THE OPTIMAL NUMBER, SIZE, AND LOCATION OF COTTON GINS IN OKLAHOMA

By

TOMMY ESHLEMAN

Bachelor of Science
Northwestern Oklahoma State University
Alva, Oklahoma
1979

Master of Arts
Washington State University
Pullman, Washington
1982

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Thesis Approved:

Daniel S. Tilley

Thesis Adviser

Phil Kenkel

David M. Henneberry

David Henneberry

Thomas C. Collins

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Background

Cotton lint was the sixth most important agricultural commodity in Oklahoma in 1993 with a value of $64.4 million from production of 265,000 bales. Oklahoma was the twelfth largest of the 17 cotton growing states in 1993, but the ranking changes considerably from one year to the next as cotton production in Oklahoma is quite variable. In 1990, a record yield in Oklahoma of 496 pounds per acre boosted production to 382,000 bales with a lint value of $116 million, making it the ninth largest cotton growing state in the nation that year. Oklahoma hit a ten year low in cotton production of 173,000 bales in 1989. From 1988 to 1992, cotton production in Oklahoma averaged 262,000 bales per year. (USDA, ERS, Cotton Situation, various issues).

Cotton production is confined mainly to the southwestern quarter of Oklahoma, with the center of production being the Jackson-Tillman County area. This area contains the largest number of gins, the largest gins, and the warehousing facilities.

The 1990 marketing year is emphasized in this study since it was the most recent year that data was available at the time of the study. There were 60 cotton gins reporting to the Oklahoma Corporation Commission in Oklahoma in the 1990 marketing year, and a total of 63 gins operating in Oklahoma according to the Oklahoma Department of Agriculture. Over 80 percent of the gins reporting to the Corporation Commission were small capacity gins processing less than 10,000 bales each that year. The top 20 percent (12 largest gins) processed 50 percent of the total cotton produced in Oklahoma in 1990. Excess capacity in the smaller gins averaged 57 percent greater than that of the top 20 percent of the larger gins for the 1990 marketing year, suggesting that further concentration of ginning in Oklahoma could achieve a more efficient market structure.

The Oklahoma Department of Agriculture (1982) reported 79 gins operating in Oklahoma in 1980. The 20 percent reduction in gin numbers from 1980 to 1990 reflects dramatic improvements in harvesting, seed cotton storage, transportation to the gin, and ginning cotton, as well as reduced planted acreage of cotton. However, these new methods have not been adopted by all participants in the Oklahoma cotton industry. Stripper vs. picker harvesting and trailer vs. module assembly and transport affect the relative efficiency of the industry and greatly influence the number of ginning facilities required to serve the industry.

Harvesting cotton with a picker greatly reduces the amount of trash in the cotton compared with cotton harvested with a stripper. A picker allows cotton to be removed from the plant with a minimum of foreign material, while leaving immature bolls for later harvest. This leads to higher quality lint in the harvest basket. Strippers also harvest cotton but include as well burs, sticks, leaf, bark, and immature bolls from the plant. As a result, the effective capacity of the gin (bales ginned per hour) is increased when ginning picked cotton since less foreign material must be removed. Pickers predominate in irrigated cotton areas, giving gins serving those areas a capacity and cost advantage. Gins which process only picker cotton are also cheaper because they require less machinery to remove foreign matter.

Some areas of Oklahoma may not be able to utilize cotton varieties which are most easily harvested with picker machines since a preponderance of high winds may cause high field losses by blowing seed cotton from the bolls to the ground before they can be harvested. The 20 percent of the cotton ginned in Oklahoma that is harvested with pickers is primarily in irrigated regions of Jackson County. For the top 20 percent of the largest gins, the percentage of cotton harvested by picker machines doubles to 30 percent, indicating that most areas served by the largest plants gin predominantly stripper cotton.

The method of assembly-transport also affects gin capacity. Cotton hauled short distances in trailers is less costly to transport than modules, but it takes more time to load into the gin. Modules load faster, thus increasing the effective capacity of the gin. The module builder is the most advanced system of cotton assembly and transport to the gin. The module builder packs cotton into a tight, self-contained unit which can be stored on the farm or transported and stored on the gin yard. This system enables a cotton farmer to optimize his harvest time by allowing harvest to continue in the field uninterrupted by long waits at the gin during peak harvest. If the gin is equipped with a module loader, ginning time and cost is reduced as well. A farmer hauling cotton in a trailer is limited by the number of trailers he has available for storage because the cotton cannot be unloaded from the trailer until the gin is ready to process it. Oklahoma regulations prohibit gins from owning trailers and renting them to farmers, thus adding to the need for module storage. The Oklahoma cotton harvest begins around October 1 and extends through March 1, with the peak activity occurring from November 10 to December 20. Because modules can be stored on the farm or on the gin grounds, the effective annual capacity of gins is increased by lengthening the ginning season beyond the normal harvest period. These factors play an important role in determining the location, size, and number of gins required to adequately serve a production area.

In 1990, 54 percent of all cotton harvested in Oklahoma was transported to gins in modules (Oklahoma Department of Agriculture). Of the cotton ginned in the top 20 percent of the largest gins, 73 percent was transported in modules indicating greater adoption of advanced assembly-hauling technology in areas served by large capacity gins.

The per bale cost of assembling and transporting cotton from the farm to the gin in trailers is less than one-third that for modules for a haul within 15 miles of the gin. This is due to the additional cost of building the module which constitutes the bulk of the total cost of a haul of this distance. Hauling rates within this range are not generally quoted by the mile, but by a flat rate. Transportation costs for modules become more economical vs. trailers as the distance of the haul increases because the variable cost of transporting a heavier, more dense load eventually overcomes the initial fixed cost of building the module.

Stripped cotton has about seven times more foreign material than picked cotton. On the average, 2200 pounds of stripped cotton are required to process a 480 pound bale of lint, compared to only 1500 pounds of picker cotton (Mayfield and Willcutt, 1985). As a result, over 30 percent more time and resources are required to produce an equal amount of lint from seedcotton harvested with a stripper.

Similarly, gins equipped with a module loader can gin moduled cotton approximately 25 percent faster than loose cotton loaded from a trailer.

The Oklahoma cotton ginning industry is the only ginning industry in the U.S. that is regulated as a public utility. As a public utility, the Oklahoma Corporation Commission regulates ginning rates and decisions concerning exit and entry of gins based upon the needs of the industry. The Oklahoma Corporation Commission began its regulation of cotton gins in 1915 under Section 35 of Article 9 of the Oklahoma Constitution, due to farmer concerns of gin monopolies during the early to mid 1900's, a time when cotton production was growing rapidly in Oklahoma. Concerns as to whether the Oklahoma cotton ginning industry exhibits the characteristics of a natural monopoly requiring regulation have been registered since this time. The first notable objection was brought forth by Ballenger (1936), who concluded in an Oklahoma Agricultural Experiment Station Bulletin released in May of that year that "The regulation of cotton gins as public utilities in Oklahoma appears to have resulted in higher rather than lower ginning rates to the cotton farmers of the state than they would have obtained under competitive conditions."

The main regulatory concern addressed in this study is the Oklahoma Corporation Commission's charge of licensing new gins, allowing gins to shut down, and preventing gins to "supply, lease, rent, or furnish to farmers any device used to transport bulk seed cotton to a cotton gin and/or gin yard" (Oklahoma Corporation Commission, 1980). To make informed decisions of this type, a regulatory agency must have an understanding of the effects of structural changes upon the costs, profitability, and efficiency of the industry. An efficient industry structure benefits producers, ginners, and merchandisers by improving the competitiveness of the industry. Previous research by Cleveland and Blakely (1976) suggested that the Oklahoma cotton industry could have benefitted from a more efficient organizational structure in 1976, a time period which precedes recent changes in cotton assembly and transportation methods. They found that ginning costs could be significantly reduced if some method of seedcotton storage (before ginning) could be found to extend the ginning period and thus increase the effective capacity of the gin. Seedcotton storage has now become widespread with the advent of the module builder-transport system. These changes in the cotton industry highlight the need for a more current analysis of the structure of the Oklahoma cotton industry in a dynamic economic and technological environment.

Objectives

The primary objective of this research is to determine the efficiency of the Oklahoma cotton industry as measured against an optimal organizational structure. Specific objectives are:

1. To determine the current cost of cotton transportation, ginning, and warehousing;

2. To evaluate the cost savings of an optimal gin configuration as determined by a mixed integer transhipment model of the industry;

3. To determine the optimum number, size, and location of cotton gins in Oklahoma to efficiently serve the needs of producers;

4. To evaluate the impact of changes in harvesting and transportation methods on the optimal number, size, and location of cotton gins in Oklahoma;

5. To determine whether specific geographical regions, classes of cotton producers, or classes of ginning firms are likely to be positively or negatively impacted by a transition to a more efficient industry structure.

Methodology

This analysis will entail the construction of a mixed integer transshipment model with fixed quantities at supply and demand points. The mixed integer programming model is designed to minimize the total cost of assembly, transport, and processing from farm to gin to warehouse to domestic and export demand points.

CHAPTER II

LITERATURE REVIEW

Three areas of research are reviewed in this chapter. The first traces the evolution of location theory and its application to the market structure of industries through the use of linear and integer programming. The second describes the use of those techniques in the analysis of cotton gin location. The third examines an extension of the linear and integer programming approach for the study of long-run multiple period adjustments.

Location Theory and Plant Location Studies

The prudent regulator would view the organization of the industry in question much the same as the manager of a private operation involving multiple plants dispersed geographically over a region. Both would strive to design a marketing system which would provide for the efficient flow of raw materials from their source through stages of processing to their ultimate destination points. The aim is to select the optimum shipping patterns, processing techniques, plant sizes, locations, and numbers of plants required to minimize the cost incurred for the total system

(French, 1977).

The first attempt to model this problem was made by von Thunen (1826), a German agriculturist whose work focused on transportation costs and land rent within a closed economy. His work attempted to determine what commodities should be produced for a specific location given the demand sources for these commodities.

Weber (1929) modified that approach to determine the best location for the production of a product given an uneven geographical distribution of raw product. His "material index" helped determine if an industry was materially oriented or market oriented. If the weight of local material used to produce a product is greater than the weight of the final product, then the material index was greater than one; and processing plants should be located near the source of the raw product to take advantage of transportation economies.

Palander (1935) was the first to apply location ideas to the neoclassical theory of the firm. He modified some of the weaknesses of Weber's theory (1929), giving a broader framework to the influence of transportation routes and transport mediums upon industrial location. He also introduced the concept of spatial competition in the analysis of market areas.

Hoover (1948) extended this analysis within a partial equilibrium framework, including a treatment of diminishing returns to scale. He expanded the treatment of transfer costs, land use competition, adjustment and change in industrial location, and the role of public policy in the determination of the location of economic activity.

Losch (1954) presented a general equilibrium system containing interrelationships of all locations, with optimal economic regions in the shape of a hexagon. His work was the first to emphasize the influence of demand on locational analysis, attempting to model spatial variation in demand as well as in costs. He favored a profit maximization approach over the least-cost approach of earlier investigators.

This body of material provided the foundation which enabled later researchers to apply programming techniques to quantify spatial relationships. Stollsteimer (1963) produced an empirical application of a programming framework developed by Lefeber (1958) and Isard (1956) capable of determining the least cost number, size, and plant location of pear-packing facilities given discrete supply and demand areas without restrictions on uniform density of supply and demand. Data requirements for the model include:

1. Quantity of raw material to be assembled from each supply area;
2. Costs of transporting a unit of material from each supply area to each potential plant site;
3. A plant cost function determining the cost of processing a fixed total quantity of material in a varying number of plants; and
4. Specification of potential plant locations.

The area studied in northwestern California was served by five pear packing facilities and was separated from other production areas by mountains. The model specified twelve potential sites.

The results of his study gave the minimum total assembly cost, plant size, and location associated with each of 12 different plant number scenarios (through 12 plant sites). The assembly costs were then added to total plant costs to find the least cost scenario. Stollsteimer (1963) noted a limitation of his study in that the system did not simultaneously minimize assembly, processing, and distribution costs. For this study, the least cost scenario was one centrally located packing facility with the capacity to handle the production of the entire region.

King and Logan (1964) used a transshipment model inspired by Kriebel (1961) to allow the flow of commodities from supply areas through intermediate locations for processing or storage and on to final demand destinations. In this case, the problem to be solved in the California cattle slaughter industry was whether to slaughter cattle at the source of supply and ship meat to demand points or to ship cattle for slaughter at potential intermediate locations and then ship meat to demand points. Economies of scale were considered as slaughter costs varied with the number of animals processed. Regional adjustments in slaughter costs were allowed due to differences in utility rates, union wage rates, and property taxes.

Each of 32 supply areas for live animals within California was considered a potential intermediate transshipment area for slaughter. Each area was also a demand point for beef. The model allowed any area to slaughter a greater quantity of beef than was required to meet the area's demand, thus becoming a transshipment point for beef going to other areas. The model also allowed imports of live animals and beef from other states, but no live animals were shipped out of state and all beef produced and imported was consumed in-state.

When run using constant per unit processing costs, the model indicated slaughter should occur in all 32 areas to minimize total system costs. Another run allowing per unit processing costs to vary according to scale economies indicated that only 17 areas should slaughter and transship meat to minimize total system costs. A major problem was that the model did not allow for every potential transshipment area to take advantage of plant scale economies by allowing variable cost structures at each potential transshipment point. Processing costs in each area were instead determined by the size of plant needed to process the total supply of live animals in each area.

Cotton Gin Location Studies

Fuller and Washburn (1974) used a mixed integer plant location model to determine the least cost organization of cotton gins in New Mexico in 1973 as well as the optimum length of the processing season. Separate studies were done for four regions covering most of the cotton-producing areas in the state. Those regions grew irrigated cotton harvested with pickers. Areas in eastern New Mexico which produce dryland cotton harvested with strippers were not included in this study.

The four regions were served by 40 existing gins. The location model modified the existing marketing system to include field storage of seedcotton with ricks (a precursor to modules) which built a 6 feet tall by 8 feet wide free standing bundle of cotton which could be stored in the field. It required assembly equipment designed for loading and transporting seedcotton. This system, like modules, would allow significant plant-scale economies to be realized. The model allowed four different gin size capacities; 8, 16, 32, and 40 bales-per-hour. In the model the potential number of gin sites was restricted to 12 each for the two largest study areas, the Pecos Valley and the Rio Grande Valley. Three possible gin sites were prescribed for the Hidalgo County area and four possible sites for the Luna County area. The model was run to determine the least cost configuration for three possible ginning season scenarios (four, six, and nine months), using three possible cotton production estimates (an average, a reduced, and a record crop year), giving nine least cost solutions in all. Results consistently indicated that all four areas would reduce total system costs by converting to a smaller number of larger capacity gins. For the four-month ginning season at average crop production levels, the optimal organization for the Pecos Valley would have one 40 and two 16 bale-per-hour gins. The Rio Grande Valley would have one 40 bale per-hour-gin while Luna County would have one 24 bale-per-hour gin, and Hidalgo County would have one 8 bale-per-hour gin.

Fuller et al. (1976) modified the above study by formulating a minimum-cost-flow network problem to incorporate more realism into the model without increasing computation time. This study examined only the Rio Grande Valley, an irrigated area then served by 14 existing cotton gins. Each plant had a piecewise linear variable cost function, and each was allowed to increase seasonal capacity by employing overtime labor shifts, giving two levels of variable labor cost for each plant. When the ginning capacity of the regular shift was exceeded, the excess cotton could still be ginned at the more expensive overtime rate, but which could be more cost effective than activating another gin. Another important cost tradeoff occurred by allowing field storage of seedcotton, giving a longer ginning season and thus increasing total capacity without increasing per hour capacity. The extra cost of seed cotton storage could be more cost effective than activating another gin.

Since the study area was characterized by excess ginning capacity due to a downward trend in cotton production, some reduction in the optimal number of gins required to serve the industry was expected. To determine how much of a reduction in gin numbers could be attributed to this excess capacity and how much could be attributed to seed-cotton storage, the model was first run using three scenarios. The first simulated the existing structure of 14 gins operating at 1974 levels. The second determined the optimal solution without seed-cotton storage in the field. The third determined the optimal solution with seed cotton storage. The difference in the total system cost between the first and second instances gives the cost savings attributable to the elimination of excess plant capacity while the difference in cost between the second and third situations gives the cost savings attributable to the seed-cotton storage alternative. The optimal number of gins expected to serve the area decreased from the existing 14 for the first situation, to 9 for the optimum structure without the seed-cotton storage alternative. The third situation gave an optimum plant structure with the opportunity to store seed-cotton in the field by reducing the number of gins to six.

Cleveland and Blakely (1976) used the mixed integer programming technique to determine the optimum size, location, and number of cotton gins and warehouses for three study areas in the Oklahoma and Texas Plains Region for 1974. The aim of the study was to find the least cost organization of the industries in each study area by modelling all sectors within the marketing system simultaneously. Costs for farm to gin transport, ginning, gin to warehouse transport, warehousing, and warehouse to demand point transport were all included in the model. A partial equilibrium analysis was specified to determine the direction and magnitude of structural changes in the industry in lieu of a dynamic modelling effort.

The three study areas were the Altus area (five counties in southwestern Oklahoma), the Lubbock area (nine counties in the western Panhandle of Texas), and the Abilene area (four counties in the West Central portion of Texas adjoining the other two areas). These areas were characterized by an overcapacity of gins. However, gin numbers remained high (though decreasing over time) due to the desire on the part of cotton producers to have ready access to gins so cotton hauling trailers could be emptied and returned to the field quickly. Without a method of seed-cotton storage, gins must be close by to accommodate these producers.

The Cleveland and Blakely (1976) study was designed to determine the effects of seed-cotton storage upon the optimal number of gins needed to serve these areas. An initial modelling scenario was made for each study area using a conventional 14-week ginning season which reflected the peak cotton harvesting season. A second scenario was made to simulate the adoption of seed-cotton storage in the field which allowed for an extended 32-week ginning season. The results showed significant total-system cost savings for both ginning season scenarios with large decreases in the number of gins serving the areas. For the Altus study area, the number of gins required to serve the region for a 14-week ginning season decreased from the existing 39 gins at 24 locations to just four large capacity (42 bale-per-hour) gins under the optimal organization. Total system costs decreased nearly 30%, over $3 million. For the 32-week ginning season, just two large-capacity gins would serve the area and minimize total-system costs. The cost savings over the optimal 14-week solution were $412,000 (a 5 percent reduction). The greatest reduction in total-system costs was due to the elimination of excess gin capacity while savings from adopting seed-cotton storage systems were much smaller, but still significant.

Capstick et al. (1983) formulated a model to analyze the long-run potential of the Arkansas cotton industry and determine if the existing gin capacity and locations were organized efficiently in 1976. As in previous studies, an extended ginning season utilizing on-farm seed-cotton storage was specified. A new concept was developed in relation to the extended season to account for the opportunity cost of money which is not available to the producer due to having to wait to sell his cotton. As in the Cleveland and Blakely (1976) study, the entire marketing system was modelled to obtain a simultaneous solution for the optimum industry structure. The study covered 26 cotton producing counties in Arkansas served by 212 active gins.

The Capstick et al. (1983) model allowed five potential gin capacity sizes (7, 14, 21, 28, and 35 bales-per-hour) in 94 potential gin locations. Nonlinear cost functions were specified for 14-week and 32-week ginning seasons, both of which were allowed to occur in a single model run. This was an innovative feature of the model since previous studies solved for the ginning season scenarios separately, not simultaneously. The "synthetic" or "building block" method of Knudston (1958) was used to construct the cost functions for each ginning season length, which entails deriving short-run cost functions from physical input-output relationships, and then constructing a long-run cost function from the individual short-run cost functions. The nonlinear cost function was divided into seven linear functions to run the model with a separable programming algorithm. To access the opportunity cost, a 10 percent per annum charge was placed on the value of the cotton ginned in the extended season.

Warehouse locations were specified using a combination of existing locations and new sites where necessary. All warehouses were allowed to have unlimited capacities for the model to select optimum location and size.

Results indicated that the current marketing system was not efficient and significant total system cost savings could be realized. The model indicated that an optimal industry structure would consist of a total of 29 gins, 12 operating on a 14-week ginning season and 17 operating on a 32-week season, with 15 warehouse locations. The 14-week gins would have capacities of 10 bales-per-hour or less, while the 32-week gins would require capacities in the 21 to 35 bales-per-hour range. In a second run where opportunity costs were included, solutions varied little from those without that feature. The authors noted a weakness of this model was that the transition cost of moving from the existing structure to the optimum structure was not considered.

The work of Ethridge et al. (1985) represented a departure from the previous programming studies on cotton gin location by using Markov chain analysis to describe and predict structural changes in the West Texas cotton industry. The study incorporated both the stationary transition probability assumption of the traditional Markov chain technique and a nonstationary transition probability assumption. The study modelled changes in the size and activity level of cotton gins from 1967 to 1979, estimating transition probabilities of movement from one structural state to another. The size groups were categorized according to ginning capacity, while activity levels were specified as new entrants, dead gins, inactive gins, and active gins. The impact of explanatory variables upon these changes was determined by least squares regression, allowing projections of the structure of the industry. Projections made using the stationary transition probability assumptions were compared to projections made using the assumption of nonstationary transition probabilities in order to assess the effect of technological change on the organizational structure of the industry. Explanatory variables for the nonstationary Markov chain procedure were:

1. Gin labor costs;
2. Gin energy costs;
3. Ginning capacity utilization rate, 3-year lagged moving average;
4. Change in county cotton production level, 3-year lagged moving average;
5. Time-trend proxy for gradual technological change; and
6. Percent of module cotton ginned, proxy for periodic technological change.

The model made projections for the years 1984, 1989, 1994, 1999, and 2034, the latter year having achieved an equilibrium gin structure. The stationary model projected that 104 of the original 376 active gins would leave the industry by 1999 and that small capacity gins would give way to larger capacity gins. By comparison, the nonstationary model projected that 172 gins would leave the industry by 1999, indicating an acceleration of exit due to technological change. Other significant variables, in addition to the two technological variables, were cost of labor and energy. Changes in cotton production and gin plant utilization were not significant in determining structural change in gin organization, but the authors noted that those conclusions may be due to a lack of major shifts in these variables over the sample period.

Dynamic Plant Location Studies

Sweeney and Tatham (1976) proposed a mixed integer programming model for the single-period location problem synthesized with a dynamic programming procedure to determine the optimal industry warehouse structure over multiple periods. The system was created to achieve the following objectives:

1. To evaluate the number and location of warehouse configurations;
2. To evaluate these configurations over time to determine changes due to shifting supply and demand patterns;
3. To allow interdependence in costs among warehouses for a single period and across periods;
4. To allow nonlinearities caused by fixed costs of alternative configurations and by variable costs of system throughput; and

5. To provide a feasible and efficient computational framework.

The second objective above was neglected by previous studies in cotton gin location; and as such, they may not have provided optimal solutions over a long-run planning horizon.

Optimal solutions to the static warehouse location problem are obtained via mixed integer programming for each of "T" periods in the long-run planning horizon. Each period solution is evaluated for each of the other periods, giving T alternative configurations for each period. From these configurations, the one which minimizes the total cost of operation and relocation is determined by dynamic programming. Since this approach does not guarantee that the long-run optimal solution will consist of a sequence of static optimal solutions, the authors modified that approach by limiting the number of alternative solutions in each period to the "best rank" order (lowest cost) static solutions for that period. Dynamic programming is then used to determine the minimum cost path through T periods considering the costs of moving from one warehouse configuration to another.

A typical static warehouse location problem was formulated minimizing total distribution and warehousing costs with restrictions on warehouse capacities and guaranteeing that demand quantities are met. A specialized version of Benders partitioning procedure was used to obtain optimal static solutions, while a second best solution was found by adding a constraint making the best solution infeasible. This procedure is continued until the desired number of rank order solutions are found.

Sweeney and Tatham (1976) applied this model to a problem involving two plants as supply sources, five warehouse locations, 15 demand points, and a 5-year planning horizon. A shifting demand pattern was forecast for the 5-year planning horizon which was accounted for in the demand constraints set for each planning period. Ten rank order solutions were obtained for each period, and relocation costs for closing a warehouse site and for opening a new site were used as input for the dynamic programming model. To satisfy conditions for the ranking procedure, five more solutions were required for period one and 10 more for period two to verify that the original dynamic solution was optimal. Two warehouse locations were required in the first two planning periods and a third for the last three planning periods.

Sweeney and Tatham (1976) noted that another use for the model is to plan relocations over time when the existing warehouse structure is known to be inefficient. In this case, starting the procedure with a suboptimal initial warehouse configuration could lead to a different minimum cost path over time, but the configuration in the final planning period will likely be the same as when starting the procedure at an optimal static configuration.

Kilmer et al. (1983) used the methodology of Sweeney and Tatham (1976) to determine long-run dynamic adjustments in number, size, and location of citrus packinghouses for the Indian River market district of eastern Florida in 1980. The area was characterized by a southerly shift in production, with existing packinghouses predominantly located near older grove areas. The study identified 13 supply areas with 13 potential packinghouse locations and 10 demand points. A mixed integer program was used to minimize the total assembly, transportation, variable packing, and distribution costs given fixed supply and demand quantities. The optimal plant configuration was obtained, a constraint imposed to eliminate the optimal plant number solution from the feasible set, and the problem run again to find a near optimal solution. This procedure was repeated until 10 solutions were obtained for each year in a 5-year planning horizon.

Transition costs of closing existing plants or opening new plants are contained in the static model. The transition cost of going from one plant structure to another was the investment servicing cost of all existing plants which are being closed. Thus, the industry will move from one plant configuration to another only if the cost of the new structure is less than the cost of the old structure minus the investment servicing cost of the plants exiting the industry.

A departure from Sweeney and Tatham (1976) involved consideration of costs in future periods, since using the same cost structure for the entire planning horizon biases the dynamic programming solutions toward the initial plant configuration. The dynamic programming model determines the optimum path of structural adjustment required to minimize total system costs over the planning horizon. A lower bound on the optimal multiperiod solution was found by summing the optimal static solutions for each period. This solution represents the optimal plant configuration adjustment path when no transition costs are considered. An upper bound is then found by subtracting this solution from any feasible solution to the multiperiod problem. Using this method for each period, only the static solutions whose difference from the optimal static solution is less than the difference between two dynamic solutions need be considered in the dynamic program.

Results of this study showed that 24 existing packinghouse plants should close during the first planning period (1979-80) while 11 should remain open and 6 new large plants should be built. By the final year of the planning horizon (1983-84), two more plants would close. The optimal dynamic solution does not include the optimal static solution for the first, second, and third periods of the planning horizon, which illustrates the necessity of including transition costs in a dynamic framework to obtain an optimal industry structure. However, the dynamic solution in this study could not be verified since the bounding condition set forth to determine which static solutions to include in the dynamic model was not met due to time and computer cost constraints.

CHAPTER III

CONCEPTUAL MODEL, METHODOLOGY, AND DATA

Introduction

A model for the Oklahoma cotton ginning industry is presented in Chapter III. The first section describes the operation of the current marketing system from the farm to the ultimate demand points at mills or export locations.

The second section provides the relevant theory of the firm and programming techniques applied to the transportation and plant location problem. This treatment is then extended to dynamic programming techniques used to allow efficiency changes in market structure to occur over time to provide more realism to the model.

In the third section, a model is presented which applies the theory and techniques in section two to the current organization of the Oklahoma cotton ginning industry to determine optimal industry structure. Constraints are identified, and methods of incorporating them into the model are explained.

The final section describes the data sources and synthesis used to provide input for the empirical study.

Oklahoma Cotton Marketing System

Four different combinations of harvest methods and transportation systems used are included in the model:

1. Stripper cotton transported in trailers (ST);
2. Stripper cotton transported in modules (SM);
3. Picker cotton transported in trailers (PT); and
4. Picker cotton transported in modules (PM);

Based upon survey data, 50 percent of the cotton ginned in Oklahoma from the 1990 crop year was in the ST category, 34 percent was in the SM category, 3 percent was in the PT category, and 13 percent was in the PM category.

For cotton ginned in the top 20 percent of the largest gins in Oklahoma, the ST category claimed 12 percent of the cotton, less than a quarter of the total for that category, while the SM category accounted for 24 percent of the cotton, over 70 percent of the total in that category. All 13 percent of the cotton in the picker-module category was processed by the largest 20 percent of the gins.

Approximately two-thirds of the cotton produced in Oklahoma is ginned in plants equipped with a universal density press which produces uniform bales ready for storage and international shipping. Those without this equipment produce modified flat bales which must be compressed into uniform bales at the warehouse. There are five cotton warehouses in Oklahoma, two of which operate only during bumper crop years when the capacity of the other three is exceeded.

Transportation of cotton from gins to warehouses is accomplished by truck at a rate which averages roughly one quarter the cost of transportation from farms to gins. Once at the warehouse, if the cotton is in a modified flat bale, it is compressed into a universal density bale. A farmer will normally not store his cotton for more than 8 to 10 months before selling, and a buyer normally stores his cotton at the warehouse up to 4 months longer before shipment to demand points. The universal density bales are then shipped by rail or truck to domestic demand points or to ports for export.

The majority of the cotton grown in Oklahoma is sold to Telcot, the buyer-marketing arm of the Plains Cotton Coop in Lubbock. Many other cotton brokers buy from farmers as well. Telcot ships Oklahoma cotton by truck and rail to 10 different demand points, six domestic markets in the southeastern U.S. and four export locations. The domestic markets are in the states of Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia. The export locations included ports in California, Texas, Washington, and Canada. Telcot shipped 47 percent of their cotton to export locations in 1990.

Mathematical Programming

The plant location problem has been most successfully analyzed by mathematical programming techniques which provide a logically consistent method for evaluating alternative economic scenarios and industry structures. The most basic of the techniques used is linear programming, which has been applied to a wide variety of economic problems, proving its value as a powerful decision-making tool through four decades of scrutiny. Linear programming also provides a foundation for the development of more sophisticated techniques such as integer, stochastic, and nonlinear programming.

The linear programming method allows a decision-maker to construct a comprehensive model which can simultaneously determine optimal factor use toward the achievement of a desired goal, be it profit maximization, cost minimization, or some other objective. Linear programming involves optimizing a linear objective function subject to a system of linear resource, logistical, or policy constraints. It is often applied to production problems which maximize profit or revenue, but it is equally as useful in solving transportation and plant location problems by minimizing assembly, transportation, and processing costs at any level of a firm or sector's decision-making process or for an entire system (Hazell and Norton, 1986).

The standard form of the linear programming model is given by the equation:

$$Optimize\ Z = \sum_{j=1}^{n} c_j x_j$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j < b_i \qquad for\ all\ i = 1...m \qquad (resource\ constraint)$$

and

$$x_j > 0 \qquad for\ all\ j = 1...n \qquad (non\text{-}negativity\ condition)$$

where

Z = value to be optimized;

x_j = choice variable representing the level of the jth activity; the model will determine the optimal level of each j = 1 to n activities;

c_j = the marginal change in Z resulting from a one unit change in the jth activity (per unit factor cost for a cost minimization problem);

a_{ij} = the quantity of the ith resource required to produce one unit of the jth activity for i = 1 to m resources; and

b_i = the amount of the ith resource or other constraint available for use in the alternative activities.

The model contains m constraints due to scarce resources, logistics, or policy considerations, which are represented as rows in the linear programming tableau. The quantity of each resource that must be allocated among the competing activities is represented as b, and is referred to as the right-hand-side (RHS) value.

The model contains n activities, each of which represents a unique production or marketing process. These activities are columns in the linear programming tableau, and the x_j's represent the optimal quantity of the jth activity as determined by the model.

The model contains n*m input-output coefficients, represented by the a_{ij}'s, which indicate the quantity of resource i necessary to produce one unit of activity j. All a_{ij}'s in one column give the level of each of m resources associated with one point on a classical production surface. Other points on the production surface are represented by the activities in the other columns.

The top row of the typical linear programming tableau contains the objective function. Each of the c_j's in the objective function gives the amount of change in Z, the value being optimized, for a one unit change in the jth activity. The linear programming model allocates the m resource quantities available (b_i's) to the n activities such that the Z value is optimized, giving solution values for all x_j's in the process.

Implicit in the linear programming model are eight assumptions concerning the nature of the production-marketing activities and resource constraints. These are:

1. Optimization - The maximization or minimization of the objective function value;

2. Fixedness - One or more of the constraints are fixed for the time period under consideration, having a nonzero RHS value;

3. Finiteness - There is a known, finite number of activities and constraints;

4. Determinism - All c_j's, b_i's, and a_{ij}'s are known constants;

5. Continuity - All resources and activities can be used and produced in fractional units;

6. Homogeneity - All units of the same resource (row) and the same activity (column) are identical;

7. Additivity - The total product from the use of two or more activities is the sum of their individual products, so no interactive effects between activities are permitted; and

8. Proportionality - The marginal change in the objective function given a change in the jth activity (the c_j's), and the resource requirements per unit of activity do not change with the level of activity used, resulting in a Leontief production function which is described by a linear ray through the origin.

The last two assumptions together assure linearity in the activities, giving the procedure its name, linear programming. These assumptions are strict and must hold for all rows and columns in the linear programming tableau, but need not hold for the production process itself.

If these conditions are too restrictive for the problem at hand, there are methods which can be used to relax some of these assumptions. If the proportionality assumption is not appropriate, separable programming allows the incorporation of several activities in a model which provide a piecewise linear approximation of nonlinear relationships between inputs and outputs. If the additivity assumption is not appropriate, a separate activity can be defined to represent complimentary or supplementary relationships between two or more activities. If the fixedness assumption is not appropriate, a dynamic model can be constructed to reflect multiple-period growth and changing resource constraints. If determinism is not appropriate, stochastic models can be built to estimate the c_j, a_{ij}, and b_i coefficients.

The continuity assumption is often not realistic when resources cannot be used in fractional units or when output cannot be produced in fractional units. For example, the construction of a new plant to more efficiently serve an area must be done in whole units since building a fraction of a plant is not possible. Integer programming is an extension of linear programming where some or all of the variables are restricted to integers, thus insuring that solutions for those variables will not be in fractional units. Models which contain both continuous and integer variables are called mixed integer programming models. Several algorithms have been developed to analyze integer programming models, but none are uniformly efficient in their ability to compute optimal solutions, especially in larger models (Taha, 1987). The branch-and-bound method offers the most successful technique in solving integer and mixed integer programming problems.

The branch-and-bound method begins by finding the linear programming solution to the problem being modelled. If the linear programming solution contains only integer values for the integer-constrained variables, then it is also the integer programming solution. If any of the integer-constrained variables are fractions in the linear programming solution, then the original solution space is branched into two subsets, eliminating parts which do not include feasible integer values. The linear programming solution is then found for each subset. The branching procedure is repeated for each subset until a linear programming solution is found which has integer solutions for the integer-constrained variables, at which point partitioning is discontinued for that particular branch. The entire process is carried out until each branch terminates with an integer solution, and the best of these terminal integer solutions becomes the optimal integer or mixed integer programming solution.

The computational efficiency of this procedure is enhanced by bounding, whereby each continuous solution obtained from each subset is compared to the best terminal integer solution obtained at that point in the branching process. If the continuous solution is inferior to the best terminal integer solution, then that branch is terminated and deleted from consideration, or fathomed.

A transshipment model is a special formulation of a transportation cost-minimization problem which allows a shipment from any supply source to pass through any other source or destination point before reaching its designated demand destination. As such, the number of transshipment points in this model is equal to the sum of the supply sources and the demand destinations. A model constructed this way automatically determines the least-cost transportation route without a priori knowledge of this route (Taha, 1987). This formulation of the linear mixed integer programming technique will be utilized in our analysis of the Oklahoma cotton industry.

While linear and mixed integer programming techniques provide powerful tools for the analysis of many economic optimization problems, they are limited in their ability to analyze multiperiod adjustments in industry structure when supply and demand conditions are changing or when the costs of opening and closing plants constitute a large proportion of the total costs of moving from one industry structure to another (Kilmer et al., 1983). As a result, dynamic programming methods are needed to analyze structural change over time in an economic environment characterized by change.

The dynamic programming procedure of Ballou used mixed integer programming to find optimal solutions to a static warehouse location problem for each of T periods in a long-run planning horizon, given differing supply and/or demand projections for each period. Since it is not computationally feasible to consider every possible warehouse configuration, the number of configurations examined in each period is limited to the optimal solutions found for each period, which is then evaluated for each of the other periods. This gives T alternative configurations for each of T periods. From these configurations, the one which minimizes the total cost of operation and relocation from one period configuration to the next is determined by dynamic programming.

Sweeney and Tatham (1976) modified this approach by limiting the number of alternative solutions considered in each period by a ranking procedure. The ranking procedure involves finding the optimal plant configuration for each period. A constraint is imposed to eliminate the optimal plant number solution from the feasible set, and the problem is solved again to find a near optimal solution. This procedure is repeated until a specified number of solutions is obtained for each year in the planning horizon, giving the best rank order (lowest cost) static solutions for each period. Dynamic programming is then used to determine the minimum cost to the industry of moving from one period configuration to the next, through all T periods, considering the transition costs of each move. The transition costs include the cost of opening and closing plants. The dynamic programming model takes the following form:

$$v_t^*(s) = \min\ [v_{t,s} + N_{t,sr} + v_{t+1}^*\ (r)] \qquad t = 1\ \ldots T:$$

where $v_t^*(s)$ is the cost of the best dynamic solution of industry adjustment from one period to the next, starting at period t with plant configuration s; $v_{t,s}$ is the total system cost (assembly, transport, and processing) of plant configuration s in period t; $N_{t,sr}$ is the transition cost of industry adjustment from plant configuration s in period t to plant configuration r in period t+1; and $v_{t+1}^*(r)$ is the cost of the best dynamic solution of industry adjustment from one period to the next, starting at period t+1 with plant configuration r. A lower bound on the optimal multiperiod solution is found by summing the optimal static solutions for each period. This solution represents the optimal plant configuration adjustment path when no transition costs are considered. An upper bound is then found by subtracting this solution from any feasible solution to the multiperiod problem. Using this method for each period, only the static solutions whose difference from the optimal static solution is less than the difference between two dynamic solutions need be considered in the dynamic program.

Kilmer et al., 1983) modified the dynamic programming methodology of Sweeney and Tatham (1976) in several ways. Transition costs of closing existing plants or opening new plants are contained in the static model. The transition cost of going from one plant structure to another is the investment servicing cost (debt-servicing plus return on net investment) of all existing plants which are being closed. Thus, the industry will move from one plant configuration to another only if the cost of the new structure is less than the cost of the old structure minus the investment servicing cost of the plants exiting the industry. Costs in future periods beyond T (the last year in the planning horizon) are discounted to period T to avoid biasing the dynamic programming solutions toward the initial plant configuration. The dynamic programming model determines the optimum path of structural adjustment needed to minimize total system costs over the planning horizon.

Hypothesized Model

The Oklahoma cotton industry is analyzed in this study with a mixed integer transshipment model which minimizes total assembly, transport, processing, and distribution costs from farm to gin to warehouse to domestic or export demand locations. The model assumes fixed quantities at supply and demand points and that per bale costs are known for the activities. The cost minimizing equation takes the form

$$MIN\ Z = \sum_{i=1}^{60} \sum_{j=1}^{4} \sum_{k=1}^{60} C_{ijk}X_{ijk} + \sum_{j=1}^{4} \sum_{k=1}^{60} \sum_{l=1}^{3} C_{jkl}X_{jkl} + \sum_{k=1}^{60} \sum_{m=1}^{2} C_{km}X_{km} +$$

subject to

$$\sum_{m=1}^{2} C_m X_m + \sum_{m=1}^{2} \sum_{n=1}^{10} C_{mn} X_{mn} + \sum_{k=1}^{60} \sum_{l=1}^{3} \sum_{h=1}^{2} Y_{klh} f_{klh}$$

$$\sum_{j=1}^{4} \sum_{k=1}^{60} X_{ijk} = S_i \quad (i = 1,...,60)$$

$$\sum_{i=1}^{60} \sum_{j=1}^{4} \sum_{k=1}^{60} X_{ijk} =$$

$$\sum_{j=1}^{4} \sum_{k=1}^{60} \sum_{l=1}^{3} X_{jkl} =$$

$$\sum_{k=1}^{60} \sum_{m=1}^{2} X_{km} =$$

$$\sum_{m=1}^{2} X_m =$$

$$\sum_{m=1}^{2} \sum_{n=1}^{10} X_{mn}$$

$$\sum_{m=1}^{2} X_{mn} = D_n \quad (n = 1,...,10)$$

$$\sum_{j=1}^{4} \sum_{k=1}^{60} \sum_{l=1}^{3} X_{jkl} \le Y_{klh} CAP_{klh} \quad (k = 1,...,60; l = 1,...,3; h = 1,2)$$

$$Y's,\ X's \ge 0,\ Y's \text{ are integers}$$

where

C_{ijk} = per bale transportation cost from supply area i to gin location k, by cotton type j.

X_{ijk} = quantity of cotton transported from supply area i to gin location k, by cotton type j.

C_{jkl} = per bale ginning cost of cotton type j at gin location k for gin size l.

X_{jkl} = quantity of type j cotton processed at gin location k by gin size l.

C_{km} = per bale transportation cost from gin location k to warehouse location m.

X_{km} = quantity of cotton transported from gin location k to warehouse location m.

C_m = per bale storage cost at warehouse location m.

X_m = quantity of cotton stored at warehouse location m.

C_{mn} = per bale transportation cost from warehouse location m to demand destination n.

X_{mn} = quantity of cotton transported from warehouse location m to demand destination n.

Y_{klh} = open gins at location k of size l with season length h.

f_{klh} = annual fixed costs of gins at location k of size l with season length h.

S_i = fixed quantity of cotton from supply area i.

D_n = fixed quantity of cotton received by demand destination n.

CAP_{klh} = gin capacity in location k of size l with season length h.

There are i = 1...60 supply areas transporting j = 1...4 types of cotton (ST, SM, PT, and PM) to the k = 1...60 gin locations. Each type of cotton has a different transportation cost structure. Stripper cotton is more costly to transport per mile due to the extra foreign material contained in it. Cotton in modules is more costly to transport to the gin for short hauls than cotton in trailers due to the extra cost of building the module. The module becomes more economical vs. the trailer as the length of haul increases. Each cotton type incurs a different flat rate transportation cost per bale within 15 miles of the gin. Each cotton type also incurs a different transport cost per bale per mile if the cotton is hauled more than 15 miles to a gin.

There are j = 1...4 types of cotton processed at k = 1...60 gin locations by l = 1...3 gin sizes, based upon a 100 day (3-month) output level. Variable costs for ginning differ according to the type of cotton and the size of the gin. Stripper cotton is more expensive to gin due to the extra foreign material which must be removed. Cotton loaded into the gin from a trailer is more expensive to gin than moduled cotton loaded into a gin equipped with a module loader due to the extra time and labor required. Ginning costs also decrease as the capacity of the gin increases due to economies of scale in production.

After the cotton has been ginned, it can be considered all of the same type, and the cost of transporting from any of the k = 1...60 gin locations to the m = 1...2 warehouse locations is the same per bale per mile. Warehousing costs per bale are also considered to be identical for the two warehouse locations. Transportation costs from the two warehouse locations to the n = 1...10 demand destinations are considered identical for each warehouse location since the two warehouses are only 34 miles apart while the demand destinations are hundreds to thousands of miles away.

There are k = 1...60 possible gin locations of l = 1...3 different sizes with h = 1,2 season lengths, regular season (100-day, or three-month harvest season) and extended season (three months longer than the regular season, or 200 days). These options are in the integer activities section, whereby the model solves for the number and size of gins at each possible location. A gin can attain an extended season capacity only if it receives stripper-module or picker-module type cotton since cotton hauled to gins in trailers cannot be stored for an appreciable length of time. The extended season option effectively doubles the regular 3-month capacity of a gin. While modules can be stored longer than 3 months, cotton farmers do not generally favor doing so due to quality concerns. The capacity of a large, regular season gin was set at 25,000 bales per year (25 bales per hour, 10 hour work day), and the extended season capacity would double to 50,000 bales. The capacity of a medium, regular season gin was set at 15,000 bales per year with an extended season capacity of 30,000 bales. The small, regular season gin capacity was set at 5,000 bales per year with an extended season capacity of 10,000 bales. These numbers were calculated using averages from the capacity data reported in the Oklahoma Corporation Commission (1990) accounting records. Fixed costs associated with gins do not vary with the extended season option, so there are only three different fixed cost numbers based upon gin size.

The S_i values represent the supply of cotton from each supply area, which is fixed at the 1990 crop year levels.

The D_n values represent the amount of cotton shipped to each demand point, which is fixed at the amounts determined by the market shares given by Telcot, the marketing arm of the Plains Cotton Coop, for the 1990 marketing year. The 1990 crop was 45 percent larger than the average for the past 10 years and therefore the solutions determined in the model are capable of handling larger crops.

The unique features of this study involve its use of detailed accounting data provided by gin records submitted to the Oklahoma Corporation Commission, and its potential use by regulators to assess the economic impact of policy decisions on the cotton industry. Previous studies determined the number, size, and location of gins which would be required to serve a region assuming all cotton would be shipped to the gin in modules. This study uses the current level of module usage in Oklahoma in finding a model solution for the number, size, and location of gins required to serve Oklahoma, which is a more realistic situation. The model could help estimate the impact of licensing a new gin, letting a marginal gin close down, or allowing gins to rent trailers and module equipment to farmers to extend the effective ginning season.

Data Sources and Synthesis

Data on ginning costs, capacity, and output were obtained from accounting records which each gin is required to submit to the Corporation Commission on an annual basis. Data on the amount of cotton ginned by type (stripper vs. picker, trailer vs. module) for each gin was obtained by a written survey which was filled out by the gin and submitted with the accounting records for the 1990 crop year. The survey was sent out by the Corporation Commission the first of February, 1992. The response rate to the survey was 38 percent, as 23 out of 60 gins turned in useful information. The survey form is shown in Appendix A. Follow-up phone surveys were used to obtain the same information from an additional 20 gins to insure adequate geographic coverage of the Oklahoma cotton growing area. In total, information was received from 60 percent of all Oklahoma gins through the written and phone surveys. These phone surveys also obtained this same type of information on surrounding cotton growing areas served by gins which were not surveyed, giving total coverage of the Oklahoma cotton growing region. Information on transportation rates, both farm-to-gin and gin-to-warehouse, was also collected during the phone surveys.

Data on the cost of warehousing was obtained in a phone interview with the Oklahoma Compress Association in Altus, and data on transportation costs to domestic and export locations was obtained in a phone interview with Telcot in Lubbock, TX. Both of these organizations are owned by the Plains Cotton Coop in Lubbock, which handles around 80 percent of all the cotton grown in Oklahoma.

Data on farm-to-gin transportation costs by cotton type (ST, SM, PT, and PM) were synthesized from available rate information. Quotes for transport rates for stripper cotton hauled in trailers were fairly constant at $2.00 per bale within 15 miles of the gin. Utilizing this rate and assuming that stripper cotton has 7 times more foreign material than picker cotton, the rate for PT cotton was calculated to be $1.36 per bale within 15 miles of the gin. Quotes for moduled cotton varied more than that for trailers, but averaged $50.00 per module within 15 miles of the gin. Assuming a module will contain 12 bales of picker cotton, the rate for PM cotton is calculated at $4.17 per bale within 15 miles of the gin. Using the same 7:1 ratio of foreign material in stripper vs. picker cotton, a module would contain 8.2 bales of stripper cotton, which results in a hauling rate of $6.10 per bale within 15 miles of the gin. It is clear that trailers are the most economical transport method for short hauls within 15 miles of the gin.

The calculations for costs per bale per mile for hauls over 15 miles are more complicated. Quotes for modules ranged from $1.25 per mile to $2.00 per mile. Using the higher $2.00 number, the rate per bale per mile is calculated at 16.7 cents for PM cotton, and 24.4 cents for SM cotton. No quotes could be obtained for trailer hauls over 15 miles, so this data was calculated from data contained in Mayfield and Willcutt (1985) on cotton transportation costs. Although this data was out of date and not directly usable, the relative percentage difference between the variable costs of hauling moduled versus trailer cotton was assumed to be accurate, and was used in conjunction with the quotes for modules noted above to calculate the rate per bale per mile for cotton hauled in trailers. These rates were calculated at 31.7 cents per bale per mile for ST cotton, and 21.7 cents per bale per mile for PT cotton. In all cases, these rates are added to the flat rate within 15 miles to obtain the total cost of the haul. All hauls within 15 miles incur the flat rate only. Table 1 contains the farm-to-gin transport rate structure for all cotton types.

TABLE 1

FARM-TO-GIN HAULING RATE STRUCTURE BY COTTON TYPE

COTTON TYPE*	FLAT RATE WITHIN 15 MILES OF GIN ($/BALE)	ADDED COST OUTSIDE 15 MILES OF GIN ($/BALE/MILE)
ST	2.00	.317
SM	6.10	.244
PT	1.36	.217
PM	4.17	.167

* S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

Ginning costs for the four types of cotton must also be calculated from the available data. The Oklahoma

Corporation Commission (1990) accounting records were used to determine the average variable costs of ginning for each gin. The gin sizes were categorized as large (25,000 bales per year), medium (15,000 bales per year), and small (5,000 bales per year) based upon their output-capacity per 100 day season. These numbers were then adjusted for the relative composition of stripper vs. picker and trailer vs. moduled cotton for each gin. Based upon information obtained from ginners and the 7:1 ratio of foreign material in stripper versus picker cotton, picker cotton is assumed to cost only 70 percent as much to gin as stripper cotton, while moduled cotton is assumed to cost only 80 percent as much to gin as cotton loaded into the gin from trailers. Adjusting for these cost differences, we arrive at 12 different average variable cost numbers based upon size and type of cotton ginned. This ginning cost structure is shown in Table 2.

TABLE 2

AVERAGE VARIABLE COST FOR GINNING BY
GIN SIZE AND COTTON TYPE

GIN SIZE*	COTTON TYPE**	AVERAGE VARIABLE COST ($/BALE)
LARGE	ST	22.51
MEDIUM	ST	23.62
SMALL	ST	25.86
LARGE	SM	18.01
MEDIUM	SM	18.89
SMALL	SM	20.69
LARGE	PT	15.76
MEDIUM	PT	16.53
SMALL	PT	18.10
LARGE	PM	12.60
MEDIUM	PM	13.23
SMALL	PM	14.48

* Large = 25,000 bales per year; Medium = 15,000 bales per year; Small = 5,000 bales per year

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

Using averages of quotes by ginners, the cost of transporting cotton from the gin to the warehouse was 4.5 cents per bale per mile. The cost of warehousing cotton included several components. A receiving fee of $2.25 per bale is charged to all cotton entering the warehouse. Approximately one-third of this cotton must be compressed into universal density bales for further shipment to demand destinations. The other two-thirds have been compressed into universal density bales at the gin and need no further processing. The cost of compression at the warehouse is

$8.00 per bale, so applying one-third of this cost gives an average of $2.65 per bale for all cotton moving through the warehouse. The cost of storage is $1.67 per bale per month. A farmer typically stores cotton in the warehouse up to 8-10 months, while the buyer may store it an additional 4 months. Assuming a maximum storage period of 12 months, and assuming farmers and buyers store an equal amount of cotton during each month of this period, the average storage period for a typical cotton crop would be 6 months, giving an average storage cost of $10.00 per bale. Finally, a loading fee of $4.00 per bale is charged for all cotton being shipped to demand destinations. This gives a total warehousing cost of $18.90 per bale.

The actual shipping rates for cotton shipped from Telcot to 6 domestic and 4 export destinations are illustrated in Table 3. Where both rail and truck transport modes are utilized for a particular destination, the rate for the mode carrying the largest quantity is used in the model.

TABLE 3

WAREHOUSE-TO-DEMAND-POINT TRANSPORTATION COSTS

DEMAND POINT AND PREDOMINANT MODE OF TRANSPORTATION	COST ($/BALE)	SHARE OF TOTAL COTTON SHIPPED TO EACH DEMAND POINT
ALABAMA DOMESTIC TRUCK	11.00	10.9%
CALIFORNIA EXPORT RAIL	11.45	33.9%
CANADA EXPORT RAIL	17.10	1.4%
GEORGIA DOMESTIC TRUCK	12.50	17.4%
NORTH CAROLINA DOMESTIC TRUCK	14.15	12.7%
SOUTH CAROLINA DOMESTIC TRUCK	13.40	10.5%
TENNESSEE DOMESTIC TRUCK	13.25	0.3%
TEXAS EXPORT TRUCK	7.00	6.3%
VIRGINIA DOMESTIC TRUCK	15.00	0.4%
WASHINGTON EXPORT RAIL	11.45	5.1%

DATA SOURCE: RICK SHEPARD, TELCOT, PLAINS COTTON COOP, LUBBOCK, TX

CHAPTER IV

RESULTS OF MIXED INTEGER OPTIMIZATION

Organization

The results of the mixed integer model are presented in Chapter IV, and the possible affects on Oklahoma farmers and ginners are analyzed. The first section describes the current cost of the Oklahoma cotton marketing system based upon accounting records and interview data.

The second section compares the cost of the optimal cotton marketing system as determined by the model to the cost of the current system and examines the implications of the new structure to industry participants.

The third section details the gin size and locations determined by the model, the supply areas and cotton types served by each gin location, and the associated transport and ginning costs.

The fourth section discusses the possible implications of greater concentration of the cotton ginning industry which would result from a transition to an optimal market structure.

The final section illustrates the impact of the optimal cotton market structure on individual supply areas and gin locations, showing which areas stand to gain and lose under the optimal gin configuration.

Costs of Current Cotton Marketing System

To evaluate the cost of a more efficient cotton marketing system as determined by the model, we must first determine the costs incurred with the current gin configuration. These costs were not determined by the model, but were calculated directly from cost data obtained from the Corporation Commission accounting records, along with transportation and warehousing data obtained by phone surveys.

The cost of transportation from the farm to the gin was calculated using the same per bale transportation cost data used in the model. In the current system, all cotton from a particular supply area went to the gin serving that area, and incurred the flat rate for hauls within 15 miles of the gin, based upon the type of cotton being transported.

The Corporation Commission accounting records contained variable and fixed cost data which were aggregated to give the total ginning cost for the system for the 1990 marketing year.

The gin to warehouse transport cost was calculated based upon the actual amount of cotton shipped from each gin to the warehouse, using the same 4.5 cent per bale per mile rate used in the model.

The warehousing cost was calculated by taking the average warehousing cost per bale as determined in the data section ($18.90 per bale), and the warehouse to demand point shipping cost was calculated using rates and demand point shares which were quoted from Telcot, the marketing arm of the Plains Cotton Coop which owns the Altus warehouse and ships the majority of cotton ginned in Oklahoma. Both the warehousing costs and the shipping costs to the demand points would be exactly the same as those determined by the model for the optimal system. Regardless of the gin configuration, the same amount of cotton would be warehoused at the same cost, and the amounts shipped to demand points would remain the same and would incur the same costs.

It was estimated that the total cost of transporting cotton from the farm to the gin in Oklahoma during the 1990 marketing year was $1.25 million. The total cost of ginning cotton was estimated to be $13.72 million of which $9.32 million was variable cost and $4.40 million was fixed cost. The total cost of transporting the cotton from the gin to the warehouse was estimated at $690,000 while the warehousing cost was estimated to be $6.58 million. The total cost of transporting the cotton from the warehouses to the ten different demand locations was $4.14 million, giving a total marketing system cost of $26.38 million. These costs are shown in Table 4.

TABLE 4

TOTAL COST BREAKDOWN OF OKLAHOMA COTTON MARKETING SYSTEM

COMPONENT	1990 ($)	OPTIMAL ($)	CHANGE
SUPPLY-AREA-TO-GIN-LOCATION TRANSPORT COST	1,250,000	1,640,000	30.5%
GINNING COSTS	13,720,000	9,410,000	-31.4%
VARIABLE	9,320,000	6,910,000	-25.8%
FIXED	4,400,000	2,500,000	-43.3%
GIN-TO-WAREHOUSE TRANSPORT COST	690,000	470,000	-31.4%
WAREHOUSING COST	6,580,000	6,580,000	0.0%
WAREHOUSE-TO-DEMAND-POINT TRANSPORT COST	4,140,000	4,140,000	0.0%
TOTAL MARKETING SYSTEM COST	26,380,000	22,240,000	-15.7%

Results of Mixed Integer Model and Implications

The theoretical model, as hypothesized, would require 15,622 activities, 360 of which are in the integer portion of the model, and 914 rows, 360 of which are in the integer portion. To increase the computational efficiency of the model, the choice of extended season gins was eliminated from locations where there was no cotton transported in modules from any areas which were a reasonable distance from the gin location, since the extended season capacity is dependent upon storing modules. Also, gin locations were eliminated if the 1990 ginning output of the gins currently serving the area was far below their capacity, and the supply of cotton from surrounding areas was deemed to be insufficient to warrant the current number of gins serving that area. For example, if a production region contained a number of gins, each of whose ginning output was far below their capacity, then some of these gin locations would be eliminated as a candidate for the model to choose. The final model contained 14,789 activities columns and 621 rows.

The object of the model is to show how the total costs associated with marketing cotton in Oklahoma could be reduced if gins were utilized in a more efficient manner. The main cost savings would be expected to result from the benefits of economies of scale, i.e. the reduction in per bale variable costs associated with ginning cotton in larger gins operated at or near full capacity. Savings in fixed costs would also be expected to result from using a smaller number of gins. The results of the mixed integer model support these expected savings.

In order to benefit from economies of scale that result from using a smaller number of larger capacity gins, the system must absorb an increase in the cost of transporting cotton from the farm to the gin. Since the number of gins and gin locations needed to process the Oklahoma cotton crop would be reduced, the distance that cotton must be transported to the nearest gin would increase for many farmers. And since transporting seedcotton is more inefficient than transporting lint cotton (ginned) in uniform density bales, the total cost of transporting cotton to gins would be greater than with the current gin configuration.

Results of the mixed integer model show that the total cost of transporting cotton from the farm to the gin with the optimal gin configuration would increase by $380,000 over the current gin configuration, to $1.64 million. This is 30.5 percent greater than the cost with the current market structure. This increase in marketing system cost is more than compensated by a $4.3 million decrease in total ginning cost. The total variable ginning cost is reduced by 25.8 percent to $6.91 million while the total fixed ginning cost is reduced 43.3 percent to $2.50 million giving a total ginning cost of $9.41 million, 31.4 percent below the ginning cost of the current gin configuration.

Savings are also realized in transporting cotton from gin to warehouse, because the smaller number of gins with large capacities would be collectively located closer to the warehouses. While each bale of cotton travels the same distance from farm to gin to warehouse as in the current configuration, the distance from farm to gin is increased in many cases, but the distance from gin to warehouse is decreased in those cases. A modest savings of $220,000 would accrue to the marketing system, as the total transport cost from gin to warehouse would decrease to $470,000. The total cost of warehousing cotton and transporting cotton to the ten demand points remains the same as with the current gin configuration, at $6.58 million and $4.14 million respectively. The total cost savings of the optimal gin configuration versus the current gin configuration is $4.14 million, which amounts to $11.90/bale for the 1990 marketing year. These cost comparisons are shown in Table 4. If we assume that the farmer price for cotton is the market price minus the cost of processing and distribution (the marketing margin), then we could expect that the $11.90/bale savings in the marketing system cost would be realized at the farm level.

Optimal Size and Location of Gins in Oklahoma

Figure 1 shows the Oklahoma cotton growing area, the gins currently serving the area as reported to the Oklahoma Corporation Commission, and the optimum configuration of gins required to serve Oklahoma as determined by the mixed integer model. Table 5 describes the supply areas and gin locations used in this study, along with the amount of cotton produced in each area in 1990.

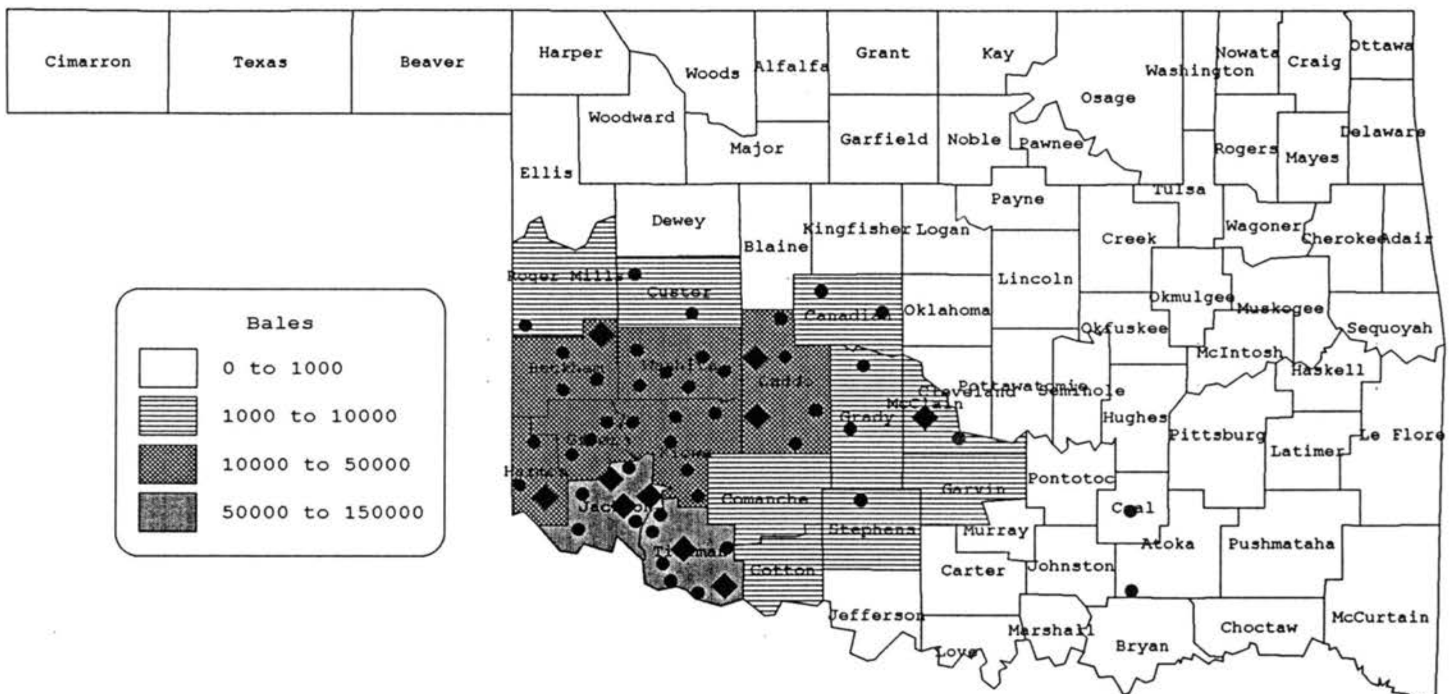

FIGURE 1. COTTON PRODUCTION AND GIN LOCATIONS IN OKLAHOMA, 1990

◆ GIN LOCATIONS UNDER MODEL SOLUTION

● CURRENT GIN LOCATIONS

TABLE 5

OKLAHOMA COTTON SUPPLY BY AREA, 1990

AREA NUMBER	LOCATION	TOTAL BALES
1	ALTUS	23415
2	HUMPHREYS	23409
3	TIPTON	19959
4	3S3W FREDERICK	18863
5	MARTHA	14152
6	CHATTANOOGA	12600
7	HOLLIS	12145
8	1W ALTUS	11091
9	HEADRICK	11626
10	HOLLIS	10214
11	FREDERICK	9839
12	MANGUM	9501
13	DAVIDSON	9281
14	BURNS FLAT	8197
15	6W1N FREDERICK	7922
16	GRANDFIELD	7546
17	GOULD	7140
18	SENTINEL	6443
19	EAKLY	6224
20	LONE WOLF	6039
21	GOTEBO	5821
22	DILL CITY	5744
23	CARNEGIE	5527
24	ELK CITY	5329
25	MTN VIEW	5171
26	ROOSEVELT	4751
27	ELK CITY	4631
28	WAYNE	4557
29	1E MINCO	4319
30	BUTLER	4114
31	SNYDER	3958
32	ROCKY	3881
33	CLINTON	3618
34	ELDORADO	6284
35	WASHINGTON	3251
36	8E2S DAVIS	3026
37	GRANITE	2567
38	CORDELL	2339
39	COWDEN	2161
40	9S6W MANGUM	1948
41	8E MARLOW	1836
42	CHICKASHA	1672
43	ANADARKO	1541

TABLE 5 (Continued)

AREA NUMBER	LOCATION	TOTAL BALES
44	DELHI	1462
45	CARTER	1427
46	SAYRE	1355
47	SWEETWATER	1121
48	APACHE	1056
49	HINTON	941
50	YUKON	879
51	CALUMET	785
52	HINTON	530
53	LOOKEBA	368
54	COALGATE	255
55	KENEFIC	226
56	BLAIR	0
57	MANGUM	1200
58	VINSON	1481
59	HOBART	8095
60	ERICK	3185

Recall that the regular season capacity for a gin is based on a 100 day (3 month) ginning period. The model allowed a gin to double its capacity (extended season gin) if it received cotton transported in modules, since the modules could be stored either on the farm or on the gin yard for an additional 100 day period. In the model, a large gin has a regular season capacity of 25,000 bales, with an extended season capacity of 50,000 bales. The fixed cost associated with a large gin is $330,000. A medium sized gin has a regular season capacity of 15,000 bales per year and an extended season capacity of 30,000 bales per year. The fixed cost associated with a medium sized gin is $170,000. A small size gin has a regular season capacity of

5,000 bales per year, with an extended season capacity of 10,000 bales per year. The fixed cost associated with a small gin is $69,000.

The model solution includes a large sized gin with a total extended season capacity of 50,000 bales per year at Altus in Jackson County. The Altus location would receive a combined total of 12,410 bales of stripper-trailer cotton from the Humphreys, Headrick, and Eldorado supply areas. This location would receive a combined total of 22,350 bales of stripper-module cotton from the Humphreys, Martha, Altus, Gould, and Eldorado supply areas. A total of 6,070 bales of picker-trailer cotton would come from the Humphreys and Headrick supply areas, while 9,169 bales of picker-module cotton would be received from the Altus supply area. Table 6 shows the breakdown of cotton that would be ginned in the Altus location by type of cotton, supply area source, and the cost of transporting the cotton to the Altus location.

TABLE 6

AMOUNT AND COST OF COTTON TRANSPORTED TO THE ALTUS GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
2	ST	4837	2.00	9675
9	ST	3488	2.00	6976
34	ST	4085	5.49	22424
TOTAL	ST	12410		39075
2	SM	8427	6.10	51406
5	SM	10189	6.10	62156
8	SM	555	6.10	3383
17	SM	980	9.03	8849
34	SM	2199	8.78	19311
TOTAL	SM	22351		145105
2	PT	3745	1.36	5094
9	PT	2325	1.36	3162
TOTAL	PT	6071		8256
1	PM	9169	4.17	38235
GRAND TOTAL		50000		230670

* Supply area number as described in Table 5

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution includes a large sized gin with an extended season capacity of 50,000 bales per year at Martha, also in Jackson County. The Martha location would receive 17,216 bales of stripper-trailer cotton from the Martha, Mangum, Lone Wolf, Granite, and Russell supply areas. A total of 2,383 bales of stripper-module cotton would come from the Altus, Lone Wolf, and Russell supply areas. The Martha and Mangum supply areas would ship 4,242 bales of picker-trailer cotton to the Martha location, while the

Altus and Martha supply areas would contribute 26,158 bales of picker-module cotton to the Martha gin location. Table 7 shows the relevant breakdown of cotton going to the Martha location.

TABLE 7

AMOUNT AND COST OF COTTON TRANSPORTED TO THE MARTHA GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
5	ST	1132	2.00	2264
12	ST	5986	2.63	15742
20	ST	5314	4.22	22426
37	ST	2567	3.90	10011
40	ST	1461	3.27	4777
57	ST	756	2.63	1988
TOTAL	ST	17216		57210
1	SM	1171	6.10	7142
20	SM	725	7.81	5660
40	SM	487	7.08	3448
TOTAL	SM	2382		16249
5	PT	283	1.36	385
12	PT	3515	1.79	6293
57	PT	444	1.79	795
TOTAL	PT	4242		7472
1	PM	13075	4.17	54524
5	PM	2547	4.17	10622
8	PM	10536	4.17	43937
TOTAL	PM	26159		109083
GRAND TOTAL		50000		190015

* Supply area number as described in Table 5

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a large sized gin with an extended season capacity of 50,000 bales at the Headrick location, also in Jackson County. The Headrick location would gin 23,187 bales of stripper-trailer cotton from the Humphreys, Tipton, Gotebo, Roosevelt, Snyder, Rocky, and Hobart supply areas. A total of 18,870 bales of stripper-module cotton would be ginned from the Tipton, Headrick, Roosevelt, Snyder, and Hobart supply areas. The Headrick location would receive 7,943 bales of picker-module cotton from the Humphreys and Headrick supply areas. Table 8 shows the breakdown of cotton that would be ginned in the Headrick location under the optimal gin structure.

TABLE 8

AMOUNT AND COST OF COTTON TRANSPORTED TO THE HEADRICK GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
2	ST	781	2.00	1562
3	ST	2409	2.00	4818
21	ST	1894	10.24	19395
26	ST	3573	4.85	17328
31	ST	2976	2.95	8780
32	ST	3881	8.34	32368
55	ST	226	27.68	6256
59	ST	7447	5.17	38503
TOTAL	ST	23187		129008
3	SM	12574	6.10	76702
9	SM	3488	6.10	21276
26	SM	1178	8.30	9779
31	SM	982	6.83	6704
59	SM	648	8.54	5531
TOTAL	SM	18869		119992
2	PM	5618	4.17	23428
9	PM	2325	4.17	9696
TOTAL	PM	7943		33124
GRAND TOTAL		50000		282124

* Supply area number as described in Table 5

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a large sized gin with a total extended season capacity of 50,000 bales per year in Frederick in Tillman County. The Frederick location would receive 21,946 bales of stripper-trailer cotton from the Tipton, Frederick, Frederick-Red River, Davidson, and Frederick-Alpine supply areas. A total of 28,054 bales of stripper-module cotton would come from the Frederick-Red

River, Frederick, Davidson, and Frederick-Alpine supply areas. Table 9 gives a breakdown of the cotton going to the Frederick gin location.

TABLE 9

AMOUNT AND COST OF COTTON TRANSPORTED TO THE FREDERICK GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
3	ST	4976	2.00	9952
4	ST	7545	2.00	15090
11	ST	3936	2.00	7871
13	ST	2320	2.00	4641
15	ST	3169	2.00	6338
TOTAL	ST	21946		43892
4	SM	11318	6.10	69039
11	SM	5903	6.10	36011
13	SM	6080	6.10	37086
15	SM	4753	6.10	28995
TOTAL	SM	28054		171130
GRAND TOTAL		50000		215022

* Supply area numbers as described in Table 5
** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a large sized gin with a total extended season capacity of 50,000 bales per year at Elk City in Beckham County. The Elk City location would receive 25,000 bales of stripper-trailer cotton from the Burns Flat, Sentinel, Dill City, Elk City, Butler, Clinton, Cordell, Delhi, Carter, Sayre, Sweetwater, and Erick supply areas. A total of 23,965 bales of stripper-module cotton would be shipped from the Elk City, Burns Flat, Sentinel, Dill City, Butler and Erick supply areas. The breakdown of cotton that would be handled by the Elk City gin location is shown in Table 10.

TABLE 10

AMOUNT AND COST OF COTTON TRANSPORTED TO THE ELK CITY GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
14	ST	1979	2.95	5838
18	ST	1555	7.07	10994
22	ST	1386	4.85	6722
24	ST	2025	2.00	4050
27	ST	3936	2.00	7873
30	ST	993	6.12	6077
33	ST	2714	5.49	14897
38	ST	2339	7.39	17285
44	ST	1462	7.07	10336
45	ST	1427	3.59	5123
46	ST	1355	4.22	5718
47	ST	1121	6.44	7219
60	ST	769	8.66	6660
TOTAL	ST	23061		108792
14	SM	6218	6.83	42469
18	SM	4888	10.00	48880
22	SM	4358	8.3	36171
24	SM	3304	6.10	20154
27	SM	695	6.10	4237
30	SM	3121	9.27	28935
60	SM	2416	11.22	27108
TOTAL	SM	25000		207951
33	PT	905	3.75	3392
GRAND TOTAL		48965		320135

* Supply area numbers as described in Table 5
** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a medium sized gin with a total extended season capacity of 30,000 bales per year at the Grandfield location in Tillman County. The Grandfield location would receive 3,960 bales of stripper-trailer cotton from the Chattanooga, Grandfield, and East Davidson supply areas, while 20,093 bales of stripper-module cotton would come from the Chattanooga, Davidson, Grandfield, and East Davidson supply areas. The breakdown of the cotton that would be processed at the Grandfield gin location is shown in Table 11.

TABLE 11

AMOUNT AND COST OF COTTON TRANSPORTED TO THE GRANDFIELD GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
6	ST	2003	2.00	4007
16	ST	1200	2.00	2400
36	ST	756	2.95	2232
TOTAL	ST	3960		8638
6	SM	10597	6.10	64639
13	SM	881	8.30	7312
16	SM	6346	6.10	38712
36	SM	2270	6.83	15501
TOTAL	SM	20093		126164
GRAND TOTAL		24053		134802

* Supply area numbers as described in Table 5

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a medium sized gin with a total extended season capacity of 30,000 bales per year at Gould in Harman County. The Gould gin location would handle

10,743 bales of stripper-trailer cotton shipped from the Hollis, Gould, and Vinson supply areas, while 19,257 bales of stripper-module cotton would be transported from the Hollis and Gould supply areas. This gin situation is shown in Table 12.

TABLE 12

AMOUNT AND COST OF COTTON TRANSPORTED TO THE GOULD GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
7	ST	4372	2.00	8744
10	ST	2962	2.00	5924
17	ST	1928	2.00	3856
58	ST	1481	2.95	4369
TOTAL	ST	10743		22893
7	SM	7773	6.10	47414
10	SM	7252	6.10	44237
17	SM	4232	6.10	25816
TOTAL	SM	19257		117467
GRAND TOTAL		30000		140360

* Supply area numbers as described in Table 5
** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a medium sized regular season gin with a total capacity of 15,000 bales per year at Eakly in Caddo County. The Eakly location would be required to gin 15,000 bales of stripper-trailer cotton from the Eakly, Carnegie, Minco, Cowden, Hinton, Calumet, Hinton, and Lookeba supply areas. The cotton breakdown for the Eakly gin location is shown in Table 13.

TABLE 13

AMOUNT AND COST OF COTTON TRANSPORTED TO THE EAKLY GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
19	ST	6224	2.00	12448
23	ST	2222	2.00	4444
29	ST	1769	9.29	16434
39	ST	2161	2.00	4322
49	ST	941	6.12	5759
51	ST	785	12.14	9530
52	ST	530	6.12	3244
53	ST	368	2.63	968
GRAND TOTAL		15000		57148

* Supply area numbers as described in Table 5

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The model solution included a medium sized regular season gin with a total capacity of 15,000 bales per year at the Carnegie location, also in Caddo County. The Carnegie gin location would handle 15,000 bales of stripper-trailer cotton from the Gotebo, Carnegie, Mountain View, Anadarko, and Apache supply areas. Table 14 shows the breakdown of cotton which would be ginned at the Carnegie location under the optimal gin configuration.

TABLE 14

AMOUNT AND COST OF COTTON TRANSPORTED TO THE CARNEGIE GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
21	ST	3927	2.00	7854
23	ST	3305	2.00	6610
25	ST	5171	2.00	10342
43	ST	1541	5.80	8938
48	ST	1056	6.44	6801
GRAND TOTAL		15000		40544

* Supply area numbers as described in Table 5
** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

The final gin location included in the model solution is a medium sized gin with a regular season capacity of 15,000 bales per year at Washington in McClain County. The Washington gin location would receive 15,000 bales of stripper-trailer cotton shipped from the Wayne, Minco, Washington, Marlow, Chickasha, Yukon, Coalgate, and Kenefic supply areas, as depicted in Table 15.

TABLE 15

AMOUNT AND COST OF COTTON TRANSPORTED TO THE WASHINGTON GIN LOCATION UNDER THE MODEL SOLUTION

SUPPLY AREA*	COTTON TYPE**	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
28	ST	4557	2.63	11985
29	ST	2550	9.29	23690
35	ST	3251	2.00	6502
41	ST	1836	12.78	23464
42	ST	1672	5.49	9179
50	ST	879	11.83	10399
54	ST	255	40.36	10292
GRAND TOTAL		15000		95510

* Supply area numbers as described in Table 5
** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

This gives a total of ten gins at ten different locations, a significant reduction from the 60 gins currently serving the Oklahoma production area. Table 16 shows the relevant variable ginning costs associated with each gin location chosen by the model based upon the amount of each type of cotton which the gin must process. The annual fixed costs associated with each gin chosen by the model, determined by the size of each gin, is shown in Table 17.

TABLE 16

VARIABLE GINNING COST FOR EACH GIN UNDER THE MODEL SOLUTION

GIN LOCATION, SIZE, AND COTTON TYPE*	NO. OF BALES	GINNING COST ($/BALE)	TOTAL VARIABLE COST ($)
	ALTUS, LARGE, EXTENDED-SEASON		
ST	12410	22.51	279343
SM	22351	18.01	402535
PT	6071	15.76	95673
PM	9169	12.60	115530
TOTAL	50000		893080
	MARTHA, LARGE, EXTENDED-SEASON		
ST	17216	22.51	387535
SM	2382	18.01	42908
PT	4242	15.76	66860
PM	26159	12.60	329604
TOTAL	50000		826907
	HEADRICK, LARGE, EXTENDED-SEASON		
ST	23187	22.51	521945
SM	18869	18.01	339838
PM	7943	12.60	100086
TOTAL	50000		961869
	FREDERICK, LARGE, EXTENDED-SEASON		
ST	21946	22.51	494001
SM	28054	18.01	505255
TOTAL	50000		999256
	GRANDFIELD, MEDIUM, EXTENDED-SEASON		
ST	3960	23.62	93528
SM	20093	18.89	379562
TOTAL	24053		473090
	GOULD, MEDIUM, EXTENDED-SEASON		
ST	10743	23.62	253751
SM	19257	18.89	363764
TOTAL	30000		617515
	EAKLY, MEDIUM, REGULAR-SEASON		
ST	15000	23.62	354300
	CARNEGIE, MEDIUM, REGULAR-SEASON		
ST	15000	23.62	354300

TABLE 16 (Continued)

GIN LOCATION, SIZE, AND COTTON TYPE*	NO. OF BALES	GINNING COST ($/BALE)	TOTAL VARIABLE COST ($)
	ELK CITY, LARGE, EXTENDED-SEASON		
ST	23061	22.51	519103
SM	25000	18.01	450250
PT	905	15.76	14255
TOTAL	48966		983608
	WASHINGTON, MEDIUM, REGULAR-SEASON		
ST	15000	23.62	354300

* S = stripper harvested; P = picker harvested; T = trailer transport; M = Module transport

TABLE 17

FIXED GINNING COST FOR EACH GIN UNDER THE MODEL SOLUTION

GIN LOCATION AND SIZE	TOTAL FIXED COST ($)
ALTUS, LARGE, EXTENDED-SEASON	327,743
MARTHA, LARGE, EXTENDED-SEASON	327,743
HEADRICK, LARGE, EXTENDED-SEASON	327,743
FREDERICK, LARGE, EXTENDED-SEASON	327,743
GRANDFIELD, MEDIUM, EXTENDED-SEASON	171,401
GOULD, MEDIUM, EXTENDED-SEASON	171,401
EAKLY, MEDIUM, REGULAR-SEASON	171,400
CARNEGIE, MEDIUM, REGULAR-SEASON	171,400
ELK CITY, LARGE, EXTENDED-SEASON	327,143
WASHINGTON, MEDIUM, REGULAR-SEASON	171,400

After the cotton is ginned, there are two choices of where the cotton can be shipped to be stored. The model determined that 258,965 bales of cotton would be shipped from Oklahoma gins to the warehouse location in Altus. This is consistent with current shipping patterns. The model determined that 89,053 bales of cotton would be shipped to the warehouse location in Frederick, which is also consistent with the current situation. The amount of cotton shipped from each gin to the relevant warehouse, and the transportation costs are shown in Table 18.

TABLE 18

GIN-TO-WAREHOUSE TRANSPORTATION COSTS UNDER THE MODEL SOLUTION

GIN LOCATION TO WAREHOUSE*	NO. OF BALES	TRANSPORT COST ($/BALE)	TOTAL COST ($)
G1W1	50000	0.05	2500
G5W1	50000	0.40	20000
G9W1	50000	0.50	25000
G17W1	30000	1.35	40500
G19W1	15000	4.00	60000
G23W1	15000	3.30	49500
G24W1	48965	2.90	141999
G11W2	50000	0.05	2500
G16W2	24053	1.70	40890
G35W2	15000	6.00	90000

* G = gin location (area numbers as described in Table 5); W = warehouse location (1 = Altus, 2 = Frederick);

The total amount of Oklahoma cotton shipped from the warehouse locations to the various domestic and export demand points were fixed in the model as stated in Chapter 3. The cost of shipping to any particular demand point is the same for each warehouse location. The amount and cost of shipping cotton to the ten demand points is shown in Table 19. The amount of cotton shipped to each demand point from each warehouse location could vary from the amounts determined by the model, but the total amount of cotton going to each demand point will be the same, as will the costs associated with transportation.

TABLE 19

WAREHOUSE-TO-DEMAND-POINT TRANSPORTATION COSTS UNDER THE MODEL SOLUTION

WAREHOUSE LOCATION SHIPPING TO DEMAND POINTS*	NO. OF BALES	TRANS COST ($/BALE)	TOTAL COST ($)
ALTUS TO ALABAMA	37934	11.00	417274
ALTUS TO CALIFORNIA	47022	11.45	538402
ALTUS TO CANADA	4872	17.10	83315
ALTUS TO GEORGIA	60555	12.50	756939
ALTUS TO NORTH CAROLINA	44198	14.15	625406
ALTUS TO SOUTH CAROLINA	36542	13.40	489661
ALTUS TO TENNESSEE	1044	13.25	13834
ALTUS TO TEXAS	25405	7.00	177837
ALTUS TO VIRGINIA	1392	15.00	20881
FREDERICK TO CALIFORNIA	71304	11.45	816432
FREDERICK TO WASHINGTON	17749	11.45	203225

* THE ACTUAL AMOUNT OF COTTON GOING FROM ANY ONE WAREHOUSE TO ANY DEMAND POINT COULD VARY AS LONG AS THE TOTAL AMOUNT GOING TO EACH DESTINATION CORRESPONDS TO THE AMOUNTS STATED ABOVE

Impact of Optimal Gin Structure on Farmers and Gins

It would be reasonable to expect that many cotton farmers would have a negative attitude toward a reduction in gin numbers in Oklahoma from the current 60 gins to the optimal number of 10 as determined by the model. Under the current gin configuration, it was assumed that no farmer would have to haul cotton more than 15 miles to the nearest gin, except in a few extreme cases. A transition to a more efficient gin structure would require many farmers to transport cotton a greater distance. In order for any one cotton farmer to benefit from a transition to the optimal market structure, the added cost of transporting cotton a longer distance to the gin must be less than $11.90/bale, which is the per bale savings gained by having a more efficient gin configuration. Table 20 gives a breakdown of the supply areas which would incur higher transportation costs due to the increased cotton hauling distance to the gin under the optimal structure.

TABLE 20

SUPPLY AREAS INCURRING HIGHER TRANSPORTATION COSTS UNDER THE MODEL SOLUTION

SUPPLY AREA TO GIN*	COTTON TYPE**	NO. OF BALES	COST/BALE ($) CURRENT	OPTIMAL	EXTRA
S12G5	ST	5986	2.00	2.63	0.63
S14G24	ST	8197	2.00	2.95	0.95
S18G24	ST	6443	2.00	7.07	5.07
S20G5	ST	5314	2.00	4.22	2.22
S21G9	ST	1894	2.00	10.24	8.24
S22G24	ST	5744	2.00	4.85	2.85
S26G9	ST	3573	2.00	4.85	2.85
S28G35	ST	4557	2.00	2.63	0.63
S29G19	ST	1769	2.00	9.29	7.29
S29G35	ST	2550	2.00	9.29	7.29
S30G24	ST	4114	2.00	6.12	4.12
S31G9	ST	2976	2.00	2.95	0.95
S32G9	ST	3881	2.00	8.37	6.34
S33G24	ST	2714	2.00	5.49	3.49
S34G1	ST	4085	2.00	5.49	3.49
S36G16	ST	756	2.00	2.95	0.95
S37G5	ST	2567	2.00	3.90	1.90
S38G24	ST	2339	2.00	7.39	5.39
S40G5	ST	1461	2.00	3.27	1.27
S41G35	ST	1836	2.00	12.78	10.78
S42G35	ST	1672	2.00	5.49	3.49
S43G23	ST	1541	2.00	5.80	3.80
S44G24	ST	1462	2.00	7.07	5.07
S45G24	ST	1427	2.00	3.59	1.59
S46G24	ST	1355	2.00	4.22	2.22
S47G24	ST	1121	2.00	6.44	4.44
S48G23	ST	1056	2.00	6.44	4.44
S49G19	ST	941	2.00	6.12	4.12
S50G35	ST	879	2.00	11.83	9.83
S51G19	ST	785	2.00	12.14	10.14
S52G19	ST	530	2.00	6.12	4.12
S53G19	ST	368	2.00	2.63	0.63
S54G35	ST	255	2.00	40.36	38.36
S55G35	ST	226	2.00	41.63	39.63
S57G5	ST	756	2.00	2.63	0.63
S58G17	ST	1481	2.00	2.95	0.95
S59G9	ST	7447	2.00	5.17	3.17
S60G24	ST	3185	2.00	8.66	6.66
S13G16	SM	881	6.10	8.30	2.20
S17G1	SM	980	6.10	9.03	2.93

TABLE 20 (Continued)

SUPPLY AREA TO GIN*	COTTON TYPE**	NO. OF BALES	COST/BALE ($) CURRENT	OPTIMAL	EXTRA
S20G5	SM	725	6.10	7.81	1.71
S26G9	SM	1178	6.10	8.30	2.20
S31G9	SM	982	6.10	6.83	0.73
S34G1	SM	2199	6.10	8.78	2.68
S36G16	SM	2270	6.10	6.83	0.73
S40G5	SM	487	6.10	7.08	0.98
S59G9	SM	648	6.10	8.54	2.44
S12G5	PT	3515	1.36	1.79	0.43
S33G24	PT	905	1.36	3.75	2.39
S57G5	PT	444	1.36	1.79	0.43

* S = supply area; G = gin location shipped to (all numbers as described in Table 5)

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

From this table we can calculate that two supply areas would suffer a net loss due to the transition to the optimal market structure. A net loss (the amount of the extra transport cost per bale with the optimal structure above the $11.90 per bale marketing system gain) would occur in the Coalgate supply area, where farmers would have to haul 255 bales of stripper-trailer cotton 136 miles to the nearest model gin in Washington, resulting in a net loss of $26.46 per bale ($38.36-$11.90) or $6,747 total. The other net loss would be realized by the Kenefic supply area, where farmers would have to haul 226 bales of stripper-trailer cotton 140 miles to a gin in Washington, resulting in a net loss of $27.73 per bale ($39.63-$11.90) or $6,266 total.

These losses could be reduced by roughly $5 per bale if the farmers in this area transported the cotton in modules, since module hauling becomes more economical with longer hauls, but would still result in a net loss to both areas. However, the mixed integer model does not allow cotton to be hauled by modules in areas where that is not the current practice.

Both the Coalgate and the Kenefic supply areas are in the southeastern region of Oklahoma, far removed from the major cotton growing region in southwestern Oklahoma. All told, 481 bales of cotton would be hauled at a net loss to farmers, which is one tenth of one percent of the total Oklahoma crop in 1990. All other supply areas listed in table 21 would incur higher transport costs of hauling cotton to the nearest gin, but would realize a net gain from the optimal gin marketing system since the added transport cost would be less than the $11.90 per bale savings gained from the more efficient gin configuration. All supply areas which are not listed in table 20 would have the same hauling distance under the optimal gin configuration as with the current gin structure, and as a result would realize a net gain of the entire $11.90 per bale. These supply areas are shown in Table 21.

TABLE 21

SUPPLY AREAS INCURRING THE SAME TRANSPORTATION COSTS UNDER THE CURRENT STRUCTURE VS. THE MODEL SOLUTION

SUPPLY AREA TO GIN*	COTTON TYPE**	NO. OF BALES	COST/BALE ($) CURRENT	OPTIMAL	EXTRA
S2G1	ST	4837	2.00	2.00	0.00
S2G9	ST	781	2.00	2.00	0.00
S3G9	ST	2409	2.00	2.00	0.00
S3G11	ST	4976	2.00	2.00	0.00
S4G11	ST	7545	2.00	2.00	0.00
S5G5	ST	1132	2.00	2.00	0.00
S6G16	ST	2003	2.00	2.00	0.00
S7G17	ST	4372	2.00	2.00	0.00
S9G1	ST	3488	2.00	2.00	0.00
S10G17	ST	2962	2.00	2.00	0.00
S11G11	ST	3936	2.00	2.00	0.00
S13G11	ST	2320	2.00	2.00	0.00
S15G11	ST	3169	2.00	2.00	0.00
S16G16	ST	1200	2.00	2.00	0.00
S17G17	ST	1928	2.00	2.00	0.00
S19G19	ST	6224	2.00	2.00	0.00
S21G23	ST	3927	2.00	2.00	0.00
S23G19	ST	2222	2.00	2.00	0.00
S23G23	ST	3305	2.00	2.00	0.00
S24G24	ST	2025	2.00	2.00	0.00
S25G23	ST	5171	2.00	2.00	0.00
S27G24	ST	3936	2.00	2.00	0.00
S35G35	ST	3251	2.00	2.00	0.00
S39G19	ST	2161	2.00	2.00	0.00
S1G5	SM	1171	6.10	6.10	0.00
S2G1	SM	8427	6.10	6.10	0.00
S3G9	SM	12574	6.10	6.10	0.00
S4G11	SM	11318	6.10	6.10	0.00
S5G1	SM	10189	6.10	6.10	0.00
S6G16	SM	10597	6.10	6.10	0.00
S7G17	SM	7773	6.10	6.10	0.00
S8G1	SM	555	6.10	6.10	0.00
S9G9	SM	3488	6.10	6.10	0.00
S10G17	SM	7252	6.10	6.10	0.00
S11G11	SM	5903	6.10	6.10	0.00
S13G11	SM	6080	6.10	6.10	0.00
S15G11	SM	4753	6.10	6.10	0.00
S16G16	SM	6346	6.10	6.10	0.00
S17G17	SM	4232	6.10	6.10	0.00

TABLE 21 (Continued)

SUPPLY AREA TO GIN*	COTTON TYPE**	NO. OF BALES	COST/BALE ($) CURRENT	OPTIMAL	EXTRA
S24G24	SM	3304	6.10	6.10	0.00
S27G24	SM	695	6.10	6.10	0.00
S2G1	PT	3745	1.36	1.36	0.00
S5G5	PT	283	1.36	1.36	0.00
S9G1	PT	2325	1.36	1.36	0.00
S1G1	PM	9169	4.17	4.17	0.00
S1G5	PM	13075	4.17	4.17	0.00
S2G9	PM	5618	4.17	4.17	0.00
S5G5	PM	2547	4.17	4.17	0.00
S8G5	PM	10536	4.17	4.17	0.00
S9G9	PM	2325	4.17	4.17	0.00

* S = supply area; G = gin location (all area numbers as described in Table 5)

** S = stripper harvested; P = picker harvested; T = trailer transport; M = module transport

Impact of Additional Module Adoption on Optimal Market Structure

The model was used to estimate the impact on the optimal gin configuration if the percentage of cotton transported to gins in modules increased over time. To accomplish this, the average growth in the use of modules to haul cotton to the gin over the previous seven year period in Oklahoma was calculated to be 4.89 percent per year. The seven year period was used to calculate the growth trend since there was no apparent trend in module use before this period. The same 1990 Oklahoma cotton production numbers were used since it was a large crop year, so results would show the minimum adjustment that would be made. Oklahoma cotton production was quite variable but showed no stable growth or decline trend over the seven year period. The RHS data for the amount and type of cotton (ST,SM,PT, and PM) transported from each supply area were adjusted to reflect the projected increase in the use of modules for each year in a five year planning horizon. The mixed integer model was then used to find the optimal gin configuration and marketing system cost for each of the five years in the planning horizon. The results listed in Table 22 show that there would be no change in the optimal gin configuration from the original optimal structure, but total marketing system costs would be marginally reduced each year as more and more cotton is transported to the gins in modules. This cost savings is due to the increased efficiency of ginning moduled cotton, as the variable ginning cost in the 5th year drops 1.6 percent from the first year to $6.80 million, a savings of $109,000. This more than compensates for an increase in the cost of transporting cotton from the farm to the gin, as transporting moduled cotton is more costly than transporting cotton in trailers for short hauls. The total cost of transporting cotton from the farm to the gin increased 5.9 percent from the original optimal solution to the 5th year solution, to $1.73 million a $96,000 increase over the five year horizon. All other marketing costs stay the same over the 5 year period, giving a total savings of only $12,000 over the 5 year planning horizon as a result of the progressive adoption of module hauling methods.

TABLE 22

COMPARISON OF OPTIMAL COTTON MARKETING SYSTEM COST IN OKLAHOMA OVER 5-YEAR PLANNING HORIZON

COMPONENT	1ST YEAR OPTIMAL ($)	5TH YEAR OPTIMAL ($)	CHANGE
SUPPLY-AREA-TO-GIN-LOCATION TRANSPORT COST	1,640,000	1,730,000	5.9%
GINNING COSTS	9,410,000	9,300,000	-1.2%
VARIABLE	6,910,000	6,800,000	-1.6%
FIXED	2,500,000	2,500,000	0.0%
GIN-TO-WAREHOUSE TRANSPORT COST	470,000	470,000	0.0%
WAREHOUSING COST	6,580,000	6,580,000	0.0%
WAREHOUSE-TO-DEMAND-POINT TRANSPORT COST	4,140,000	4,140,000	0.0%
TOTAL MARKETING SYSTEM COST	22,240,000	22,230,000	-0.1%

As stated previously, a dynamic programming model would be required to analyze the changes in gin configuration which would minimize costs over time when the economic environment in which we are operating is characterized by significant changes in variables which affect supply and demand. For the cotton ginning industry these changing variables could be associated with production methods such as the adoption of picker machines for harvesting, transport methods such as the adoption of module hauling technology, and the demand for cotton.

Based upon the most recent ten year history in cotton production in Oklahoma, it was determined that there was no clear trend in the demand for and the supply of cotton which could be used to predict a change in production over a five year planning horizon. As a result, it was not considered important to run the mixed integer model using increased or decreased cotton production as a variable of change in the system.

Changes in production methods have occurred at the national level as is seen in the increased use of picker machines to harvest cotton in place of stripper harvesters. This development has the potential to decrease ginning costs significantly and thus impact the optimal gin configuration. However, this change in harvesting methods has been limited in Oklahoma, as well as the high plains region of Texas, due to the windy conditions which characterize these areas. The use of picker harvest technology requires planting cotton varieties which enable cotton bolls to be easily separated from the plant. These cotton varieties are susceptible to high winds which blow the cotton bolls off the plant before it can be harvested. For this reason it was not considered to be feasible to run the model using increased usage of picker machines as a variable of change in the system.

This left the adoption of module hauling technology as the only variable which could reasonably be expected to increase significantly over the coming years. As illustrated in the section above, the adoption of module hauling technology did not result in any change in the optimal gin configuration over time, nor were marketing system costs reduced by an appreciable amount.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary objective of this research was to determine the efficiency of the Oklahoma cotton industry. Specific objectives were:

1. To determine the current cost of cotton transportation, ginning, and warehousing;
2. To evaluate the cost savings of an optimal gin configuration as determined by a mixed integer transhipment model of the industry;
3. To determine the optimum number, size, and location of cotton gins in Oklahoma needed to efficiently serve the needs of cotton producers;
4. To evaluate the impact of changes in harvesting and transport methods on the optimal number, size, and location of cotton gins in Oklahoma;
5. To determine whether specific geographical regions, classes of cotton producers, or classes of ginning firms are likely to be positively or negatively impacted by a transition to a more efficient industry structure.

For objective one, the current cost of cotton transportation, ginning, and warehousing was calculated independent from the model, using data from industry sources, including detailed accounting data on costs incurred by each gin as reported to the Oklahoma Corporation

Commission. The total cotton marketing system cost was found to be $26.38 million, including $1.25 million for hauling cotton from farms to the gin, and $13.72 million for ginning the cotton.

For objective two, the mixed integer model of the cotton marketing system determined that cotton farmers could realize a savings in the total cost of processing and transporting cotton from the farm to the ultimate demand points of $4.14 million or $11.90 per bale for the 1990 crop under the model solution. A large savings in total ginning costs of $4.3 million could be realized by taking advantage of economies of scale gained by ginning cotton in large capacity gins under an optimal gin configuration. This more than compensates farmers for a slight increase in the cost of transporting cotton a longer distance to the gin, amounting to $380,000. The optimal market structure would also lead to a slight reduction in the cost of transporting cotton from the gin to warehouse locations of $220,000. The total cotton marketing system cost under the model solution would be $22.24 million.

For objective three on the optimum number, size and location of gins needed to serve Oklahoma, the study found that the Oklahoma cotton ginning industry is currently characterized by over-capacity and an excess number of gins needed to effectively serve the industry given the current level of production and methods of cotton harvesting and transportation. The model solution would reduce the number of gins serving the Oklahoma cotton growing region from the current 60 gins to ten. The model solution included large-sized extended-season gins with a total capacity of 50,000 bales per year which would be located at Altus, Martha, and Headrick, all in Jackson County, at Frederick in Tillman County, and at Elk City in Beckham County; medium-sized extended-season gins with a total capacity of 30,000 bales per year which would be located at Grandfield in Tillman County and at Gould in Harman County; medium-sized regular-season gins with a total capacity of 15,000 bales per year which would be located at Eakly and Carnegie, both in Caddo County, and at Washington in McClain County.

For objective four, the projected further adoption of module hauling technology over a five year period based upon recent trends in module adoption in Oklahoma showed no change in the optimal gin configuration over the five year period. Only a slight savings in marketing costs would be realized by the projected increase in module usage over this period. Further adoption of picker harvesting in Oklahoma was deemed unlikely due to the windy conditions which cause field losses in picker cotton varieties, and was not modelled in this study.

For objective five, the impact of the optimal gin configuration on individual cotton farmers was shown to result in a net benefit of up to $11.90 per bale for farmers in all but two supply areas. The supply areas which would suffer a net loss to farmers were the Coalgate and Kenefic supply areas located in Southeastern Oklahoma, far from the major cotton producing region. Cotton farmers in these two areas would have to haul a combined total of 481 bales of cotton 136-140 miles to the nearest gin in Washington. Small capacity gins would be impacted most from the reduction in gin numbers, as the model solution included five large and five medium sized gins to serve Oklahoma.

Implications

The model determined that the Oklahoma cotton industry could become more efficient by reducing the number of gins serving the area and by using larger capacity gins to take advantage of economies of scale. The major supply areas, especially in Jackson County, are already served by large capacity gins, but could still benefit from a more efficient utilization of existing technology. In this highly irrigated region where advanced harvest and hauling technology is the rule, processing costs are lower than the average for Oklahoma, but further cost savings could be realized if the gins were used at or near their full capacity. Even with a high level of moduled cotton being transported to these gins, their ginning production rarely exceeds their regular season capacity. As a result, this area is not realizing the full potential benefit of storing cotton modules to increase the ginning season, and thus reduce the number of gins needed to serve the area.

This situation points out some key limitations of the study with respect to farmer resistance to a reduction in gin numbers. Many farmers desire to have gins within a close distance from the farm, and to have their cotton ginned as soon as possible. Those farmers may not currently have access to module equipment and thus could incur crop losses due to harvest delays.

Another limitation of the study involves the extended ginning season used in the model of 200 days, or roughly twice as long as a regular ginning season. This could be an obstacle to the timely sale of cotton by farmers. A marketing delay caused by storing cotton modules for later ginning could present cash flow problems for farmers who need to pay loans or have other cash needs.

Another limitation in the analysis of further adoption of module technology over a five year period was that increases in investment costs for module equipment was not considered. Only the increased variable cost rate of module hauling was included.

Those considerations suggest that a transition to a more efficient market structure could meet with resistance. However, market forces have reduced the number of gins in Oklahoma by 24 percent over the past decade, roughly the same as the decline in gins nation-wide. This decrease in gin numbers in Oklahoma was inferred by Cleveland and Blakley (1976), where they found that only two super sized gins (extended season capacity of 64,688 bales per year) would be needed to efficiently serve the five Oklahoma counties of Tillman, Kiowa, Jackson, Greer, and Harmon in 1976, assuming that module assembly and transport methods were used exclusively. Such a system would lead to a total cotton marketing system savings of $28.28 per bale. The results of the research in this paper support the Cleveland and Blakely (1976) conclusion of the economic validity of decreasing gin numbers and increasing gin sizes. The study suggests that any regulatory activity by the Corporation Commission which would prevent the entry or expansion of large capacity gins into the industry in order to protect smaller gins would not be in the best economic interest of Oklahoma cotton farmers. The regulation preventing gins from owning and renting trailers and module assembly-transport systems would also be considered an economic detriment to the cotton marketing system. If gins could provide this assembly and transport service to farmers, they could extend their ginning season, increase their effective capacity, and reduce the total cost of ginning in the system.

The study should not be considered as a recommendation to the Oklahoma Corporation Commission to actively pursue a policy leading to the reduction of gin numbers in Oklahoma.

The study supports the view that regulatory activities should not be used to counter market forces in the area of entry and exit of gins or concerning gins providing transportation and storage services.

It should be noted here that the gin locations included in the solution of the model need not be considered as the exact locations which would result in a more efficient market structure. While the optimal number of ten gins would not change, the exact locations of the gins could differ without significantly adding to the cost of the marketing system. For a gin whose location was not picked by the model solution, but is very close to a location that was picked, it is likely that either gin location could serve that area without an appreciable loss of efficiency in the marketing system. The main objective of the model is to determine the total number and size of gins serving any particular area.

Recommendations for Further Research

While future changes in Oklahoma cotton production and adoption of picker machine harvest technology could not be realistically estimated from recent trends in Oklahoma, the mixed integer model could have been utilized to show the affect on the efficiency of the marketing system if one were to assume such changes ad hoc. By changing the RHS values for the supply constraints, various scenarios depicting the optimal market structure given changes in key variables could easily be accomplished.

The most likely scenarios to investigate would include changes in cotton production based upon national or international trends in the demand for cotton. There was no discernable trend for cotton production in Oklahoma, as the recent history shows a significant amount of volatility from one year to the next.

Another scenario for the optimal cotton marketing structure in Oklahoma could be solved using a more aggressive rate of adoption of module hauling technology than the 4.89 percent per year rate that was used in the study. Once again, national levels of module usage could have been assumed, since the percent of module versus trailer utilization is greater in most other cotton producing states than in Oklahoma.

If the above scenarios, or any combination of the above scenarios, were to lead to significant changes in the optimal gin configuration over some future period of years, then a dynamic feature would become feasible for the model to determine the least-cost transition to the projected optimal gin marketing structure at the end of this period. However, the current mixed integer model would need to be further simplified in order to economically obtain the large number of solutions needed for the dynamic model.

Another possible area of research could study the affect of the cost savings of the optimal market structure on the price received by farmers for cotton. It was assumed in this study that the entire cost savings would be reflected in a reduced marketing margin and thus would all accrue to the cotton farmer. However, it is possible that the increased concentration of gins serving the industry under the optimal gin configuration could lead to a greater ginning profit percentage than under the current system, resulting in a farmer price for cotton that does not reflect the entire cost savings of the optimal system. The fact that most gins serving the Oklahoma region are farmer owned coops should alleviate this concern somewhat, but research into this area might still be warranted. In addition, if the gin structure given by the model solution would increase the price received by farmers for cotton as suggested above, we could expect the supply response would be to increase production, especially in those areas where the net benefit of a more efficient gin structure is not negated by a longer, and thus more expensive haul to the gin. The possible impact could be to further concentrate cotton production in the supply areas closest to the gins chosen by the model solution.

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APPENDICES

APPENDIX A

SURVEY FORM AND EXAMPLE OF COTTON GIN RESPONSES

Gin License Number____________

Gin Name:____

Contact person:______________________Telephone #____________

Address:____

Location:____

Client information

Name address and county	Bales Ginned	% of bales by harvesting method: picked	% of bales by harvesting method: stripped	% of bales by delivery method: trailer	% of bales by delivery method: modules	est miles from gin
Example						
John Doe route 5 Altus,OK	400	75	25	10	90	10

VITA

Tommy Eshleman

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE OPTIMAL NUMBER, SIZE, AND LOCATION OF COTTON GINS IN OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Alva, Oklahoma, June 13, 1956, the son of Robert M. and Geneva J. Eshleman. Married Cathy J. on June 11, 1976. Children are James T. born on April 10, 1984, and Kristi M. born on November 15, 1989.

Education: Graduated from Alva High School, Alva, Oklahoma, in May 1974; received Bachelor of Science degree in Economics from Northwestern Oklahoma State University in May 1979; received Master of Arts in Agricultural Economics from Washington State University in February 1982; completed requirements for the Doctor of Philosophy at Oklahoma State University in July, 1994.

Professional Experience: Assistant Professor of Economics, University of Nebraska-Kearney, August 1992 to Present; USDA National Needs Fellow, Department of Agricultural Economics, Oklahoma State University, August 1989 to August 1992; International Trade Analyst, Department of Agricultural Economics, Oklahoma State University, November 1987 to August 1989; Economist, American Soybean Association, St. Louis Missouri, May 1982 to May 1987.