Improving Log Trucking Efficiency by Using In-Woods Scales

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ABSTRACT

We evaluated weight data from 47,953 truckloads of wood delivered to forest products mills in nine southern states to determine the effect of in-woods scale use on reducing the variability of net and gross weights. Four mill-owning companies provided the data and indicated whether in-woods scales were used for each load. We used these data to compare the mean tare, net, and gross weights of truckloads using scales to those not using scales. Trucks using scales had average tare weights only 108 lb greater, but their net payload averaged 1,799 lb higher than trucks not using scales. The coefficient of variation for the net payload was 38% lower for loads with scales than those without ($P < 0.001$). Individual southern states have different regulations regarding maximum gross vehicle weight (GVW), so we calculated a GVW index to remove state bias and allow comparisons of loads across states. Loads using scales were within 2% of the legal maximum GVW 54% of the time compared with 30% for loads not weighed in-woods. We estimated haul costs for trucks using scales at $7.44 per ton, compared with $7.74 per ton for trucks not using scales ($P < 0.001$). We found that 11% of loads with in-woods scales had haul costs exceeding $8.00 per ton, compared with 32% of loads not using scales. Across all data, scales represent a 4% savings on per-ton haul costs with even greater savings available as fuel prices increase.

Keywords: trucking, transportation, efficiency, savings, payload, gross vehicle weight

Transportation is often the most expensive aspect of the wood supply chain and can be the limiting production factor for the logging contractor. Each state has its own limits on the maximum gross vehicle weight (GVW) that vehicles are allowed to haul, which in most Southeastern states mirrors the federal 80,000-lb weight restriction on interstate highways. In addition, most states allow a tolerance above the GVW of normal tractor-trailers on state highways for those trucks loaded outside traditional factory settings, primarily vehicles hauling agricultural and forestry products loaded in the field. The justification for these tolerances is that the conditions where trucks are loaded are not conducive to accurately controlling the payload that will be put on the truck, so an additional 5–10% of the GVW is allowed (depending on the state) between the loading location and the first delivery point.

Weight restrictions, coupled with increased fuel prices, have placed an emphasis on hauling the maximum legal load every trip for logging contractors. Since the 1970s, equipment manufacturers have been developing methods to weigh logging trucks in the woods, as they are being loaded. Two forms of in-woods scales continue to be prevalent in the industry. One involves locating a load measuring device on the truck and trailer themselves. These onboard scales require both the tractor and trailer to be outfitted, which can become expensive with a large trucking fleet and are not useful if logging contractors subcontract a portion of their hauling to vehicles not equipped with scales. Mobile platform scales have also been adopted by some contractors. These devices typically support up to two axles of the tractor-trailer and provide feedback to the loader operator on the amount of weight added to the vehicle. The main difficulty with platform scales in the woods, historically, has been ensuring they are on firm, level ground to provide an accurate measure. This project focused on the potential for efficiency gains and cost savings from fully loading trucks by using any form of in-woods scales.

Previous studies have investigated the relationship of log truck load weights, efficiency, and cost. Several studies have also evaluated the use of in-woods scales to reduce GVW variability and to obtain increased average payloads. Beardsell (1986) found that using weighing devices, such as in-woods scales, and comparing those measurements with reported mill weights led to an overall reduction in GVW variability. Shaffer et al. (1987) used case studies involving a Georgia logging contractor and a Virginia logging contractor to determine the benefit of using onboard scales. Scale implementation by the Georgia logging contractor caused a 25% reduction in net payload variability and reduced the occurrence of overweight fines. However, the researchers found that scale use had no effect on the mean net payload weight in the Georgia case study. They found that if the Georgia logging contractor invested in scales, he could expect an estimated 24.3% internal rate of return (IRR) on his investment from cost savings. The Virginia logging contractor, however, could only expect an IRR of 9.8% because of large amounts of overloading that occurred without scale use (mean net payload actually decreased by 7% after scale implementation). The Virginia case study also showed that onboard scale weights were 98–99% accurate when compared with corresponding reported mill weight measurements. Overboe et al. (1988) determined that providing information about load weights to loader operators caused a slight decrease in load weight variability and an increase in overall profits. McNeel (1990) studied the effect of scale use on truck weights. He found that using

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onboard electronic scales increased the mean net payload by 2.07 tons (8% increase). Gallagher et al. (2004) compared the difference in GVWs of trucks that used scales to trucks that did not use scales. They determined that trucks that used scales to weigh loads in the woods had higher net payloads than those that did not use scales. Also, the researchers found that scaled loads had a higher average GVW and less variability in GVW than those that were not weighed in the woods. Hamsley et al. (2007) discovered that loading trucks more uniformly reduced GVW variability and, in turn, increased revenues and cost savings to the logging contractor. They also found that through hauling loads with less variable GVWs, logging contractors could increase their mean net payloads.

Other studies have also focused on the financial benefits associated with scale implementation. Beardsell (1986) found that by eliminating underloading and overloading, average payload could increase substantially. He estimated gross annual savings of $153,000 and $431,000 to two mills if all log trucks arrived carrying the maximum legal GVW. Beardsell's assumptions included a haul rate of $2.30 per loaded mile (1986 dollars) and a maximum log truck tare, or empty, weight of 27,000 lb. Stuart (1995) examined the benefit of hauling fully loaded log trucks. He determined that for a logging contractor using trucks that averaged 77,500 lb GVW loaded, the logging contractor could increase the annual profit margins by $27,000 and $37,500, at cut and haul rates of $12 and $16 per ton, respectively, by simply hauling one additional ton per trip. Shaffer and Stuart (1998) suggested loader operator training or scale implementation to optimize payloads by reducing weight variability. Also, in their study, loggers reported recovering the initial cost of onboard electronic scale implementation in less than 1 year through a combination of increased payloads and decreased overweight fines. Our study examined the variability of tare, net, and gross weights to determine whether more uniform GVWs yielded increased net payloads and cost savings.

Methods

We collected data on log truck weights over a ten month period from January to October 2008 from forest products mills across the Southeast. All mills that provided data were owned by four member companies of the Wood Supply Research Institute. The data reported from each mill included the date, the time each truck weighed in, the time each truck weighed out, the state where each load was hauled, a supplier/logger code, the GVW, the tare weight, the net payload, and a brief description of the product each truck hauled. Mills also indicated which suppliers or loggers used scales in their operations.

To limit our study to 18-wheel tractor-trailers, we analyzed only truckloads that had tare weights between 12.5 and 20 tons. This reduced our population from more than 50,000 loads to 47,953 loads. We then separated these loads into two groups: scale users and all others. There were 24,109 truckloads using scales, or 50.3% of the total population. The remaining 23,844 truckloads, 49.7% of the total population, did not use scales.

The two aspects of our data analysis were:

1. Comparing the means and variability of tare, net, and GVWs of trucks using scales with those of trucks not using scales.
2. Estimating the potential cost savings from increasing the use of in-woods scales on logging operations in the different Southeastern states.

Table 1. Summary statistics for the full data set.

	Number of loads	
	Without scales	With scales
State		
Alabama	14,360	17,514
Florida	1	0
Georgia	2,444	229
Louisiana	0	47
Mississippi	898	5,546
North Carolina	57	0
South Carolina	21	344
Texas	172	32
Virginia	6,156	132
Product		
Hardwood Pulp	2,634	2,726
Hardwood Saw	403	1,084
Pine pulp	9,023	7,146
Pine saw	5,850	12,460
Unknown	6,261	1,229
Number of contractors	140	36
Number of mills	52	32

Statistical Analysis Software was used to analyze the data to determine mean values of truck tare and net weights along with their coefficients of variation (CVs) for scale users and non-scale users alike. Determining mean values allowed us to analyze the average difference in weight between trucks that used scales and those that did not. Calculating the CV of truck tare and net weights allowed us to determine the variability of truck configurations and payloads for scale users and non-scale users.

To objectively compare the GVW of trucks using scales to those not using scales across several states, we had to account for different GVW limits by state. To do this, we created a GVW index to remove potential bias. The GVW index was calculated by dividing the GVW of each load by the legal maximum GVW (plus tolerances) of the state where it was hauled. An index value of 1.0 indicates a truck that is fully loaded to the maximum legal state limit, including tolerances. Index values of less than 1.0 indicate underloaded trucks, and index values greater than 1.0 indicate overloaded trucks. The result of subtracting 1.0 from the index value represents the percentage by which each truckload was under or overloaded. For example, a GVW index value of 1.15 for a load hauled in Alabama would indicate the load was 15% over the legal weight, which would indicate the load weighed 101,200 lb, as Alabama has an 88,000-lb GVW limit, including tolerances. We used the GVW index to compare mean values, as well as variability (CV) for scaled and unscaled loads. We also examined a frequency distribution of GVW index values for scaled and unscaled loads to determine the proportion of loads that were underloaded, overloaded, and within 2% of the legal maximum GVW allowance.

In addition to examining all scaled loads and all unscaled loads as two large populations, we also divided the data by state for further analysis. We included only data from the six states that reported loads delivered both with and without scales in the data set (Table 1). These states were Alabama, Georgia, Mississippi, South Carolina, Texas, and Virginia. The majority of the data were from locations in Alabama, which could affect inferences for other states, particularly considering it has the highest GVW limit including the tolerance. Within each of these six states, we determined the mean GVW index for scaled and unscaled loads to estimate the average potential payload gain for each state from use of scales. We also

Table 2. Tare weight, net payload, and gross vehicle weight (GVW) index values for trucks with and without the use of in-woods scales.[a]

		Scale	No scales	Difference
Tare (empty), lb	*n*	24,109	23,844	265
	Mean	30,243	30,142	101
	% CV	5.3	6.0	−0.7
Net Payload, lb	Mean	54,974	53,175	1,799
	% CV	6.8	10.9	−4.1
GVW index	Mean	0.98	0.96	0.02
	% CV	4.2	6.3	−2.1

[a] CV, coefficient of variation.

examined the relationship between the truck tare weight and net payload for scaled and unscaled loads.

The second portion of our study dealt with estimating the potential cost savings from adding in-woods scales to logging operations in Southeastern states. To estimate haul costs and potential cost savings, we assumed trucks would average three loads per day over the year with a 45-mile loaded haul distance (Mendell et al. 2006). We calculated the average daily operating cost for a tractor trailer at $600 by using the machine rate method and assuming 10 hours worked per day over 50 weeks of the year (Miyata 1980). We also assumed $120,000 purchase price for a new tractor trailer with a 6-year economic life; a 20% salvage value; 10% of the average annual investment for interest, insurance, and taxes; 60% of the depreciation expense in maintenance, repair, and tires; driver wage of $16 per hour with 40% fringe expenses; and diesel cost of $2.50 per gallon.

We estimated the cost of adding scales to a logging truck to be $6,000 ($3,500 per tractor and $2,500 per trailer), based on discussions with local equipment dealers. One set of platform scales cost $23,000, which would yield similar per truck costs if four trucks operated on the same set of scales, though costs would change if more or fewer trucks were used. We also assumed a 5-year useful life for scales.

Using these assumptions and the results from our statistical analyses, we estimated average per-ton haul costs for trucks loaded with and without the use of scales. We calculated the mean haul cost and CV for all scaled loads and compared these values to those of unscaled loads. To further compare the difference in haul costs between scaled and unscaled loads, we constructed a frequency distribution of the haul costs to determine the proportion of loads (scaled and unscaled) that were below or above the average haul cost. We also estimated the payback period (in years) for a logging contractor adding scales to his operation assuming potential payload gains that ranged from 0.25 to 2.0 tons per load.

The final part of our analysis involved examining cost savings from scale implementation on the state level. We examined payload gain and cost savings benefits in one state with a low GVW tolerance versus those in a state with a higher GVW tolerance. We chose South Carolina as our state with a low GVW tolerance (4,272-lb tolerance), and we chose Alabama to serve as our state with a high GVW tolerance (8,000-lb tolerance). Savings were calculated for the logging contractors in each state on an annual basis.

Results and Discussion

Tare weights for trucks with scales were slightly (101 lb) but significantly higher ($P < 0.001$) than tare weights for trucks not using scales (Table 2). For practical purposes, the truck tare weights were equivalent, as 100 lb represents only a 0.34% difference in weight. The statistical significance is due in large part to the very large sample size involved. The variability of the tare weights was less for trucks using scales (5.3%) compared with those not using scales (6.0%). Trucks loaded using scales also achieved a significantly larger ($P < 0.001$) mean net payload (1,799 lb greater) than trucks loaded without the use of scales. The CV of loads with scales (6.8%) was also significantly lower ($P < 0.001$) than that of other loads (10.9%). Loggers using scales thus obtained a 38% reduction in the variability of their net payloads compared with loggers that did not use scales. Loggers using scales achieved a mean GVW index value of

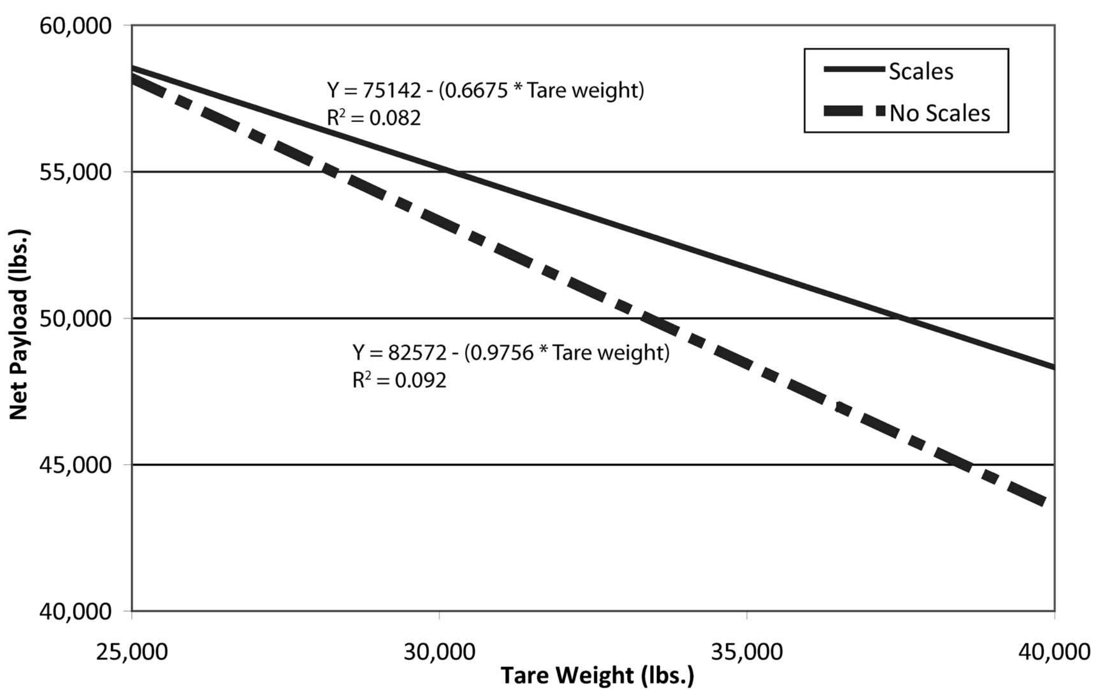

Figure 1. Observed trends in net payload versus tare weight for truck loads delivered with and without the use of in-woods weighing.

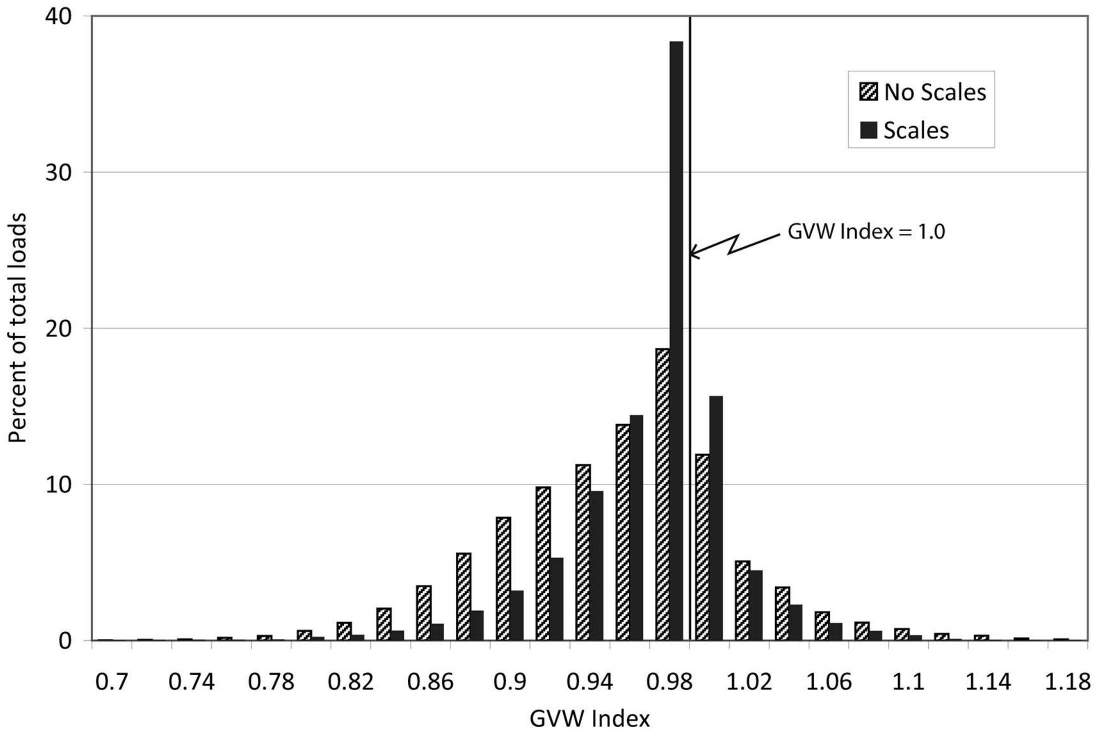

Figure 2. Distribution of loads delivered with and without scale use in the woods by gross vehicle weight (GVW) index (1.0 = state GVW limit).

Table 3. Sample size, legal gross vehicle weight (GVW) limit, observed mean GVW, GVW index, net payloads with and without scales, and potential payload gain for six states in the US South. All weights are given in pounds.

					Mean payload			
State	Loads	GVW limit	Mean GVW	Mean GVW index	With scales	Without scales	Potential payload gain	*P* value[a]
AL	31,874	88,000	85,280	0.969	55,390	54,860	530	0.0001
GA	2,673	84,000	83,190	0.990	54,930	52,260	2,670	0.0001
MS	6,444	84,000	83,730	0.997	53,800	52,620	1,180	0.0001
SC	365	84,272	83,880	0.995	53,880	50,320	3,560	0.0327
TX	204	84,000	86,350	1.028	55,050	57,290	−2,240	0.2017
VA	6,288	84,000	80,090	0.953	52,120	49,600	2,520	0.0001

[a] Test for significant difference between mean payload with scales and mean payload without scales by state.

0.98, compared with a value of 0.96 for those without scales. This indicates that loggers who used scales to weigh loads were using 2% more of the legal maximum GVW allowed in their state than loggers who did not use scales. Also, trucks using scales had GVW index values that varied 33% less than those of trucks loaded without the use of scales ($P < 0.001$).

Trucks loaded using scales averaged higher payloads across a range of tare weights from 12.5 to 20 tons, although the data exhibited substantial variability (Figure 1). This suggests that trucks loaded using scales will have higher net payloads than those loaded without the aid of scales regardless of tare weight. The net payload gain for scaled loads versus unscaled loads was positively related to tare weight, growing larger as tare weight increased.

Trucks loaded with the help of scales were less likely to be either underloaded or overloaded than trucks loaded without the use of scales (Figure 2). Underloading (GVW index < 0.98) was observed twice as frequently for trucks without scales than for those using them. Likewise, overloading (GVW index > 1.02) was 46% more frequent for trucks without the use of scales. Finally, the shape of this distribution is skewed toward underloading, which is far more prevalent than overloading. Underloading increases per-ton hauling costs and requires additional truck trips to deliver the same volume of wood. It should also be noted that 54% of scaled loads were within 2% of the legal maximum GVW compared with 30% of unscaled loads.

The total number of loads (with and without scales) hauled within each state ranged from 204 in Texas to 31,874 in Alabama (Table 3). The mean GVW index of all loads hauled within each state varied from a low of 0.953 in Virginia to a high of 1.028 in Texas. For every state except Texas, the data suggested that the use of scales could significantly ($P < 0.05$) increase average payload. Potential gains ranged from 530 lb per load in Alabama to over 2,500 lb in Georgia and Virginia and over 3,500 lb in South Carolina. Texas was the only state where we observed trucks loaded without scales hauling greater net payloads than those using scales; however, the mean GVW for the trucks observed in Texas exceeded the GVW limit by 2,350 lb. Reasons for this outlier in the data set might include the much smaller sample size in the state and a high instance of overloading within the non-scale user group. The data from other states clearly suggest an inverse relationship between state GVW

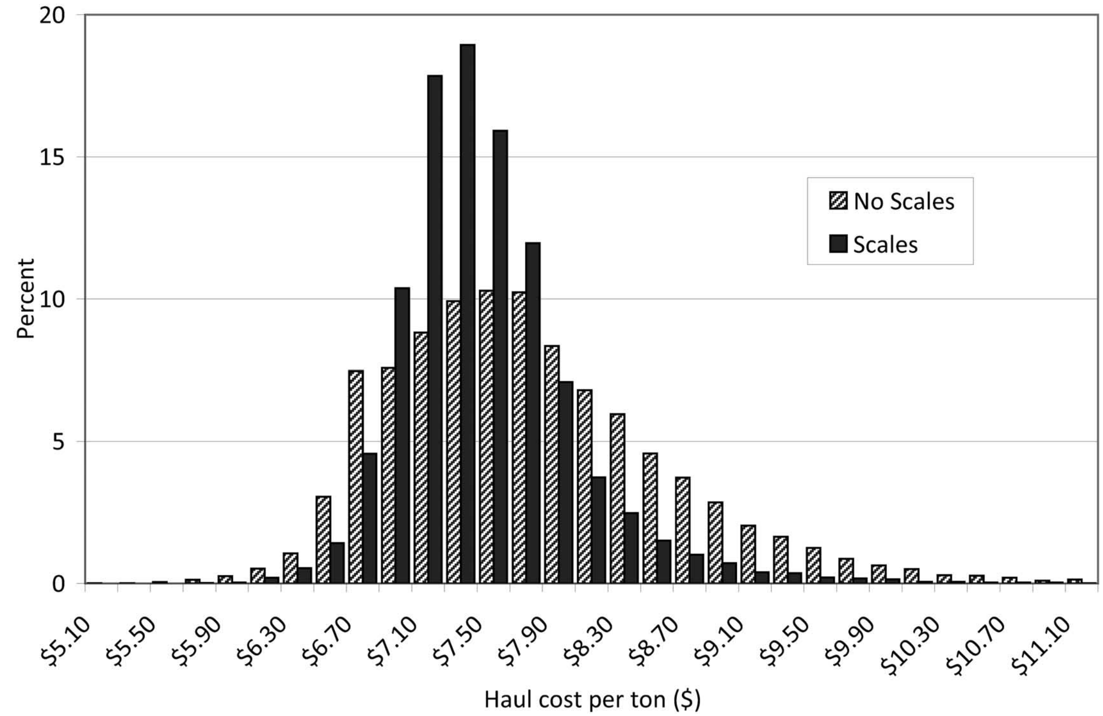

Figure 3. Distribution of estimates of hauling cost per ton for loads delivered with and without the use of scales in the woods.

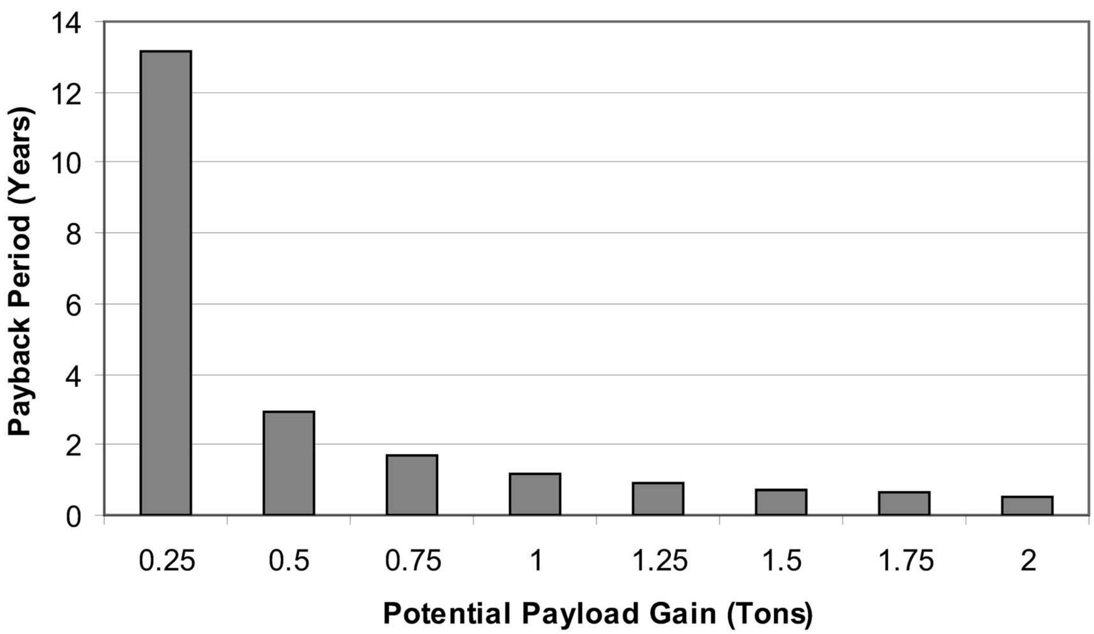

Figure 4. Estimated payback period (years) associated with the purchase of scales as affected by the potential payload gain (tons) obtained with the use of scales in the woods. Cost and operating assumptions include three loads per truck per day, 26 ton base payload, $6,000 per truck for scales, and a 5-year useful life.

limit and average payload gain from scale use. Thus, logging contractors appear to have the most to gain in states with more restrictive GVW limits.

Use of scales provided a higher payload for all products ($P < 0.001$). Hardwood pulpwood, pine pulpwood, and pine sawtimber each increased GVW index by roughly 0.7% with scales versus without, and hardwood sawtimber increased GVW index by 1.4%.

We also estimated haul costs for loads with and without the use of scales. For trucks loaded using scales, the average haul cost was estimated at $7.44 per ton, with a CV of 7.4%. Trucks loaded without the use of scales had an estimated haul cost of $7.74 per ton (an average increase of 4.0%) with a CV of 11.5%. Furthermore, only 11% of loads using scales had estimated costs exceeding $8.00 per ton compared with 32% of loads not using scales (Figure 3).

We calculated the payback period to cover the investment in scales as the potential payload gain varied (Figure 4). Assuming an average scale life of 5 years, any payload gain above 0.40 ton per load associated with scale implementation allowed a logging contractor to recover the $6,000 investment per truck in less than 5 years. For example, we observed potential payload gains of 1.75 tons in South Carolina and 1.25 tons or more in Georgia and Virginia (Table 3). Payback periods for scales in each of these states would be 12 months or less.

We also analyzed potential cost savings from scale implementation on the state level. Using the potential payload gain numbers listed in Table 3, we compared potential savings for an average logging contractor in Alabama with those for an average logging contractor in South Carolina. We found that the Alabama logger would save around $0.02 per ton, or $350 per truck per year, whereas the South Carolina logger would save $0.43 per ton, or $8,790 per truck per year, from adding scales to his logging operation.

Across all data, scales represent a 4% savings on per-ton haul costs. Greater use of full payload potential would offer even greater savings when fuel prices increase. Many factors in the wood supply chain are beyond the control of logging contractors, but the amount of wood loaded on their trucks is directly in their control. Purchase and use of scales, either onboard truck or platform models, will permit weighing of trucks in the woods to ensure that they are fully loaded and reduce the likelihood of overloads. Such investments are paid back quickly through the reduction of underloading and should be seriously considered by logging contractors as a means of improving the profitability of their trucking operations.

Conclusion

These findings agree with most previous work on in-woods scales in forestry operations (e.g., Shaffer et al. 1987, McNeel 1990, Shaffer and Stuart 1998), yet the data show that only half of the loads delivered were loaded with the aid of in-woods scales. Also of interest is that only 22% of the contractors delivering loads used in-woods scales (Table 1; 13 contractors delivered some loads both with and without scales). Given the potential financial benefit, the lack of adoption of in-woods scale technology is perplexing. Reasons for and against the addition of scales were outside the scope of this research. Other researchers have noted that consuming mill overweight policies have been more influential in scale adoption decisions than state laws (Gallagher et al. 2004). Additional research is needed to determine how to increase scale adoption throughout the logging community.

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