Systems Analysis – Cotton Ginning and Seed Cotton Transport

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Abstract

Introduction

Cotton producers in the United States (U.S.) produce, harvest, and process approximately 18 million bales of cotton per year of the world-wide production of 100 million bales. We have evolved from hand-harvesting to machine harvesting, placing cotton in modules rather than trailers, storing modules on the turn-row and transporting cotton modules to gins with module trucks. Agricultural engineers have played major roles in the development of the current system. Faculty in the Texas A&M University (TAMU), Department of Biological and Agricultural Engineering (BAEN) have led the efforts to advance technology for handling, storage, and preservation of lint and seed quality from the harvesting point through the gin. Professor Emeritus Lambert Wilkes (Wilkes et al, 1974) is credited with developing the 'module builder' method of seed cotton handling and storage with funding from Cotton Incorporated in the early 1970s. Approximately 90% of all cotton produced in the U.S. today is placed in 10 to 16 bale modules. The module system of handling seed cotton is credited by some as the primary reason we have far fewer cotton gins operating today. Although we have fewer gins we have maintained producer's option of producing cotton at a level that is relatively constant or increasing. (See Figure 1.)

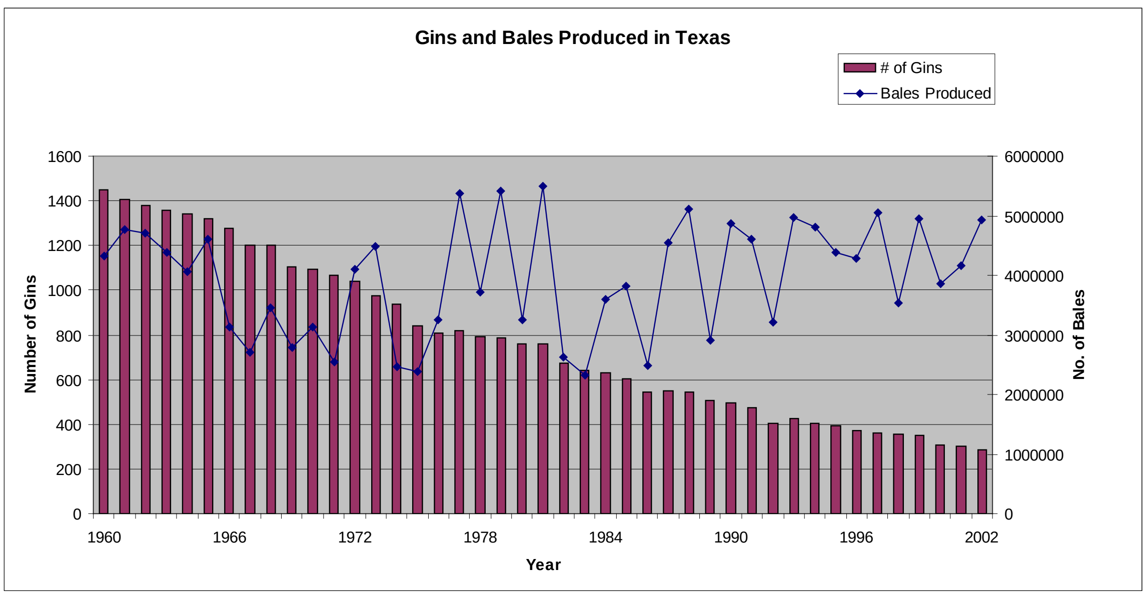


Figure1: Number of operating gins and cotton production in bales from 1961 through 2003 in Texas. ***(Parnell, et al., 2004)***

In Texas alone, gin numbers since 1960 have plummeted from close to 1,400 to less than 280 active gins in the 2004 ginning season (figure 1). The number of operating gins for cotton producing states in the U.S. followed similar declining trends. Regression results with number of Texas active gins as a function of time from 1983 to 2003 suggests than there will be no operating gins in 2018 (R^2 value 0.98). Of course this will not happen. From Figure 1, it is evident that Texas production numbers are remaining steady and even increasing slightly at around 5 million bales. It is anticipated that there will a production of 7 million bales in this state this year (2004/2005).

The reduction in number of operating gins across the cotton belt as demonstrated with Texas data, suggest that gins will either increase their respective ginning rates, increase the length of the ginning season, transport seed cotton longer distances from the turn-row to the gin storage site, or adopt a combination of all of these scenarios.

Transportation of modules over longer distances and transporting along the Dwight D. Eisenhower System of Interstate and Defense Highways (Interstate System) now becomes critical. Currently, seed cotton module transportation trucks, when loaded with a module, exceed the federal requirement of 34,000 pound tandem-axle weight limit. Drivers for gins must not use the Interstate System when transporting modules from the field to the gin. For those gins located near Interstate System roads, owners have experienced large fuel and maintenance costs due to longer return-trips along (lesser load-bearing) Farm-to-Market, county or state roads. Costs could be reduced significantly by establishing a different transportation method that would keep axle weight within requirements and allow the use of the Interstate System. It has been suggested that operating hours per day of less than 24-hours and longer ginning seasons (6 to 9 months) may provide significant reductions in ginning costs.

It is assumed that the goal of any new paradigm of harvesting/ginning will have the following priorities:

1. Maintain the option of producing cotton at levels of 5 million bales per year for Texas and 18 million bales per year nationally.
2. With the increasing speed associated with harvesting, it is assumed that producers will want to harvest their cotton crops as quickly as possible and place their cotton in modules. This priority presumes that the quality losses associated with weathering of cotton in bolls far exceed quality losses with seed cotton in modules.

The ginning rates for the newer gins have progressed to the point that a number of cotton gins can process 60 bales-per-hour (bph). This rate of ginning will result in a 500-pound bale from the bale press every minute. One ginner has indicated a possible expansion to 90 bph. (This will likely require two presses.)

Goals and Objectives:

The goal of this study is to develop a mathematical (system) model of the ginning industry that can be used to provide answers to the following questions such as the following:

1. How many gins are needed in each production area?
2. Is there a more efficient work schedule for cotton ginning than 24-hours per day, 7-days per week?
3. Can we "farm out" a portion of the cotton dedicated to one gin that may be exceeding be 200% utilization to another having a commitment of less than 100% utilization and provide a more efficient harvesting/ginning system?
4. Is there a process that can be used to partially pay producers for the cotton in modules that may not be ginned for 4-6 months after harvesting?
5. How far can gins travel to acquire modules for ginning before it is too costly? On what basis will this decision be made?
6. Can we develop an alternative for module mover trucks that will satisfy transportation limitations for axle loadings?

The research goals are as follows:

1) Formulate practical scenarios for a new seed cotton handling, storage and ginning system that would result in extended ginning seasons and cost reductions. The issues addressed would include (a) the optimum gin size (ginning rate) (b) optimum ginning season, (c) maximize energy savings (operating off-peak), (d) maximize labor savings, (e) minimize insurance costs, and (f) minimize gin equipment maintenance costs. The evaluations will be made using Monte Carlo simulations.
2) Formulate feasible seed cotton transport systems that could be implemented in Texas with the gin service area expanded to 100 and 150 miles.
    a) Study use of semi-tractor trailers (STT), or other system, for moving seed cotton modules from the farm to long-term storage locations near a gin with simulations.
    b) Develop a method of loading and unloading seed cotton modules into STT, or other system, and demonstrate the feasibility of this method on model systems.

Systems Model Structure

Historically, cotton was ginned as quickly as possible so that producers could sell their lint and seed. In addition, the fiber and seed quality losses are stopped when the seed cotton is ginned. As the number of active gins decline, the option to process seed cotton upon delivery to the gin does not exist. Hence, a new harvesting, seed cotton storage, and ginning management system will be adopted in the future. The structure of our proposed model can be described as follows:

- A cotton gin rated at 'R' bales-per-hour (bph) will process seed cotton at a rate of 0.8*R bph.
- A cotton gin operating at 100% utilization will process 0.8*R*1000hours. In other words, 100% utilization corresponds to a 1000 hour season operating at 80% of the rated processing rate.
- Ginning costs will include variable and fixed costs.

Variable costs include (1) bagging and ties, (2) repairs, (3) drying, (4) electricity, and (5) labor. Variable costs increase and decrease with the number of bales ginned.

Fixed costs include (1) depreciation, (2) interest, (3) insurance, (4) taxes, and (5) management. Fixed costs typically are assumed to be independent of the number of bales ginned. The cost of transporting seed cotton from the turn-row to the storage location near the gin is calculated using the following equation (Simpson et al, 2004).

$$TC = \$60 + \$2 * X \quad (1)$$

TC = transportation costs, and
X= number of miles beyond 15 miles.

Transportation costs were not incorporated in this paper. It will be the subject of a future paper.

- The 'X' in equation 1 is dependent upon the probability distribution describing the distribution of cotton as a function of distance from the gin in the cotton gin's service area. At the current time, the following relatively simple distribution will likely be used.
    - For a gin operating at 100% utilization, 50% of the cotton is located inside a 15 mile radius defined by a uniform distribution. The remaining 50% is located at a distance that is defined by linear line from the peak of the uniform distribution to a distance equivalent to the remaining 50%.
    - For a gin operating at 200% utilization, a similar process will be used to define the distances with the assumption that the yield inside the 15 mile radius can approach a limit of the number of bales define by 200% utilization.

Ginning cost survey data (Valco et. al. 2003 and Valco 2004) were gathered for Texas ginning facilities. Procedures for estimating fixed and variable per bale costs were published by Fuller et al. (1993). The Valco data were arranged by gin category according to ginning rates. Variable costs were obtained in the survey or calculated from the data. The variable costs reported by Valco et al (2003) are the variable costs used in this paper. Fixed costs were calculated by the authors using assumptions and data provided in the Valco survey.

Results

The following results illustrate the procedures used to calculate variable and fixed costs using the data from the Valco survey. The ginning rate categories were as follows: (1) <10bph, (2) 10-15bph, (3) 15-25bph, (4) 25-35bph, and (5) >35bph.

Table1a. Fixed cost data for the 10-15bph data set. Data in columns 1-3 came from the Valco survey. Percentage utilization is calculated (0.8*bph*1000). % utilization is the ratio of the data in column 2 divided by the corresponding data in column 4. Hours per season is % utilization times 10 or the fraction of utilization multiplied times 1000 hours. Investment cost was approximated by 0.1 million * bph.

Gin	Bales per Season	Bales per hour-rated bph	Bales @ 100% util	% utilization	Hours per Season	Investment Cost $M
OK-4	1,412	10	8000	18	177	1.00
TX-11	14,471	12	9600	151	1507	1.20
TX-15	5,404	12	9600	56	563	1.20
TX-20	10,934	14	11200	98	976	1.40
TX-25	5,350	10	8000	67	669	1.00
TX-28	8,599	10	8000	107	1075	1.00
TX-32	13,404	11	8800	152	1523	1.10
TX-36	5,466	14	11200	49	488	1.40
TX-38	5,779	10	8000	72	722	1.00
TX-39	2,403	13	10400	23	231	1.30
TX-40	9,187	12	9600	96	957	1.20
TX-48	11,459	12	9600	119	1194	1.20
TX-54	6,436	11	8800	73	731	1.10
TX-57	3,095	12	9600	32	322	1.20
average	7,386	11.6	9314	80	795	1.2
min	1,412	10.0	8000	18	176	1.0
max	14,471	14.0	11200	152	1523	1.4

Table1b. Fixed cost data for the 10-15bph data set. Depreciation was calculated based upon 10-year life and zero salvage value. A 5% interest rate was used to calculate interest fixed cost. A 25% tax corporate tax rate was used based upon an assumed $5 per bale profit. Management fixed cost utilized the procedure described by Fuller et al (1993).

Gin	Deprec. $M	Interest $M	Insurance $	Taxes $	Manage $	Total Fixed $1,000	Total Fixed Per bale
OK-4	0.100	0.130	11824	1765	58000	$301.09	$213.24
TX-11	0.120	0.155	39742	18089	58000	$391.24	$27.04
TX-15	0.120	0.155	21608	6755	58000	$361.77	$66.94
TX-20	0.140	0..181	34468	13668	58000	$427.44	$39.09
TX-25	0.100	0.130	19700	6688	58000	$313.89	$58.67
TX-28	0.100	0.130	26198	10749	58000	$324.45	$37.73
TX-32	0.110	0.142	36708	16755	58000	$363.92	$27.15
TX-36	0.140	0.181	23532	6833	58000	$409.67	$74.95
TX-38	0.100	0.130	20558	7224	58000	$315.29	$54.56
TX-39	0.130	0.168	16506	3004	58000	$375.87	$156.42
TX-40	0.120	0.155	29174	11484	58000	$374.06	$40.72
TX-48	0.120	0.155	33718	14324	58000	$381.45	$33.29
TX-54	0.110	0.142	22772	8045	58000	$341.27	$53.03
TX-57	0.120	0.155	16990	3869	58000	$354.26	$114.46
average	0.12	0.151	25250	9232		360	71
min	0.10	0.130	11824	1765		301	27
max	0.14	0.181	39742	18089		427	213

Table2. Data in all columns came from the Valco (2003) survey. Missing data was estimated by using average values. Some data points were table outside of 3 standard deviations of the mean and were replaced with average values.

Gin	Bales per Season	GR bph -rated	Bagging &Ties $/bale	Repairs $/bale	Electricity $/bale	Drying $/bale	Labor $/bale	Total Variable $/bale
OK-4	1,412	10	8000	18	177	1.00	$5.29	$20.89
TX-11	14,471	12	9600	151	1507	1.20	$8.20	$22.57
TX-15	5,404	12	9600	56	563	1.20	$10.40	$20.55
TX-20	10,934	14	11200	98	976	1.40	$8.69	$23.04
TX-25	5,350	10	8000	67	669	1.00	$13.95	$28.54
TX-28	8,599	10	8000	107	1075	1.00	$5.74	$18.46
TX-32	13,404	11	8800	152	1523	1.10	$11.63	$25.54
TX-36	5,466	14	11200	49	488	1.40	$18.07	$32.95
TX-38	5,779	10	8000	72	722	1.00	$11.31	$27.55
TX-39	2,403	13	10400	23	231	1.30	$16.13	$32.89
TX-40	9,187	12	9600	96	957	1.20	$7.82	$19.54
TX-48	11,459	12	9600	119	1194	1.20	$7.15	$19.11
TX-54	6,436	11	8800	73	731	1.10	$5.63	$16.15
TX-57	3,095	12	9600	32	322	1.20	$20.46	$37.12
average	7,386	11.6	9314	80	795	1.2	$10.75	$24.64
min	1,412	10.0	8000	18	176	1.0	$5.29	$16.15
max	14,471	14.0	11200	152	1523	1.4	$20.46	$37.12

Table3. Summary of analysis of the variable, fixed, and total costs for the five ginning rate categories.

Ginning Rate Categories	Number of gins	Average Var cost	Average Fix Cost	Average Tot Cost	average % Util
<10 bph	11	25.00	34.00	59.00	88
10-15bph	14	25.00	40.00	65.00	80
15-25bph	21	20.00	31.00	51.00	120
25-35bph	14	21.00	31.00	52.00	107
>35bph	7	16.00	23.00	39.00	133
Average		21.40	31.80	53.20	

Figure 1: Gin facility numbers and production in thousand bales from 1961 through 2003, with regression of gin facilities from 1983 to 2003 and continuing to 2020.

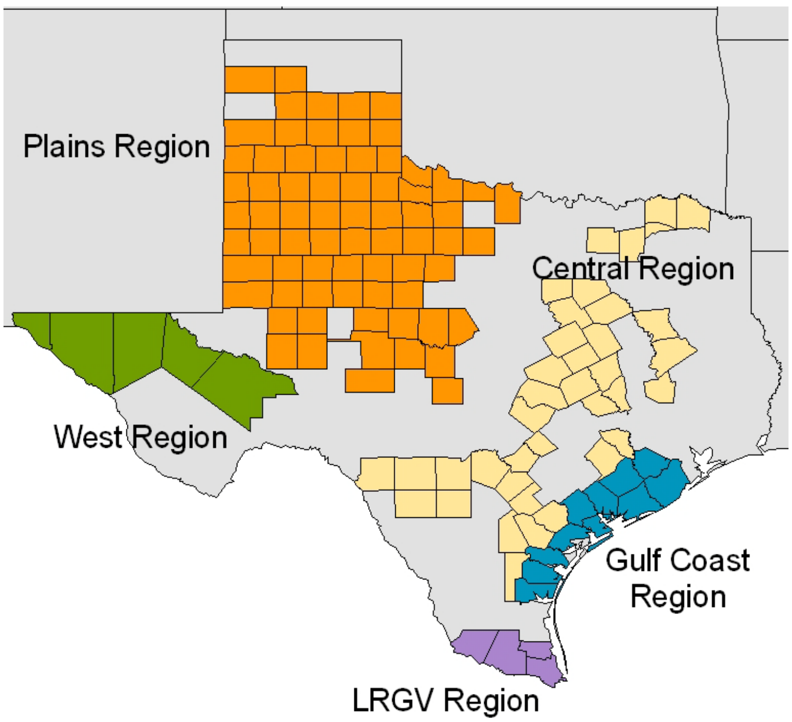
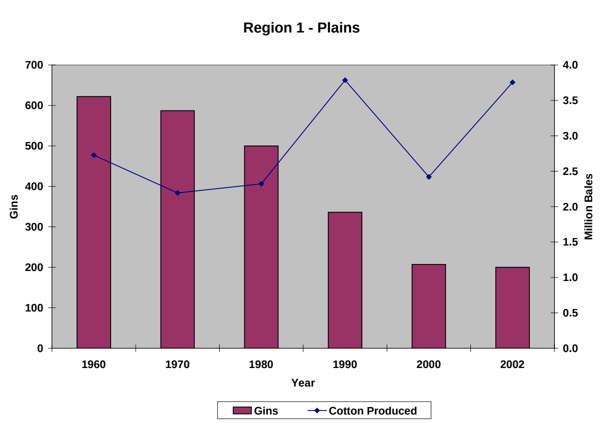
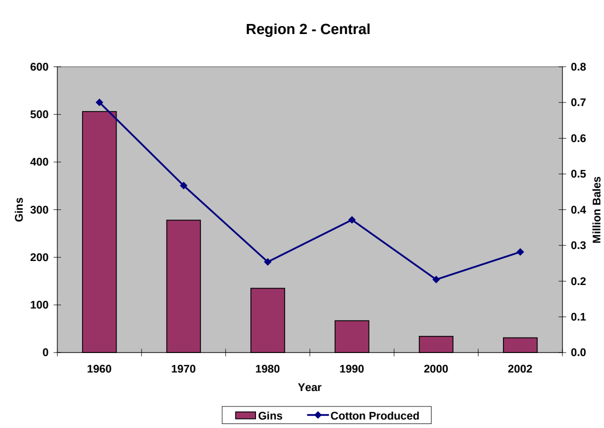


Figure 1: Five cotton production regions in Texas used for the TAMU, BAEN systems study.





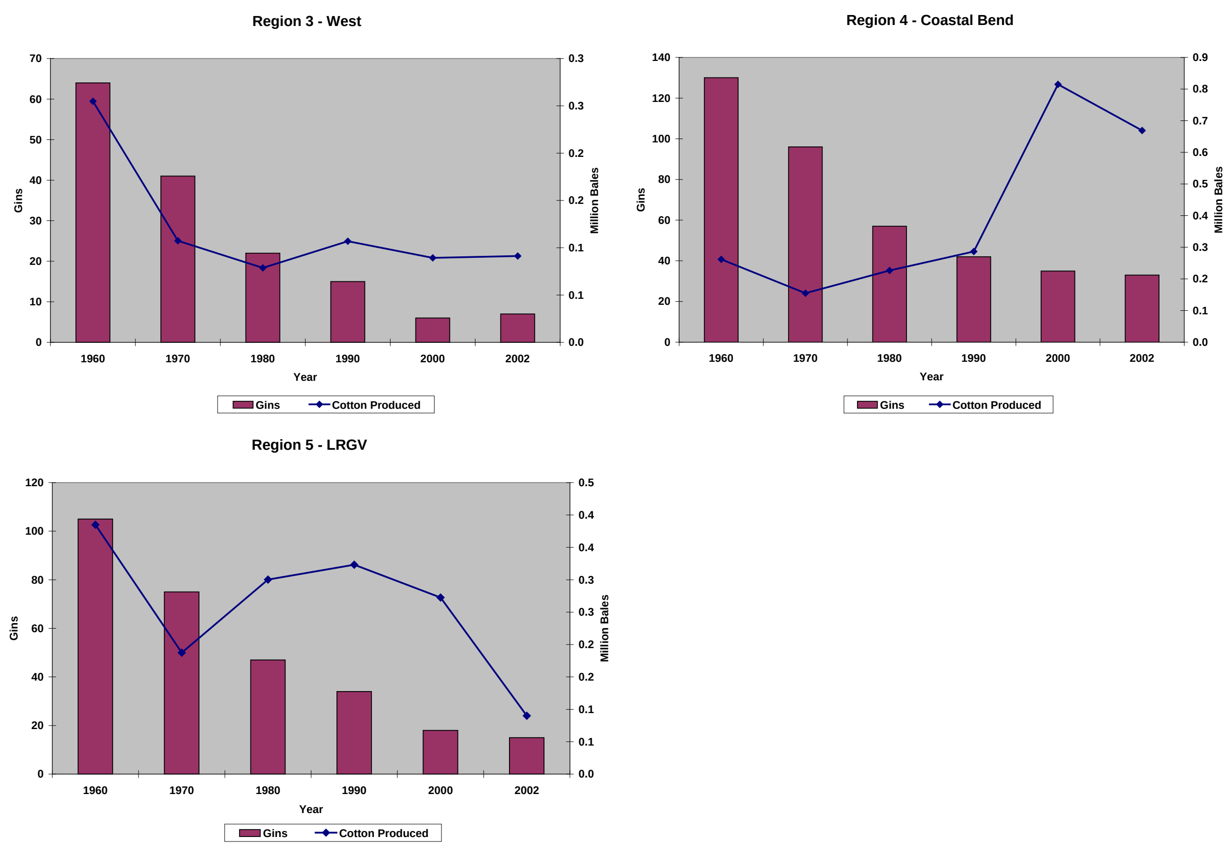


Figure 3 a-e: Regional trends of production and number of operating cotton gin facilities for each decade from 1960 to 2000 and 2002.

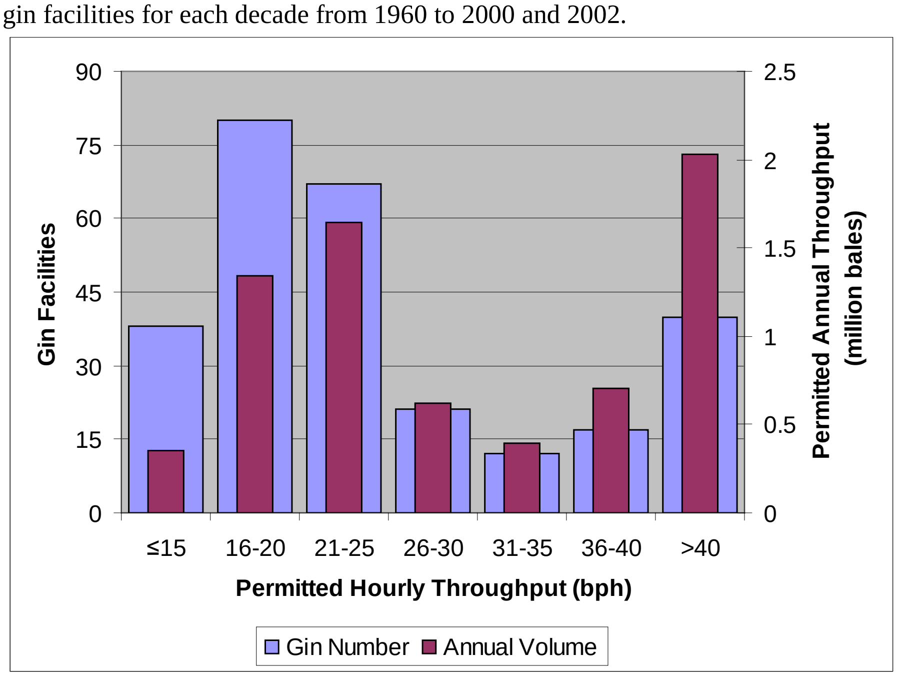


Figure 4. Number of gin facilities and annual throughput (ginning rate) of Texas gins obtained from the public record of air pollution permits submitted to the Texas Commission on Environmental Quality (TCEQ).

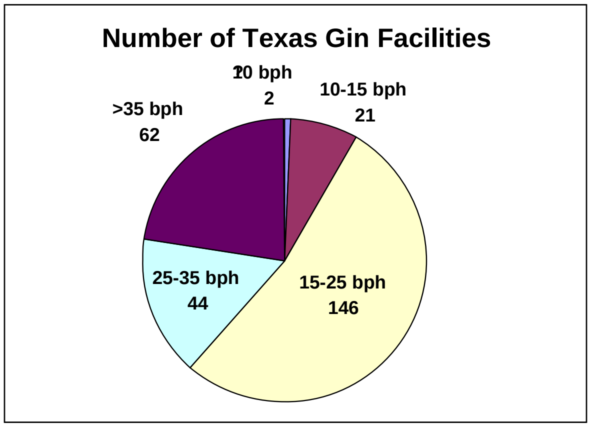


Figure4a. Number of operating Texas gins with ginning rates similar to the rates reported by Valco et al (2003).

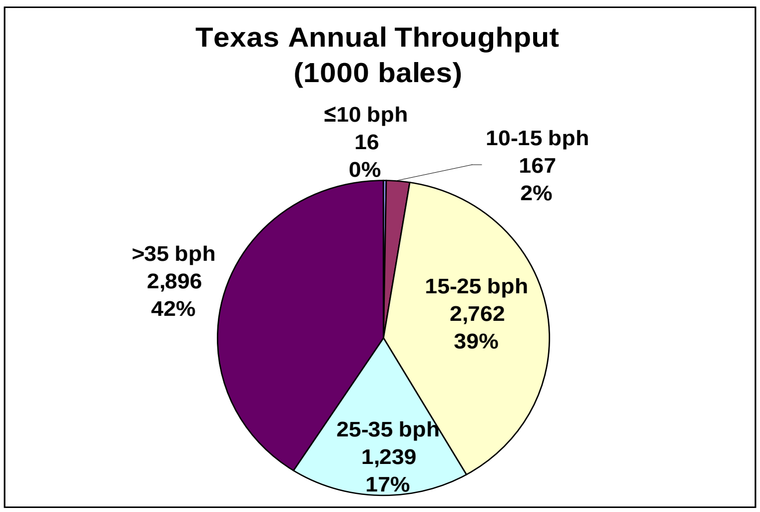


Figure4b. Annual throughput of cotton for Texas gins with ginning rates similar to the rates reported by Valco et al (2003).

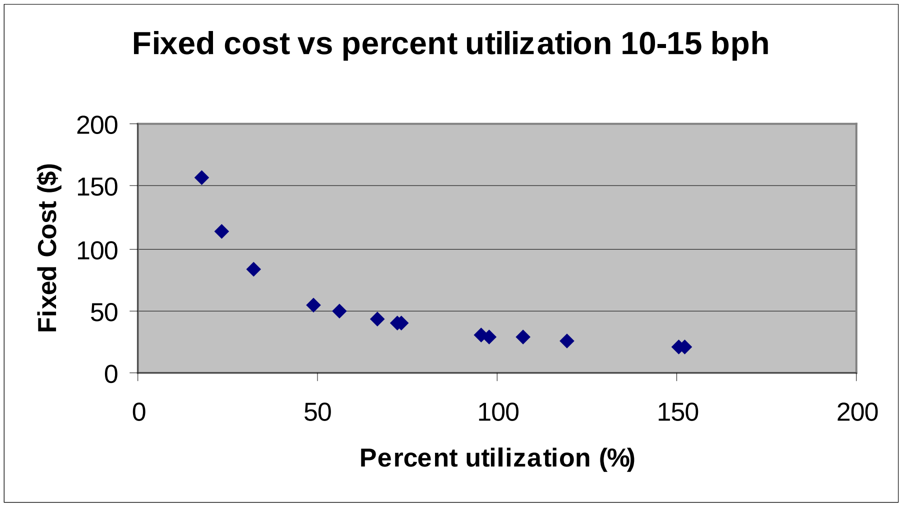


Figure5. Fixed costs versus percent utilization for the 10-15 bph
data in tables 1a and 1b.

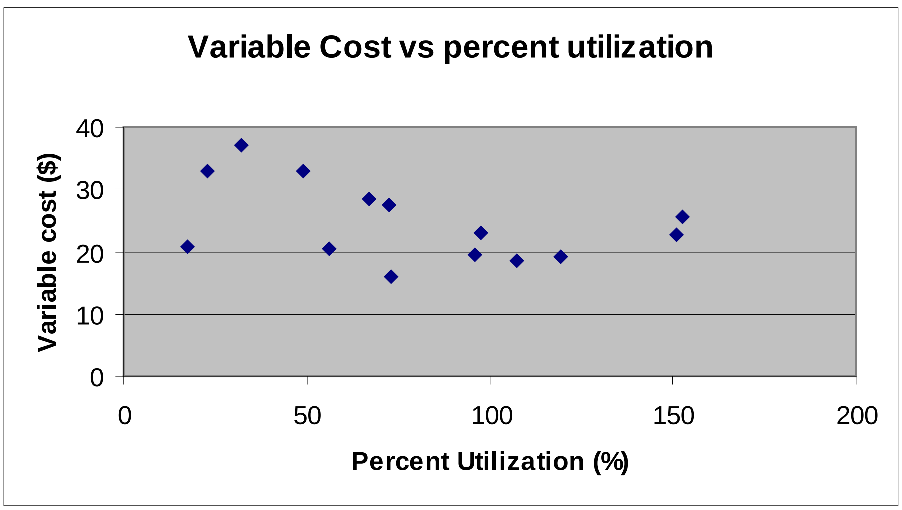


Figure6. Variable costs versus percent utilization for the 10-15 bph
data in table 2.

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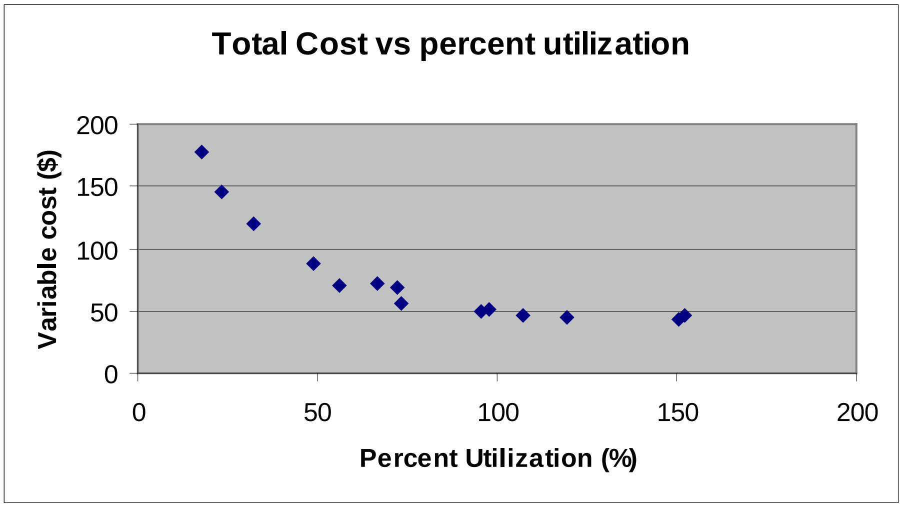

Figure7. Total costs (fixed plus variable) versus percent
utilization for the 10-15 bph data in tables 1a,1b, and 2.

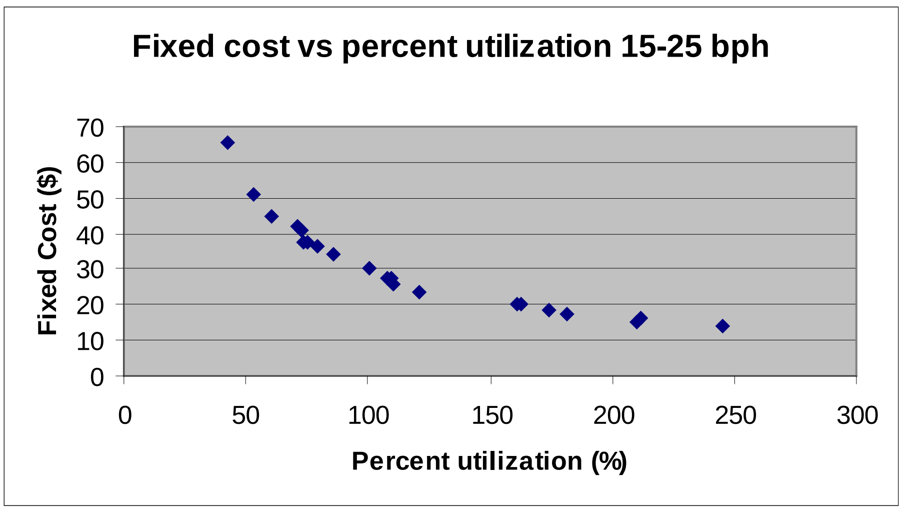

Figure8. Fixed costs versus percent utilization for the
15-25 bph data in tables 1a and 1b.

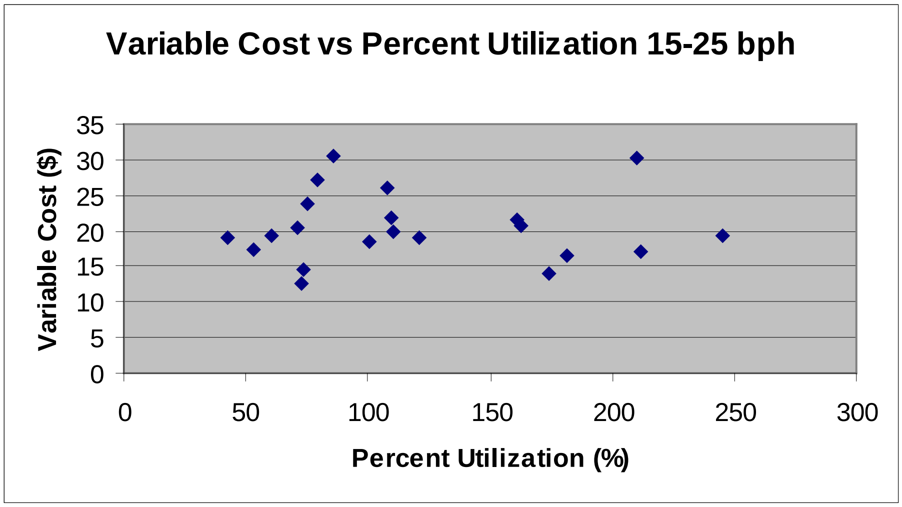

Figure9. Variable costs versus percent utilization for the
15-25 bph data in table 2.

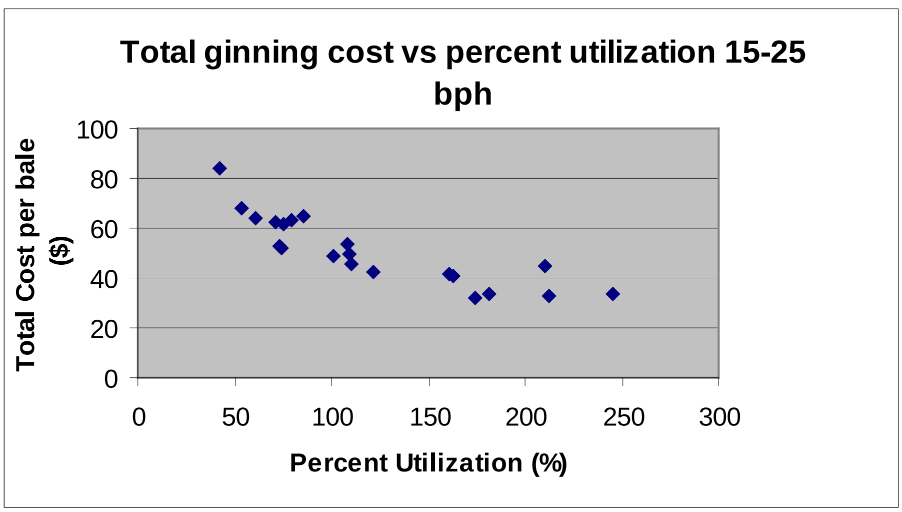

Figure10. Total costs (fixed plus variable) versus percent
utilization for the 10-15 bph data in tables 1a,1b, and 2.

Summary and Conclusions

Acknowledgments

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