A MARKOV CHAIN ANALYSIS OF STRUCTURAL CHANGES IN THE TEXAS HIGH PLAINS COTTON GINNING INDUSTRY

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Abstract

Markov chain analysis of changes in the number and size of cotton gin firms in West Texas was conducted assuming stationary and non-stationary transition probabilities. Projections of industry structure were made to 1999 with stationary probability assumptions and six sets of assumed conditions for labor and energy costs and technological change in the non-stationary transition model. Results indicate a continued decline in number of firms, but labor, energy, and technology conditions alter the configuration of the structural changes.

Key words: Markov chain, cotton ginning, industry structure.

The United States cotton industry has undergone many changes during the last three decades. Total United States acreage planted to cotton declined from 27.4 million acres in 1949 to 14.3 million by 1981, while the average yield during those same years increased from 282 to 546 pounds per acre. Total United States cotton production has remained relatively constant, but cotton production within the United States has shifted from the Southeast and Midsouth to the Southwest and West. Changes in the ginning industry have usually accompanied changes in production. Active gin numbers in the United States declined from more than 30,000 in 1900 to about 2,200 in 1981, while the average volume per gin (and gin size) increased from 345 to 6,900 bales per gin per year (United States Department of Commerce, Cotton Ginnings in the United States).

A similar trend of declining gin numbers has occurred in Texas, which had 2,713 active cotton gins in 1942 and only 759 in 1981. In 1942, the Texas High Plains area, consisting of 23 counties (Myers), produced 20 percent of the State's cotton. By 1981, more than 60 percent of cotton in Texas and 23 percent of the cotton in the United States was grown in the area. The number of active cotton gins in the area was 277 in 1942, grew to a high of 437 in 1965, but declined to 325 in 1979. The tendency in the High Plains has been for surviving gins to increase their capacity levels. A decline in harvesting time has fostered greater peak-load ginning capacities and has contributed to excess capacity in the industry. The persistent excess capacity problem and related issues of industry structure have been addressed by Campbell; Cleveland and Blakley; Ethridge and Branson; Ethridge and Myers; Fondren et al.; Fuller and Vastine; Fuller et al.; and Hudson and Jesse.

While past trends and problems in the ginning industry are clear, future changes are uncertain because the causes of adjustment are not well understood. Little information is available regarding the economic factors causing these trends, their individual impacts, and their effects on industry structure. The objective of this study is to determine the major economic factors affecting the cotton gin industry and provide conditional projections of the future structure of the Texas High Plains ginning industry.

METHODOLOGY

The Markov chain technique has been used since the 1950's to describe and predict industry structure. The earliest applications in economics were for projecting size distribution of firms. The assumption of stationary transition probabilities, i.e., that the probabilities of movement between size groups do

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not change over time, was used in these studies (Adelman; Collins and Preston). Judge and Swanson made general suggestions as to how Markov chains could be used in agricultural economics. Stationary transition Markov chain models have been used to project number and size of dairy firms in New York (Stanton and Kettunen), farm structure in England and Wales (Power and Harris), cotton's share of the United States fiber market (Smith and Dardis), and structure of the British dairy industry (Colman). In 1962, Padberg questioned the assumption of stationary transition probabilities in an analysis of the California wholesale fluid milk industry and, using a likelihood ratio test developed by Anderson and Goodman, found that his hypothesis of constancy was rejected.

Hallberg showed that when a series of transition probability matrices was found to be changing over time, the Markov chain model could be modified to incorporate the variability. In his research on Pennsylvania frozen milk product manufacturing plants, *a priori* information suggested a functional relationship between the changing probabilities and certain exogenous factors. After testing for constancy and rejecting the hypothesis of stationary probabilities, Hallberg developed a non-stationary Markov model incorporating a least squares regression equation for each cell of the transition probability matrix. The major problem with Hallberg's model lies in meeting the requirements that (1) all of the transition probabilities be non-negative and (2) their sum for any particular row be equal to one; the least squares approach does not automatically meet these constraints. Hallberg dealt with this matter by adjusting any negative transition probability to a value of zero.

Stavins and Stanton refined Hallberg's approach and met the Markov requirements without the use of *ad hoc* procedural assumptions. They specified the required equations such that each row of the transition probability matrix was handled as a separate multinomial logit model using an exponential function to ensure that all predicted probability values would be positive and would sum to unity for each row. As with Hallberg's model, a simulation procedure was used for a series of matrix-vector calculations which leads (recursively) to a conditional forecast of industry structure. The major problem with this approach is that it requires an extensive set of data and is not as flexible as Hallberg's approach if all equations cannot be estimated.

SPECIFICATION OF THE MODEL

This study made use of Markov chain analysis utilizing assumptions of both stationary and non-stationary transition probabilities. This analysis, as adapted to the ginning industry, involved categorizing cotton gins into different size and activity groups (states), tracing changes in states of gins in the study area through time (1967-1979) and estimating probabilities of movement among states. A "state" refers to a specific combination of both activity and size attributes. These transition probabilities were averaged and held stationary and then they were used to project future industry structure. The assumption of stationary probabilities was then relaxed. Least squares regression equations were estimated to relate certain explanatory variables to the probabilities of gins moving between states. Projections of industry structure with non-stationary transition probabilities and projected values of explanatory variables were simulated and compared to model solutions with the stationary transition probability assumption.

For the stationary Markov chain procedure, let n_{ijt} be the number of gins moving from state i to state j in transition t; p_{ijt} be the individual elements within the annual transition probability matrices, i.e., the probability of a gin in state i moving to state j in transition t ($p_{ijt} = n_{ijt}/\Sigma n_{ijt}$); p_{ij} be the individual elements within the stationary probability matrix, calculated as the average of the annual transition probabilities, i.e., $p_{ij} = (\Sigma_t p_{ijt})/(\text{no. of transitions})$; and P be the stationary transition probability matrix consisting of the p_{ij}. Two constraints are imposed on the elements of these matrices: (1) $0 \leq p_{ijt} \leq 1$ for all i, j, and t, and (2) $\sum_t p_{ijt} = 1$ for all i and t. These ensure that probabilities of gin movements between states fall within the range of logical probabilities and that gins in each state be in one of the defined states after each transition.

In addition to the listed definitions, let X_o be the initial starting state vector of the initial configuration of gin firm numbers in each state; X_t be the configuration vector for year t ($X_t = X_{t-1} P$); and X_e be the equilibrium configuration vector, i.e., the number of gins in each state during the year in which equilibrium (no change) is reached. Thus, given P and X_o, a series of X_t's may be projected which eventually converges to a steady state industry structure, X_e.

The Markov chain model with non-stationary probabilities involved estimation of regression equations in which p_{ijt} was expressed as a function of specified exogenous variables. The values in the cells of the 12 annual transition probability matrices (p_{ijt}) constitute the dependent variable observations for the regression equations. There is a regression equation for each cell of the probability matrix for which sufficient numbers of observations (at least eight) exist. Industry structure projections with the non-stationary transition probability Markov chain model are estimated as $X_t = X_{t-1} (\hat{P}_{ijt})$, where the $\hat{P}_{ijt}$ matrix is comprised of transition probabilities ($\hat{p}_{ijt}$) estimated from the regression equations. The non-stationary transition probabilities were estimated for each cell in the matrices by assuming or projecting values of the exogenous variables.

ANALYSIS

Gin capacity (bales per hour) was used as an indicator of cotton gin size. Data for individual gin plant equipment were collected from the United States Department of Agriculture, Agricultural Marketing Service, from which each firm's hourly rated capacity was estimated (Myers). The 376 gins in the 23-county area on which records were available over the 13 year period (12 transitions) were divided into five size and four activity groups. The size groups were: group 1 (0.1 to 9.0 bales per hour), group 2 (9.1 to 16.5), group 3 (16.6 to 21.0), group 4 (21.1 to 32.0), and group 5 (32.1 to 75.0 bales per hour). These size groups were selected by arranging the hourly capacity ratings in ascending order and locating gaps in the capacity array. Thus, the size groupings were those suggested by the historical capacity (size) data. The four activity groups, which include all possible operating conditions, were: (1) new entrants (NE),(2) dead gins (D), (3) inactive gins (I), and (4) active gins (A). The new entrant group included all gins that entered the industry after 1967, while the dead gin group included all gins that were dismantled and exited the industry since 1967. Inactive gins were defined as those that had the capability to gin cotton but were not in operation.

These size and activity groups formed twelve mutually exclusive and exhaustive gin states: new entrant, dead, inactive sizes 1, 2, 3, 4, and 5, and active sizes 1, 2, 3, 4, and 5. A 12 x 11 matrix comprised of elements p_{ijt} was developed for each annual transition and the twelve annual transitions were averaged to form the stationary transition matrix, P, Table 1. A Chi-square test of constancy developed by Anderson and Goodman for individual cells of the stationary transition matrix could not be conducted because many individual cells had no observations. With reference to Table 1, the average probability of an active gin in size group 1 staying in the same state in a transition was 0.919, while the average probability of it moving into inactive (I1) or dead (D) states the next year was 0.031 and 0.004, respectively. The stationary probability of a gin in that state increasing in size to active groups 2, 3, and 4 the next year was 0.040, 0.005, and 0.001, respectively. The overall tendency for most active gins in a transition was for them to stay in their same state. The NE probabilities in Table 1 were obtained by (1) determining the conditional probability that a new gin would enter a specific state, given that there is a new entrant, (2) estimating the probability of a new entrant in any year, and (3) multiplying to obtain the unconditional probability of a new entrant in a specific state. The conditional probabilities for A1 through A5, respectively, were 0.125, 0.438, 0.187, 0.125, and 0.125. The probability of a new entrant in a given year (.0024) was estimated as [(no. entrants)/(no. active gins during that year)]/(no. of transitions), or the average stationary probability.

In the non-stationary Markov chain procedure, factors hypothesized to affect movement among states included:

- CL = annual percentage change in the minimum wage rate (a proxy for the changes in gin labor costs);
- CE = annual percentage change in electricity rate charged to gins (a proxy for change in gin energy costs);
- U = 3-year lagged moving average of the percentage of plant capacity utilized during the harvest/ginning season;
- PRD = 3-year lagged moving average of the percentage change in production in the local county;

TABLE 1. STATIONARY TRANSITION PROBABILITY MATRIX FOR TEXAS HIGH PLAINS COTTON GINS BASED ON 1967-79 TRANSITIONS

Initial[a] state	Ending state[a]										
	D	I1	I2	I3	I4	I5	A1	A2	A3	A4	A5
NE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
D	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I1	0.236	0.535	0.000	0.000	0.000	0.000	0.229	0.000	0.000	0.000	0.000
I2	0.265	0.000	0.536	0.000	0.000	0.000	0.000	0.190	0.009	0.000	0.000
I3	0.000	0.000	0.000	0.200	0.000	0.100	0.100	0.000	0.600	0.000	0.000
I4	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000
I5	0.500	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000
A1	0.004	0.031	0.000	0.000	0.000	0.000	0.919	0.040	0.005	0.001	0.000
A2	0.003	0.000	0.016	0.000	0.000	0.000	0.000	0.971	0.010	0.000	0.000
A3	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.008	0.958	0.023	0.002
A4	0.000	0.000	0.000	0.000	0.003	0.000	0.003	0.000	0.002	0.950	0.042
A5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.010	0.986

[a]NE = new entrant, D = dead gin category, I = inactive gin, A = active gin, and size groups: 1 = 0.1 to 9.0, 2 = 9.1 to 16.5, 3 = 16.6 to 21.0, 4 = 21.1 to 32.0, and 5 = 32.1 to 75.0 bales per hour rated capacity.

T = progression of time (a proxy for gradual technological change; T = 1 for the 1967-68 transition); and

M = percentage of seedcotton ginned from modules (a proxy for a periodic technological change).

Estimates of annual percentage changes in the cost of labor were computed from minimum wages as reported by the United States Department of Commerce (*Statistical Abstract of the United States*). Data from the Southwestern Public Service Company on average cost per kilowatt hour for gins in the Texas High Plains were used for energy costs. Percent utilization of gin capacity was calculated from seasonal volume and seasonal rated capacity data (Myers). The data for annual variation in cotton production were constructed assuming that the percentage variation in production in the area around a cotton gin is the same as the variation in its county's production (United States Department of Commerce, Cotton Ginnings in the United States).

Moduling of cotton is a seedcotton harvesting/handling system in which cotton is harvested, pressed into free-standing bundles of about 10 bales, and stored in the field. It is then transported to gins on specially equipped trucks. Data on annual percentage of cotton production moduled were obtained from United States Department of Agriculture, Economic Research Service and Agricultural Marketing Service. Percentages moduled for Texas were assumed to apply to those moduled in the study area.

Two types of linear equations were derived: (1) equations for which functional relationships were directly estimated from the observations in one cell for the twelve transitions and (2) equations for which functional relationships were estimated indirectly from data on aggregates of cells. For example, the non-stationary transition probability that a gin in active group 1 moves to active group 3 in an annual transition could not be estimated because there were insufficient observations. Thus, the relationship was approximated by estimating the relationship for the probability that a gin in active group 1 moves to active group 2 or 3 using pooled data and then subtracting the probability that a gin in active group 1 moves to active group 2.

Estimated relationships and related statistics are shown in Table 2. Two factors expected to affect the non-stationary transition probabilities which were not significant in any of the equations were the annual percentage utilization of gin plant capacity, U, and the annual percentage change in cotton production, PRD. Both variables were estimated by using a 3-year moving average, embodying the assumption that management decisions regarding these two factors were made on longrun changes and not on annual variations. The 3-year moving average may have unduly reduced the variation in these variables and diminished their explanatory power. In addition, there were no large changes in either of these variables during the period from which data were used. All reported coefficient signs are realistic. As expected, signs of estimated coefficients differ between equations. For example, a rise in the rate of increase in labor costs (CL) may simultaneously increase the probability that active gins in size group 2 will become inactive (P(A2-I2)) and decrease the probability that active gins in size group 1 will remain in that state (P(A2-A1)) the following year.

Non-stationary transition probabilities could not be estimated for all cells because of an inadequate number of observations in some cells and because the regression model was not significant for some other cells. Non-stationary probability equations were estimated for 10 of the 39 non-zero cells, but those 10 cells accounted for 78 percent of total observed gin movements. The cells for which non-stationary probabilities were not estimated were given an initial value equal to their stationary transition probability value. These values were adjusted (increased or decreased) in proportion to their stationary magnitude, if necessary, to ensure that $\sum_j p_{ijt} = 1$.

INDUSTRY STRUCTURE PROJECTIONS

The estimated stationary probabilities combined with the X_t vector for 1979 produced the projected industry distribution of firms shown in Table 3. Many gins exited the industry; the number in the dead gin state grew from the 1979 total of 48 to a projected 104 by the year 1999. The industry settled at an equilibrium structure in 2034 with 104 fewer

TABLE 2. ESTIMATED NON-STATIONARY TRANSITION PROBABILITY REGRESSION PARAMETERS AND STATISTICS

Dependent variable[a]	Independent variable[b]					F-value[c]	R^2	D-W	Number of observations
	Constant	C_L	C_E	T	M				
P(A1-D)	−0.1046	0.0055	−0.0026	0.0172	−0.0043				
P(A1-I1)	0.0117	0.0021				4.71	0.3201	1.90	12
		(.0552)				(.0052)			
P(A1-A1)	1.0787	−0.0076	0.0026	−0.0219	0.0043	4.53	0.7215	2.64	12
		(.0161)	(.0903)	(.0188)	(.0642)	(.0402)			
P(A1-A2)	0.0161			0.0036		4.86	0.3271	1.98	12
				(.0520)		(.0520)			
P(A1-A3)[d]	−0.0009			0.0008					
P(A1-A4)[d]	−0.0010			0.0003					
P(A2-I2)	−0.0214	0.0014		0.0056	−0.0015	3.74	0.6159	1.91	11
		(.0427)		(.0229)	(.0352)	(.0684)			
P(A2-A2)	1.0040			−0.0083	0.0025	4.20	0.4827	2.00	12
				(.0184)	(.0246)	(.0515)			
P(A3-A3)	1.0139			−0.0126	0.0031	3.40	0.4304	1.98	12
				(.0317)	(.0853)	(.0794)			
P(A4-A5)	−0.0434	0.0033		0.0164	−0.0057	3.99	0.7051	2.08	9
		(.0564)		(.0397)	(.0285)	(.0854)			

[a] P(Ai-Aj) = probability of a gin in active group i moving to category j in a given transition. i,j, = 1,...,5, 1 = 0.1 to 9.0 bales per hour rated capacity, 2 = 9.1 to 16.5 bales per hour, 3 = 16.6 to 21.0, 4 = 21.1 to 32.0, and 5 = 32.1 to 75.0 bales per hour rated capacity.

[b] Numbers in parentheses show PR > | t |.

[c] Numbers in parentheses show PR > F.

[d] Derived equation.

TABLE 3. TEXAS HIGH PLAINS COTTON GIN INDUSTRY STRUCTURE AND PROJECTIONS UNDER ALTERNATIVE CONDITIONS, 1967-1999

		Number of gins by state										
Scenario	Year	D	I1	I2	I3	I4	I5	A1	A2	A3	A4	A5
Actual[a]	1967	10	3	1	1	1	0	119	171	36	26	8
	1972	22	4	1	0	0	0	98	176	38	28	11
	1979	48	5	7	0	0	0	56	172	48	28	21
Stationary	1984	65	3	6	1	0	0	41	165	50	28	26
	1989	80	2	6	1	0	0	30	157	51	29	30
	1994	93	2	5	1	0	0	22	149	51	29	35
	1999	104	1	5	1	0	0	17	140	51	30	39
	2034[b]	161	0	3	0	0	0	4	88	42	33	63
Baseline	1984	73	3	12	1	0	0	27	167	45	30	22
	1989	107	1	20	2	0	0	8	137	39	27	45
	1994	141	0	23	2	0	1	2	98	30	21	69
	1999	172	0	20	2	0	1	1	64	21	15	92
CL = 5%	1984	66	2	10	1	0	0	31	168	52	28	27
	1989	96	1	19	1	0	0	9	145	55	19	41
	1994	126	0	23	1	0	0	2	114	55	11	55
	1999	155	0	24	1	0	0	0	85	53	6	64
CL = 15%	1984	86	3	15	1	0	0	22	158	51	26	29
	1989	114	1	22	1	0	0	5	130	53	17	43
	1994	144	0	24	1	0	0	1	99	53	9	56
	1999	171	0	23	1	0	0	0	72	51	6	64
CE = 15%	1984	69	3	12	1	0	0	30	167	45	30	28
	1989	103	1	20	2	0	0	9	139	39	27	46
	1994	138	0	23	2	0	1	2	99	31	21	70
	1999	169	0	20	2	0	1	1	65	22	15	93
M = 50%	1984	59	2	2	1	0	0	35	177	57	31	20
	1989	77	2	11	1	0	0	14	167	51	38	25
	1994	103	1	20	2	0	0	4	142	35	34	46
	1999	130	0	24	1	0	0	1	113	21	24	74
M = 5%/yr	1984	68	3	8	1	0	0	31	168	50	33	23
	1989	91	1	12	1	0	0	12	157	45	38	29
	1994	112	0	13	1	0	0	4	142	38	41	36
	1999	130	0	12	1	0	0	2	125	32	46	40

[a]The total number of gins increases because of new entrants. Data on gin numbers (not available by size groups) show 62 dead, 43 inactive, and 310 active gins in 1983 (U.S. Dept. of Commerce, Cotton Ginnings in the United States).
[b]Stationary equilibrium.

gins than in 1979. Also, there was a movement away from small gins (those in states A1 and A2) to very large gins (state A5) from 1979 to 1999. In 1979, there were 56, 172, and 21 gins in states A1, A2, and A5, respectively. By year 1999, the industry structure was projected to have a total of 17, 140, and 39 gins in those categories, respectively.

A baseline non-stationary projection was made to provide a basis for comparison. The baseline projection consisted of the following conditions; T, time as a proxy for gradual technological change, increased by one for each successive year of projection, while CL (labor costs) and CE (energy costs) were held constant at their mean values (CL = 9.425 and CE = 6.733), and M (percentage of seedcotton ginned from modules) was held constant at its latest observed value (M = 33). Beginning with the existing industry structure for Texas High Plains cotton gins in 1979, the baseline structure was projected for 20 years. By 1999, the simulated industry structure had changed to that shown in Table 3. This simulation indicated a more rapid movement of gins out of all active gin states except A5 and out of the industry than the stationary probability solution. This comparison suggests that technological change accelerates the industry movement away from small gins toward very large gins. Gins in A2 were more likely to become inactive (I2) before exiting. Most surviving gins in A1 and A2, and many in A3 and A4, increased their capacity levels. The number of gins in A5 increased from 21 in 1979 to 92, 20 years later. In general, the baseline scenario projected more rapid changes in the same direction as the stationary solution.

The baseline was modified to allow for different rates of change in labor costs. CL was changed to 5 percent (a decrease in the rate of increase) on the assumption that inflation and wage increases would decrease and stabilize at a lower level. This decline in wage rate increases brought about a more rapid exit of gins but increased the number of gins moving into A3 and slowed the movement of gins into A5 when compared to the baseline; the mid-size gins could survive longer with slower wage increases. A change in CL to 15 percent projected a more rapid movement of gins out of A1 and A2 and into D, while all other size categories remained relatively stable, compared with the CL = 5 percent projection.

The baseline was also modified by increasing the rate of change in the CE to 15 percent per annum. Under this scenario, the structure changed very little except for a slight acceleration of gins out of A1 and into D.

An assumed increase in the level of cotton handled in modules to 50 percent altered the baseline solution 1999 projections the most in the D, A2, and A5 categories. Compared to the baseline, fewer gins exited the industry, while more entered and remained in A2, causing fewer large gins. Under an alternative scenario, a 5 percent per annum increase in cotton moduled resulted in fewer movements between states. Under this situation, more gins stayed in the A1, A2, A3, and A4 states and fewer gins moved to D and A5 states after 20 years. Thus, the gradual, complete adoption of moduling technology induced relatively fewer changes in industry structure than the present level or limited adoption of the technology. This occurred because adoption of the module handling technology is a substitute for internal plant modifications.

CONCLUSIONS

The non-stationary Markov chain procedure is preferred over the stationary approach for analysis of the cotton gin industry structure because it provides the means to examine the effects of external forces on that structure. The limitations of the non-stationary procedure used in this study can be attributed to the inadequacy of the data; the regression model performed well for explanation of transition probabilities when sufficient observations were available. The non-stationary Markov chain procedure predicted more rapid adjustments in the West Texas cotton gin industry structure than did the stationary procedure, especially in the movement of gin firms out of the small gin states and into the dead gin state. This result is consistent with the implications of studies of ginning costs in the region (Ethridge et al.; Shaw et al.) and supports the conclusion that the non-stationary projections are more realistic for the situation studied.

Four major factors were found to cause changes in gin size and number within the Texas High Plains cotton gin industry: (1) changes in the cost of labor, (2) changes in the cost of energy, (3) progression of time as an indicator of gradual technological change, and (4) proportion of cotton production moduled. Changes in cotton production and gin plant utilization rate failed to enter the model as significant factors affecting industry structure for the period for which data were available, 1967-1979. This occurred because there were no major shifts in either of these variables during the sample period.

With the progression of time, the industry structure would be characterized by an accelerated movement of small and medium sized gins toward a large gin status and of gins out of the industry. Thus, there would be fewer cotton gins in the industry, but most of the active gins would be larger. Future technological change over time is expected to accelerate the movement when compared to an extension of the past with technology held constant.

Slower increases in wage rates tend to decrease the number of gins exiting the industry. Increases in labor costs have a greater adverse impact on small gins than on larger gins. A rapid rise in the cost of labor decreases the number of small gins at an accelerated rate, most of these gins either increase their capacity or exit the industry. However, if the inflation rate declines, the cost of labor can be expected to increase at a slower rate and more small and medium gins would remain active and fewer would increase in size. As with labor costs, rapid increases in the cost of energy force many small and medium sized gins to exit and many of the surviving gins to increase capacity.

The increased use of cotton moduling tends to induce fewer movements among active gins and to enable more gins to stay active. Capital investment for moduling equipment is an alternative to investment in other technology, which results in fewer large gins. This is, in part, a substitution of one type of capacity-increasing technology (moduling) for another (gin stands). Gins utilizing modules also can store and process cotton for longer periods of time.

Projections of industry structure under the specified assumptions all indicate a decline in number of small gin firms, an increase in number of large firms, and a decrease in the total number of firms. The projections differ primarily in the rate at which these changes occur. The changes in structure have potential implications for industry participants such as cotton producers, gin firm owners and employees, equipment suppliers and other service related firms, and transportation suppliers. Gin equipment and service firms can expect increased sales and servicing of new technology, especially for the large capacity gin stands and module feeders, but fewer firms requiring equipment and service. The rate at which firms adjust depends on the manner in which labor costs, energy costs, and other factors change. High Plains cotton producers can anticipate longer average hauling distances to obtain ginning services, thus incurring high transportation costs. However, moduling technology may lower ginning costs, *ceteris paribus*. Employees of gin firms can expect fewer jobs in the industry since large plants are relatively more labor efficient; the rate of that adjustment depends on labor cost increases and the pattern of moduling technology adoption. Fewer cotton gins and remaining gins substituting equipment for labor suggest lower employment in the rural areas where gins are located.

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