Cotton Transportation and Logistics: A Dynamic System

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Abstract

The paper reviews the evolution of U.S. cotton transportation and logistics patterns over the last three decades. There have been many forces of change over this time period, with the largest change being a shift from primarily domestic market destinations to the international market. We describe the pre-1999 system and flow patterns when domestic consumption of U.S. cotton was dominant. We contrast this with current flow patterns as measured by available secondary export data and a sample of survey data from Texas cotton warehouses. The survey data show similar shipment destinations and modes of transportation for Texas cotton as observed in the Mid-1990s. The main difference is the increased percentage of export destinations, reflecting the transformation of the U.S. cotton industry into an export industry.

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INTRODUCTION

Cotton is one of the more important row crops in southern and southwestern states. The U.S. is the second-largest producer of cotton in the world and, in recent years, has produced about 20% of the world's annual supply. Texas has the largest share of U.S. cotton production at around 30% and a regional farming economy that is dominated by its production, processing, and shipment (Robinson and McCorkle, 2006). U.S. cotton industry has been in a state of change over the last three decades. As Table 1 shows, this change has been largely policy driven, though changes in technology and business innovations have played a major role. For example, U.S. transportation deregulation set the stage for a shift from interregional cotton shipments by rail to truck (see Results and Discussion). The combined impact of twenty years of U.S. commodity policy has been to encourage large supplies of cotton for the export market, which in turn has implications for U.S. cotton flows (e.g., more shipments to Pacific coast ports). The successful applications of plant breeding and pest management have further encouraged the trend towards regular exportable supplies of U.S. cotton. Trade policy agreements have probably facilitated the outsourcing of U.S. textile manufacturing, first to Mexico, and then to the Far East. This has implications for the destination and flow pattern of U.S. raw cotton shipments in general, and Texas in particular.

Table 1. Major Forces of Change in U.S. Cotton Flow Patterns, 1980-2006.

Event → Impact	Year
Truck/Railroad deregulation → Greater relative share of truck traffic of U.S. cotton	1980
U.S. Food Security Act → Implemented cotton marketing loan, subsidizing U.S. exports	1985
U.S. Food, Agriculture, Conservation & Trade Act → Implemented "Step 2" cotton demand subsidy	1990
North American Free Trade Agreement → Increased cotton exports to Mexico and Canada Increased (decreased) Mexican (U.S.) apparel manufacturing	1993
U.S. 1996 and 2002 Farm Bills → Maintained cotton friendly export provisions; expanded acreage.	2002
China accepted to the WTO → Eliminated Multi-Fiber Agreement restriction on Chinese textiles China regained top market share in textiles and U.S. cotton imports	2001
Boll weevil eradication and improved cotton varieties → Increased U.S. yield potential	2004
U.S. cotton domestic and export subsidies challenged in the WTO → not resolved	2005

There are few secondary data sources and little public analysis of current U.S. cotton distribution patterns and transportation/logistics costs. During the 1970s-1990s, the USDA Economic Research conducted regular surveys of cotton warehouses to document U.S. cotton flow patterns. However, this research program was terminated in 1997. The lack of transportation and logistics information for U.S. cotton is unfortunate given the dynamics in cotton marketing within the U.S., e.g., changes in seed cotton storage and assembly systems, evolution of fewer gins of larger capacity, noteworthy decline in U.S. mills and the important growth in foreign demand for U.S. cotton. And, as a result of the orientation away from the domestic market to the foreign market, there has been an important change in the transportation and logistics of cotton.

This paper documents recent changes in U.S. cotton transportation and logistics, with a focus on Texas. We summarize the system and flow patterns when domestic consumption of U.S. cotton was dominant (i.e., 1970s-1990s). We then contrast with the present export-based system,

documenting and discussing important forces that changed the system such as the exiting of domestic textile mills and growing international demands, which is the result of globalization. We document the current situation using more recent secondary data on U.S. cotton exports as well as results from a Texas cotton warehouse survey project.

DATA SOURCES AND DEVELOPMENT

Secondary Data Review. Most of the information in this paper is from secondary sources on historical cotton flows and exports. The U.S. flow pattern for the mid 1970s and mid 1990s was characterized by data from two USDA flow study publications (USDA ERS, 1988 and 1997). We also reviewed U.S. cotton export data since the late 1990s (USDA Foreign Agricultural Service, 2006).

Survey Methodology. Preliminary primary data from ongoing survey work are included in this study. The first phase of this primary data collection targeted Texas cotton warehouse managers as the initial transportation point. A draft survey instrument was developed after considerable consultation with and review by Texas cotton warehouse managers. The population being surveyed included the entire population of Texas cotton warehouses, who were identified from the USDA Commodity Credit Corporation list of approved cotton warehouses. The four page mail questionnaire, cover letters, and stamped return envelope were mailed to South Texas cotton warehouses in September 2006 and West Texas in October 2006. Reminder post cards and follow-up surveys were mailed to late or non-respondents. The returned survey information was coded and compiled in MS Excel and summary statistics were estimated.

RESULTS AND DISCUSSION

Review of Secondary Data

Table 2 summarizes cotton shipment information from Texas warehouses in the last two of a series of USDA publications on U.S. cotton distribution patterns (Glade and Johnson, 1988; Glade et al. 1997). Several trends can be highlighted from these historical data. First, the impact of transportation deregulation can be seen as a decline in rail traffic of Texas cotton in favor of trucking. In the mid 1980s the share was 42% rail versus 58% truck, which changed to 25% rail versus 75% truck by the mid 1990s. However, the pattern in Texas differs from the national trend in that almost all southeastern U.S. and most south central U.S. cotton shipments had shifted to trucks by the mid 1990s (data not shown). In contrast, the large volumes of cotton in Texas, the relatively long distances to destinations, and the increasing importance of Pacific coast port destinations have maintained a role for rail traffic.

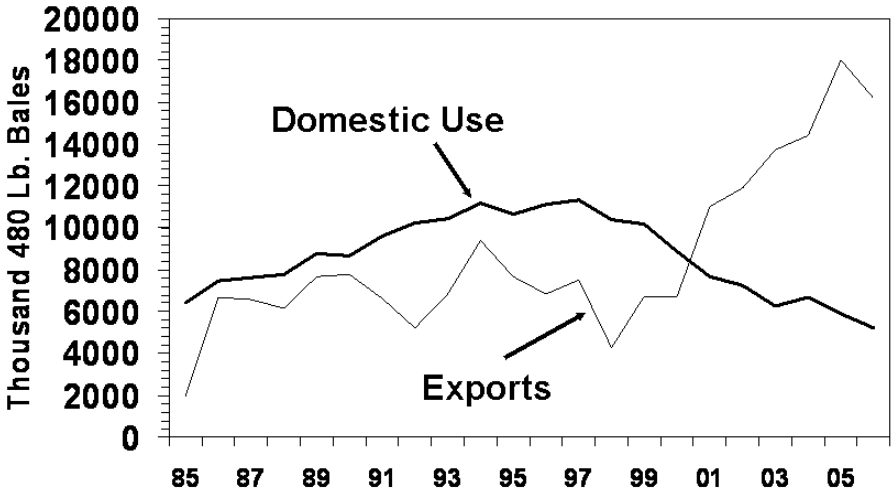
A second important point to make from these data involves the relative share of U.S. domestic mill destinations versus the export market. The total bales shipped from Texas to southeastern mill destinations increased from 37% in 1986/87 to 52% in 1993/94, Texas export shipments declined over the same period (Table 1). Shipments of U.S. cotton to domestic mill destinations followed a similar trend over a longer time frame with 45% in 1980/81, 52% in 1986/87 and 63% in 1993/94 (Glade et al., 1997). This apparent trend in increasing domestic U.S. cotton shipments is notable for how dramatically it was reversed after the mid 1990s. USDA data on U.S. cotton utilization over

Table 2. Cotton Shipments from Texas Warehouses by Destination and Mode of Transportation, 1986/87 and 1993/94.

Destination	Rail (Bales)		Truck (Bales)		Total (Bales)		% of Texas Total	
	1986/87	1993/94	1986/87	1993/94	1986/87	1993/94	1986/87	1993/94
Southeast Mill Area:								
Alabama	52,886	13,571	107,415	179,771	160,301	193,342	5.6	6.1
Georgia	23,151	29,336	206,146	314,428	229,297	343,764	8.0	10.9
North Carolina	188,355	78,304	275,173	500,091	463,528	578,395	16.1	18.3
South Carolina	62,505	89,010	149,825	377,658	212,330	466,668	7.4	14.8
Virginia	3,134	9,834	4,999	65,202	8,133	75,036	0.3	2.4
Total	330,031	220,055	743,558	1,437,150	1,073,589	1,657,205	37.4	52.5
New England	0	NR	2,169	NR	2,169	NR	0.1	NR
Interior Concentration Points [1]	[2]70,921	[2]20,757	[3]117,869	[3]187,643	188,790	208,400	6.5	6.6
Canada	1,386	32,496	9,869	3,549	11,255	36,045	0.4	1.1
Mexico	NR	147,648	NR	80,516	NR	228,164	NR	7.2
Ports:								
Atlantic Coast	10,413	0	81,650	1,616	92,063	1,616	3.2	0.1
Central Gulf	0	2,969	501	12,450	501	15,419	0.0	0.5
West Gulf	56,905	189,008	596,470	389,751	653,375	578,759	22.7	18.3
Pacific Coast	712,967	163,299	125,065	268,650	838,032	431,949	29.1	13.7
Other [4]	10,075	0	5,784	0	15,859	0	0.6	0.0
Total Shipments	1,192,698	776,232	1,682,935	2,381,325	2,875,633	3,157,557	100.0	100.0
				Percent				
Truck vs. Rail	41.5	24.6	58.5	75.4	100.0	100.0	NA	NA

[1] Nonconsuming points from which cotton is assembled and reshipped to final destination
[2] For 1986/87: Mississippi, 6,255; Tennessee, 53,026; Texas, 11,640. For 1993/94: Tennessee, 17,667; Texas, 3,090
[3] For 1986/87: Arkansas, 3,760; Louisiana, 3,576; Mississippi, 3,205; Missouri, 2,495; Tennessee, 14,510; Texas, 90,323. For 1993/94: Louisiana, 359; Mississippi, 3,420, Oklahoma, 22,794; Tennessee, 18,023; Texas, 143,047
[4] Minor destinations and destinations designated as "other" by shipping warehouse.
NR = Not reported NA = Not applicable
Source: ERS/USDA Statistical Bulletin Number 769 and 940

Figure 1. U.S. Cotton Domestic Use vs. U.S. Exports, 1985/86 - 2006/07.



Source: USDA Office of the Chief Economist, 2006.

that period show a steep decline in U.S. mill use, matched by a significant rise in U.S. cotton exports (Figure 1). This coincides with the ascendancy of Chinese textile manufacturing, and the NAFTA and WTO trade agreements, all of which likely accelerated the decline of U.S. based textile manufacturing in favor of Mexican and then Far East competition. NAFTA gave Mexican textile manufacturing a temporary edge over Chinese and other competitors in the mid 1990s. However, Chinese investment in textile manufacturing and its favorable position in the WTO led to its re-establishment of dominance over Mexico in both imports of U.S. cotton and exports of textiles to the U.S. by 2001 (Gruben, 2006).

The dramatic decline in U.S. domestic cotton utilization, and the concurrent rise in U.S. exports, occurred after 1999. Table 3 documents the export trends from 1999 through 2005 using data from USDA Foreign Agricultural Service (2006). Some points from these data are notable. First, total U.S. cotton exports rose from over 3 million bales in 1999 to almost 15 million bales in 2005 (Column 11). Second, the ascendancy of China as a consumer of U.S. cotton is striking, rising from less than 1% to over 30% of the total share of U.S. cotton exports between 1999 and 2005 (Column 3). The leveling off of Mexican and Turkish imports of U.S. cotton (Column 6) reveal these countries as important but non dominating sources of demand. Rising (in most cases) cotton exports to Bangladesh, Indonesia, Thailand, and other Pacific Rim countries also emphasize the global market for U.S. cotton, and the specific importance of Far East markets.

Table 3. Exports (Running Bales) of U.S. Cotton to Major Country Destinations, 2003-2005.

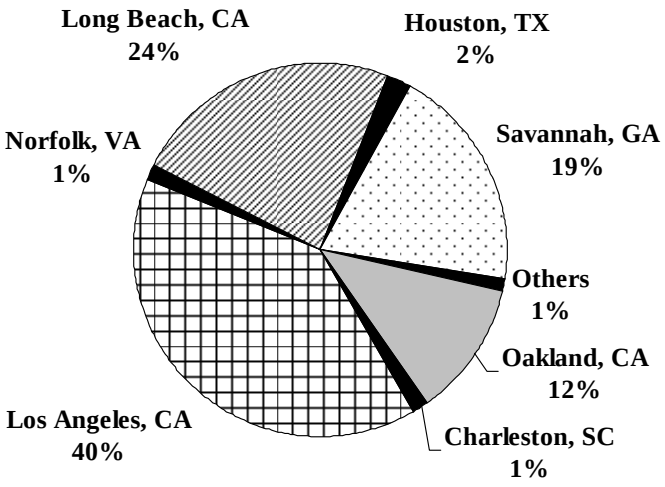
Calendar Year	Bangla-desh	Mainland China	EU-25	Indonesia	Mexico	Pakistan	Thailand	Turkey	All Other	Total Exports
1999	21,096	28,137	63,730	217,483	997,167	4,678	85,502	189,792	1,470,013	3,077,598
2000	76,160	61,669	65,633	501,736	1,810,696	3,970	217,850	875,142	2,800,180	6,413,036
2001	210,274	131,196	57,197	655,882	1,798,793	152,342	330,775	772,565	3,772,774	7,881,798
2002	242,074	532,915	114,986	768,825	1,938,227	417,415	572,799	1,262,342	3,835,946	9,685,529
2003	177,241	2,107,821	156,459	768,697	1,909,159	416,191	531,444	1,612,752	3,752,155	11,431,919
2004	169,986	4,268,199	232,861	789,918	1,662,200	424,127	531,077	1,452,823	3,268,773	12,799,964
2005	143,211	5,198,346	173,338	951,804	1,624,424	401,480	681,177	2,205,219	3,184,908	14,563,907

Source: USDA Foreign Agricultural Service (2006).

In summary, recent utilization and export data reveal a major structural shift in the U.S. from a primarily domestic market to a majority export market. Some of the transportation implications of these structural shifts include the following.

- Since Mexico remains an important, albeit not dominant, demand source for U.S. cotton, there will likely be a continuation of cotton shipments from/through Texas to Mexico.
- The discontinuance of the "Step 2" export subsidy in 2005 (Pan et al., 2006) could influence the pattern of cotton shipments from/through Texas to Mexico. The nature of the "Step 2" subsidy perhaps encouraged some truck traffic across the Mexican border which might be replaced by rail or barge to interior Mexican textile mills.
- Turkish, EU-25, and (to some extent) Indian subcontinent cotton imports influence U.S. and Texas shipping patterns by creating demand for shipments from Atlantic and Gulf ports, including Houston and Galveston. The latter Texas ports are also important as delivery points for cotton futures contracts.

Figure 2. Total Exports to the Far East by Port 2003-2005



- The dominance of the Far East, and specifically China, as a demand source for U.S. cotton highlights the continued importance of rail traffic from Texas and other interior assembly points to Pacific coast ports (Figure 2), as well as intermodal shipments of truck trailers or containers on flatbed rail cars, dedicated unit trains, and special through-rate rail/ocean shipping rates by ocean carriers back-hauling to the Far East. All of these innovations have been employed in cotton shipping for decades (Glade and Johnson, 1988; Glade et al., 1997), but their prevalence is likely to rise with the Far East cotton trade.

Texas Cotton Distribution Survey Results

Sample Size. As of Dec. 1, 2006, the authors have received fifteen survey packets out of 30 mailed for a response rate to date of 50%. The fifteen surveys account for 43 separate warehouse facilities with, significantly, a total warehouse capacity of 4,371,664 bales. Over the 2005-06 crop year, these 43 warehouse facilities report receipt of 6,066,758 bales total and 404,450 bales on average and shipment of 6,251,596 bales total and 416,773 bales on average (Table 4). For comparison, respondents were asked to provide a three year average of bales received. From 2003-2005, these warehouses report combined average receipts of 4,592,853 bales. This level of volume is significant as it represents two thirds of the average 6.8 million bales/year produced in Texas during 2003-2005. Thus these 43 warehouses are handling a majority of the volume of bales produced, stored, and shipped in Texas. The warehouse facilities surveyed so far reflect the geographical distribution of Texas cotton production.

Volume Distribution. When looking at the draw of the warehouse receipts, our survey indicates that 45% of bales were received from gins 33 miles away or less, 37% were received from gins between 33 and 67 miles away, 11% were received from gins between 67 and 100 miles away, and 7% were

from gins more than 100 miles from the warehouse. The temporal distribution of bales received reflects the varied harvest/ginning periods across Texas. On average, respondents indicate 2.7% of their receipts occur in July, 12.4% in August, 12.4% in September, 13.1% in October, 19.4% in November, 20.8% in December, 13.6% in January, 3.4% in February, and 2.2% in March or later. In contrast, the reported distribution of bales shipped throughout the year is more evenly distributed. This distribution relates more to marketing patterns and the influence of the USDA price support program (which subsidizes storage). On average, respondents indicate 3.7% of shipments occur in August, 4.1% in September, 7.3% in October, 10.8% in November, 7.1% in December, 8.4% in January, 11.7% in February, 9.3% in March, 7.7% in April, 7.9% in May, 9.3% in June, and 5.7% in July.

Shipment Destination. On average, respondents indicate that more than 85% of total annual shipments were to export markets in the 2005-06 crop year. This corresponds to the national trends where over two thirds of U.S. cotton is regularly exported (Figure 1). Respondents were asked to estimate the percentage of their export shipments leaving the US through various boarder crossings and ports. Average estimates show that 13.3% of export shipments are routed through the Mexican border, 19.8% through Houston/Galveston, 0.7% though other Gulf ports, 43.8% through the Pacific coast ports, 1.1% through Atlantic coast ports, 0.1% through Canadian border, and 9% through other boarder crossings or ports (Table 5). In general, exports leaving through Pacific coast ports were more likely to be trans-shipped through other warehouse facilities. The reason for this that Pacific coast shipments are often hauled in large quantities on unit trains, and accumulated at points like Dallas.

Export Shipments. Those warehouses shipping directly to export markets were asked to indicate modes of transportation used to move the cotton to specific points of departure at border crossings or ports. These results indicate a continuation of the historical trends shown in Table 2, i.e., current intrastate cotton shipments in Texas are mostly via truck while long haul shipments to the Pacific coast are mostly by intermodal rail (Table 5).Of those warehouses shipping to Mexico, 87.9% of those shipments were by truck, 0.5% by rail boxcar, and 11.6% by rail hauled container, on average. Of those warehouses shipping to Houston/Galveston, 66.7% of those shipments were by truck, 1.4% by rail boxcar, and 32.0% by rail hauled container, on average. Of those shipping to other Gulf ports, an average of 82% of those shipments were by truck, 14% by rail boxcar, and 4% by containers on flatbed rail cars. Of those shipping to the Pacific coast, 22.1% of those shipments were by truck, 2.3% by rail boxcar, and 75.6% by containers on flatbed rail cars.

Domestic Shipments. On average, respondents indicate that 14% of total annual shipments were to domestic markets in 2005-06 crop year. This is in sharp contrast to the 52% domestic shipments in 1994/94 (Table 2) and reflects the major structural shift of the U.S. cotton industry. Of the current domestic shipments, 35.2% were shipped to destinations in Alabama or Georgia, 49.2% in North Carolina or South Carolina, 0.2% in Virginia, 5% in Texas, and 2.6% in other locations. The differences between this domestic allocation and the historical one (Table 2) probably reflects the closure of textile mills in various parts of the Southeast. Methods of transportation used for domestic shipments were mostly trucking, which continues the historical trend, which is likely reinforced by continued economic backhaul incentives of trucks carrying goods, i.e., furniture, from the Southeast. Specifically, for shipments to Alabama or Georgia, 93.4% were by truck, 0.5% by rail boxcar, and 6.1% by container, on average. For shipments to North Carolina or South Carolina, 94.9% were by truck and 5.1% by containers on flatbed rail cars, on average. For the small amount of shipments to Virginia, all transportation was via truck. For shipments to Texas destinations,

98.4% were by truck and 1.6% by rail hauled container. Finally, for all other domestic destinations, 89.4% of shipments were by truck and 10.6% by rail hauled container.

Table 4. Summary Statistics for Operational Data from Texas Warehouses.

Item	n	Mean	Median	Min	Max
Volume (Total Volume=4,371,664 bales)					
Total storage capacity, 2005-2006 (bales)	15	291,444	120,000	3,300	2,040,050
Average number of bales received, 2003-2006	14	328,061	87,701	5,950	2,278,475
Number of bales received, 2005-2006	15	404,451	78,094	5,611	3,017,670
Number of bales shipped, 2005-2006	15	416,773	100,500	5,424	3,401,227
Warehouse Charges					
Typical receiving charge, 2005-2006 ($/bale)	14	$2.87	$2.98	$2.00	$3.50
Typical storage charge, 2005-2006 ($/bale/month)	14	$1.63	$1.95	$0.07	$2.25
Typical loading charge, 2005-2006 ($/bale)	14	$5.52	$5.00	$4.50	$6.75
Typical compress charges, 2005-2006 ($/bale)	14	$8.58	$9.25	$3.40	$9.95
Typical late pick-up charge, 2005-2006 ($/bale)	7	$1.53	$1.88	$0.15	$3.00
Typical late pick-up charge, 2005-2006 ($/bale/day)	2	$1.63	$1.63	$0.25	$3.00

Table 5. Shipments to Export Markets by Border Crossing or Port.

Border Crossing or Port	Percent of all Export Shipments	Percent of Direct Export Shipments		
		By Truck	By Rail Boxcar	By Container
Mexican Border	13.3	87.9	0.5	11.6
Houston/Galveston	19.8	66.7	1.4	32.0
Other Gulf Ports	0.7	81	14	4
Atlantic coast	1.1	100	0	0
Pacific coast	43.8	22.1	2.3	75.6
Other	9.1	52.5	2.5	45.0

SUMMARY

The U.S. cotton market has undergone a major shift from having considerable domestic demand to primarily supplying foreign demand. The distribution of this foreign demand is diverse, but most concentrated in the Far East. This has accentuated the transportation patterns within the U.S. and Texas that supply cotton to ports of exit. The major Texas patterns continue to involve truck shipments to interior concentration/trans-shipment by rail to the Pacific coast, truck shipment to western Gulf ports for export, and truck shipments to the Mexican border.

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