced to expand.

Analysis of U.S. Cotton Export System

This analysis uses the results for a cost minimizing mathematical programming model that was developed by agricultural economists at Texas A&M University to represent the U.S. cotton transportation and logistic system. The model's framework minimizes the total cost of shipping, handling, and storing cotton that originates at 673 gins and flows to 443 warehouses across the U.S. over four quarterly periods. The model allows routing cotton shipments from originating gins to warehouses, possibly through reconsolidation warehouses in Memphis or Atlanta, and then on to either sixteen U.S. ports, eleven domestic mill regions, or four major intermodal facilities (and thence by rail to major West Coast, Gulf and East Coast ports). Boxcar shipments are allowed between two Mid-south origins (Memphis and Monroe, LA) and Laredo, TX. Only the results for Arkansas, Louisiana and Texas are reported in this study.

For the Delta region, the model also allows non-Memphis warehouses to ship cotton to Memphis warehouses to reflect the possibility of Mid-South reconsolidation and Intercontinental Exchange (ICE) cotton certification. Another transshipment warehouse was located in Atlanta to reflect the emerging pattern of warehouse-to-warehouse shipments from as far west as Texas to be pre-staged in Atlanta.

Cotton shipments in the model are driven by the pull effect of constraints that require historical amounts of cotton to be delivered to the final demand points (i.e., ports and mills). Secondary export data were compiled by WISERTrade to characterize cotton demand at U.S. ports for 2008. Census data were used to allocate 2008 U.S. mill use to the eleven sub-state regions (mostly in the southeastern U.S.). The model then ships and stores cotton every quarter to satisfy the imposed demands while minimizing specified costs.

Road mileages for trucking between originating gins, warehouses, intermodal facilities, ports, and mill locations were calculated using standard mapping software. Railroad mileages between intermodal or boxcar origins and port destinations were obtained from relevant railroad industry websites. Trucking cost base rates and fuel surcharges were developed based on information collected from various industry sources. These data were used to estimate statistical relationships between trucking mileage and cost. The resulting regression parameters were used to derive point estimates of trucking costs for the specific distance matrix elements for all gin-warehouse, warehouse-intermodal, warehouse-port, and warehouse-mill combinations. Shipping costs from intermodal points to ports were calculated using rail mileage multiplied by the average representative railroad rates obtained from the Surface Transportation Board, railroad industry representatives, and cotton shippers.

The Least Cost shipping model sources cotton from actual gin points, routing flows to nearby warehouses. The focus of this analysis is on the cotton flows within Arkansas, Louisiana, and Texas. Table 1 shows the number of warehouse and gin points modeled in the study area. From there cotton is either stored, shipped to intermediate (i.e., intermodal facilities) or domestic destinations (mills or U.S. ports of exit). Table 2 shows the decimal share of flow from origins in the study area to various destinations. Flows from Texas largely flow to the Port of Houston,

the Mexican border, or Southern California. Table 2 identifies these destinations, although the results are somewhat skewed by a large supply remaining in carryover storage for the year modeled. The flows from Arkansas also reflect considerable carryover storage given the proximity to Memphis warehousing. Louisiana and Arkansas origins both ship to domestic U.S. textile mills in the Southeast.

Table 1. Cotton Origin Points for Arkansas, Louisiana and Texas

| | Warehouses | Cotton Gins |
|-----------------|------------|-------------|
| Arkansas | 40 | 62 |
| Louisiana | 13 | 43 |
| Texas | 91 | 278 |
| Regional Totals | 144 | 383 |

Table 2. Least Cost Model Predicted Destinations of Arkansas, Louisiana, and Texas Cotton Flows

| | U.S. Mills | TX/LA Gulf Coast | West Coast | Mexican Border | Other |
|-----------|------------|---------------------|---------------|-------------------|-------|
| Arkansas | 11.7% | | | | 88.3% |
| Louisiana | 43.0% | 57.0% | | | |
| Texas | 13.6% | 20.1% | 2.5% | 15.9% | 48.0% |

Spatial Equilibrium Model for Export Flows

The international cotton model employed in this analysis includes 416 excess supply regions and 25 excess demand regions. The excess cotton supply regions include 410 U.S. regions (warehouses) and 6 foreign regions (Australia, Brazil, India, Sub-Saharan Africa, Uzbekistan, and other exporting countries). Included among the excess cotton demand regions are 11 U.S. regions (domestic mills) and 14 foreign demand regions (Bangladesh, China, EU-27, Hong Kong, Indonesia, Japan, Mexico, Pakistan, South Korea, Taiwan, Thailand, Turkey, Vietnam, and other importing countries).

In the U.S. portion of the model is an extensive transportation network that connects excess supply regions with excess demand regions and ports via truck (truck chassis and flatbed) and rail. Excess supply regions are linked to excess demand regions within the U.S. via truck. There are 15 U.S. ports which are linked to the excess supply regions either by truck direct shipments or truck to 5 intermodal (rail loading) sites. These 15 U.S. ports are then linked to the excess demand regions via vessels except Mexico which are land border port crossings ports thus shipments are terrestrial. A representative port in each of the foreign excess supply regions is also linked by maritime costs to each of the foreign excess demand regions.

The data used for the spatial model are composed of estimation of domestic and foreign excess demand and supply equations; cotton handling and storage costs; and railroad, truck, ship costs. The excess demand and supply equations were estimated for each location by using

supply and demand elasticities and production/consumption quantities. In the U.S. part of the model, the excess supply regions are warehouses which are optimal solution to the least cost shipping model developed by Fraire et al. Cotton received at those warehouses are supplied and carried through the subsequent crop year with estimated storage charges. Furthermore, based on the transportation costs/rates (truck and rail) estimates from Fraire et al, each U.S. excess supply region is connected to U.S. excess demand regions (mills), U.S./Mexico border crossing sites and ports. The estimates of ocean freight rates from U.S. ports to different foreign excess demand regions were estimated based on the difference between the cotton export price (FOB) and the import price (CIF). Due to the lack of data by port, in the first instance, all U.S. ports were assumed to have a similar freight rate. Subsequently, the ocean freight rates were adjusted to the equivalent historic flow patterns for each port.

Results

Model validation was performed by comparing historic flows patterns with flows associated with the base model. Data from WISERTrade on U.S. export flows and compared to model-generated flows. Table 3 presents historic flows compared to the solution of the base model. The base model projected flows were within the ranges observed at all ports during the years of 2007 to 2009. Accordingly, the model was judged adequate for purposes of carrying out study objectives.

Table 3. Comparison between Exports by Port Model Estimates and Observed Data

(Exports in 1,000 480 lbs. Bales)

| Port | 2007 | 2008 | 2009 | 3-Year Average | Base Model | Difference* |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------|
| Savannah | 2,994.4 | 1,733.3 | 1,966.4 | 2,231.4 | 2,294.2 | 2.8% |
| Norfolk | 298.0 | 250.6 | 270.8 | 273.1 | 274.1 | 0.3% |
| New Orleans | 857.1 | 369.2 | 362.1 | 529.5 | 530.2 | 0.1% |
| Houston, TX | 1,733.2 | 1,514.6 | 1,581.2 | 1,609.7 | 1,590.2 | -1.2% |
| Laredo-El Paso | 1,075.0 | 907.0 | 986.0 | 989.3 | 1,052.9 | 6.4% |
| L.A.-Long Beach | 6,106.5 | 7,446.2 | 5,314.6 | 6,289.1 | 6,375.6 | 1.4% |
| Oakland | 706.1 | 431.8 | 303.9 | 480.6 | 386.6 | -19.5% |
| Charleston | 682.2 | 446.9 | 310.7 | 479.9 | 310.5 | -35.3% |
| Hidalgo-Brownsville | 325.0 | 443.0 | 353.0 | 373.7 | 311.4 | -16.6% |
| Gulfport | 89.0 | 131.0 | 101.0 | 107.0 | 46.4 | -56.6% |
| Mobile | 50.0 | 28.0 | 14.0 | 30.7 | 74.3 | 142.4% |
| Others | 155.1 | 155.2 | 439.2 | 249.8 | - | - |
| Total US | 15,071.5 | 13,856.8 | 12,002.8 | 13,643.7 | 13,246.4 | -2.9% |

* Relative to the 3 year average.

Baseline Model Results

The baseline model indicates that LA/LB is the dominant port of export with 6.38 million bales (table 3). The variance from historical cotton shipments is among the smallest, 1.4 percent. Savannah is the second most important port with 2.29 million and a variance of 2.8 percent. Houston and Laredo were third and fourth, respectively, with variance from -1.2 percent for Houston to 6.4 percent for Laredo. New Orleans was the fifth most important port, exporting a projected 538,000 bales with a variance of 0.1 percent. The remaining ports each shipped less than 400,000 bales and had variances ranging from 0.3 percent for Norfolk to 142 percent for Mobile. This latter port, however, has historically handled only minor shipments, so this large variance is not considered a major enough issue to warrant further analysis.

Results for Panama Canal Expansion

The first scenario to be analyzed was a reduction of 10 percent in ocean freight rates as a result of Panama Canal expansion (PCE) for vessels originating from the U.S. Gulf and South Atlantic ports to Asian and Pacific countries. The second scenario analyzed a 28 percent reduction in ocean freight rates for the same origins and destinations.

Effects on Flow Patterns and Exports

Decreasing the ocean freight rate from U.S. Gulf and Atlantic ports (Savannah, Norfolk, New Orleans, Houston, Charleston, Gulfport, and Mobile) to Asian and Pacific importing countries (China, Indonesia, Thailand, Bangladesh, Pakistan, Honk Kong, Japan, South Korea, Taiwan) due to PCE is expected to increase cotton exports via the Panama Canal. U.S. Gulf and Atlantic ports are expected to increase their share of total U.S. cotton exports. Pacific Coast ports, however, are expected to experience a reduction in exports.

A 10 percent reduction in ocean freight rates for the routes that travel via the Panama Canal is estimated to increase U.S. cotton exports via the Gulf and Atlantic ports except Gulfport, Mississippi, and Mobile, Alabama (table 4). The absolute change in exports was the largest for the port of Savannah, Georgia, followed by the port of Houston, Texas. The increase from 2,294 to 3,965 thousand bales (72.8 percent increase) in exports positioned the port of Savannah as the leading cotton exporting port passing the LA/LB ports (down to 3,837 from 6,375 thousand bales). The total absolute change for the U.S. Gulf and Atlantic ports was equivalent to a positive 2,617 thousand bales, which in relative value this is equal to a 51.1 percent increase.

Furthermore, the share of U.S. cotton exports through the Panama Canal increased from 38 percent (5,119 thousand bales) to 58 percent (7,737 thousand bales) after the expansion. West Coast ports decreased shipments considerably by reducing total exports approximately 2,538 thousand bales. The route via the intermodal option (rail to West Coast ports) reduces its share of total U.S. cotton exports by 20 percentage points (from 51 percent to 31 percent). The largest decrease in exports occurs in the LA/LB ports, going from 6,375 to 3,837 thousand bales, in relative terms, this is equivalent to a decline of approximately 40 percent.

Table 4. Estimated Change in U.S. Cotton Flows Resulting from Reducing Ocean Freight Rates by 10 Percent due to the Panama Canal Expansion (1,000 480 lbs. bales)

| Port | Base Model | 10% Reduction | Absolute Change | Change (%) |
|---------------------------------------|-----------------|-----------------|-----------------|--------------|
| Savannah | 2,294.2 | 3,965.5 | 1,671.3 | 72.8 |
| Houston | 1,590.2 | 2,074.9 | 484.7 | 30.4 |
| New Orleans | 530.2 | 744.2 | 214.0 | 40.3 |
| Charleston | 310.5 | 572.9 | 262.4 | 84.5 |
| Norfolk | 274.1 | 334.3 | 60.2 | 21.9 |
| Gulfport | 46.4 | 20.9 | -25.4 | -54.7 |
| Mobile | 74.3 | 24.5 | -49.7 | -66.9 |
| <i>Total U.S. Gulf and Atlantic</i> | <i>5,119.9</i> | <i>7,737.2</i> | <i>2,617.3</i> | <i>51.1</i> |
| Los Angeles/Long Beach | 6,375.6 | 3,837.3 | -2,538.2 | -39.8 |
| Oakland | 386.6 | 386.2 | -0.3 | -0.1 |
| <i>Total West Coast</i> | <i>6,762.2</i> | <i>4,223.5</i> | <i>-2,538.6</i> | <i>-37.5</i> |
| Laredo-El Paso | 1,052.9 | 1,179.2 | 126.3 | 12.0 |
| Hidalgo-Brownsville | 311.4 | 182.9 | -128.4 | -41.2 |
| <i>Total U.S.-Mexico Border Ports</i> | <i>1,364.3</i> | <i>1,362.1</i> | <i>-2.20</i> | <i>-0.2</i> |
| Total U.S. Ports | 13,246.4 | 13,323.3 | 76.9 | 0.6 |

As expected, cotton flow patterns resulting from the analysis of scenario two (28 percent ocean freight rate reduction) are similar to scenario one in direction, but larger in magnitude. The ports of Savannah and Houston increased cotton exports to 4,566 and 2,621 thousand bales, respectively (table 5). An important point is that the port of Houston becomes the nation's second largest cotton exporter. The ports of New Orleans, Charleston, and Norfolk more than doubled their exports with increases up to 185 percent for Charleston. Total exports from the Gulf and Atlantic ports rose to 9,990 thousand bales from 5,120 thousand bales for the base model (an increase of 95.13 percent). Such increases in exports via the Gulf and Atlantic ports indicate that the PCE could increase the canal's share in total U.S. cotton exports to 74 percent from 38 percent in the base model.

West Coast ports undergo an extreme decline in exports, going from 6,762 thousand bales to 2,147 thousand bales. Another key observation is that the intermodal option reduces its share of total U.S. cotton exports. Only 15 percent of total U.S. cotton exports are shipped via the West Coast ports. The largest factor for such reduction is the decrease in exports via the LA/LB ports, down to 1,762 thousand bales which places LA/LB as the third most important port for the U.S. cotton exports.

Although cotton flows are altered with lower ocean freights for the Atlantic and Gulf ports, total U.S. cotton exports are only modestly impacted. For the 10 percent freight rate reduction scenario, the increase in total U.S. cotton exports was equal to 76.9 thousand bales which is equivalent to a 0.6 percent increase (table 4). In the second scenario, a 28 percent reduction in ocean freight rates increases total U.S. cotton exports. Although still a modest

increase in relative terms (1.9 percent), total U.S. cotton exports rose to 13,493 thousand bales, up by 247.2 thousand bales (table 5).

Table 5. Estimated Change in U.S. Cotton Flows Resulting from Reducing Ocean Freight Rates by 28 Percent due to the Panama Canal Expansion (1,000 480 lbs. bales)

| Port | Base Model | 28% Reduction | Absolute Change | Change (%) |
|---------------------------------------|-----------------|-----------------|-----------------|--------------|
| Savannah | 2,294.2 | 4,566.3 | 2,272.1 | 99.0 |
| Houston | 1,590.2 | 2,621.6 | 1,031.4 | 64.8 |
| New Orleans | 530.2 | 1,271.9 | 741.7 | 139.9 |
| Charleston | 310.5 | 886.5 | 576.0 | 185.5 |
| Norfolk | 274.1 | 623.1 | 349.0 | 127.3 |
| Gulfport | 46.4 | 20.9 | -25.4 | -54.8 |
| Mobile | 74.3 | 0.0 | -74.3 | -100.0 |
| <i>Total U.S. Gulf and Atlantic</i> | <i>5,119.9</i> | <i>9,990.3</i> | <i>4,870.4</i> | <i>95.1</i> |
| L.A.-Long Beach | 6,375.6 | 1,762.1 | -4,613.4 | -72.3 |
| Oakland | 386.6 | 385.3 | -1.3 | -0.3 |
| <i>Total West Coast</i> | <i>6,762.2</i> | <i>2,147.5</i> | <i>-4,614.8</i> | <i>-68.2</i> |
| Laredo-El Paso | 1,052.9 | 1,169.8 | 116.9 | 11.1 |
| Hidalgo-Brownsville | 311.4 | 185.5 | -125.8 | -40.4 |
| <i>Total U.S.-Mexico Border Ports</i> | <i>1,364.3</i> | <i>1,355.3</i> | <i>-9.0</i> | <i>-0.6</i> |
| Total U.S. Ports | 13,246.4 | 13,493.6 | 247.2 | 1.9 |

U.S. Producer Prices and Revenues

As the PCE occurs, there would be an anticipated reduction in ocean freight rates which corresponds to a decrease in transportation costs linking the U.S. producers (warehouse level) to importers in the Asian and Pacific importing countries. This increases price and production in U.S. regions that ship via the Panama Canal. For example, in scenario one, U.S. cotton-producing regions that ship via the Panama Canal experience an increase in price that ranges from \$0.89/bale (Arizona) to \$7.03/bale (South Carolina) (table 6). Most of the U.S. cotton production regions experienced an increase in price. However, in California and Oklahoma, prices decrease as the Panama Canal expansion occurs. Prices decreased modestly for those U.S. regions since exports are diverted to Asian and Pacific importing countries via the West Coast ports.

As noted in Table 6, the state with the largest gain in revenue due to the PCE was Texas. The increase in producer revenues for that state was equal to \$20.76 million. Taking into account the relatively small change in price that occurs in Texas (\$2.63/bale) when compared to the other states, the main reason for such increase in producer revenue is the an expansion of cotton production³. Georgia and Tennessee had significant gains in producer revenues as well with \$15.27 million and \$13.40 million, respectively. The gain for Georgia is relevant to discuss since the port of Savannah is located in that state and local cotton producers were the beneficiaries of

³ According to NASS (2010c), cotton production for the state of Texas was approximately 6.3 million bales for the 2008/09 market year, which represented 40 percent of U.S. production.

this expansion. Although the impacts were relatively small, as expected, the states that depend heavily on West Coast ports experienced a decline in producer revenues (Oklahoma and California).

Table 6. Estimated Annual Increase in U.S. Cotton Producer Revenues and Warehouse Price Resulting from Reduction in Ocean Freight Rates due to Panama Canal Expansion

| State | 10% reduction | | 28% reduction | |
|-------------------|--|-------------------------|--|-------------------------|
| | Revenue Change <i>Million Dollars</i> | Price <i>\$/Bale</i> | Revenue Change <i>Million Dollars</i> | Price <i>\$/Bale</i> |
| Texas | \$20.76 | \$2.63 | \$81.45 | \$10.43 |
| Georgia | \$15.27 | \$6.92 | \$44.36 | \$19.95 |
| Tennessee | \$13.40 | \$5.97 | \$42.22 | \$18.59 |
| Arkansas | \$9.59 | \$5.67 | \$29.20 | \$17.13 |
| Mississippi | \$7.07 | \$5.95 | \$21.36 | \$17.81 |
| North Carolina | \$6.86 | \$6.25 | \$22.93 | \$20.68 |
| Missouri | \$4.37 | \$5.45 | \$12.99 | \$16.08 |
| South Carolina | \$3.57 | \$7.03 | \$11.07 | \$21.63 |
| Louisiana | \$3.09 | \$6.28 | \$8.79 | \$17.74 |
| Alabama | \$2.76 | \$5.10 | \$8.42 | \$15.45 |
| Virginia | \$1.23 | \$5.77 | \$4.44 | \$20.72 |
| Florida | \$0.54 | \$6.76 | \$1.57 | \$19.60 |
| Arizona | \$0.40 | \$0.89 | \$1.12 | \$2.51 |
| New Mexico | \$0.25 | \$4.78 | \$0.81 | \$15.31 |
| Kansas | \$0.05 | \$5.44 | \$0.14 | \$16.02 |
| Oklahoma | – \$0.11 | – \$0.41 | \$3.02 | \$10.70 |
| California | – \$0.84 | – \$0.59 | – \$2.73 | – \$1.91 |
| U.S. Total | \$88.25 | \$4.70 | \$291.13 | \$15.20 |

In scenario two, the 28 percent reduction in ocean freight rates from Gulf and Atlantic ports to Asian and Pacific markets is estimated to increase annual producer revenues for all cotton producing states except California. The state with the largest gain is Texas, with an increase in producer revenue equal to \$81.45 million. As discussed earlier, Texas is a special case since most of the gain in revenue is due to increased cotton production (up 68,000 bales) and not higher prices.

Other states underwent a larger increase in price, but there was less impact on producer revenues. For example, with respect to prices, cotton producers in South Carolina and Virginia were the greatest beneficiaries of higher prices attributed to the Panama Canal expansion, with increases of \$21.63/bale and \$20.72/bale, respectively. However, because production in those two states is relatively small compared to the others, producer revenues were less when compared to Texas and Georgia.

Cotton producers in Oklahoma accrue gains in producer revenues rather than losses. This occurs because a portion of Oklahoma cotton shipments were routed via the port of Houston rather than the intermodal route. Revenue losses to producers in California were estimated at \$1.91 million which is relatively small when compared to the gains by other states.

In both scenarios, the producer revenue for U.S. cotton increased as the PCE takes place. A 10 percent reduction in ocean freight rates from Gulf and Atlantic ports to Asian and Pacific importing countries is projected to increase annual cotton producer revenues by approximately \$88.25 million (table 6). In relative terms, the total increase in producer revenue for the U.S. is equal to 2.1 percent. For scenario two, the 28 percent rate reduction causes a greater positive impact on the producer revenue for the U.S. The revenue gains to cotton producers are larger when the savings in cost due to the Panama Canal expansion is fully considered. Hence, the total increase in U.S. cotton producer revenue is equal to \$291.13 million, which, in relative terms, is equivalent to an increase of 6.9 percent.

U.S. Cotton Competitiveness in the World Market

The impact of the PCE on the competitiveness of exporting countries is evaluated with the focus on exports, prices, and revenue. Table 7 presents the results of the scenarios that were analyzed. Both scenarios indicate that India, Brazil, Sub-Saharan Africa, Uzbekistan and the Rest of the World Exporters all experience lower exports, prices, and revenues attributed to PCE. Among these countries/regions, the Rest of the World Exporters were the most affected by the PCE. Individual and large cotton exporting competitors, such as Brazil and India, lose competitiveness in global cotton trade and losses occur within the national industries. For example, in scenario two, exports, price, and producer revenue in Brazil are estimated to decrease by 17.99 thousand bales, \$1.91/bale, and \$9.91 million, respectively. However, in both scenarios, these losses in exports, prices, and revenues are very modest in relative terms. Brazilian exports, price, and revenue are reduced by 0.6, 0.7, and 1.4 percent, respectively. Meanwhile, with the exception to the Rest of the World Exporters, the losses to other exporting countries are lower than those of Brazil.

Due to the Panama canal expansion and its potential reduction in ocean freight rates for the Gulf and Atlantic ports to Asian and Pacific markets, the U.S. gains competitiveness through increases in exports, prices, and producer revenue (table 7). For scenarios one and two, the increase in exports is equal to 76.95 and 247.27 thousand bales, respectively. Cotton price and producer revenues also increase in both scenarios. There are greater impacts from scenario two due to the larger reduction in ocean freight rates. With a 28 percent reduction in ocean freight rates, the cotton price and producer revenue increase to \$15.20/bale and \$291.13 million, respectively.

Table 7. Estimated Effects of Panama Canal Expansion on Cotton Exports, Prices, and Revenue for Selected Countries

| Exports (1,000 480 lbs. bales) | 10% reduction | 28% reduction |
|--------------------------------|---------------|---------------|
| United States | 76.95 | 247.27 |
| India | -5.63 | -17.97 |
| Brazil | -5.64 | -17.99 |
| Sub-Saharan Africa | -1.99 | -6.34 |
| Uzbekistan | -0.60 | -1.91 |
| Rest of the World | -8.85 | -28.27 |
| Prices (\$/bale) | 10% reduction | 28% reduction |
| United States | \$4.70 | \$15.20 |
| India | -\$0.60 | -\$1.91 |
| Brazil | -\$0.60 | -\$1.91 |
| Sub-Saharan Africa | -\$0.60 | -\$1.91 |
| Uzbekistan | -\$0.60 | -\$1.91 |
| Rest of the World | -\$0.60 | -\$1.91 |
| Revenues (million \$) | 10% reduction | 28% reduction |
| United States | \$88.25 | \$291.13 |
| India | -\$3.12 | -\$9.91 |
| Brazil | -\$3.09 | -\$9.83 |
| Sub-Saharan Africa | -\$2.61 | -\$8.31 |
| Uzbekistan | -\$1.94 | -\$6.19 |
| Rest of the World | -\$4.91 | -\$15.62 |

U.S. Industry Suggestions for Mitigating Bottlenecks

In an attempt to identify additional methods to relieve future bottlenecks to U.S. cotton exports, industry input was gathered. Discussions with major cotton merchandisers and warehouse managers in the Mid-south and Southern Plains provides somewhat conflicting reports related to improving cotton flow through warehouses. The latter has been routinely identified as a bottleneck in accessing timely supplies of cotton to fill cotton shipping orders. Cotton shipping orders typically involve the selection of individual bales required by the buyer or another shipper. U.S. cotton bales are identified and sold on an individual basis because the quality traits of any particular bale may differ from other bales. Therefore, filling shipping orders can be relatively slow when compared to treating cotton as a homogeneous commodity. There are various ideas on how to improve this process, but merchandisers and warehouses are reluctant to sacrifice the ability of the U.S. marketing system to sell/deliver bales by individual quality characteristics. Selling bales on an individual basis is seen as a comparative advantage of the United States over its foreign competitors. At this point and for the foreseeable future, that advantage is seen to trump the disadvantage of slow bale identification and movement to fill shipping orders.

Another suggestion centered on the desire by some in the cotton shipping industry to increase the number of bales per load. Currently, truckloads of cotton are constrained to 88 bales within a container, or 90 bales on a flatbed truck. Most truckloads from warehouses to ports involve 88-bale loads that are transferred to containers at the port. One suggestion from industry was to use 96-bale “high cube” containers, allowing 96-bale truckloads to transport cotton to port, thus reducing the number of truckloads for a given supply. This alternative scenario assumes that cotton truck shipments could obtain a waiver from state regulatory agencies related to weight limits. The precedent for this is may be supported waivers received by grain trucks during the grain harvest.

In the Waiver Scenario, one third of the flat bed vans would be allowed to ship 96 bales per load. These changes would be implemented as follows: 1) only shipments from warehouses to ports are affected; 2) shipments from warehouses to ports are made via three modes – boxcars, flatbed vans, and truck chassis; 3) only one-third of the flatbed vans are allowed to use the waiver while no boxcars or truck chassis shipments may use this waiver; and 4) the cost of flatbed van shipments is estimated based on adjusting for 96 bales for flatbed vans instead of 88.

The Waiver Scenario was solved and compared to the Baseline Scenario. By allowing for larger truckloads, holding the aggregate supply constant, the overall number of truckloads was reduced. This resulted 9,245 88-bale truckloads, replaced by 8,604 96-bale loads. The aggregate national shipping/handling/storage cost declined by 0.08% from \$749.2 million to \$748.6 million for a total reduction of \$600,000. The truck portion of this cost reduction is \$354,789, or 0.8% of the truck costs, while the other \$250,000 in cost reduction is results from other costs savings related to fewer truckloads. These are minimal cost savings which may be partially eroded since the analysis does not take into account the availability of larger containers.

Summary and Implications

The transportation system in the United States is under constant use and strain. This system of roads, rail, ports and waterways is also of crucial importance to the efficiency and competitiveness of the U.S. cotton industry. As global cotton mill use expands, greater demands than ever before will be placed on this system. Constraints and improvements in U.S. transportation will ultimately influence cotton exports, shipping patterns and world trade. The purpose of this study was to assess U.S. transportation infrastructure and the potential impacts of improvements on the U.S. cotton industry.

The United States is forecast to export 15.75 million bales of cotton in 2011, representing about 87 percent of the cotton crop. China was the largest market for U.S. cotton in 2010, accounting for 35 percent of all U.S. cotton exports. Turkey, Mexico, Indonesia and Vietnam accounted for 34 percent of U.S. cotton exports. Los Angeles/Long Beach, Savannah, Houston and Laredo are the major ports through which the majority of U.S. cotton was exported.

Results of our spatial equilibrium analysis indicates that under most normal cotton shipping scenarios, the port of LA/LB retains its dominance, especially for exports to Asia. Savannah, Houston and Laredo also continue as major export ports. Laredo retains its importance as the primary port for cotton exported to Mexico. New Orleans, Charleston and

Norfolk remain key suppliers of cotton to Europe and the Middle East. Oakland continues as an important port for Asian markets, while Hidalgo, Texas remains important for exports to Mexico.

The completion of the Panama Canal expansion (PCE) in 2014 has major implications for altered shipping patterns throughout the United States. These results assume a 28 percent reduction in ocean transportation rates for cotton shipments to Asian markets attributed to the PCE.

The United States generally gains from the PCE in several ways. First, total cotton exports are estimated to increase by 247,000 bales, or about two percent. Important regional shifts in trade do occur, however. Exports from India are estimated to decline, as do exports from Brazil and Uzbekistan. Along with these export declines are estimated drops in price and producer revenues for these countries, ranging from \$6.0 million in Uzbekistan to \$10 million in Brazil and India. U.S. prices are estimated to increase by \$0.03/pound, while revenues rise by \$291 million.

Due to lower ocean transportation costs from Gulf and South Atlantic ports, these ports are estimated to double their share of U.S. cotton exports. Houston is estimated to become the nation's second largest cotton exporting port after Savannah, expanding cotton volume by two-thirds to 2.6 million bales. Exports from the port of Savannah are estimated to double to 4.6 million bales. New Orleans, Charleston and Norfolk are all estimated to increase their volumes of cotton exports from 1.0 million bales to 3.6 million bales.

Exports from Texas land-based ports of Laredo and Hidalgo are mixed, with overall export volume down nine percent to 1.4 million bales. Laredo is estimated to gain about 11 percent in export volume to 1.2 million bales, while exports from Hidalgo would decline 40 percent to 185,000 bales.

Gains for the Gulf, South Atlantic and Texas ports come at the expense of the West Coast ports. Cotton exports from LA/LB are estimated to decline 72 percent to 1.8 million bales, while export volumes from Oakland are down marginally to 385,000 bales.

References

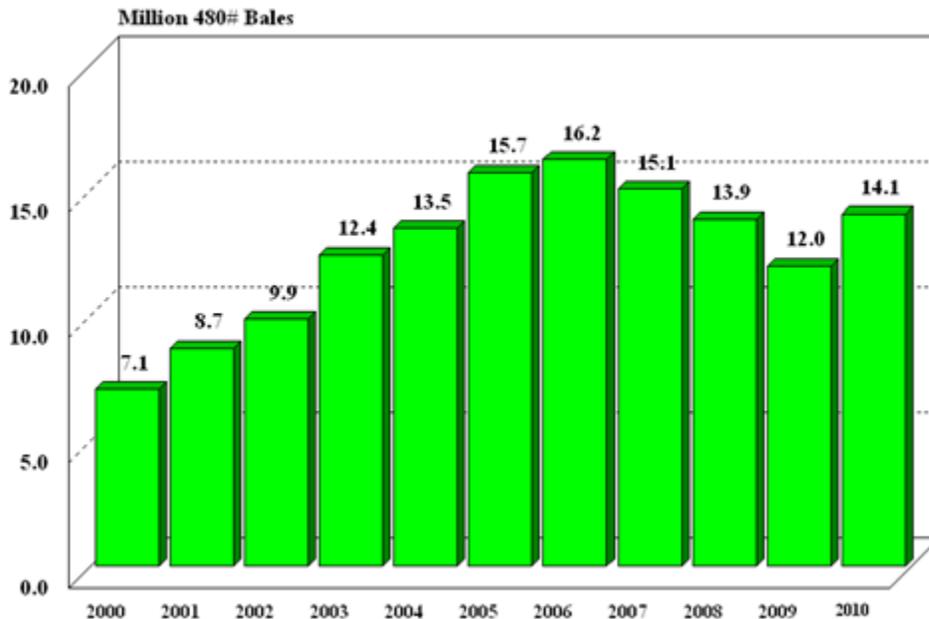
- Costa, R.F. and C.P. Rosson, III. "The Impacts of Improving Transportation Infrastructure in Brazil on the World Soybean Market." 49th Annual Transportation Research Forum, Fort Worth, TX, March 17 – 19. 2008.
- Costa, R., C.P. Rosson, J.R.C. Robinson, S.W. Fuller. "The Impacts of the Panama Canal Expansion on World Cotton Trade," work in progress, 2011.
- Enke, S. "Equilibrium Among Spatially Separated Markets: Solution by Electric Analogue." *Econometrica* 19:40-47. 1951.
- Fraire, F., P. Lai, J. Robinson, S. Fuller and J. Park. "Least-Cost Shipping and Storage of West Texas Cotton." Transportation Research Forum Annual Meeting, Ft. Worth, Texas. 2008.

- Fuller, S.W., L. Fellin, and K. Eriksen. "Panama Canal: How Critical to U.S. Grain Exports." *Agribusiness: An International Journal* 16(4):435-57. 2000.
- Fuller, S.W., T.H. Yu, L. Fellin, A. Lalor, and R. Krajewski. "Effects of Improving Transportation Infrastructure on Competitiveness in World Grain Markets." *Journal of International Food & Agribusiness Marketing* 13(4):61-85. 2001.
- Horton, T. "Mallory Alexander International: More Than A Warehouse." Cotton Farming. Available online at: http://www.cottonfarming.com/home/2006_MarCF-Mallory.html. Accessed on May 27, 2008.
- Institute for Water Resources, US Army Corps of Engineers. "The Implications of for Panama Canal Expansion to U.S. Ports and Coastal Navigation Economic Analysis, IWR White Paper, December 2008.
- Panama Canal Authority (ACP). "The Panama Canal Expansion and Its Impacts on World Trade," Power Point Presentation by Manianela Dengo, October 4, 2010.
- Research and Innovation Technology Administration, Bureau of Transportation Services, US Department of Transportation, "American's Container Ports: Freight Hubs That Connect Our Nation to Global Markets," Washington, DC: June 2009.
- Robinson, J.R.C., J.L. Park, and S. Fuller. "Cotton Transportation and Logistics: A Dynamic System." Transportation Research Forum Annual Meeting, Ft. Worth, Texas. 2007.
- Salin, Delmy. "Impact of the Panama Canal Expansion of the U.S. Intermodal System," Agricultural Marketing Service, USDA, Washington, DC: January 2010.
- Samuelson, P.A. "Spatial Price Equilibrium and Linear Programming." *American Economic Review* 42(1):283-303. 1952.
- Takayama, T. and G.G. Judge. *Spatial and Temporal Price and Allocation Models*. Amsterdam, North Holland Publishing Co. 1971.
- University of Virginia, Miller Center for Public Affairs. "Well Within Reach: American New Transportation Agenda," David R. Goode National Policy Conference, Introduction, Charlottesville, VA, October 2010.
- USDA, Foreign Agriculture Service (FAS/USDA). *Global Agricultural Trade System (GATS)*. Washington D.C. Available at <http://www.fas.usda.gov/gats/default.aspx>, last accessed December 2010.
- USDA, Foreign Agriculture Service (FAS/USDA). *Production, Supply, and Demand (PS&D) online database*. Washington D.C. Available at <http://www.fas.usda.gov/psd/>, last accessed December 2010.
- USDA, National Agricultural Statistics Service (NASS/USDA). Washington D.C. Available at <http://www.nass.usda.gov/>, last accessed May 2008.
- USDA. "Cotton Backgrounder", Outlook Report CWS-07B-01, ERS, USDA, March 2007.
- WISERTrade: Port HS Database. Available at <https://www.wisertrade.org/ftweb/ftbegin>, last accessed December 2010.

Figures

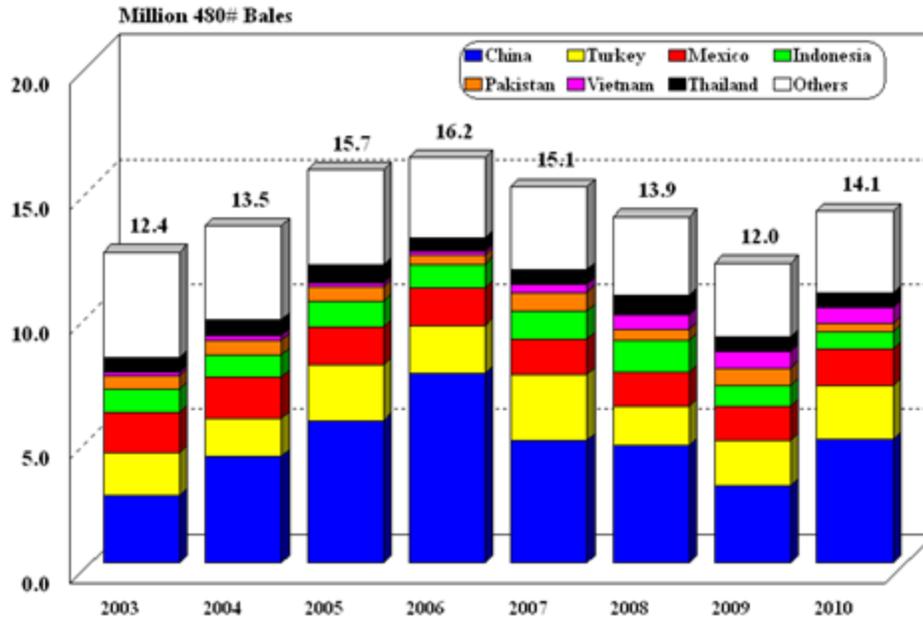
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Figure 1. U.S. Cotton Exports, 2000 - 2010



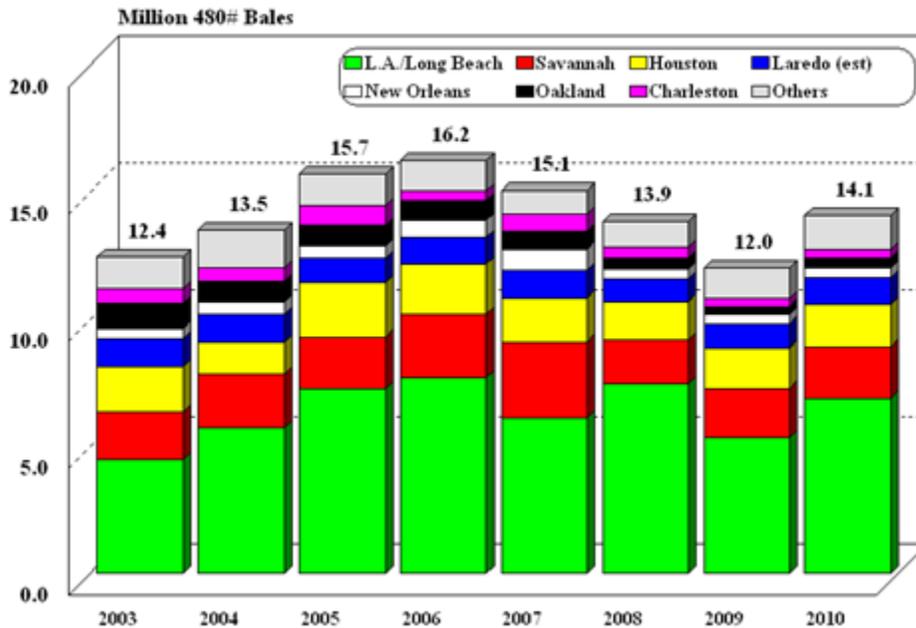
Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 2. Volume of U.S. Cotton Exports by Market



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 3. U.S. Cotton Exports by Port



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 4. Top U.S. Ports for Cotton Exports, 2010

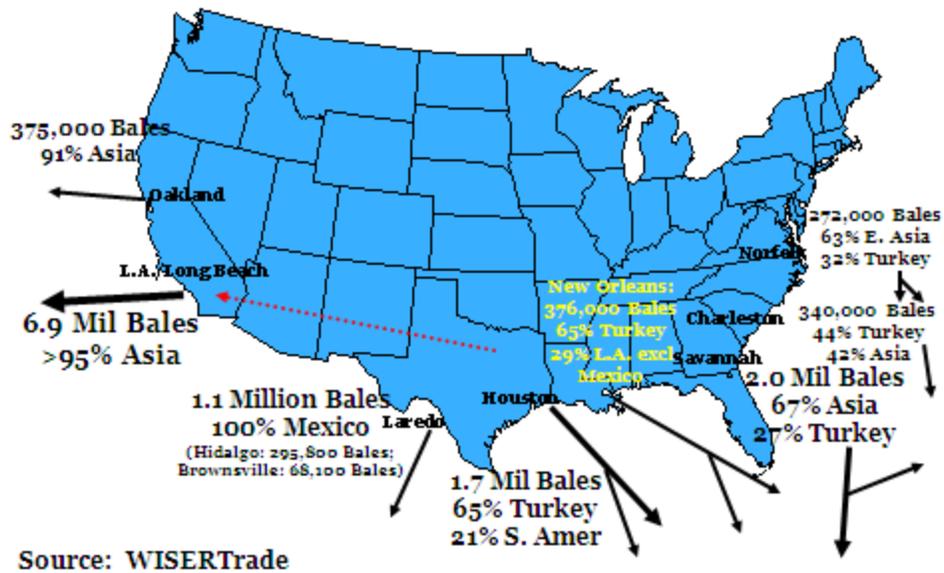


Figure 5. Top U.S. Ports for Cotton Exports, 2003

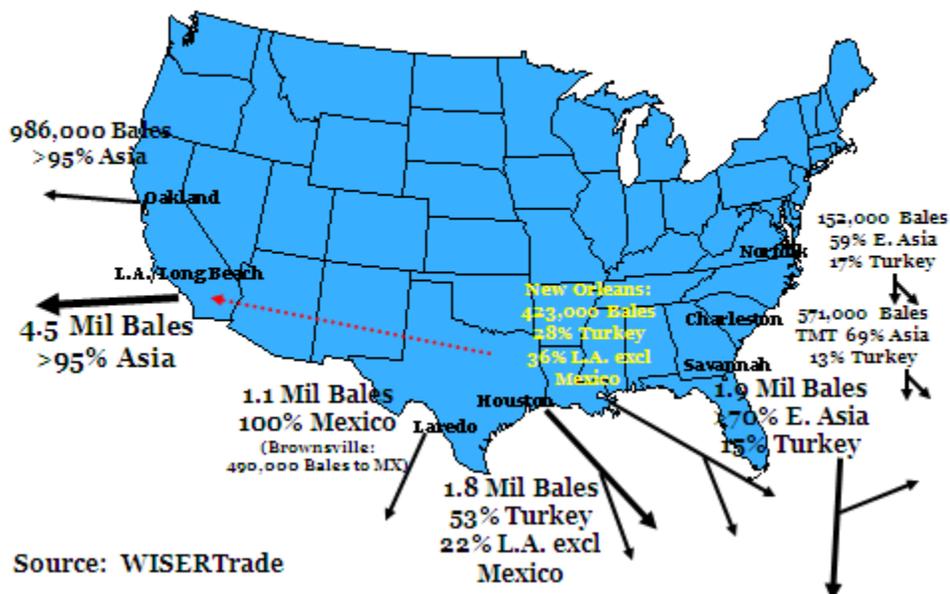
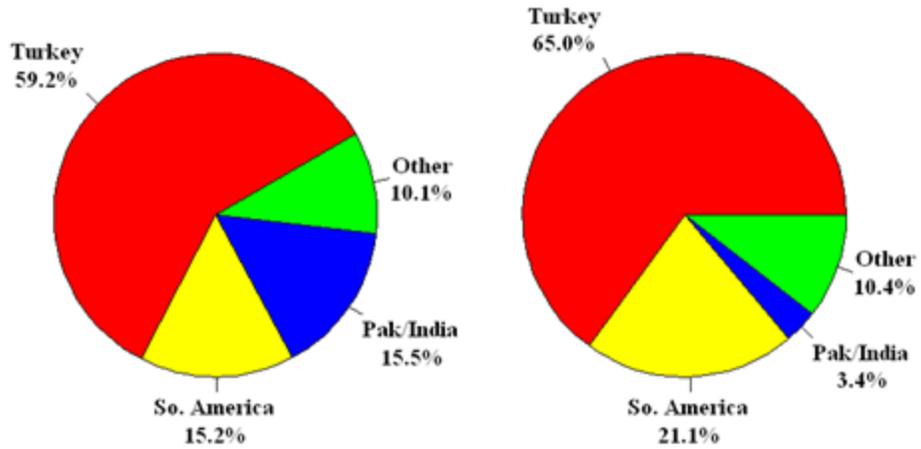


Figure 6. Cotton Exports through Houston by Destination

2009: 1.58 Million Bales

2010: 1.66 Million Bales

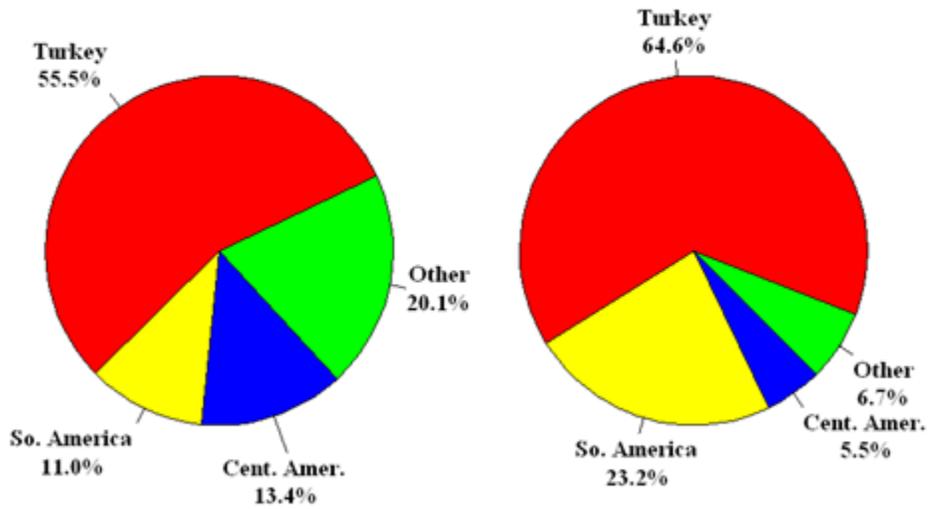


Source: WiserTrade

Figure 7. Cotton Exports through New Orleans by Destination

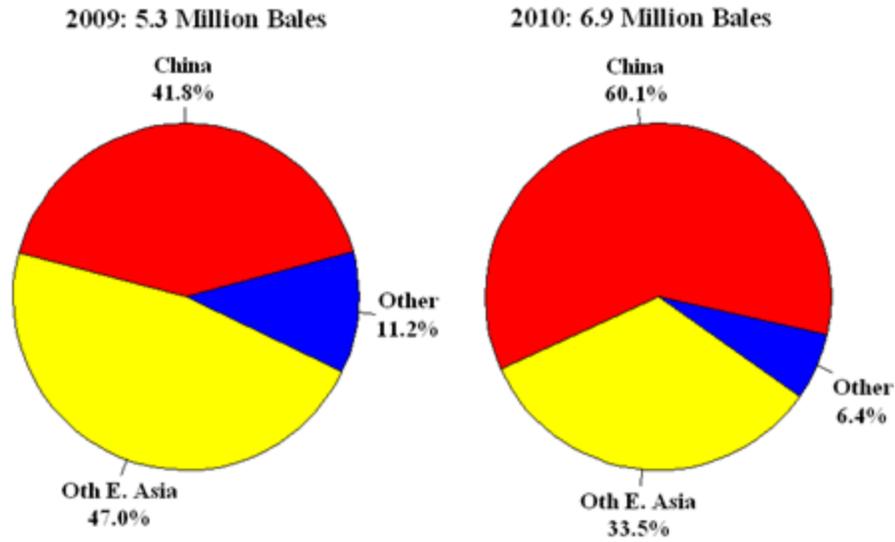
2009: 361,900 Bales

2010: 376,000 Bales



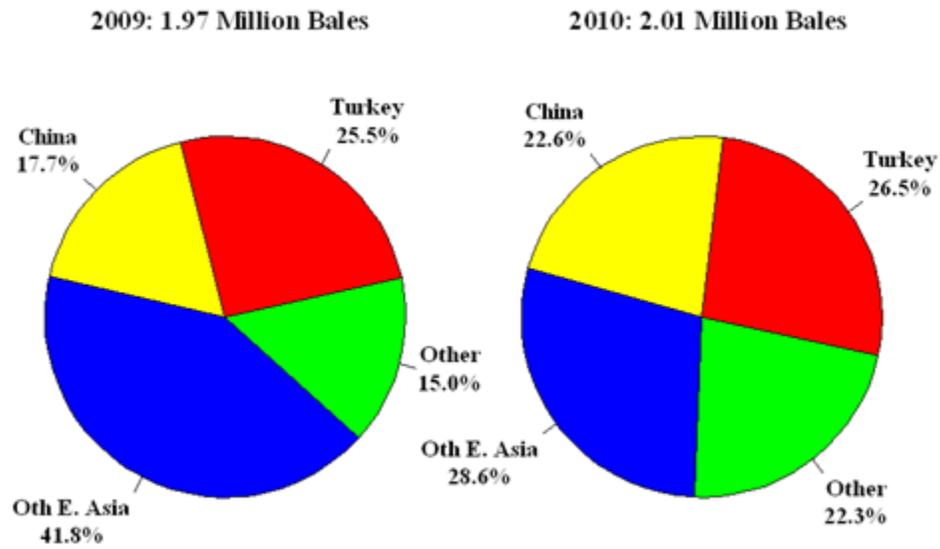
Source: WiserTrade

Figure 8. Cotton Exports through L.A./Long Beach by Destination



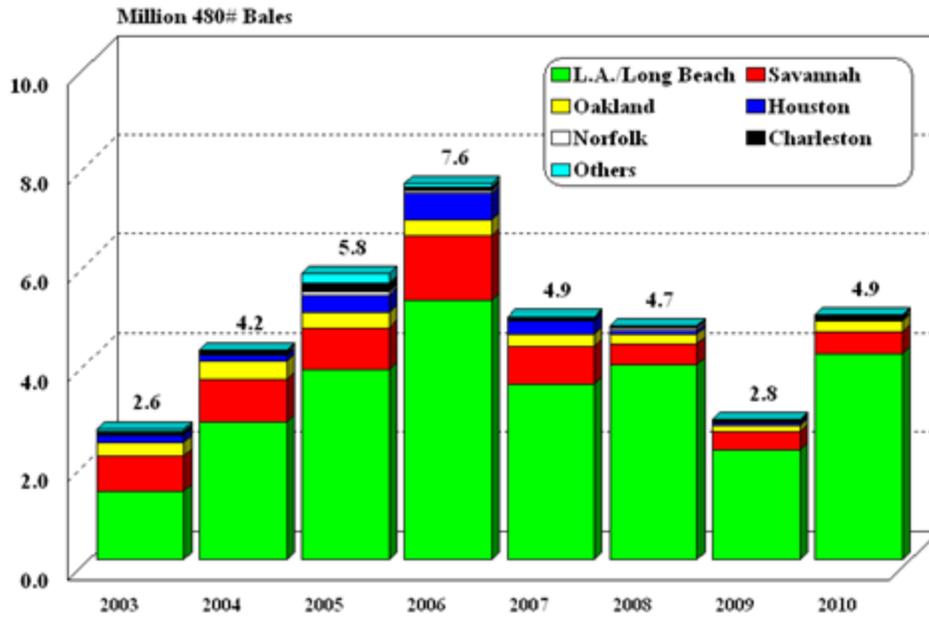
Source: WiserTrade

Figure 9. Cotton Exports through Savannah by Destination



Source: WiserTrade

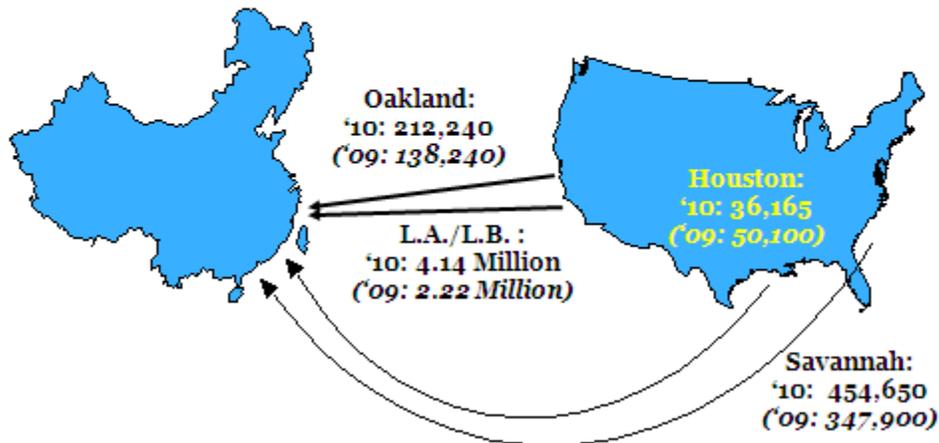
Figure 10. U.S. Cotton Exports to China, 2003 - 2010



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

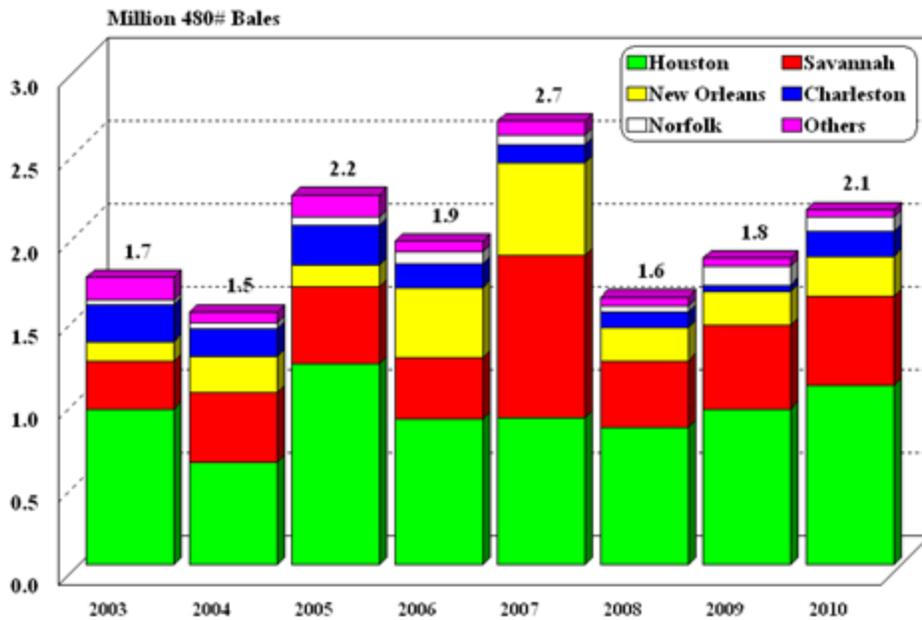
Figure 11. Top U.S. Ports for Cotton Exports to China

2010: 4.93 Million Bales
(2009: 2.82 Million Bales)



Source: WISERTrade

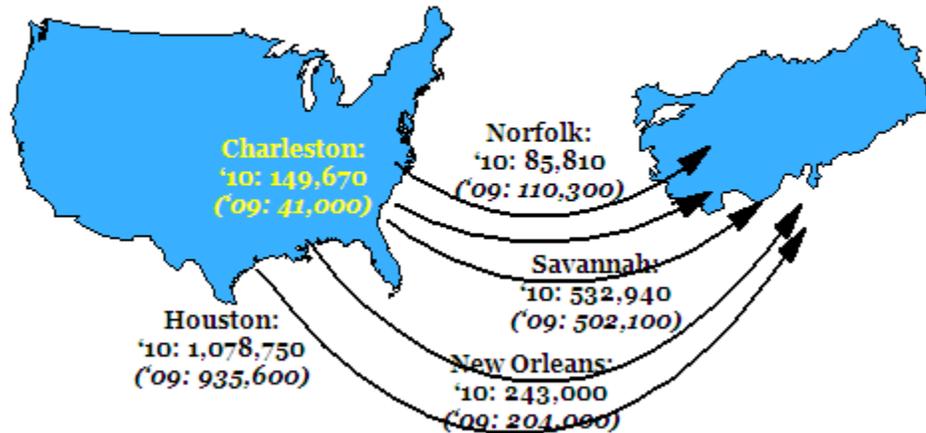
Figure 12. U.S. Cotton Exports to Turkey, 2003 - 2010



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

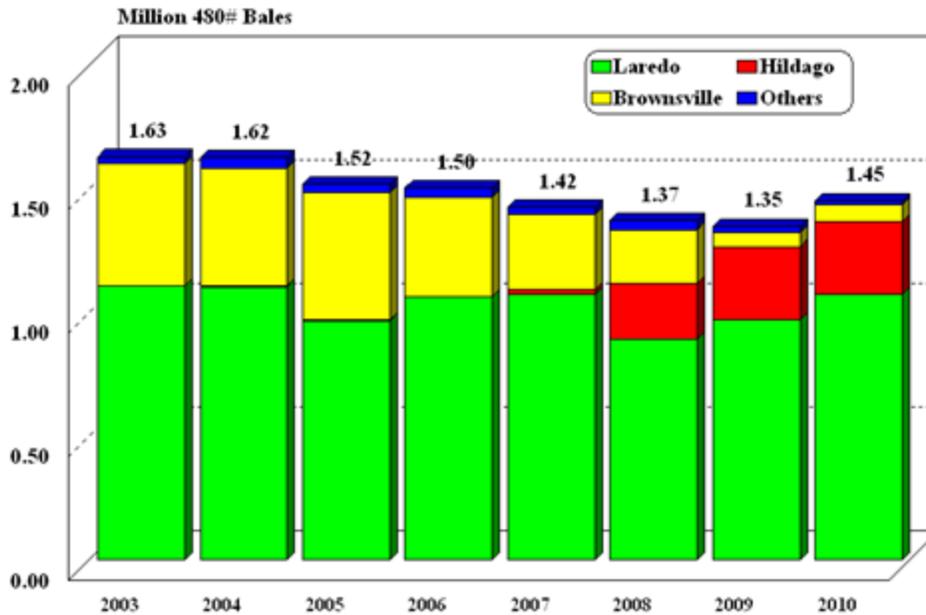
**Figure 13. Top U.S. Ports for Cotton Exports to Turkey
2010: 2.14 Million Bales**

(2009: 1.84 Million Bales)



Source: WISERTrade

Figure 14. U.S. Cotton Exports to Mexico, 2003 - 2010



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 15. Top U.S. Ports for Cotton Exports to Mexico

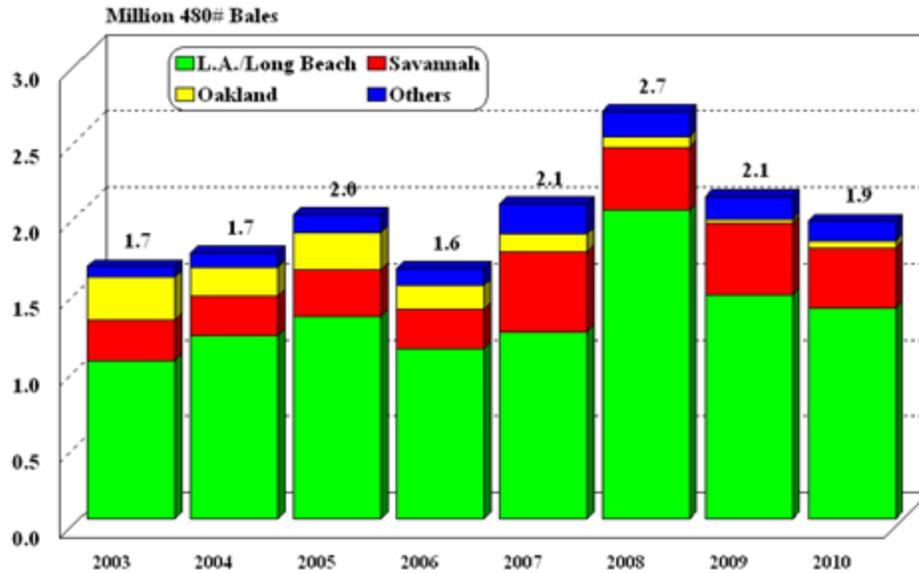
2010: 1.45 Million Bales

(2009: 1.35 Million Bales)



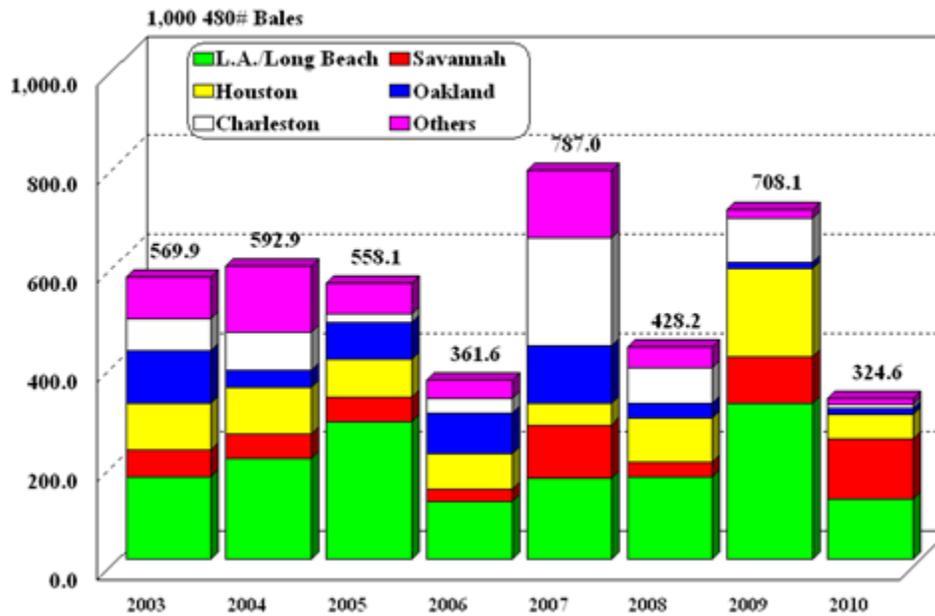
Source: WISERTrade;
Volumes Estimated Using
Unit Value from FAS

Figure 16. U.S. Cotton Exports to Indonesia, Vietnam and Thailand, 2003 - 2010



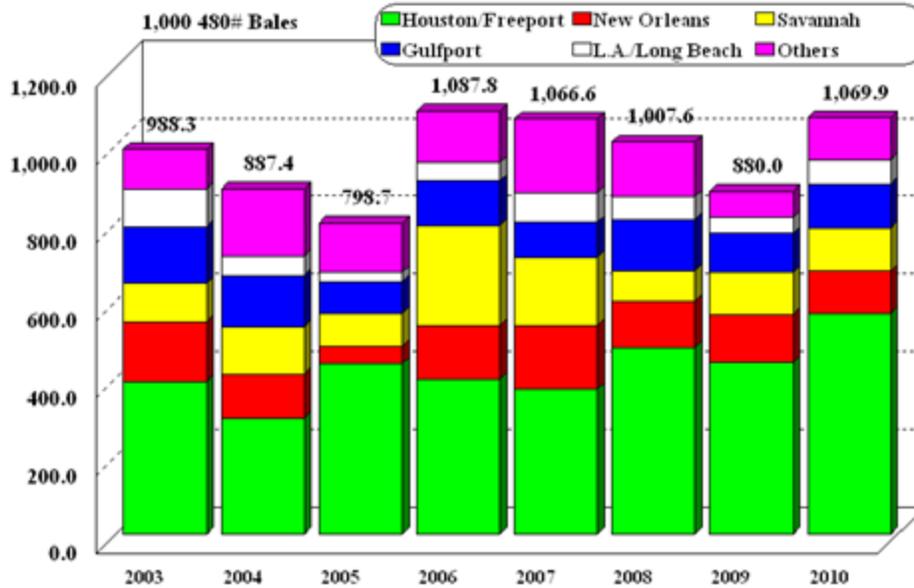
Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 17. U.S. Cotton Exports to Pakistan, 2003 - 2010



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 18. U.S. Cotton Exports to Latin America (Excl Mexico), 2003 - 2010



Source: Global Agricultural Trade System (GATS), USDA Foreign Agricultural Service, <http://www.fas.usda.gov/gats/default.aspx>

Figure 19. Top U.S. Ports for Cotton Exports to Latin America (excluding Mexico)

**2010: 1,069,900 Bales
(2009: 876,000 Bales)**



Top Ports of Origin
 Houston: 383,400
 Freeport: 184,000
 Gulfport: 113,700
 Savannah: 110,900
 New Orleans: 108,000
(Gulfport & New Orleans switched places from 2009)

Top Destinations
 Peru: 351,700
 Colombia: 237,400
 El Salvador: 143,100
 Guatemala: 114,300
 Brazil: 111,800
(Colombia #1 in 2009)

Source: WISERTrade