THE IMPACTS OF PRODUCTION VARIABILITY ON THE MISSISSIPPI GINNING INDUSTRY

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Abstract

Agricultural production variability can have substantial impacts on agribusinesses that are dependent on that production. Cotton gins provide an example of such a business. This analysis addresses the impacts of production variability on the optimal organization of the ginning industry in Mississippi. A non-linear programming model is used to determine the optimal organization under two scenarios: (1) when cotton production is held at mean levels and (2) after accounting for production variability. In addition, the impacts of potential increases in acreage variability are explored. Findings suggest that the opportunity cost of variability in the level of production on the ginning industry is large. However, increases in acreage variability above historical levels are not expected to dramatically change the optimal organization of the ginning industry in Mississippi.

Introduction

Many agribusinesses are heavily dependent on agricultural production as their primary revenue source. As such, the ebbs and flows of agricultural production have a large impact on the profitability of those businesses. Uncontrollable factors affect primarily yield (although weather can have an effect on acreage planted or harvested), which ultimately affects agricultural production. Government policy, however, can also have an effect on production. The 1996 Federal Agricultural Improvement and Reform (FAIR) Act effectively eliminated direct subsidization of many crops by separating payments from acreage reduction and planting requirements. This "de-coupling" may have the effect of increasing the variability of acres planted to a given crop over time. If acreage variability does increase, it could have implications for agribusinesses that are dependent on the production of specific commodities. Cotton gins are an example of such an agribusiness.

Other government or quasi-government programs such as Boll Weevil Eradication (BWE) have been found to dramatically increase cotton acreage in areas where it has been successfully applied (Bryant et al.). Parvin estimates that BWE could result in an increase of about 300,000 acres in Mississippi. Increased planting flexibility afforded by the FAIR Act and other programs such as the BWE are often countervailing and may ultimately lead to an increase in acreage variability.

Despite the potential implications that production variability may have on agribusinesses, there has been little empirical research addressing these potential impacts. Much of the existing literature deals with price risk management schemes for agribusiness firms. There has been substantial general work on the ginning industry in various regions of the U.S. For example, Cleveland and Blakely, Ethridge, Roy and Myers, and McPeek all analyzed the ginning industry in the High Plains of Texas. Fuller, Eastman, and Dewbre, and Fuller and Washburn examined the Lower Rio Grande Valley and Eastern New Mexico. Capstick et al. examined Arkansas, while Miley and Roberts (1944, 1945) and Robinson and Mancill studied Mississippi. Most of these studies estimated the optimal organization (structure) of the industry and most come to the same general conclusion. That is, the optimal structure is one that embodies a smaller number of larger capacity gins. This general finding reflects the economies of size that are available in the cotton gin.

McPeek made an important contribution to the study of cotton gins when he assumed that the ginning industry in the Texas High Plains fit the model of a monopolistically competitive industry. Cotton gins offer what some may consider to be an essentially undifferentiated product, ginning. However, he argued that ginning is differentiated in the sense of convenience of location. That is, a cotton gin that is located in a specific area is more convenient to cotton producers in that area. Thus, these cotton gins exhibit a spatial monopoly for ginning services. However, they cannot fully exert monopoly power because it is possible for cotton producers to transport their cotton to other gins. The difference between charges for the ginning service between two gins should not exceed the cost of transportation plus some convenience premium.

McPeek analyzed the optimal structure of the ginning industry in the Texas High Plains. However, under the assumption of monopolistic competition, the resulting optimal structure included both large and small gins, which is different than previous studies. This result was believed to be more realistic because it allowed for smaller gins to operate in areas with less cotton production, thereby reducing transportation costs to areas of higher cotton production. The primary limitation of McPeek's analysis was that he assumed that the level of cotton production was fixed at historical mean levels. Thus, there was no consideration of the impact of production variability on the optimal structure of the ginning industry. The current study extends this work by

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incorporating the impacts of the underlying distribution of cotton production on the optimal industry structure in Mississippi under the conditions of less-than-perfect competition. This will allow the derivation of the cost of cotton production variability to the ginning sector.

Economic Concepts

Figure 1 shows the equilibrium output of a firm under both perfect competition and imperfect competition. The primary difference between the two market structures is that under perfect competition, the demand function facing the firm (D'D') is horizontal (i.e., the individual firm has no impact on price). Under imperfect competition, the firm faces a downward sloping demand function (DD), suggesting the firm has some influence over price (or market power). The source of market power, in this case, would result from the convenience of location to the cotton producer (the demander of ginning services). The equilibrium quantity of ginning services is determined by the intersection of the marginal cost (MC) of providing ginning services with the marginal revenue (MR) of providing ginning services. Under perfect competition, the MR of ginning services is denoted by the horizontal demand curve (D'D').

Figure 1 shows that the quantity of ginning services produced under perfect competition (q') is greater than the quantity produced under imperfect competition (q), and the price (ginning charge) under perfect competition (p') is less than the price under imperfect competition (p). The difference between q' and q is often termed "excess capacity" (Chamberlin; McPeek). That is, this firm could produce as much as q' under perfect competition, which minimizes the average cost. However, because of the market power created by the convenience of location, the firm only produces q. Thus, one expects to observe firms operating with market power to produce less than its "efficient" output (efficient in this context refers to that output which minimizes its average cost per unit of output). Thus, it is important to identify what levels of "excess capacity" exist and account for them in empirical models of industry structure.

Methods

The analysis is divided into four major parts. First, a survey was conducted to gather basic data on the ginning industry in Mississippi. Second, a non-linear programming model was used to estimate the optimal structure of the ginning industry when cotton production was held at historical mean levels (i.e., this model simulates the optimal structure with no cotton production variability). Third, a chance-constrained non-linear programming model was used to account for the underlying distribution of cotton production (i.e., this model introduces cotton production variability into the model of optimal industry structure). Finally, a second chance-constrained programming model was used to estimate the impacts of an increase in acreage variability on the optimal structure. These results provided an indication of the monetary impacts of increased acreage variability on the ginning industry.

Gin Survey

A survey was mailed to 120 cotton gins in Mississippi that were members of the Southern Cotton Ginners Association (the National Agricultural Statistics Service reports that there were 127 active cotton gins in 1998) during the summer of 1998. Figure 2 shows the number of gins in each county. A total of 48 returned usable responses for a usable response rate of 40%. The focus of the survey was to determine capacity, transportation cost and practices, ownership structure, gin charges, and ginning cost.

Capacity is a central issue to this analysis. Ginners were asked for make and model of ginning equipment to determine the engineering rated capacity of the machinery. Ginners were also asked to provide an estimate of the maximum capacity they could gin under ideal conditions (i.e., with a sufficient supply of cotton), which served as the maximum capacity for the gin. This value represents a capacity that accounts for machine inefficiencies. Then, ginners were asked for their actual processing rate in 1998. This served as the actual capacity for the gin. The difference between the maximum capacity and actual capacity served as the estimate for the "excess capacity" of the gin. Ideally, one would like to estimate the cost function and demand function for each gin so that the difference between q and q' in Figure 1 can be directly derived. However, difficulty in deriving these estimates necessitates the use of a proxy. Thus, the "excess capacity" derived from the survey is assumed to represent the difference between q and q' in Figure 1.

The second set of questions dealt with transportation costs and practices. Ginners were asked to provide some information regarding the average transportation costs, how the cotton was transported, and the average transportation distance. This allowed a derivation of an average transportation cost of cotton per bale per mile. Finally, ginners were asked to provide information on gin charges and total ginning cost.

Gins were divided into four size categories based on survey responses, NASS classifications, and previous work (McPeek). These were Size 1 (up to 14 bales per hour (bph)), Size 2 (15 to 21 bph), Size 3 (22 to 28 bph), and Size 4 (greater than 28 bph). Responses to all questions were averaged based on gin size. For example, an average capacity was determined from survey responses for Size 1 gins, Size 2, etc. The number of gins in Mississippi that fell into each size category was determined using data from the *Cotton Ginnings Annual Report: 1998* published by NASS.

The number of gins in each size category was multiplied by the average characteristics for that group to determine the industry characteristics. For example, the average maximum capacity per gin for Size 1 group was multiplied by the number of gins in that group to determine the industry capacity in Size 1 gins. The total capacity in each size group was combined to determine the capacity for the entire Mississippi ginning industry. All other variables were calculated in a similar manner. The resulting set of estimated characteristics served as the base data for the optimization models. As a check, the estimated number of bales processed arising from the survey was compared to the actual number of bales processed. The survey results suggested 1.7 million bales were processed in 1998, which is approximately equal to the actual (Boyd and Hudson). Thus, the data from the survey are believed to be representative of the actual ginning industry.

<u>Non-Linear Programming Model</u>

To assess the impacts of production variability, a non-linear programming approach was used. First, a baseline model was used to determine the optimal industry structure assuming that the level of cotton production is held constant at mean levels. This model is designed to determine the optimal number, size, and location of cotton gins in Mississippi that minimizes the total industry cost. The objective function is defined as:

$$(1)\quad Min(TOTALCOST) = \sum_i (GINCOST_i + TRNCOST_i),\ for\ i = 1..4$$

where $GINCOST_i$ is the total ginning cost across the four size groups, $TRNCOST_i$ is the total transportation cost across the four size groups, and the four size groups are as previously defined. Thus, the objective function is essentially the joint minimization of both ginning and transportation cost.

The objective function is subject to the following set of constraints/equations. First is the equation for the individual gin cost function:

$$(2)\quad GCOST_{i,j} = \alpha_i + \beta_i \left(1/ FUNCSUP_{i,j}\right),\ for\ i = 1..4\ and\ j = 1..n.$$

The variable $GCOST_{i,j}$ is the per bale average cost of ginning cotton in a Size i gin in the destination region j. The $FUNCSUP_{i,j}$ is the supply of cotton going to destination gin j of size i. The functional relationship found in equation 2 represents a non-linear function of the number of bales processed.

A destination gin is defined as a gin of a given size that is located in a destination region. For this analysis, Mississippi is divided into 59 regions. The majority of these regions are individual counties. However, some counties were combined to form regions because cotton production in these counties is small and inconsistent. It is possible to have multiple gins of the same size, multiple gins of different sizes, or both in each destination region.

The parameters for the right hand side of equation 2 were estimated externally to the optimization model. A gin cost simulation model called GINMODEL (Mississippi State University) was used to estimate ginning costs at various levels of utilization for different size gins. That is, GINMODEL estimates the average total cost of ginning at utilization levels ranging from 10 to 100% assuming the gin has an estimated capacity in bales per hour. Thus, GINMODEL was used to estimate the costs for various utilization levels for each size group previously defined. These cost estimates served as the dependent variable in a set of regressions with the number of bales processed serving as the independent variable. The functional form was as shown in equation 2 and was estimated using Ordinary Least Squares. A regression equation was estimated for each size group gin, and the resulting parameter estimates were then used in equation 2.

The second equation relevant to the objective function was:

$$(3)\quad GINCOST_i = \sum_j GCOST_{i,j} * FUNCSUP_{i,j},\ for\ i = 1..4\ and\ j = 1..n.$$

Equation 3 represents the total ginning cost for each size group, which is used in the objective function. The transportation costs were calculated as follows:

$$(4)\quad TRNCOST_i = \sum_s \sum_j TCOST_{i,s,j} * COT_{i,s,j},\quad for\ i = 1..4, s = 1..59, and\ j = 1..n,$$

where $TCOST_{i,s,j}$ is the transportation cost per bale of cotton from the source region s to the destination gin size i in region j, $COT_{i,s,j}$ is the number of bales of cotton going from source region s to gins size i in destination region j. A source region is one of the previously defined 59 regions in Mississippi. Cotton can be shipped from a source region to itself as the destination or to any adjacent region in Mississippi (cross border transport to and from other states was considered, but examination of production data showed that this was minimal). Only the immediately adjacent regions to a source region were considered feasible destinations because of the prohibitive costs of transporting a bulky, low valued product like unginned cotton over large distances.

Transportation regions were calculated from region center to region center. This was multiplied by the per bale per mile transportation cost calculated from the survey to determine the per bale transportation cost between each source and feasible destination region. For cotton transported from the source region to itself, the distance was calculated from the outer boundary to its center.

The number of bales to be processed in each gin of size i ($FUNCSUP_{i,j}$) is given by the following:

(5) $$FUNCSUP_{i,j} = \sum_{s} COT_{i,s,j},\ for\ i = 1..4, s = 1..59, and\ j = 1..n.$$

Equation 5 shows that the cotton processed by a particular gin of size i in the destination region j is given by the amount of cotton that is transported to that gin from the various source regions. The variable $FUNCSUP_{i,j}$ is restricted by the following:

(6) $$FUNCSUP_{i,j} \leq ACTCAP_{i,j},\ for\ i = 1..4\ and\ j = 1..n,$$

where $ACTCAP_{i,j}$, which is derived from the survey responses above, is the actual capacity of gin size i in the destination region j. Thus, the amount processed by any individual gin cannot exceed the actual processing capacity of that gin. Because the difference between the maximum and actual processing capacity reflects the "excess capacity," utilizing actual capacity imposes the constraint of imperfect competition on the model.

The amount of cotton available in each source region was derived by taking the mean of cotton production in that region for the 1954-1998 period. By utilizing only the mean values, it is assumed that that level of cotton production determines the optimal structure of the ginning industry (i.e., no variation in production exists). This is essentially the point at which the McPeek analysis of the Texas High Plains stopped. The results of this model reflect the optimal number, size, and location as well as the minimum cost for the ginning industry in Mississippi when cotton production is held at historical mean levels.

Chance-Constrained Programming Model

A chance-constrained programming model is used to incorporate the effects of production variability on the optimal structure, and thus cost, of the Mississippi ginning industry. The resource considered to have an underlying distribution in this case is cotton production. However, cotton production contains two random variables—yield and acreage. To account for this, the following formula (Bohrnstedt and Goldberg) is used:

(7) $$V(AY) = [E(A)]^2 V(Y) + [E(Y)]^2 V(A) - V(A)V(Y),$$

where V(AY) is the variance of cotton production, E(A) is the mean of cotton acres, V(A) is the variance of cotton acres, E(Y) is the mean of cotton yield, and V(Y) is the variance of cotton yield. This approach has two primary limitations. First, both yield and acreage are assumed to be normally distributed. Secondly, yield and acreage are assumed to be independent. However, this approach is deemed appropriate for this analysis because of the analytical difficulty in handling 59 potentially different distributions—one for each source region. One advantage of this approach is that it easily lends itself to an analysis of the impacts of changes in the variance and/or mean of these variables.

The variance (standard deviation) of cotton production enters into the chance-constrained model through the following:

(8) $$COT_{i,s,j} = \overline{COT}_{i,s,j} + z_\alpha \sigma_s,$$

where σ_s is the standard deviation of cotton production in the source region s and z_α is the z-score at the α significance level. Equation 8 enters into equation 5 of the original model. The intent of this equation is to insure that the ginning industry has sufficient capacity to process all cotton some percentage of the time, which is reflected by the significance level α. This can be viewed as a type of "safety first" criteria whereby gins do not want to exceed their "effective" operating capacity. The reason for this desire is that exceeding this capacity could be costly through rapidly increasing labor and wear-and-tear expenses. Ginners could conceivably increase the length of the ginning season to accommodate increased cotton production, but wear-and-tear on machinery would increase as well. The limitation of this approach is that it is inflexible towards the options available to the ginning industry. That is, the assumed capacities of gins are fixed and cannot be increased by increasing season length—any increases in cotton production must be met by adding gins. However, the approach does provide an approximation of the cost of production variability to the ginning industry.

Increased Acreage Variability

In addition to assessing the impacts of production variability on the ginning industry, one primary objective of this analysis was to determine the impact an increase in acreage variability might have on the optimal structure of the ginning industry. This was accomplished with the use of the above chance-constrained programming model. The nature of costs of production and prices in the region along with the planting flexibility afforded by the FAIR Act suggest that acreage variability could increase. For this analysis, a mean-preserving 30% increase in acreage variability was assumed (that is, the mean number of acres remained the same, but the variance of acres was increased 30%). Thus, the variance for acres of cotton was increased by 30% and entered into equation 7. The above model was then recomputed to determine the impact of this acreage variability increase on the optimal structure of the Mississippi ginning industry.

Data Considerations

Primary data were derived from the survey discussed above. Secondary data on yield, acreage, and production for the years 1954-1998 were derived from the Mississippi Agricultural Statistics Service. Other data on gin industry characteristics were obtained from the National Agricultural Statistics Service. All optimization models were estimated using the MINOS solver in the General Algebraic Modeling System software.

Results

The results of the non-linear model assuming cotton production at historical mean levels (Model 1) are shown in Table 1 and compared to the current actual ginning industry structure as derived from the survey. The optimal industry structure shows a total of 35 gins (3 Size 1, 1 Size 3, and 31 Size 4 gins) compared with 127 gins in the current structure. As with previous studies of gin structure, the results of this study suggest a much smaller number of larger gins than currently exist. However, the optimal model did show some smaller gins were optimal, which is different than previous studies of the Mississippi ginning industry and consistent with the findings of McPeek for the Texas High Plains.

Model 1 results showed that no net savings were available in transportation cost of cotton. Size 1, 2, and 3 gins showed transportation cost savings could be realized through the reduction in the number of those gins. However, the cost increase for Size 4 gins outweighed any realized savings from the smaller gins. This is logical because larger gins located at more centralized locations require transporting a greater amount of cotton over a larger distance. Thus, the optimal structure would increase transportation cost by about $3.4 million. Similarly, ginning cost is expected to decrease in the optimal structure for gin size 1 to 3. A larger number of large gins is expected in the optimal model resulting in a increased ginning cost for that size group. Overall, however, ginning costs are expected to be about $65 million less with the optimal structure. Model 1 shows that a cost savings of about $62 million could be achieved with the smaller number of larger gins as compared to the current structure. However, this cost savings assumes that cotton production is at historical mean levels. That is, it does not account for the effect of cotton production variability.

The results for the chance-constrained model assuming an α level of 0.05 (Model 2) is shown in Table 2. That is, Model 2 represent the optimal structure of the Mississippi ginning industry under the assumption that the industry has sufficient capacity to process all cotton 95% of the time. Results suggest that achieving sufficient capacity to cover all cotton production 95% of the time almost doubles the number of necessary gins from 35 (Model 1) to 67. There are 4 Size 1 gins, 5 Size 2 gins, 2 Size 3 gins, and 56 Size 4 gins in the optimal organization. Again, the preponderance of gins is in the largest size group, but adding the variability of cotton production requires additional smaller gins as well. This is likely because smaller gins are introduced in areas that are not consistently large cotton producing regions, but have the potential (or have shown a propensity) to increase acreage.

Maintaining this level of capacity also appears to be costly, resulting in about $40 million in additional cost to the ginning industry in Mississippi. There is an increase in transportation cost of about $6.1 million compared to Model 1, with the large monetary increase in Size 4 gin category. There is also an expected increase in ginning cost of about $34 million, again with Size 4 gins making the largest contribution to that increase. Thus, maintaining sufficient capacity to cover cotton production 95% of the time increases transportation cost by moving cotton to a greater number of gins as well as increasing ginning cost. This result suggests that the opportunity cost of production variability is quite substantial compared to the situation with no production variability. That is, maintaining sufficient capacity to process all cotton production 95% of the time results in almost doubling industry size and cost.

An interesting comparison arises between the current industry cost (Table 1) and the results of Model 2 (Table 2). This comparison reveals that the results of Model 2 are much closer in terms of industry cost and number of gins to the actual than under the situation when no cotton production variability is considered (Model 1). This may suggest that, at least to some extent, the industry is currently accounting for production variability and maintaining additional capacity to ensure sufficient capacity to cover above-average cotton production most years. Despite this similarity, however, these results indicate that the industry is maintaining excessive capacity at a cost to the industry.

Finally, Table 3 shows the results of the case when a 30% increase in acreage variability is assumed (Model 3) compared with the results of Model 2. These results suggest that an increase in acreage variability of this magnitude will have only a marginal impact on gin industry structure. That is, increasing acreage variability by 30% increases industry cost by $2.5 million or 2.87%.

For comparison, Figure 3 shows the number of gins in each county resulting from Model 3. Note that the concentration of cotton gins remains in the Mississippi River Delta area. The shaded area of Figure 3 represents the counties that were combined due to lack of cotton production. In the original structure, no cotton gins are operating in that region. However, when the underlying distribution of cotton production is considered, 1 gin for that region was found to be optimal.

Conclusions

This analysis utilized a non-linear programming model to demonstrate the potential impacts of production uncertainty on the ginning industry in Mississippi. A survey was conducted to ascertain the current operating practices of gins in this region, and these data were used to form the basis of the programming model. The ginning industry was assumed to operate under an imperfectly competitive market structure. A model was estimated under the assumption that cotton production was held at its historical mean level and the results of this model served as a baseline for comparisons. A chance-constrained model was used to incorporate cotton production variability into the optimization framework. Finally, the effects of an increase in acreage variability on the optimal industry structure were examined.

Production variability can have potentially large impacts on agribusinesses that are dependent on that production. In this case, the introduction of production variability almost doubled the cost of ginning and the number of gins. Although considerable work has been done analyzing the impacts of policies that affect acreage on the production sector, little has been performed on the agribusiness support industries. This analysis suggests that attention to these sectors is warranted.

Second, potential increases in acreage variability as a result of the FAIR Act or other state and local programs does not appear to have significant impacts on industry organization. That is, after incorporating both yield and acreage uncertainty inherent in the system from the underlying distribution of cotton production, additional acreage variability appears to only marginally increase industry cost. This could have important implications from a policy perspective in that the effects of government policy do not appear to significantly affect industry cost, at least for cotton gins in Mississippi. However, it should be noted that years of government support of the cotton industry may have led to an industry structure that is carrying excessive capacity relative to existing needs as evidenced by a comparison of the actual gin industry structure with the optimal structure. Thus, a reduction in government support may ultimately lead to a displacement of some cotton gins. To what extent the current downsizing in the industry is a result of the economies of size of larger gin plants as compared to the effect of a reduction in government support to the cotton industry needs to be investigated. Nevertheless, the results of this analysis suggest that increases in acreage variability are not likely to have a substantial impact on industry organization or cost.

A limitation to this research is that the measure of excess capacity used in this analysis is a proxy. That is, one would prefer to have the estimates of the demand equation for ginning in order to find the point of tangency between the cost and demand functions. The nature of pricing for gin services is complex and the data did not exist to estimate the demand functions. However, if the estimates of excess capacity are accurate, they can be effectively used as a proxy for this point. Future research in this area could address the degree of market power for ginners and to what extent that market power may be changing as gin capacities become larger necessitating larger market areas to cover costs.

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Table 1. Optimal Gin Structure Assuming Cotton Production at Mean Level vs. Current Gin Structure.

Gin Size	Current Cost ($)	Optimal Cost ($)	Difference ($)
	Transportation		
Size 1	1,594,293	95,404	1,498,890
Size 2	609,491	6,575	602,914
Size 3	2,440,755	11,850	2,328,908
Size 4	408,733	8,262,200	-7,853,467
Subtotal	5,053,271	8,476,029	-3,422,758
	Ginning		
Size 1	52,927,520	1,321,400	51,606,120
Size 2	14,961,847	304,150	14,657,697
Size 3	32,087,617	969,350	31,118,267
Size 4	5,068,054	37,004,000	-31,935,946
Subtotal	105,045,038	39,598,900	65,446,138
TOTAL	110,098,309	48,074,929	62,023,380

Table 2. Optimal Cotton Gin Structure Assuming Cotton Production at Mean Levels vs. Optimal Structure with Sufficient Capacity to Process Cotton Production 95% of the Time.

Gin Size	Optimal Cost ($) at Mean Cotton Production	Optimal Cost ($) with Sufficient Capacity 95% of Time	Difference ($)
		Transportation	
Size 1	95,504	283,890	-188,487
Size 2	6,575	351,090	-344,515
Size 3	111,850	267,770	-155,920
Size 4	8,262,200	13,697,000	-5,434,800
Subtotal	8,475,029	14,599,750	-6,123,721
		Ginning	
Size 1	1,321,400	1,991,400	-670,000
Size 2	304,150	3,367,800	-3,063,650
Size 3	969,350	2,065,200	-1,095,850
Size 4	37,004,000	65,994,000	-28,990,000
Subtotal	39,598,900	73,481,400	-33,819,500
Total	48,074,929	88,018,150	-39,943,221

Table 3. Optimal Gin Industry Structure With Sufficient Capacity to Process All Cotton 95% of the Time vs. Optimal Structure Assuming a 30% Increase in Acreage Variability.

Gin Size	Optimal Cost ($) With Sufficient Capacity 95% of Time	Optimal Cost ($) With 30% Increase in Acreage Variability	Difference($)
		Transportation	
Size 1	283,890	402,400	-118,510
Size 2	351,090	133,700	217,390
Size 3	267,770	142,790	124,980
Size 4	13,697,000	14,921,000	-1,224,000
Subtotal	14,599,750	15,599,890	-1,000,140
		Ginning	
Size 1	1,991,400	2,373,300	-381,900
Size 2	3,367,800	1,297,100	2,070,700
Size 3	2,065,200	1,153,800	911,400
Size 4	65,994,000	70,119,000	-4,121,000
Subtotal	73,418,400	74,943,200	-1,524,800
TOTAL	88,018,150	90,543,090	-2,524,940

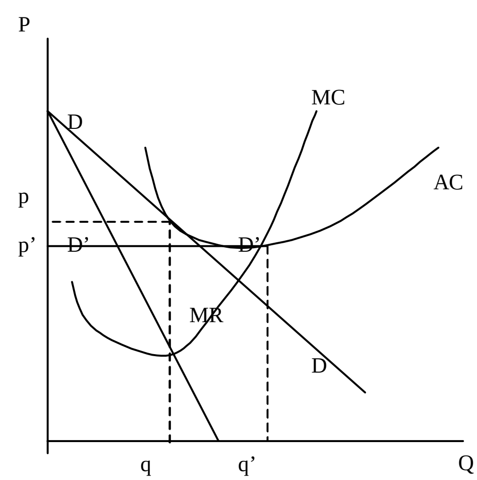

Figure 1. Optimum Price and Quality for an Imperfectly Competitive and Perfectly Competitive Firm.

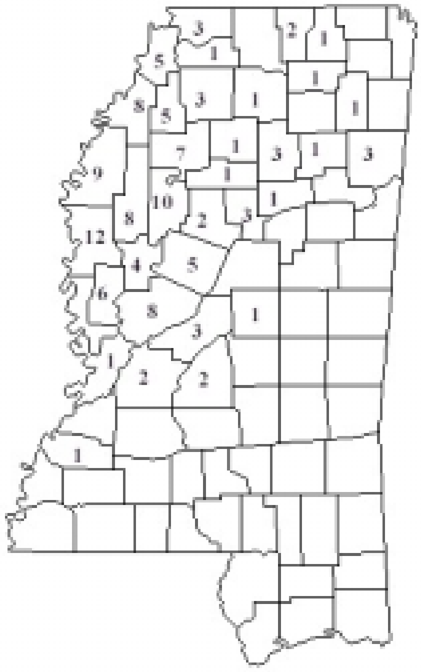

Figure 2. Location of Cotton Gins in Mississippi in 1998. Source: NASS.

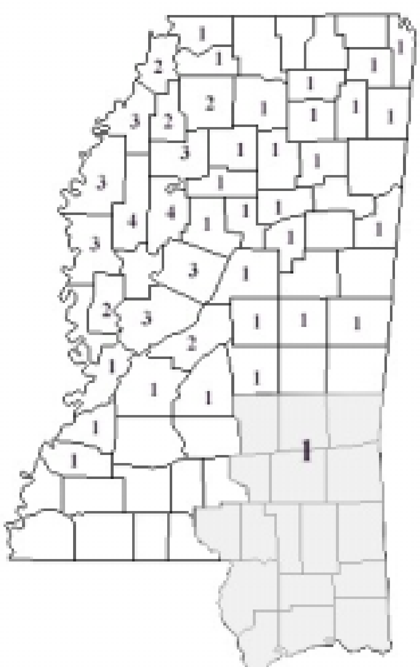

Figure 3. Optimal Location of Gins With Sufficient Capacity to Process All Cotton 95% of the Time Assuming a 30% Increase in Acreage Variability. Source: Model 3.