Changes in the Structure of the Texas High Plains Cotton Ginning Industry, 1967-1999

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Abstract

Projections were made of the cotton gin industry structure in a 23-county study area of the Texas High Plains. Data on gin size and activity status (active, inactive, dead) were gathered on 385 gin firms for the period 1967 to 1979 and used to establish probabilities of movement between size and activity states. Using Markov chain procedures, future industry structure projections were made under conditions of both stationary and non-stationary transition probabilities with the non-stationary transition probabilities estimated as functions of exogenous variables. All projections showed declining numbers of active gin firms, but with large declines in numbers of small firms and increasing numbers of large firms. The analysis also indicated that energy cost increases have less impact on industry structure than do labor cost increases and that adoption of module seedcotton handling technology slows the exit of gins from the industry and the movement toward very large plants.

Acknowledgements

The authors wish to acknowledge the assistance of the Cotton Division, Agricultural Marketing Service, USDA, with basic data collection, of Roy Stewart for computer programming assistance, and of James Graves, Kary Mathis, and Dale Shaw in the preparation of this report. This study was supported by the Institute for Research in Food and Fiber Production, Texas Tech University, and the Texas Agricultural Experiment Station; it also benefitted from earlier analysis of T.R. Owens sponsored by Cotton Incorporated.

Key words: Markov chain analysis, cotton ginning, industry structure projections

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CHANGES IN THE STRUCTURE OF THE TEXAS HIGH PLAINS COTTON GINNING INDUSTRY, 1967-1999

Don E. Ethridge, Sujit K. Roy, and David W. Myers[1]

Introduction

Numerous changes have occurred in the U.S. cotton industry during the last three decades. Total acreage planted in 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 (29).[2] There has been a major shift in cotton production within the United States from the Midsouth (Missouri, Arkansas, Tennessee, Mississippi, Louisiana, Illinois, and Kentucky) and Southeast (Virginia, North Carolina, South Carolina, Georgia, Florida, and Alabama) to the Southwest (Texas and Oklahoma) and West (California, Arizona, New Mexico, and Nevada) regions. In 1948, for instance, production of cotton in the U.S. was distributed as follows: Midsouth-42%, Southeast-24%, Southwest-24%, and West-10%. By 1981, production of cotton decreased to 22% for the Midsouth and 5% for the Southeast, while the share of Southwest and West in total U.S. production rose to 40% and 33% respectively (29).

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[2] Numbers in parentheses refer to sources in the List of References.

The 23-county Texas High Plains study area (Figure 1) is in the Southwest U. S. production region. In 1979, 19% of the total U. S. cotton production was grown in these counties. The High Plains economy is highly dependent on agriculture and its major crop, cotton. In 1979, the area's cotton production was valued at over $725 million, which accounted for 33% of the High Plains total agricultural production value (28).

After it has been harvested, the movement of cotton lint within the High Plains marketing system is characterized by: (a) on farm assembly of seed cotton and transportation to a cotton gin, (b) ginning of seed cotton and transportation to a warehouse, (c) storage at the warehouse and recompression for shipment, if needed, and (d) merchandising services and market distribution as performed by merchants in moving cotton to textile mills and export outlets. Since ginning is an extension of the farm production process, shifts in the ginning industry have usually occurred along with changes in production. The persistent trend in decreases in harvest time has fostered the adoption of greater peak-load ginning capacities in the ginning industry. While the ginning season may be defined as October 1 to March 1, most of the volume ginned in the past has been done in a 12-16 week period, creating a serious over-capacity problem for the rest of the year (5). A lack of storage capability for seed cotton has been a major gin

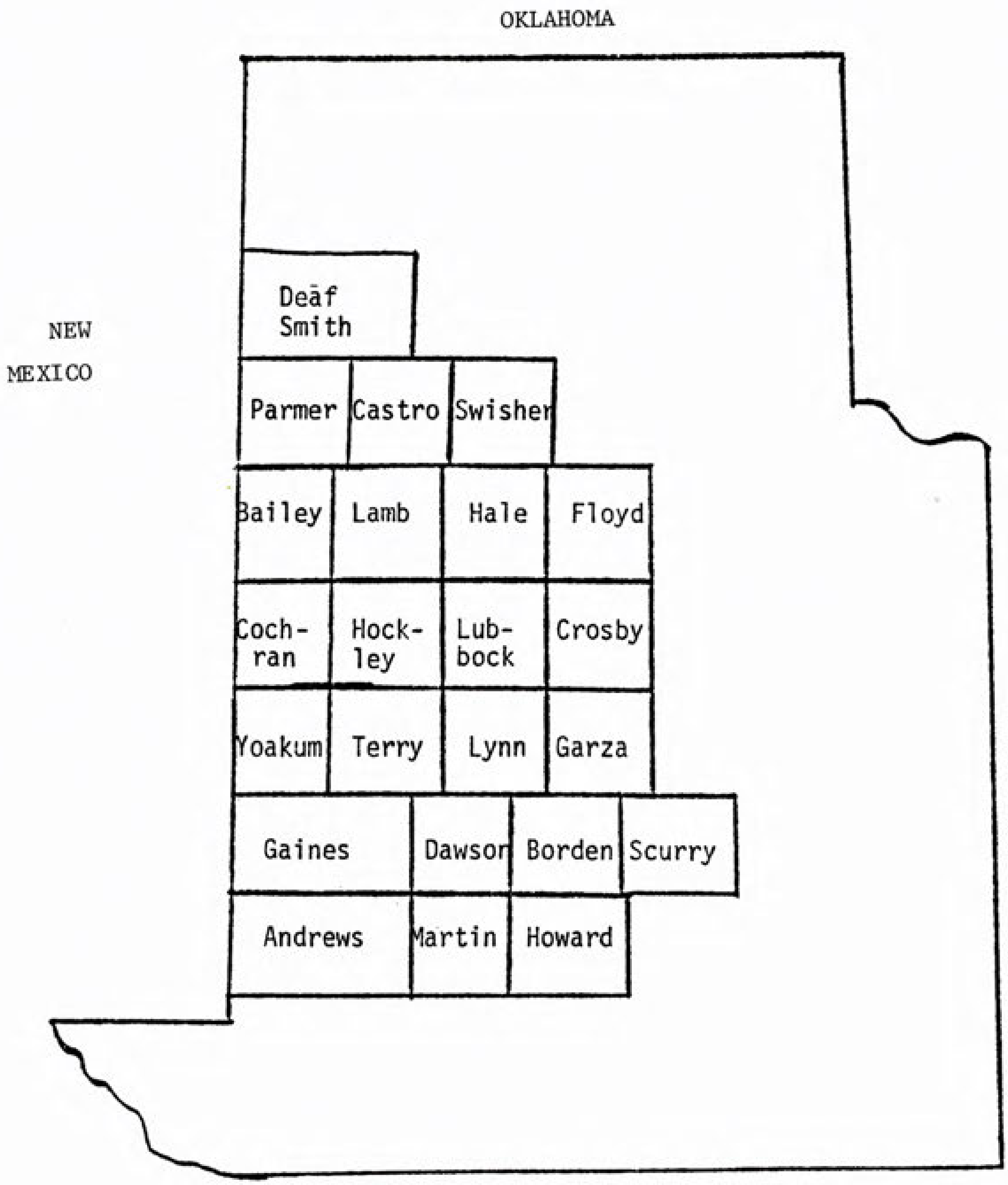

Figure 1: Location of the 23 County Texas High Plains Study Area.

management problem, especially during that part of the season when the harvesting rate exceeds the ginning rate. Due to these and other factors, High Plains gin managers have been faced with rising fixed and variable costs which have, in turn, contributed to certain trends in the structure of the industry.

Since 1900 active gin numbers in the U.S. declined from over 30,000 to about 2,200 in 1981 (Figure 2), while average gin size and volume ginned increased (31). However, the amount of cotton produced in the U.S. has remained relatively constant. During the years 1901-1910, the average annual cotton production was 11.3 million bales, while the average for the years 1971-1980 was 11.6 million (29). Over the past 40 years, a similar trend has been observed in Texas, with 2,713 active cotton gins in 1942 and 759 in 1981 (Figure 3). In 1942, the 23-county Texas High Plains study area produced 20% of the state's cotton. By 1981, over 60% was grown in the area. The percentage of Texas gins in the area was 10% and 47%, respectively. The number of active cotton gins in this 23-county area was 277 in 1942, grew to a high of 437 in 1965, but declined along with the state and national numbers since 1965. The tendency in the High Plains has been for surviving gins to increase their capacity levels. This is especially evident in the large gin category (capacity greater than 32 bales per hour) in the study area. In the small gin category (less than 9 bales per hour), the number of gins decreased by 45% since 1965.

While past trends and problems in the ginning industry are evident, future changes are uncertain because the causes of adjustment are not well understood. There is little information available regarding the economic factors causing these trends, individual impacts of these factors, and their effects on future industry structure. For the industry to achieve a high level of performance, it must adjust to changing economic conditions, which underscores the need to understand the impacts of external forces on the industry.

The general objective of this study was to determine the major economic factors affecting the structure of the cotton gin industry and provide conditional projections of the future structure of the Texas High Plains ginning industry. Specific objectives were to:

A. Identify factors which affect changes in the gin industry structure.

B. Develop conditional predictions of the High Plains' gin numbers and sizes.

C. Analyze the impacts of changes in the selected external variables on the future industry structure.

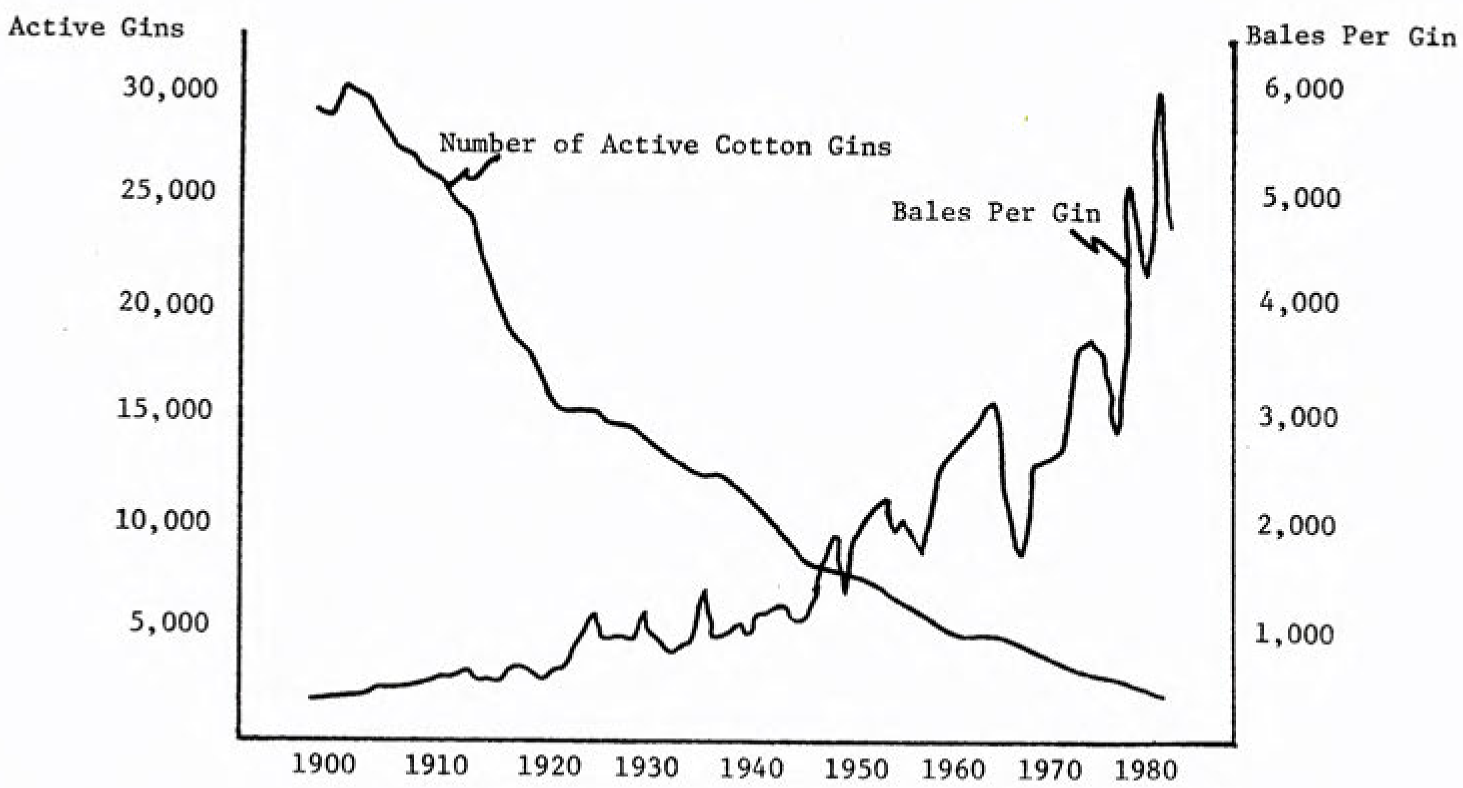

Figure 2. Number of U.S. Cotton Gins and Volume Per Gin, 1900-1980.

Source: United States Department of Commerce, Bureau of Census, "Cotton Ginnings in the United States", Washington, D.C., 1981.

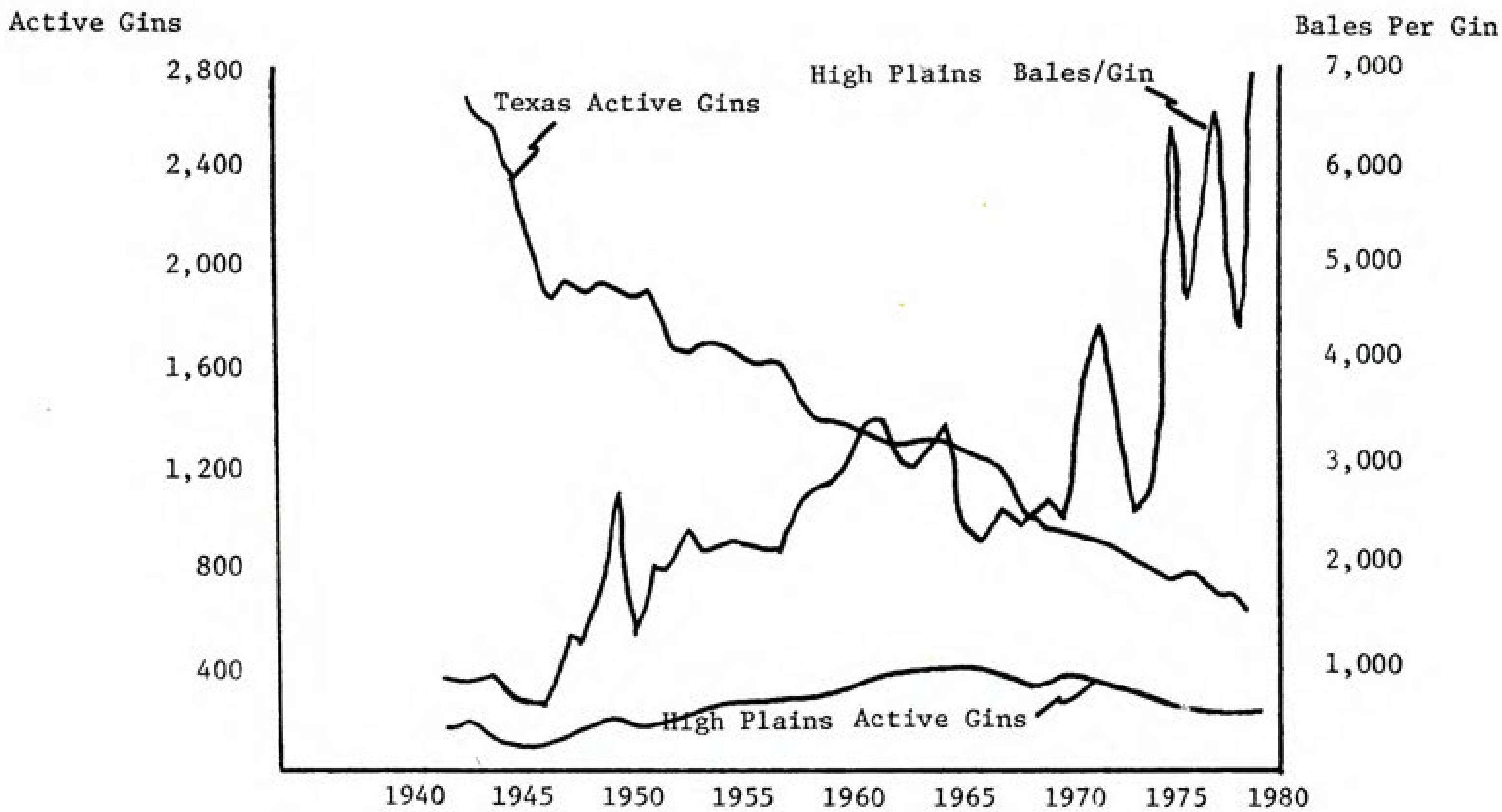

Figure 3. Number of Texas and Texas High Plains (23-County Area) Cotton Gins and the Texas High Plains Gin Volume, 1942-1980.

Source: United States Department of Commerce, Bureau of Census, "Cotton Ginnings in the United States", Washington, D.C., 1982.

Cotton Ginning Industry Studies

Previous studies of the cotton ginning industry have concentrated on industry structure, gin capacity utilization, and costs. Most of these studies have identified and investigated over capacity as the major problem in the ginning industry.

In a study of Louisiana's cotton gins, Hudson and Jesse (15) formulated a spatial equilibrium model of a least-cost structure of market organization involving location, number and size of potential cotton gins, warehouses, and oil mills. A reduction in the number of gins in the study area from 88 to 16 was found to lower ginning costs by $5.08 per bale, and assembly cost by $8.34 per bale. Cleveland and Blakely (5), in a similar study related to the Texas and Oklahoma Plains, simulated least cost market structures considering size, number and location of cotton gins and warehouses under two alternative ginning seasons. The least-cost market structure with the 14-week ginning season reduced the number of gin plants from 289 to 44 and warehouses from 37 to 10 for an industry cost reduction of 29%. The simulated least-cost market structure for a 32-week ginning season included 22 gin plants and 11 warehouses with a cost savings of 33%. Fondren, Stennis, and Lamkin (10), in a study of the cotton industry structure in the Mississippi Delta area, found the least-cost market structure to include fewer but larger and more efficient gins and warehouses.

The model reduced the number of potential gin sites from 73 to 23 and warehouse locations from 23 to 15. In a study of the cotton ginning industry in Lea County, New Mexico, Fuller, Stroup, and Ryan (13) found a cost savings from reducing the number of gins from 1973 numbers. At high production levels, alternative systems using field storage were found to realize greater savings.

One structural alternative is the processing of cotton through central ginning in which gin owners acquire and store enough seed cotton to allow gins to operate at near capacity levels for several months instead of the shorter ginning season. Central gin owners, according to Campbell (3), would take title to harvested cotton before ginning and all seed cotton of like quality would be stored, mixed, and ginned together. This would reduce ginning costs by three to seven dollars per bale from the conventional ginning method, primarily from lower labor and depreciation costs. Fuller and Washburn (12) also studied centralized cotton ginning with the objective of determining the number, size, and location of central gin plants that would minimize the total cost of assembling and processing upland cotton production in New Mexico. They projected that the Pecos and Rio Grande Valley regions would benefit the most from central ginning with a $7.73 and $9.06 savings per bale, respectively, over the conventional system.

There is a concensus among studies concerned with gin plant utilization that a major problem is the inefficient utilization of plant capacity. Ethridge and Branson (9) estimated that the U.S. ginning industry utilized only 40% of its existing capacity during 1974-1977. Fuller and Vastine (11) in their study of New Mexico cotton gins concluded that excess capacity or under- utilization of plant capacity existed even during the peak harvesting season during 1961-1971.

Most studies emphasize that excess capacity is in large part caused by the short (average of 14 weeks) ginning season. In the study by Cleveland and Blakely (4), a 32-week season and storage on the farm was found to have lower cost than a 14-week season with short term storage at the warehouse because of a higher utilization of plant capacity. Per bale costs were also found to be less for gins of larger size with higher rates of utilization. Ethridge and Branson (9) discussed how modules and ginning with the use of an automatic module feeder can increase processing efficiency by 15% and enhance the feasibility of lengthening the ginning season. Consequently, per bale ginning costs could decrease as plant utilization (and effective size) increases. They estimated that as seasonal ginning volumes increased above breakeven levels for different sizes of gins, per bale costs were significantly lower with the use of this technology.

Laferney and Glade (17) estimated that ginning costs account for approximately 50% of the overall off-farm costs between the cotton producer and the mill consumer. Shaw (20) estimated that labor related costs account for about 40% of the total ginning cost and energy costs another 10%. Rapidly rising energy costs have resulted in these costs increasing as a percentage of total ginning costs. The major energy costs to a gin is electrical energy.

Shaw et al. (22) presented three applications of GINMODEL, a model for computer simulation of ginning costs (21), to different cotton ginning problems. One application, based on a change from a 7-day to a 6-day workweek, resulted in cost savings of 37 cents per bale, with 32 cents of the savings on gin labor. Another application, with two plants consolidated into one, indicated that ginning costs with the consolidated plant would be higher than with the existing plants; variable costs were lowered, but fixed costs were much higher. In the third application, it was estimated that if the efficiency rate of a new gin plant in Arizona could be increased from 66% to 85%, ginning costs could be decreased from $32.00 per bale to $17.00.

Ethridge, Shaw, and Robinson (8) analyzed the effects of different module handling systems on cost of ginning stripper harvested cotton. The alternatives examined included two seed cotton handling systems (trailers and modules) and three gin feeding systems (suction feeding, automated module feeding using suction, and automated module feeding using blowers). Using the computer simulation model, GINMODEL, on five different plant sizes, results indicated that with plant utilization greater than 50% module handling systems lowered the ginning costs below that associated with trailer handling due to a large increase in the gin efficiency rate. Among large gin plants with above 70% capacity utilization, the module handling system with blower module feeding was the least cost method assuming that cotton can be ginned totally from modules. With a dual system accomodating both modules and trailers, automatic suction feeding had a lower cost per bale, but only for large gin plants operating at near full capacity utilization. An important observation in this study was that gins can lower their ginning costs and absorb that cost of module assembly only if they can obtain a sufficient increase in volume.

Methods and Procedures

The general procedure in the present study involved the application of the Markov Chain technique to analyze the distribution of cotton gins in different size groups and to project the future industry structure. The Markov chain technique has been applied in economic research to describe past and predict future industry structures. Most of such studies in the past were based on the assumption that the probabilities of movement of firms between size groups did not change over time (i.e. assumption of stationary transition probabilities). For instance, Collins and Preston (6) used this approach to study the size distribution and structure of the largest industrial firms in the U.S. during 1908-1958. Measuring the size of these firms by their total assets, the authors used the Markov process to estimate the effect of relative size movements on the ultimate size distribution of these firms. Adelman (1) used the same approach in an earlier study to examine the size distribution of the corporate units in the economy.

Judge and Swanson (16) reviewed the basic properties of the Markov Chain model and suggested its use in agricultural economics research. Stanton and Kettunen (25) used this technique, with stationary transition probabilities, to project the number and size of dairy farms in New York. The same methodology was used by Power and Harris (19) to the farm structure data obtained from agricultural census reports in England and Wales. In a study by Smith and Dardis (23), the Markov Chain analysis was employed to examine the competitive potential of the U.S. cotton fiber industry. Projections indicated a decline in cotton's market share in most of the end uses of the crop as non-cellulose fibers were projected to capture the majority of the markets. (The authors reasoned that if cotton was to retain its market share, quality of cotton must increase while the price must become more competitive).

Padberg's study (18) incorporated Markov Chain stationary transition probabilities to analyze the structural development within the California wholesale fluid milk industry. Methodologically, however, the assumption of stationary probabilities was rejected by the author on the basis of a likelihood ratio test developed by Anderson and Goodman (2). The need to modify the assumption of constancy of transition probabilities was emphasized in the study. Colman (7), on the other hand, could not reject the assumption of constancy statistically and offered several specific justifications for the assumption in his Markov Chain analysis of the British dairy industry structure.

A study by Hallberg (14) on frozen milk manufacturing plants in Pennsylvania demonstrated that the Markov Chain model can be modified to incorporate changing or non-stationary transition probabilities. Having rejected the hypothesis of the constancy of transition probabilities, the author suggested a functional relationship between the changing probabilities and certain exogenous factors. Least squares regression equations were estimated for the changing probabilities of each cell of the transition probability matrix using specified exogenous variables. The difficulty with this approach is that it does not automatically ensure the two Markov Chain requirements that each estimated probability is non-negative and that the sum of all probabilities across any row is equal to one. Any negative probability value in the study was assigned a value of zero. Stavins and Stanton (26), in their study on size distribution of dairy farms in New York State, refined the method by specifying the required equations in a multinomial logit framework in which each row of the transition probability matrix is handled as a separate multinomial logit model (MNLM). The application of the MNLM approach incorporating the use of an exponential function, ensured the two required conditions regarding the transition probabilities. The major problem with this approach is that it requires a complete set of extensive data, and it is not as flexible as Hallberg's method if all equations cannot be estimated.

The Markov Chain analysis, as adapted to the ginning industry in this study, involved categorizing cotton gins into different size groups, tracing changes in sizes of gins in the study area through time (1967-1979) and estimating probabilities of movement among size groups. These transition probabilities were averaged and held stationary, then used to project future industry structure. This assumption of stationary probabilities was then relaxed and an explanatory model was developed to specify exogenous variables which affect the probability of movement between groups. Using least squares regression, parameters of explanatory variables were estimated to measure relative impacts of changes in these variables on the probabilites of gins moving between size groups. Projections of industry structure with non-stationary transition probabilites were simulated and compared to model solutions with the stationary transition probability assumption.

Markov Chain Model with Stationary Tansition Probabilities

The purpose of the Markov Chain model was to evaluate changes in the current and projected number and size distribution of firms within the Texas High Plains cotton ginning industry. The model implies four basic assumptions concerning the cotton gin industry structure: (a) cotton gins can be grouped into size categories according to some valid criteria; (b) the movement of a cotton gin between size categories is a stochastic process, i.e., there is a random element associated with movement between size groups but the probability of movement can be estimated; (c) the transition probabilities of cotton gin movements between size categories is a function only of the basic stochastic process, i.e., transition probabilities are determined by forces external to the individual firm; and (d) the transition probabilities remain constant over time.

Regarding the second assumption, if the structural change in the cotton gin idustry is entirely the result of actions by individual firms, then the probabilistic model is inappropriate (18). Consequently, it was initially assumed that movements within the ginning industry of the Texas High Plains represent a stochastic process. However, the assumption of stationary transition probabilites is a rigid one because it assumes that the movement of firms between size categories observed over the specified time period will continue indefinitely. Thus, forecasts with this method assume that the (unspecified) exogenous forces will continue to act the same way in the future that they did in the past.

Data Used. A major source of data was the USDA Cotton Marketing Service Office in Lubbock, Texas. Total gin stand capacity (bales per hour) was used as an indicator of cotton gin size. Data on type and number of gin stands and saws used to measure gin stand capacity were gathered from individual gin equipment schedule reports taken from the USDA office. Using a formula[3] each firm's total gin stand

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[3]

$$GSC = X \times \frac{\pi \times D \times RPM}{12} \times Y/(2200 \times 478)$$

where GSC = gin stand capacity in bales/hour,
X = number of saws,
D = diameter of saw in inches,
RPM = manufacturer's recommended revolutions per minute,
Y = saw loading factor in lbs. lint per hour, and
π = 3.1416.

The 2200 corresponds to peripheral speed in ft/min. for a 12" saw at 700 RPM. The 478 correspond to the lint weight in a 500-lb. bale.

Developed by Calvin Parnell and Dean Ethridge, Texas A&M University, and Dale Shaw, Economic Research Service, U.S. Dept. of Agriculture.

hourly rated capacity was calculated. These measurements of size were then categorized into five different size groups, discussed in a following section.

Data on gin numbers in the study area were gathered from gin identification reports from the USDA Cotton Marketing Service and from the Texas Cotton Ginners Association (27).

<u>Gin Groups</u>. The movements of the 376 gin firms in the 23-county area were recorded over time, and these gins were divided into size and activity categories using hourly rated capacity estimate and annual volume data for each firm. The five size classes were: size group 1 = 0.1 to 9.0 bales per hour, size group 2 = 9.1 to 16.5, size group 3 = 16.6 to 21.0, size group 4 = 21.1 to 32.0, and size group 5 = 32.1 to 75.0 bales per hour. These size categories were selected by arranging the hourly capacity ratings in order and locating breaks (gaps) in the array.

The four activity classes were: new entries (NE), dead or dismantled gins (D), inactive gins (I), and active gins (A). The new entry activity included all gins that entered the industry after 1967, while the dead gin classification included all gins that were dismantled and exited the industry. Inactive gins were defined as those gins that had the capacity to gin cotton but were not in operation, while the active gin class included those gins that had the capacity and were actively operating.

These size and activity classes were then combined to form a total of twelve gin categories. For example, A1 was the designation used for active gins in size group 1.

<u>The Transition Probability Matrix</u>. Based on the assumptions and definitions of a Markov Chain model, let

n_{ijt} = the number of gins moving from state i to state j in transition t

p_{ijt} = the individual elements within the annual transition probability matrices = the probability of a gin in state i moved to state j in transition t ($p_{ijt} = n_{ijt} / \sum_j n_{ijt}$);

$\overline{p}_{ij}$ = the individual elements within the stationary probability matrix = ($\overline{p}_{ij} = \sum_t p_{ijt}$/ no. of transitions);

P = the stationary transition probability matrix consisting of the $\overline{p}_{ij}$;

X_o = the initial starting state vector or the initial configuration of gin firm numbers in each state;

X_t = the configuration vector for year t ($X_t = X_{t-1} P$)

X_e = the equilibrium configuration vector, i.e., the number of gins in each category during the year in which equilibrium (no change) is reached.

Two constraints by Markov Chain definition were imposed on the elements of these matrices: 1) $0 \leq p_{ijt} \leq 1$ for all i,j,t, and 2) $\sum_j p_{ijt} = 1$ for all i and t.

The first step in projecting industry structure involved the construction of 12 transition matrices for the period 1967-1979. A 12 x 11 matrix was developed for each individual transition (1967-68, 1968-69, etc.) with each n component containing information on the number of gins which moved from state i to state j in a given annual transition, t. A given state consisted of a gin's size group and its status as inactive or active, an entering firm, or an exiting firm (see Appendix A for examples). From those transition matrices, twelve transition probability matrices with p_{ijt} elements were formed. These twelve transition probability matrices were then averaged to form the stationary transition matrix, P. Given P and X_o, a series of X_t's may be projected. Eventually X_t would converge to an equilibrium or steady state configuration of gin groups, X_e.

Non-Stationary Markov Chain Procedure

The assumption of constant transition probabilities is relaxed and transition probabilities are allowed to vary under the alternative non-stationary Markov Chain procedure. Factors hypothesized to affect movement of firms among size groups of cotton gins included changes in the cost of labor, changes in the cost of energy, changes in utilization rate of plant capacity, variation in county cotton production, time as a proxy for gradual technological change, and percentage of cotton production moduled as a proxy for periodic technological change.

Non-Stationary Probability Estimation. The non-stationary approach of this study followed Hallberg's Markov Chain Model (14), and involved fitting a least square regression of the form:

$$\hat{p}_{ij} = \hat{a}_{ij} + \sum_{k} \hat{b}_{ijk} X_k$$

where $\hat{p}_{ij}$ = the estimated probability of a cotton gin moving from state i to state j in a transition period;

$\hat{a}_{ij}$ = the estimated intercept term of the equation;

$\hat{b}_{ijk}$ = the estimated parameter which shows the effect of X on the probability of a gin moving from state i to state j;

X_k = the exogenous variables, where k = 1, 2, ..., n.

Each cell of each of the 12 annual transition probability matrices has a calculated probability value (p_{ijt}), and these values constitute the dependent variable observations for the regression equations. There was a regression equation for each cell of the 12 x 11 probability matrix if there were a sufficient number of observations for the cell.

Exogenous Variables. The independent variables used in estimating the regression equations were defined as follows:

CL = annual percentage change in the minimum wage rate, used as a proxy for changes in gin labor costs;

CE = annual percentage change in electricity rate charged to gins, used as a proxy for changes in gin energy costs;

U = three-year moving average of the percentage of plant capacity utilization;

PRD = three-year moving average of the percentage change in production in the county in which the gin was located;

T = progression of time as a proxy for gradual technological change, where T = 1 for the 1967-68 transition, etc.;

M = percentage of seedcotton ginned from modules used as a proxy for a periodic technological change.

Data Used for Regression Analysis. Estimates approximating the annual percentage changes in the cost of labor presented in Table 1 were formulated from minimum wage figures as reported by the U. S. Department of Commerce (32). Data from the Southwestern Public Service Company (24) were used to approximate ginning energy costs. Using the company's estimates on all-electric gins' average cost per kilowatt hour in the Texas High Plains, a data set was constructed for the annual percentage change in the cost of energy (Table 1).

The percent utilization of cotton gin capacity was measured in the following manner:

Percentage Utilization of Capacity = (Seasonal Volume) ÷ (Seasonal Rated Capacity)

Seasonal Rated Capacity = HRC x ER x SOH

where HRC = hourly rated capacity;

ER = efficiency rate; and

SOH = seasonal operating hours.

SOH was assumed to be 1,000 and ER, the proportion of hourly rated capacity which a gin can maintain over a season, was assumed to be .67 (8). Seasonal volume, the number of bales each gin processed each year, was obtained from the U.S.D.A. Cotton Marketing Service Office in Lubbock.

The data set for annual variation in cotton production was constructed assuming that the variation in production in the area around a cotton gin is the same as the variation in its county's production. Cotton production data reported by the U.S. Department of Commerce (31) were used to construct this series of data. Variation in production was computed as $CPV = (CP_t - CP_{t-1}) / (CP_{t-1})$ where CPV is percentage cotton production variation, and CP is cotton production. PRD was calculated as the three-year moving average of CPV.

Table 1. Selected Data Used in Regression Analysis.

Year	CE, Percentage Change in Cost of Energy 2/	CL, Percentage Change in Minimum Wage Rate 1/	M, Percentage of Cotton Ginned from Modules 3/
1966-67	6.40	12.00	0
1967-68	-5.30	15.00	0
1968-69	0.00	13.00	0
1969-70	5.20	11.50	0
1970-71	6.30	10.30	0
1971-72	3.30	0.00	0
1972-73	-7.80	0.00	0
1973-74	25.40	18.80	0
1974-75	14.90	5.30	3
1975-76	8.10	10.00	5
1976-77	1.10	4.60	13
1977-78	27.10	15.20	19
1978-79	2.30	9.40	23

1/ Source: United States Department of Commerce. Statistical Abstract of the U.S., Bureau of the Census, 1980.

2/ Source: Southwestern Public Service Company. "Summary of Southern Division All-Electric Gin Report, 1982."

3/ Source: U.S. Dept. of Agriculture. "Charges for Ginning Cotton, Cost of Selected Services Incident to Marketing, and Related Information." Economic Research Service and Agricultural Marketing Service - annual reports.

In 1979-80 and 1980-81, 33% and 41% was ginned from modules.

Data on the annual percentage of cotton production moduled as shown in Table 1 were obtained from U.S. Department of Agriculture (30). The percentage of cotton moduled has been rising and replacing the conventional trailer system since its advent. It was assumed that the percentage moduled for the state of Texas was representative of the percentage moduled in the study area.

Industry Structure Projections. The industry structure projections with the non-stationary transition probability Markov Chain model were developed as follows:

$$\hat{X}_t = \hat{X}_{t-1} \hat{P}_{ij}, \text{ where } \hat{P}_{ij} = f(X_k).$$

In computing the series of matrix-vector calculations, the non-stationary transition probabilites were estimated for each cell in the matrices from the regression equations by assuming or projecting values of the exogenous variables (X). Non-stationary transition probabilities could not be estimated for all cells because of an inadequate number of observations for certain cells and/or because of the statistical insignificance of the regression coefficients for some cells. Those cells for which a regression equation could not be used were given a value equal to their respective stationary transition probability value.

The projections from this non-stationary model were made in order to view the singular impact of the explanatory variables, ceteris paribus, on the industry structure.

Thus, for the cells whose transition probabilities were estimated by the set of exogenous variables (X_k), the levels of all these variables were held constant at their average values, with the exception of the variable whose impact was being examined. This variable was either held constant at a new fixed level or varied at an assumed rate of change.

A projection in which T was allowed to change and other variables were held either at their mean values or, in the case of moduling, at its latest observed value was called the "baseline" solution among the non-stationary projections. In this scenario T constantly changed by one for each successive year of projection so that in the matrix-vector calculations a new $\hat{P}_{ij}$ was being multiplied with each successive transition. Each change in $\hat{P}_{ij}$ was dependent on the change in T, or the progression of a year of time. As the cells with transition probabilities that were estimated by regression procedures were changed, the other cells' probabilities were also changed because of the constraint that the sum of the transition probabilities within a given row must be equal to one.

The baseline projection was modified to incorporate selected changes in the explanatory variables. To examine the effect on industry structure from different rates of change in the cost of labor (CL), all conditions were constrained to those in the baseline solution except for CL, which was varied from the baseline CL value. The resulting industry structure was then compared to the baseline projection to show the effect of changes in CL on the industry. The impact of a change in CE was estimated in the same manner. For the impact of a particular rate of change in the percentage of cotton moduled on the cotton gin industry, the procedure was different. The other variables (CL and CE) were again held at their mean values and T changed by one for each successive year, but the percentage moduled value was changed by an assumed rate of increase each year.

Results and Analysis

Results of the Markov Chain analysis with stationary probabilites are presented first in this section, followed by results from the non-stationary transition probabilities Markov Chain model. In the non-stationary model, the probabilities of movements between states are expressed as a function of exogenous variables, some of which vary through time.

Stationary Transition Probability Solutions

Gin movements among states for the twelve transition periods are shown in Appendix A. The transition probabilites estimated for the 12 periods were averaged to form the stationary probability matrix shown in Table 2. Each probability in this matrix indicated the average probability that a gin in an initial state in any year will be in the corresponding ending state the following year. For example, the average probability of an active gin in size group 1 staying in the same category in a transition was 0.919, while average probability of it going inactive (I1) or dead (D) was 0.031 and 0.004, respectively. The stationary probability of a gin in that state increasing in size the next year to active groups 2, 3, and 4 was 0.040, 0.005, and 0.001, respectively. The general tendency for most active gins in a transition was to remain in their same size and activity category.

The new entry (NE) activity group was not included in the stationary or steady state matrix, because the probabilities in this category were conditional. The NE probabilities indicate the probability that a new gin will enter a specific group, given a new entry. The unconditional probability that a gin will enter the industry cannot be determined from the data.

These probabilites combined with the X vector for 1979 produced the projected industry size distribution of firms shown in Table 3. The trend of many gins exiting the industry, or dismantling their equipment and ceasing operations, can be seen as the number in the dead gin category grows from the 1979 total of 48 to a projected 104 by year 1999. The industry settles at an equilibrium

Table 2. Stationary Transition Probability Matrix for Texas High Plains Cotton Gins Based on 1967-79 Transitions.

Initial[1/] State	Ending State[1/]										
	D	I1	I2	I3	I4	I5	A1	A2	A3	A4	A5
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

1/ D = dead or defunct gin category.
I = inactive gin.
A = active gin.
1,...,5 = gin firm 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.

Table 3. Projected Texas High Plains Cotton Gin Industry Structure: Stationary Transition Probability Markov Chain Model.

	Number of Gins by State										
Year	D	I1	I2	I3	I4	I5	A1	A2	A3	A4	A5
Actual[1/]											
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
Projected											
1980	52	4	7	0	0	0	53	171	48	28	22
1984	65	3	6	1	0	0	41	165	50	28	26
1989	80	2	6	1	0	0	30	156	51	29	30
1994	93	2	5	1	0	0	22	147	51	29	35
1999	104	1	5	1	0	0	17	137	51	30	39
2004	115	1	4	1	0	0	13	126	51	31	43
2009	123	1	4	1	0	0	10	117	50	31	47
2014	132	1	4	1	0	0	8	109	48	32	50
2019	140	0	4	1	0	0	6	101	47	32	54
2034[2/]	161	0	3	0	0	0	4	79	42	33	63

[1/] The total number of gins is not constant because of new entries.

[2/] Stationary equilibrium

structure in 2034 with 113 of the gins that were in operation in 1979 ceasing operation. Another trend was the movement away from a small gin status (gins in state A1 and A2) to one of very large gin capacity (state A5). In 1979, there were 56, 172, and 21 gins in groups A1, A2, and A5, respectively. By the year 1999, the industry structure was projected to have a total of 17, 137, and 39 gins, respectively, in these categories.

An effort was made to use a chi-square test (2) to determine the validity of the assumption of stationary transition probabilities. However, the test could not be conducted because of the absence of any observation in a large number of individual cells. Consequently, the analysis was extended to an examination of non-stationary transition probabilities.

<u>Non-Stationary Transition Probability Solutions</u>

As discussed earlier, least squares regression equations were estimated for computing the changing transition probabilities. All inactive cells for which such equations could not be estimated were assigned stationary transition probabilities and the resulting $\hat{p}_{ij}$ matrix was used to project future industry structure.

<u>Regression Results</u>. There were two types of regression equations: 1) equations which were directly estimable through 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. Estimated equations and related statistics are shown in Table 4, and an explantion of the derivation of the estimated equations is included in Appendix B.

Annual percentage change in the cost of gin labor, CL, was a significant factor in five of the ten equations. Increases in CL increased the probability of small, active gins becoming inactive or exiting the industry [P(A1-D), P(A1-I1), P(A2-I2)]. While significant in only two equations, increases in CE, the annual percentage change in the cost of energy, had the effect of keeping small gins (A1) from increasing in size. Time was a significant variable in all but one of the equations. Increases in T raised the probability of a gin increasing its plant capacity [P(A1-A2), P(A1-A3), P(A1-A4), P(A4-A5)] and reduced the probability of a gin staying in the same active group [P(A1-A1), P(A2-A2), and P(A3-A3)]. An increase in the percentage of cotton moduled, M, raised the probability of a gin remaining active in the same group [P(A1-A1), P(A2-A2), and P(A3-A3)] while it decreased the probability of gin movement away from its existing group [P(A1-D), P(A2-I2), P(A4-A5)].

Table 4. Estimated Non-Stationary Transition Probability Regression Parameters and Statistics.

Dependent[2/] Variable	Constant	Independent Variable[3/] .CL	CE	T	M	F-Value[4/]	R^2	D-W	No. of Observ.
P(A1-D)[1/]	-0.1046	0.0055	-0.0026	0.0172	-0.043				
P(A2-I1)	0.0117	0.0021 (.0552)				4.71 (.0052)	0.3201	1.90	12
P(A1-A1)	1.0787	-0.0076 (.0161)	0.0026 (0.903)	-0.0219 (.0188)	0.0043 (.0642)	4.53 (.0402)	0.7215	2.64	12
P(A1-A2)	0.0161			0.0036 (.0520)		4.86 (.0520)	0.3271	1.98	12
P(A1-A3)[1/]	-0.0009			0.0008					
P(A1-A4)[1/]	-0.0010			0.0003					
P(A2-I2)	-0.0214	0.0014 (.1427)		0.0056 (.0229)	-0.0015 (.0352)	3.74 (.0684)	0.6159	1.91	11
P(A2-A2)	1.0040			-0.0083 (.0184)	0.0025 (.0246)	4.20 (.0515)	0.4827	2.00	12
P(A3-A3)	1.0139			-0.0126 (.0317)	0.0031 (.0853)	3.40 (.0794)	0.4304	1.98	12
P(A4-A5)	-0.0434	0.0033 (.0564)		0.0164 (.0397)	-0.0057 (.0285)	3.99 (.0854)	0.7051	2.08	9

1/ Derived equation.

2/ 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.

3/ Numbers in parentheses show PR > |t|.

4/ Numbers in parentheses show PR > F.

The annual percentage utilization of gin plant capacity (U), and the annual percentage change in cotton production (PRD) did not appear in any of the equations as significant factors affecting the transition probabilities. Both of these variables were estimated by using a three-year moving average, embodying the assumption that management decisions regarding these two factors were made on long-run changes and not on annual variations. However, the use of a three-year moving average may have reduced the variation in these variables and diminished their explanatory power.

Industry Structure Projections. The baseline non-stationary probability projections consisted of the following conditions: T, time as a proxy for gradual technological change, varied by one for each successive year of projections, while CL and CE were held constant at their mean values (CL = 9.425 and CE = 6.733), and M 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. The starting vector for 1979 was as follows: D = 48 (gins that were active at the beginning of the study, 1967, but defunct by 1979), I1 = 5, I2 = 7, I3 = 0, I4 = 0, I5 = 0, A1 = 56, A2 = 172, A3 = 48, A4 = 28, and A5 = 21. By 1999, the simulated industry structure had changed as shown in Table 5: D = 172, I1 = 0, I2 =

20, I3 = 2, I4 = 0, I5 = 1, A1 = 1, A2 = 61, A3 = 21, A4 = 15, and A5 = 92. This indicates a swift movement of gins out of the small active gin groups (A1 and A2). Most of the gins in A1 state would quickly exit the industry as would gins in A2, although A2 gins would often go inactive (I2) before exiting. Most of the surviving gins in A1 and A2, as well as many in A3 and A4, were projected to increase their capacity levels. The number of gins in A5 was estimated to increase from 21 in 1979 to 92 twenty years later.

Various projections in five-year intervals and gin movements are compared with the baseline and the stationary scenario in Table 5. Both the baseline and stationary transition probability solutions show gins moving out of size groups A1, A2, and A3 and into the D and A5 categories. However, the degree or amount of movement is different. By 1999, gin numbers were much greater in D (172 to 104) and A5 (92 to 39) in the baseline projection, while the stationary probability solution showed greater numbers in the A1, A2, A3, and A4 categories. Thus the baseline scenario projected swifter changes, but in the same direction as the stationary solution.

The baseline was modified to allow for a different rate of change in labor costs (CL). The average increase (mean value) in the cost of labor over the study period was 9.425%, as used in the baseline solution. This variable was

Table 5. Cotton Gin Industry Structure Projections Under Alternative Conditions, Texas High Plains.

		Number of Gins by State										
Scenario	Year	D	I1	I2	I3	I4	I5	A1	A2	A3	A4	A5
Actual	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	156	51	29	30
	1994	93	2	5	1	0	0	22	147	51	29	35
	1999	104	1	5	1	0	0	17	137	51	30	39
Baseline	1984	73	3	12	1	0	0	27	167	45	30	27
	1989	107	1	20	2	0	0	8	136	39	27	45
	1994	141	0	23	2	0	1	2	96	30	21	69
	1999	172	0	20	2	0	1	1	61	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	144	55	19	41
	1994	126	0	23	1	0	0	2	112	55	11	55
	1999	155	0	24	1	0	0	0	82	53	6	64
CL = 15%	1984	80	3	15	1	0	0	22	158	51	26	29
	1989	114	1	22	1	0	0	5	129	53	17	43
	1994	144	0	24	1	0	0	1	97	53	9	56
	1999	171	0	23	1	0	0	0	69	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	138	39	27	46
	1994	138	0	23	2	0	1	2	97	31	21	70
	1999	169	0	20	2	0	1	1	62	22	15	93
M = 50%	1984	59	3	2	1	0	0	35	177	57	31	20
	1989	77	2	11	1	0	0	14	166	51	38	25
	1994	103	1	20	2	0	0	4	140	35	34	46
	1999	130	0	24	1	0	0	1	110	21	24	74
M=5%/yr	1984	67	3	8	1	0	0	31	168	50	33	23
	1989	91	1	12	1	0	0	12	156	45	38	29
	1994	112	0	13	1	0	0	4	140	38	41	36
	1999	130	0	12	1	0	0	2	122	32	46	40

changed to 5.0% (a decrease in the rate of increase) on the assumption that inflation and wage increases might decrease and stabilize at a lower level in the future. This scenario, when compared to the baseline solutions, brought about a less rapid exit of gins (D = 155) and increased the number of gins moving into A3 (53, compared to 21 in the baseline solution by 1999), but projected fewer gins moving into A5. This suggests that lower annual increases in labor costs would decrease the movement out of A2 and A3 into D and A5. The change in CL to 15% induced an increased movement of gins out of A1 and A2 and into D, while all other size categories stayed relatively stable compared with the projected situation with CL at 5%. There was an exit of 171 gins by 1999, leaving no gins active in the A1 state.

The baseline was modified also by increasing the rate of change in cost of energy (CE) to a 15% increase per annum. The mean value for CE during 1967-79 was 6.733%, but for the last six years of the study, 1974-79, the average increase was 13%. Thus, the CE = 15% scenario implied a continuation of high energy cost increases. This scenario affected the baseline projections very little.

An assumed increase to 50% in the level of cotton moduled altered the baseline projections for 1999 the most in the D, A2, and A5 categories. Compared to baseline solutions, fewer gins exited the industry (D = 130), while more gins entered and remained in A2, resulting in fewer large gins (A5 = 74). A change in the baseline scenario by allowing the percentage moduled to increase by 5% per annum caused fewer movements between categories. Under this situation, more gins stayed in the A1, A2, A3, and A4 categories and fewer gins moved to A5 states after twenty years (1999) than with moduling held at 50%.

Summary and Conclusions

Cotton gins have been operating under a situation over the years in which the cost per bale of ginning cotton has been increasing. Studies show that the majority of variable costs are labor and energy related. However, the specific impacts of these costs on industry structure have not been investigated. Gin operators have tried to manage these inputs and utilize ginning capacity more efficiently, but face the perennial problem of a short ginning season and volatile cotton production. The use of more energy efficient technology, such as higher-rated capacity gin stands and larger diameter saws, and labor-replacing technology has been well documented, while its impact on the number and size of cotton gins has not. The advent of another type of technological innovation, cotton modules, has been shown by studies to increase the efficiency of the ginning operation; however, measuring its impact on the industry structure has received little attention. The general objective of this study was to identify the major economic factors affecting the structure of the cotton gin industry and provide conditional projections of the future structure of the industry in the Texas High Plains.

The study area included 23 counties with 385 cotton gins. Data on ginning volumes and individual technological changes were gathered for the years 1967-79. Gin capacity was estimated from each gin's equipment make-up and utilization rates were estimated assuming seasonal operation time of 1,000 hours. These constructed data sets were all based on primary data except for annual gin volume data, which were secondary.

Gins were categorized into twelve different size and activity groups and changes in gin size and number were traced from year to year using a stationary Markov Chain procedure. Probabilities of movement were estimated and used to project the future industry structure. A non-stationary Markov Chain model was developed on the basis of regression equations for probabilities of gin movements among size groups. Ten different equations were estimated. Using these equations and constraining all factors but time at their base levels, a baseline industry structure was simulated for 20 years. The levels of explanatory variables were changed to evaluate the effects of those changes on industry structure.

Of seven simulation scenarios, including the baseline and the stationary transition probability scenarios, three showed dramatic changes in the industry. The scenario with the high rate of increase in labor costs (CL = 15%) showed that of the 337 gins that were active in 1979, only 64% (214) were active 20 years later. None out of 56 and only 69 of 172 remained in active size groups one and two, respectively; most of these gins exited the industry. In the simulation with energy costs increasing at a high rate (CE = 15%), the same general trend occurred, but more of the small (A1 and A2) and medium (A3) size gins moved into the large size groups A4 and A5. The number of gins in A5 increased from 21 in 1979 to 93 by year 1999. A steady increase in the adoption of module technology decreased the rate of exit of gin firms from the industry and slowed the movement into the very large gin group.

Changes in cost of labor, CL, changes in cost of energy, CE, progresssion of time as an indicator of gradual technological change, T, and proportion of cotton production moduled, M, were the four major factors affecting the gin size and number within the Texas High Plains industry. The impact of the progression of time on the industry structure is an accelerated movement of small and medium gins toward a large gin status and exiting the industry. In other words, there will be fewer cotton gins in the industry, but most of the active gins will be larger. Technological change over time is expected to accelerate the movement when compared to an extension of the past based only on annual averages.

An increase in the cost of labor affects the industry structure in a manner as to increase the number of gins exiting the industry. Changes in labor costs have a greater 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. This signals the small gin manager of a need to increase capacity and decrease ginning costs per bale if he plans to stay in the industry. As with labor costs, rapid increases in the cost of energy forces many small and medium size gins to exit and many of the surviving gins to increase their capacity. With these adjustments, gin equipment and service firms can expect increased sales and servicing of new technology, especially the large capacity gin stands and module feeders, but fewer firms requiring equipment and service. The High Plains cotton producer can anticipate traveling longer distances to have his cotton ginned and have fewer gins among which to choose. 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 stay active and fewer would increase in size.

The increased use of cotton moduling tends to induce fewer movements among active gins and enable more gins to remain active. However, it must be remembered that size in this study was measured solely by gin stand capacity; gins cannot, under this measurement, increase size except by increasing gin stand capacity. Since the advent of moduling, the investment of capital into moduling equipment (module feeders, module movers, etc.) has replaced investment into other technology (gin stands) and the addition of this type of equipment increases the effective gin plant capacity. Therefore, the result of fewer large gins is, in part, a substitution of one type of capacity-increasing technology (moduling) for another (gin stands). However, there are no data available with which to include plant capacity increases due to moduling. With moduling, gins are also aided by the additional ability to store cotton for longer periods of time.

There are several types of implications from this research for individual firms. Small gin managers and owners may wish to formulate future expectations and plan accordingly. If management foresees energy and/or labor costs increasing at a higher rate, in order to survive as an active gin they most likely must enlarge the gin's capacity and increase annual volume to lower the cost per bale of cotton.

Cotton producers, cottonseed oil mills, and cotton distribution specialists must anticipate the movement of many gins to larger capactiy and the exit of many gins from the industry. Producers will likely pay higher transportation costs because of longer average hauls. However, moduling technology may cut their ginning costs, other things remaining constant.

Industries related to the ginning industry such as the gin equipment and gin service industries also would be affected by these changes. Many gin firms will increase their capacity and buy new technology from equipment companies, much of it probably labor-replacing. On the other hand, fewer small gins in the industry will result, which would cause a permanent drop in demand for some types of gin equipment and service. For those equipment companies that sell and/or service module builders and feeders, the advent of moduling is especially important to them. If these company managers expect the percentage of cotton moduled to keep increasing as one projection shows, 73% of all cotton gins active in 1979 would still be active by year 1999 and many would have purchased other equipment such as gin stands and presses. This could mean more equipment sales of traditional technology as well as more sales of moduling equipment because of more firms staying in the industry.

A smaller number of active cotton gins coupled with existing gins replacing labor with equipment may mean less total employment in rural communities. Towns that lose some or all of the nearby cotton gins, especially due to increases in labor or energy costs, could suffer economically. However, the region as a whole, especially cotton producers, will benefit from the industry adjustment in the form of lower ginning charges and a more efficient market structure than would be the case without the adjustment. Among the various scenarios examined, a steady increase in the percentage of cotton moduled would likely have the most favorable impact on the Texas High Plains economy.

One of the limitations of this study was the inadequacy of the data for estimating the regression equations within the non-stationary Markov Chain procedure. The number of observations ranged from 9 to 12, and more observations would have been preferable and possibly more conclusive. The study was limited to the time period 1967-79 because these were the only years for which the data on gins were available. Also, more complete data on moduling and other operations of gins, wage rates, and other cost items would have strengthened the analysis. Also, new entries were not included in the projection process because the data provided information only on conditional probabilities on new entries, i.e., the state into which an entering gin would enter, given a new gin entry.

While information gathered and projections made in this study contribute to the understanding of the Texas High Plains ginning industry, there are other major information and research needs. More specific data are needed on labor costs, levels of technology in use, equipment use, operating practices, energy usage, and other related information. A study on the advent of module storage, its trends and impact on the industry is needed, as this factor alone could permanently change the industry and not much information in this regard is currently available. Also, a study on the substitutability of the different types of technology for each other within the industry is needed. Follow-up research from this study could include a study on the projections that were made and their specific impacts on other related industries, such as cotton seed oil mills and cotton merchants.

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APPENDIX A

Transition Matrices (n_{ijt}) for Markov Chain Analysis of Texas High Plains Cotton Gins.

NIJ Transition No. 1 from 1967 to 1968:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	0	0
D	10	0	0	0	0	0	0	0	0	0	0
IS1	0	1	0	0	0	0	2	0	0	0	0
IS2	0	0	1	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	0	0	0	1	0	0
IS4	0	0	0	0	0	0	0	0	0	1	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	4	0	0	0	0	114	1	0	0	0
AS2	0	0	3	0	0	0	0	168	0	0	0
AS3	0	0	0	0	0	0	0	0	36	0	0
AS4	0	0	0	0	1	0	0	0	0	25	0
AS5	0	0	0	0	0	0	0	0	0	0	8

NIJ Transition No. 2 from 1968 to 1969:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	1	0	0	0	0
D	10	0	0	0	0	0	0	0	0	0	0
IS1	1	3	0	0	0	0	1	0	0	0	0
IS2	1	0	2	0	0	0	0	1	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	1	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	3	0	0	0	0	108	5	0	0	0
AS2	0	0	0	0	0	0	0	167	1	1	0
AS3	0	0	0	0	0	0	0	0	36	1	0
AS4	0	0	0	0	0	0	0	0	0	26	0
AS5	0	0	0	0	0	0	0	0	0	0	8

Appendix A (Continued)

NIJ Transition No. 3 from 1969 to 1970:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	0	0
D	13	0	0	0	0	0	0	0	0	0	0
IS1	2	1	0	0	0	0	3	0	0	0	0
IS2	1	0	1	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	2	0	0	0	0	104	4	0	0	0
AS2	0	0	1	0	0	0	0	172	0	0	0
AS3	0	0	0	0	0	0	0	0	36	0	1
AS4	0	0	0	0	0	0	0	0	0	26	2
AS5	0	0	0	0	0	0	0	0	0	1	7

NIJ Transition No. 4 from 1970 to 1971:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	1	0	0	0
D	16	0	0	0	0	0	0	0	0	0	0
IS1	3	0	0	0	0	0	0	0	0	0	0
IS2	2	0	0	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	1	3	0	0	0	0	97	5	1	0	0
AS2	0	0	1	0	0	0	1	172	2	0	0
AS3	0	0	0	0	0	0	0	0	36	0	0
AS4	0	0	0	0	0	0	0	0	0	27	0
AS5	0	0	0	0	0	0	0	0	0	0	10

Appendix A (Continued)

NIJ Transition No. 5 from 1971 to 1972:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	0	0
D	22	0	0	0	0	0	0	0	0	0	0
IS1	0	3	0	0	0	0	0	0	0	0	0
IS2	0	0	0	0	0	0	0	1	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	1	0	0	0	0	97	0	0	0	0
AS2	0	0	1	0	0	0	1	175	1	0	0
AS3	0	0	0	0	0	0	0	0	37	2	0
AS4	0	0	0	0	0	0	0	0	0	26	1
AS5	0	0	0	0	0	0	0	0	0	0	10

NIJ Transition No. 6 from 1972 to 1973:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	2	0	0
D	22	0	0	0	0	0	0	0	0	0	0
IS1	1	2	0	0	0	0	1	0	0	0	0
IS2	0	0	1	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	2	3	0	0	0	0	91	2	0	0	0
AS2	2	0	3	0	0	0	0	165	6	0	0
AS3	0	0	0	1	0	0	0	0	36	1	0
AS4	0	0	0	0	0	0	0	0	1	26	1
AS5	0	0	0	0	0	0	0	0	0	0	11

Appendix A (Continued)

NIJ Transition No. 7 from 1973 to 1974:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	1	1	0	0
D	27	0	0	0	0	0	0	0	0	0	0
IS1	1	4	0	0	0	0	0	0	0	0	0
IS2	3	0	1	0	0	0	0	0	0	0	0
IS3	0	0	0	1	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	6	1	0	0	0	80	5	0	0	0
AS2	2	0	7	0	0	0	0	154	4	0	0
AS3	0	0	0	1	0	0	0	1	42	1	0
AS4	0	0	0	0	0	0	0	0	0	24	3
AS5	0	0	0	0	0	0	0	0	0	0	12

NIJ Transition No. 8 from 1974 to 1975:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	0	1
D	33	0	0	0	0	0	0	0	0	0	0
IS1	0	6	0	0	0	0	4	0	0	0	0
IS2	0	0	5	0	0	0	0	3	1	0	0
IS3	0	0	0	0	0	0	1	0	1	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	2	0	0	0	0	73	4	1	0	0
AS2	2	0	3	0	0	0	0	155	1	0	0
AS3	0	0	0	2	0	0	0	1	42	2	0
AS4	0	0	0	0	0	0	0	0	0	23	[illegible]
AS5	0	0	0	0	0	0	0	0	0	0	15

Appendix A (Continued)

NIJ Transition No. 9 from 1975 to 1976:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	1	0	0	0
D	35	0	0	0	0	0	0	0	0	0	0
IS1	1	7	0	0	0	0	0	0	0	0	0
IS2	2	0	6	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	1	0	0	1	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	0	6	0	0	0	0	67	5	0	0	0
AS2	0	0	6	0	0	0	0	156	0	1	0
AS3	0	0	0	1	0	0	0	2	42	1	0
AS4	0	0	0	0	0	0	1	0	0	22	2
AS5	0	0	0	0	0	0	0	0	0	0	18

NIJ Transition No. 10 from 1976 to 1977:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	0	0
D	38	0	0	0	0	0	0	0	0	0	0
IS1	3	6	0	0	0	0	4	0	0	0	0
IS2	0	0	7	0	0	0	0	5	0	0	0
IS3	0	0	0	0	0	0	0	0	1	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	1	0	0	0	0	0
AS1	0	0	0	0	0	0	64	2	1	1	0
AS2	0	0	0	0	0	0	0	160	4	0	0
AS3	0	0	0	0	0	0	0	0	43	0	0
AS4	0	0	0	0	0	0	0	0	0	23	1
AS5	0	0	0	0	0	0	0	0	1	0	19

Appendix A (Continued)

NIJ Transition No. 11 from 1977 to 1978:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	1	0	0	0
D	41	0	0	0	0	0	0	0	0	0	0
IS1	3	2	0	0	0	0	1	0	0	0	0
IS2	3	0	4	0	0	0	0	0	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	1	0	0	0	0	0	0	0	0	0	0
AS1	0	2	0	0	0	0	62	3	1	0	0
AS2	0	0	3	0	0	0	0	164	0	0	0
AS3	0	0	0	0	0	0	0	0	48	2	0
AS4	0	0	0	0	0	0	0	0	0	23	1
AS5	0	0	0	0	0	0	0	0	0	0	20

NIJ Transition No. 12 from 1978 to 1979:

Category	D	IS1	IS2	IS3	IS4	IS5	AS1	AS2	AS3	AS4	AS5
NE	0	0	0	0	0	0	0	0	0	1	0
D	48	0	0	0	0	0	0	0	0	0	0
IS1	0	3	0	0	0	0	1	0	0	0	0
IS2	0	0	5	0	0	0	0	2	0	0	0
IS3	0	0	0	0	0	0	0	0	0	0	0
IS4	0	0	0	0	0	0	0	0	0	0	0
IS5	0	0	0	0	0	0	0	0	0	0	0
AS1	1	2	0	0	0	0	55	5	0	0	0
AS2	0	0	2	0	0	0	0	164	2	0	0
AS3	0	0	0	0	0	0	0	1	46	2	0
AS4	0	0	0	0	0	0	0	0	0	25	0
AS5	0	0	0	0	0	0	0	0	0	0	21

Appendix B

Non-Stationary Transition Probabilities Derived from Regression Equations

Equations which could not be estimated for certain cells directly by regression due to an inadequate number of observations were derived by grouping cells and their observations together, estimating equations for groups of cells, then subtracting to estimate transition probabilities for individual cells. Equations and relationships were derived for three such cells' transition probabilites, P(A1-A3), P(A1-A4), and P(A1-D). The equations were derived in the following manner: 1) P(A1-A3) = P(A1-A2,3) - P(A1-A2), 2) P(A1-A4) = P(A1-A2,3,4) - P(A1-A2,3), and 3) P(A1-D) = 1 - P(A1 - A2,3,4) - P(A1-A1) - P(A1-I1). P(A1-A2,3) was an equation of the combined cells with the elements P(A1-A2) and P(A1-A3), while P(A1-A2,3,4) was an equation of the combined cells with elements P(A1-A2), P(A1-A3), and P(A1-A4). The third derivation was based on the constraint that the sum of a row's elements equals one. The derived equations are shown below.

1) P(A1-A3) = P(A1-A2,3) - P(A1-A2)

= (0.0152 + 0.0044 T) - (0.0161 + .0036T)

= - 0.0009 + 0.0008 T

where P(A1-A3) = the probability of a gin in active group 1 moving to group 3 in an annual transition.

According to this equation, P(A1-A3) increases with time. The supporting statistics for the estimated equation for P(A1-A2,3) were: F-Value: 7.70 , PR > F: 0.0196, R^2 = 0.4350, D-W: 1.94, and n = 12.

2) P(A1-A4) = P(A1-A2,3,4) - P(A1-A2,3)

$$= (0.0142 + 0.0047\ T) - (0.0152 + 0.0044\ T)$$

$$= -0.0010 + 0.0003\ T$$

where P(A1-A4) = the probability of a gin in active group 1 moving in to group 4 in an annual transition.

This equation indicated that P(A1-A4) increases with time. The supporting statistics for P(A1-A2,3,4) were: F-Value: 9.52, PR > F:0.0115, R^2 = 0.4878, D-W:1.91, and n = 12.

3) P(A1-D) = 1 - P(A1-A2,3,4) - P(A1-A1) - P(A1-I1)

$$= 1 - (0.0142 + 0.0047\ T) - (1.0787 - 0.0076\ CL + 0.0026\ CE - 0.0219\ T + 0.0043\ M) - (0.0117 + 0.0021\ CL)$$

$$= -0.1947 - 0.0026\ CE + 0.0055\ CL + 0.0172\ T - 0.0043\ M$$

where P(A1-D) = the probability of a gin in active group 1 exiting the industry in an annual transition.

In this equation, an increase in CL and T had the effect of increasing P(A1-D), while an increase in CE and M decreased P(A1-D)

Attempts to estimate regression equations for transition probabilities of other cells failed frequently because of lack of adequate observations. Some cells [P(I1-I1), P(I1-A1), P(I2-I2), P(A2-A3) and P(A4-A4)] had enough observations, but none of the hypothesized variables were statistically significant.