Adoption of Value-adding Processes in Swedish Sawmills

Anders Roos, Matti Flinkman, Armas Jäppinen and Mats Warensjö

Roos, A., Flinkman, M., Jäppinen, A. & Warensjö, M. 2000. Adoption of value-adding processes in Swedish sawmills. Silva Fennica 34(4): 423–430.

Adding value to lumber by processing it after sawing and standard drying is one means for the sawmilling industry to increase market shares in competition with other materials, e.g. glass, steel, concrete, aluminium, and plastics. In this study the adoption patterns of value-adding processes used in Swedish softwood sawmills were analysed based on production data from 1995. About 90 % of the sawmills applied a value-adding process after initial sawing and drying, and 72 % of the sawmills applied two or more processes. The total share of processed sawnwood was about 40 %. Important dimensions of value-adding processes are: extra drying and production of blanks for doors/windows and for furniture; surface-treatment, mainly planing, which is sometimes associated with preservation and painting; length trimming and pallet production; extra drying and production of edge-glued panels and laminated beams; and stress grading and production of building components. The association of different value-adding dimensions with location, ownership and production characteristics were investigated. The total share of value-added production were higher for private sawmills than for mills owned by forest companies or by forest owners' associations, and it was higher for mills in southern Sweden than for sawmills in other parts of the country. Value-added share does not clearly correlate with mill size or with the dominating tree species being sawn.

Keywords sawmilling, production structure, technology adoption
Authors´ address Swedish University of Agricultural Sciences, Department of Forest Management and Products, P.O. Box 7060, SE-750 07 Uppsala, Sweden
Fax +46 18 3800 **E-mail** anders.roos@sh.slu.se
Received 19 January 2000 **Accepted** 19 September 2000

1 Introduction

The main properties of softwood lumber on the market has not changed fundamentally for several decades. Wood is, however, being replaced in several sectors by other materials, such as concrete, glass, steel, aluminium, and plastics. This competition will probably continue in the 21st century (Baudin 1989a and b, FAO/ECE 1999a). An increasing supply of low cost commodity lumber from several countries in Europe because of growing inventories and improved infrastructure is also expected (Affärsvärlden 1999, FAO/ECE 1999b). One way for sawmills to meet these challenges is to shift towards more advanced production adapted to different customer needs. A common view among analysts of the sawmilling industry is that increasing customer demand for high quality wood products, and more competition in the industry, will require improvements in sawmill production (Cohen 1992, NUTEK 1992, Ruddell and Stevens 1998). Better coordination and integration of technology, logistics, organization, and information – both upstream to the logging operations, and downstream to the market – are also often advised (Lönner 1991, 1997, Hansen et al. 1996, Bengtsson 1997). Not only does the internet marketing channel increase competition but it also offers opportunities for specialized sawmills with high value-added shares to reach new markets (FAO/ECE 1999b). Increasing adoption of value-adding technologies in the sawmills can therefore be expected.

In the search for future strategies in the sawmilling industry, additional knowledge is needed about the structure and level of value-adding technologies in the industry. Better insights into how value-adding processes are combined, and whether adoption takes place sequentially or along different dimensions, will improve the understanding of possible strategic choices available to the sawmilling industry in the future.

Issues concerning the adoption of new technologies in the sawmilling sector – i.e. technology transfer, the adoption process, and time lags between innovation and adoption – especially in the United States have been discussed by Rosenberg et al. (1990). In a study of the Canadian sawmilling industry, Cohen and Sinclair (1989) identified three dimensions of technology adoption: computerization, process monitoring and production boosting. Strategic technology and marketing choices, and their impacts on performance, have been investigated by Rich (1986) and by Cohen and Sinclair (1990, 1992). Bush and Sinclair (1991) identified different strategic groups in the sawmilling business concerning marketing and production strategy. Niemelä and Smith (1996) studied interregional differences between softwood lumber producers in Finland and different regions of western Canada and western United States regarding customer-, product-, and market area strategies. Important differences in product and market focus among the sawmilling industries in the different regions were identified. Several studies mentioned above (e.g. Cohen and Sinclair 1992, Bush and Sinclair 1992, Niemelä and Smith 1996), refer to Porter's (1980) generic types of competition strategies (overall cost leadership, differentiation, and focus).

The structure and economic situation of the Swedish sawmilling industry has been studied by Flinkman (1987) and Flinkman and Lönner (1997). Repeated surveys have documented changes in the Swedish sawmilling industry since the 1960s. The latest inventory is from 1995 (Warensjö 1997, Warensjö and Jäppinen 1997). The results indicate a development towards more market-oriented production and more value-adding processes applied in the industry. The share of value-added production increased for most processes from 1990 to 1995: for extra drying to order by 150 %, edge-glued panels by 140 % and blanks for furniture by 100 %. Stress grading and laminated beams have also increased. Decreasing quantities were recorded for painting and finger jointing.

The adoption of value-adding technologies and how these processes are combined has however not been examined in detail. This paper presents a study of the structure and level of value-adding processes implemented in Swedish softwood sawmills. The aim of this study was to identify and analyse value-adding dimensions among Swedish sawmills. We describe the sorts of solutions for value-adding production, after initial sawing and drying to 18 % moisture content, and how they were combined in the Swedish sawmills. We considered a set of 13 processes that transform the lumber into high-quality wood and/or adapt it to specific uses or customer groups. The relationships between attributes of the sawmills and dimensions of value-adding processes were also investigated.

2 Material and Methods

The data were obtained from the 1995 sawmill inventory, which is presented in detail in Warensjö (1997) and Warensjö and Jäppinen (1997). The database contains detailed information about the technology and production of Swedish sawmills producing more than 5000 m^3 in 1995 (306

Table 1. Summary statistics about the sawmills in the study, N = 248.

Mills in southern Sweden	112 mills (45 %)
Ownership:	
Private	205 mills (83 %)
Company	25 mills (10 %)
Forest owners' assoc.	18 mills (7 %)
Total production	12.8 Mm^3 (Pine 42 %; Spruce 58 %)

mills). The data were collected in a postal survey consisting of questions designed with the assistance of a panel of experts and representatives from the sawmilling sector. The managing director or another person in the management of the mill filled out the questionnaire. We asked about the volumes processed in 13 specified value-adding processes plus a miscellaneous option. These volumes were then transformed to percentages of the produced and bought sawn lumber. The analysis was performed at enterprise or site-level, not at the corporate level. Volumes processed at another site but by the same company were not considered in the study.

Statistics about the data is shown in Table 1. In total, 306 mills were included in the survey. When sawmills with no permanent production, hardwood sawmills, and sawmills with missing data had been withdrawn we had 248 sawmills as a basis for this study. The sample accounts for 87 % of the total 1995 sawnwood production in the country (Statistical Yearbook of Forestry 1997).

Most sawmills in Sweden are owned and managed as private saw-milling enterprises. The other two main owner categories are forest companies – owning both forest land plus pulp and paper industries – and forest owners' cooperatives. Almost half the sawmills are in southern Sweden.

Factor analysis refers to a group of multivariate methods for describing the interrelationship of a data set in a few factors or dimensions (Mulaik 1972, Hair et al. 1987). We applied principal component (factor) analysis (Mulaik 1972) to summarize the information about the use of several value-adding processes in a few components. These components can also be considered as dimensions of value-adding technology adoption.

Table 2. Value-adding processes.

Process	Share of sawmills employing the process, per cent	Share of total production and bought lumber, per cent
1. Planing	56.5	17.5
2. Drying to order	58.5	10.6
3. Stress grading	26.2	3.7
4. Length trimming to order	32.3	2.7
5. Building components	10.9	2.2
6. Pallets	21.0	1.7
7. Laminated beams	8.9	1.6
8. Blanks for furniture	14.1	1.0
9. Preserved wood	14.5	0.9
10. Blanks for doors/windows	16.1	0.7
11. Finger jointing	10.1	0.7
12. Edge-glued panels	5.6	0.4
13. Painting	6.0	0.1
14. Other	40	6.7
15. Value-added share*	90	42

* Percentages that are processed in one or more value adding processes

The relationship between the individual factor scores and properties of the sawmill, such as ownership, location, production volume, and tree species were analysed in linear regressions.

3 Results and Comments

Different value-adding processes are adopted to varying degrees by the individual sawmills. The total shares of the lumber production in the sawmills that are processed in each value-adding transformation vary between zero and 100 %. It should be noted that the sum of different value-adding shares at one sawmill can be more than 100 % since the lumber may be transformed in more than one value-adding process. The data do, however, not include information about the quantities that are transformed in two or more value-adding processes. Table 2 presents the share of the sawmills that apply different processes, and the corresponding total volume shares.

Most sawmills (about 90 %) apply some value-adding technology whereas the total volume share that is processed in one or more value-adding process is about 42 %. The most common processes are planing and extra drying (below 18 % moisture content), both of which adopted by more than half the sawmills. Intermediate shares were noted for stress grading, length trimming to order, manufacturing of building components, pallets and laminated beams. Technologies involving small percentages of the total volume are production of blanks for furniture, preserved wood, blanks for doors/windows, finger jointing, edge-glued panels, and painting. The percentages only include processing at the sawmill. Some unprocessed volumes are shipped to special treatment units, e.g. planing factories, which could explain the comparably low percentage recorded for planing, 17.5 %.

Fig. 1 shows that 72 % of the sawmills used more than one treatment, and 36 % applied more than three value-adding processes.

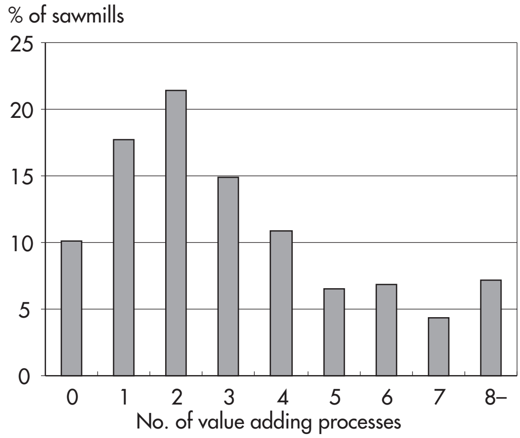

Fig. 1. Distribution of sawmills on number of value adding processes.

Further analyses showed that correlations for most pairs of value-adding processes are positive, indicating that the adoption of one value-adding technology increases the likelihood of almost any other technology. In addition, pairwise correlations between the adoption percentages are mainly positive.

The principal component factor analysis results after orthogonal (Varimax) rotation are shown in Table 3. Kaiser's measure of sampling adequacy is 55 %, which is fairly low but acceptable for factor analysis (SAS Institute 1993). We conclude that the analysis can be justified, despite weak correlations indicated by the Kaiser measure, also because the database includes most Swedish sawmills, and not a sample.

Following recommendations by Hair et al. (1987) factor loadings higher than 0.3 are regarded as significant. Loadings slightly less than 0.3 may, however, in some cases indicate relationships that can be discussed and analysed. The number of factors was determined after inspection of the screen table, eigenvalues and after judging the interpretability of the factors (Everitt and Dunn 1991, SAS Institute 1993). Five factors account for 53 % of the total variance among the surveyed sawmills. The sixth factor with an eigenvalue slightly more than 1 is difficult to interpret and it has therefore not been further considered in the discussion.

The results must be interpreted with caution for three main reasons. First, the data are not particularly suitable for factor analysis and the factors obtained are not entirely distinct or stable. Second, technologies with high overall adoption rates are sometimes mixed with rare technologies. This may lead to erroneous conclusions unless the results are checked against general knowledge about sawmill production. Finally, it must be stressed that we have identified dimensions of technology adoption that can be applied to varying degrees by the sawmills. These dimensions, or factors, do not necessarily describe specific types of sawmills.

Factor 1 includes blanks for furniture and for doors/windows. Drying to order also displays a significant loading on this factor. The dimension reflects specialized production for the building and furniture industries. Factor 2 is named surface treatment and is mainly defined by planing as the most important value-adding process. Preservation and painting and, to a lesser degree, finger jointing are also included in this factor. Factor 3 involves length trimming to order and pallets. Factor 4 is defined by three variables: laminated beams, edge-glued panels and drying to order. For this factor drying to order accounts for a larger share of the volume, whereas beam and edge-glued panel production is less frequent. Factor 5 is principally defined by building components and stress grading. In addition, planing and finger jointing approached significant loadings, indicating that the production of building

Table 3. Factor loadings after Varimax rotation (N=248) with factor interpretations.

	Factor 1 Drying/ blanks	Factor 2 Surface treatment	Factor 3 Length trimming/ Pallets	Factor 4 Drying/ glued wood	Factor 5 Stressgrading/ Building components	Factor 6
Blanks for Furniture	**0.89**	–	–	–	–	–
Blanks for doors/windows	**0.87**	–	–	–	–	–
Preservation	–	**0.80**	–	–	–	–
Planing	–	**0.75**	–	–	0.23	–0.23
Painting	–	**0.61**	–	–	–	–
Pallets	–	–	**0.80**	–	–	–
Length trimming	–	–	**0.79**	–	–	–
Laminated beams	–	–	–	**0.71**	–	–
Edge-glued panels	–	–	–	**0.68**	–	–
Drying	**0.35**	–	–	**0.58**	–	**–0.32**
Building components	–	–	–	–	**0.73**	–
Stressgrading	–	–	–	–	**0.67**	–0.24
Finger jointing	–	0.27	–	–	0.26	**–0.46**
Other	–	–	–	–	–	**0.81**
Eigenvalue	1.9	1.8	1.4	1.2	1.1	1.0
Proportion explained	14	13	10	9	8	7

Bold: factor loading ≥|0.3|, not bold: |0.2|≤ factor loading<|0.3|, – : factor loading<|0.2|

Table 4. Regression results N = 248.

Explanatory variables	Dependent variables Factor scores					
	Factor 1 Drying/ blanks	Factor 2 Surface treatment	Factor 3 Length trimming/ Pallets	Factor 4 Drying/ glued wood	Factor 5 Stressgrading/ Building components	Value-added share, percent
Intercept	–0.10	–0.29	0.82***	–0.83***	–0.56**	23.2***
South	–0.16	0.19	–0.14	–0.19	0.55***	8.5*
Private mill	0.09	0.23	–0.47**	0.60***	0.40**	14.8**
Total production	–1.4E-6	–4.4E-7	–3.3E-6**	4.7E-6***	3.8E-6***	6.3E-5
Pine, %	4.6E-3*	9.9E-4	–5.0E-3*	4.6E-3*	–5.5E-3**	–0.032
F-value	2.05	1.24	2.67	6.13	11.77	3.09
Adjusted R^2	0.017	0.004	0.026	0.077	0.148	0.033

*** significant at the 1 % level, ** 5 % level, * 10 % level

components involves several processing steps that add value to the product. In this case the end-use product is a building component used in the industry for prefabricated houses or for the construction sector.

The linear regressions presented in Table 4 reflect the relationship between the individual factor scores and properties of the sawmill, such as ownership, location, production volume, and tree species. In addition, a regression was performed where the percentage of value-added lumber is the dependent variable.

The adjusted R^2-values are low, which is typical for cross sectional models. The first two factor regressions do not result in any significant coefficients, probably because they reflect well-established technologies adopted throughout the country by different types of sawmills. For the regressions on Factors 3, 4 and 5 and where the dependent variable represents value-added share, the F-values indicate significance probabilities below 0.05. Several coefficients in these models are significantly different from zero at the 5 % or 1 % level of significance.

The regression on factor scores for Factor 3 suggest that this group of processes are negatively associated with private ownership and total production volume. It is mostly applied at mills using spruce.

Factor 4, indicating high values on laminated beams, edge-glued panels and drying to order, is not associated with a particular geographical location. However, it is more common for private mill ownership, and on large sawmills using pine.

High scores for Factor 5 are associated with southern location, private ownership and mill size, whereas a high pine percentage has a negative relationship with this type of value-adding process. The interpretation of this result is that sawmills producing building components are mainly concentrated in southern Sweden, where spruce dominates, and where the main markets in the populated parts of Sweden and in continental Europe are located.

The results in the last column in Table 4 reflect that the value-added share increases for sawmills in southern Sweden, although the relationship is weak. Value-adding also increases for private ownership whereas no general effect can be seen for mill size and species composition.

4 Discussion

This study shows that the adoption of value-adding technologies in sawmills takes place along different dimensions. The dimensions are: extra drying and production of blanks for doors/windows and for furniture; surface treatment, including planing, in some instances associated with preservation and painting; length trimming and pallets; extra drying, sometimes associated with production of glued wood; and finally, stress grading and production of building components. We also conclude that value-adding, although it has been discussed for several years in the sawmilling industry, still involved only small percentages of the total volume production in 1995. This fact could be explained by a tradition within the industry and by the risks associated with investments in further processing.

The results confirm that the different types of value-adding processes are associated with specific characteristics of the sawmills. The total value-added share of these processes is positively associated with southern location and private ownership. Pine and spruce dominate for different value-adding processes. Separate dimensions of value adding are applied at small and larger sawmills.

Future investigations could connect the value-added percentages to economic data that describe how much value the different processes add. In a dynamic perspective, emerging technologies could also be distinguished from more mature processes. Judging from earlier inventories in 1990 (Warensjö 1997) increasing dimensions of value adding are Factor 1 (drying/blanks), Factor 3 (length trimming/pallets), Factor 4 (drying/glued wood), and Factor 5 (stress grading/building components) whereas reductions have been recorded for Factor 2 (surface treatment). Developments since 1995 have been less well documented although there are indications of a trend towards more value adding together with a general structural change in the industry.

This study also contains limitations that must be highlighted. Factor results do not automatically indicate a true technological connection between different processes and they thus require careful intepretation as do the regression results. This remark is particularly valid where the value-adding processes account for only a minor part of the total production. Endogenity problems may complicate the analysis of the regression results because of the complexity of the decision making in a sawmill.

The general structure of value-added processing in Swedish sawmills clearly indicate that the sawmills organise their value-adding operations in a rational structure, concentrating their efforts in related operations where they can utilise machines and skills for several products and markets.

Acknowledgements

This project was financed by the Swedish Council for Forestry and Agricultural Research, SJFR. The authors wish to thank David Cohen, Juha Niemelä, Göran Lönner, Mats Nylinder and Ulf Olsson for valuable comments. Any errors remain the full responsibility of the authors.

References

Affärsvärlden 1999. Inte så gyllene längre ("Not so golden any longer"). Article in the Swedish business weekly "Affärsvärlden" No. 42.

Baudin, A. 1989a. Den svenska trävarumarknaden – del 1: Förbrukning inom delsektorer 1970–1988. R. 6. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

— 1989b. Den svenska trävarumarknaden – del 2: Analys. R. 8. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

Bengtsson, K. 1997. Integration skog-såg-marknad-Principer och möjligheter. Undervisningskompendium 5. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

Bush, R.J. & Sinclair, S.A. 1991. A Multivariate model and analysis of competitive strategy in the US hardwood lumber industry. Forest Science 37(2): 481–499.

Cohen, D.H. 1992. Adding value incrementally: A strategy to enhance solid wood exports to Japan. Forest Products Journal 42(2): 40–44.

— & Sinclair, S.A. 1989. An inventory of innovative technology use in North American processing of wood structural panels and softwood lumber. Canadian Journal of Forest Research 19(12): 1629–1633.

— & Sinclair, S.A. 1990. The adoption of new manufacturing technologies: impact on the performance of North American producers of softwood lumber and structural panels. Forest Products Journal 40(11/12): 67–73.

— & Sinclair, S.A. 1992. The strategic management paradigm and the wood building products industry: A model of strategies and firm profitability. Forest Science 38(4): 786–805.

Everitt, B.S. & Dunn, G. 1991. Applied multivariate data analysis. Arnold. London.

FAO/ECE 1999a. A summary of "The competitive climate for wood products and paper packaging: The factors causing substitution with emphasis on environmental promotions". Geneva Timber and Forest Discussion Papers, (ECE/TIM/DP/16). United Nations Economic Commission for Europe, FAO, Geneva.

FAO/ECE 1999b. Forest products annual market review 1998–1999, Timber Bulletin - Vol LII (1999), No. 3 (ECE/TIM/BULL/3). United Nations Economic Commission for Europe, FAO, Geneva.

Flinkman, M. 1987. Sågverksindustrins kostnads- och intäktsstruktur 1975–1985. U 24. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

— & Lönner, G. 1997. Svensk sågverksnärings struktur och internationella konkurrensförmåga. Undervisningskompendium 3. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

Hair, J.F., Anderson, R.E. & Tatham, R.L. 1987. Multivariate data analysis. Ed 2. MacMillan, New York. 449 p.

Hansen, E.N., Bush, R.J. & Fern, E.F. 1996. An empirical assessment of the dimensions of softwood lumber quality. Forest Science 42(4): 407–414.

Lönner, G. 1991. Sågverksnäringens framtidsutsikter och strategival. U 39. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

— 1997. Trävarumarknaden i Europa på lång sikt – Efterfrågeutveckling och exportmöjligheter. Undervisningskompendium 2. The Swedish University of Agricultural Sciences. Department of Forest-Industry-Market Studies. Uppsala.

Mulaik, S.A. 1972. The foundations of factor analysis. McGraw-Hill, New York.

Niemelä, J.S. & Smith, P.M. 1996. A cross-national investigation of softwood sawmill marketing strategies. Forest Science 42: 290–299.

NUTEK. 1992. Sågverksindustrin inför sekelskiftet. Summary volume. R 1992:34. Stockholm, Sweden.

Porter, M.E. 1980. Competitive strategy: techniques for analysing industries and competitors. Macmillan. New York.

Rich, S.U. 1986. Recent shifts in competitive strategies in the U.S. forest products industry and the increased importance of key marketing functions.

Forest Products Journal 36(7/8): 34–44.
Rosenberg, N., Ince, P., Skog, K. & Plantinga, A. 1990. Understanding the adoption of new technology in the forest products industry. Forest Products Journal 40(10): 15–22.
Ruddell, S. & Stevens, J. 1998 The adoption of ISO 9000, ISO 14001 and the demand for certified wood products in the business and institutional furniture industry. Forest Products Journal 48(3): 19–26.
SAS Institute 1993. User's guide, release 6.03 edition. NC, United States.
Statistical Yearbook of Forestry 1997. Official Statistics of Sweden/ National Board of Forestry. Jönköping, Sweden, 353 p. ISBN 91-88462-33-1.
Warensjö, M. 1997. Såg 95 – Del 1. R 251. The Swedish University of Agricultural Sciences. Department of Forest Products. Uppsala.
— & Jäppinen, A. 1997. Såg 95 – Del 2. R 252. The Swedish University of Agricultural Sciences. Department of Forest Products. Uppsala.
Total of 29 references