Liro
Forestry Solutions

PROJECT REPORT

PR 74

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A DIFFERENTIAL CONTRACTOR PAYMENT SYSTEM

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Executive Summary

The financial success of harvesting operations depends on keeping costs as low as possible while minimising loss of value of the resource. The New Zealand industry is investing in systems and research that will improve the quality of marketing, supply chain management decisions and harvesting operations to improve value recovery.

Many of the new systems will be used by independent logging contractors, who are increasingly asking why they should use such tools. The contractors who undertake most harvesting operations are paid a rate per unit volume, which only encourages them to maximise the volume they produce. Quality is specified but there is no positive motivation for the logging contractor to maximise the value recovered from a stand. By aligning contractor and company goals, increased value should be realised

Liro investigated several "value based" payment systems. The system which seemed the most promising, and which will be described in this project report, is the differential payment system.

The grades that a contractor is likely to cut from a stand should be grouped into a minimum of five groups of similar value with each grade given a relative value that reflects its importance to the forest owner. Using the contract logging rate as a weighted average and the predicted grade out-turn from the stand, the differential rates are set by giving both contractor and forest owner the same proportion of their income from each group of grades. Differentials should be set so that there is no more than $15 to $20 between the highest and lowest rates. The contractor is then paid those rates using weighbridge totals for the duration of the time that it takes to harvest an area.

Predicted grade out-turn used to set differential rates should not be too accurate or there may be no opportunity to improve, hence no incentive left for contractors to improve value recovery.

With enough differential steps and less than $20 between highest and lowest grades, changes in cutting instructions have only minor effects on contractor income, allowing differentials to remain the same for all the wood loaded off a landing or from a setting.

Volume produced per day has a larger effect on contractor income than improving quality with any value based payment scheme, so a contractor can still decide to ignore quality and over-produce. For this reason, there must be adequate rewards available for improving value.

A major change to the cutting instruction could be compensated for without changing the differential by allowing increased volume to be harvested.

A case is made for each of the recommendations and detailed instructions on deriving differential logging rates and using the system are outlined. A manual calculation sheet is attached and an Excel spreadsheet is available on request from Liro.

Value Based Payment Systems

The objective of any harvesting operation must be to maximise the profit margin by minimising costs and maximising value. There is often a mistaken belief however, that the only way to improve your margin is to minimise your costs. There is a balance to be found between the need to reduce costs and maximising value to leave the largest margin possible (Figure 1). A complicating factor is that costs are easily shown, but the industry does not have many accurate methods to measure loss of value in a way that can be shown on a balance sheet.

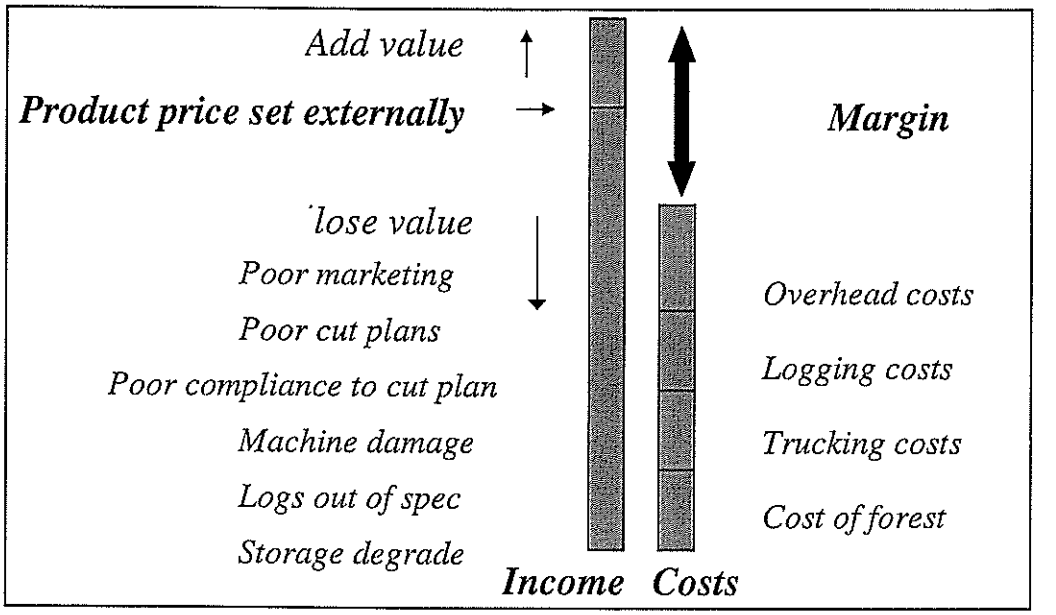


Figure 1. Objective – Maximise the margin

The independent logging contractors who undertake most harvesting operations are paid a rate per unit volume, which only encourages them to maximise the volume they produce. Quality is specified but there is no positive motivation for the logging contractor to maximise the value recovered from a stand.

The New Zealand industry is investing in systems and research that will improve the quality of marketing, supply chain management decisions and harvesting operations to improve value recovery. Many of these new systems will be used by the contractors, but they are increasingly asking why they should use such tools if they are only contracted to produce as many tonnes per day as possible.

The customer service ethic starting to permeate the industry indicates that only those contractors who provide truly excellent services for forest owners should be employed and that the method of payment is not as important as the amount. At the same time, many agree that some reward for quality would assist to align the goals of forest owner and contractor, and for this reason Liro was contracted to investigate value based payment systems.

Literature Review

A literature review on the topic found a large amount of literature on motivating and paying employees on the value of their output but little on quality incentives for independent contractors in the forest industry. Relevant papers are summarised below:

Duggan, M. 1990. Incentive Payment systems. In "Manpower Management in Logging", the proceedings of a Seminar held in Rotorua, June, 1990. The New Zealand Logging Industry Research Association.

Introduction to crew and contractor payment systems in NZ and contractor payment systems in Pacific North West and Sweden. Differential logging rates for contractors are discussed but the body of the paper focuses on incentives for forest workers.

Plasse, D. 1996. A Merit-Based Remuneration Programme For Forestry Contractors. Canadian Pulp and Paper Association Woodlands Section 1996 Annual Meeting, pp E47 - E50.

Alliance Forest Products - Lake St. John area, introduced a merit based remuneration programme for contractors in 1994. As well as a rate per ton, an additional 5 to 10 percent was offered, based on the quality of the operation. Goals were set for up to 5 quality criteria in each of two areas; one on product quality, the other on the quality of forest management. Each criteria was weighted according to its overall importance in relation to other criteria, and then for each criteria, up to five assessment classes were set up with corresponding remuneration percentages for each. eg shown in figure 2.

The system had to be easy to supply so the criteria chosen were only those which were already being measured.

Product quality (up to 3% bonus)			Quality of Forest Management (up to 4%)			
Logs in spec 1%	Logmaking 1%	Maximise volume 1%	Cutover 1%	Breakage 1%	Waterways 1%	Skid trails 1%
2 errors in 20 logs-1%						
3-10/20 logs 0.6%	etc					
>10 errors in 20 logs 0.0%						

Figure 2. Merit-based remuneration worksheet

Stumpage sales

Another method of rewarding contractors on the value of their production that is in use, but not published, is stumpage sales. This is used in the United States and by Rayonier New Zealand Limited. Logging contractors of different sizes purchase standing trees and make their money on the margin between purchase price and the price that they sell the harvested log products for.

Small contractors however are unlikely to bid well for the stand because they do not have the economies of scale to market well. Large harvesting organisations find themselves having to employ contractors so are faced with the same problem as most New Zealand forest owners – do they pay for volume or quality?

Incentive payments investigated by Liro

Three systems were investigated during the course of the year. These were:

- Value based payment: Contractor is paid a percentage of the value of the crop
- Stepped payment: Contractor is paid a flat rate per tonne for most grades, but one to three grades which are of high value to the forest owner attract a logging rate substantially higher than the base.
- Differential payment system: Grades sit in five to ten groups which all attract a different logging rate with a spread of up to $20 per tonne between the highest and lowest rates.

The system which seems the most promising and which will be described in this project report is the differential payment system. Our experience with the other two systems follows:

Value based payment system

This system required the use of the Timber Tech electronic logmaking and analysis tools.

- A representative sample of stem descriptions was collected from the stand with the logmaking tool. Using the current cutting instructions, this batch of stems was cut with the PC version of the optimiser to get grade out-turn. With the MARVL estimate of total volume per hectare and market values, the value of the stand in $/ha was calculated. [eg $40,000/ha]
- The contractors daily cost, production rate and total volume per hectare was used to calculate the cost of harvesting each hectare. [eg. $8,000/ha]
- The contractors costs were expressed as a fraction of the value of the stand. [eg 8000/40,000 = 20%]
- Each day the Timber Tech calipers record the volume of each grade produced by the contractor.
- Each evening contractor production and market values are used to calculate the value of timber harvested, and contractor income is calculated by using the current contractor share fraction. [eg $22,000 harvested x 20% = $4,400]

Any change in cutting instructions would necessitate recutting the sample stems to calculate a new stand value and then a new contractor share. Most of the actions would be automatic, so that every time a new set of cutting instructions were sent electronically from managers to logging tools a new contractor share would be enabled. When the tools made their last report to the database at night the contractor share would be calculated and payments made on that basis.

The reasons that this system is not being recommended are that the Timber Tech technology is not yet in general use or mature enough to assure that every stem will go through the system, and that no user will make mistakes on the skid or in the office.

An unpublished report on the system is available on request from Liro.

Stepped payment

This system was being used in an Australian hardwood operation. Six or seven standard mill grades that made up a substantial part of the total production volume were on a flat rate. Two to three grades were worth substantially more to the forest owner and these attracted a logging rate almost double that of the norm.

The base and top logging rates were calculated using an average logging rate and estimates of stand composition by grade. In stands with a small volume of high value grades, the system has few disadvantages. In stands where the proportion is high and the estimates inaccurate, there will be wild variations in contractor income independent of contractor performance.

Differential Payment System

General Description of System

Grades are placed in five to ten groups that all attract a different logging rate with a spread of up to $20 per tonne between the highest and lowest rates.

The grades that a contractor is likely to cut from a stand should be grouped into a minimum of five groups of similar value with each grade given a relative value that reflects its importance to the forest owner. Using the contract logging rate as a weighted average and the predicted grade out-turn from the stand, the differential rates are set by giving both contractor and forest owner the same proportion of their income from each group of grades. Differentials should be set so that there is no more than $15 to $20 between the highest and lowest rates. The contractor is then paid those rates using weighbridge totals for the duration of the time that it takes to harvest an area.

With enough differential steps and less than $20 between highest and lowest grades, changes in cutting instructions have only minor effects on contractor income, allowing differentials to remain the same for all the wood loaded from a landing or setting.

Volume produced per day has a larger effect on contractor income than improving quality with any value based payment scheme, so a contractor can still decide to ignore quality and over-produce to. For this reason contractor production may need capping for the forest owners margin to be maximised. The grade out-turn prediction used to calculate the differential must be low to leave some quality incentive for the contractor.

A major change to the cutting instruction could be compensated for without changing the differential by allowing increased volume to be harvested.

Figure 3 shows the printed output of a differential calculator.

				Average logging rate	12
Log group	Grade	Vol/ha	Priority Value	Total value	
1	PS 3.7	18.24	90.00	1641	
1	PS 6.1	15.78	90.00	1420	
1	PS 4.9	8.86	90.00	798	
1	PS 5.9	14.17	90.00	1276	
2	S 6.1	109.98	80.00	8799	
2	S 5.5	62.82	80.00	5025	
3	S 4.3	19.49	75.00	1462	
3	S 3.7	27.71	75.00	2078	
4	A_EXP 8.1	67.20	70.00	4704	
4	J 12.1	58.47	70.00	4093	
5	K 5.9	36.92	60.00	2215	
6	J 3.7	31.96	55.00	1758	
6	A_EXP 4.1	38.32	55.00	2108	
7	KI 3.7	7.33	50.00	367	
8	MK	4.42	40.00	177	
8	AG	59.44	40.00	2377	
9	WASTE	29.40	0.00	0	
				0	
				0	
				0	
				0	
				0	
				0	
		610.51012		40296.71	
			Total logging cost	7326.121	

Logging Group	Logging Rate
1	$16.36
2	$14.54
3	$13.64
4	$12.73
5	$10.91
6	$10.00
7	$9.09
8	$7.27
9	$0.00
10	
11	
12	
13	
14	
15	

Figure 3. Print Output from Liro's differential calculator

- Grades and their estimated available volumes are first listed.
- The next step is to group grades. Grades that are manufactured from similar quality stem material should be grouped together. In this way a change in cut plan involving substitution of one grade for another is less likely to have an effect on contractor income.
- The final step is to enter relative values for each grade of logs that represent their economic importance to the forest owner and then spread or close those relative values until the difference between the highest and lowest differentials is $10 to $20.

Setting Relative Values

The values put against each log grade should represent the value each party places on those logs, however market values will give extreme results. Consider figure 4 using relative values from the forest owner's point of view.

With an average logging rate of $12, the range runs from $3.64 to $18.19. This is too extreme, as contractors would not want to pull pulp for $3.64/m³.

From the contractor's point of view, the larger logs are cheaper to extract, so priority values based on logging cost might look like Figure 5.

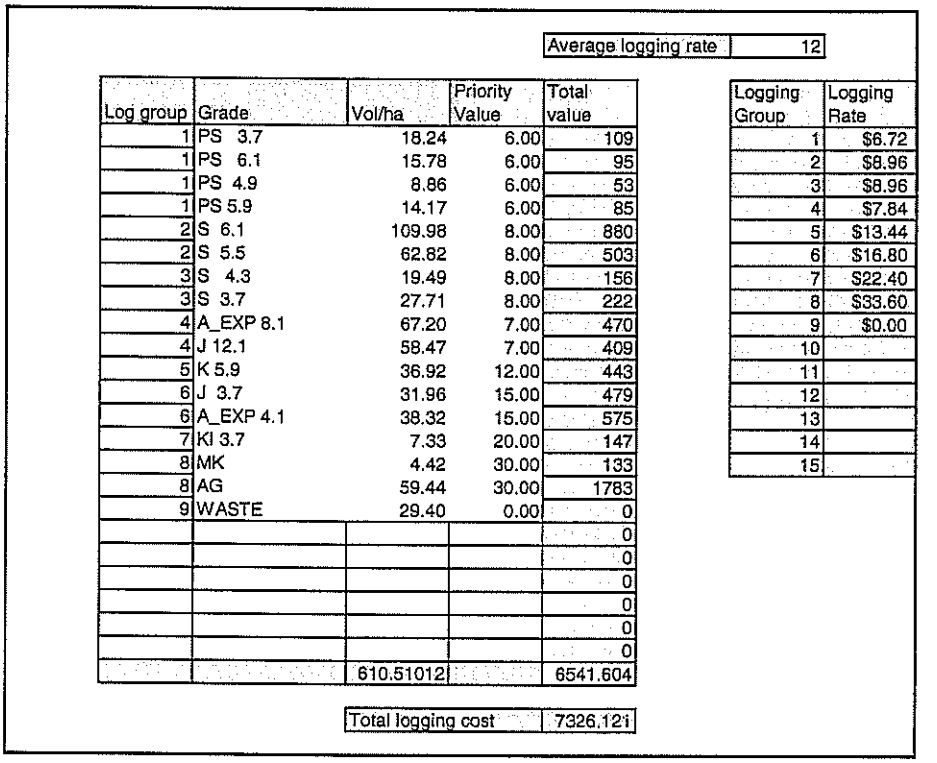
This example is as extreme in the opposite direction. Although these rates might reflect the cost of logging, the pulp extraction cost is higher than it is worth.

The compromise is to use relative values that give a smaller range, but still reward the contractor for good value recovery. Figure 6 gives an example. The relative values used are not necessarily those that would be used in a log optimising tool.

				Average logging rate	12
Log group	Grade	Vol/ha	Priority Value	Total value	
1	PS 3.7	18.24	150.00	2735	
1	PS 6.1	15.78	150.00	2366	
1	PS 4.9	8.86	150.00	1329	
1	PS 5.9	14.17	150.00	2126	
2	S 6.1	109.98	125.00	13748	
2	S 5.5	62.82	125.00	7852	
3	S 4.3	19.49	115.00	2241	
3	S 3.7	27.71	115.00	3187	
4	A_EXP 8.1	67.20	110.00	7392	
4	J 12.1	58.47	105.00	6140	
5	K 5.9	36.92	90.00	3323	
6	J 3.7	31.96	80.00	2557	
6	A_EXP 4.1	38.32	80.00	3066	
7	KI 3.7	7.33	60.00	440	
8	MK	4.42	30.00	133	
8	AG	59.44	30.00	1783	
9	WASTE	29.40	0.00	0	
				0	
				0	
				0	
				0	
				0	
				0	
		610.51012		60417.34	
			Total logging cost	7326.121	

Logging Group	Logging Rate
1	$18.19
2	$15.16
3	$13.94
4	$13.06
5	$10.91
6	$9.70
7	$7.28
8	$3.64
9	$0.00
10	
11	
12	
13	
14	
15	

Figure 4. Liro differential calculator – forest owner extreme



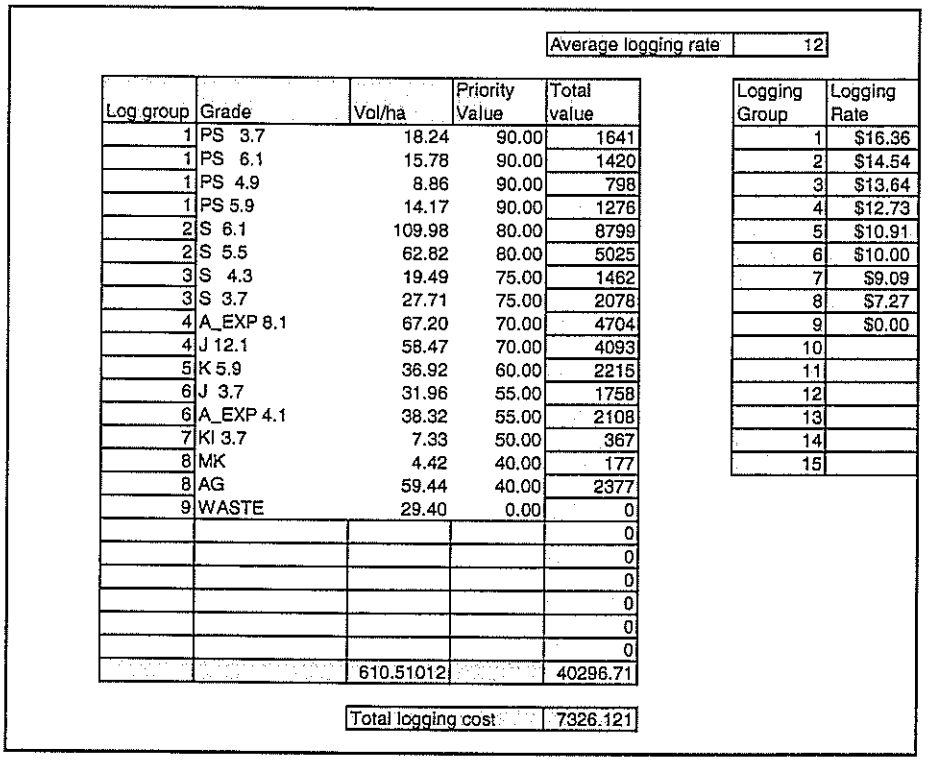
Average logging rate: 12

Log group	Grade	Vol/ha	Priority Value	Total value
1	PS 3.7	18.24	6.00	109
1	PS 6.1	15.78	6.00	95
1	PS 4.9	8.86	6.00	53
1	PS 5.9	14.17	6.00	85
2	S 6.1	109.98	8.00	880
2	S 5.5	62.82	8.00	503
3	S 4.3	19.49	8.00	156
3	S 3.7	27.71	8.00	222
4	A_EXP 8.1	67.20	7.00	470
4	J 12.1	58.47	7.00	409
5	K 5.9	36.92	12.00	443
6	J 3.7	31.96	15.00	479
6	A_EXP 4.1	38.32	15.00	575
7	KI 3.7	7.33	20.00	147
8	MK	4.42	30.00	133
8	AG	59.44	30.00	1783
9	WASTE	29.40	0.00	0
				0
				0
				0
				0
				0
				0
		610.51012		6541.604

Total logging cost: 7326.121

Logging Group	Logging Rate
1	$6.72
2	$8.96
3	$8.96
4	$7.84
5	$13.44
6	$16.80
7	$22.40
8	$33.60
9	$0.00
10	
11	
12	
13	
14	
15	

Figure 5. Liro differential calculator – contractor extreme



Average logging rate: 12

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2	S 5.5	62.82	80.00	5025
3	S 4.3	19.49	75.00	1462
3	S 3.7	27.71	75.00	2078
4	A_EXP 8.1	67.20	70.00	4704
4	J 12.1	58.47	70.00	4093
5	K 5.9	36.92	60.00	2215
6	J 3.7	31.96	55.00	1758
6	A_EXP 4.1	38.32	55.00	2108
7	KI 3.7	7.33	50.00	367
8	MK	4.42	40.00	177
8	AG	59.44	40.00	2377
9	WASTE	29.40	0.00	0
				0
				0
				0
				0
				0
				0
		610.51012		40296.71

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Logging Group	Logging Rate
1	$16.36
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9	$0.00
10	
11	
12	
13	
14	
15	

Figure 6. Liro differential calculator – compromise values

The number of differential steps

When differentials have been used in the past there have often been just three levels used: pulp, sawlog and pruned logs. A large proportion of the improvements in value recovery come from turning low value sawlog into high value sawlog however, and a three step differential gives no

incentive to do this. A minimum of five differential steps better match forest owner and contractor goals as shown in Figure 7.

The front series in Figure 7 shows grade out-turn using the Timber Tech optimiser cutting a batch of stems with relative values close to market values, reflecting company goals. Differentials were then worked out for these trees using three and six steps. The second series in Figure 7 shows the grade out-turn when the optimiser used the three values that the contractor would get paid. With three differentials there is no alignment of goals between contractor and forest owner. The third series in Figure 7 (at the back) using the 6 differential steps as relative values in the optimising engine shows grade out-turn well aligned to the front series, the company goals.

It is recommended that a minimum of five differential steps be used.

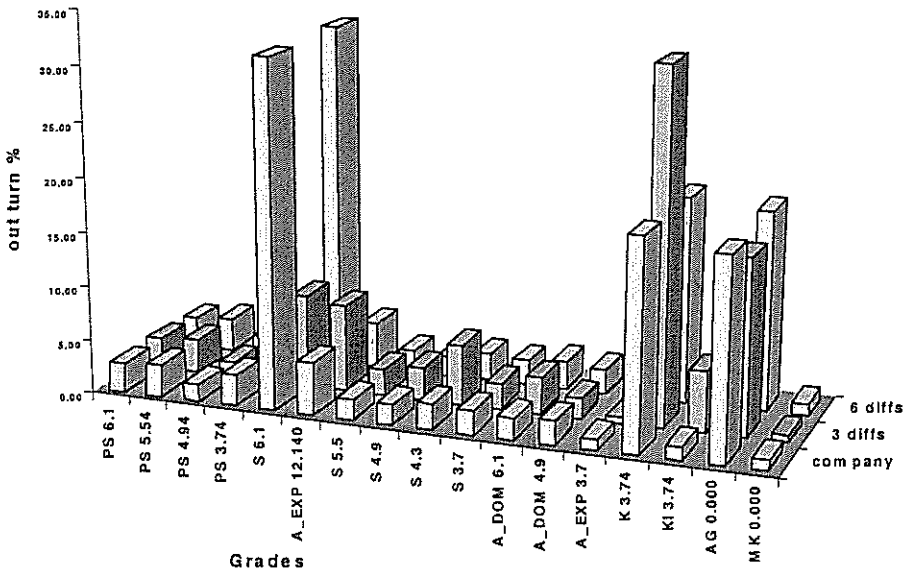

Figure 7. Effect of number of differentials on contractor motivation

Estimating Grade Volume Out-turn

Many of the problems people have had with differentials is that the estimate of grade out-turn has a major effect on the success of the system and the estimate is often wrong. To overcome this a stand should be opened up and harvested for one or two weeks before the grade out-turn estimates are made and the differentials set and payments to the contractor backdated. There is a danger that any assessment which is too accurate will remove the contractor's opportunity to improve grade out-turn, hence income. The results of an unstaged audit demonstrate this point.

A hauler operation was audited by measuring all logs that arrived for processing with Timber Tech electronic calipers but not marking log solutions on them. The manual logmaker worked as usual and his production was measured by counting and measuring all logs which arrived at the stacks. The comparison of the two results over a four day audit is shown in Figure 8. The manual operator produced products worth 89% of the value achieved by the operator with an electronic caliper (mill gate prices)

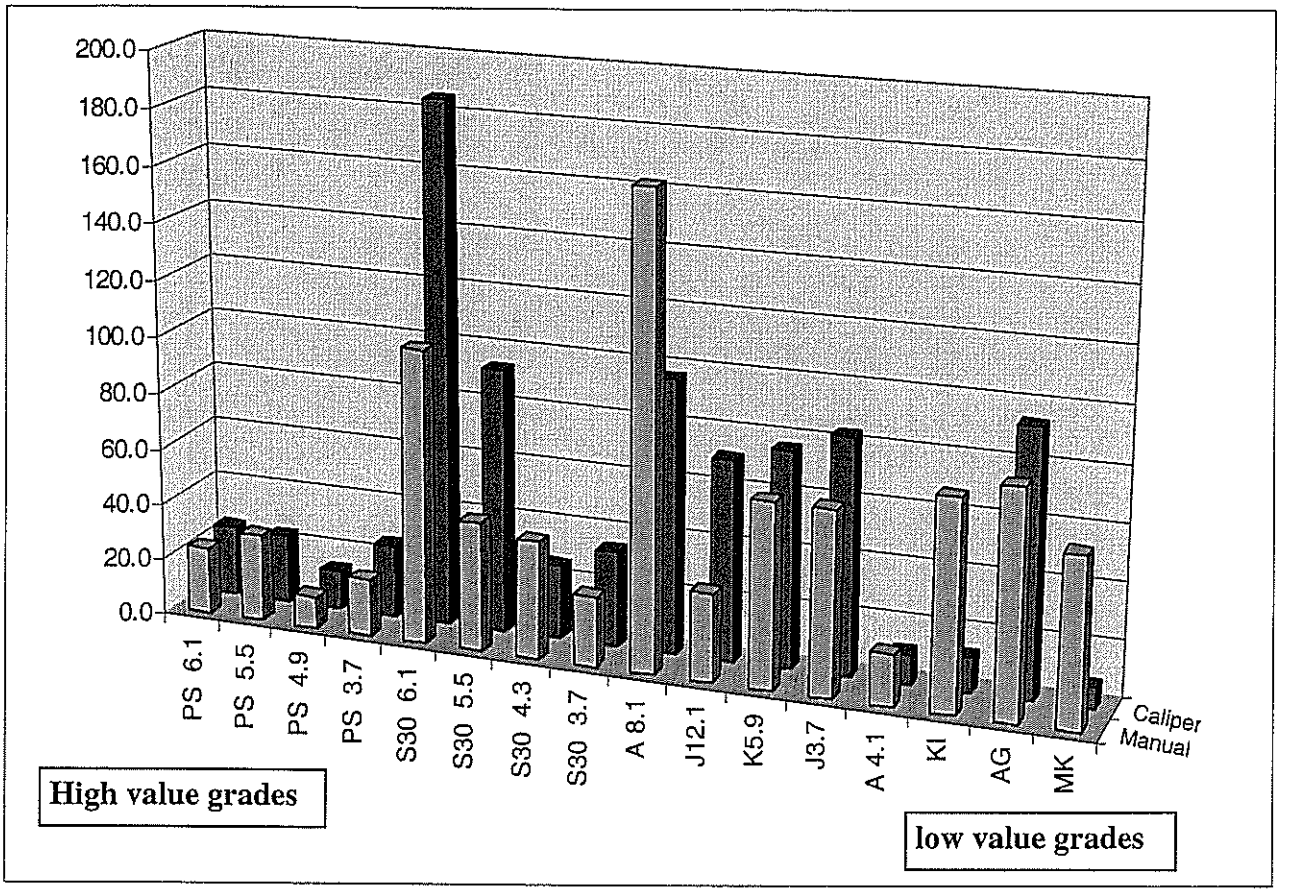

Figure 8. Grade out-turn comparison between electronic and manual logmaking

Assume that this hauler operator is offered a differential payment to improve his value recovery with seven differential steps between \$13/t and \$29/t. He purchases a caliper and improves value recovery by 11%. This gives an extra benefit to him of \$143/day or \$33,000 per year. It gives the forest owner a benefit of \$11.46 per tonne, \$2,500 per day or \$590,000 per year.

If a perfect assessment of the stand was carried out with all the available technology there would be very little opportunity to improve the value of the stand. A one percent improvement in grade out-turn is only worth \$11per day to the contractor.

As will be shown in the next section, with any value based payment system we have looked at, production rate has a greater effect on contractor income than quality. For the example above, if the contractor was able to produce more than his daily target he would only have to pull another 6.5 tonnes per day to make \$143/day extra, so why should he be interested in using electronic aids, or in improving value recovery. Forest owners should set differentials with conservative grade out-turn estimates to leave an incentive for the contractor to excel. Fixed quotas could give a further motivation.

Sensitivity Analysis.

What effect do changes in contractor productivity, changes in cut plans, and incorrect estimates of grade volume out-turn have on forest owner and contractor incomes?

An example was set up with 4 days production for a hauler crew – 927m³ from 535 butt logs, 352 trees per hectare and production of 210m³ per day.

Grades were assigned to 7 groups, and with a logging rate of $22, seven differential steps were used over the compartment. Appendix Two shows the base case. With this base, the effect of variations on contractor and company income were assessed, and are reported under three headings:

- The assessment of the stand grade out-turn or volume was wrong
- The assessment of the stand out-turn was right
- The cut plan is changed

The assessment of the stand is wrong

Estimate of volume is wrong

5% more (or less) volume is harvested than the estimate suggested. If it is spread evenly across all grades it leaves the contractor's income the same for every 210 tonnes logged, but the company's income is up (down) 5% on their estimate

Estimate of quality was low

If group 1 and 2 grades are estimated 10% lower, and other grades are estimated 7% higher than actual harvest, then each ha is estimated to be worth $59,519, and the estimate of total volume was right.

The harvest is better quality than expected - the same volume but worth $60,417, an extra 897/ha. The contractor's income is $4,704 per day at 210m³, an increase of $82.58 per day, and the net effect for the company is $669.55/ha extra - the major share of the increase in value.

The logging rate is up $0.39/m³, although the company income is up $1.54/m³ on budget. Extra logging cost is an inappropriate measure of a change in the margin between income and costs. A conservative estimate of the grade out-turn of the stand leaves some incentive for a contractor to strive for value while the forest owner receives most of the reward. The perfect assessment of a stand before harvest may be very expensive to obtain, and may also remove any possibility of the contractor being able to improve value and earn extra income.

Estimate of quality was high

If group 1 and 2 grades are estimated to be 10% higher volume and other grades are estimated 7% lower than the actual harvest, then each ha is estimated to be worth $61,315.

The harvest is lower quality than expected – the same volume but worth $60,417 ($897/ha) less than estimated. The contractor's income is $4,621 per day at 210m³, a decrease of $80.30 per day, or $0.38 cents/m³.

The assessment of the stand is right

Contractor increases production

An increase of 5% increases contractor income by 5%, or $231/day. Increasing production by 10% increases income by 10% or $462/day.

The cost per tonne stays the same, but contractor income increases sharply, independent of value.

Same production and same vol/ha, but the contractor finds 10% more group 1+2 logs, 5% less of all other group logs

The stand value goes up to $61,920, an extra $1,503.

The contractor income is $4,736 per day, an extra $72/day or 34c/$m^3$.

The net result for the forest owner is an extra $1,304/ha or $2.23/$m^3$. The forest owner wants the contractor to be striving for value, not volume.

The cut plan is changed

The stand is harvesting as expected. Differentials stay the same for the whole compartment.

Take pruned grades off the cutting list

The stand value drops to $58,365, costing the forest owner $2,052.

Contractor income drops to $4,469, a drop of $149 per day

Swap priorities of S longs and S shorts

Far more group 3 differentials are paid, less group 2 logs.

The stand value drops to $58,412, costing the forest owner $2,005/ha.

The contractor income drops to $4,434, a drop of $160 per day (an unlikely example)

Risk Management

Summary of Risk to Contractor

- Change production with no more quality

  ±5% production rate ± $231/day
  ±10% production rate ± $462/day for contractor, but no change to forest owner

- Large change to Cut plan -$160/day

- Original estimate of grade out-turn over or underestimated top two grades 10% makes a difference to contractor of ± $80/day

- An original estimate of grade out-turn that is perfect removes the opportunity for extra income by extracting more high value grades, so is counter-productive.

As with the current payment system, the greatest risk is producing over or under target production rate. Next is a change to the cut plan, although this carries substantially less risk than volume produced per day. The more differential steps there are, the smaller the gap between them, so the smaller the effect if grades are cut.

Contractors make more by overproducing with any value based payment system as with the current system. It is more profitable to ignore value and overproduce. If the quality or volume targets are set too high the contractor must ignore quality and push production rate to make the business viable.

The practical suggestion may be to use a conservative target which the contractor can achieve and then restrict over production, so extra income can only be made by producing more quality from the stand.

A major change in the cutting plan reduces the contractor's income, but if it is too large a drop, rather than change the differential rate, which would have major logistical and accounting implications, it may be easier to allow the contractor to extract another 5 to 10 tonnes per day

The argument which states that restricting a contractors output has the long term effect of holding logging rates up is not valid when contractors are regularly tendering for new contracts. The current practice of setting a price and then allowing overproduction has huge financial benefits for contractors but none for forest owners, especially where overproduction is at the expense of quality.

Appendix 1 - Setting and using differentials

1. Estimate the volume in the stand by grade.

For the first week or two that a contractor is in a stand opening it up, forest owner representative and contractor should endeavour to harvest a representative sample of the trees that are growing in the whole stand. The Timber Tech log optimising caliper could be used on all stems during this time and the log stocks data and stem descriptions collected.

At the end of the period, divide the total volume of each grade by the total number of trees harvested to estimate the average volume of each grade in each tree, then adjust these volumes using the number of trees per hectare estimated by pre-harvest plotting., e.g. stocks recovered from 100 stems corrected for 315 trees per hectare:

Grade ID	Volume	Correct- (x 315/100)	Market Value	Value per hectare
A12	5.9	18.59	90	$1,673
CNI 6	120	378.00	110	$41,580
CS4.1	7.2	22.68	50	$1,134
CV2.7	4.15	13.07	90	$1,177
JN4 4.1	6.45	20.32	80	$1,625
JN88.1	5.95	18.74	80	$1,499
K11.1	23.3	73.40	90	$6,606
KIS4.1	0.65	2.05	44	$90
KIS 6.1	6.2	19.53	45	$879
RM4 3.7	10.2	32.13	70	$2,249
RM5 4.9	3.9	12.29	70	$860
RM6 6.1	13.75	43.31	70	$3,032
Wa	9.05	28.51	0	$0
		682.61		$62,403

Note: When opening up the stand, the forest owner would benefit by collecting very detailed electronic stem descriptions to be used for analysis during harvest by logging managers and marketing staff. To be of value the stem descriptions should be better than those used by production logmakers, but such descriptions take longer. For this reason the forest owner could provide another logmaker while the sample is being collected. The first two weeks of harvest are the first opportunity to collect accurate stand characteristics such as branch sizes, severity of sweep, internode lengths, out of round, off-centre pith etc, essential to fine-tune the marketing process.

Care should be taken that the grade out-turn estimate is conservative to ensure that the opportunity for extra income by extracting more high value grades is not removed. If the Timber Tech electronic logmaking caliper is used on all stems to get the perfect log grade out-turn, and this was used to set differentials, then a contractor would have to achieve perfect grade out-turn to achieve a standard daily income. If using a Timber Tech caliper when opening up the stand, reduce the out-turn estimate of higher value grades to ensure that the contractors have some opportunity to earn extra income by creating value.

2. Calculate the contractor's daily cost

Calculated as usual eg $3,000/day

3. What is the contractor's daily target for the setting?

Negotiated/calculated as usual, e.g. 250 t/day

4. Derive the average logging rate in the usual manner

e.g. $3,000/250 = $12/t. Alternatively, use a tendered rate, if that has been the rate setting mechanism.

5. Calculate differentials

Use the manual calculation sheet (Appendix 3) or the Liro's differential calculator (Figure 3) as follows:

- Group all grades likely to be cut into groups of similar value – at least five and probably a maximum of ten
- On sheet or calculator enter average logging rate, grade names and the estimated volume per hectare for each grade
- To the left of each grade name put the group number
- Enter relative values for each grade.
- Calculate differentials for each group
- Change relative values until the range from highest to lowest suits your operational requirements

6. Change cutting plans in the normal manner

The differential is already set for each group of grades.

7. Calculate contractor income.

On receiving weighbridge reports, multiply the volume of each grade by the relevant differential to calculate the contractor income.

Appendix 2 Sensitivity Analysis Example

Batch run - original cut plan																			
535 trees in batch, Manl says 352 trees per hectare					927m3	Daily									Average logging rate		22.00		
Grade:	Value	Num	SED	Volume	Vol/ha	prod													
											Log group	Grade	Vol/ha	Priority Va	Total value		Logging G	Logging Rate	
PS 3.7	150.00	42.00	44.64	27.72	18.24	6.59					1.00	PS 3.7	18.24	150.00	2735.34		1.00	31.74	
PS 6.1	150.00	24.00	41.97	23.98	15.78	5.70					1.00	PS 6.1	15.78	150.00	2366.43		2.00	26.45	
PS 4.9	150.00	16.00	42.59	13.47	8.86	3.20					1.00	PS 4.9	8.86	150.00	1329.28		3.00	23.71	
PS 5.9	150.00	21.00	44.81	21.54	14.17	5.12					1.00	PS 5.9	14.17	150.00	2126.11		4.00	22.22	
S 6.1	125.00	233.00	35.86	167.16	109.98	39.75					2.00	S 6.1	109.98	125.00	13747.74		5.00	17.66	
S 5.5	125.00	162.00	34.32	95.48	62.82	22.71					2.00	S 5.5	62.82	125.00	7852.31		6.00	12.70	
S 4.3	115.00	65.00	34.45	29.62	19.49	7.04					3.00	S 4.3	19.49	115.00	2241.23		7.00	6.35	
S 3.7	115.00	118.00	33.14	42.12	27.71	10.02					3.00	S 3.7	27.71	115.00	3186.57		8.00		
A_EXP 8.1	110.00	71.00	42.43	102.13	67.20	24.29					3.00	A_EXP 8.1	67.20	110.00	7391.54		9.00		
J 12.1	105.00	121.00	23.58	89.87	58.47	21.14					4.00	J 12.1	58.47	105.00	6139.78		10.00		
K 5.9	90.00	161.00	24.78	56.12	36.92	13.35					5.00	K 5.9	36.92	90.00	3323.02		11.00		
J 3.7	80.00	392.00	19.08	48.57	31.96	11.55					5.00	J 3.7	31.96	80.00	2556.65		12.00		
A_EXP 4.1	80.00	271.00	23.72	58.25	38.32	13.85					5.00	A_EXP 4.1	38.32	80.00	3065.76		13.00		
KI 3.7	60.00	24.00	35.62	11.14	7.33	2.65					6.00	KI 3.7	7.33	60.00	439.81		14.00		
MK	30.00	12.00	38.48	6.72	4.42	1.60					7.00	MK	4.42	30.00	132.70		15.00		
AG	30.00	734.00	16.40	90.34	59.44	21.48					7.00	AG	59.44	30.00	1783.05				
WASTE	0.00	601.00	23.93	44.69	29.40	10.12							0.00	0.00	0.00				
				883.22											0.00				
															0.00				
															0.00				
Income/day															0.00				
			vol			Logging G	Logging Rate								0.00				
PS 3.7	1.00	31.74	6.59	209.22		1.00	31.74								0.00				
PS 6.1	1.00	31.74	5.70	181.00		2.00	26.45						581.11		60417.34				
PS 4.9	1.00	31.74	3.20	101.67		3.00	23.71												
PS 5.9	1.00	31.74	5.12	162.62		4.00	22.22						Total logging cost		12764.37				
S 6.1	2.00	26.45	39.75	1051.52		5.00	17.66												
S 5.5	2.00	26.45	22.71	600.60		6.00	12.70												
S 4.3	3.00	23.71	7.04	167.03		7.00	6.35												
S 3.7	3.00	23.71	10.02	237.48															
A_EXP 8.1	3.00	23.71	24.29	575.90															
J 12.1	4.00	22.22	21.14	469.65															
K 5.9	5.00	17.66	13.35	235.70															
J 3.7	5.00	17.66	11.55	204.01		Contractor income													
A_EXP 4.1	5.00	17.66	13.85	244.63		210 tonnes x $22 =		4621.14											
KI 3.7	6.00	12.70	2.65	33.65		Diff payments		4621.24											
MK	7.00	6.35	1.60	10.15															
AG	7.00	6.35	21.48	136.42															
			210.05	4621.24															

Figure 9. Sensitivity analysis example

Appendix 3. Manual Calculation Sheet

Differential logging rate - Manual calculation sheet

Liro Limited
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	Average logging rate (R)	

1

Log group	Grade	Vol/ha (a)	Priority Value (b)	Total value (axb)=c
Total volume	d		Total value =	

Instructions:

Enter average logging rate - based on daily cost divided by target production in tonnes per day.
or annual cost of operation divided by annual cut (use Liro Ltd costing model).

Box 1

Enter Grade names.
For each grade enter estimate of volume per year or per hectare, a.
For each grade enter priority values - start with market value and adjust to reflect market demand, b.
Estimate total value, c = axb
Decide how many steps or groups there will be in the payment system and assign each grade to a group.
Total volumes, d, and values, e.

Box 2

Estimate total logging cost, m, where m = average logging rate (R) x total volume (d)

Box 3

Add volume and value totals for each log group and enter into appropriate spaces, volume totals = f, value totals = g
Calculate the proportion (h) of each groups value (g) compared to the total value (e), where h = g/e
Use the same proportion (h) on the total logging cost (m) to assign a logging cost for that log group, (n).
This gives this log group equal importance for both contractor and forest owner.
Divide total group logging costs (n) by group volume totals (f) to give differential logging rate for each log group

2

Total logging cost, m = d x R	

3

	Group 1	2	3	4	5	6	7	8	9	10	
Volume totals (add 'a's) = f											
Total value (add 'c's) = g											
Group as % of total value, h=g/e											Must add to 100
Logging cost, n = hxm											
Logging rate n/f											

Figure 10. Manual Calculation Sheet