Mississippi State University
Professional Paper 99-010

Department of Agricultural Economics
October 1999

Potential Implications of Production Variability on Agribusiness: The Case of Cotton Ginning in Mississippi

Shawn Boyd and Darren Hudson

Corresponding Author
Darren Hudson
Department of Agricultural Economics
Mississippi State University
P.O. Box 5187
Mississippi State, MS 39762

hudson@agecon.msstate.edu
Phone: 662-325-7998
Fax: 662-325-6614

Abstract

Cotton ginning represents an agribusiness that is heavily dependent on production agriculture. Recent changes in farm legislation and other government policies may have a long run impact on the variability of cotton production. This paper examines the potential impacts of increased production variability on the cotton ginning industry in Mississippi. A programming model is used to derive the optimal structure of the ginning industry under certainty. Potential implications of production variability are discussed and extensions to the model are proposed.

Keywords: cotton, ginning, production variability, mathematical programming

POTENTIAL IMPLICATIONS OF PRODUCTION VARIABILITY ON AGRIBUSINESS: THE CASE OF COTTON GINNING IN MISSISSIPPI

The 1996 Federal Agriculture Improvement and Reform (FAIR) Act has brought about many changes in production agriculture. One of the many changes deals with how producers go about making crop mix decisions. By allowing producers greater flexibility in planting, FAIR has significantly changed the nature of income support provided to farmers by the federal government (Lesley). Cotton producers have more cropping options, making profitability and risk management key factors in crop-planting decisions. Producers are taking advantage of this new found flexibility and changing their crop mixes to take advantage of the more profitable cropping opportunities. The planting flexibility provisions found in the FAIR Act may have already affected the number of acres planted in cotton in Mississippi according to the United States Department of Agriculture's (USDA) estimates, Mississippi growers planted approximately 860,000 acres of cotton in 1998. It is rare for cotton producers in Mississippi to plant less than one million acres of cotton.

What kind of effect does the producers new found flexibility have on agribusiness support industries? The cotton industry provides an excellent example of an industry whose commodity demands a large network of support industries. In 1996, Mississippi was the fourth leading cotton producing state in the country producing 1,876,000 bales. During that same year, cotton led all crops in Mississippi with cash receipt of $649 million. Cash receipts from cottonseed produced in Mississippi totaled $77.1 million in 1996 (Mississippi Agricultural Statistics). The amount of cotton produced in Mississippi affects more than just cotton producers. Cotton requires an extensive infrastructure and provides a stimulus to the Mississippi economy. In Mississippi there are approximately 4,044 businesses that are cotton-related and these firms employ over 22,000 Mississippians (Cotton). Large amounts of money are generated in the local economy as a result of the infrastructure of support industries associated with cotton. Money generated by cotton production passes from the fuel distributors to farm implement dealers to the local gins (Lesley). These and many other firms are dependent on high volume cotton production.

Even though Mississippi's cotton acreage has been declining the past few years, there is evidence that there are federal and state programs available that might reverse this trend. One such program is the Boll Weevil Eradication (BWE) Program. There are several benefits that can be obtained eradicating the boll weevil. The four major benefits seen in the states participating in a BWE program are as follows: 1.) The amount of pesticides used by producers was greatly reduced, 2.) Due to a reduction in chemical use, the per acre costs of production decreased, 3.) Cotton lint yields increased, and 4.) Farmers are able to plant more acres to cotton. The increase in cotton acreage in Mississippi due to the Boll Weevil Eradication Program is estimated at 326,000 acres (Parvin, 1996). The Boll Weevil Eradication Program, or lack of such a program, will continue to have a significant impact on the number of acres planted to cotton through the cost of production.

Whether cotton acreage continues to decline as a result of the planting flexibility afforded producers by the FAIR Act or begins to climb due to the implementation of the Boll Weevil Eradication Program, acres planted in cotton will likely become more variable in Mississippi compared to years past.

The purpose of the study is to determine how the support industries, especially cotton gins, in Mississippi will be affected by the variability in cotton production due to changes in farm legislation and farm programs like the Boll Weevil Eradication Program? Before the impacts of changing cotton acreage can be determined, the existing structure of the ginning industry in Mississippi must be identified along with the optimum structure of the Mississippi ginning industry. Once these two objectives have been met, the impact of cotton acreage flexibility on the optimal structure can be examined.

Conceptual Framework

Much of the current work on the optimum structure of the ginning industry has focused on producers in areas other than Mississippi. One study that did focus on the ginning industry in Mississippi was conducted by Robinson and Mancill (1997) which analyzed the impact of potential declines in cotton acreage on the sustainability of cotton gin operations. The major question dealt with was the sustainability of cotton gins in the areas of the state where distances between the cotton producers and the gins are the greatest. Robinson and Mancill explain how the sustainability of cotton gins can be analyzed in terms of both the short-run and the long-run, but only the short-run implications are discussed in their paper. Another point brought up by Robinson and Mancill involve the implications of an individual producer’s planting decisions on the ginning costs and the ginning availability to all of the remaining producers around a given gin.

Miley and Roberts (1945) were involved in an extensive study that observed the operations of cotton gins in four counties in central Mississippi during the 1940's. Even though the dollar figures are not comparable, some of the conclusions drawn in this study and the study conducted by Robinson and Mancill are similar. Both studies point out, as one might expect, the average cost of ginning increases as the volume of cotton produced decreases.

The studies mentioned above were conducted based on a similar assumption of the cotton ginning industry falling under the market structure framework of perfect competition. McPeek (1997) took a different approach. The purpose of this study was to determine the optimal organizational structure of the cotton ginning industry in the Texas Southern High Plains. Specifically, McPeek wanted to determine the optimum size, number, and location of cotton gins in this region. The results found in this particular study differed in that the optimal structure of the ginning industry determined in the study included both large and small gins. The unique aspect of these results centers around the fact that the study included several smaller gins. The difference in McPeek's results and the results from similar optimal market structure studies can be linked to the assumption under which this study was conducted. McPeek's study was conducted under the assumption that the ginning industry in the Texas Southern High Plains meets the characteristics of a monopolistically competitive industry. This assumption may hold for the ginning industry in Mississippi. A monopolistically competitive market has the following characteristics: 1.) A large number of buyers and sellers, 2.) The firms within the market provide a differentiated product, 3.) Participants have limited influence over price, and 4.) Market entry and exit is more difficult than that of a firm in a perfectly competitive market. In the case of the ginning industry, the product provided by the firms in the industry is the ginning service. One might argue that this type of service is homogeneous in nature; however, Chamberlin (1962) explains that product differentiation may be based on several different factors. These factors include but are not limited to such items as consumer convenience to the seller's location and the overall business reputation of the business owner. McPeek states, "The condition relevant to the ginning industry in the Southern High Plains of Texas is the convenience of the seller's locations. These spatial considerations determine the degree of differentiation of the ginning service." This condition holds true for the Mississippi ginning industry.

Methods and Procedures

A survey was mailed to 120 Mississippi cotton gins during the summer of 1998. The survey's primary objective was to determine the operational structure and the processing capacity of Mississippi cotton gins. Responses to some of the questions in the survey were classified into four different size groups, similar to that used by Misra, et. al. in their study of the ginning industry in the Texas High Plains (Misra et. al.). These four size groups were based on the average bales per hour (bph) processing capacity, and were defined in the following manner:

(Size 1) Up to 14 bales per hour,

(Size 2) 15-21 bph,

(Size 3) 22-28 bph,

(Size 4) Greater than 28 bph.

Average ginning cost per bale, total ginning cost, and seed cotton transportation cost were calculated for each size group and for the overall Mississippi ginning industry. Using the responses on the surveys and data from the National Agricultural Statistics Service (NASS), gin distribution and the processing volume by size group was determined for the Mississippi ginning industry. An estimation of the total number of gins in each size category was made based on NASS data. The total number of bales processed for the 1997 season was derived by multiplying the average number of bales processed per gin for each size group (as determined from the survey responses) times the number of estimated gins in that size group. To determine average transportation cost, the average per bale transportation cost for each respective size group was multiplied by the average number of bales ginned for that size category. The average ginning cost per bale for each group was multiplied by the average number of bales ginned to derive total ginning cost for each group.

In order to determine the optimal number, size, and location of gins in Mississippi, a non-linear programming model was developed. This model was based on the model developed by McPeek (1997). McPeek's model was a non-linear programming model used to determine the optimum structure of the gins in the Texas Southern High Plains. Mississippi was divided into 59 regions. The majority of these regions are simply the counties located in Mississippi; however, some counties were grouped together due to the fact that the amount of cotton produced within those particular were so small. Four alternative sizes of gins (in terms of hourly capacity) were derived using results obtained from the survey. The possible number of each size gin per county was determined by using the following model:

Objective Function:

1. Minimize $TOTALCOST = \sum_{i}(GINCOST_{i} + TRNCOST_{i})$; for i = 1 - 4

Subject To:

2. $GCOST_{i,J} = \left[\alpha_{i} + \beta_{i}\left(\frac{1}{FUNCSUP_{i,J}}\right)\right]$; for i = 1 - 4, j =1 - n

3. $GINCOST_{i} = \sum GCOST_{i,J} * FUNCSUP_{i,J}$; for i = 1 - 4, j = 1 -n

4. $TRNCOST_{i} = \sum_{S}\sum_{J}(TCOST_{i,S,J} * COT_{i,S,J})$; for i = 1 -4, j = 1 - n, s = 1- 64

5. $FUNCSUP_{i,J} = \sum_{S}(COT_{i,S,J})$; for i = 1 - 4, j = 1 - n, s = 1 - 64

6. $FUNCSUP_{i,J} \quad EFFCAP_{i,J}$; for i =1 - 4, j = 1 - n

Where:

i :	The four alternative gin sizes.
S :	The 64 source quadrants.
J :	The destination gins.
TOTALCOST :	The total cost to the ginning industry which includes ginning cost and transportation cost from farm to gin.
GCOST :	The average cost per bale per destination gin.
GINCOST :	The total cost of ginning for the gin groups.
FUNCSUP :	A function to define the supply of cotton going to each gin.
TRNCOST :	The total cost of transportation for the gin groups.
$COT_{i, S, J}$:	The amount, in bales, of cotton transported from supply point AS@ to the destination gin AJ@ of size Ai@.
$TCOST_{i, S, J}$:	The per bale cost of transporting cotton from supply point AS@ to the destination gin AJ@.
$EFFCAP_{i, J}$:	The effective capacity per size Ai@ gin given a predetermined level of excess capacity.

Using this optimization model, the optimum size, number, and location of cotton gins in Mississippi can be determined.

<u>Results</u>

Survey Results

Of the 120 original surveys sent in the mail, a total of 48 gins returned usable questionnaires. This represents a usable response rate of approximately 40%. Active gins are located in 36 counties throughout the state and gins in 23 of these counties returned usable surveys.

During the 1997 season, the average rated hourly capacity of responding gins was approximately 25 bales per hour; however, the actual processing volume was approximately 20 bales per hour. By subtracting the actual processing volume (20) from the average rated hourly capacity (25), the excess capacity of the Mississippi ginning industry can be found. During 1997, the gins in Mississippi did not operate at full capacity and had an average excess capacity of 5 bales per hour. The average length of the ginning season was about 60 days. Mississippi gins operated at approximately 17 hours per day on average, with an average down-time of about 2 hours.

Responding gins reported an average ginning cost (variable and fixed) of about $35.96 per bale. Additional information was obtained by calculating the average ginning cost for each of the four different size groups. Small gins with capacities below 14 bph had a ginning cost of $36.97 per bale, while gins with capacities of 15 to 21 bph reported an average cost of $40.12 per bale. The costs for the two larger size gins were $35.29 for gins with 22 to 28 bph and $33.85 for gins with greater than 28 bale per hour capacity. In general, ginning volume is expected to be inversely related to average cost. That is, as processing volume increases in a given plant size, average cost is expected to decline. However, this was not what the survey data indicated for the gins in the size 2 group. The reason for this result is not completely clear but, it could be that data for this size group were misreported by the respondents. Alternatively, it could be that many small gins are older and fully depreciated. If this is the case, reported average cost could be much lower than expected for newer gins. Thus, it could be that the cost reported for size 1 is small compared to size 2 gins. The total cost of ginning in 1997 for the Mississippi ginning industry was calculated at about $64.5 million.

Eighty-five percent of the usable responses indicated that the ginners transported seed cotton from the producer's field to the gin. Approximately 87% of the cotton coming to the gins was transported by module. Gins paid the cost of transporting the cotton to the gin by module 98% of the time. The remaining cotton was transported to gins using trailers, and producers incurred that cost 97% of the time. The average distance of transporting cotton from the farmer's field to the gin was approximately 12 miles. The average transportation cost was $43.95 per module. An average of 13.64 bales of cotton was transported in one module. These data suggest an average module transportation cost of $3.22 per bale or $0.27 per bale per mile. Size 3 gins (22-28 bph) experienced the highest transportation cost at $3.82 per bale, while size 1 gins (up to 14 bph) had the lowest cost at $2.12 per bale. Size 2 and 4 (15-21 bph and greater than 28 bph) incurred costs of $2.39 and $3.48 per bale, respectively. The total module transportation cost for the ginning industry in Mississippi in 1997 was estimated at approximately $5.0 million. Transportation cost for trailer hauled cotton was not analyzed in the same manner as cotton hauled by module. In most instances (97% of the time), producers incurred the cost of hauling seed cotton to the gin by trailer. Therefore, gins rarely have to account for this type of transportation cost.

Total Cost for Ginning 1997

Ginning industry costs for Mississippi were calculated by adding total transportation costs and total ginning costs for each size group. Results indicate that the ginning industry incurred a combined cost of approximately $69.6 million in 1997. Smaller gins with capacities below 14 bales per hour incurred approximately $29.3 million, size 2 gins (15-21 bph) showed about $10.8 million, and size 3 gins (22-28 bph) carried about $24.9 million of the combined industry cost.

The largest gins with capacities greater than 28 bales per hour incurred $4.3 million of the combined industry costs. As one might expect, ginning costs accounted for 93% of the combined industry cost. Given that the Mississippi ginning industry processed over 1.7 million bales of cotton in 1997, results indicate that the ginning industry experienced a combined cost of about $39.47 per bale, or 7.9 cents per pound of cotton. The most commonly reported gin charge was 8 cents per pound of cotton, indicating that the industry was covering variable and fixed costs.

The following procedure was used to obtain the excess capacity in the Mississippi ginning industry. Ginners were also asked to report what they believed to be their maximum daily capacity. That is, ginners were asked to provide their estimate of the maximum amount of cotton they could process in a 24 hour period under ideal conditions. This was divided by the numbers of hours processed in that 24 hours to derive a maximum hourly capacity. This maximum hourly capacity was multiplied by the average season length and hours of processing time per day to determine maximum seasonal capacity. Gins in the four size categories responded in the following manner: Size 1 gins (up to 14 bph) were estimated to have a perceived average maximum seasonal capacity of 11,049 bales per gin, size 2 gins (15-21 bph) were estimated to have a perceived average maximum seasonal capacity of 16,991 bales per gin, size 3 gins (22-28 bph) were estimated to have a perceived average maximum seasonal capacity of 24,812, and size 4 gins (greater than 28 bph) were estimated to have a perceived average maximum seasonal capacity of 40,796 bales per gin. Extrapolation of the reported total maximum seasonal capacities per gin by size groups for the Mississippi ginning industry showed a total maximum seasonal capacity of about 2.0 million bales for Mississippi in 1997.

Comparison of the actual processing volume to maximum seasonal capacity reveals that the ginning industry in Mississippi had an excess capacity of 286,443 bales in 1997, indicating approximately 14% of unused capacity. The smaller gins (size 1 and 2 gins) operated with an excess capacity of 9% and 12% respectively, while the larger gins operated with excess capacities of 17% and 28%. It is likely that the larger gins have volumes that allow this size gin to sustain more excess capacity. However, these gins may be in a more precarious position if cotton acreage continues to decline.

Nonlinear Programming Model Results

The optimal size, number, and location of cotton gins in Mississippi were determined with the use of a non-linear optimization model, similar to the one used by McPeek. Using this model, the optimal number of gins needed to gin all of the cotton in Mississippi at the lowest possible cost to the industry was determined to be 18 Size 1 gins (up to 14 bph), 21 Size 2 gins (15-21 bph), 19 Size 3 gins (22-28 bph), and 19 gins of Size 4 (greater than 28 bph), resulting in a total of 77 gins.

Further results indicate the ginning costs for each gin size group are as follows: Size 1 gins (up to 14 bph) $13.81 million, Size 2 gins (15-21 bph) $20.69 million, Size 3 gins (22-28 bph) $21.64 million, and Size 4 gins (greater than 28 bph) $29.00 million. The transportation cost incurred for each size group under the optimal gin structure were $1.35 million, $3.36 million, $3.33 million, and $6.00 million for gin sizes 1 through 4 respectively.

In order to compare the optimal gin structure and the optimal gin structure derived in this study, the following estimated average cost equations were used:

(1.) Size 1 Gins: *Average Cost* = 24.29 + 508214.90 (1000 + # Bales)

(2.) Size 2 Gins: *Average Cost* = 21.56 + 593836.70 (1000 + # Bales)

(3.) Size 3 Gins: *Average Cost* = 21.39 + 623010.20 (1000 + # Bales)

(4.) Size 4 Gins: *Average Cost* = 20.95 + 673988.80 (1000 + # Bales)

In the above equations, average cost is the dependent variable and the average processing volume (the number of bales) is the independent variable. The average processing volume was taken from the survey responses. These cost equations are similar to the ones used by McPeek (1997).

The results of the estimated cost equations are as follows: Size 1 gin's ginning cost was $52.93 million, Size 2 gin's cost was $14.96 million, Size 3 gin's cost was $32.09 million, and Size 4 gin's ginning cost was $5.07 million. As stated earlier, total transportation cost equaled $5.05 million for the four different size gins resulting in a total ginning cost for the current Mississippi ginning industry of $110.10 million.

The optimal gin structure is compared to the current ginning industry in Table 1. According to the non-linear programming model, the optimal gin structure could result in a cost savings of $62 million to the industry per year. The optimal structure would result in increased transportation costs due to fewer gins processing the cotton. Thus, the cotton would have to be transported over greater distances. However, the cost savings associated with the reduced number of gins more than offsets the transportation cost increase.

From Table 1, the conclusion is that the optimal structure contains a smaller number of total gins, but the allocation has shifted primarily to the largest gin category. This reflects the economies of size that are available in the cotton gin. In addition, cotton production is concentrated in the Delta region of Mississippi. Thus, the geographic concentration of cotton production offers the ability to capture those economies of size without significantly increasing the transportation cost.

Conclusions

Using a non-linear programming model to jointly minimize transportation and ginning cost, this analysis found that the ginning industry in Mississippi could significantly decrease total ginning cost by having a smaller number of larger size gins. Given an imperfectly competitive market structure, however, the existence of smaller gins to service smaller, more remote areas is still optimal. These results suggest that the ginning industry will continue to shrink as it has in the recent past as more firms attempt to capture the economies of size with larger gin plants.

This study has a couple of primary limitations. First, the underlying distribution of cotton production is not considered. That is, the optimal structure is derived using the mean county cotton production. The variability of cotton production may induce the ginning industry to maintain excess capacity to cover the fluctuations in cotton production, resulting in a large optimal structure for the gin industry. Second, the capacity of each gin size is fixed. It is conceivable that gins could expand output by adding labor or extending the ginning season. This effect would likely serve to further reduce the number of necessary gins. These issues need further exploration.

References

Chamberlin, E. *Theory of Monopolistic Competition*. Eighth Edition, Harvard University Press, Cambridge, MA, 1962.

McPeek, B. "Optimum Organization of the Cotton Ginning Industry in the Texas Southern High Plains." Unpublished Master's Thesis, Department of Agricultural and Applied Economics, Texas Tech University, Lubbock, TX.

Miley, D. and A. Roberts. "The Economics of Cotton Gin Operation." Mississippi State College, Bulletin 421, 1945.

Parvin, D. "The Impact of Boll Weevil Eradication on Mississippi Acreage and Yield." Department of Agricultural Economics, Mississippi State University, Staff Paper 95, 1996.

Robinson, J. and D. Mancill. "The Effect of Planting Flexibility on Cotton Industry Infrastructure." *1997 Beltwide Cotton Conferences Proceedings*, Cotton Economics and Marketing Conference, National Cotton Council, Memphis, TN, pp. 306-309.

Table 1. Optimal Gin Structure Assuming Cotton Production at Mean Levels 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**