

THE CONCEPT OF A
ROUNDWOOD PRICE LEVEL AND ITS DETER-
MINATION IN FORESTRY

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SUOMENKIELINEN SELOSTE:
RAAKAPUUN HINTATASO JA SEN MÄÄRITTÄMINEN

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Problems involved in measuring a roundwood price level

The price level of roundwood is a widely used and important concept in forestry and its determination is one of the most important tasks of forest statistics. The concept is frequently used, however, without sufficient clarity as to its meaning. Again, there is often too little attention paid as to whether the price level has been determined by scientifically acceptable methods.

These drawbacks probably mainly arise from the difficulty of defining the concept and of empirical determination. The main difficulties seem to be:

1. Roundwood consists of many different categories of timber: sawlogs, veneer logs, pulpwood, fuelwood etc. In the prices of a single category, differences in tree species, wood quality — which itself is based on several characteristics — and the size of timber cause great variation.
2. Different categories of timber and even separate parcels of the same kind are often measured in different units and different degrees of barking, which complicates price comparisons. For example with pulpwood and pitprops, varying bolt lengths complicate price comparisons for even the same category of timber.
3. There are great local differences in roundwood prices. These depend mainly upon the location of the parcel in relation to consumption and industrial centres and transport routes.
4. The size of the parcel sold may cause differences in roundwood prices.
5. In Finland, as in some other countries, there are currently in use two main principles for the sale of timber: sale on the stump and delivery sale. The corresponding terms are *stumpage price* and *delivery price*, the latter including the cost of felling and haulage to the road, railway, river bank or place of consumption when this is in the vicinity of the forest.
6. In addition to these factors, the density of the trees marked for cutting, the terrain and other factors affecting logging costs have a bearing upon the *stumpage price*.

Roundwood prices are often examined in the form of time series with a view to analysing short and long-term price variations. To permit a reliable assessment of price variations at different times, price determinations should be carried out on a uniform basis throughout the period, eliminating such factors as variations in timber size, grades etc., i.e. variations in the commodity itself. Naturally, the price should also be expressed in terms of a comparable volume unit (e. g. solid cu.m., excl. bark).

In practice, prices cannot be determined by taking such a great number of

factors into account since all the conditions are often not sufficiently known. For example, exact grading is still commonly neglected in the roundwood market. Further, timber sizes, stand density, terrain and other factors affecting costs are either completely unknown or very difficult to standardize.

In view of the many problems involved in the determination of the roundwood price level some scientists are pessimistic as to the possibility of establishing a roundwood price reporting system, at least as far as stumpage prices are concerned (see ZIVNUSKA 1958). In a country such as Finland, where the roundwood market constitutes one of the most important internal markets, roundwood statistics are essential. It is only a question of how such statistics can be compiled at a reasonable cost to satisfy the demands of precision.

It is obvious that practical reasons necessitate the abandoning of a concept that would satisfy all theoretical requirements. The minimum requirements, however, should be that:

1. roundwood prices are determined by timber categories and by tree species (e. g. pine sawlogs, spruce sawlogs, or perhaps softwood sawlogs, spruce pulpwood, birch fuelwood, etc.). Local circumstances would determine how detailed the classification should be;
2. the price of each kind of timber is determined in terms of the same unit of measurement;
3. stumpage and delivery prices are determined separately and delivery prices for a certain degree of primary conversion (e.g. the degree of barking) and a certain stage of delivery.

It must be stressed, however, that the requirements of price statistics depend on the nature of forestry and the methods of roundwood marketing. Consequently, requirements vary greatly in different countries. When for example a roundwood market is well developed, a more detailed timber classification can be used. Thus an assortment of different grades may be suitable, if grading is generally adopted.

A question of great importance is whether price level should refer to a certain region or to selected places or price points. The comparison of the prices prevailing at different periods of time would be on a more accurate basis if the prices were quoted for certain points of location to eliminate local variations.

On the other hand, production in forestry does not take place at a few points as it does in mining and in industry, instead timber is harvested annually from large areas. Therefore the method of determining stumpage prices at a few points is not applicable. Moreover, in many cases it is impossible because fellings shift from one area to another annually. On the other hand, it would be possible to take some point of transport (lake, railway or highway site) as a basis for delivery prices.

If stumpage and delivery prices are required on the same local basis, a region instead of a point should be taken as the basis for price determination. Further, practical reasons justify the determination of roundwood prices with reference to forestry or administrative areas rather than to price points.

Determination of a regional price level

When determining the price level of roundwood for a certain region, the aim is to calculate average prices (stumpage and delivery prices) for each assortment of timber (possibly by tree species) per volume unit.

To be able to deal with the average prices of a region, each assortment of timber should represent the average size and quality of the timber in the area. In other respects, too, prices should represent average conditions in the area. This applies to transportation and outlet conditions, size of parcels, terrain conditions, stand density, etc.

To ensure the true representation of the price observations is an important and, perhaps the most difficult, problem of regional price level determination (ZIVNUSKA 1958). The most favourable conditions exist where the forests of the area under observation consist of few holdings and the area is still large enough to exclude the impact of purely casual factors on prices in different years. Data can then be collected annually on all sales and prices. Conditions of this kind may exist in areas where the majority of forests belong to the State or where large-scale forestry is practised.

It is not possible to collect material covering all timber sales in areas where the forests are mainly in private hands and especially where they are small. Finland has approx. 300 000 private forest holdings selling timber, more than 100 000 of these on an annual basis. Conditions similar to those in Finland prevail in all Northern European countries, too. For reasons of expense alone, complete enumeration is not feasible.

In cases like this, roundwood prices can be determined by sampling. The author carried out a pilot survey in 1954 in a limited area of Finland (in the area of the District Forestry Board of Central Finland), using the forest holding as a basic unit (HOLOPAINEN 1956).¹

The investigation was primarily planned for the purpose of felling statistics. The method used was stratified sampling with variable sampling fractions. Stratification was carried out on the basis of the size of the holding after the private holdings had been listed in the area (excl. holdings with an annual timber production under 20 cu. m., i. e. holdings producing timber predominantly for domestic use). The sample of 1 227 units was allocated between different strata according to Neyman's optimum allocation rule, except that all forest holdings of over 500 hectares were included.

The size of the population and of the sample, as well as the allocation of the latter into different strata, is shown in Table 1. Sample units in each strata were selected at random. The material from the sample holdings was collected by foresters of the District Forestry Board and local forest management associations by interviewing the owners.

¹ Later on the survey has been continued on a country-wide basis.

Table 1. Size and allocation of the sample
Taulukko 1. Näytteen suuruus ja kiintiöinti

Stratum (size of holding hectares)	Population <i>Perusjoukko</i>		Sample (as designed) <i>Näyte (suunniteltu)</i>			Sample (excl. no reply) <i>Näyte (vastauksen antaneet)</i>		
	Number of holdings N	Forest area 1000 ha	n	Sample ratio (f), %		n	Sample ratio (f), %	
				f _n	f _{area}		f _n	f _{area}
0 (6 — 20)	5 379	74.2	173	3.22	3.29	173	3.22	3.29
1 (20 — 30)	3 584	89.2	179	4.99	4.97	176	4.91	4.92
2 (30 — 50)	3 609	139.1	202	5.59	5.63	201	5.57	5.61
3 (50 — 100)	2 751	191.0	211	7.69	7.64	210	7.63	7.61
4 (100 — 200)	1 343	184.6	194	14.40	14.40	188	14.00	13.88
5 (200 — 300)	334	80.6	111	32.55	32.51	106	31.74	31.04
6 (300 — 500)	184	69.1	95	51.63	51.20	93	50.54	50.06
7 (500 — 750)	45	27.4	45	100.00	100.00	45	100.00	100.00
8 (750 — 1000)	8	6.6	8	100.00	100.00	7	87.50	87.35
9 (1000 +)	9	11.8	9	100.00	100.00	8	88.89	88.71
Total	17 246	873.6	1 227	7.08	18.53	1 207	7.00	18.09

The price data were collected on the majority of sample holdings from written measurement certificates or sales contracts. A smaller proportion of price data was based on purely oral reports made by forest owners.¹

As can be seen from the Table, the response was very good: only 20 forest holdings coming under the «no reply» group. In the felling year 1953/54, however, less than half the holdings in the sample had made timber sales.

From the material collected, average prices were calculated for the following categories of timber: softwood sawlogs, spruce pulpwood and pitprops, pine pulpwood and pitprops, and birch fuelwood, all in Finnmarks per cu.m. solid measure without bark.

Sometimes the average prices of roundwood are calculated as a simple mean of price observations, irrespective of the size of the parcels sold. As, however, prices vary with the size of the parcel, the method often leads to faulty results. Therefore it is advisable to weight the price observations with the corresponding quantities sold. Only average prices thus computed satisfy the equation:

income from timber sales = amount sold x average price.

From a sample such as this it is possible to determine the precision of the estimated means by calculating the sampling variances or standard errors for the averages. In stratified sampling this is done in two phases, i. e. first, variance or standard error is computed for each stratum, then the standard error of the entire sample is calculated.

¹ The costs of the survey were reduced by combining the survey with the collection of felling data.

The variance for the unweighted mean in each stratum is obtained from the usual equation:

$$V_{(\bar{p}_u)} = (1 - f_h) \frac{s_h^2}{n_h} \quad (1)$$

where

$$s_h^2 = s_{(\bar{p}_u)}^2 = \frac{\sum (x_{hi} - \bar{x}_h)^2}{n_h - 1}$$

The variance of the mean in the entire sample is calculated according to the equation.

$$V_{(\bar{p}_u)} = \frac{1}{N^2} \sum N_h^2 (1 - f_h) \frac{s_h^2}{n_h} \quad (2)$$

and

$$E_{(\bar{p}_u)} = \sqrt{\frac{1}{N^2} \sum N_h^2 (1 - f_h) \frac{s_h^2}{n_h}}$$

In calculating the variance for the weighted mean the weighting must be done in equation (1). In each stratum, accordingly,

$$s_{(\bar{p}_w)}^2 = \frac{\sum q_i (p_i - \bar{p}_w)^2}{\sum q_i} \quad (3)$$

The variance for the weighted mean in the entire sample is then obtained from the equation.

$$V_{(\bar{p}_w)} = \frac{\sum q_h^2 V_{(\bar{p}_w h)}}{\sum q_h^2} \quad (4)$$

and the sample error from the equation

$$E_{(\bar{p}_w)} = \sqrt{\frac{\sum q_h^2 V_{(\bar{p}_w h)}}{\sum q_h^2}} \quad (5)$$

Key to symbols:

- $n (n_h)$ = number of price observations in the sample (and in stratum h)
- $f (f_h)$ = corresponding sample fractions
- s_h^2 = variance of price observations in stratum h
- $N (N_h)$ = number of units in the population (and in stratum h)
- p_{hi} = single price observation i in stratum h
- q_{hi} = corresponding size of the parcel sold
- $\bar{p}_u (\bar{p}_w)$ = estimated unweighted (weighted) mean of the prices
- L = number of strata

Table 2. Average prices (\bar{p}_w , \bar{p}_u) with standard errors ($\varepsilon(\bar{p}_w)$, $\varepsilon(\bar{p}_u)$)
Taulukko 2. Keskihinnat ja niiden keskivirheet

Category Puulaveralaji	\bar{p}_w	$\varepsilon(\bar{p}_w)$	\bar{p}_u	$\varepsilon(\bar{p}_u)$
Fmk per cu.m. solid measure under bark — mk/k-m ³ kitta				
Stumpage prices: Kantohinnat:				
1. Softwood sawlogs — Havusahatukit	2 167	16.2	2 100	19.9
2. Spruce pulpwood and pitprops — Kuusipaperi- ja kaivospuut	1 276	25.3	1 182	24.4
3. Pine pulpwood and pitprops — — Mäntypaperi- ja kaivospuut	798	22.1	776	25.4
4. Birch fuelwood — Koivuhalat	548	61.3	468	61.1
Delivery prices: Hankintahinnat:				
1. Softwood sawlogs — Havusahatukit	2 538	18.7	2 441	19.3
2. Spruce pulpwood and pitprops — Kuusipaperi- ja kaivospuut	2 279	17.5	2 179	16.8
3. Pine pulpwood and pitprops — Mäntypaperi- ja kaivospuut	1 802	15.7	1 739	20.0
4. Birch fuelwood — Koivuhalat	1 647	25.4	1 622	22.6

The standard errors for both the unweighted ($\varepsilon(\bar{p}_u)$) and weighted ($\varepsilon(\bar{p}_w)$) means of the prices can be seen from Table 2. The latter are smaller in general. The investigation also clearly indicates that the standard errors for prices were considerably smaller than those for removal. The results show that average prices of satisfactory reliability can be obtained even with a smaller sample than the one used here. Moreover, if the area contains State or other larger forests from which data on all sales is easily compiled on the basis of complete enumeration, the standard error for the whole area is reduced still further. If timber from forests belonging to timber companies is mainly used in the owner's establishment, the prices are artificial and should be excluded from price statistics.

It should be pointed out that the sampling method is justified only when the region and the number of holdings are fairly large. For small areas and a small number of holdings complete enumeration should be applied.

Price index for roundwood

It was noted earlier that there are factors that hamper comparisons between different years and areas. As the method is based upon mean prices for each category of timber, it is not possible to eliminate the effect of differences in timber quality and dimensions, parcel size etc. although these factors may be followed and controlled for example by collecting corresponding data in connection with the sample.

It is worth noting too, that the method gives comparable results as regards the price levels in different years, only on the condition that the areal distribution of sales in the region remains fairly even from year to year. If roundwood demand and sales — and prices — vary greatly in the region under observation, economic conditions cause shifts in sales in different parts of the region. In period of depression the demand for roundwood and sales is often concentrated on the proximity of transportation routes and in boom periods it is dispersed to remoter parts of the region. Under such conditions, annual averages do not give a fully comparable level of the prices of the region. This drawback can be eliminated by selecting areas with a sufficiently even demand for roundwood.

The prices determined per region and timber category enable price indexes showing changes from year to year in roundwood prices to be calculated. The index can be made either for each category separately or for all categories, i. e. for the whole »cubic metrage sold».

a. Price index for each separate category

The index can be constructed in different ways, according to what it is intended to represent.

The following may be noted:

$q_{itk} = q_{1tk}, q_{2tk}, \dots, q_{ntk}$, = quantities of a certain category (k) of timber sold in regions $i = 1, 2, \dots, n$ in the year t

$\bar{p}_{itk} = \bar{p}_{1tk}, \bar{p}_{2tk}, \dots, \bar{p}_{ntk}$ = corresponding (weighted) mean prices.

The quantities q_{ik} sold can be ascertained at the same time as the prices by applying the sampling method.

The average price for the whole country (\bar{p}_{tk}) is expressed by the equation

$$\bar{p}_{tk} = \frac{\sum \bar{p}_{itk} q_{itk}}{\sum q_{itk}} \quad (6)$$

By calculating the average price for each successive year in this way and taking one of the years (t) as the basic year, an index series representing changes in the prices of the timber category concerned is obtained according to the equation

$$I_t^{t+1} (P_k) = \frac{\bar{P}_{t+1, k}}{\bar{P}_{tk}} \cdot 100 \quad (7)$$

Unless permanent regional weights are used the price index calculated can show changes even in cases where the prices in different regions remain unchanged. This is what happens if changes in the annual sales are different in various regions.

The above variation can be eliminated by applying the same regional sales figures for all the years, i.e. by using permanent regional weights. In the main, use can be made of figures representing average quantities sold over a period of several years.

As observed by SAARI (1931, pp. 17, 94—95), each index has its own task to perform. An index calculated according to variable weights represents roundwood price movements from the standpoint of the cost estimates of the buyers (e.g. the wood industry). An index with constant weights shows price movements from the point of view of forestry (the forest owners).

b. General index of roundwood prices.

Statistics on the prices and price indexes of particular tree species and timber categories are required for several purposes. For instance, they can be used to compare the price movements of different tree species and timber categories thus giving important information for the calculation of the relative advantages of growing different tree species and for calculating rotation periods.

On the other hand, figures showing the general development of roundwood prices are often required. Where the prices and quantities sold of the different timber categories are known, it is possible to construct an index representing the price development of them all. Such an index is obtained from the equation

$$I_t^{t+1} (P) = \frac{\bar{P}_{t+1}}{\bar{P}_t} \cdot 100 \quad (8)$$

in which

\bar{P}_t and \bar{P}_{t+1} = the average prices of all timber categories and regions.¹

By weighting the average prices for the various regions by the amounts sold

¹ Here the usual LASPEYRES' index formula has been taken as the basis for index calculation. In a problem such as this, however, the logarithmic index of DIVISIA-TÖRNQVIST often offers certain advantages. One of these is that it measures the changes in the logarithms of the index and sub-indexes and thus considerably simplifies computation work (see TÖRNQVIST 1952, p. 12, 16).

of all timber categories per region, the average price for the whole country is obtained. An index series showing price development is obtained from the average prices for the different years

To calculate a price index for the whole country showing price development from the point of view of forestry (forest owners), the same regional volume figures preferably average quantities sold over several years must be used as the weight throughout the series.

In calculating a price index for all timber categories, the question also arises whether the same »cubic metrage sales» (composition of sale) should be used for each area in different years, i. e. should different timber categories be weighted with permanent weights or should the structure vary. In point of fact, the relation between the timber categories hardly ever remains the same. Changes occur which are partly casual, partly due to developments in the economic situation and partly due to trends, i. e. to longterm developments in the demand structures of the different kinds of roundwood. Typical of such developments in Finland and several other countries is the increase in the demand for pulpwood in relation to that for sawn timber on the roundwood market.

SELIN (1957, pp. 45—53, 104—106) has calculated the stumpage price index based on the »yield-cu.m» values in Finland for the years 1934/35—1954/55. Selin's index assumes that the structure of sales is the same as that of silvicultural cut calculated by ILVESSALO (SELIN 1957, pp. 102, 105). Since the basis is artificial, no great value can be attached to this index.

If instead of the »yield-cu.m» values, figures representing the real sales' structure calculated as an average over a relatively long period are applied, an index thus constructed might perhaps be used as a general index of roundwood prices to elucidate changes in the price level. With a view to practical forestry however, greater use could probably be made of a price index of roundwood for which the real amounts of the different kinds of timber sold in the area concerned each year are used as the weighting figure. More simply expressed, the basis for the index is the price obtained by dividing the total sales revenue from the different timber categories by the quantity sold expressed in solid cubic metres.

An index calculated in this way would register changes not only in prices but also in sales structure and would thus indicate revenue aspects on the roundwood market from the point of view of the forestry. Those engaged in forestry are not so interested in how the price of the particular structure of cubic metre varies, as in how the price per cubic metre sold from the forest develops with the fluctuation in market conditions and, particularly, when it develops in a determined direction. There is all the more reason for this attitude since the composition of the timber categories to be made up from forestry holdings and even stands of a definite structure varies according to fluctuations on the market.

Some special problems

The question arises whether the effect of technical development, particularly the development of the transportation system and methods, on regional averages of roundwood prices should be eliminated. Among other things, this effect can be seen in decreasing transportation costs¹ due to new roads, railroads etc. and other things being equal, it increasingly affects the stumpage prices within the area in question.

Sometimes the effect of the development of transportation techniques is eliminated by determining roundwood prices for certain »zones», for example at a distance of 0—2 km from the transportation routes.

Such a restriction of the basis for regional price statistics would be very difficult in the long run. Further if the principle is systematically adopted, the influence of more intensive felling techniques (for example, felling smaller trees for pulpwood etc.) should be similarly eliminated. This is hardly possible in practice.

Taking all these difficulties into consideration, it is perhaps preferable for the average prices of different timber assortments to be computed for the entire region without any artificial restrictions. Technical developments are a different problem, the effect of which must be considered and taken into account when interpreting price statistics.

Changes in the structure of the utilization of wood may also affect prices. Variations in the structure of the wood sold can generally be followed if there are statistics on commercial fellings. On the other hand, in regard to domestic utilization, it may be more difficult to establish a correlation between the forest owners' utilization and sales, since there are generally no annual statistics available. In Finland the matter can be examined on the basis of the results of timber utilization studies.

It is also worth noting that the development of marketing methods may create problems in compiling roundwood statistics, as ZIVNUSKA (1958) has pointed out. This is the case if, for example, substantial transfers from sales on the stump to delivery contracts, or vice versa, take place in the roundwood market. In Finland, for example, a clear tendency from sales on the stump to change to delivery contracts is discernible. While, in the 1930s an average of 70 per cent of commercial removals from farm forests were sold on the stump (KAILA 1946), according to studies by the author, the recent corresponding share (average for 1955/56—1956/57) was only 37 per cent. A trend of this nature may in itself affect stumpage prices. In fact, in some parts of Finland, the number of sales on the stump has been reduced to such an extent as to render the determination of the level of stumpage prices difficult. In the near future, the empirical determination of the stumpage price level may become impossible.

¹ Provided that the road is constructed by the public authorities etc. If the road is constructed by the buyer he deducts the construction cost from the price of the roundwood. Even then a new permanent road may in time increase the price in its vicinity.

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SUOMENKIELINEN SELOSTE:

RAAKAPUUN HINTASO JA SEN MÄÄRITTÄMINEN

Raakapuun hintataso on metsätaloudessa varsin yleisesti käytetty käsite ja raakapuun hintatilasto metsätalouden tärkeimpiä tilastoja. Toisaalta hintatason määrittäminen kohtaa metsätaloudessa tiettyjä vaikeuksia, joita aiheuttaa etenkin useiden tavaralajien esiintyminen markkinoilla, tavaralajien sisäiset laatuerot, menekkiaseman erilaisuudesta ja erilaisista hankintaoloista johtuvat hintojen suuret paikalliset vaihtelut ja myyntitapojen erilaisuus.

Tutkimuksessa käsitellään näitä ongelmia silmällä pitäen sellaisen raakapuun hintatilaston laatimista eri tavaralajeille, joka tekisi mahdolliseksi hintatason paikallisen ja ajallisen vertailun. Kaikin puolin tyydyttävän hintatilaston laatiminen siten, että itse hyödykkeessä ilmevä vaihtelu samoin kuin kuljetusolojen ja teknillisen kehityksen aiheuttamat menekkiolojen vaihtelut voitaisiin kokonaan eliminoida, ei tekijän käsityksen mukaan ole mahdollista. On tyydyttävä eräänlaiseen kompromissiin, jossa olennaisimmat »häiriöt» eliminoidaan ja muut kuin markkinoista johtuvat tekijät pyritään ottamaan huomioon hintasarjoja tutkittaessa.

Tutkimuksessa kiinnitetään erityistä huomiota oikean edustavuuden toteuttamiseen hintahavaintojen keräämisessä. Siinä suhteessa metsälöperusjoukosta poimittu otanta tarjoaa suuria mahdollisuuksia.

Edelleen käsitellään tutkimuksessa mahdollisuuksia raakapuun hintaindeksin laskemiseen ja eri menetelmiä indeksin laatimiseksi.

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