Dr. A. ZAMFIR, lecturer
Dr. A. HARAP
D. LĂZĂROIU
M. ALTĂR

Determination of Optimum Solutions in view of Turning the Resinous Lumber Mass to Account by means of Mathematical Methods *

Forests have always made up one of the main riches of Romania. They spread on an area of about 6.45 million hectares, i.e. about 27 per cent of the country's territory.

The main wood species populating the forests of Romania are: beech-trees — about 44 per cent; spruce — and fir-trees — 33 per cent; oak-trees — 9.4 per cent.

There results herefrom that the resources of resinous wood occupy the second place in the structure of our lumber stock, after the broad-leaved trees, but they detain the first place in economic value if the production trends and world trade of wood products are also taken into account. For this reason we have, in our study, dealt only with the optimum turning to account of the resinous lumber mass, both from the standpoint of meeting the internal needs and from that of export.

It is well known that, in the past, wood products, with crude oil and cereals, were our traditional export goods. Although the situation has changed radically in the years of socialist construction, our export showing change in structure and becoming diversified, nevertheless the delivery of wood products abroad still is an important source of foreign currency. In 1967 wood products (besides cellulose, paper and paper products) still represented 14.63 per cent of our total exports.

It is also planned, for the next few years, that the export of wood products will hold an important place, taking into account the rich existing resources

*) The following have also collaborated to the elaboration of this paper: eng. C. Emanoil, Dr. eng. A. Iacovlev, D. Mocianu, D. Rădulescu, P. Şerban.

and also the modern production capacity created in the wood processing industry. The key problem which arises is that, in conditions of a rational exploitation of the lumber mass, the contribution of foreign currency brought in by the wood industry should increase, as large as possible a volume of foreign currency being obtained for the products resulting from one cubic meter of lumber mass.

Resinous wood may be turned to account on the home market and abroad under numerous forms, however, with a higher or lower economic efficiency. If we only refer to a primary processing phase, which makes up the object of this study, we find, for instance, that the specification stakes — pieces 12—16 cm thick at the narrow end and 4—8 m. long — is very little in demand for export and its price per cubic meter is low. This material may, however, be mechanically processed into narrow boards and battens, beams with parallel or unparallel faces, these products being easier to turn to account abroad. Likewise, round timber can be chemically processed into cellulose paste.

Obviously, the problem of increasing resinous wood export in this primary processing stage does not arise. The concern and the success obtained during the years of socialist construction with regard to the displacement of the export centre of gravity from raw products (logs, sleepers, fire wood) to that of superior semi-manufactured goods (plywood, veneer, laminated board, chipboards, fibre building boards) and finished products (furniture, etc.) are well known. In 1966 our export of wood products consisted of: 50.2 per cent resinous and broad-leaved tree lumber, 8.3 per cent plywood, veneer, laminated board, 3.1 per cent chip-boards and fibre building boards, 21.3 per cent furniture. An improvement of this pattern is expected until the end of the present 5-year plan.

Returning to our study regarding the optimization of the turning to account of the resinous wood mass, it must first be shown that it has nevertheless been necessary to deal, in a primary phase with the initial processing stages of the lumber mass. The model comprises both home consumption and export availabilities, and sets the problem of finding the optimum structure for turning the various assortments and dimensions of the lumber mass to account, in a first processing phase. In this phase the part available for export has been limited precisely by the restriction of the model, the main object of the present study being to determine the optimum structure of home consumption in the very scope of ensuring superior turning to account of the lumber mass in subsequent processing stages. However, even under these conditions care was taken that the part available for export should ensure a maximum entry of foreign currency.

PREPARATORY WORK

The elaboration of the model required the preliminary solving of some method problems linked with the gathering of data, determination of the home market prices to be used in computation, choice of the optimization criterion, etc.

It was thus first necessary to choose the sorting variant of the lumber mass. As it is well known, the sorting of the lumber mass is generally effected in two variants: dimensional sorting and industrial sorting. What finally

interests economy is the industrial sorting on basis of which the balance of wood products is drawn up. Both sortings have as an object the standing timber mass. Dimensional sorting is concretized by grouping the lumber according to its dimensions at the narrow end (length being variable in accordance with the State standard provisions). Industrial sorting is based on dimensional sorting and it groups wood assortments according to the dimensions and qualitative characteristics stipulated in the standards. Since there are overlappings with respect to dimension between the industrial assortments (e.g. lumber for cellulose, pitprops and part of the piles and of the mill saw lumber) dimensional sorting cannot coincide with industrial sorting.

Therefore, industrial sorting is made by adopting a certain *sorting variant* which aims to achieve a certain assortment usually considered as being the most valuable from the standpoint of use value. Such sorting variants are the ones effected with respect to the achievement of a maximum volume of logs for resonance and mill saw timber (raw material for lumber).

Normally, the sorting variant ensuring the most valuable assortment from the economic standpoint should be adopted and optimization should be achieved with respect to this criterion through the instrumentality of price, as the monetary expression of value.

Since the present price system for wood is not in agreement with its value, it has been necessary to further critically examine the prices of the assortments to be included in the model and, to a certain extent, to correct them.

Thus, in our opinion, the main deficiency of the wholesale prices established in 1963 for the assortments of lumber products forming the raw material basis of the wood processing industry was the underestimation of standing timber. The selling price of the latter is made up of the forest tax which represents the total expenses effected by the sector of silviculture in proportion with the yearly production capacity of the forests, expressed by the volume of the main products plus the yearly average of the volume of products in the culture operations planned for the 1960—1965 period. This average tax has been differentiated on basis of technical-economic computations, by species or groups of species, resources (main, secondary and accidental products) and by dimensional assortments.

Nevertheless, the price at which standing timber is delivered to the exploitation sector by the sector of forestry does not cover its production expenses and therefore this sector operates at a loss, being financed from the budget.

We can get a clearer image on the price level of standing timber in Romania by comparing it with that of a few European countries.

Table 1

Price of standing timber in a few European countries (mean values in lei/cu.m.) *

Species	Assortment	Romania	USSR	Sweden	France
Resinous	Thick	26	64	—	335
	Average	13	52	205	136
	Thin	9	47	160	—

* For the other countries the values have been determined on basis of the price in foreign currencies lei, for standing timber, corrected by a 3.33 coefficient to make it correspond, to a certain extent, to the level of our home prices in lei.

In the conditions where the price of standing timber is established below its value, implicitly the cost price and the price of the products in which it enters as raw material as, for instance, precisely the assortments forming the object of our model, are distorted. The "redeeming" of this underestimation, which was noticed on the occasion of the 1963 wholesale price adjusting operations, was achieved through the price of the resinous lumber which includes a high accumulation quota assessed in the form of the tax on goods circulation.

According to our opinion the level of resinous lumber wholesale price has been established correctly. However, one should, instead of including an exaggeratedly large accumulation in the price of this product, have established it closer to the value of standing timber and of round timber which, among other effects would also have stimulated its more economical employment in the units which process it.

Based on this consideration, the prices of raw resinous lumber and of round timber have been re-computed in view of being used in the model, the following results being reached by a more appropriate distribution of the correlation tax:

Table 2

Item	Specification	Present mean selling price lei/cu.m.	Re-computed mean selling price lei/cu.m.
1	Raw resinous wood for lumber and other products	123	312
2	Round resinous timber for piles	388	388
3	Wooden posts for electrical and telecommunication aerial lines	344	344
4	Resinous round timber for pitprops *	187	245
5	Resinous round building timber (piles, round beams) *	360	360
6	Resinous split and round timber for chemical and semi-chemical paste in the cellulose and paper industries	146	256
7	Resinous lumber	711.80	711.80

* Notwithstanding all the corrections introduced in the computation when determining selling prices, there are still some deficiencies.

Considering these prices as being closer to the value of the respective products we suggest that the estimations in the model should be made on their basis.

The authors also analyzed the possibility of using the cost price as a basis of estimation, but the conclusion was reached that this solution is unacceptable for two reasons:

a) The cost price of the assortments included in the model is distorted consequently to the inadequate level of the price for standing timber;

b) Present methods for planning and following up the cost price in the sector of wood industrialization and exploitation does not permit the cost price to be distributed according to assortments, quality and dimensions.

A final problem which had to be solved before proceeding to the elaboration of the model, was that of choosing the criterion of optimization.

Generally, the decision problems appearing in the domain analyzed present alternative possibilities for the utilization of the various categories of lumber or of the products resulting from them, the economic aim being to determine the best (optimum) variant for the utilization of the resinous lumber mass.

It is well known from the general theory of linear programming that in the case where a certain problem of planning or of decision is approached, using the means of optimum programming, it is essential to define what is actually understood by "the best variant", in other words the economic criterion of optimization should be accurately defined. This, since a plan that is optimum from a given standpoint may no longer be optimum from another one.

There results herefrom that in the case where a decision economic problem is solved by means of mathematical methods, a unique optimization criterion should be determined. Otherwise, when there are several criteria, some generally plead for a certain solution, and others for another, which makes it impossible to reach a decision.

The optimization criterion may be expressed as a synthetic indicator, however complex, on condition that it should be unique.

Particular stress was laid on this aspect since, in our case, the problem may be stated under various aspects, various economic criteria for optimization being adopted.

The two more important criteria that interest us are:

a) making the total internal production expenses a minimum;

b) making the inflow of foreign currency a maximum.

As already shown, an economic problem can only be solved by means of mathematical programming methods if a unique criterion is adopted.

In this case, three possibilities may be adopted:

1. We give up one of the criteria. In other words, we take as the function objective either making internal expenses a minimum or making inflow of foreign currency a maximum.

2. We solve the problem taking as a basis one of the criteria and then continue the computations as a function of the other criterion, taking into account the results obtained in the first working stage. We see, for instance, what the maximum volume of foreign currency that can be obtained is. On the basis of this control figure we introduce, in the mathematical model, a new restriction which should refer to the minimum volume of foreign currency that must be obtained and we take as the objective function the other criterion, making the internal expenses a minimum while ensuring a given volume of foreign currency . Obviously, it is also possible to work the other way round, in other words to make the volume of foreign currency a maximum in the conditions where a given maximum for internal expenses is not exceeded.

3. Finally, a complex criterion may be adopted, comprising both criteria.

We consider it proper for the problem to be solved both in conditions 2) and in conditions 3), and, from the solutions obtained on basis of an economic-financial analysis — in which other factors that it has not been possible to establish quantitatively are taken into the computation in view of being introduced into the mathematical model — to adopt the solution appreciated as being the best.

MATHEMATICAL MODEL

The following notations are introduced in view of elaborating the mathematical model:

I. *The unknowns of the problem*, whose magnitude is to be determined by solving the model, are:

X_1 — quantity of building timber (perches-posts) of 5—10 cm. ⌀ thin wood;
X_2 — quantity of pulp wood, of 5—10 cm. ⌀ thin wood.
X_3 — quantity of battens, 5—10 cm. ⌀ thin wood;
X_4 — quantity of building timber (posts-stakes), 10—14 cm. ⌀ medium wood II;
X_5 — quantity of pitprops, 10—14 cm.⌀ medium wood II;
X_6 — quantity of pulp wood, 10—14 cm. ⌀ medium wood II;
X_7 — quantity of T.E. post timber, 10—14 cm.⌀ medium wood II;
X_8 — quantity of conversion logs, 10—14 cm.⌀ medium wood II;
X_9 — quantity of building timber, 14—20 cm.⌀ medium wood I;
X_{10} — quantity of potprops, 14—20 cm.⌀ medium wood I;
X_{11} — quantity of pulp wood, 14—20 cm.⌀ medium wood I;
X_{12} — quantity of pile timber, 14—20 cm. ⌀ medium wood I;
X_{13} — quantity of T.E. post timber, 14—20 cm. ⌀ medium wood I;
X_{14} — quantity of conversion logs, 14—20 cm. ⌀ medium wood I;
X_{15} — quantity of pitprops, 20—24 cm. ⌀ thick wood III;
X_{16} — quantity of pile timber, 20—24 cm. ⌀ thick wood III;
X_{17} — quantity of T.E. post timber, 20—24 cm. ⌀ thick wood III;
X_{18} — quantity of conversion logs, 20—24 cm. ⌀ thick wood III;
X_{19} — quantity of pile timber, 24—34 cm. ⌀ thick wood II;
X_{20} — quantity of conversion log, 24—34 cm. ⌀ thick wood II;
X_{21} — quantity of pile timber, ⌀ > 34 cm. thick wood I;
X_{22} — quantity of conversion logs ⌀ > 34 cm. thick wood I;
X_{23} — quantity of fire wood;
X_{24} — quantity of fibre building boards from fire wood;
X_{25} — quantity of pulp wood from fire wood.

II. *The quantities of woods, by assortments, available for processing*, to be taken into account, are noted by:

A_1 — available quantity of 5—10 cm. ⌀ thin wood;
A_2 — „ „ „ 10—14 cm. ⌀ medium wood II;
A_3 — „ „ „ 14—20 cm. ⌀ medium wood I;
A_4 — „ „ „ 20—24 cm. ⌀ thick wood III;

A_5 — available quantity of 24—34 cm. ⌀ thick wood II;
A_6 — „ „ „ ⌀ > 34 cm. thick wood I;
A_7 — „ „ „ fire wood.

III. Another element to be taken into consideration is the existing *production capacity*. Since, in the framework of the model, each plant will not be represented separately, the production capacities will be those at the level of national economy, obtained by summing-up the individual production capacities.

Obviously, in case we want to concomitantly solve the problem of the optimum determination of timber mass and that of the optimum distribution of production charges by plants, it is necessary to include individual production capacity in the computation.

In the present case our intention is for the problem of optimum distribution of the production charges to be solved later, after the optimum structure of the assortments has been determined.

We note the production capacities as follows:

C_1 — production capacity of sawmills;
C_2 — production capacity of pulp wood plants.

IV. — Certain *limits*, between which the quantity produced will vary, should be determined for each assortment.

Generally, the lower limit will refer to the requirement of producing the minimum quantities necessary for home consumption, as well as, eventually, the fulfilment of firm contracts concluded abroad.

The upper limits, determined on basis of statistical-mathematical methods, will also include, generally, the quantities of various assortments proper for sales abroad. Obviously, certain situations of conjuncture must, here, also be assigned a magnitude, in order to be included in the computation.

In this sense, we shall make the following notations:

b_1 — minimum quantity of 5—10 cm. ⌀ thin wood required as building timber (perches-posts);
b_2 — minimum quantity of 5—10 cm. ⌀ thin wood required for battens;
b_3 — minimum quantity of 10—14 cm. ⌀ medium wood II, required as building timber (posts-stakes);
b_4 — minimum quantity of 10—14 cm. ⌀ medium wood II, required as pitprops;
b_5 — minimum quantity of 10—14 cm. ⌀ medium wood II, required for T.E. posts;
b_6 — minimum quantity of 10—14 cm. ⌀ medium wood II, required as conversion logs;
b_7 — minimum quantity of 14—20 cm. ⌀ medium wood I, required as building timber;
b_8 — minimum quantity of 14—20 cm. ⌀ medium wood I, required as pitprops;
b_9 — minimum quantity of 14—20 cm. ⌀ medium wood I, required for piles;
b_{10} — minimum quantity of 14—20 cm. ⌀ medium wood I, required for T.E. posts;
b_{11} — minimum quantity of 14—20 cm. ⌀ medium wood I, required as conversion logs;

b_{12} — minimum quantity of 14—20 cm. ⌀ medium wood I, required as pitprops;
b_{13} — minimum quantity of 20—24 cm. ⌀ thick wood III, required for piles;
b_{14} — minimum quantity of 20—24 cm. ⌀ thick wood III, required for T.E. posts;
b_{15} — minimum quantity of 20—24 cm. ⌀ thick wood III required as conversion logs;
b_{16} — minimum quantity of 24—34 cm. ⌀ thick wood II, required for piles;
b_{17} — minimum quantity of 24—34 cm. ⌀ thick wood II, required as conversion logs;
b_{18} — minimum quantity of ⌀ > 34 cm. thick wood I, required for piles;
b_{19} — minimum quantity of ⌀ > 34 cm, thick wood I, required for conversion logs;
b_{20} — minimum quantity of fire wood;
b_{21} — minimum quantity of fire wood for fibre building boards;
b_{22} — minimum quantity of pulp wood;
B_1 — maximum quantity of 5—10 cm. ⌀ thin wood, required as building timber (perches-posts);
B_2 — maximum quantity of 5—10 cm. ⌀ thin wood, required for battens;
B_3 — maximum quantity of 10—14 cm. ⌀ medium wood II required as building timber (posts-stakes);
B_4 — maximum quantity of 10—14 cm. ⌀ medium wood II, required as pitprops;
B_5 — maximum quantity of 10—14 cm. ⌀ medium wood II, required for T.E. posts;
B_6 — maximum quantity of 10—14 cm. ⌀ medium wood II, required as conversion logs;
B_7 — maximum quantity of 14—20 cm. ⌀ medium wood I, required as building timber;
B_8 — maximum quantity of 14—20 cm. ⌀ medium wood I required as pitprops;
B_9 — maximum quantity of 14—20 cm. ⌀ medium wood I, required for piles;
B_{10}— maximum quantity of 14—20 cm. ⌀ medium wood I, required for T.E. posts;
B_{11}— maximum quantity of 14—20 cm. ⌀ medium wood I, required as conversion logs;
B_{12}— maximum quantity of 14—20 cm. ⌀ medium wood I, required as pitprops;
B_{13}— maximum quantity of 20—24 cm. ⌀ thick wood III, required for piles;
B_{14}— maximum quantity of 20—24 cm. ⌀ thick wood III, required for T.E. posts;
B_{15}— maximum quantity of 20—24 cm. ⌀ thick wood III, required as conversion logs;
B_{16}— maximum quantity of 24—34 cm. ⌀ thick wood II, required for piles;
B_{17}— maximum quantity of 24—34 cm. ⌀ thick wood II, required as conversion logs;
B_{18}— maximum quantity of ⌀ > 34 cm thick wood I, required for piles;
B_{19}— maximum quantity of ⌀ > 34 cm. thick wood I, required as conversion logs;

B_{20}— maximum quantity of fire wood;
B_{21}— maximum quantity of fire wood for fibre building boards;
B_{22}— maximum quantity of pulp wood.

V. We shall note by p_i the home price of product i, and by P_i the world market price obtained (in foreign currency). We therefore have:

p_1 — home price of assortment "building timber (perches-posts) of 5—10 cm. ⌀ thin wood";
p_2 — home price of assortment "pulp wood of 5—10 cm. ⌀ thin wood";
p_3 — home price of assortment "battens of 5—10 cm. ⌀ thin wood";
p_4 — home price of assortment "building-timber (posts-stakes) of 10—14 cm. ⌀ medium wood II";
p_5 — home price of assortment "pitprops of 10—14 cm. ⌀ medium wood II";
p_6 — home price of assortment "pulp wood of 10—14 cm. ⌀ medium wood II";
p_7 — home price of assortment "wood for T.E. posts, of 10—14 cm. ⌀ medium wood II";
p_8 — home price of assortment "conversion logs of 10—14 cm. ⌀ medium wood II";
p_9 — home price of assortment "building timber of 14—20 cm. ⌀ medium wood I";
p_{10}— home price of assortment "pitprops of 14—20 cm. ⌀ medium wood I";
p_{11}— home price of assortment "pulp wood of 14—20 cm. ⌀ medium wood I";
p_{12}— home price of assortment "round wood for piles of 14—20 cm. ⌀ medium wood I";
p_{13}— home price of assortment "wood for T.E. posts of 14—20 cm. ⌀ medium wood I";
p_{14}— home price of assortment "wood for conversion logs of 14—20 cm. ⌀ medium wood I";
p_{15}— home price of assortment "pitprops of 20—24 cm. ⌀ thick wood III";
p_{16}— home price of assortment "wood for piles of 20—24 cm. ⌀ thick wood III";
p_{17}— home price of assortment "wood for T.E. posts of 20—24 cm. ⌀ thick wood III";
p_{18}— home price of assortment "conversion logs of 20—24 cm. ⌀ thick wood III";
p_{19}— home price of assortment "wood for piles of 24—34 cm. ⌀ thick wood II";
p_{20}— home price of assortment "conversion logs of 24—34 cm. ⌀ thick wood II";
p_{21}— home price of assortment "wood for piles of ⌀ > 34 cm. thick wood I";
p_{22}— home price of assortment "conversion logs of ⌀ > 34 cm. thick wood I";
p_{23}— home price of assortment "fire wood";
p_{24}— home price of assortment "fibre building boards of fire wood";
p_{25}— home price of assortment "pulp wood of fire wood";
P_i — price for abroad, in foreign currency, of assortment i ($i = 1, 2, ..., 25$).

VI. To write down the mathematical model we shall also note by:

X_i^{int}— the quantity of product i destined to home consumption ($i = 1, 2, ..., 25$); and by:
X_i^{exp}— the quantity of product i to be exported.

Using the above notations the mathematical model is:

a) *Function to be optimized.* As already shown, two criteria may be considered in the case of our problem, viz. either making internal expenses a minimum, or making the foreign inflow a maximum. Since it has been considered that both criteria should be employed in the computation, a third criterion, based on these two, has been elaborated. This criterion involves the maximum increase of the difference between the quantity of foreign currency obtained, transformed in lei, and the home price of the entire production.

In other words, the adopted function to be optimized, is:

$$\alpha \sum_{i=1}^{25} P_i X_i^{exp} - \sum_{i=1}^{25} p_i X_i = max. \tag{1}$$

α — transformation coefficient of foreign currency into internal lei.

$$X_i = X_i^{int} + X_i^{ext} \qquad (i = 1, 2, ..., 25) \tag{2}$$

With respect to the second relation, it expresses the fact that the sum between the quantity of each product to be consumed at home plus the quantity to be exported is equal to the quantity of the respective assortment that will be produced.

Taking relation (2) into account, relation (1) may also be written:

$$\alpha \sum_{i=1}^{25} P_i X_i^{exp} - \sum_{i=1}^{25} p_i (X_i^{int} + X_i^{exp}) = max.$$

or

$$\sum_{i=1}^{25} (\alpha P_i - p_i)\ X_i^{exp} - \sum_{i=1}^{25} p_i X_i^{int} = max. \tag{2'}$$

In relation (2) the difference

$$\alpha_i P_i - p_i \tag{3}$$

represents the difference between the equivalent value in lei of the price obtained abroad and the home price; it appears as a "profit". Therefore, the function to be made optimum (2) requires that the difference between the "profit" obtained by export and the cost price of production destined to home consumption be made a maximum.

Other criteria that could be adopted in the case of the problem considered are

$$\sum_{i=1}^{25} p_i X_i^{exp} = max. \tag{4}$$

In other words, making the inflow of foreign currency obtained from exported production a maximum. However, in this case, a supplementary restriction of the form

$$\sum_{i=1}^{25} p_i X_i \leqslant K \tag{5}$$

should be taken into consideration. In other words, total internal expenses should not exceed a certain upper limit K.

Finally, a third criterion that could be adopted is

$$\sum_{i=1}^{25} p_i X_i = min. \tag{6}$$

In other words, making the total internal expenses a minimum. However, in this case, a suplementary restriction of the form

$$\sum_{i=1}^{25} P_i X_i^{exp} \geqslant E \tag{7}$$

should also be taken into consideration. In other words, the foreign currency inflow should at least be equal to a certain determined amount E.

b) *Restrictive conditions*

Regarding the restrictive conditions, these will be of several types, viz.:
— with reference to the available quantities of wood:
— with reference to the existing production capacity;
— with reference to the supply, in quantity, of the various assortments required by home consumption;
— with reference to the maximum convenient quantities to be produced for export.

We therefore have:

$$\sum_{i=1}^{4} X_i \leqslant A_1 \tag{8}$$

$$\sum_{i=5}^{8} X_i \leqslant A_2 \tag{9}$$

$$\sum_{i=9}^{14} X_i \leqslant A_3 \tag{10}$$

$$\sum_{i=15}^{18} X_i \leqslant A_4 \tag{11}$$

$$\sum_{i=19}^{20} X_i \leqslant A_5 \tag{12}$$

$$\sum_{i=21}^{22} X_i \leqslant A_6 \tag{13}$$

$$\sum_{i=23}^{25} X_i \leqslant A_7 \tag{14}$$

Relations (8)—(14) make imperative the following conditions: the quantities of the various assortments to be produced (X_i) should not exceed the available quantities of raw material.

We still have:

$$X_8 + X_{14} + X_{18} + X_{20} + X_{22} \leqslant C_1 \tag{15}$$

$$X_2 + X_6 + X_{11} + X_{25} \leqslant C_2 \tag{16}$$

Restriction (15) refers to the fact that the capacity of the saw-mills will not be exceeded, and restriction (16) refers to the fact that the capacity of the pulp wood plants will not be exceeded.

Finally, we still have the restrictions:

$$X_1^{int} \geqslant b_1 \tag{17}$$

$$X_3^{int} \geqslant b_2 \tag{18}$$

$$X_4^{int} \geqslant b_3 \tag{19}$$

$$X_5^{int} \geqslant b_4 \tag{20}$$

$$X_7^{int} \geqslant b_5 \tag{21}$$

$$X_8^{int} \geqslant b_6 \tag{22}$$

$$X_9^{int} \geqslant b_7 \tag{23}$$

$$X_{11}^{int} \geqslant b_8 \tag{24}$$

$$X_{12}^{int} \geqslant b_9 \tag{25}$$

$$X_{13}^{int} \geqslant b_{10} \tag{26}$$

$$X_{14}^{int} \geqslant b_{11} \tag{27}$$

$$X_{15}^{int} \geqslant b_{12} \tag{28}$$

$$X_{16}^{int} \geqslant b_{13} \tag{29}$$

$$X_{17}^{int} \geqslant b_{14} \tag{30}$$

$$X_{18}^{int} \geqslant b_{15} \tag{31}$$

$$X_{19}^{int} \geqslant b_{16} \tag{32}$$

$$X_{20}^{int} \geqslant b_{17} \tag{33}$$

$$X_{21}^{int} \geqslant b_{18} \tag{34}$$

$$X_{22}^{int} \geqslant b_{19} \tag{35}$$

$$X_{23}^{int} \geqslant b_{20} \tag{36}$$

$$X_{24}^{int} \geqslant b_{21} \tag{37}$$

$$X_2^{int} + X_6^{int} + X_{11}^{int} + X_{25}^{int} \geqslant b_{22} \tag{38}$$

and likewise

$$X_i^{exp} \leqslant B_i \qquad (i = 1, 2, ..., 25) \tag{39}$$

Restrictions (17—38) impose on the X_i^{int} unknowns the condition that they should be so determined as to ensure home requirements.

With respect to restriction (39), it imposes on the X_i^{exp} unknowns the condition that they should not exceed the maximum quantities B_i appreciated as convenient to be exported.

Finally, the last restrictions will be those of non-negativity, that are specific to most problems of linear programming. Hence

$$X_i^{int} \geqslant 0 \ (i = 1, 2, ..., 25) \tag{40}$$

$$X_i^{exp} \geqslant 0 \ (i = 1, 2, ..., 25) \tag{41}$$

The relationship between all the unknowns X_i^{int}, X_i and X_i^{exp} are given by

$$X_i = X_i^{int} + X_i^{exp} \quad (i = 1, 2, ..., 25) \tag{42}$$

Hence, the mathematical model for determining the optimum structure of resinous wood assortments contains 50 X_i^{int}, X_i^{exp} unknowns which must satisfy a number of 81 equations and inequations.

In case relation (4) is adopted as the function to be made optimum, relation (5) should also be added to the system of restrictions, and in case relation (6) is adopted, relation (7) should also be added to the system of restrictions.

CONCLUSION

Solving the model thus elaborated allows to determine the following:

— best-suited possibility of turning to account the various forms of round wood as a function of the diameter groups in which this wood is subdivided;

— quantities of round timber to be transferred from one alternative to another in view of ensuring the optimum turning to account;

— difference between the value of the products resulting from the present processing form and the value of the products to be obtained from an optimum assortment structure;

— quantity of round wood now used in a raw state (round) that might be economically replaced by other materials;

— conditions in which small-sized round wood should be processed into squared products, the most economical form being sought out of the following possible three:

a) at the plant nearest to the site of forestry operation;

b) at the collecting centres to which this timber is to be forwarded, depending on its origin and destination (home consumption and export);

c) the endowment, either of the present plants or of the collecting centres, with the necessary number of 10—12″ saw-mills — the best fit for sawing small-sized round timber — in view of obtaining as complete as possible a utilization of the equipment, i.e. maximum yield;

— quantity of squared (sawed) products convenient for export, resulting from the thin wood now sold abroad in its raw state, determining the difference of income in foreign currency, that could be obtained in this manner.

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DETERMINATION DES SOLUTIONS OPTIMUM POUR LA MISE EN VALEUR DE LA MASSE D'ESSENCES RESINEUSES A L'AIDE DES METHODES MATHEMATIQUES

Ce travail comprend les chapitres suivants:

— Eléments introductifs où l'importance du bois dans notre économie nationale est présentée; on insiste particulièrement sur nos exportations de produits forestiers et on recommande l'utilisation des méthodes mathématiques de calcul pour le thème étudié.

— Délimitation de l'objet de l'étude (choix de l'espèce ligneuse). Parmi les trois groupes principaux d'espèces forestières de nos forêts, à savoir: hêtre, pin/sapin et chêne, on a choisi comme objet de cette étude les espèces résineuses pin/sapin, pour les considérations d'ordre technique et économique, énumérées dans ce travail.

— Structure de la balance de la masse d'essences résineuses dans la République Socialiste de Roumanie. On détermine les éléments quantitatifs et de structure nécessaires au modèle mathématique, et on présente l'assortiment par dimensions de la masse ligneuse mise en valeur résultant des possibilités annuelles des forêts d'essences résineuses, ainsi que l'assortiment industriel de la masse ligneuse d'essences résineuses fournie à la production.

— Méthode de la détermination des prix à utiliser pour le modèle mathématique employé, afin de rendre optimum l'emploi et la mise en valeur des essence résineuses.

— Modèle mathématique. On expose le modèle mathématique contenant 50 inconnues, qui doit satisfaire un nombre de 86 équations et inéquations.

— Nécessité de rendre optimum la masse ligneuse de Roumanie pour l'exportation, par rapport à la structure de la consommation de perspective des importateurs probables.

On fait une analyse de la structure de perspective de la consommation, où se détachent les tendances actuelles et de perspective en ce qui concerne la consommation et les importations probables de certains pays capitalistes importateurs, de la République Socialiste de Roumanie.

ОПРЕДЕЛЕНИЕ ОПТИМАЛЬНЫХ РЕШЕНИЙ ОСВОЕНИЯ СМОЛИСТОЙ ДРЕВЕСНОЙ МАССЫ ПРИ ПОМОЩИ МАТЕМАТИЧЕСКИХ МЕТОДОВ

Представляемая работа охватывает следующие разделы:

— Введение, в котором показывается значение древесины в нашем народном хозяйстве, и особенно в экспорте изделий деревообрабатывающей промышленности и рекомендуется, как тема для исследования, использование математических методов расчета.

— Ограничение объекта исследования (выбора сорта древесины). Из трех основных групп древесных сортов наших лесов, а именно: бук, ель/сосна и дуб — предметом исследования были выбраны смолистые сорта — ель/сосна из перечисленных в работе соображений технического и экономического порядка.

— Структура баланса смолистой древесной массы в Социалистической Республике Румынии. Определяются количественные и структурные элементы, необходимые математической модели, и представляется сортировка древесной массы по размерам, вытекающим из годовой возможности смолистых лесов, предназначенных для освоения, а также индустриальная сортировка древесной смолистой массы, пущенной в производство.

— Методика установления потребительских цен при составлении математической модели для оптимизации и освоения смолистых масс.

— Математическая модель. Представляется математическая модель, содержащая 50 неизвестных, которые должны удовлетворить 86 уравнений и неравенств.

— Необходимость оптимизации древесной массы для экспорта, по отношению к структуре перспективного потребления возможных импортеров из Социалистической Республики Румынии. Проводится анализ структуры перспективного потребления, из которого выводятся современные и перспективные тенденции потребления и импорта некоторых капиталистических стран, возможных импортеров из Социалистической Республики Румынии.