Short-run and long-run costs for milling rainforest cabinetwood timbers

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Summary

This paper provides estimates of short-run and long-run average costs of portable sawmills and discusses the implications of using portable rather than fixed-site sawmills for milling rainforest cabinet timbers in northern Queensland, Australia. Ten portable and eight fixed-site sawmills were surveyed in northern Queensland, and the findings, combined with information from other sources, were used to develop a financial model of milling costs. Financial analysis reveals that, because fixed costs for portable sawmills are low, the cost structure is dominated by variable costs, in particular labour costs. The rate of sawn timber recovery had a major effect on milling cost. The estimated short-run average total cost of milling rainforest timber with a portable sawmill was \$162 m^{-3} of roundlog (\$361 m^{-3} sawntimber), assuming a 45% recovery rate and a roundlog throughput of 344 $m^3\ y^{-1}$. This is higher than the median contract milling price of \$140 m^{-3} of roundlog (\$311 m^{-3} of sawntimber), suggesting that some portable sawmillers (especially part-time operators) do not take all costs into account. The financial model was also used to derive sawmilling long-run average cost curves, based on varying sizes of portable sawmills**.** The bandsaw has the lowest milling cost for log throughput from zero to about 60 $m^3\ y^{-1}$, the Lewis saw from 60 $m^3\ y^{-1}$ to 185 $m^3\ y^{-1}$, the Forestmill from 185 $m^3\ y^{-1}$ to 1240 $m^3\ y^{-1}$ and the Supermill beyond 1240 $m^3\ y^{-1}$.

The financial model developed indicates that even where all costs are included, portable sawmills can be competitive with fixed-site mills in an infant or declining industry situation, and can also play a role in farm woodlot forestry.

Keywords: portable sawmills; cost analysis; Queensland

Introduction

Sawmills in northern Queensland have traditionally processed a diverse range of high-quality timbers from local rainforests. Over 100 species are suitable for milling, and many of them produce timber highly prized for cabinet-making, furniture and flooring. However, sawmilling activity contracted dramatically with the World Heritage listing of the Wet Tropics rainforests in 1988 and associated logging bans on public and some private land, and is currently restricted to a small number of fixed-site mills and a variety of portable mills[1] which procure timber from privately-owned native forests.

The low stumpage prices paid by fixed-site mills relative to the final sawn timber prices is a source of contention, with landholders believing that these mills can obtain timber at low prices because of the lack of competition. This situation is fairly typical in forestry. The use of portable sawmills by full-time and part-time millers has increased in recent years. Portable sawmills compete with traditional fixed-site sawmills on the local market, but are not seen as a major threat to their future.

Lack of investment and ageing equipment have been suggested as causes of inefficiency in fixed-site mills in northern Queensland. According to Keto (cited by RAC 1992), mill closures in the region indicated the rainforest timber resource was declining before World Heritage listing in 1988. This was due to the log allocation from native public forests being progressively reduced. The Queensland Government stated that raw materials for mills in the area were scattered and that the mills were technologically outdated (RAC 1992). The World Heritage listing resulted in a substantial decrease in the availability of rainforest cabinet timbers. The annual average removal of rainforest cabinet timber from public and private land in the three years prior to the declaration of the Wet Tropics of Queensland World Heritage Area (WTWHA) was 66 000 m^3, with lower-grade structural timbers accounting for a further 52 000 m^3 (Moore 1992). Following the ban on harvesting in the WTWHA, the harvest from private land initially increased. Overall, however, there was a much reduced timber supply, with lower log quality, fragmented sources and less accessible locations, leading to increased harvesting and processing costs. In this situation, interest arose in portable sawmills, with lower equipment and operating costs and possibly also environmental benefits, as an alternative to traditional fixed-site mills.

[1]The terms ‘mobile’ and ‘portable’ sawmill are used interchangeably in this paper. All portable sawmills are mobile although not all mobile mills are portable. Portable mills can be differentiated as those that can be dismantled and moved to inaccessible areas by means of human or animal transport and are generally used in developing countries. In northern Queensland both types are used.

While some research on portable sawmilling has been undertaken in other countries (Verissimo *et al.* 1992, 1995; Barros and Uhl 1995) and in other Australian states (Stewart and Hanson 1998), little research has been undertaken in northern Queensland, where numerous species of cabinet timbers are milled. Portable sawmills can be moved easily between sites within or near forests. Much of the biomass can be left on-site, hence reducing transport costs. If larger volumes are milled, however, portable mill operators often revert to a fixed-site setup, allowing more efficient use of ancillary equipment and a more settled base for labour (Smorfitt *et al.* 2003).

Economic theory divides costs of production into short-run costs (when levels of some factors of production are fixed) and long-run costs, for which levels of all factors (including buildings, plant and equipment) can be varied. Short-run costs are divided into fixed costs, incurred regardless of whether any production takes place, and variable costs which depend on the level of production. Frequently, the interest is in calculating *average* costs per unit of output, as a measure of production efficiency. In the case of timber milling, short-run costs would include any costs for registration, insurance, and shelter of equipment and product, while variable costs would include for example fuel and blade-sharpening costs. The 'textbook' pattern of short-run costs in relation to level of output is depicted in Figure 1. Average total short-run cost typically follows a U- or L-shaped curve with respect to output, with the declining stage due to spreading of overhead costs over more units of output, which is countered by rising average variable costs at high output. In long-run cost analysis where different plant (sawmill) sizes are considered, the average milling cost varies with the size of plant used. Economic theory postulates that the long-run average cost curve — also called the *planning curve* — is the 'envelope' of linked lowest-cost segments of a number of short-run average cost curves for different mill types and sizes.

This paper explores fixed and variable costs of portable sawmilling and the implications for choice of mill type for milling cabinetwoods in northern Queensland. The role of portable sawmills in the regional forest industry is examined. The research method used to develop a financial model of milling costs is outlined. Development of the model and its use to estimate short-run cost curves and perform sensitivity analysis of critical parameters are discussed. A long-run average cost curve is then estimated, with reference to a portable bandsaw and three portable circular sawmills of varying capacities. Finally, implications for sawmilling policy are examined.

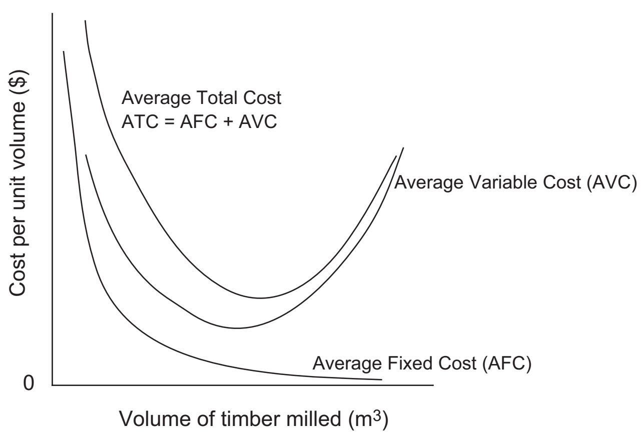

Figure 1. Traditional forms of average total, fixed and variable cost curves as reported in economic theory

Types and relative performance of portable sawmills

The simplest form of portable saw is the chainsaw, frequently attached to a lightweight metal frame positioned over the log. Chainsaw mills are wasteful of timber (due to the wide cut or kerf), require considerable manual handling of logs, have low throughput, typically produce rough sawn surfaces, and are best suited to low-value low-volume milling or as a means to break down logs for further sawing (Smorfitt *et al.* 2001a).[2]

A range of makes and models of circular and bandsaw portable sawmills are available. Circular sawmills may use a single- or double-blade configuration. A double-blade configuration features a vertical and horizontal blade operating at the same time, cutting two sides of flitches or boards with one pass over the log. With a single-blade configuration, orientation may be switched between vertical and horizontal between passes. Folkema (1992) reported that circular sawmills had long been used by Canadian farmers, but sales dropped following the introduction of portable bandsaw mills in 1982.

The relative suitability of circular saws and bandsaws for milling high-quality boards for cabinet-making, and the recovery rates achievable, continue to be debated between proponents of each type of mill (Smorfitt 2000; Smorfitt *et al.* 2001a,b). Bandsaw proponents argue that higher recovery rates are achievable, and that bandsaws are more suitable for milling logs into a variety of dimensions, as well as for slabbing of logs for subsequent resawing into finished dimensions. Circular saw proponents point to the higher throughput achievable with circular saws and refer to the wave effect of a wandering bandsaw blade, resulting in further costs associated with dressing of sawn boards. Bandsaw proponents claim a well-cut board from a bandsaw should need little dressing, and that any wave effect is due to a lack of operator experience or poor maintenance of the mill.

The question arises as to the extent to which portable sawmills can displace fixed-site mills, particularly in the processing of timber from small farm plots of mixed-species hardwoods. While greater timber recovery is expected from portable sawmilling than traditional fixed-site milling, low recovery rates are also possible. This would be the case, for example, if portable sawmilling of rainforest timber species were compared with fixed-site milling of plantation-grown exotic species. For example, the recovery rate for acacia species with poor form is likely to be about 25%. Likewise, a case study of portable sawmilling of over-mature, poorly managed Queensland maple produced recovery

[2] The authors' interviews of sawmillers in the Philippines revealed that some customers will not purchase chainsawn timber due to the uneven sawn surfaces. On the other hand, it is contended by an anonymous reviewer that in the Solomon Islands, most of the rosewood (*Pterocarpus indicus*) is sawn by chainsaw, sometimes without a frame, and the surfaces are commonly no rougher than when using circular saws.

rates of about 20% (I. Venables, portable sawmill operator, Ingham, 1998, *pers. comm.*). Traditional fixed-site sawmillers argue that portable sawmillers are unable to produce high-quality sawn timber. Output quality depends on species milled, log size and quality, tree age, whether logs are from plantations or regrowth or mature wood, prevalence and severity of growth stresses and reaction wood, and relative amounts of sapwood and corewood, as well as the milling technique, experience and ability of the operator. Smaller and younger logs often have more growth stresses and thus are more difficult to mill without boards warping and twisting. Larger logs also create problems for portable millers in that the log cannot always be cut into halves or quarters to relieve stress. There are, however, examples of experienced portable sawmillers supplying major domestic markets with high-quality sawn timber for over 15 y.

The use of portable sawmills by landowners milling their own timber, and the establishment of portable sawmill businesses by entrepreneurs, has increased in northern Queensland in recent years. Landholders indicate that portable sawmillers pay higher stumpage prices than fixed-site sawmillers, leading to suggestions of profiteering by fixed-site sawmill operators. However, operators of traditional fixed-site sawmills claim the higher stumpage prices paid by portable sawmillers are possible only because these sawmillers fail to account for workers' compensation and industry association costs, and selectively purchase high-quality logs (Smorfitt 2000).

Method of obtaining milling cost data

The research reported here and in other publications (Smorfitt 2000; Smorfitt *et al.* 2001a,b, 2003) was part of a wider study on sawmilling of farm-grown timber in northern Queensland which involved collecting data on sawmilling costs.

Reliable data for portable sawmilling operations were difficult to obtain. Whilst some data on log throughput and recovery from other countries and states were available, estimating mill performance parameters for northern Queensland is complicated by the wide variety of hardwood species milled. For example, more than 150 native species, most with commercial timber quality, were planted during 1992–1996 in the Community Rainforest Reforestation Program. As a result, it was necessary to seek data on milling costs from a number of sources, including literature review, consulting manufacturers' specifications, informal discussions with operators of portable and fixed-site sawmills (including field days and visits to local operators), a survey of portable and fixed-site sawmill operators, and a detailed case study (Smorfitt 2000).

Fixed-site sawmill operators in Queensland were reluctant to provide information, much of which was regarded as commercially sensitive (Bennett 1990). In northern Queensland there was antagonism to research due to costs imposed on sawmillers and landholders from the 1998 World Heritage listing of the Wet Tropics of Queensland rainforests, which removed most of the native forest resource from the timber industry. However, sawmillers do appear amenable to one-on-one discussions, where they were willing to voice opinions about forest policy and express views on sawmilling activities. In these instances, sawmillers often provide useful insights into timber milling and details of their operations that would not be forthcoming under a more structured approach. An interview survey technique was chosen in preference to postal or telephone surveys due to the expected higher response rate and more detailed disclosure. Visits to milling sites and interviews with managers also reduced the number of unanswered and inappropriately answered questions, and allowed the interviewer to assess, through observation, factors such as the age and condition of milling equipment.

Selection of the population sampling frame and sample

The traditional method of developing a population list or sampling frame and then carrying out probability sampling could not be applied in this study. DPI (1998) reported that seven fixed-site sawmills operate in northern Queensland. The number of portable sawmills was difficult to determine, because these mills were not spatially identified and not all have to be licensed under the *Sawmill Licensing Act (Qld) 1936*. Information from the Department of Primary Industry revealed that 19 registered sawmillers operate in northern Queensland on the coastal belt between Ingham and Cairns or on the Atherton Tablelands. Eight fixed-site and 10 portable sawmillers participated in the survey while one fixed-site sawmiller refused.

Development of questionnaires for the sawmill operator survey

Data sought from sawmillers were primarily of a commercial nature including information relating to sawmill cost structures, age of equipment and sources of log input. The scope of this survey was restricted to data that would generally not be obtainable from other sources, in order to limit questionnaire length and maximize response rate. For example, manufacturers' stated equipment sale prices and maintenance schedules and the cost of bank finance (which were available from other sources) were not sought in the survey.

Separate questionnaires were developed for portable and fixed-site sawmillers, but with considerable overlap to ensure comparability of data. The initial questions were based on information provided by portable sawmill manufacturers and their agents at field days, visits to two fixed-site sawmills, and 'grey' literature on portable sawmilling. A fixed-site sawmiller in south-eastern Queensland provided critical feedback on the initial questionnaire, commenting that he would not be prepared to provide some of the commercially-sensitive information sought. The questionnaire was revised, re-evaluated by two portable sawmill operators in northern Queensland, and further changes made. Even during the survey, it became apparent that sawmillers were unable to provide costs for milling timber, and a question was added on what they would charge to mill timber on a contract basis.

Fourteen questions were specific to the sawmill and its operations, and six were open-ended. Four broad areas were covered:

- issues affecting the industry and individual firms
- issues associated with acquisition of resources and volume of timber milled
- sawmilling operations such as type of equipment used, number of employees, sawn timber recovery rates and factors affecting the level of recovery

- general state of the industry and conditions faced by individual operators.

Open-ended questions covered the following areas:
- main factors affecting sawmillers' current and future milling activities
- whether the sawmiller had plans to acquire new milling or associated equipment in the near future, and if so what type of equipment
- main difficulties faced in sourcing logs
- whether sawmillers regard portable sawmills as complementary or competitive with fixed-site-sawmills
- whether sawmillers consider feasible the replacement of a fixed-site sawmill with a number of portable sawmills
- sawmillers' views about the future of the timber industry in northern Queensland.

We took notes of responses to these open-ended questions to allow content analysis. The survey data were encoded and entered into Excel spreadsheets and various descriptive statistics were obtained. The sample was not sufficiently large for inferential statistical methods to be applied.

Development of the financial model

Survey findings were integrated with information from other sources in developing the financial model of milling costs. Relevant cost categories were identified from the survey, a case study of milling of Queensland maple (*Flindersia brayleana*) as reported by Smorfitt (2000), and data obtained from banks and equipment manufacturers and sellers. The financial model does not take into account the costs of purchasing logs or snigging and haulage, nor drying, treatment or marketing costs. While these are relevant costs of producing seasoned sawn timber, they do not depend on the type of mill. The basic financial model was specified for a portable bandsaw, with 5 hp petrol motor, a cut 45 cm wide and 10 cm deep, and a blade kerf of 2 mm.

Critical parameters

Through discussions with sawmillers and literature reviews, three parameters were hypothesised as most critical in milling cost analysis, namely number of operating days per year, daily mill throughput, and sawn timber recovery rate. Best-bet estimates of these parameters are presented in Table 1.

Table 1. Key parameters of the milling cost model

Parameter	Standard level
Working time (days worked y^{-1})	172
Quantity of timber milled (m^3 of roundlog per 8-h day)	2
Sawn timber recovery rate (fraction of roundlog input volume recovered, %)	45

Derivation of the estimate of annual working time

Portable mills operate in the open, and lose operating time in wet weather. The potential annual number of days of milling was based on provisions for Australian workers specified by Department of Employment, Vocational Education, Training and Industrial Relations, including a five-day working week, four weeks annual holiday and eight working days sick leave. The wet tropics area covered by this study averages 143 rain days per year (a representative figure over wet and drier areas). An operator can mill on some of these days and may take some vacation days during the wet periods, and may work on some weekends; 172 working days per year was assumed.

Daily throughput

Based on information from the operator of a small portable mill, two people — the owner and a part-time employee — were assumed to operate the mill for logistic purposes and for worker safety, with a throughput of 2 m^3 roundlog per 8-h day.

Rate of recovery of sawn timber

Many factors affect the rate of recovery, and it was not possible to incorporate all these factors in a financial model. Recovery rate is particularly unpredictable for the milling of numerous native forest timbers of highly variable timber type, log quality and log size. The median recovery rate of all survey respondents (fixed-site and portable sawmills) was 40.4%, which is similar to the rate of 37% reported by the Queensland Timber Board (1996) for fixed-site sawmills. Based on licensing classification, the mean recovery rate for portable sawmills reported in the survey was 44.2%, compared to the fixed-site sawmill average of 36.4%. A recovery rate of 45% was used for the standard analysis; we considered this to be realistic in view of our survey results, anecdotal evidence and our literature review.

Elements incorporated in the milling cost model

The main variables incorporated in the financial model were costs of equipment acquisition, operating costs and labour costs. Detailed assumptions and cost estimates are reported in Appendix A. No discounting to present values was necessary because all costs (including equipment acquisition costs through leasing) were calculated on an equal annual basis[3].

Purchases of logs

Log purchase costs were omitted as this analysis examined milling costs and their variation with mill size. Alternatively it could have been assumed that portable and fixed-site sawmillers pay the same price for logs of equal quality, and thus purchase price was not brought into account in the financial analysis.

[3]An alternative would be to use an equivalent annual cost model. This was not employed because portable sawmills and ancillary equipment constitute a relatively short-term and liquid investment, and overhead costs are small relative to labour and other operating costs. The assumption that the equipment items are leased in effect converts costs over the life of the equipment to an equivalent annual cost.

Sawntimber recovered annually

This is the product of the volume of roundlog timber milled per day, the number of days worked per year and rate of recovery of sawn timber.

Queensland Timber Board (QTB) subscription

While the annual $1200 QTB subscription was not a legal requirement for portable sawmill operations, a comment frequently made by fixed-site sawmillers was that portable sawmillers do not contribute towards industry costs. The QTB subscription was included to allow comparison with fixed-site sawmill milling costs on a 'level playing field'.

Equipment acquisition costs

Costs of the three major pieces of equipment used in a portable milling operation (sawmill, chainsaw and vehicle) were taken as leasing payments. The vehicle was assumed to be second-hand, with a value of $10 000, and the sawmill was priced at $8000. A lease duration of 5 y, an interest rate of 12% (the interest rate on leases at the time of model development) and no residual value were used to calculate weekly payments.

Equipment operating costs

The hourly costs of operating equipment were obtained from manufacturers, agents and equipment operators. Apart from labour, the main cost items in operating a portable sawmill are fuel, servicing and replacement blades.

- A vehicle is used to move the sawmill between sites where milling takes place. The distance travelled and thus operating costs (mainly fuel and tyres) were based on the number of operating days. Information on basic vehicle operating costs was obtained from the Royal Automobile Club of Queensland (RACQ).
- The chainsaw is used to trim logs and to cut them into appropriate sizes. A chainsaw agent recommended a service interval of 20 h at a cost of $30 per service plus spares, over an expected machine operating life of 3000 h. The resulting service frequency appeared to be excessive in the light of discussions with chainsaw operators in the northern Queensland timber industry, so we adopted a service interval of 40 h and spark plug replacement in the analysis.
- Labour was calculated on an hourly basis and treated as a variable cost. The pay rate for the casual employee was set at \$13.34 h^{-1} including sick and recreational leave (based on award rates in 1999), and the owner's rate of \$18.46 h^{-1} equates to an all-inclusive annual salary of about $36 000. Workers compensation and superannuation for both the owner and employee were included.

Algebraic formulation of the milling cost model

The financial model may be presented algebraically. Total annual costs (TC) are the sum of the total fixed (TFC) and total variable costs (TVC). Each of these cost categories can in turn be broken down into their constituents, as:

$$TFC = TFCm + TFCv + TFCc + TFCo$$

and

$$TVC = TVCm + TVCv + TVCc + TVCl$$

i.e. TC = (TFCm + TFCv + TFCc + TFCo) + (TVCm + TVCv + TVCc + TVCl), where

TFCm = sawmill fixed costs,
TFCv = vehicle fixed costs,
TFCc = chainsaw fixed costs,
TFCo = other fixed costs,
TVCm = sawmill variable costs,
TVCv = vehicle variable costs,
TVCc = chainsaw variable costs,
TVCl = labour variable costs.

The short-run average total cost per unit of volume milled (ATC \$$m^{-3}$) thus becomes ATC = TC/VS where VS is the volume of sawntimber output, or ATC = TC/VL where VL is the volume of roundlog milled.

Short-run milling cost estimates and sensitivity analysis

The financial model was used to derive short-run average total, fixed and variable cost curves in relation to mill throughput. Table 2 presents a summary of the financial estimates for the

Table 2. Cost structures for a portable bandsaw mill cutting 344 m^3 y^{-1} of roundlog timber into 155 m^3 of sawn timber

Cost category	Amount (\$ y^{-1} or \$ m^{-3})	Note*
Fixed costs of milling sawntimber		
Leased equipment		
Landrover	2656	1a
Sawmill — portable	2125	1b
Chainsaw	757	1c
Small tools	200	2
Fixed cost component of operating costs		
Vehicle	892	3
QTB subscription	1200	4
Total fixed costs	7830	
TFC m^{-3} — roundlog	23	
TFC m^{-3} — sawntimber	51	
Variable costs of milling sawntimber		
Landrover	1480	3
Sawmill	2293	5
Chainsaw	420	6
Worker's wage	18361	7
Owner's wage	25407	8
Total variable cost	48043	
TVC m^{-3} — roundlog	140	
TVC m^{-3} — sawntimber	310	
Total costs (TFC + TVC)	55872	
TC m^{-3} — roundlog	162	
TC m^{-3} — sawntimber	361	

*Explanatory notes are provided in Appendix A base case. The total cost to mill 344 m^3 y^{-1}of roundlog timber was $55 872. The cost of milling rainforest timber was estimated as $162 m^{-3} roundlog ($361 m^{-3} sawntimber), excluding cost of log purchase and based on a 45% recovery rate. This is higher than the median contract milling price of $140 m^{-3} roundlog ($311 m^{-3} sawntimber) obtained in the sawmiller survey, the difference (based on a 45% recovery rate) being about 13.5%. Notably, the lowest contract milling price quoted by a portable sawmiller of $80 m^{-3} roundlog ($178 m^{-3} sawntimber) was only half the estimated milling cost.

Variable costs accounted for about 86% of the total milling cost. The labour-intensive nature of portable sawmills is illustrated by the fact that labour accounted for 91% of total variable costs. The operating costs for the sawmill and vehicle account for about 5% and 3% of total variable costs respectively. Leasing costs for the vehicle and sawmill represent 34% and 27% of TFC respectively. However, combined they account for only 8.5% of ATC.

Milling cost sensitivity in relation to key parameters

Figure 2 reports the sensitivity analysis of AFC, AVC and ATC in relation to mill throughput. It was necessary to convert the costs to logarithms (to the base 10) to compress the vertical scale so that cost differences are apparent. When the number of operating days per year and hence annual output volume was increased for given fixed costs, the ATC and AFC fell. This decrease was most pronounced at low levels of output, with unit costs becoming relatively constant for annual throughput of more than 80 m^3 roundlog.

Milling cost in relation to annual number of operating days

The effect on average total milling cost of varying the number of operating days in the base case (172 days) is summarised in Table 3. Increases beyond 172 days had relatively little impact; for example, an increase from 200 to 210 days decreased average roundlog milling costs by only $1 m^{-3}.

Milling cost versus daily roundlog throughput

The effect of varying the level of annual throughput (number of operating days × daily throughput) on milling cost (ATC in $ m^{-3} of sawn timber) is illustrated in Figure 3. From the base case of 172 operating days and 2 m^3 day^{-1}, an increase in throughput of 0.5 m^3 of roundlog per day decreases ATC from $361 m^{-3} to $290 m^{-3} of sawn timber (log$_{10}$ values of 2.56 and 2.46 respectively). For an annual throughput of more than about 100 m^3 of roundlog, there was little cost decrease with increasing throughput.

Sensitivity of average total cost to recovery rate

The sawntimber ATC was estimated for recovery rates at 10% intervals varying from 25% to 65%, reflecting the full spectrum of possible recovery rates as revealed by the literature review and sawmiller survey. The impact of recovery rate on ATC is illustrated in Figure 4. At the base case roundlog throughput

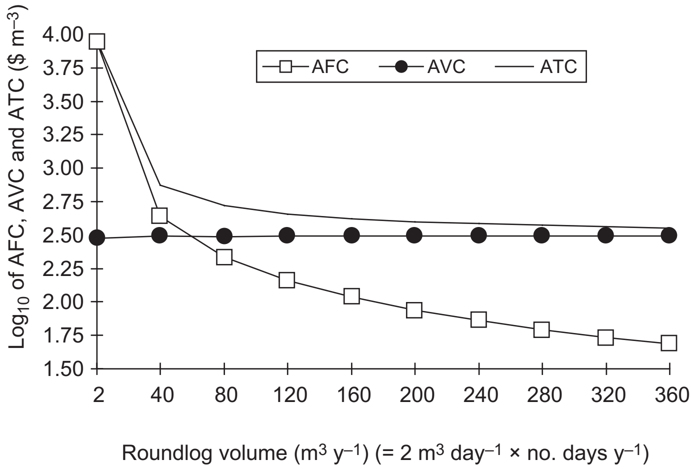

Figure 2. Average costs per unit volume of sawn output for portable sawmilling of rainforest cabinet timbers at 45% recovery. The vertical (cost) axis is presented in logarithmic scale to highlight differences in costs throughout the output range.

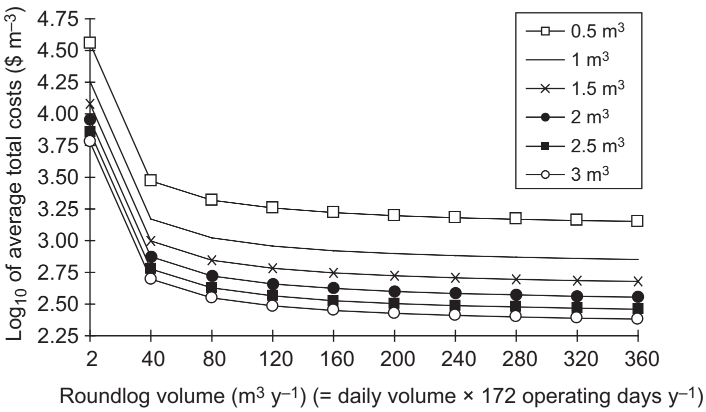

Figure 3. Average total cost per unit volume of sawn output of portable sawmilling for various levels of daily roundlog throughput at 45% recovery. The vertical axis is drawn on a logarithmic scale to provide separation of average cost curves at efficient throughput volumes.

Table 3. Average total cost at varying numbers of annual operating days ($m^{-3} sawn timber)

Parameter	Annual number of operating days						
	10	20	172	190	200	210	220
Average milling cost ($m^{-3} of roundlog)	526	337	162	160	159	158	157
Average milling cost ($m^{-3} of sawntimber)	1168	748	361	356	354	352	350

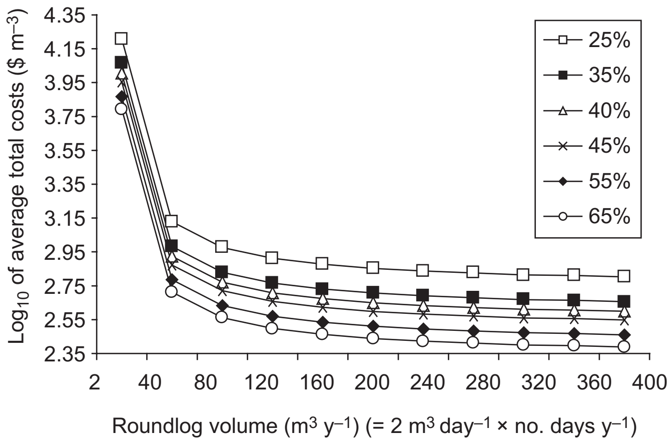

Figure 4. Average total cost per unit volume of sawn output of portable sawmilling for various rates of sawntimber recovery. The vertical axis is drawn on a logarithmic scale to provide separation of average cost curves at efficient throughput volumes.

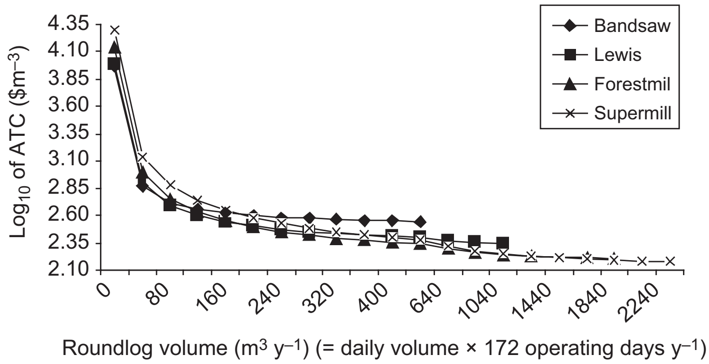

Figure 5. Average total cost (ATC) of sawmilling, per unit volume of sawn output, for four different sizes of portable sawmill. The least-cost mill option switches between mill types as roundlog volume increases. The vertical axis is drawn on a logarithmic scale to provide separation of average cost.

(344 m^3 y^{-1}), the cost of milling timber was \$637 m^{-3} of sawn volume at a recovery rate of 25%, falling to \$245 m^{-3} at a recovery rate of 65% ($\log_{10}$ values of 2.80 and 2.39 respectively). At lower throughput, the difference was greater due to the effect of the averaging of fixed costs.

Development of a long-run average total cost curve for portable sawmills

The financial model was used to derive long-run average sawmilling cost curves, based on varying sizes of portable circular sawmills**.** The long-run average cost (LRAC) or planning curve provides information relevant to the choice of sawmill size to minimise costs at any specific level of output, when contemplating investment in a mill. The steps in a mill investment typically include choosing an appropriate mill and associated plant, negotiating the price, arranging finance, undertaking training on mill operation, and awaiting delivery. Given the relatively low cost of portable sawmills, with no need for supporting buildings, the long-run period (for which all milling inputs can be varied) can be a matter of weeks, even with allowance for a period for training in some instances. However, it would be a poor investment decision for a miller to purchase or lease a mill and then find it had inappropriate capacity for the intended operation.

Overhead and operating costs were calculated for a small bandsaw portable mill and for three circular sawmills of varying sizes, namely Lewis, Forestmil and Supermill. The recovery rates used in the calculations were 45% and 40% for the bandsaw and circular saws respectively.

The average total cost for each mill type was plotted on the same axis to develop the LRAC curve in Figure 5. The choice of mill size which would minimize LRAC at any level of output can be read from this graph. The bandsaw has the lowest milling cost for annual log throughput from zero to about 60 m^3, the Lewis saw from 60 m^3 to 185 m^3, the Forestmill from 185 m^3 to 1240 m^3 and the Supermill beyond 1240 m^3.

Discussion

The cost structure of portable sawmilling is dominated by variable costs, and by labour costs in particular. The sawn timber recovery rate has a major effect on milling cost. The lack of accurate record-keeping by both fixed-site and portable sawmills precludes accurate calculations of recovery rates. The average recovery rates indicated by portable sawmillers were higher than those of fixed-site mills, and this tends to be supported by anecdotal evidence and previous studies. However, in northern Queensland portable sawmillers frequently purchase logs selectively based on species, log quality and dimensions, favouring a higher recovery rate than can be attained by fixed-site sawmillers purchasing all standing timber on a plot at a lower generic price. The lack of detailed record-keeping by the surveyed fixed-site and portable sawmillers prevented them from calculating their milling costs.

The \$80 m^{-3} (roundlog) contract milling price quoted by a portable sawmiller was about half the \$162 m^{-3} (roundlog) figure estimated by financial analysis. This suggests that some portable sawmillers operate mills on a cashflow basis and do not bring all costs into account. Partial cost recovery may occur due to lack of information on costs and failure to allow for equipment replacement and all labour costs, i.e. a cash-in-hand approach is adopted. Alternatively, mill operators may be utilising idle capacity for contract milling and hence excluding sunk costs when setting the contract rate. Their ability to mill at these prices may also stem from the fact that many have another income source, operate on a part-time basis and seek to cover operating costs only. Theoretically, many of the costs incurred by fixed-site sawmills should be encountered by portable mills, but some are avoidable.

Larger milling equipment has higher fixed costs but operates at lower ATC at greater throughput. The throughput level at which a miller intends to operate will, in large part, determine the most cost-effective sawmill size, as reflected in the LRAC curve. The 'long run', in which a new portable sawmill can be purchased and made operational, may be a matter of weeks.

The role of portable sawmills will vary between regions and industry conditions. In a situation of milling large volumes of homogeneous plantation-grown timber, the high throughput and economies of scale may well make portable sawmilling less practical. However, in an establishing timber industry, or the later stages of a declining industry, where log resources are limited, less accessible and more widely scattered, portable sawmills may be a valuable tool in the harvesting of the resource. Northern Queensland is in an unusual position. It is experiencing a reduction in log resources due to the World Heritage listing of the rainforests, and the resultant decline in the timber industry is necessitating the closure of a number of fixed-site sawmills. However, government-assisted attempts to re-establish a cabinet timber resource on privately-owned land present the industry with a resource to be harvested in the future. The lead time before this new resource can be harvested is likely to see further fixed-site sawmill closures, a scenario where portable sawmilling may be cost-effective.

Portable sawmills may also have a role in niche markets such as cutting ‘bark-to-bark slabs’ and other forms of natural feature timber. There is potential for landholders undertaking farm forestry to mill timber for their own use such as boards for sheds and other agricultural uses, but landholders need to carefully weigh up all issues and costs if milling for commercial markets. Portable sawmills also have a demonstrated role in developing countries where capital is scarce and low-technology systems suit the community.

Conclusion

Short-run average cost curves for portable sawmilling of rainforest timber species in northern Queensland are highly responsive to daily throughput and the rate of sawn-timber recovery. Data from various sources, including mill manufacturers’ specifications, the limited cost information available from mill owners, and some subjective estimates, were needed to derive milling costs in relation to throughput volume. Within the number of days available annually for milling, short-run costs follow an L-shaped pattern with respect to mill throughput volume, the cost structure being dominated by variable costs. The throughput volume for which the cost curve flattens out depends on mill size, and the long-run average cost curve (composed of the lower segments of various short-run average cost curves), was also found to be approximately L-shaped.

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Appendix A. Notes and calculations for the sawmill financial model

1a. Vehicle lease cost			
Leasing of second-hand Landrover valued at $10 000 for 5 y, at weekly payment of ($)			51.07
1b. Portable sawmill lease cost			
Lease of portable sawmill from new, valued at $8000 including sales tax for 5 y, at weekly payment of ($)			40.86
1c. Chainsaw acquisition (lease) costs			
Purchase price including full sales tax ($)			1910
Term of lease (y)			3
Weekly payment ($)			14.56
2. Small tools			
Total cost $1000, with annual write-off of $200. Anything less than $300 or life span less than 3 y can be written off in the first year but because we calculated annual operating costs over a period we have averaged the costs over 5 y.			
3. Annual vehicle operating costs			
Distance travelled (km)		15000	
Cost type	Fixed costs ($ y^{-1})	Variable costs ($ y^{-1})	
Registration	426.00		
Insurance	466.00		
Fuel		1040.40	
Tyres		150.00	
Services		290.00	
Annual operating costs	892.00	1480.40	
In the analysis, the Total Vehicle VC (fuel, tyres services) are allocated on the basis of the proportion of actual days worked to maximum potential days worked of 172.			
4. Queensland Timber Board subscription	$1200		

Appendix A. (continued)

5. Annual operating costs — bandsaw

Cost type	Quantity used per annum	Price ($)	Total ($)
Spare parts			
Blades	6	150.00	900.00
Spark plugs	7	2.00	14.00
Number of services per annum	7	80.00	560.00
Fuel (L)	1204	0.68	818.72
Total annual operating costs			2292.72

Fuel at 7 L per day. Blades cut 30 m^3 sawntimber or 67 m^3 input. Service every 200 h with spark plug replacement. No. of services = Total annual hours/200.

6. Annual operating costs — chainsaw STIHL model 064

Trees to be sawn are felled by either the farmer or a contractor. The agent's recommended service interval is every 20 h at a cost of $30 per service. The chainsaw has a lifespan of 3000 operating h.

Cost type	Quantity used per annum	Price per unit ($)	Variable costs ($)
Spare parts			
Bar	1	94.90	94.90
Chain	2	40.00	80.00
Spark plugs	4	2.00	8.00
Service	4	30.00	120.00
Fuel	172	0.68	116.96
Total annual operating costs			419.86

We assumed a 40-h usage service interval and spark plug replacement (consistent with user practice but more than agent's recommended service interval) and average daily usage of 1 h. Bars are replaced after 1000 h and chains after 600 h. Fuel usage of 1 L per day.

7. Worker's labour cost

Wage rate ($ h^{-1})		11.37
Workers compensation (%, $)	11.36	1.29
Superannuation (%, $)	6.00	0.68
Total cost ($ h^{-1})		13.34
Total salary for full year ($)		18 361.11

Source: Department of Employment, Vocational Education, Training and Industrial Relations

8. Owner's labour cost

Wage rate ($ h^{-1})			15.00
Workers compensation (%, $)	11.36		1.70
Superannuation (%, $)	6.00		0.90
			$17.60
Total salary (total cost h^{-1} × maximum days worked y^{-1} × 8 h per day) ($)			24 223.10
Leave loading ($15 h^{-1} base wage rate × 38-h week × 4 weeks y^{-1} × 0.175) (no., %, $)	4	17.5	399.54
Sick leave ($15 h^{-1} base wage rate × 38-h week × 0.2 (to get daily rate) × 8 days × $\frac{172}{200}$ (for 172 operating days y^{-1})) (no., $)	8		784.24
Total salary for full year ($)			25 406.88
Total cost ($ h^{-1})			18.31

Source: Department of Employment, Vocational Education, Training & Industrial Relations

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