ALABAMA COOPERATIVE Extension SYSTEM

ANR-1347

ALABAMA A&M AND AUBURN UNIVERSITIES

Logging Efficiency and Cost

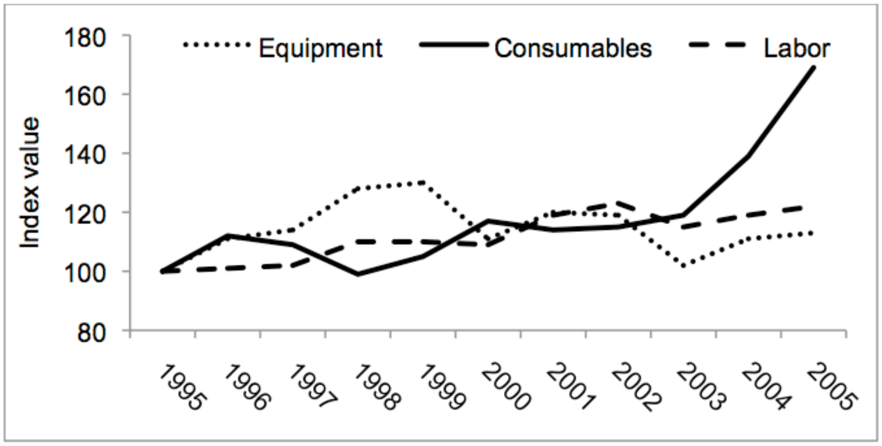

Figure 1. Logging cost indices for equipment, consumables, and labor
Data from Stuart, W. B., L. A. Grace, C. B. Altizer, and J. J. Smith. 2007. 2005 Logging cost index. http://www.fwrc.msstate.edu/pubs/WSRI-2005Final.pdf.

Productivity of logging operations increased steadily through the 1970s and 1980s as mechanized logging operations expanded to include most types of logging. Since the early 1990s, productivity growth slowed as few new technologies and methods were introduced and adopted in the United States. Also, during that time, logging has become a more complex business with the expansion of rules and regulations, the adoption of certification, and a more competitive marketplace for wood products.

As fully mechanized logging became widespread, a primary concern for cost control was efficient utilization of capital by optimizing equipment use. Increasing the system production per shift, week, or month lowers the capital, or fixed cost, per unit of operation. To achieve a balanced system, the contractor changes the operational system (machine kind and number) or operational method (technique) to maintain system balance and achieve high capital efficiency. The decline in fixed cost per ton (figure 1) has reduced the value of using fixed machine cost as a driving factor for system organization. The decline is due to a large number of factors such as delayed investment in machines to minimize capital costs and an increase in contracting to reduce capital cost and liability. This cost control was imperative due to the disparity between rising logging costs and decreasing logging contract rates over the past decade. Stagnant incomes, highly variable fuel costs, and rising labor costs have increased the complexity of effective cost control. Contractors need to develop methods to project cost and revenue in a way that provides a tool for planning and negotiation. Those methods should result in the development of performance measures that can be applied at the appropriate scale (e.g., tract, week, month, or year).

Performance measures that describe the system can be powerful tools to track changes over time and track progress and setbacks in response to system changes. The basic measures start at the machine level with utilization rate, operational efficiency, mechanical availability, and production rate. At the system level, important measures are production rate, production cost, labor productivity, and capital productivity. Performance measures can be used as benchmarks to determine the status of an operation. The benchmarks are carefully considered to ensure improvement in the system. A good set of performance measures and benchmarks is like a machine instrument cluster that helps the operator determine whether the system is operating correctly and where the problem areas might be.

Machine Measures

Operational Efficiency

Operational efficiency (OE) is the ratio of available working time to scheduled time. Increasing operational efficiency relies on control of operation downtime to the greatest extent possible. Move time, weather delays, inefficient communication, and indecision can all decrease operational efficiency. The dilemma is that many sources of delay are beyond the contractor's control. In addition, transportation delays may be due to actual or perceived cost savings in mill operations or mill inventory control.

The sources of operational delays are numerous. Table 1 identifies a number of reasons for delay or missed loads, the percent of total production missed as a result, and the frequency of the delay. The list provides a good guide for the relative importance of planning issues that could be addressed to improve operational efficiency. Relative rankings on this list would change due to season, geography, and market conditions.

Most of the sources in the table are directly or indirectly related to planning and scheduling. The remainder can be influenced by either planning or execution. Improvements in planning can be accomplished by establishing and achieving a number of planning benchmarks:

Acquire long-term plans from consumers for wood consumption and specification changes (12 months).

- Determine expected wood flow and harvesting conditions from known future harvests.
- Establish reasonable lead time to plan future harvests.
- Establish minimum known tract acreage and volume in the planning horizon (3 months).
- Communicate current tract status with wood buyers.
- Acquire written harvest plans for tracts.
- Insure adequate communication with customers and consumers.

Mechanical Availability

Mechanical availability (MA) of a machine is determined by the reliability of the components. Each component has a mean time between failures (MTBF) and a mean time to repair (MTTR). The reliability of the whole machine is determined by the reliability of each of the components (if one fails the whole machine stops). If each of five component systems took 5 hours (MTTR) to repair every 495 hours (MTBF), the reliability of the systems would be 99 percent (495/500) and the mechanical availability would be $0.99 \times 0.99 \times 0.99 \times 0.99 \times 0.99$, or 95 percent. There are relatively little public data on the reliability and mechanical availability of machines. A survey of operators of CTL harvesters found machines had mechanical availability of about 78 percent for fixed heads and 82 percent for dangle heads. Older reviews from the 1970s estimate mechanical availability between 75 and 85 percent. Improvements in manufacturing and design have likely improved mechanical availability significantly since then.

Utilization Rate

The utilization rate (UR) is the ratio of time available for production (considering time lost in mechanical and operational delay) to total scheduled time. Many basic references on machine production indicate that estimates for utilization rate range from 65 to 75 percent. Even so, general estimates aren't valid since operational factors are so important. Both components of UR are under some control of the contractor through the purchase of new equipment, preventative maintenance, and system management and planning. The full range of estimates could be from quite low (40 percent)

Table 1. Delay Sources: Frequency and Impact on Average Firm Production

Source	Loads (% missed)	Frequency (%)
Weather: roads, woods	5	26
Planning: stumpage, access, harvest plan, equipment, trucking	4	22
Market: quota, mill closed, mill handling	3	38
Mechanical: scheduled, unscheduled	2	22
Stand and tract issues	2	12
Labor	1	15
Vacation	1	6
Regulations	<1	1
Total	**18**	**100**

Data from Greene, W. D. et al., 2004. Causes and costs of unused logging capacity in the southern United States and Maine. *Forest Products Journal 54*(5):29-37 to quite high (85 percent). Utilization rate is the primary indicator of whether resources (machines and labor) are fully utilized. Solving problems with lower-than-expected UR requires close examination of mechanical availability and operational efficiency.

A benchmark utilization rate can be set using an approach such as the one in table 2. The approach is based on a typical timber sale to calculate the effect of moving time on UR and OE. Scheduled and unscheduled mechanical downtimes and operational delays are calculated as a proportion of machine hours. Scheduled machine hours (SMH) are defined as total scheduled operator time per day, per harvest, or per year. The productive machine hours (PMH) equals SMH multiplied by UR.

As OE and MA get smaller, it is more likely that the time spent in repair might overlap time spent waiting for trucks or moving. For example, if the loader broke down on Friday, the operator might have run out of quota after one more load anyway.

The maximum utilization rate possible is the rate that could be achieved if each machine were working independently. The situation is commonly referred to as cold (versus hot) operations where the next operation processes or transports logs from log storage. As long as buffers are not exhausted, machines can operate at the maximum utilization rate. In hot logging, where buffers are minimal or absent, the slowest production rate sets the production rate of the operation. In table 2, the maximum UR required reflects that skidding sets the overall production rate since the maximum UR required equals the maximum UR possible. Any additional delays in skidding would reduce the UR of the other machines. The limit on productivity in the skidding function adds operational delay to the other machines. The change decreases operational efficiency of the feller buncher and loader to 71 percent and 75 percent, respectively. The loader and feller buncher could suffer lower mechanical availability with little effect on system production.

Production Rate

The system production rate is often an obvious number when evaluated on a daily or weekly basis. While loads or tons per day or per week are an indicator of the production rate, that estimate does not lend itself to analysis. The production rate for a machine should be in weight or volume/PMH.

Table 2. Estimated Operational Efficiency, Mechanical Availability, and Utilization Rate for a Three-Machine Harvesting System

Item	Formula	Skidder	Feller buncher	Loader
Production (tons/PMH)	A	28	40	35
Sale size (tons)	B	3000		
Minimum hrs/sale	C = B/A	107	75	86
Move and prep hrs/sale	D	5	3	5
Scheduled maintenance (hr/hr)	E	0.05	0.05	0.05
Unscheduled maintenance (hr/hr)	F	0.05	0.1	0.05
Operational delay (hr/hr)	G	0.05	0.05	0.1
Delay overlap %	H	0%	0%	0%
Total loss (hr/hr)	**I = (E+F+G)*(1-H)**	**0.15**	**0.2**	**0.2**
Minimum scheduled hrs	J = C*(1+I)+D	128	93	108
Maximum UR possible	K = C/J	84%	81%	79%
Mechanical availability	L = 1-(((E+F)*C)/J)	92%	88%	92%
Maximum operational efficiency	M = 1-((G*C+D)/J)	92%	93%	87%
Maximum UR required	N = C/maximum of J	84%	58%	67%
Observed operational efficiency	M = 1-(L-N)	92%	71%	75%

Production could be estimated at a gross level (annual production/ annual PMH). The finest level for production estimates would be the at the harvest or tract level (tract volume/tract PMH).

There are a few tools or production models available to estimate machine production given certain stand and machine attributes. On occasion, these models are incorporated into computer models. The USDA Forest Service Operations Work Unit maintains references and links to many of these models (see http://www.srs.fs.usda.gov/forestops/home.htm). In general, the models should be used with caution because they are often based on older equipment, include limited range of conditions, or are heavily influenced by specific operators and systems. Contractors tracking their own production over a range of conditions can develop estimates that are better than most models.

System Variables

System Cost

The total system cost includes labor, overhead, transportation, contractor payments, consumables, and capital cost (principal and interest). Most of the costs are straight forward and can be summed over any applicable period (week, tract, month, or year). However, contractors must specifically decide how to annualize and distribute capital costs. During a loan period, the most appropriate capital cost is the payment applied toward retirement of capital. This is calculated by the lien holder and can be estimated in spreadsheet and accounting software programs. For older machines, or those without outstanding loans, typical methods include a standard depreciation formula for the expected life of the machine or a projected decline in resale value of the machine after each year of use. Services track sale and trade-in prices for equipment, which may be accessed through an equipment dealer or subscriptions.

Another important aspect of cost is the tax consequence. Contractors pay income taxes on the net income they receive. All expenses, including interest payments, can be deducted from gross income to reduce net income and therefore tax liability. Capital costs as they are incurred cannot be deducted, but owners can deduct a depreciation amount from gross income. The depreciation amount is determined by Section 179, the MACRS depreciation rule and economic life specified for each type of equipment. In 2008, equipment purchases under $250,000 could be expensed entirely under Section 179 from taxable income. Depreciation and expense rules in the federal and state tax code have changed regularly over the past decade.

The typical approach for cost analysis is to calculate the fixed costs (interest, principal, insurance, and taxes) and variable costs (fuel, lube, tires, maintenance, and repair) separately (table 3). The fixed cost

Table 3. Before-Tax Machine Cost Calculations for a $200,000 Machine

			Year				
			1	**2**	**3**	**4**	**5**
Variable cost ($/PMH)	Fuel and lube	A			20		
	Maintenance and repair	B			15		
	Total	**C=A+B**			**35**		
Fixed cost ($/yr)	Interest payment	D	14989	12189	9126	5576	2111
	Labor	E	47190	47190	47190	47190	47190
	Insurance	F	10000	7714	5810	4286	3143
	Total expense	G=D+E+F	129929	124843	119875	115001	110194
	Principal payment	H	29849	32649	35712	39062	42727
	Total	**I=G+H**	**159778**	**157492**	**155588**	**154064**	**152921**
Scheduled machine hrs/yr		J			2200		
Utilization rate		K			75%		
Productive machine hrs/yr		L=J*K			1650		
Production rate (tons/PMH)		M			25		
Variable cost ($/ton)		N=C/M			1.40		
Fixed cost ($/ton		O=I/(L*M)	3.87	3.81	3.77	3.73	3.70
Total cost ($/ton)		**P=N+O**	**5.27**	**5.21**	**5.17**	**5.13**	**5.10**

[1] The machine has a 5-year life and is financed with 10 percent down, 9 percent APR, and sixty monthly payments.

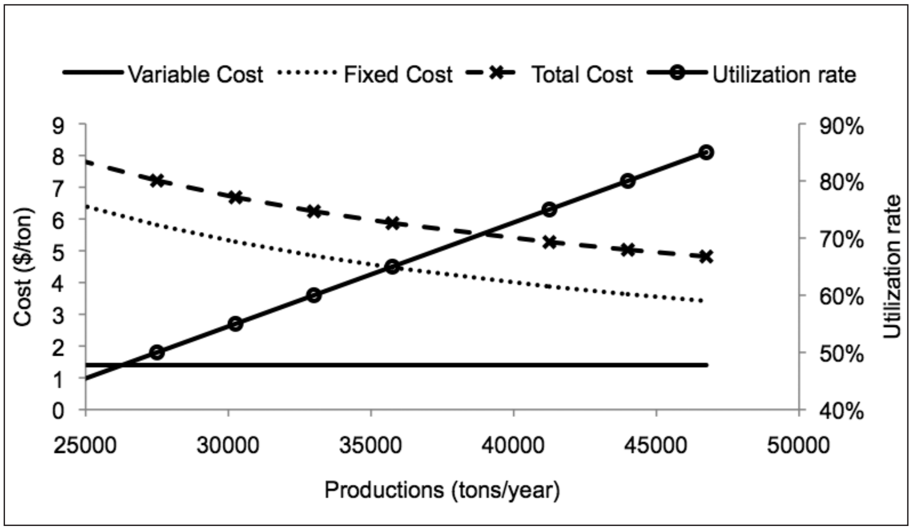

Figure 2. Impact of machine production per year on per-unit costs
[1]Changes in annual production are made possible by increasing the productive hours, which are indicated by the changing utilization rate.

per unit is the annual production divided by the annual fixed cost. The variable cost per unit equals the production per PMH divided by the cost per PMH. Fixed cost per ton is sensitive to annual production and, therefore, annual scheduled hours and the utilization rate (figure 2). Variable cost per ton is related only to variable costs and the hourly production rate.

Variable costs are best estimated using operation records but can also be estimated using several rules of thumb that have been published. Fuel consumption rules of thumb are often based on machine horsepower. General maintenance and repair rules of thumb are often linked to a depreciation formula. More specific information is on repair is available in resources like the CAT® Performance Handbook. In addition, machine manufacturers may have guidance on machine hours to rebuild/replace major components given the operating conditions.

Labor Productivity

One of the chief drivers in mechanization is the availability and cost of labor. In many respects, it is difficult to tell whether cost or availability is more important. Even though wages for logging workers have kept pace with other occupations, working conditions and social status limit the acceptability of logging work to the general population. For some time, logging wages have increased faster than the rate of inflation. If labor productivity (tons/labor hour) does not increase at the same rate, labor costs become uncontrollable and the logging business becomes unsustainable.

In 2001, a survey of logging contractors in Alabama found labor productivity (of woods workers only) had a very wide range, from 1.4 to 10.5 tons per scheduled hour (figure 3). The scheduled labor hours include all workers on the operation (3 workers × 40 hours/week = 120 hours per week). The average was nearly 5 tons per hour. What makes the variability so large? Better mechanical availability from newer or better-kept machines; better operational efficiency from larger tracts or better planning; and higher machine production rates from bigger machines, fewer sorts, bigger trees, less hardwood, or better terrain all play a role in changing this number. The goal of an individual contractor would be to define labor productivity based on his or her system and sites and find cost-effective ways to improve.

Figure 3. Range in labor productivity for a sample of Alabama logging firms (from 2001)

The improvement always has to consider the limiting factor in the operation. For example, if the market is limiting, that means reduced labor hours rather than increased production. The target for annual improvement in labor productivity should be equal to or greater than the annual growth in wages.

Capital Productivity

This measure is capital value (the total current value of woods equipment) divided by annual production. The variation in capital productivity was considerably lower than that for labor productivity for the same group of logging contractors (figure 4). One reason for this is the relatively good relationship between a machine's value and its ability to produce wood. Contractors at the low end of the scale are affected by difficult harvesting conditions or increased processing requirements (e.g., stroke delimbers, chippers). Contractors at the high end of the scale may be in very favorable production conditions, may have extended production life from their machines, or may have labor-intensive systems (e.g., hand felling and limbing). Contractors would evaluate capital productivity during equipment purchase decisions. Maximizing capital productivity is seldom a goal of operations since it could be achieved partially by decreasing labor productivity.

Capital and labor productivity combined gives a more complete view of the operation. Consider that an operation designed to accomplish a specific goal has a potential level of capital productivity. If that operation is well managed, that system could have higher levels of labor productivity, too. Figure 5 shows

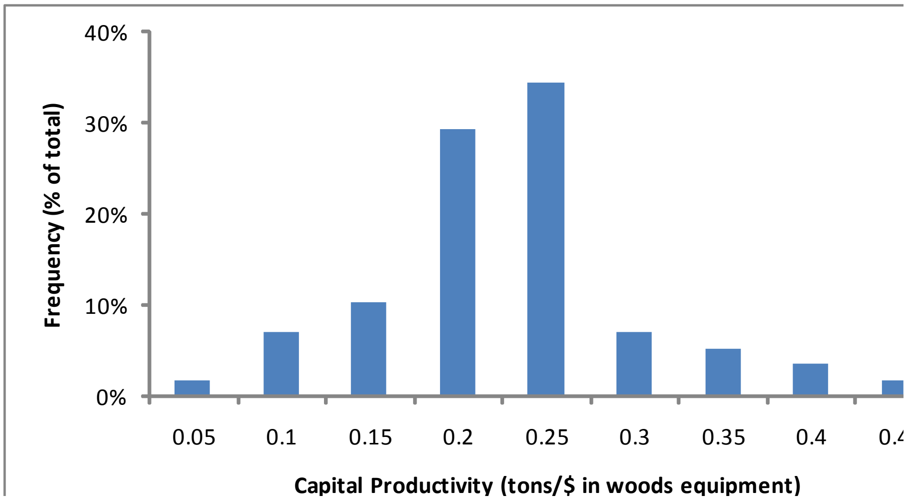

Figure 4. Range in capital productivity for a sample of Alabama logging firms (from 2001)

the range in both numbers for that same group of contractors. Operations with low capital productivity could be operations in difficult situations (terrain) or those with high processing demands (chipping). Either situation limits labor productivity. Increasing capital productivity in the same system also yields potential increases in labor productivity. The maximum labor productivity occurs when capital productivity is between 0.2 and 0.3 (see figure 5). This level of capital investment is favored because more than 60 percent of contractors are in this range (see figure 3). At high levels of capital productivity (>0.3), contractors are typically 30 to 50 percent below the maximum labor productivity achieved in this sample. This is likely due to a combination of the factors mentioned previously that lower utilization rate. To achieve high capital productivity, contractors operate older equipment or have partially manual operations. Either way, labor productivity is capped due to low production rates or low utilization rates, which are caused by low mechanical availability.

Conclusion

The number that reflects a contractor's ability to generate net income is *total cost per ton*. While that number is important, it does not reveal any important changes to the operation that could be made to improve net income.

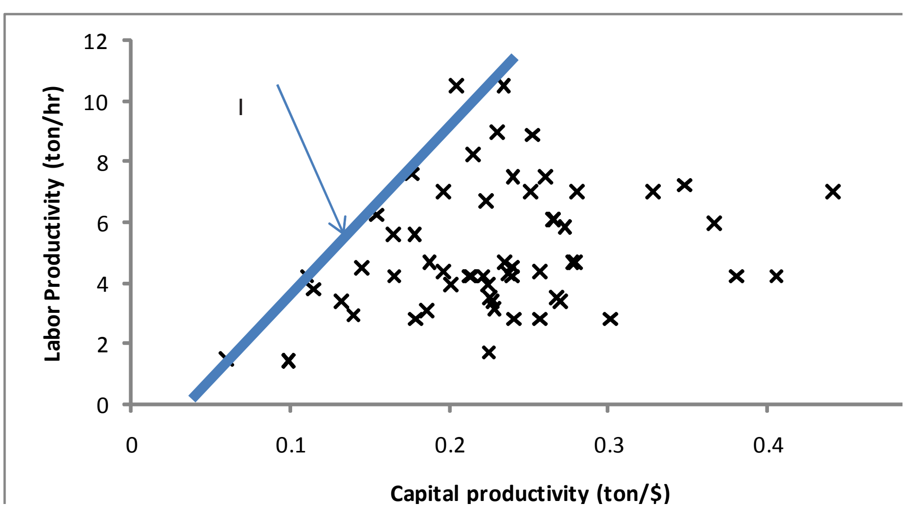

Figure 5. Combined labor and capital productivity, or a sample of Alabama loggers (from 2001)

[1]The optimum performance line indicates the highest combination of labor and capital productivity.

System performance measures that include labor, machine, and capital utilization can identify important system limits. Understanding how to measure and improve the utilization of labor, capital, and consumable resources is critical to achieving cost and production goals.

Resources

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