Significance of raw material quality for finger jointing of knot free boards

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ABSTRACT

This study has been carried out in cooperation with a company which manufactures finger jointed knot free pine boards (*Pinus Sylvestris L*). Production equipments consist of e.g. wood scanner, automatic cutting saws and finger jointing device. The raw material is scanned and the output data from the scanning operation is stored together with data about raw material price, selling price, raw material supplier etc. For manufacturing finger jointed boards, lower class raw material has been used according to standard saw mill grading rules. The grading rule in this case is extended with demands on moisture content and on minimum distance between branch whorls. Dimension of timber in the study is 32 * 175 mm^2 and it is delivered from different Swedish saw mills. Total amount of timber in the study is 5000 m^3.

The result shows that raw material with the lowest price is that which gives the highest yield of knot-free boards. It also shows the significance of how the raw material supplier in following the agreements on grading rules and continual follow ups.

INTRODUCTION

The manufacture of mouldings of solid pine wood makes high demands on the raw materials used. Traditionally, the raw material for these products has to be of high and uniform quality, sorted in accordance with standardized quality rules. In the Nordic countries these standardized rules are generally associated with “The Green” and “The Blue” books (Anon 1982, Anon 1994) and the European standard EN-1611-1, (Anon 2000). Shortages in raw materials in addition to higher prices for the higher wood qualities have led the manufacturers of mouldings to look for an alternative. One possibility is a knot-free finger-jointed board material.

To cut wood pieces with acceptable characteristics from a raw material, which according to the quality rules is of low quality and therefore cheap, followed by finger jointing into a clear board is one way of adding value to the wood material (Maness & Wong, 2002). In their simulation study, they have shown that the value and the quality of the cut material are influenced not only by the raw material quality but also by other factors such as the scanner equipment and the material handling. In the manufacture of a knot-free finger-jointed product, the raw material constitutes a considerable part of the total cost. According to Zuo *et al*. (2003), the quality of the raw material in the cutting has a decisive influence on the productivity. A raw material of low quality is cheap but harder to process while a raw material of higher quality is of course more expensive but easier to process.

The properties e.g. annual ring width, distance between whorls etc., of the wood in trees are influenced by genetic and environmental factors and are also influenced by decades of human management. It is difficult to make objective comparisons between today's quality and that of former times, since the old statistics relating to the quality of the sawn timber are difficult to interpret. Nylinder & Törnmark (1985) note that a change has taken place with respect to wood quality, but they are of the opinion that this can be due to the method of valuation method, definition and interpretation of wood quality. They suggest furthermore that the quality in the Swedish forest in the future may change for the worse, but that this can be compensated for by a better handling of the raw material after felling. The quality has also changed in North America. This has taken place at the same time as the availability of first generation forests has decreased (Bowyer *et al*. 1986; Pelllicane *et al.* 1987).

Sandberg & Johansson (2006) have made a comprehensive literature review on the effect of knottiness on Scots pine and Norway spruce by using various techniques. They have studied the difference between square and star sawing patterns on the volume yield during production of knot-free components from sawn boards of Scots pine. They showed that the sawing pattern has a great influence on the volume yield of knot-free components.

OBJECTIVES

The aim of this study was to compare the volume yield and contribution margin in the manufacture of clear finger-jointed boards of sawn timber from four selected saw mills in Sweden.

MATERIALS AND METHODS

The major product of the studied company is a clear finger-jointed board for planed architraves and skirting fillets. In this study clear finger-jointed board means that the components are free from growth characteristics like knots and resin pockets, discoloration, holes and also from vane, splits and cracks. For the production of clear finger-jointed boards, the company purchases a specific quality of raw material of Scots pine from several saw mills.

Raw Material

The raw material used in this study is side-boards of Scots pine with a cross sectional dimension of 32 by 175 mm^2. The requirement on the raw material suppliers starts with the lowest grade VI according to the Swedish sawn timber grading rule (Anon 1982). Additionally, the moisture content shall be approximately 12 %, and that there shall be an optimal length of at least 400 mm between knots and other undesirable defects. For this study only four suppliers have been chosen. The suppliers are located in the Central part of Sweden.

For the investigation, archive data from year January 2005 until December 2007 have been used. One of the raw material suppliers (Saw mill D) has been a supplier only since December 2006. The selected data from the production statistics comprise a total of slightly more than 5 000 m^3 used in almost 200 runs, Table 1.

Table 1: Summary of the raw material volumes included in the study

Supplier	Raw material volume [m^3]	Proportion [%]	Number of runs
Saw mill A	1 953	38,7	73
Saw mill B	550	10,9	26
Saw mill C	2 163	42,8	81
Saw mill D	382	7,6	17
Total:	5 048	100,0	197

Raw Material Price

The raw material price development purchased from all suppliers between January 2005 and December 2008 is presented in Fig. 1. Here, the raw material price has been normalized for reasons of secrecy. During the investigated period, the price of sawn wood in general has risen. This may also be seen on the price development of the raw material included in the study. The price level was stable at the level of 100 until the end of 2006 but rose strongly in 2007.

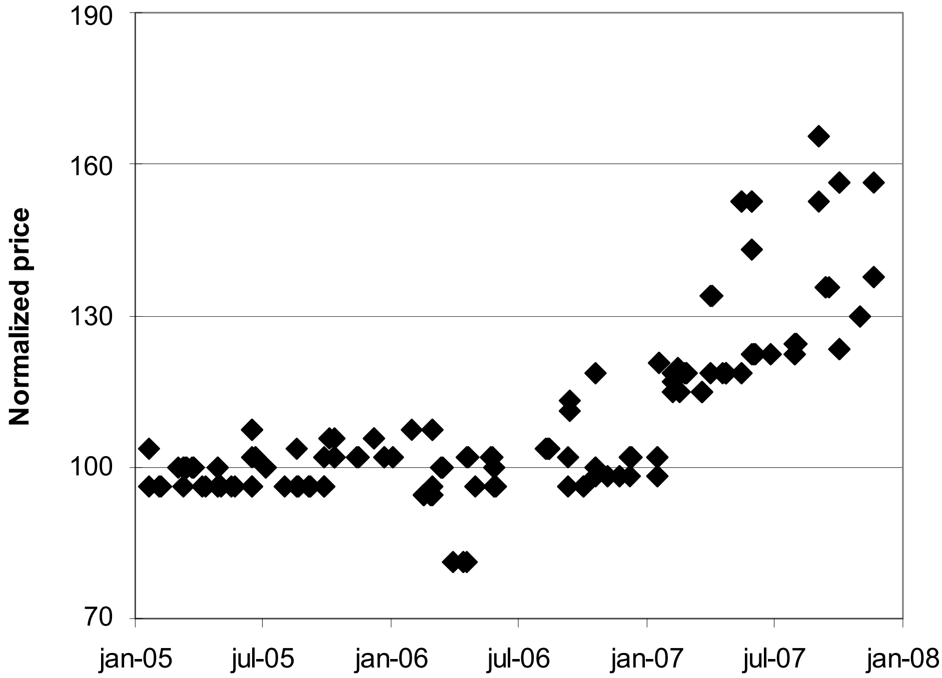

Figure 1: Price development for the raw material from the in the study chosen suppliers

Clear Board Production

Fig. 2 shows a schematic production flow, including the data collection. At the intake, the 175 mm wide raw material is splitted into two fairly equal boards. Then each board is scanned with all data necessary registered. After that all undesirable features, such as knots, cracks, vane etc are cut away from each board using an automatic cuter. The remaining clear wood pieces are finger-jointed pressed and planed. The primarily product of the company is to manufacture clear finger-jointed boards. However, there are jointed products like battens where knots are allowed almost without any restrictions. The residuals are used as fuel for heating the company premises or for sale.

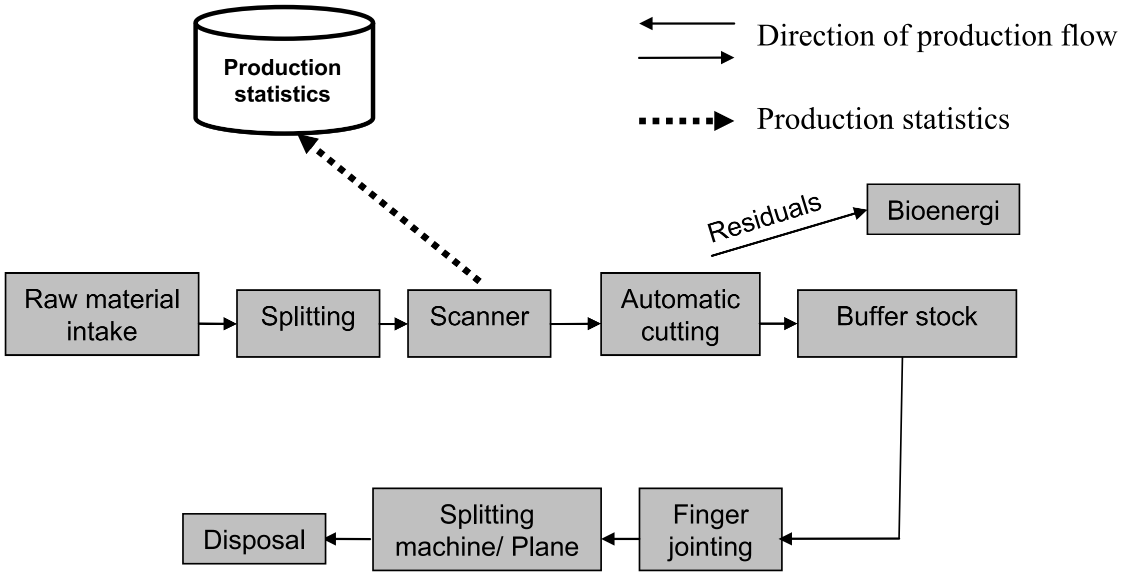

Figure 2: Schematic description of the production flow and storage of the production statistics

Clear wood pieces are produced by the automatic cuter according to the optimal cutting length information received from the scanner. The clear boards are grouped into four different length categories (230-369, 370-399, 400-549 and 550-750 mm) which constitute components B, C, D and E. A clear board with a length of 2220 mm is a specific product, component A, and is not finger-jointed, table 2.

Table 2: Description of the sorted and grouped products.

Description	Component	Remarks
Clear boards with a fixed length of 2220 mm,	A	not finger-jointed
Clear pieces in falling lengths within the interval 550 - 750 mm	B	finger-jointed
Clear pieces in falling lengths within the interval 400 - 549 mm	C	finger-jointed
Clear pieces in falling lengths within the interval 370 - 399 mm	D	finger-jointed
Clear pieces in falling lengths within the interval 230 - 369 mm	E	finger-jointed
Pieces for joining into battens in falling lengths without knot restrictions	G	finger-jointed
Split, cut into chips		

Generally, in those cases where the scanner identifies a clear board longer than the maximum length of a component, the optimization function of the scanner will mark one or several cross-cuts. In the configuration of the scanner, it is possible to guide the optimization towards a desired length component by giving a higher value. In the optimization the placing of the cross cut kerfs is determined by the value set as input data for the calculation of the maximum total value (Åstrand, 1996).

The mechanical equipment around the finger-jointing in the studied company cannot handle boards longer than 750 mm. Clear boards of lengths above 750 mm but less than 2220 mm are cut into two ore more of the length categories, fig 3. Clear boards longer than 2220 mm are cut to one 2220 mm board and one or more of the length categories, provided that the length is sufficient.

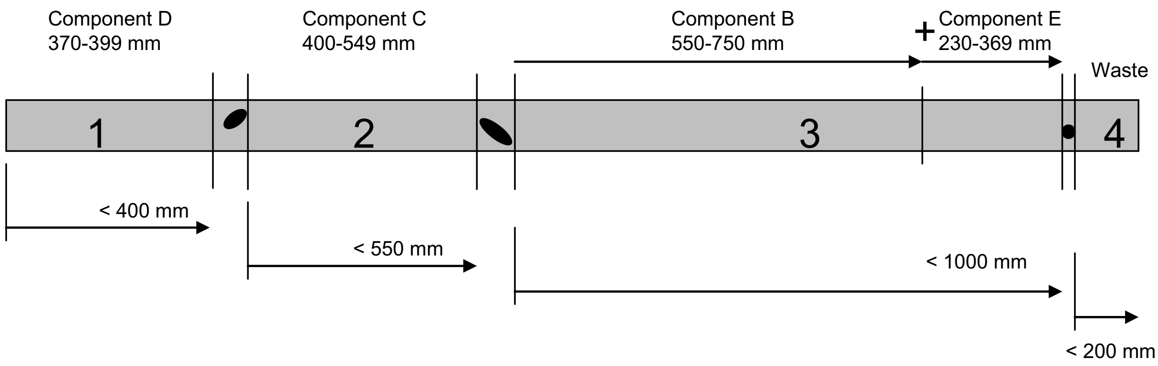

Figure 3: Illustration for cross cut kerfs along a sawn board with four clear board zones

The split material data generated by the scanner will be stored in a database at the end of each shift and when a supplier and/or product are changed. The scanner statistics consist of the number of each component and total length of every category. The data is also supplemented with details concerning the supplier, raw material costs and dimensions, earnings, production and working time.

RESULTS

Volume yield

As shown in table 3, of the total volume of raw material included in the study, 59 % has been refined into clear finger-jointed boards and 8 % into finger-jointed battens and the remainder residuals has been sold to be used as fuel.

Table 3: Calculated volume yields of the refined products and residuals

Product	**Volume [m^3]**	**Proportion [%]**
Clear finger-jointed boards	2979	59
Battens	393	8
Residuals	1676	33
Total:	**5048**	**100**

The average volume yield is calculated for each supplier for the period as shown in Fig. 4. The distribution of total volume clear boards grouped into components varies between the different saw mills.

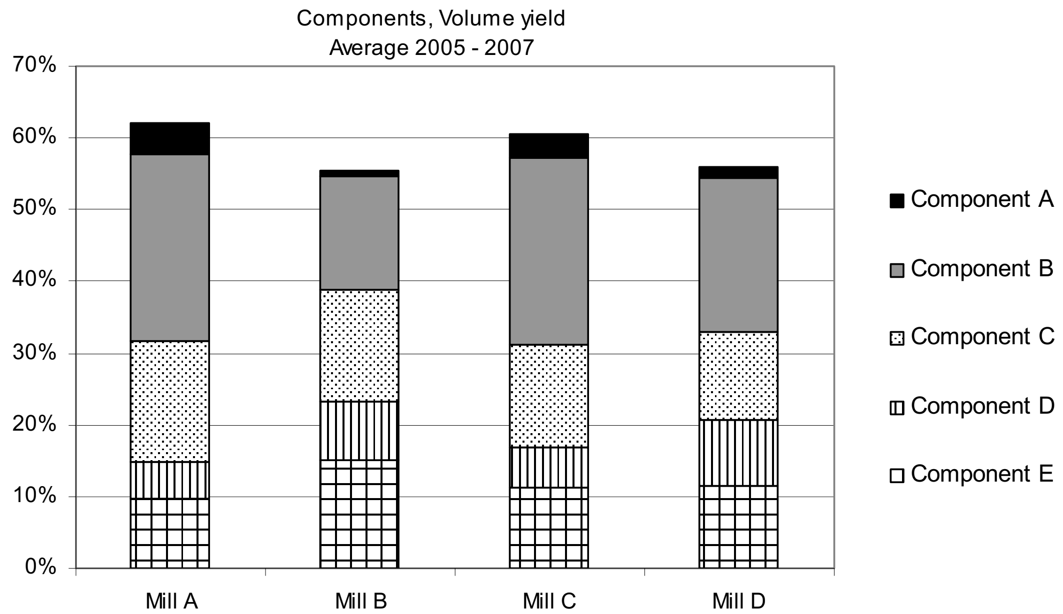

Figure 4: Illustration of the average total volume yield of clear boards and average distribution of components per supplier during the whole period

Contribution Margin

The Contribution Margin (CM) for each supplier has been calculated (Eq. 1) as the earnings from the sale, i.e. the Revenue (R) of the produced articles, after deduction of the Variable Costs (VC).

$$CM = R - VC \qquad (1)$$

Fig. 5 shows the normalized contribution margin per raw material volume of the different suppliers over time. This makes it possible to compare different suppliers with each other. This comparison shows not only a variation between the different suppliers but also variations between different runs with raw material from the same supplier. A clear increasing trend may be observed for both Saw mill A and Saw mill B while Saw mill C remains at a constant level. There are only a small number of runs with material from Saw mill D, but the contribution margin per raw material volume is lower than that of the other suppliers during the corresponding period.

The company has carried out regular reviews of each supplier with respect to volume yield and the economic result. However, it has not been possible to carry out a continuous, systematic analysis and follow-up since suitable tool was unavailable.

To make it possible for the company to continuously follow-up the production result and suppliers, a follow-up tool has been developed in this study. The report generator has a direct coupling to the database generated by the scanner, and thus makes it possible for the company to carry out analyses of the ongoing production or directly in connection with a concluded run. However, the company does not wish to publicise the details of the follow-up tool.

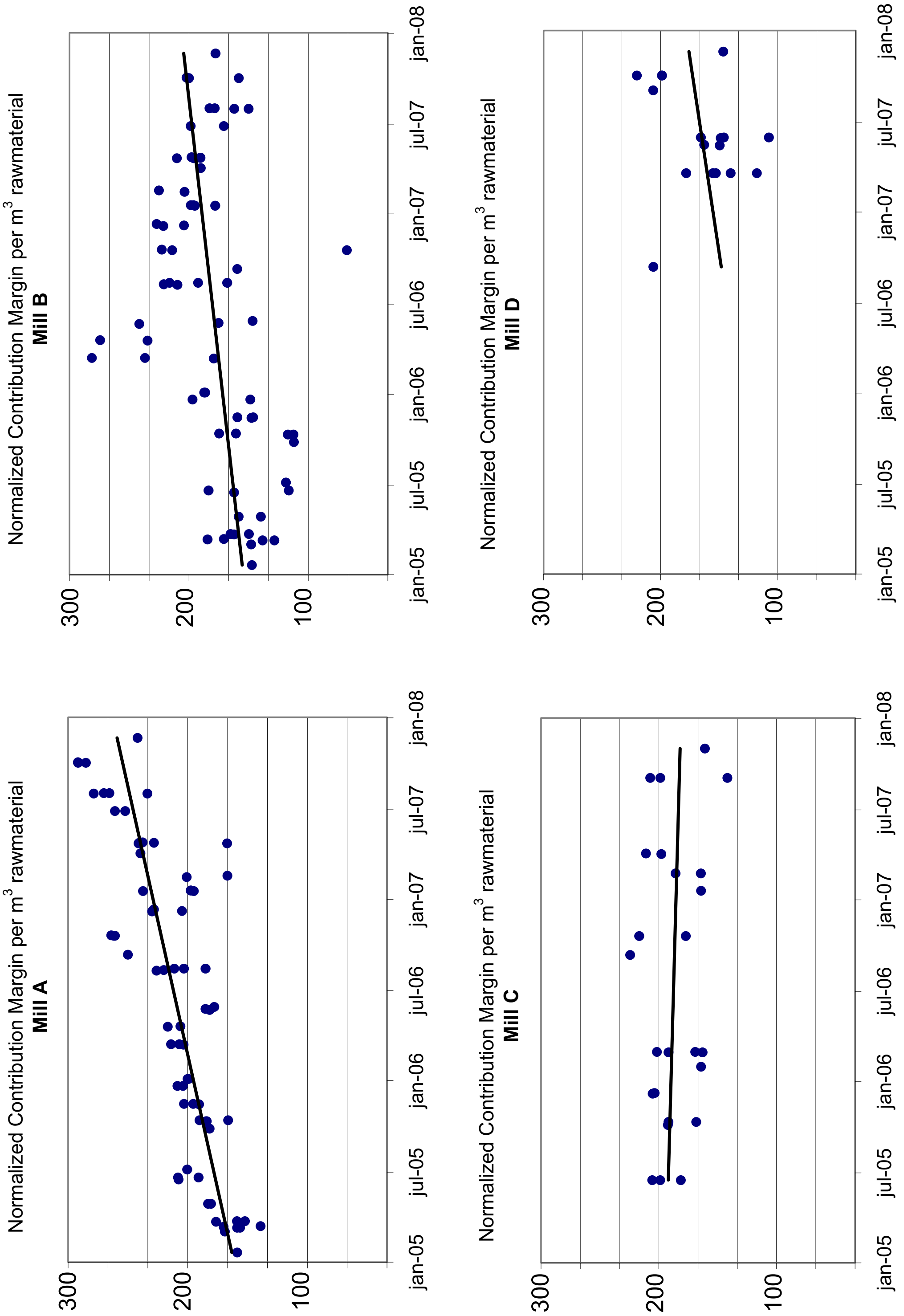

Figure 5: The contribution margin per raw material volume from different saw mills. Values are normalized

DISCUSSION

The price of the sawn boards does not always correspond fully to the timber quality. A study of this kind is hard to realize. The difference in raw material price between different suppliers at a given point in time may have several causes. It includes factors like long-term agreements, made with a supplier or that a supplier does not fully feel the prevailing market price. Another reason may be that a temporary supplier is allowed to deliver a small quantity of raw material practically without any price negotiations.
During the period studied, the raw material price has reached levels which the studied company had not previously experienced. Parallel with the price increase, the demand for the company's products has increased and thereby also the need for raw material. The company's experience during the period of investigation was that a situation had arisen where there was a shortage in the required raw material. The demands from the host company on the raw material may be hard for the many saw mills to fulfil. The moisture content requirement of 12 %, is one limitation. In addition, the required raw material dimensions can exclude certain saw mills as suppliers, since a relatively large diameter logs are required. To establish relationships with new raw material suppliers under these conditions, probably rises price levels even more.

The fact that the cheapest raw material gives the highest volume yield of clear board may in part be due to the dialogue which the studied company has carried on with some of its large raw material suppliers. Another contributory factor is probably the geographical origin of the saw timber and the treatment of the sawn article at the individual saw mill concerned.
During the whole of the studied period, there were relatively large differences in contribution margin per raw material volume between the various suppliers included in the study. The differences increased during the period and reached a level in the autumn of 2007 where the best raw material gave a contribution margin per raw material volume which was almost 50 % higher the lowest on the corresponding occasion. To a certain degree, this may be explained by the fact that the company have been carrying a dialogue with its most important suppliers for a long time, with a view to specifying its demand with regard not only to the wood quality but also to other factors such as package design, dirt and oil stains etc. The host company feels that the different suppliers vary in their sensitivity to the specified demands which are put forward.

The distribution between length components and the total clear board volume in the respective category varies with the saw mill supplying the raw material. The differences may be explained by different parameters. The geographical origin is probably important, even though this cannot be shown on the basis of this study. The yield is also influenced by the sorting by each saw mill, which in turn is dependent on the price negotiations between the buyer and seller. Two of the saw mills included in the study belong to the same company where the saw timber is distributed to the two mills according to the top diameter. The top diameter probably also influences the volume yield, since smaller top diameters give logs which come farther from the butt log. In this way, they give a sawn board with properties which differ with respect to the knots. The proportion of clear component from each supplier varied over the studied period. In addition, there was a difference in the total volume of clear board between different years for the same saw mill. It is probable that the dialogue regarding quality carried on between the company and the different suppliers might have contributed.

The host company has previously carried out follow-ups of its respective suppliers. A supervision of the supplier quality is necessary and it is even more valuable if it can be carried out almost in real time. The dialogue between the company and each supplier has greater significance if the follow-up is carried out in direct connection with the use of the raw material concerned.

The results of the negotiations relating to raw material purchases influence the quality and price, and these in turn influence the profit contribution. The costs which the company has in the form of salaries, maintenance, depreciation, new investments and demands on capital yield must be covered by the profit contribution. For this reason, it is very important to monitor the development of the contribution margin with time, which is one task for which the newly developed evaluation tool can be used.

CONCLUSIONS

In this study a total volume yield of 59 % has been refined into clear finger-jointed boards. The result showed that the cheapest raw material gives the highest volume yield and the best contribution margin of clear board. Mill A showed the highest (62 %) clear board volume yield and Mill B the lowest (55 %). Mill A and Mill B showed an increasing contribution margin per raw material volume. However, Mill C near remains at a constant level. The contribution margin per raw material volume from Mill D was lower than that of the other suppliers during the corresponding period.

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