MANAGING COTTON GIN INVENTORY SYSTEMS: SYSTEMS MANAGEMENT APPROACH USING SIMULATION

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Abstract

The goal of a cotton gin manager is to provide a value added service to the cotton producer at the lowest cost and as quickly as possible. With the reduction in the number of cotton gins to approximately 230 in the state of Texas, smaller gins are being displaced by larger gins to meet the production on the farm level, which approaches 5.5 million bales annually. This has required the gin managers to transport seed cotton modules further distances to take advantage of any economies of scale that may exist. A decision support software package was developed and published for cotton gin managers and producers to determine the economic risks and benefits of transporting seed cotton modules from the field to the gin. The software provided results that showed long distance hauling can reduce the total ginning cost per bale realized by the gin by operating at a point where total cost(fixed and variable costs) per bale is optimized at 200 percent utilization in gins rated at or above 60 bales per hour. However, a systems analysis was needed to ensure that longer hauling distances will not have any adverse effects on the operation of the gin. Longer haul distances, up to 100 miles, may require procedural changes within the inventory system of the gin to ensure that the number of seed cotton modules present on the gin yard is sufficient to supply the gin throughout the season. Downtime within the ginning operation caused by lack of seed cotton at the gin could reduce or eliminate any savings that were possible when the gin operates at a point that is considered optimal. In this paper, simulation is used to evaluate whether or not the current management practices employed by the gin are adequate to prevent any downtime within the system due to lack of module inventory on the gin yard.

Introduction

Texas has experienced a reduction in the total number of gins opening each season from over 1600 in the 1960's to approximately 230 in 2013, shown in figure1, while the production at the farm level stays constant at 5 million bales annually. The possible solution as gins became fewer was to increase processing capacity, gin longer seasons, or travel further distances to pick up seed cotton modules in order to 1) process all the seed cotton produced in the state and 2) operate at levels that would reduce the total cost of ginning to the producer. The trend within the ginning has been to increase processing capacity per gin per day as reported by Norman et al. (2006). Parnell et al. (2005) introduced the concept of developing decision support software using variable and fixed costs versus "percent Utilization" (%U) and reported that the total per bale costs increased significantly as the percent utilization dropped below 100%U.

The initial release of a Decision Support Software (DSS) was developed to help gin managers and producers make decisions about what it would cost to gin cotton in years where neighboring gins may not open due to low production volumes and sending module trucks further distances to pick up seed cotton modules. The initial DSS provided useful information but can be improved upon to provide more information including: 1) What does it cost to haul round modules on semi-tractor trailers, 2) will the gin experience a shortage of modules on the yard preventing the gin from processing, 3) what is the needed storage capacity of the gin yard, and 4) how do all these issue impact the total cost of ginning realized by ginner and producer. Management science tools can be used to evaluate the operational changes and the associated cost.

Using simulation, data can be generated that will help build calculations into the DSS that will provide the gin manager with information that can be used to determine if the transportation system can maintain an adequate inventory of seed cotton modules on the gin yard to ensure that the gin will continue to process seed cotton. Subsequently, simulation data can be used to evaluate the impact of changes in the transportation system before they are implemented by the gin based on inventory available on the gin yard and the cost of ginning.

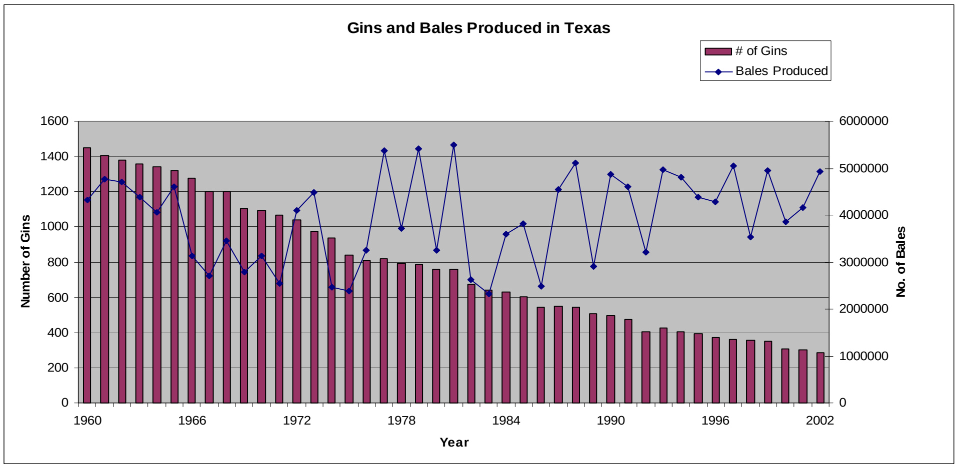

Figure 1. Number of operating gins and cotton production in bales from 1961 through 2003 in Texas (Parnell et al. 2005).

Background

Past research concluded that there was a relationship between fixed cost per bale and the percent utilization at which the gin was operating (Parnell et al. 2005). Emsoff et al. (2007) published research findings that included models and algorithms for determining optimal season lengths in terms of percent utilization (%U) and minimal ginning cost for four different ginning rate categories as shown in Table 1. The concept of %U, as defined by Fuller et al. (1993), is that a gin operating at 100 %U would on average process seed cotton at 80% of its rated capacity (GR) for 1000 hours per season. Percent utilization is calculated using equation 1 below.

$$\%U = \frac{BG}{GR * 0.8 * 1000} \qquad (1)$$

where:

BG = bales ginned during a given season
GR = rated ginning rate in bales per hour (bph)
0.8 = fraction corresponding to the equipment efficiency
1000 = hours of operation without downtime, corresponds to 100 %U

For example, if a gin rated at 30 bph gins at 100 %U, it would gin 24,000 bales (30*0.8*1000). If a gin is operating at 50 %U, then the gin is processing cotton for 500 hours regardless of the size of gin (Parnell et al., 2005a; 2006a).

Table 1. Optimal season lengths for each gin rating category found by Emsoff (2007).

Optimal Season Length in Terms of %U		
Category	Rating	Opt. %U
I	<15	170%
II	15-25	180%
III	25-40	190%
IV	>40	200%

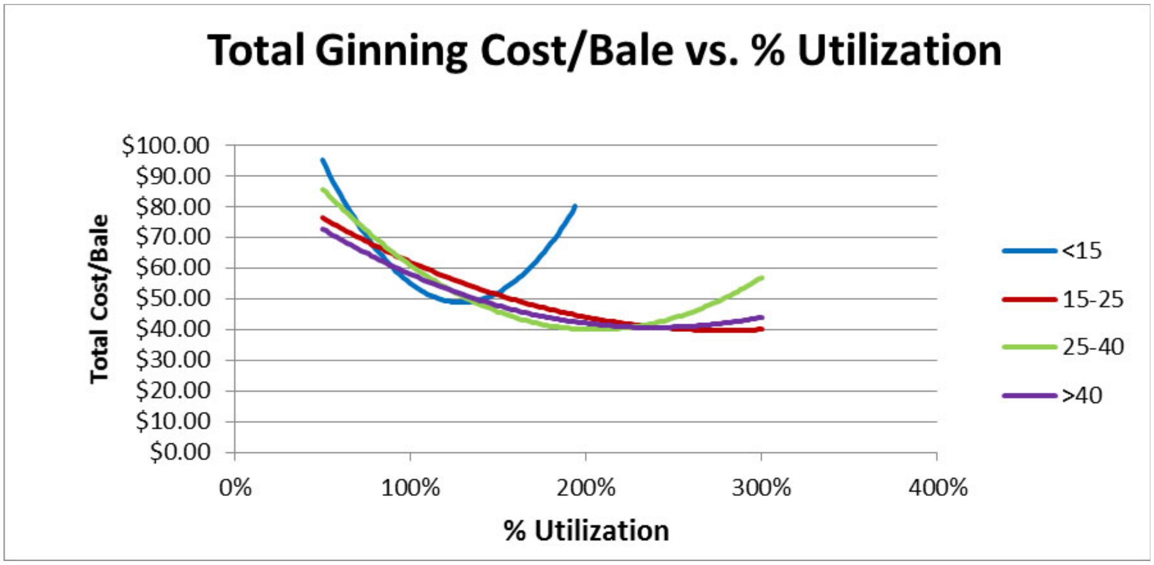

Figure 1. Percent utilization and predicted total cost per bale for four categories of rated gin capacities.

In many cases, seed cotton would have to be transported further distances from the turn row to the gin yard to reach a goal of 200 percent utilization. Increased one-way distances would result in higher total transportation cost that could potentially supersede any savings realized in the ginning side of the operation. In order to help producers and ginners make decisions about transportation and expanding the area served by a gin, a decision support software Package (DSS) was developed to aid in management decisions regarding the overall benefit or detriment that increasing the number of bales ginned or transporting seed cotton modules further distances would have on the overall cost of ginning if neighboring gins did not open their doors during a given season. Since the initial release of the DSS it has undergone an update and changes that allows the user to better tailor the output to their particular operation. A sample summary output of the DSS is shown in Figure 2.

Cotton Transport Simulation Model

Summary Sheet

Scenario 1		**Scenario 2**	
Fixed Cost/Bale	$ 19.31	Fixed Cost/Bale	$ 17.00
Variable cost/Bale	$ 25.00	Variable cost/Bale	$ 25.00
Total Ginning Cost/Bale	$ 44.31	Total Ginning Cost/Bale	$ 42.00
Transport Cost/Bale	$ 10.28	Transport Cost/Bale	$ 11.08
Sum of Costs/bale	$ 54.59	**Sum of Costs/bale**	$ 53.08
% Utilization	175%	% Utilization	200%

By operating using Scenario 2 you will operate at a predicted $1.51 less per bale for all bales ginned throughout the season.

Figure 2. Summary output of decision support software.

Goals and Objectives of Decision Support Software

The goal of this research is to assist the cotton industry, specifically cotton gins, by developing simulation models and incorporating them into decision support software that can be easily used by the gin manager or producer. The goal of the software is to provide answers for questions such as the following:

1. What would be the ginning cost per bale if I were to increase my ginning rate?
2. What effect does transporting modules further distances have on the cost of ginning per bale?
3. Can I extend the gin season by taking more seed cotton to gin and see a reduction in ginning cost per bale?
4. Will increased transportation distances create excess downtime due to lack of modules on the yard?

Materials and Methods

The decision support software incorporates models that can provide useful information pertaining to the cost of transportation but lacks the capability to calculate information on whether or not the transportation system employed by the gin will be sufficient to maintain a sufficient module inventory level on the gin yard. If the gin lacks inventory on the yard to meet the processing capacity, the gin will experience downtime. Increased downtime within the ginning operation will increase the cost per bale, possibly eliminating any savings realized by processing more seed cotton.

For instance, a 60 bph gin will require 5 modules per hour, or 120 modules per day. If the beginning inventory on the gin yard at the beginning of each day plus the arrival rate of modules is not sufficient to meet the processing demand of the gin, then there will be downtime within the system. Through the use of data generated by simulation, models can be developed to incorporate into the DSS that will provide information to gin managers about what the effect of changes on their operation will be from year to year.

A cooperating gin located in the southern high plains of Texas that processes primarily stripper harvested cotton provided data from the 2012-2013 ginning season that was used to build the baseline distributions that were used in the Monte Carlo simulations. The cooperating gin had a rating of 70 bales per hour and operates at or near 200 percent utilization, or 110,000 bales per season. During the 2012 season this gin was operating at 175 percent utilization and ginned 98,000 bales. Parameters to be incorporated from the gin data were: the number of modules called in each day, average distance to modules, and the average ginning rate each day. This is data that most gins collect and have readily available. Figures 4, 5, and 6 are the frequency distributions of data from the cooperating gin.

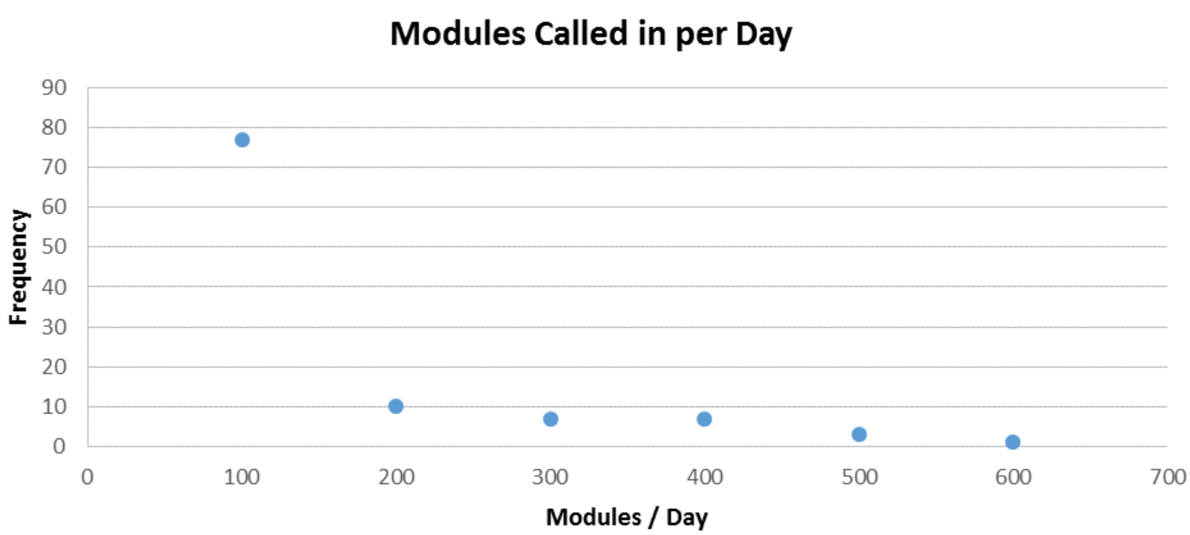

Figure 3. Frequency distribution showing the number of modules called in each day at the cooperating gin.

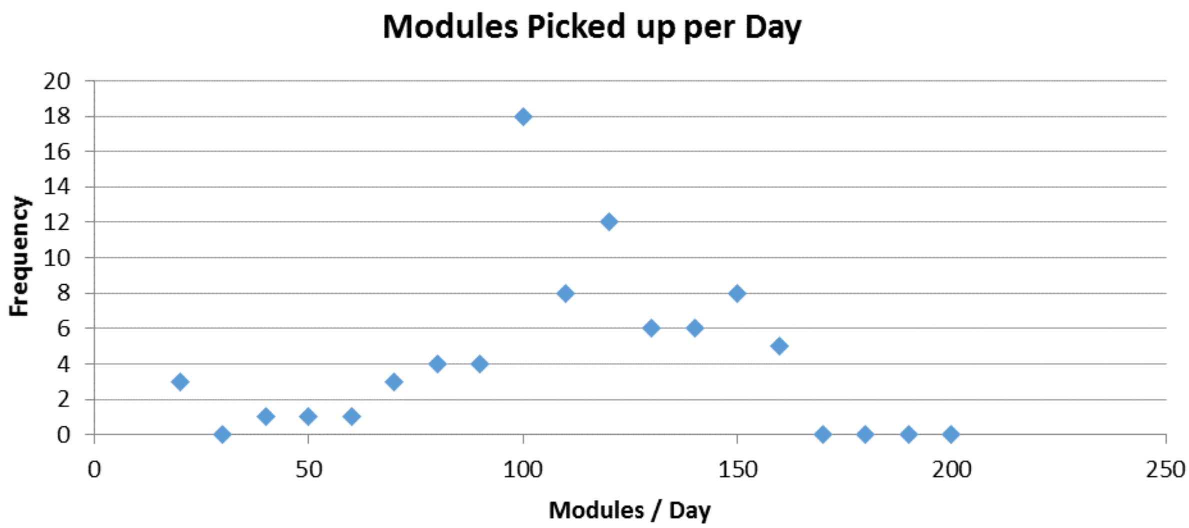

Figure 4. Frequency distribution showing the number of modules picked up and delivered to the gin yard each day at the cooperating gin.

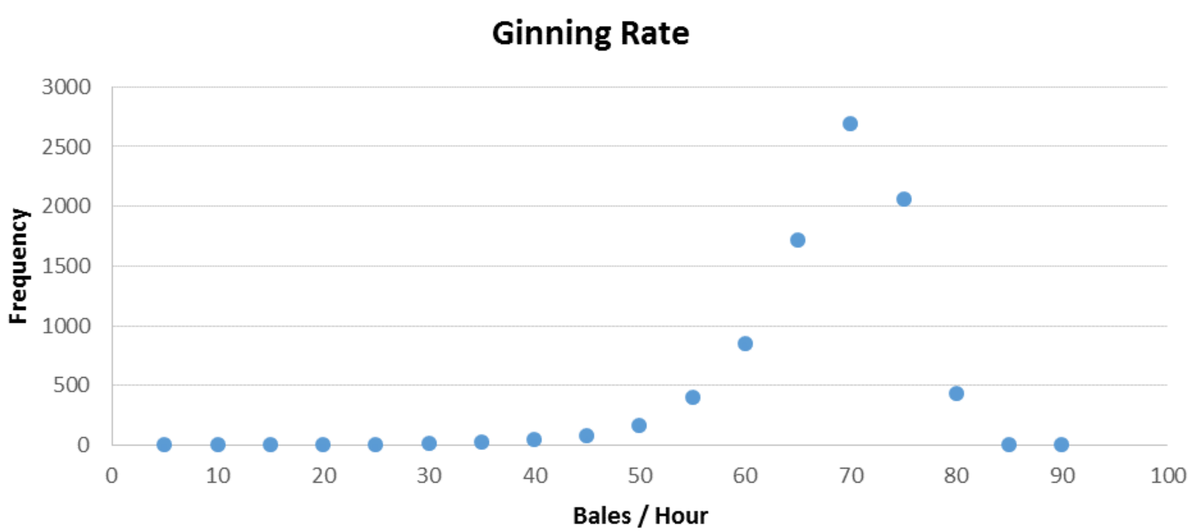

Figure 5. Frequency distribution showing the processing rate at the gin in bales per hour at the cooperating gin.

The cost of downtime was calculated as the cost incurred while not processing seed cotton; in this simulation it does not represent lost revenue. Thus, the simulated ginning rate times the hourly cost to gin. Equation 2 shows and example cost of downtime calculation.

$$COST_{DT} = bph\ x\ TGC/bale\ x HOURS_{DT} \qquad (2)$$

where:

$COST_{DT}$= total cost incurred due to downtime
bph = simulated bales per hour
TGC/bale = total cost to gin a single bale
$HOURS_{DT}$ = numbers of hours downtime due to module shortage

Using empirical data collected from a cooperating gin, continuous distributions were developed to simulate independent variable that effect to module inventory available at the gin. The distributions developed were used to simulate the baseline scenario.

Subsequent simulations were performed after varying three factors: 1) % utilization the gin is operating at; 2) one-way distance to modules; and 3) number of available module trucks.

In total, five scenarios were simulated: 1) baseline; 2) increased % utilization; 3) increased average distance; 4) increased average distance and increased % utilization; and 5) increased average distance, increased % utilization, and increased number of trucks.

Results and Discussion

Ten replications of each scenario were made using the Monte Carlo Simulation package developed to evaluate seed cotton module transportation and storage systems. The results are shown in tables 2, 3,4,5,6 and figures 7,8,9,10,11.

Baseline

Table 2. Averages of data generated from 10 trials of scenario 1.

Gin Rating	70.00	Days to Wait before ginning	7.00
% Utilization	175.00%	Average Distance To Modules	24.94
Bales/Module	12.00	Cost of Downtime	2400.00
Total Modules Needed	8166.67	Average Downtime Hours	0.00
Max	8228.60	Average Downtime Cost	0.00
Max Storage Available	2500.00	Average Trucks Available	8.50
		Max Inventory level	1199.30
		Days Transporting	87.60
		Days Ginning	93.30

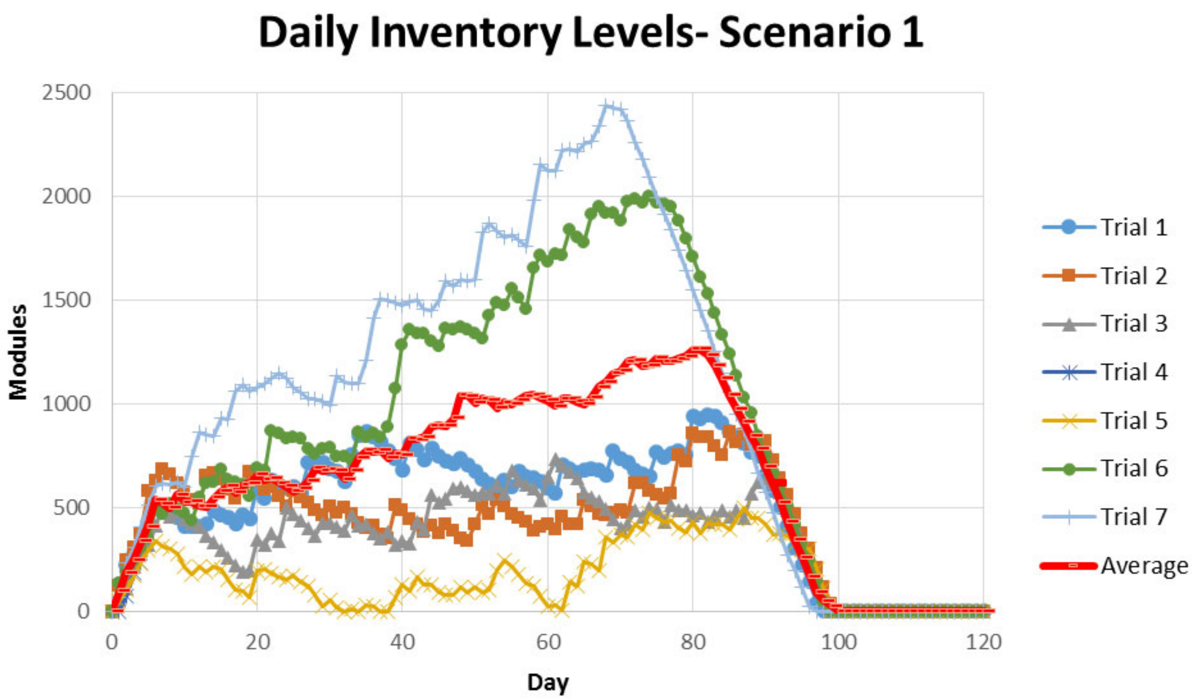

Figure 6. Daily ending inventory of trial 1-10 of scenario 1.

Increased % Utilization

Table 3. Averages of data generated from 10 trials of scenario 2.

Gin Rating	70.00	Days to Wait before ginning	7.00
% Utilization	200.00%	Average Distance To Modules	32.26
Bales/Module	12.00	Cost of Downtime	2400.00
Total Modules Needed	9333.33	Average Downtime Hours	418.04
Max	9397.00	Average Downtime Cost	1003292.28
Max Storage Available	2500.00	Average Trucks Available	8.51
		Max Inventory level	742.76
		Days Transporting	115.50
		Days Ginning	115.00

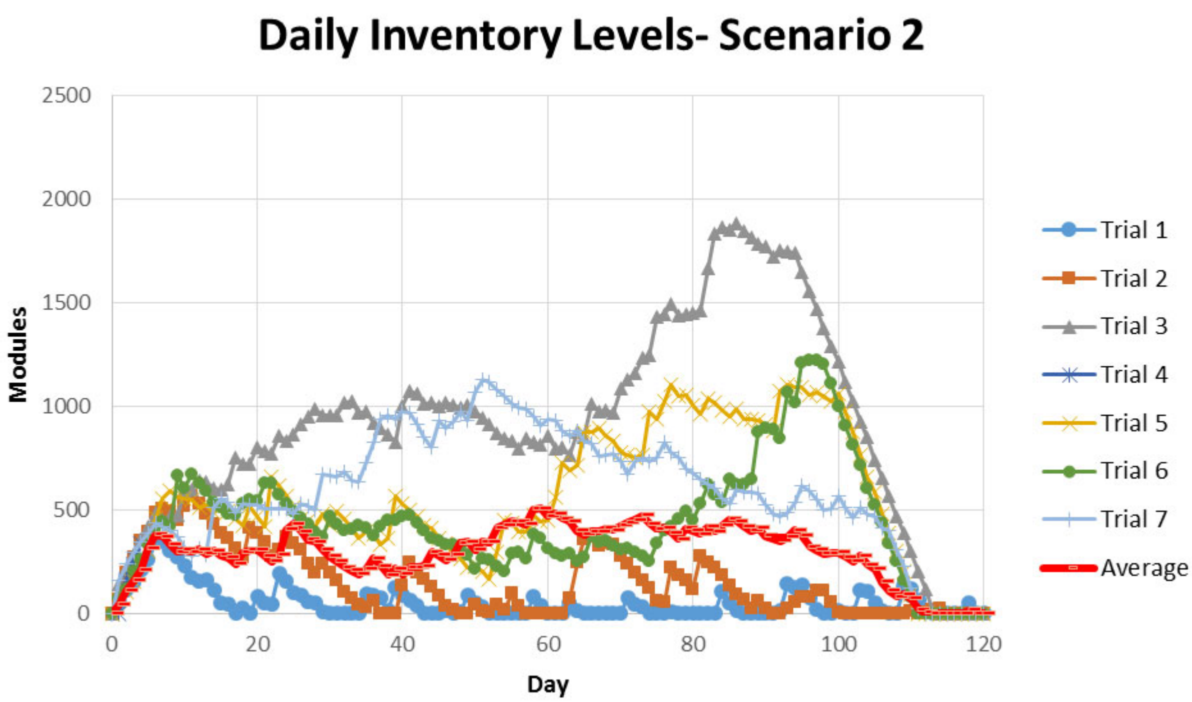

Figure 7. Daily ending inventory of trial 1-10 of scenario 2.

Increased Average Distance

Table 4. Averages of data generated from 10 trials of scenario 3.

Gin Rating	70.00		Days to Wait before ginning	7.00
% Utilization	175.00%		Average Distance To Modules	41.75
Bales/Module	12.00		Cost of Downtime	2400.00
Total Modules Needed	8166.67		Average Downtime Hours	519.05
Max	8233.10		Average Downtime Cost	1245730.61
Max Storage Available	2500.00		Average Trucks Available	8.51
			Max Inventory level	359.70
			Days Transporting	124.70
			Days Ginning	119.40

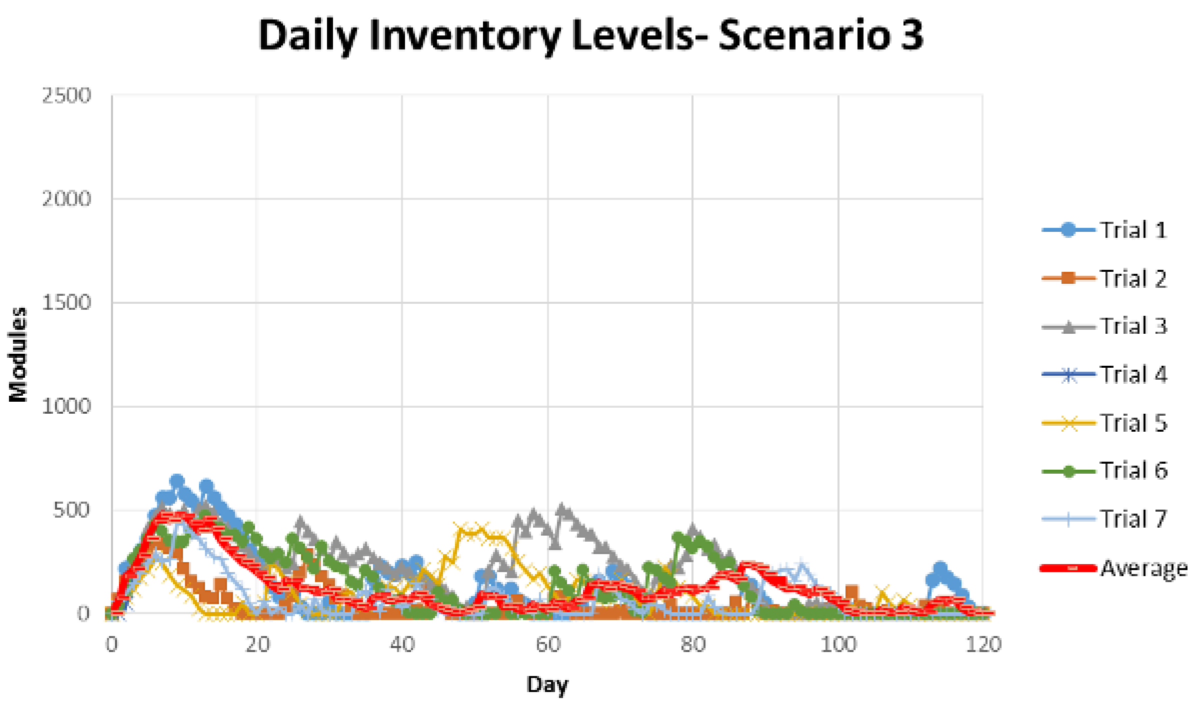

Figure 8. Daily ending inventory of trial 1-10 of scenario 3.

Increased %U and Average Distance

Table 5. Averages of data generated from 10 trials of scenario 4.

Gin Rating	70.00		Days to Wait before ginning	7.00
% Utilization	175.00%		Average Distance To Modules	42.20
Bales/Module	12.00		Cost of Downtime	2400.00
Total Modules Needed	8166.67		Average Downtime Hours	387.17
Max	8242.70		Average Downtime Cost	929209.06
Max Storage Available	2500.00		Average Trucks Available	8.51
			Max Inventory level	584.81
			Days Transporting	117.60
			Days Ginning	112.50

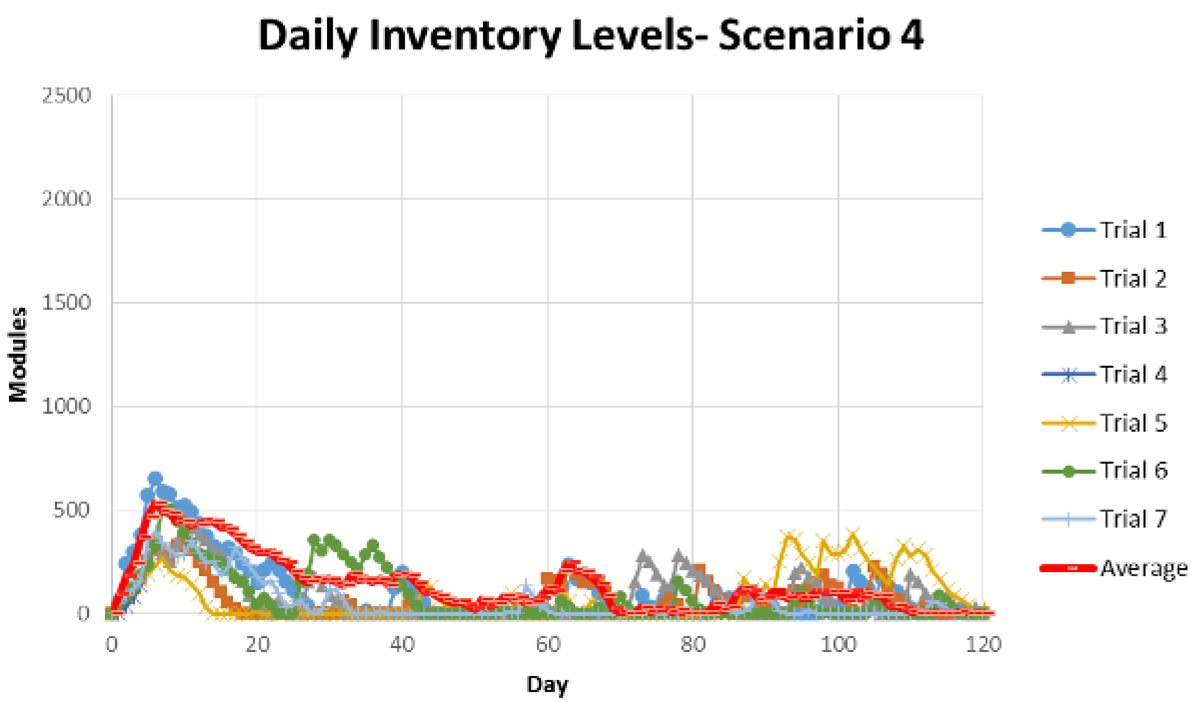

Figure 9. Daily ending inventory of trial 1-10 of scenario 4

Increased Average Distance, Increased % Utilization, and Increased number of Trucks

Table 6. Averages of data generated from 10 trials of scenario 5.

Gin Rating	70.00	Days to Wait before ginning	7.00
% Utilization	200.00%	Average Distance To Modules	42.05
Bales/Module	12.00	Cost of Downtime	2400.00
Total Modules Needed	9333.33	Average Downtime Hours	146.80
Max	9399.00	Average Downtime Cost	352329.19
Max Storage Available	2500.00	Average Trucks Available	12.35
		Max Inventory level	1836.43
		Days Transporting	95.30
		Days Ginning	107.50

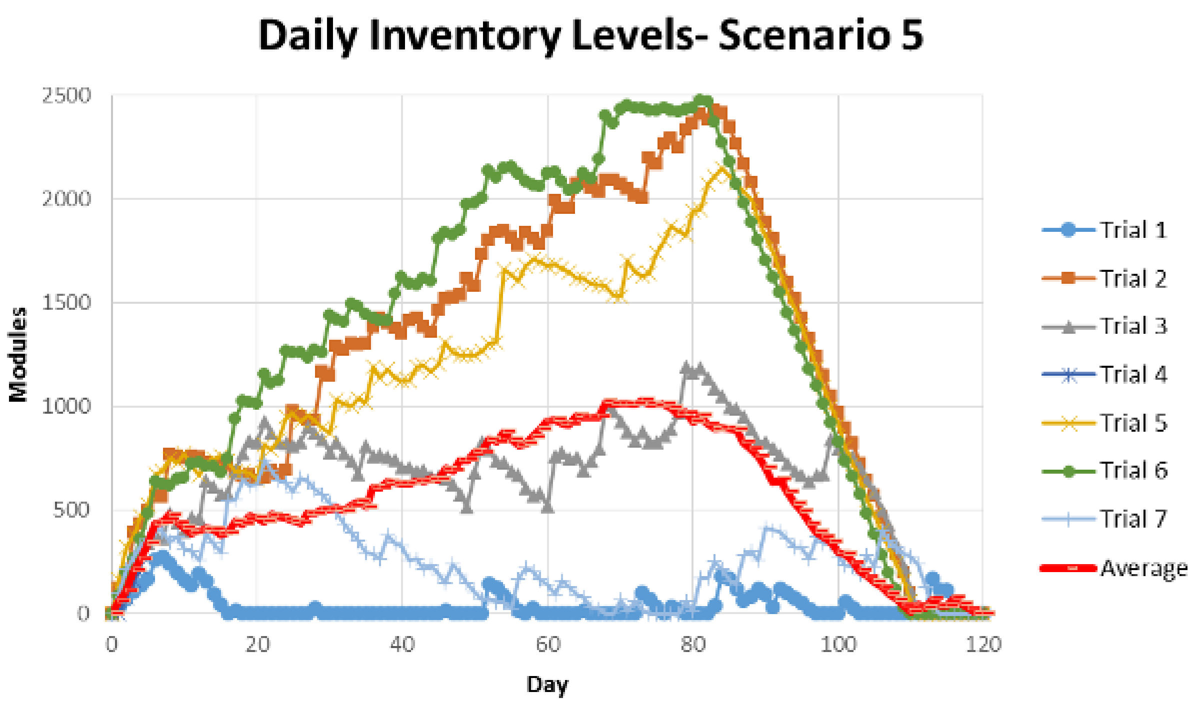

Figure 10. Daily ending inventory of trial 1-10 of scenario 5.

Summary

A simulation package was developed to represent the transportation system used by a cotton gin. Demonstrated in this paper was the ability to vary different operational aspects stochastically to collect data that will assist with future model development. Data that most gins have on hand can be used to build a baseline for each of the four rated gin capacity categories.

This simulation will be used in future work to generate data for a model that can be incorporated in a decision support software package to provide data that will assist cotton gin managers and producers in making operational changes.

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