Price Systems for Standing Sales of Industrial Roundwood in Finland

JUKKA MALINEN[1*] AND HARRI KILPELÄINEN[2]
[1]University of Eastern Finland, P.O. Box 111 (Yliopistokatu 7), FI-80101 Joensuu, Finland
e-mail: jukka.malinen@uef.fi, Telephone: +358 50 522 6469
[2]Finnish Forest Research Institute, P.O. Box 68 (Yliopistokatu 6), FI-80101 Joensuu, Finland

Malinen, J. and Kilpeläinen, H. 2013. Price Systems for Standing Sales of Industrial Roundwood in Finland. *Baltic Forestry* 19(2): 307–315.

Abstract

Price systems for industrial roundwood vary considerably between countries depending on the number and size of the sellers and buyers and government interactions. Roundwood is a heterogeneous raw material meaning that different species, qualities and dimensions have different value potential for different end-uses. In the long term, price levels and price systems offer signals for roundwood production to forest owners who are capable of considering the economic feasibility of different actions required to grow appreciated raw material. In the study, five different price systems, pricing by roundwood assortments (PbA), pricing by total volume (PbV), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD), were compared by using bucking simulations. Price systems were analysed by the relationship between sale value and wood paying capability (WPC) which is a residual value of a raw material to the wood buyer, after deducting all the reasonable costs of manufacturing, distribution, marketing and otherwise conducting a business. The analysis included performance of the price systems in different stand types and elasticity of the price systems against changed log-length demand. The PbV and the PbSF tend to produce excessive sale values for the stands where WPC was low, and exceedingly low sale values for the stands where the WPC was high. The sale values were divided more by the WPC of the stand in the cases of the PbA, PbAF and PbD.

Key words: bucking; price systems; roundwood markets; roundwood price; price-quality relationship

Introduction

Price systems and measuring methods of industrial roundwood vary considerably between countries depending on the relative number and size of the sellers as well as the buyers and government interactions (e.g. Quayle 2003). The price system refers to the method for determining the value for the traded roundwood, such as price per hectare, price per harvested cubic metre, price per harvested roundwood assortment, i.e. the roundwood for a pre-determined purpose. Regardless of differences in market and price systems used, there is no realistic change to adapt perfect competitive market mechanisms for roundwood sale due to the heavy transportation costs, diversity of forest ownership including government and forest industry including their different economic and management interest, and externalities associated with harvesting of roundwood (Kant 2009). Therefore, the selection of price systems means tackling the advantages and disadvantages of the local markets.

Due to the insufficiency in roundwood market mechanisms, several reports have been produced to compare roundwood markets and provide recommendations (Hamilton et al. 2008, Development of… 2009, Kant 2009, Malinen et al. 2010a). The global trend is towards reforms leading to the creation of a competitive, flexible market. Recommendations include a wide range of proposals, such as improved public administration, improved contract design, microeconomic reform, transparency in reporting and pricing, improved information on markets and electronic market places.

Roundwood is a heterogeneous raw material, which means that different species, qualities and dimensions have different value potential for different end-uses. Accordingly, many countries applied pricing systems where the sale value of raw material, i.e. the net revenue of the forest owner, is connected to the end-use; for example, saw logs have a higher price per unit volume than pulpwood or energy wood, and on the other hand, special roundwood assortments, such as utility poles and veneer logs, have a higher price per unit volume than saw logs (Malinen et al. 2006). Consequently, bucking objectives, including log dimension and restrictions for external quality, play a crucial role in the price transmission, i.e., the process

in which upstream prices affect downstream prices, from the wood processing industry to the forest owners.

In the long term, price systems and price levels of roundwood offer signals for roundwood production to forest owners. Price premiums and discounts should communicate and prompt the changes needed in production to the producers. Within the limitations of a growing site, the forest owners are able to consider economic feasibility of different actions, such as species selection for forest regeneration, silvicultural treatments of the stand, and possible investments, such as fertilising or pruning, and rotation period (e.g. Brukas and Brodie 1999, Rojo et al. 2005). Thus, it is important that the price level and price systems of roundwood reflect the value of the raw material in the possible end-uses, thus providing incentives to grow raw material which has the greatest added-value in the further processing and products.

In addition to roundwood, many other raw materials also have problems with heterogeneous quality and therefore price systems related to quality have been developed. For example, the quality of goat and sheep milk, and consequently the price, is dependent on the physical and chemical composition and on hygienic and sanitary factors (Pirisi et al. 2006), and the quality and the price of hard coal is dependent on net calorific value, ash content and sulphur content (Lorenz and Gruziński 2003). If the price system and price levels provide incorrect information, especially price differentials based on quality, it can lead to distortions in the market and market insufficiency as reported, for example, in the cotton (Hudson et al. 1998) and beef industry (Purcell 2002).

There are several methods to trade roundwood and they can be categorised into two different classes: standing sales and delivery sales. The main difference between these sale types is who harvests the roundwood and makes the decision on how to buck the trees. This also affects the price systems used in the pricing of roundwood.

The most typical price system in the roundwood trade is pricing where each roundwood assortment has its own unit price. Although different roundwood assortments have their own distinctive prices, the values of the raw material in the end-use varies greatly also within each roundwood assortment. This problem is most severe for saw and veneer logs, for which the value recovery per cubic metre in production varies considerably according to log dimensions and external quality (e.g. Salven 2008, Gjerdrum 2009). Although the unit price of saw logs may vary to some extent according to the dimensions and external quality of logs, the variation is sometimes unclear to the forest owner, and thus, the incentives to produce high quality raw material are absent. Certain roundwood sellers and wood procurement enterprises have been applying extensions of pricing by assortments by dividing roundwood assortments to sub-groups according to size and external quality, such as branchiness, or top-end diameter of the logs (e.g. Wood trade rules 2011). The most comprehensive price system based on roundwood assortment is pricing by log dimensions. In this price system, some roundwood assortments may be priced by using unit price per unit volume, but certain assortments are priced using a different price for each log length-diameter class. It is also possible to divide roundwood assortment into qualities, thus, the price of the log depends on the roundwood assortment, volume, quality and log length-diameter class.

One alternative for pricing of roundwood in standing sales is pricing by total volume, where roundwood is priced by negotiating one price per cubic metre for total harvesting volume. In principle, the pricing is easy to understand and straightforward to apply from the forest owner's point of view. However, the buying bids by the other buyers of wood, based on alternative pricing systems, confuse the comparison between different bids.

In addition to pricing by total volume, in the Final Report of investigation of Roundwood trade by the Finnish Ministry of Employment and Economy (2009), the pricing based on stem size fractions was suggested for Finnish roundwood trade when applying harvester measurements. In the pricing by stem fractions, each tree is divided into previously agreed stem fragments based on the diameters of the stem. The rationale of the pricing by stem size fractions is that the stem is divided into segments by the potential end-use value, regardless of the bucking practiced, and thus, leaving possibilities to optimise bucking according to market needs.

The aim of the study was to compare five different price systems for the standing sales of clear cutting Scots pine stands in southern and central Finland. The price systems in roundwood trade were pricing by roundwood assortments (PbA), pricing by total volume (PbV), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD). The study included analysis of the relationship between sale value and wood paying capability (WPC), performance of the price systems in different stand types, elasticity of the price systems against changed log-length demand and the usability of PbV when using pre-information acquired from models of Malinen et al. (2010b) (PbV_{model}) or ARVO software (PbV_{ARVO}) (ARVO-software 2010).

Materials and Methods

Study Data

The study data were collected by measuring 577 standing sample trees from 51 Scots pine (*Pinus sylvestris* L.) dominated study stands from southern and central Finland (Figure 1) (Malinen et al. 2006). Measurements in each stand were made from 2-5 sample plots, 200-300 m^2 each. Every tree from each plot was measured for the dimensions (incl. diameter at breast height, height of the tree, heights of the lowest dead and living branch, heights of the thickest dead and living branch) and assessed for the stem quality, with particular attention to visually estimating the occurrence and measuring the effective lengths of the technical defects (e.g., sweep, crooks, branchiness, and scars) affecting the grading of roundwood assortments.

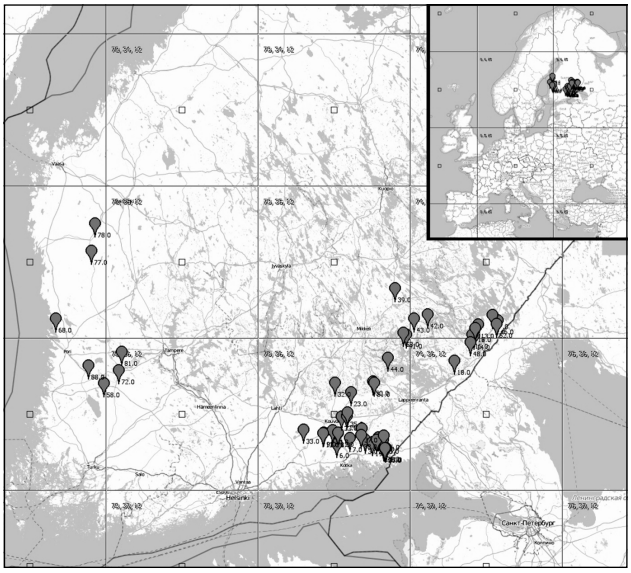

Figure 1. Location of the study stands

All pines from the sample plots were theoretically bucked by the bucking simulator based on dynamic programming (Kilpeläinen 2002). Bucking simulations were used in order to estimate the volumes of different roundwood assortments, length-diameter distributions and qualities of logs. In the bucking-to-value simulator, the stem volumes of the sample trees from the stump height to the top were calculated using the taper curve models based on tree species, breast-height diameter and height of the trees (Laasasenaho 1982). The heights of the stumps were calculated by the stump height models of Laasasenaho (1982) as a function of tree species and breast-height diameter. Based on the dimensions, external quality and bucking requirements for each roundwood assortment, the bucking simulator calculated the optimal bucking alternative maximising the value of the stem utilising price matrices for different roundwood assortments. The prices for price matrices were based on the average sales prices for roundwood assortments in May 2011 in eastern Finland (Savo and Northern Karelia) and WPC's of the logs (Table 1–3) at the stump by round wood assortments and log length-diameter distribution.

Wood Paying Capability

The wood paying capability (WPC) is considered a residual value that can be paid for by the wood raw material or the products of the industrial process after all costs (excluding wood) have been reduced from the sale price of the products (Jylhä et al. 2010). In general, as the length and the diameter of the saw logs increases, the WPCs of the saw logs per cubic metre increases (Salven 2008) due to lower production costs and higher value of sawn timber.

WPCs of the logs were estimated according to the average values of production in the Finnish wood processing industries. The estimates were based on expert interviews and unpublished industrial studies, and thus, the WPCs of the logs are reported as relative values of originals where length 52 dm and diameter-class 20 cm was set to 100 (Tables 1–3). The perspective of the study was the independent sawmills' viewpoint when buying saw logs for their own needs and selling pulpwood to pulp or paper corporations. In this case, the harvested pulpwood was sold forward for 18 €/m^3, excluding harvesting costs. WPCs of the logs included wood procurement costs, which were assumed at 7.48 €/m^3 for harvesting sawable roundwood assortments and 12.61 €/m^3 for harvesting pulpwood (Torvelainen 2011). Transportation costs were assumed at 6.91 €/m^3 for sawable roundwood assortments and 8.89 €/m^3 for pulpwood. For all roundwood assortments, general management overhead was assumed to be 2.98 €/m^3.

Price systems

The price systems tested were:

- Pricing by roundwood assortments (PbA)
- Pricing by total volume (PbV)
- Pricing by stem size fractions (PbSF)
- Pricing by assortment fractions (PbAF)
- Pricing by log dimensions (PbD)

In the PbA each roundwood assortment has one unit price (Table 4). In the PbV, one price per cubic metre is applied to all harvested roundwood regardless of roundwood assortment recovery. The price is set case-by-case according to the estimated roundwood assortments. The roundwood assortment recoveries and the

Table 1. Relative WPC's of the grade A Scots pine butt logs

Log length (m)	Log top-end diameter-class (cm)					
	20	22	24	26	28	30+
2.8	78.9	83.5	91.6	95.7	99.2	98.6
3.1	85.8	91.6	99.8	104.4	107.9	107.9
3.4	92.8	99.8	107.9	113.1	116.6	117.2
3.7	99.8	107.9	116.0	121.8	125.3	126.4
4.0	106.7	116.0	124.1	130.5	134.0	135.7
4.3	113.7	124.1	132.2	139.2	142.7	145.0
4.6	114.8	125.3	134.0	140.4	144.4	146.7
4.9	116.0	126.4	135.7	141.5	146.2	148.5
5.2+	117.2	127.6	136.9	142.7	147.3	149.6

Table 2. Relative WPC's of the saw logs

Log length (m)	Log top-end diameter-class (cm)								
	15	16	18	20	22	24	26	28	30+
3.7	66.3	72.1	76.7	81.4	84.9	88.4	90.7	91.9	93.0
4.0	72.1	77.9	83.1	88.4	91.9	95.9	98.3	99.4	100.6
4.3	77.9	83.7	89.5	95.3	98.8	103.5	105.8	107.0	108.1
4.6	79.7	84.9	91.3	97.1	101.2	105.2	107.6	109.3	109.9
4.9	81.4	86.0	93.0	98.8	103.5	107.0	109.3	111.6	111.6
5.2+	82.6	88.4	94.2	100.0	104.7	108.1	110.5	112.8	114.0

Table 3. Relative WPC's of the small-diameter saw logs

Log length (m)	Log top-end diameter-class (cm)		
	12	13	14
2.8	32.5	40.6	47.6
3.7	44.1	52.2	59.2
4.3	55.7	63.8	70.8
4.9	60.3	68.4	75.4

price estimates were obtained either by the models of Malinen et al. (2010b) (PbV_{model}) or by ARVO software (Arvo-Software 2010) (PbV_{ARVO}). In the PbSF, the stem was divided into fractions according to the stem diameters. Each stem section exceeding the minimum diameter has its own unit price. Minimum log lengths for the stem sections in the PbSF were 2.8 m for diameters over 26 cm, 3.7 m for diameters over 15 cm and 2.8 m for the diameters over 7 cm. The PbAF was similar to the PbA with the exception that the butt logs were divided into two roundwood sub assortments based on the top end diameter, and consequently, saw logs were divided into three sub assortments. In the PbD, each saw log was valued according to the WPCs of the logs based on the log quality, top-end diameter and length. Pulpwood has one unit price throughout the study.

The sale values and WPCs of the sample trees and stands were calculated according to the volumes of different roundwood assortments achieved from the bucking simulations. However, the estimated roundwood assortment recoveries and PbV were calculated according to the roundwood assortment recovery

Table 4. Roundwood assortments, their unit prices and diameter requirements used in the bucking simulations of pricing by assortments (PbA), pricing by stem fractions (PbSF) and pricing by assortment fractions (PbAF)

Pricing method, timber assortment	Unit price (€/m^3)	Min. diameter (cm)	Min. length (m)	Max. length (m)
PbA				
Grade A butt log	58	21	2.8	6.1
Conventional saw log	55	15	3.7	6.1
Small-diameter saw log	22	12	2.8	4.9
Pulpwood	18	7	2.8	5.2
PbSF				
Stem fraction 26+ cm	58	26	2.8	
Stem fraction 15+ cm	55	15	3.7	
Stem fraction 7+ cm	18	7	2.8	
PbAF				
Grade A butt log 28+ cm	60	28	2.8	6.1
Grade A butt log 21+ cm	58	21	2.8	6.1
Conventional saw log 26+ cm	57	26	3.7	6.1
Conventional saw log 18+ cm	55	18	3.7	6.1
Conventional saw log 15+ cm	50	15	3.7	6.1
Small-diameter saw log	22	12	2.8	4.9
Pulpwood	18	7	2.8	5.2

models by Malinen et al. (2010b) or by ARVO software (Arvo-software 2010) and the sale values of PbV were calculated using estimated assortment recoveries and total volume achieved from bucking simulation. The sale values were based on the previously mentioned price systems and unit prices. The average sale value in each price system was scaled to the same level, that is, the total sale value of bought roundwood was the same regardless of price system.

ARVO software

ARVO software is a decision support tool for assessing the amount and value of harvestable timber, including predictions of timber assortment recoveries, length-diameter distributions of logs and value recovery. Predictions are based on previously collected cut-to-length harvester's stem data (stm-data), which is stored in software as a stem database. By using easily achievable search variables ARVO software produces stem group estimates including stem diameters at ten centimetre intervals for each stem. This stem group can be bucked by using a bucking simulator included in ARVO software to achieve the estimates of timber assortment recovery, value and log length-diameter distributions. ARVO software is also capable of predicting the technical quality of stems to be used in bucking simulations.

Comparisons of the price systems

The performance of price systems was tested assuming two marketing scenarios. The first scenario

depicted normal marketing circumstances, where the demand for saw logs at the time of harvesting is the same as it was at the time of buying the roundwood. The second scenario represented circumstances where the WPC for the grade A butt log and conventional saw log lengths of 5.2 metres was assumed to increase by 20 per cent compared to other log lengths from the time of buying to the time of harvesting, and the change is reflected in the bucking objectives. According to Piira et al. (2007), if some log lengths, diameters or length-diameter combinations within roundwood assortment are emphasised over others, the recovery of the assortment diminishes.

Roundwood assortment recoveries, and thus, the sale value recoveries, are mainly dependent on the average stem size of the stand and the technical quality of the stems. For studying the performance of the price systems in different stand types the data were divided into five subgroups based on the soil fertility and average stem volume (Table 5).

Table 5. Classification of stands. OMT is for site fertility of *Oxalis-Myrtillus* type, MT is for site fertility of *Myrtillus* type, VT is for site fertility of *Calluna* type and VT is for site fertility of *Vaccinium* type, according to Cajander (1926). A_vol is the average stem volume of stand

Site class	Site fertility	Average size
Class 1	OMT, MT	A_vol < 0,6 m^3
Class 2	OMT, MT	0,6 m^3 ≤ A_vol ≤ 0,75 m^3
Class 3	OMT, MT	A_vol > 0,75 m^3
Class 4	VT, CT	A_vol < 0,55 m^3
Class 5	VT, CT	A_vol ≥ 0,55 m^3

The linear relationship between the sale value and the *WPC* of the stand was preferred, thus the relationship between the sale values and the *WPC*'s were analysed by the Pearson correlation coefficient and linear regression analysis. The price transmission (u_t) was also estimated by comparing the standwise sale value (u_s) to the standwise *WPC* (u_{WPC}). In the analysis of price transmission, standwise sale value and *WPC* was scaled to an average of 100. The price transmission was calculated by the formula:

$$u_t = u_s - u_{WPC} \quad (1)$$

Therefore, if the u_t of the stand is negative, the sale value of the stand is considered low compared to *WPC*. Conversely, if the u_t of the stand is positive, the sale value of the stand is considered high compared to *WPC*.

In the comparison of the prediction of roundwood assortment recovery by models (Malinen et al. 2010b) and ARVO software (Arvo-software 2010), the relative root mean square error (RMSE%) was applied. The RMSE% was calculated by the formula:

$$RMSE\% = 100 * \frac{\sqrt{\sum_{j=1}^{n} (y_{ij} - \hat{y}_{ij})^2}}{\frac{n-1}{\hat{y}_i}} \quad (2)$$

where n is the number of observations, y_{ij} is the real value of variable i in stand j, $\hat{y}_{ij}$ is the estimated value of variable i in stand j and is the mean of the estimates of variable i.

Results

Statistical measures show how the price systems returned added-value in the end uses, and the comparison of the sale values to the WPCs is presented in Table 6. The standwise examinations showed that the WPCs correlated best with the PbD, the PbAF being the second best. The PbA, the PbV_{model} and the PbV_{ARVO} were similar in correlation. This was expected since they are based on the estimated roundwood assortment recoveries and therefore the correlations of the PbV_{model} and the PbV_{ARVO} reflect the values of the PbA.

Table 6. Correlation coefficients, adjusted r squares and standard errors of estimate (sale value) of the model for sale value and WPC of the stands in price systems of pricing by roundwood assortments (PbA), pricing by total volume, volume estimates by models (PbV_{model}), pricing by total volume, volume estimates by ARVO software (PbV_{ARVO}), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD). All correlation coefficients were highly significantly different from zero ($p < 0.001$)

Pricing method	CC	R^2	Std.Err.
PbA	0.903	0.812	0.126
PbV_{model}	0.794	0.630	0.275
PbV_{ARVO}	0.825	0.681	0.257
PbSF	0.643	0.401	0.431
PbAF	0.937	0.876	0.101
PbD	0.999	0.999	0.008

The relationship between the sale value and the WPC was studied by analysing the price transmission between WPC and the sale value by the WPC (Figure 2). The PbV_{model} and the PbV_{ARVO} and PbSF produced

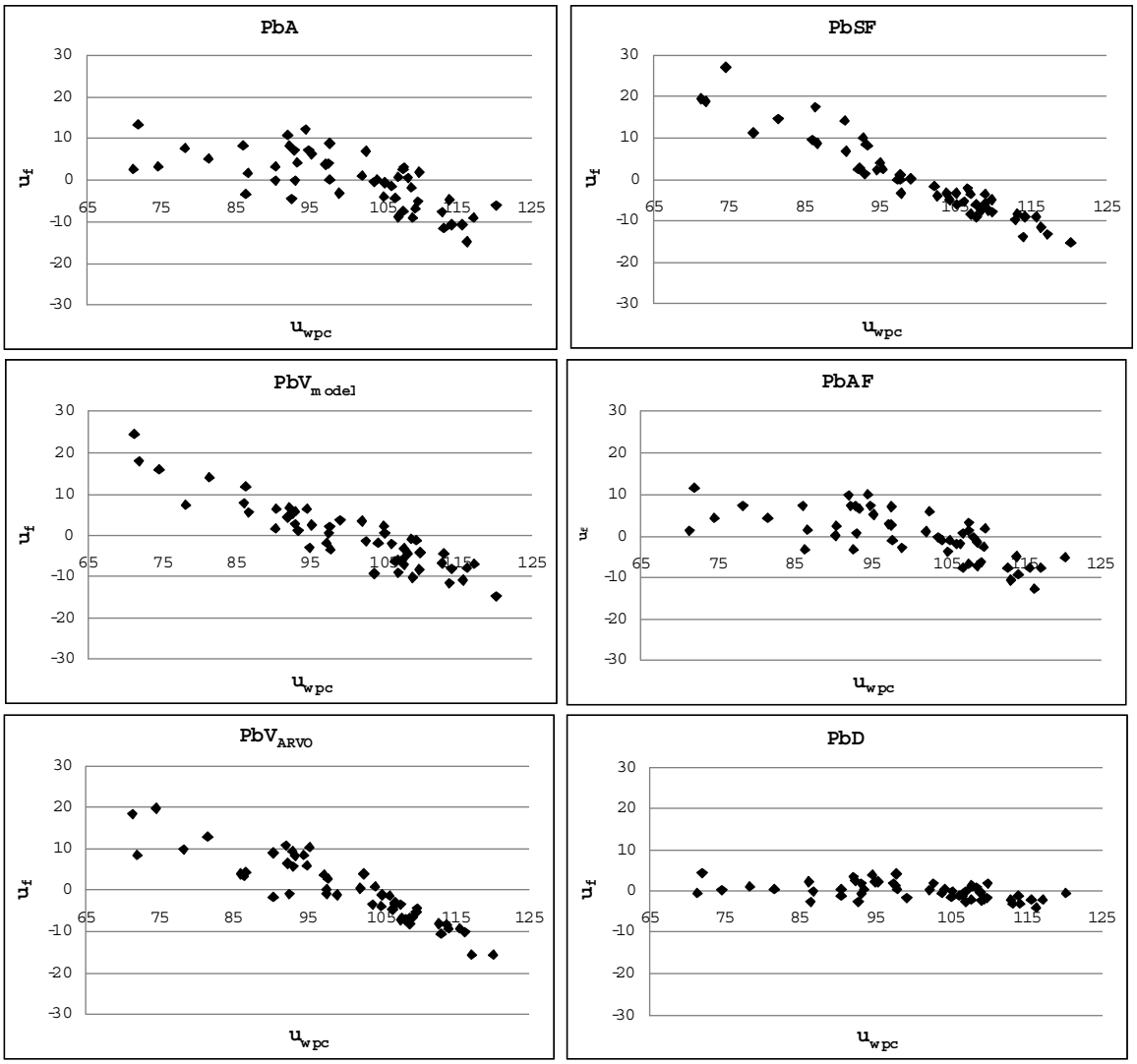

Figure 2. The price transmission (ut) between WPC and the sale value by the relative wood paying capability (up) in price systems of pricing by roundwood assortments (PbA), pricing by total volume, volume estimates by models (PbVmodel), pricing by total volume, volume estimates by ARVO software (PbVARVO), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD)

excessive sale values for the stands in which WPC was low, and exceedingly low sale values for the stands where the WPC was high, whereas the sale values were divided more by the WPC of the stand in the cases of the PbA, the PbAF and PbD.

The flexibility of the price systems in the changing market circumstances was tested through the market scenario where the WPC for the grade A butt log and conventional saw log lengths of 5.2 metres increased by 20 per cent compared to other log lengths (Table 7). With the PbV_{model} and the PbV_{ARVO} and the PbSF the price is not influenced by the bucking method practised, thus changing the method of bucking did not affect the sale value. For the PbD, the reduction

Table 7. Relative changes of sale value (%) when the wood paying capability for the log lengths of 5.2 m was increased by 20 per cent compared to other lengths in price systems of pricing by roundwood assortments (PbA), pricing by total volume, volume estimates by models (PbV_{model}), pricing by total volume, volume estimates by ARVO software (PbV_{ARVO}), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD)

Pricing method	Relative change of sale value (%)
PbA	-2.44
PbV_{model}	0.00
PbV_{ARVO}	0.00
PbSF	0.00
PbAF	-2.50
PbD	-3.03

in the sale value was the largest and the reduction in the PbA and PbAF was over 0.5 percentage points smaller than for the PbD.

According to the correlations between the sale value and the WPC calculated by the subgroups of the stands, the PbSF performed poorly in almost all subgroups; the only statistically significant difference from zero was observed in the subgroup where the soil fertility was low and the average stem size was smaller (Table 8). On the other hand, the PbD performed well in all subgroups. The PbA and the PbAF performed well in all the subgroups except where the site fertility was low and the average stem size was larger (Class 5). The PbV_{model} and the PbV_{ARVO} performed best when the fertility was high and the stem size was larger. In general, the correlations were low in the subgroups where the fertility was low and the average stem size was larger.

Table 8. Correlation coefficients of the sale values and WPCs of the stands by subgroups (Table 3) in price systems of pricing by roundwood assortments (PbA), pricing by total volume, volume estimates by models (PbV_{model}), pricing by total volume, volume estimates by ARVO software (PbV_{ARVO}), pricing by stem size fractions (PbSF), pricing by assortment fractions (PbAF) and pricing by log dimensions (PbD). (* *p*-value = < 0.05, ** *p*-value < 0.01, *** *p*-value < 0.001

Pricing method	Class 1	Class 2	Class 3	Class 4	Class 5
PbA	0.95***	0.92***	0.93***	0.96***	0.46
PbV_{model}	0.78**	0.67*	0.78***	0.48	0.78*
PbV_{ARVO}	0.82**	0.63	0.91***	0.83*	0.37
PbSF	0.35	-0.43	0.13	0.77*	0.73
PbAF	0.96***	0.92***	0.95***	0.96***	0.53
PbD	1.00***	1.00***	1.00***	1.00***	1.00***

The PbV_{model} and the PbV_{ARVO} were compared to the average price per cubic metre obtained by the PbA. The PbV_{ARVO} (45.30 €/m^3) was closer to PbA (45.59 €/m^3) than the PbV_{model} (46.54 €/m^3). The ARVO estimates were slight underestimates and the estimates by the roundwood assortment models were overestimates. Also the relative root mean square error (RMSE%) was lower for the PbV_{ARVO} (5.89) than for the PbV_{model} (7.21). The standard deviations of the PbV_{ARVO} (2.60) and PbV_{model} (2.62) were smaller than the standard deviations of PbA per cubic metre (4.03).

Discussion and conclusions

In the study, five different price systems for the standing sales of clear cutting Scots pine stands in southern and central Finland were compared. The basis for the study was standing sales, where the roundwood buying contracts are agreed within the limited knowledge of the amount and quality of roundwood to be sold or bought. Furthermore, roundwood is more frequently measured by the harvester used to harvest roundwood, and the quality of the bought roundwood is seldom observed. This has to be considered when developing roundwood price systems for the conditions of roundwood trade where standing sales are applied.

Alternatively, for example in most cases in Sweden, the roundwood is measured at the roadside or at the production plant by officials of regional Timber Grading Associations, which are non-governmental independent organisations. Saw logs are priced according to dimensions and quality based price lists, where each diameter-length class and grade has its own price. However, the sale values of the logs assessed using visual grading are not necessarily in accordance with the real values of the sawn timber produced (Chiorecu and Gronlund 2003). Moreover, automatic grading has been found less accurate than manual grading for all logs in the test set consisting of pine and spruce logs from five sawmills in different parts of Sweden (Enlund 2004).

The flexibility of price systems in the changing market circumstances was tested assuming the WPC for the grade A butt log and conventional saw log lengths of 5.2 metres increasing 20 per cent compared to the other log lengths. In most circumstances, changing bucking objectives is possible under all price systems excluding PbD. The price matrix used in bucking optimisation is not agreed in the contract, despite the fact that the price matrix does affect the roundwood assortment recoveries and the sale value (Piira et al. 2007). A larger price difference in the price matrix leads to smaller volume recovery of the assortment, since the optimisation aims to maximise the amount of the most valuable dimensions instead of maximising the total amount of roundwood assortment. In the PbV, the agreed price is calculated according to estimated roundwood assortment recoveries and therefore the bucking outcome does not affect the sale value. The PbSF is independent of the bucking practised and therefore the sale value remains the same. When using the PbD, prices for each log length, diameter and quality are agreed and the bucking should be done according to the contract.

The study was conducted by using bucking simulations, which guarantees optimal bucking outcome and value according to the given bucking objectives. In practice, working mode and skills of harvester operator crucially affect the bucking decisions and thus, the recovery of timber assortments and dimensions; this could not be considered in the study. Moreover, WPC's of the study represents average circumstanc-

es. Occasionally, markets, product specifications or production may produce significantly different WPC's for timber assortments and dimensions and the results of this study are not valid.

In the development of the price systems the largest challenges are the habits and attitudes of the parties in the wood procurement and utilisation chain. Throughout history, roundwood trade has developed in diverging directions in different countries, and each partner judges how any proposed changes might affect their benefits. Wood buyers are under pressure to create higher value for the mills while cutting down the costs of procurement. This results in the fact that new systems and mechanisms of timber trade which demand time to become familiar with are hard to implement. Forest owners are used to the current price systems and the changes suggested by the buyers can often arouse suspicions of their objectives.

In conclusion, PbD has clear advantages compared to other price systems. It gives the seller an indication of what kind of timber is valuable, offering incentives to grow high quality timber, and if the price list is correct, the outcome of bucking should meet the needs of the buyer. However, PbD lacks freedom to cut stems as wanted and, therefore, optimise the raw material according to the existing market demand if the current demand differs from the agreed price list. Consequently, the usability of the price systems varies depending on the objectives and the end use, and the obstacles in the use of alternative price systems should be reduced.

Acknowledgements

This work was conducted in the Finnish Forest Research Institute's research project" Assessing quantity, quality and value of wood raw-material for timber trade and procurement". Some parts of the study were supported through the project "Developing the Scots Pine Resource in the Northern Periphery Programme of European Union (2008-2010). The authors are grateful to Juha Metros, Erkki Salo and Tapio Ylimartimo for the field data collection and Erkki Verkasalo of reviewing the manuscript. We want to thank many persons in the Finnish enterprises of wood product industries for their help in data collection and for commenting on the preliminary results.

References

Arvo-Software. 2010. A software for producing prediction of harvestable timber, assortment recoveries, length-diameter distributions and value recovery. (http://www.metla.fi/metinfo/arvo/)

Brukas, V. and Brodie, J. D. 1999. Economic optimisation of silvicultural regimes for Scots pine using dynamic programming. *Baltic Forestry* 5(1): 28-34.

Cajander, A. K. 1926. The theory of forest types. *Acta Forestalia Fennica* 29: 1-108.

Chiorescu, S. and Grönlund, A. 2003. The visual grading system for Scots pine logs in relation to the quality of sideboards produced. *Forest Products Journal* 53: 53-60.

Development of Finnish Wood Market – International Benchmark. Wood Markets in Sweden, Germany, Austria and France. 2009. Appendix in Final Report of investigation of Roundwood trade by Ministry of Employment and Economy, composed by Pöyry Forest Industry Consulting Oy. 42 pp.

Enlund, J. 2004. Automatic grading of softwood sawlogs for pricing using external geometry. *Scandinavian Journal of Forest Research* 19: 38–47.

Gjerdurm, P. 2009. Norwegian forestry and the pine timber trade. In: P. Gjerdrum (Editor), Markets for Scots pine roundwood in the north-western regions of Norway, Sweden, Finland and Scotland. Norwegian Forest and Landscape Institute, p. 10-19.

Hamilton, J., Gentle, G., Thomson, J., Kelly, M., Morton, A. and Macleod, D. 2008. Economic policy settings in the forest and timber industry – An inter-jurisdictional comparison. Report prepared for Department of Primary Industries, Victoria, Australia. 74 pp.

Hudson, D., Ethridge, D. and Segarra, E. 1998. Incorrect price information for a heterogeneous commodity: A conceptual synthesis. Review of Agricultural Economics 20(2): 365-376.

Jylhä, P., Dahl, O., Laitila, J. and Kärhä, K. 2010. The effect of supply system on the wood paying capability of kraft pulp mill using Scots pine harvested from first thinnings. *Silva Fennica* 44(4): 695-714.

Kant, S. 2009. Global trends in ownership and tenure of forest resources and timber pricing. Prepared for Ontario professional foresters association. 64 pp.

Kilpeläinen, H. 2002. Apteeraussimulaattorin käyttöohje. [Handbook of bucking simulator]. Finnish Forest Research Institute, Joensuu Research Unit. 24 pp. (unpubl.) (In Finnish)

Laasasenaho, J. 1982. Taper curve and volume functions for pine, spruce and birch. *Communicationes Instituti Forestalis Fenniae* 108: 1–74.

Lorenz, U. and Gruziński, Z. 2003. Hard coal for energetic purposes: price – quality relationship; international coal market observations and Polish practice. *Applied Energy* 74(3-4): 271-279.

Malinen, J., Kilpeläinen, H., Wall, T. and Verkasalo, E. 2006. Variation in the value recovery when bucking to alternative timber assortments and log dimensions. *Forestry Studies | Metsanduslikud Uurimused* 45: 89-100.

Malinen, J., Berg, V. and Kilpeläinen, H. 2010a. Roundwood pricing mechanisms and their performance in Scots pine roundwood markets. Metlan työraportteja / Working Papers of the Finnish Forest Research Institute 174. ISBN 978-951-40-2256-2.

Malinen, J., Piira, T., Kilpeläinen, H., Wall, T. and Verkasalo, E. 2010b. Timber assortment recovery models for clear-cutting stands in southern Finland. *Baltic Forestry* 16(1): 102-112.

Malinen, J., Kilpeläinen, H. and Ylisirniö, K. 2013. Prehas software for pre-harvest assessment of timber assortments. Submitted to *International Journal of Forest Engineering*.

Piira, T., Kilpeläinen, H., Malinen, J., Wall, T. and Verkasalo, E. 2007. Leimikon puutavaralajikertymän ja

myyntiarvon vaihtelu erilaisilla katkontaohjeilla. [Estimating timber assortment recoveries and sale value by different bucking objectives]. *Metsätieteen aikakauskirja* 1/2007: 19–37. (In Finnish)

Pirisi, A., Laurent, A.and Dubeuf, J.P. 2006. Basic and incentive payments for goat and sheep milk in relation to quality. *Small Ruminant Research* 68: 167-178.

Purcell, W.D. 2002. Communicating value to cattle producers: issues, opportunities, and looking ahead. *Journal of Animal Science* 80: 87-92.

Puumarkkinoiden toimintaa koskeva selvitys – Työ ja elinkeinoministeriö. 2009. [Final Report of investigation of Roundwood trade by Ministry of Employment and Economy]. Pöyry Forest Industry Consulting Oy. 84 pp. (In Finnish)

Quayle, M. 2003. Log supply and price adjustment mechanisms in industrialized economies: Impacts on small-scale forest farmers. *Small-scale Forest Economics, Management and Policy* 2: 93-108.

Rojo, A., Diéguez-Aranda, U., Rodrķgues, R. and Gadow, K. 2005. Modeling silvicultural and economic alternatives for Scots pine (*Pinus sylvestris* L.) plantations in northwestern Spain. *Forestry* 78: 385–401.

Salvén, O. 2008. Laatupuu – puutuoteteollisuuden liiketoiminnan perusta. Laatupuulla parempiin päiviin – Laatupuuprojektin päätösseminaari. [Quality timber – the basis for the wood product business. Better days with quality timber – the closing seminar of the quality timber project]. Karstula 13.2.2008. (In Finnish)

Torvelainen, J. 2011. Harvesting and transportation of roundwood. In: Ylitalo, E. (Editor of series), Finnish Statistical Yearbook of Forestry 2011: 195-213.

Wood trade rules. 2011. The rules for trading in timber. Directorate General of State Forests at the Ministry of Environment Republic of Lithuania. http://gmu.lt/wood_trade_rules/ (Accessed 20.5.2013)

Received 23 September 2013
Accepted 28 November 2013

СИСТЕМЫ ЦЕНООБРАЗОВАНИЯ ПРИ ПРОДАЖЕ ПРОМЫШЛЕННЫХ КРУГЛЫХ ЛЕСОМАТЕРИАЛОВ В ФОРМЕ ЛЕСА НА КОРНЮ В ФИНЛЯНДИИ

Ю. Малинен и Х. Килпеляйнен

Резюме

Системы ценообразования на промышленные круглые лесоматериалы значительно различаются в разных странах в зависимости от числа и размеров компаний-продавцов и покупателей, а также влияния государства. Круглые лесоматериалы являются гетерогенным сырьем; это означает, что древесина различных пород, свойств и размеров обладает различной потенциальной ценностью для разных конечных потребителей. В долгосрочной перспективе уровни цен и системы ценообразования содержат ориентиры по производству круглых лесоматериалов для лесовладельцев, которые способны проанализировать экономическую целесообразность различных действий, необходимых для выращивания ценного сырья. В настоящем исследовании с помощью моделей раскряжевки проводится сравнение пяти различных систем ценообразования: ценообразование по круглым сортиментам (PbA), ценообразование по общему объему (PbV), ценообразование по размерам фракций стволов (PbSF), ценообразование по сортиментам (PbAF) и ценообразование по размерам бревен (PbD). Системы ценообразования подвергаются анализу с точки зрения взаимосвязи между продажной стоимостью и рентабельностью древесины (WPC), определяемой как остаточная стоимость сырья для покупателя древесины после вычета всех разумных затрат на производство, дистрибуцию, маркетинг и иных операционных издержек. Анализ осуществляется с учетом эффективности систем ценообразования для различных типов насаждений и эластичности систем ценообразования в условиях колебаний спроса на пиловочник разной длины. Ценообразование по общему объему (PbV) и ценообразование по размерам фракций стволов (PbSF), как правило, приводит к формированию чрезмерно высокой продажной стоимости в насаждениях с низкой рентабельностью древесины (WPC) и исключительно низким показателям продажной стоимости в насаждениях с высокой рентабельностью древесины (WPC). Показатели продажной стоимости максимально варьируют при ценообразовании по рентабельности древесины (WPC) в насаждениях в случаях ценообразования по круглым сортиментам (PbA), ценообразования по сортиментам (PbAF) и ценообразования по размерам бревен (PbD).

Ключевые слова: раскряжевка; системы ценообразования; рынки круглых лесоматериалов; цена на круглые лесоматериалы; соотношение цена-качество