ECONOMIC MODELS UNDERLYING FOREST POLICY PROGRAMS

AN EVALUATION OF ENDS AND MEANS

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SELOSTUS:

*METSÄPOLIITTISTEN OHJELMIEN PERUSTANA
OLEVAT TALOUDELLISET MALLIT*

TUTKIMUS PÄÄMÄÄRISTÄ JA KEINOISTA

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Preface

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Contents

1. Introduction

Forest policy has two aspects: economic and social. Because of this dualism, the implementation of forest policy means pursuing matters pertinent to economic and social policy within forestry. Economic policy consists in the deliberate variation of means in order to attain certain aims (TINBERGEN 1956, p. XI). Social policy can be defined by the same analogy; there is a difference in aims only. An analysis of policy objectives can be performed in terms of either economics or some other social science. Sometimes these standpoints are interchangeable. It has been shown that a programme for social policy can be based on an economic framework — at least regarding the setting of a goal (KUUSI 1961). This may be a necessity in the sense that social goals are not always measurable and, even if they were, their implementation must be paid by the economy concerned. Besides, a clear-cut analysis in economics is more readily feasible than it is in the other social sciences. On the other hand, an analysis made purely in terms of economics will prove incomplete, but the economic model behind the analysis will provide a bench-mark for assessing deviations from the economic goals set. Hence assumptions about the development of the economy being considered are of prime importance for both economic and social policy.

Of course, it is also possible to think of economic and social policy merely in terms of a game-theoretical undertaking, with no restrictions on the economic and social behaviour imposed by predetermined aims. This is in fact a realistic definition of economic and social policy in certain many-party democracies (notably Finland) where »political realities» tend to replace purely economic criteria in economic programs. However, an economist is supposed to delineate the course of events to be chosen by the economy concerned in order to attain certain aims. This delineation has the nature of an information and is intended to affect the political game. If it fails to do so, a new program must be designed with the restriction that politicians did not take account of the information offered.

Our concern here is economic policy in forestry with clearly stated objectives. These objectives are commonly called aims — as a distinction from means. Aims are defined *a priori* by rational statements on the motives of economic activity [1]; they are determined on the basis of an economic model representing

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[1] One of the essential motives is usually the maximization of some economic magnitude (welfare, profit, value added, *etc.*) within the advance restrictions imposed.

the economic behaviour of those concerned. An aim is usually indicated by policy makers (often politicians) in verbal terms. It is the task of the economist to provide a quantitative expression for the phenomenon to be analyzed in approaching the aim (*cf.* TINBERGEN 1956, pp. 21—32; LINNAMO 1957, pp. 272—285). The success or failure of an economic policy in achieving the aims depends to a large extent on the economic model used. The model is supposed to offer some of the means by which economic policy is implemented. Such means in the model are called controlled variables (or instrumental variables). The task of the policy maker is to try to change the coefficients of these variables in a desired way, as it may be suggested by the economist. There are also policy instruments of an institutional nature. Changing these often means a change in the social value hierarchy which determines the permissible limits for the use of instrumental variables. Our concern here are the policy instruments present in the model. Controlled variables are essential to the policy maker in that he can influence them, while assuming a certain behaviour of the non-controlled variables.

The purpose of this study is to trace the economic models used in certain studies and to evaluate whether the economic theory envisaged by a model is consistent with its aims in forest policy. Secondly, we shall endeavour to point out assumed improvements for models that can be used as a basis for forest policy.

To create some degree of order in the examination of the models, distinction is made between short and long run models. Short run in economics refers to a period long enough to change the utilisation of production capacity, but too short to alter the capacity itself. Long run means a period long enough to change the quantity of plant and equipment. The actual time covered by a long run or short run analysis is therefore of minor importance in drawing this distinction; technical supply conditions, not time, are the deciding factor (*cf.* BOULDING 1955, p. 570; *cf.* also RIIHINEN 1962, p. 8). The same distinction applies also to long and short run in forestry; we speak about long run when capital inputs and/ or changes in technology are assumed in changing the supply conditions; otherwise we are dealing with short run — regardless of how long a historical time is involved. Similarly, we speak about short run or long run forecasts depending on whether these are based on a short or long run model. Alternative forecasts are needed in determining the goals for forest policy. The purpose of forecasts is usually to illustrate the trends in the market for forest products under certain conditions. It is then assumed that economically optimal programs are not affected by the employment situation. If this is not the case, »social» deviations from the optimal goal may take place. Such deviations may also occur as a result of political realities.

Models underlying forecasts may exhibit alternative economic theories depending on the purpose of the forecasts. According to the economic theory illustrated by models, the forecasts can be classified as follows:

1. forecasts of demand
2. forecasts of supply
3. forecasts of consumption
   a. forecasts of actual consumption
   b. forecasts of potential consumption.

Forecasting demand means estimating the demand curve for a future period (*cf.* DUERR and VAUX 1953, pp. 446—447; RIIHINEN 1962, p. 9). Alternatively, two or more points along a demand curve can be determined instead of the complete curve to form a forecast of demand. As will be found out later in this study, the latter procedure may be the more usual. Apart from serving as one of the components in a forecast of consumption, forecasts of demand also provide an indication of possible prices at different levels of consumption.

Forecasting of supply involves drawing a future supply curve or determining more than one point along it.

Once both the future demand and supply curves have been estimated, the abscissa [1] of the intersection of these gives a forecast of actual consumption (*cf.* DUERR and VAUX 1953, pp. 422—423; VAUX 1954). Thus there is no difference between the method of forecasting actual consumption and those of forecasting demand and supply. Forecasting potential consumption calls for a different procedure. Here, the consumption expected is determined on the basis of a statistical relationship between past consumption and certain predetermined variables. The demand and supply curves are not taken into account. In other words, the point determined is that which corresponds to the intersection of the theoretical demand and supply curves under given circumstances. If future consumption is estimated as the abscissa of the intersection of the demand curve and a supply curve which is assumed to be a horizontal line at a given price level, this, too, is termed a forecast of potential consumption (*cf.* RIIHINEN 1962, p. 10). Accordingly, a forecast of potential consumption, which American authors call »potential requirements», has two slightly different connotations: it refers (*a*) to forecasts that have been made without knowing either demand or supply curves, and (*b*) to forecasts developed on the basis of a known demand curve assuming that goods can be supplied at a given price.

The above distinctions are based on the economic nature of forecasts. They are operational and can — when set against their economic implications — be used in evaluating the consistency of a model and its purpose. There are other possible objects for forecasting — such as the expected output or sales —, but these are simply statistical refinements of forecasts of consumption. If we include stocks with appropriate lags in the model, we attain these refinements. The same can be performed also by using output or sales series instead of consumption series.

Since the above classification constitutes the system of reference in terms of

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[1] The horizontal axis is taken to represent quantity, and the vertical axis price.

which the economic significance of the models actually used are to be judged, we wish to make this point so clear as to avoid confusion of economic and statistical aspects and of certain conventional matters of fact.

Forecasts have numerous functions, some of which have been mentioned in the above study by the present author (RIIHINEN 1962, p. 8). In this study we are particularly concerned with their implications for forest policy. Especially in areas where forestry has no comparative advantage [1] economists have to reconcile the differences between productivity, strategic and similar aspects in determining the proportion of the national product to be allocated to forestry. Once the production goal in forestry has been given an unmeasured extent (e.g. domestic wood requirements), the goal thus expressed must be measured. The starting point then are trends in the markets for forest products. If the production goal chosen is not based on the market, the consumption of wood in certain forest areas of the world with inadequate reforestation programmes may result in such a scarcity of wood that its increased price will turn consumers away from wood and enforce the adoption of substitute materials. Also, high prices for forest products — at the same time as there are unutilised forests — may cause considerable losses to the society as a whole. If, on the other hand, the production capacity of the forests were fully utilised, such large quantities of wood would finally be grown in certain areas of the world, that its price would hardly cover the cost of production (cf. VAUX 1950, p. 463). This might bring about considerable losses for both public authorities and private people because capital and labour could have been allocated more profitably to other undertakings. It depends largely on the models used in determining the policy objectives to what extent the profitability aspect will be taken into account: to what extent the measures taken within forestry contribute to the maximization of national income, etc.

2. Theoretical Models Used in Certain Studies

21. Method of Examination

In the following chapters, theoretical models used in studies of the economic foundations of forest policy will be examined. These models have not always — if ever — been specified in advance or presented in an explicit form; they are here crystallized from an often obscure context. This part of the present study will be given a good deal of attention, because by analyzing models of earlier studies light can be thrown upon the relationship between the theoretical aspects of a model and its purpose. Furthermore, the consideration of these models offers a worth while starting point for assumed improvements.

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[1] This is the concept used in the theory of international trade to explain the gains from the trade between different countries. It can be found in several textbooks of economics.

22. Studies Made in the United States

The *McSweeney-McNary Act* passed in 1928 provided for making »a comprehensive survey of the present and prospective requirements for timber and other forest products in the United States, and of timber supplies, including a determination of the present and potential productivity of forest lands therein, and of such other facts as may be necessary in the determination of ways and means to balance the timber budget of the United States» (*Act of May 22, 1928*). Since that date appraisals have been published with a view to establishing a long run equilibrium, conditioned by different economic requirements, in the United States' timber economy. At the beginning, drain ratio was used in drawing conclusions about wood consumption in relation fo forest resources. At the same time, however, attempts were made to develop a more critical method of ascertaining a long run production goal. By analyzing the models implicit in determining a production goal it is possible to evaluate how well the economic-theoretical requirements for a forest policy have been taken into account.

In 1931, a study initiated by the *United States Timber Conservation Board* was published (MASON and BRUCE 1931). An analysis of wood consumption and production in this study was extended to the year 2000. Wood consumption was analyzed in terms of two components: population and consumption of wood per head.

In estimating the consumption of wood per head in 2000 wood consumption and forest area per head in the base period in certain European countries and the United States are correlated. The observation is made that consumption per head in the United States deviates considerably from the regression line obtained. The authors assume that, in the future, wood consumption per head in the United States will be closer to the regression line, i.e. its ratio to forest area per head in the United States will be the same as that of the European wood consumption per head is to the forest area per head. Estimating wood consumption by this method means attempting to determine the intersection of the future demand and supply curves without knowing the curves themselves. The forecast thus obtained is neither one of demand nor of supply, but one of consumption (potential consumption); only one point of each curve is known. This kind of analysis does not explain why the consumption of wood per head declines with time. Its economic foundations are inadequate in that it does not pay attention to the possibility of determining a production goal which (a priori) tends to maximize the total net revenue from forestry.

In 1946 the *United States Forest Service* published a study on future wood requirements (*Potential Requirements . . . 1946*). According to the terms of reference, the aim was to determine the potential timber requirements in certain future periods. It can be concluded from the definition of potentional requirements that the production goal and the long run equilibrium of demand and

supply are considered the same in consistance with the provisions of *McSweeney - McNary Act*.

According to the above study by the *Forest Service*, »potential requirements» refers to »the quantity of timber that might be used by consumers afforded reasonable latitude in choice of readily available materials, including timber products, in a national economy functioning at a high level of employment and output» (*Potential Requirements* . . . 1946, p. 1). RETTIE (1948, pp. 237—242) subsequently offered an alternative definition of potential requirements as »the quantity of timber and timber products which we would probably use at some future date under conditions of reasonably adequate supply». In terms of economics, the concept of »potential requirements» as used by the Forest Service means the quantity of timber to be used in a future period assuming that the price of timber in relation to the prices of competing materials will remain the same as in the base period (*cf.* VAUX and ZIVNUSKA 1952, p. 322).

SHAMES (1946) developed a forecast of the United States' sawnwood consumption for an 18-year period which he called the building cycle. The choice of the building cycle, as far as it can be traced from his study, is based on the similarity of certain parts of historical time series. Similarly, the method used seems, in many details, to arise from historical analogy (*cf.* DUERR and VAUX 1953, pp. 415—416), according to which it is assumed that »history repeats itself». On the basis of the building cycle following the first World War, SHAMES analyzed the influence of nine factors affecting sawnwood consumption. The indexes obtained may be considered as some sort of gross regression coefficients, even if they are not estimated by the customary regression analysis. In the following step, he estimated the percentage trends in each factor up to the target cycle and multiplied these by the gross regression coefficients. By comparing the resultant consumption figures with the base period consumption, a percentage change with a plus or minus sign due to each factor analyzed is obtained. By adding the change indexes algebraically, the author arrives at the net influence on sawnwood consumption caused jointly by nine factors.

One of the econometric handicaps of the method used by SHAMES is the fact that — in a way — gross regressions are summed up instead of estimating the coefficients simultaneously. Another weakness is noted by the author himself: some of the explanatory variables are intercorrelated (SHAMES 1946, p. 485). The adverse effects of this handicap are less serious if single points only are forecast. Instead, the assumption about arithmetically linear relationships implicit in the study is not necessarily justified. However, we shall concentrate ourselves mainly on economic implications of the model used.

SHAMES' method of determining the demand elasticity from relative changes in price and consumption in a three-year period (1930—32) (using as control periods the two-year periods of 1920—21 and 1927—28) may be due to his desire to replace the multiple regression analysis as a means of estimating the
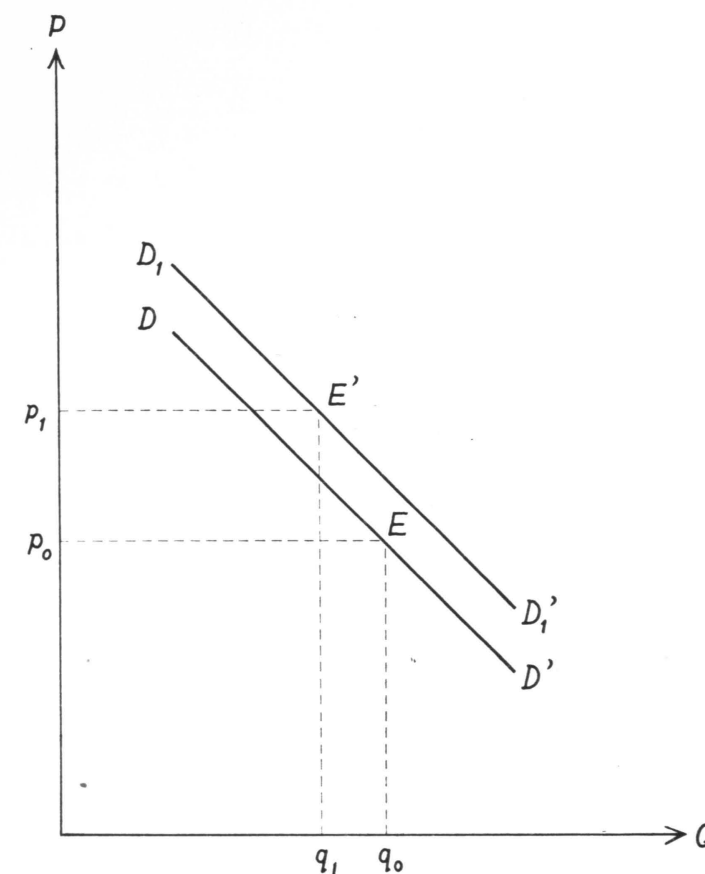
Figure 1.

coefficients of the explanatory variables by a simpler (but subjective) method. Difficulty in identifying the shifts of demand and/or supply curves may have encouraged the selection of periods as short as these.[1]

The economic model implicit in Shames' study can be illustrated by reference to Fig. 1, in which P = price and Q = consumption of sawnwood. Suppose that demand in the base period is represented by a negatively sloped straight line *DD'*. In the base period, quantity q_0 is consumed at price p_0. Due to changes in the demand shifters (explanatory variables other than price), the demand curve of the base period, *DD'*, shifts upwards by the target period (D_1D_1'), and the price rises ($.5 \times .1 = 5$ per cent) (p_1). Because of this shift, the quantity consumed diminishes from q_0 to q_1. — In short, the substantial economic content

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[1] On the problem of identification, see KLEIN (1953, pp. 92—100); TINTNER (1960, pp. 44—46, 238—243); VALAVANIS (1959, pp. 85—106).

of the method consists of seeking along a predetermined horizontal price line the point at which the demand curve intersects this line. We shall return later in this study to the possibility of using this type of model to ascertain a forest production goal.

In the study published in 1958 by the *United States Forest Service* (*Timber Resources* . . . 1958), two basic assumptions have been made: 1. war between the great powers will be avoided during the target period, but military preparedness will be maintained; and 2. economic prosperity will continue under high-level employment (unemployment not more than 4 per cent) (*Timber Resources* . . . 1958, p. 369). — Since the quantity of timber to be used in the future fluctuates according to factors not easy to gauge in advance, the Forest Service developed three alternative forecasts based on varying forecasts of population, gross national product, relative price of timber, and of certain additional assumptions.

The Forest Service first made a basic forecast of timber consumption (»medium projected demand») for the years 1975 and 2000. The assumptions made were as follows: a. the population of the United States in 1975 will be 215 millions, and in 2000 275 millions; b. the price of timber in relation to the prices of competing materials will remain the same as in the base period; c. the forecasts of gross national product are 630 billion dollars and 1,200 billion dollars in 1975 and 2000, respectively (counted with 1953 price level) (*Timber Resources* . . . 1958, p. 371).

»Medium projected demand» served as a basis for another alternative forecast for 2000. This »upper projected demand» was derived on the assumption that the relative price of timber will remain unchanged, but population will increase to 360 millions, and cross national product to 1, 450 billion dollars. No corresponding alternative for 1975 was developed, as it would have deviated only slightly from »medium projected demand». An additional assumption in both the »medium projected demand» and »upper projected demand» is that the proportion of timber in relation to raw materials other than those used in manufacturing food and fuels will remain at the base period level.

The »lower projected demand» is based on the same assumption about population and gross national product as the »medium projected demand». However, the price assumption for the »lower projected demand» is that future prices of timber products will rise substantially faster than prices of substitute materials. This would lead to price-induced substitution of nonwood materials for timber products and a declining rôle of industrial wood in the United States' economy.

The model implicit in the above study may be illustrated insofar as it relates to sawnwood. Data on other end uses are in part incomplete, and in part they are admitted to be rough estimates derived without a consistent method, even though the results for all the end uses are presented consistently.

It is conceivable that the assumptions about the demand shifters (gross national product and population) are the same. Thus the reduction of the

quantity of timber to be consumed from the »medium projected demand» to the »lower projected demand» is due merely to an upward shift of the horizontal supply curve (price line). The »medium projected demand» and the »lower projected demand» thus represent two points along the same demand curve and give an idea of the assumed price elasticity of sawnwood consumption in the target period. The »upper projected demand» is obtained on the assumption that the demand shifters grow at a given rate as compared with the »medium projected demand». Hence it represents a single point along another (otherwise unknown) demand curve.

The Forest Service assumes a rise of 38 per cent in the absolute price of sawn-wood from the 1948—52 average to 1975, and 97 per cent from the same base period to 2000. The corresponding percentage reductions in sawnwood consumption are 14 and 30 (*Timber Resources* . . . 1958, p. 421). The »upper projected demand» is 14 per cent greater than the »medium projected demand» (*op. cit.*, p. 422). The model traced above may be illustrated by reference to Fig. 2.

In the light of the above considerations, the five-alternative forecast developed by the United States Forest Service is a forecast of potential consumption; it is rendered such by the assumption about a horizontal supply curve, *i.e.* about the equality of unit supply price irrespective of the quantity supplied (*cf.* p. 7, above). Finally, a forecast of demand based on two points is also obtained. Its method, however, differs from that of customary demand forecasts, since it is in a way a result of two forecasts of consumption. The reverse order, proceeding from demand to consumption is theoretically more natural, though not always feasible. No predetermined price is then required.

VAUX (1950) studied sawnwood consumption in California housing.[1] His aim was to determine the amount of sawnwood required for housing in 1946—55 and 1956—65. By »requirements» VAUX means such an estimate of future sawn-wood consumption as will balance demand and supply at the level of long run production costs (VAUX 1950, p. 465). In constructing the model of demand for new dwellings from observed data he explains variation in the number of new dwellings built annually by four variables (average annual money income per family, relative number of vacant appartments, costs due to appartment ownership, and annual increase in the number of families). The ultimate model of demand for new dwellings is obtained by calculating from the resultant linear (semilogarithmic) equation the net regression of new dwellings built in a year on the cost of appartment ownership. VAUX does not develop the corresponding supply model, but shifts the demand curve obtained to the forecast period (according to the assumed trends in demand shifters), and determines the intersection of demand and supply in 1946—55 and 1956—65 on the basis of the estimated price (*op. cit.*, pp. 492—495).

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[1] It is to be noted that Vaux, contrary to most others, presents his models in an explicit form.

Relative
price of
sawnwood,
%

D_i = demand curve
in a given year

L_i = "lower projected demand"
in a given year

M_i = "medium projected demand"
in a given year

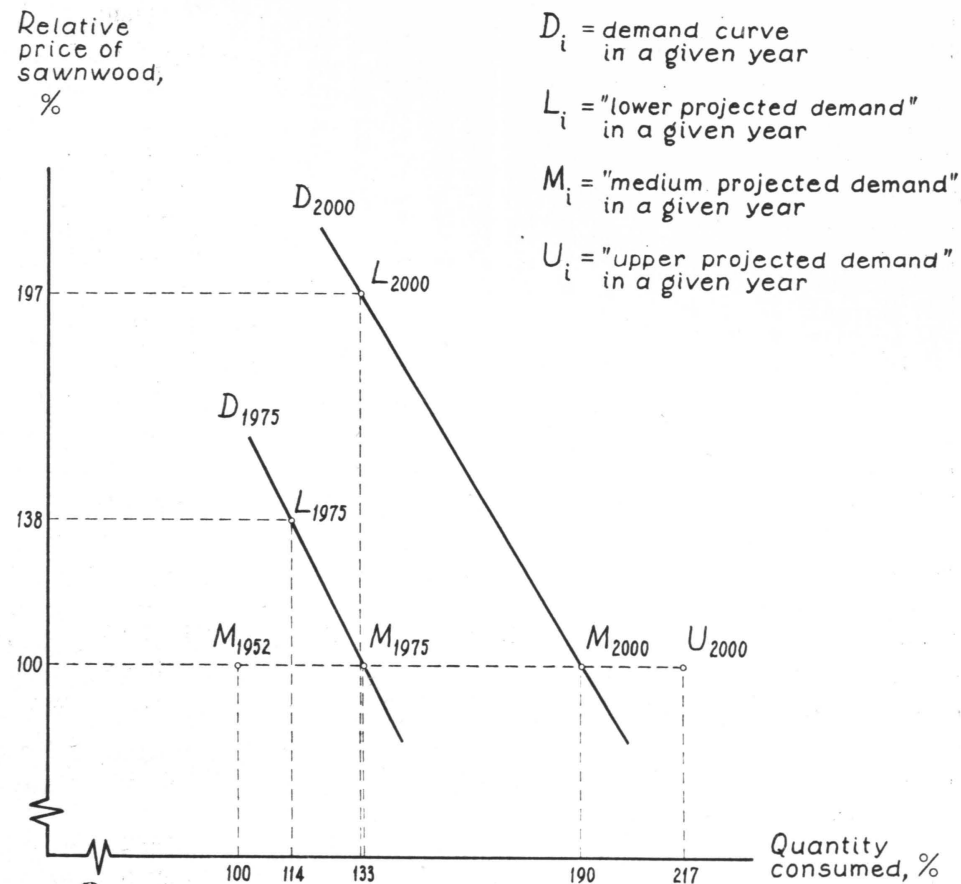U_i = "upper projected demand"
in a given year

Figure 2.

According to the terminology adopted in the introduction to the present study, the forecast developed by VAUX is that of potential consumption. The forecasts describing requirements for new dwelling units are converted into sawnwood requirements on the basis of a thorough analysis of sawnwood quantities used in dwellings of different size.

In another study made by VAUX (1954) a forecast of actual consumption is developed. A model of the consumption of sugar pine (*Pinus lambertiana*) sawnwood is developed from the observation period data (1900—1950). The variables explaining consumption in the linear equation are: stumpage price, the California gross product and the competitive position of California made sawnwood (ratio of the U.S. sawnwood output to the California sawnwood output) (VAUX 1954, p. 22). By substituting the assumed values of the demand shifters in the resultant equation, the demand curve of the observation period is shifted to

the forecast period (2010—2069). In the following step, a potential supply curve (= marginal cost curve) is traced through many stages. The intersection of the demand and supply curves determines (a) the optimum extent of the measures required to make the sugar pine stands produce commercially valuable timber; (b) the cost of the last increment unit of the measures; and (c) the forecast annual consumption (*op. cit.*, p. 39). — It is obvious that the assumption of a perfectly competitive market is implicit in the model used.

VAUX notes explicitly that the outcome of his study will depend essentially on how far the programme assuming the maximization of value added is actually followed. Since it deals with a production goal, it is logical to aim at an economically optimal result.

23. Studies of the United Nations' Specialized Agencies

Since the second World War the specialized agencies of the United Nations, mainly the Food and Agriculture Organization of the United Nations and the United Nations' economic commissions in different parts of the world, have endeavoured to guide the international forest policy. Because of the large reconstruction programs, the scarcity of wood may have been felt most strongly in Europe. This was stressed, for example, in the international timber conference held in Marianske-Lazne, Czechoslovakia in 1947. The shortage of wood was alleviated considerably during the following two years. Thus also the interest of international organizations was transferred from the previous scarcity to the question of whether the »temporary balance» will continue also after lifting the controls on timber market everywhere. Will there still be timber shortage in Europe? What are the trends in the demand for and supply of wood in the coming decade? The Food and Agriculture Organization of the United Nations (FAO) undertook, in co-operation with the United Nations' Economic Commission for Europe (ECE), to provide an answer for these questions.

The study prepared jointly by the above two organizations was published in 1953 (*European Timber Trends* . . . 1953). In terms of the method used it may be considered as a land mark in the field of international timber market study. For the first time the aim is to develop both demand and supply curves under given assumptions. In other words, the idea is rejected that either one of these could be represented by a horizontal line. While in the previous studies one point only was determined along either a demand or a supply curve (otherwise unknown), the FAO/ECE study arrives at two pairs of demand and supply curves, each of which are represented by two points.

European Timber Trends and Prospects gave rise to certain important conclusions. If the economic growth in Europe will continue as assumed in the study, though at a rate somewhat lower than the expansion of industrial production

generally, a relatively much more rapid rise in the consumption of pulp products, and hence in the need for timber of pulping dimensions, was to be expected. Given the application of vigorous forestry measures, timber production could be considerably expanded in the coming decades. Despite these measures, supplementary supplies of timber would be increasingly required, either from the Soviet Union or from North America, or both.

The course selected to balance the European timber economy implied reliance on its own forests rather than on extra-European supplies. This required a series of measures designed to increase supplies while limiting any rise in the relative price of timber which might turn consumers away from wood. These measures were termed »a dynamic forest policy».

FAO and ECE developed forecasts of industrial wood consumption by end uses on alternative assumptions about the relative price of timber and the European gross product. These end use forecasts were finally converted into roundwood equivalents. The demand forecasts for roundwood were based on the following alternatives (*European Timber Trends . . .* 1953, p. 307):

	Consumption million cu.m. without bark, if the European gross product rises by	
	50 per cent	20 per cent
Relative price remains at pre Korean-War level (1950)	237	210
Relative price rises considerably (∼ 25 per cent)	210	186

It can be assumed that the alternatives of relative price of timber representing the same level of European gross product are two points along the same demand curve. The growth of European gross product tends to shift this curve to the right. Thus, in Fig. 3, two demand curves (D_{20} and D_{50}) are obtained depending on whether the European gross product will rise by 20 per cent or 50 per cent. Although the demand curves are otherwise unknown, they are here assumed to continue as straight lines. In Fig. 3 the horizontal axis represents consumption and the vertical axis relative price. The 1950 industrial wood consumption (181 cu.m., solid measure) is taken as 100. Similarly, the relative price in the base period is 100.

The forecasts of the supply of roundwood are based on the same alternative assumptions about trends in the relative price of timber as in the case of demand forecasts:

	Production under	
	base period forest policy	dynamic forest policy
Relative price remains at pre Korean-War level (1950)	157	167
Relative price rises considerably (∼ 25 per cent)	157	201

If the above production figures are interpreted literally, the forest policy followed in the base period would mean a completely inelastic supply until 1960.

This alternative is thus represented by the price axis (S_0) in Fig. 3. Under dynamic forest policy the supply would instead become more elastic (S_{D_2}). FAO and ECE assume timber imports from extra European sources as 10—20 million cu.m. (roundwood) per year. DICKSON (1954, p. 16) has therefore drawn a more logical conclusion about the supply curves. Since it is perhaps reasonable to expect increased imports to Europe as the prices in Europe rise, the supply curve S_{O_1} is drawn in Fig. 3 on the assumption that at price 100 imports equal 167 million cu.m., and at price 125 they are 177 million cu.m. Under dynamic forest policy we obtain the supply curve S_{D_2} (*cf. European Timber Trends . . .* 1953, p. 307).

It is conceivable from Fig. 3 that only under dynamic forest policy is it possible to avoid a considerable rise in the price of timber. Depending on whether the growth of the European gross product is 20 per cent or 50 per cent between the base period and 1960, the rise in the price of timber is 12—21 per cent (the intersection of D_{20} or D_{50} and S_{D_2}).

Since 1960 it has been possible to check the validity of both the assumptions and results of the above FAO/ECE study. We will content ourselves here to state that even many of the minor components of European timber consumption have in the main followed the course delineated in the study. This is all the more true for large aggregates and basic assumptions. However, this is not an all important test for the economic theory envisaged by the model used. Our concern here is the model, and we shall not go into an accuracy analysis. The model is superior to most others applied in analyzing the requirements for forest products.

There are other studies made by international organizations (*World Pulp and Paper . . .* 1954; *Possibilities for the Development . . .* 1954; *Pulp and Paper Prospects . . .* 1955, *etc.*). These are not, however, directly connected with forest policy, at least not with production goals. The majority of these studies rest on the assumption of a horizontal supply curve; they may thus be classified as forecasts of potential consumption.

24. A Model Applicable in Finland

The modern theory of international trade — how it is generated and what is gained from it — is essentially an explanation of the volume of exchange. The importance of neither exports nor imports is emphasized. It is at the same time also an explanation for the balancing of payments and employment. It is widely recognized that national programmes for a certain growth of production assuming full employment can greatly benefit from the developments of the theory of international trade. Attention there is drawn to how increased exports influence national income and the balance of payments. This influence is customarily

Relative price,
per cent of base
period level

125
121

112

100
   87   92   98 100 103   111   116   122   131 Quantity
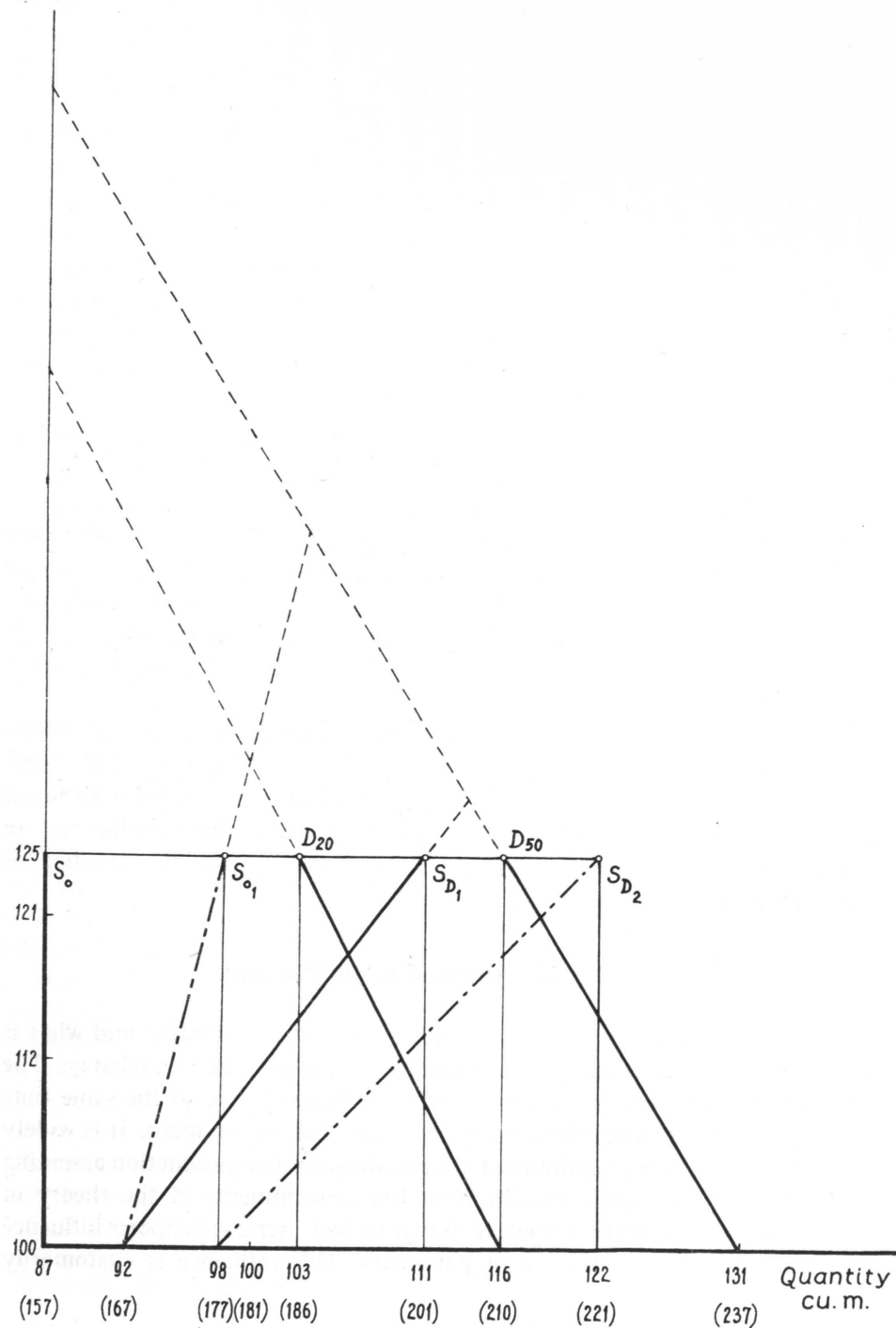 (157)   (167)   (177)(181)(186) (201) (210)   (221)   (237)   cu. m.

Figure 3.

illustrated by the so-called income-spending analysis, which may be summarized as follows.

Suppose that part of the income due to increased exports (Δ_e) is consumed and another part is used to increase imports, while nothing is saved. Denoting the proportion of income due to increased exports, used to increase imports (marginal propensity to import), by P_m, the national income will increase by $1/P_m \cdot \Delta_e$. If still another part of the income derived from increased exports is saved, increased exports are balanced by growing imports and savings assuming that investments are kept constant. The increase in national income then equals $1/(P_m + P_s) \Delta_e$, in which P_s stands for marginal propensity to save. Depending on the phase of business cycle, the increase in national income due to increased exports may result in growing investments and increase imports by an amount larger than the increase in exports (cf. KINDLEBERGER 1953, pp. 154—180).

The old concepts of comparative advantage and reciprocal demand as used in the theory of international trade are still the foundations of the modern explanation. Their unique validity in certain cases may, however, be questioned. Such is the case, for example, in a number of small countries with easily created balance of payment problems. Thus, in Finland, arguments may be presented for more diversified industrial production. An economist could perhaps refute most of these arguments using the old conceptual apparatus of the theory of international trade. The defect of this apparatus, however, is that it is developed as an *ex post* analysis assuming free international exchange of goods and services, free capital and income transfers, and free mobility of labour. The history of international trade presents respectable attempts to eliminate the trade barriers imposed by national boundaries. These attempts have in Europe met with most success as late as the early 1960s. But the balance of payments problem will remain, though somewhat alleviated.

The theory of international trade does not indicate very clearly the motives behind the selection of a national economic policy under circumstances where free trade is not established. Under such circumstances there are still means available to delineate a programme that will maximize the growth of the national product and create full employment. The number of alternative production programmes, though infinite in theory, is in practice rather limited because of several restricting factors. Those responsible for national economic planning in small countries may, after having studied alternative production programmes, find the balance of payments problem decisive in selecting the industries to be expanded. This was the case in Finland in 1960, when the *Economic Planning Committee* published its report (*Talousohjelmakomitean . . .* 1960). It was found that the ratio, to exports, of imports required for a given production for exports (propensity to import production inputs) in the wood industry is about 1/20 and in forestry practically zero. In the metal industry this ratio is about 1/3, in the other manufacturing industries about 1/4, and in the transportation indus-

tries and traffic about 1/5. It is conceivable that, owing to the low propensity to import production inputs in the wood industry, expansion of this industry leads itself to balancing the international payments at a level higher than that of the other industries would do. This was the reason the *Economic Planning Committee* decided to recommend maximizing the growth of the national product by expanding the pulp and paper industry in the first place. By doing so, however, it also defined a production goal for forestry. There is a certain input-output matrix of the national economy as a whole that will maximize the growth of the national product. This matrix gives the inputs that the wood industry requires from forestry in order to produce a certain output. Alternative matrices on the composition of the wood industry can be produced depending on aims. The aim may be the maximization of profit or of some more general welfare concept. For an economist the selection of aims need not be a problem. He may work on the assumption of maximization of profit or value added and leave the problem of income distribution open to debate.

While the above matrices — one to determine the place of the wood industry in the national economy and another one to establish an optimal structure for this industry — guide the decision making in planning economic growth, the ultimate decision on the prospective expansion of the wood industry is usually based on a forestry programme. The question arises then as to what period ought to be chosen during which to reach the economic growth goal. Depending on the legislation in each country the contribution of forestry to this goal may be different. If the situation is similar to that in Finland, forestry can hardly be regarded as a transitory industry. If it were seriously curtailed, such problems would be created as how to pay the imported production inputs required by the other industries. Legislation offers some protection against this kind of situation, but it does not necessarily prevent us from approaching it. Thus, the *Private Forestry Law* of 1928 in Finland does not provide for the relative extent to which mature forests may be cut; it deals with their regeneration only. The selection of an expansion period for the wood industry is subject to other decisions aiming at more general targets. Among these targets is full employment with a maximum growth of the national product.

The *Economic Planning Committee* chose the period 1960—69 during which the national economy should be balanced for the economic growth goal. It did not explicitly indicate the period during which forestry should be adapted to the expansion of the wood industry implied in the program. It did recognize the need for intensified silvicultural measures, but the extent of these measures has only later been determined. It was obviously implicitly assumed that the cost of these measures will not be economically prohibitive. We take the justification of this assumption for granted, although the economies to be obtained from alternative sivilcultural programmes vary within a wide range.

The wood industry in Finland is dependent on a horizontal demand curve, the

price level of which varies with changes in extra-Finnish demand and supply. We do not intend to develop an operational solution for this type of demand function. It is useful, however, to realize that its theoretical consideration is feasible through a moving equilibrium approach (*cf.* VAUX and ZIVNUSKA 1952). Thus in the case of demand for Finnish wood industry products we have to recognize the shifts in demand due both to demand shifters proper which change with time (income, *etc.*), and changes in consumption habits brought about by price increases as a result of scarcity of supply in relation to potential requirements. Neither the form of the demand curve, nor the relative scarcity of wood in the world can be appreciably affected by the Finnish supply. This is true despite the fact that the allowable cut in the Finnish forests need not be curtailed, but can even be raised, in order to increase the allowable cut permanently in the future (see KUUSELA 1959, HEIKURAINEN *et. al.* 1960; KUUSELA and NYYSSÖNEN 1962).

In view of the above considerations, it is the long range view of the world market for wood industry products that must serve as a basis for the forestry programmes in Finland, on the one hand.

On the other hand, the supply of wood industry products depends on the demand-supply relations of round timber. The expansion of pulp and paper industry in Finland in 1960s may result in a shift of the wood industry's demand curve for round timber so as to cause a drastic rise in its price. Rising stumpage prices in turn, assuming constant techniques, will raise the costs in the wood industry, thus affecting its supply curve. Since it is a long range perspective in forestry to expect intensified silviculture and increased timber volumes as a result of enhanced stumpage prices, not least because of the joint nature of agriculture and forestry, the wood industry may have to be prepared to pay higher stumpage prices in the future. However, if these are not justified by the long-run production costs of the wood industry, the demand for round timber will adjust the stumpage prices at a level that the industry can afford.

The operational difficulty of a production goal analysis has obviously turned the attention of foresters away from the economics of the expanding wood industries and of intensified forestry. The gap thus left may be filled with mensurational data, but these do not tell much about the economies gained or lost depending on the programme chosen. Although an economist should in the main be interested in economic implications, social and political aspects often dominate the treatment of basically economic topics. True, the implications of a decision based on an economic analysis may call for a subsequent analysis of the social behaviour of forest owners, *etc.*, but this is not the primary consideration. It is a secondary analysis that may or may not suggest a revision of the decision on the forestry and wood industry policy chosen, yet knowing the possible deviation from a programme that is economically optimal, *a priori*.

It is not possible here to develop an operational approach for the economics

of the Finnish wood industries and forestry. However, it is obvious that, in addition to the moving equilibrium type of demand analysis mentioned above, a supply analysis of wood industry products based on an analysis of demand for and supply of round timber ought to be carried out. In other words, a model explaining jointly economics of the wood industry and forestry is needed to establish a production goal for either one of these or both.

25. Other Studies

It is possible to examine in this study only a part of the studies on timber consumption prospects. Most of these studies have been made in the United States or in international organizations, but there are also other attempts in this field.

STREYFFERT (1957) has published an investigation into the timber prospects in the world. He uses data obtained from previous FAO/ECE, *etc.*, studies, but tries to fit these into a new model. The economic theory employed by STREYF-FERT (*op. cit.*, p. 105) is in the main the following: There will be enough forest products available in response to the demand for them with no rise in their price relative to competing materials, or with any other factors making timber more expensive and more difficult to use under the assumptions specified. Price of timber relative to that of competing materials is left out of consideration in the belief that an important source of uncertainty is thus eliminated (*op. cit.*, p. 74). The model adopted therefore does not basically differ from those used in certain previous studies referred to above (*Potential Requirements . . .* 1946, *etc.*): the forecast refers to the amount of timber that would be consumed in the future assuming that the relative price of timber will remain at its base period level. — It is advisable to simplify a model as much as possible, unless objections for this are raised by criteria other than simplicity. In this particular case the simplification by rejecting the relative price as an explanatory variable may have caused an economic contradiction in assuming implicitly that any quantity can be produced at the same unit price.

In a study on the future prospects of the Canadian forest industries (*The Outlook . . .* 1957) the model of forecasting timber consumption varies in different end uses, and it cannot be traced in detail from the above study. It can be inferred, however, that a forecast of potential consumption is developed, with a subsequent check against factors determining supply. The most important explanatory variable is the gross national product, while the relative price of timber is assumed to remain at its base period level.

3. Economics of Production Goal

31. General Theoretical Aspects

The brief review of the models implicit in the above studies suggests a division of them into two categories with respect to their purpose. Some of them aim at analysing the long run production goal of forestry in a given area. Others would seem to deal with future timber consumption with no explicit recognition of an (economic) production goal, although it is hardly merely a pedestrian interest in consumption habits that has initiated these studies.

On the other hand, the goal often means simply a quantity of timber to be produced, with no consideration of its economic implications. A production goal has seldom been conditioned by economic advance requirements for the model underlying forecasts.

On the following pages, an endeavour will be made to throw light upon the economic theory required as a basis for a forecast model used in a production goal analysis.

By production goal as used here is meant the quantity of timber, with appropriate quantitative weights, that ought to be produced to satisfy the timber requirements of a given region in a future period. In the daily usage requirements is a subjective concept that does not give a hint for its closer study, nor does it lend itself for determination. The term timber requirements in this study refers to the quantity of timber desired to be brought into consumption, under certain assumptions, from the forests of the region being considered (*cf.* RIIHINEN 1958, p. 137).

In selecting the theory required as a basis for a production goal analysis, it is advisable to recall the function of theory in general and, on the other hand, its function in this particular case. By theory, in the general sense, is meant an established invariable allowing for random exceptions, expressed mathematically, in graphs or in words. It is customary to call such invariables models. The more completely a theory envisaged by a model describes or explains the phenomenon being studied in the light of certain criteria, the better it is. Additional criteria for a model are simplicity and universality (relatively speaking).

Although a theory should in the first place describe phenomena as they exist in nature, restrictions may be imposed on it in certain cases. When the behaviour of the entrepreneurs is described in economics, it is in general assumed that this behaviour is rational, which means that one of the aims of the activity is the maximization of profit. This rationality postulate is not fully shared by economists; not, at least regarding the short term price decisions of the enterprices (*cf.* PAAKKANEN 1957). The belief in profit maximization is crystallized in the marginalistic price theory. The differing opinions about its validity may in several cases arise from a narrow and static interpretation of the marginalistic

theory or its substitute, the full-cost principle, without realizing the connecting points that the different theories may have in a case-by-case examination. PAAKKANEN (1957, p. 64) states to this effect that the above pricing principles are not contradictory if account is taken of time as a pricing factor.

Once the decision has been made on economic, political and/or strategic grounds as to what needs forestry in a given region should serve, these needs — more appropriately termed requirements — must be measured. It would seem rational to aim at a requirements concept that will *a priori* maximize the total net revenue from forestry in a given period under the advance restrictions imposed. The problem is then different from that of examining the behaviour of entrepreneurs in respect to their price decisions. The interest is not so much in the actual behaviour, but in how this behaviour should be in order to achieve an optimal economic result. The goal is not necessarily set for one enterprise, but for a larger group of these — most often for a section of the national economy: forestry and the wood industries. It is not determined in the belief that those dealing with forestry and forest products behave as a group with a view to maximizing the profit from forestry in the region being considered, but in trying to point out the programme with which an optimal result may be achieved, if our theory of the above behaviour is founded well enough. The forecast manifesting this programme is based on the best estimate of the relationship between the factors that explain variations in timber consumption in the observation period.

An economic goal once set is pursued using the instruments of forest policy at the disposal of each country or region. Deviations from the economically optimal goal — if this is known — occur consciously or unconsciously. Conscious deviations may often be caused by social factors that must be taken into consideration at the expense of economic factors. The model originally based on profit maximization in forestry does not, however, thus lose its significance either in explaining timber consumption or in aiming at the goal. Even so it serves as a guide to a relevant description of the consumption of forest products. The forecast based on the model provides a bench mark from which deviations from a desirable economic goal can be measured.

Production goals in forestry (the quantity of timber, with appropriate quantitative weights[1], to be used in a future period) have been defined in several ways. These definitions reflect the model followed in determining future wood requirements. The models used in certain forecasts were abstracted briefly above. It is conceivable that there are studies (MASON and BRUCE 1931; *Potential Requirements* . . . 1946; *Timber Resources* . . . 1958) which determine the potential consumption of timber in certain future periods. SHAMES' study (1946) belongs

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[1] It is assumed that the volume of forest products required is computed with the aid of actual weights for the different end uses (*cf.* pp. 36—37, below).

to the same category, although its method is different. *World Pulp and Paper* . . . (1954), STREYFFERT's study (1957), *Paper for Printing Today* . . . (1952), *Paper for Printing and* . . . (1954), *etc.* are also, despite slight differences in the method, forecasts of potential consumption. On the other hand, there are studies, such as *European Timber Trends* . . . (1953) and the study by VAUX (1954), which with regard to their economic models are forecasts of actual consumption (*cf.* p. 7, above).

It may be worth while to note here that studies with two different types of models have been taken as forecasts of potential consumption. In both of these types supply is assumed »sufficient», *i.e.* technical supply conditions do not prejudice the consumption obtained from the analysis of demand for forest products. »Sufficiency» is, however, then an ambiguous concept. In some of the studies it implies that the price of timber in relation to the prices of competing materials remains at its base period level; in others it carries the implication that future price has been determined by projecting the base period price to the forecast period without tracing the supply schedule proper. On the other hand, price has sometimes referred to the price of a given forest product as measured by the »general price level». The assumption of an unchanged price may have been implicit in a procedure in which potential consumption has been determined on the basis of the statistical relationship between the base period consumption and one or more demand shifters. All of the studies reviewed above deal with the base period price level, regardless of whether they refer to an absolute price or a relative price understood in different ways. Where the price concept is chosen to be the constant price deflated by the »general price level» the aim is to obtain a price representing the purchasing power prevalent in the base period.

The above conceptual differences in price are not necessarily instrumental to the justification of different price notions. Instead, they do determine the economic significance of a study insofar as this is intended to serve as a basis for policy decisions. More often than not practical advantages are obtained by selecting a certain price concept, but this does not always coincide with the theoretical ideals suggested by aims.

Another theoretical aspect calling for attention is the fact that most of the models underlying forecasts are based on a static[1] theory of demand and supply, accompanied by an implicit assumption of perfect competition. It is apparent that the international market is highly imperfectly competitive and therefore does not easily lend itself to description by static models. Time lags are present not only in international, but also in interregional trade. Price formation does not follow the pattern of free play of demand and supply. On the contrary, the price of forest products is often a predetermined variable — fixed in negotiations between the parties concerned, *etc.* Many other imperfections could be cited.

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[1] »Static» in this study refers to the fact that the variables in the model are entered without time lags, *i.e.* the variables refer to the same period.

The models adopted often may, or may not, be justified by the aggregate nature of the variables used: they represent average economic behaviour within a wide range of circumstances, and the weighting system used largely determines the success or failure of the analysis based on these variables. Also, the predominance of long term influences among the objects of most studies performed to date may render a decision making model unnecessary. At the same time, however, it means partial omission of theoretical foundations. An analysis of decision making is based on explicit assumptions about the type of competition present in the market being studied and it therefore guides the research worker to the adoption of a dynamic model (cf. RIIHINEN 1962). However, we shall find out later in this study that dynamic features can be included in a model also by a seemingly static analysis. An example of this is the so-called moving equilibrium analysis where it is assumed that demand and supply move constantly from one equilibrium to another.

32. Long Run Competitive Equilibrium

There cannot be any stereotyped prescription for the model of a production goal analysis. It may be inferred, however, that, for example, in the United States the market for forest products is more perfectly competitive than in the European countries. Hence a static type of analysis based on a competitive long-run equilibrium of demand and supply, modified in accordance with the dynamic requirements for the underlying model, may satisfactorily comply with the requisite economic theory. Yet it must be admitted that no empirical production goal analysis to date has been based on fully adequate economic foundations. This is perhaps due mainly to the lack of data on some of the relevant variables. The economic-theoretical framework of a forest production goal analysis under the assumption of a perfectly competitive market has been analysed by VAUX and ZIVNUSKA (1952). The paper produced by them on the subject is helpful in evaluating the adequacy of the models used in a number of subsequent studies all over the world (cf. RIIHINEN 1958).

To be economically significant, the analysis of a forest production goal characteristic of a competitive long-run equilibrium [1], must be based on an analysis of both demand and supply. The quantitative production goal thus is a forecast of actual consumption (cf. p. 7, above). However, its determination must recognize the dynamic features of the problem. Thus the first approximation of the goal on a merely static basis does not suffice, although it formally corresponds to a long-run equilibrium situation. In fact, it is hardly any better than a forecast of potential consumption which assumes sufficient supply (cf. p. 7, above). »Sufficiency» implicit in the forecast of actual consumption does comply with the

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[1] It is assumed that the reader is familiar with the concept of competitive long-run equilibrium with all its economic implications which are expounded in several textbooks of economics.

rationality postulate; it refers to the situation where marginal revenue equals marginal cost and average revenue equals average cost. Dynamic requirements can be complied with in an analysis expounded by VAUX and ZIVNUSKA (1952). A series of demand approximations are called for by the fact that relative scarcity of wood may appear before reaching a timber growth goal. This scarcity and the subsequent rise in forest products' prices may turn consumers away from wood; partly temporarily and partly permanently, if preferences change. Hence an optimal production goal and the adjustment period during which the goal is reached cannot be fixed *a priori* without considering the interplay of demand and supply in the adjustment period. In other words, demand for wood in any one period depends on the demand in the previous period. Similarly, the supply functions in consecutive periods are interrelated.

The programme adopted in developing forest resources is of central importance in determining the production goal by the above moving equilibrium approach. The concept of allowable cut has for long been the mensurational tool used in implementing a certain programme. Its determination was recently simplified by the adoption of the »corrected Austrian formula» for this purpose (KUUSELA 1959). Several allowable cut calculations have been performed since (HEIKURAINEN et. al. 1960, etc.).

It now seems that the absolute cut need not necessarily be lowered in order to reach a given growth goal. The age class distribution of the forests and the forest improvements assumed largely determine the cutting programme to be followed in the timber economy being balanced for the production goal. Still the technical supply conditions in the adjustment period may be scarce in relation to demand, thus causing price-induced substitution for wood.

33. A Dynamic Approach with a Particular Reference to the United States

The above static approach of reasoning out a dynamic model is logical in that it pays explicit attention to the economic incentives of forest management and recognizes the dynamic element present in the determination of a production goal. Yet we may consider a somewhat more operational approach to the same problem. We do not necessarily aim at empirical applicability, but rather to point out which time series, or their substitutes, are required in order to estimate the parameters of the model to be developed. Even so, we do not imply that the variables to be included in the forthcoming model will provide a nearly perfect explanation if measured, *e.g.* by the coefficient of multiple correlation. This is not an essential aim in a policy model; it is essential to indicate the variables that are likely to be most significant in designing an economically optimal forestry program. Also, it is not suggested that the model can be applied to a cross-section

analysis, *e.g.* to explaining regional differences in timber consumption. We assume for simplicity that the model points out theoretical relationships between variables in a closed economy. In an application there are practical ways of including in the analysis a relatively little foreign trade in forest products. One way of doing this is to substitute in the last equation either net imports or net exports in a previous period, as the case may be. The cutting decision will in any case depend in part on previous experience on the foreign trade in forest products.

To give more content to the model we may recall the circumstances in which such a model is required. — In such countries as the United States, where reforestation has not been an attractive object for private business, wood easily becomes so scarce as to lose ground to competitive materials. To avoid this situation, and to maintain a safe position in the availability of strategic materials, there is a need for planned timber production. The planning usually starts when serious inroads have developed in the forest resources and the timber-based industries continue to expand. It is then obvious that, as a long term influence, the scarcity of growing stock is reflected in stumpage prices, while changes in the costs of logging, transport and manufacturing also affect them. The amount of exploitable growing stock in any period is affected by the pre-existing growing stock, previous cuttings, and amounts of money expended in reforestation and improvements. Finally, the quantity demanded depends on the stumpage price level in relation to prices of competitive materials and the disposable income of the public.

We may recall at this point the difficulty of providing a universally applicable model for a forest production goal. Not only universality, but also an operational solution for a particular case is considered almost insurmountable. Thus DUERR (1960, pp. 527, 537) points out this difficulty, but leaves »the hunting season open».

Some of the variables in the model describing the above course of events are likely to have lags distributed over a long span of time, perhaps a few decades. Hence it is not easy to provide enough degrees of freedom. We have to recognize this difficulty, although in an application it is possible to reduce the number of lags. Even as a mere specification, if this is logical enough, the model will tell something about the policy measures necessary to achieve certain aims. The estimation techniques in the case of distributed lags are complicated, but these have been expounded by several econometricians (see *e.g.* KLEIN 1958).

In order to comply with certain estimation criteria (see *e.g.* RIIHINEN 1962, pp. 14—16), the model may be written in the form of the following three equations.

$$S_\tau = f_0\ (S_{\tau-1}, S_{\tau-2}, \ldots, S_{\tau-g}, Q_{t-1}, Q_{t-2}, \ldots, Q_{t-k}, I'_{t-1}, I'_{t-2}, \ldots, I'_{t-l}, T);$$

$$P_t = f_1\ (S_\tau, C_{t-1}, T);$$

$$Q_t = f_2\ (P_t, Y_{t-1}, Y_{t-2}, \ldots, Y_{t-m}, T);$$

where
S_τ = growing stock per inhabitant at the point of time τ in the year t;

P_t = stumpage price in relation to the prices of competitive materials in the year t with appropriate quantitative weights;

Q_t = quantity of timber cut in the year t;

I'_{t-1} = marginal propensity to expend in reforestation and improvements in the year $t-1$ ($= \Delta I : \Delta R$, where I = expenditure in reforestation and improvements, R = forestry revenue);

C_{t-1} = cost of logging, transport and manufacturing in the year $t-1$, with appropriate quantitative weights;

Y_{t-1} = real disposable income per inhabitant in the year $t-1$;

T = time;

g, k, l and m = maximum lags to be determined separately in each case [in accordance with the principle followed in (A) and (B), below].

It may be illustrated by way of an example how the model presented above can be developed towards an application. We take the first equation to transform it into a more explicit form. Certain assumptions must then be made about the form of function. There are two possible alternatives that can be considered as feasible approximations for the first equation. These are given by (A) and (B) below; they represent linear relationships in absolute and relative terms, respectively.

(A)
$$S_\tau = c + \sum_{g=1}^{n} \alpha_g\, S_{\tau-g} + \sum_{k=1}^{n} \beta_k\, Q_{t-k} + \sum_{l=1}^{n} \gamma_l\, I_{t-1} + \zeta\, T + u;$$

(B)
$$S_\tau = 10^c \cdot \prod_{g=1}^{n} S_{\tau-g}^{\alpha_g} \cdot \prod_{k-1}^{n} Q_{t-k}^{\beta_k} \cdot \prod_{l-1}^{n} I_{t-1}^{\gamma_l} \cdot 10^{\zeta T} \cdot 10^u.$$

In (A) and (B), c = a constant;

ζ = the secular time influence in S_τ corresponding to a unit change in T;

u = a random variable;

α_g, β_k, and γ_l = long term elasticities; these are obtained as sums of the corresponding short term elasticities, for example:

$$\sum_{g=1}^{n} \alpha_g\, S_{\tau-g} = \alpha_1\, S_{\tau-1} + \alpha_2\, S_{\tau-2} + \ldots + \alpha_\delta\, S_{\tau-\delta} + \lambda\, \alpha_\delta\, S_{\tau-\delta-1}$$

$$+ \lambda^2 \alpha_\delta\, S_{\tau-\delta-2} + \ldots + \lambda^\nu \alpha_\delta\, S_{\tau-\delta-\nu}$$

$$(\alpha_g = \alpha_g,\ g = \leqq \delta)$$

$$\alpha_g = \underline{\lambda^\mu\, \alpha_{g-\mu}},\ g = \mu + \delta > \delta$$

$$\lambda^\mu\, \alpha_\delta$$

$$\alpha_g = \lambda^\mu\, \alpha_\delta, \text{ when } g = \mu + \delta > \delta$$

$$\lambda = \leqq \lambda < 1.$$

The determination of α_g, β_k, and γ_l is based on KOYCK's (1954) findings about the time shape of economic reactions. He has developed an approximation method for these reactions. The validity of his approach lies in the assumption that the lagged influence of the variables converges from a certain lag on as a geometric series. Thus a series of coefficients α_g ($g = 1, 2, 3, \ldots, n$) from a certain index $g = r$ onwards can be approximated by $\alpha_{r+p} = \lambda\alpha_{r+p-1}$, where $p \geq 0$ and $0 \leq \lambda < 1$ (KOYCK 1954, p. 20).

The only valid method of finding out which of (A) and (B) provides a better fit is to try them out in empirical data. However, common-sense reasoning suggests here that relative changes rather than absolute in the variables be associated with each other. It is a matter of application and need not be discussed further in this context.

To interpret equation (B), above, we find that the parameter α_g shows the aggregate percentage increase due to all g lags of $S_{\tau-g}$ in respect of S_τ. More specifically, $\alpha_{\tau-1}$ shows the percentage change in S_τ due to one-per-cent change in $S_{\tau-1}$; $\alpha_{\tau-2}$ another percentage change in S_τ due to one-per-cent change in $S_{\tau-2}$, etc.

$S_{\tau-g}$ may be interpreted in terms of economics as a natural production capacity of the forests, gradually diminishing in importance as the length of the lag increases. Q_{t-k}, in turn, refers to changes in this production capacity brought about by man in previous periods; the time shape of this reaction follows the same logic as that of $S_{\tau-g}$. I_{t-1} is simply another variable representing a different aspect of changes in the production capacity, with similarly interpreted lagged influences on the current production capacity.

Since the model presented above is of a recursive type, its parameters can be estimated by the method of least squares consistently and efficiently, one equation at a time. Recursiveness means that there are no simultaneous influences between any pair of variables. One non-lagged endogenous variable at a time is added to the system while advancing from the first equation towards the last. The system comprises a causal chain, has the above advantage in statistical estimation, and is well suited to programming by means of normative forecasts.

This model is not to be taken as a universal generalization. It is assumed that in the long-term planning of forestry the cyclical fluctuations in the endogenous variables may be overlooked in the model, while the secular trend in them is accounted for by time (T). This means that no separate variable is needed to explain cyclical fluctuations. To some extent, these are accounted for by some of the variables actually included, especially as these appear with distributed lags.

In an open economy with a large international trade in forest products (as compared with domestic requirements) the model is not applicable. For a country like Finland the demand curve for forest products in the long run may be taken as a horizontal line (see RIIHINEN 1958, p. 140). One may then consider

that only a cost curve is needed to determine the most desirable production goal as the intersection of demand and potential supply (marginal cost curve, competitive profit included). However, before these two lines intersect the problem of resource allocation arises, *i.e.* alternative fields of production enter the producers' preference function.

It is perhaps still necessary to draw attention to the fact that the United States as a whole does not represent a homogenous distribution of circumstances. The conditions of timber production differ sharply from each other in different parts of the country. Hence, a special weighting system must be assumed in adding up regional variables into national aggregates. In the above model, we assume that due account is taken of all sources of heterogeneity in the data concerned. It was for this purpose that we added to the definition of some of the variables »with appropriate quantitative weights». We shall later (pp. 36—37, below) review the possibility for developing a practical method of assembling data for analyses of this nature.

We recognize that the above system may require further elaboration if applied. Thus the choice of time unit needs careful consideration. The same regards the selection of additional variables describing short term variations in the amount of timber cut, if this is desirable. Such as it is, it illustrates the theoretical principles on which an approach to the production goal can be based. Account is taken of the fact that a production goal is largely determined by the forestry program assumed for the period during which the desired production goal is achieved. Therefore, contrary to what may often be assumed, growing stock is here regarded as an endogenous variable. This is quite logical if we recognize the dual nature of the growing stock as both the production capital and the product. Assuming sustained yield management, none of these remains unaffected by considerations regarding the level of production in the long run.

No separate variable is included in the above model to account for substitution effects. In principle, this is possible by substituting into the model prices of competitive materials. Statistically this is seldom possible because of multicollinearity, lack of degrees of freedom, *etc.* Therefore, recourse may be had to the customary procedure of deflating all the monetary variables by the »general price level» which approximates changes in the prices of competitive materials and in all other prices that may enter the consumers' preference function. A suitable deflator in this case would seem to be the price index of net national product (see RIIHINEN 1962, p. 31), which is computed with changing quantity weights.

The implications to forest policy of the above model are logical. It suggests that cuttings and forestry investments are the principal long range tools in implementing forest policy. Instead, it does not indicate how the propensity to expend in regeneration and improvements can be increased except by raising the real disposable income — thus creating a larger residual item after deducting

from income the consumption expenditure and retained savings. Propensity to expend in reforestation and improvements cannot be raised by increasing the cut because it is a relative measure of expenditure. In countries like Finland, where forestry has an important position in the national economy, there is a relationship between income level, the ratio to general price level of stumpage prices and the amount of timber cut [1]. In business cycles this may be the case in many well developed national economies, but its explanation need not be attempted in a long run model. Of course, it is possible by including in the model a special business cycle variable (cf. NIITAMO 1958, p. 99; RIIHINEN 1962, p. 30). To some extent, an explanation of business cycles is provided by some of the explanatory variables actually included (Y_{t-1}, C_{t-1}, P_t).

Expediture in reforestation and improvements can be increased by certain policy measures of an institutional nature. These measures are usually based on legislation and may include subsidies to forest owners, legal obligations regarding regeneration and forest improvements, etc. Although their position in national economic policy may be reasoned by economic analysis, their implementation is a political problem. In this study we are concerned only with the economic aspects of forest policy.

Finally, we must still emphasize the practical difficulty of applying the above model. With the present statistical data, it may be considered as a final refutable hypothesis — verifiable only in principle. However, it has significance as a mere specification in depicting the economic content of the dynamic theory and the most essential forest-economic variables involved.

4. Relationship with the Goals Suggested by Certain Business Economists

Since the setting of goal as understood in this study may be confused with the traditional Central European goal setting (*Zielsetzung*), it is advisable to throw light upon the relationship between these two concepts. — The concept of goal setting in forestry was dealt with already by the old German forest economists. While sustained yield was recognized as a principle in implementing national forest policy, there did not seem to be a method of aggregating the goals for individual management units into a national goal. Or else the national goal may have been simply the sum of the goals for management units which *a priori* functioned with maximum profitability — from this moment to eternity, as suggested by Faustman's formula or its elaborations. This is in fact the salient feature in the German concept of sustained yield (*Nachhaltigkeit*). The goal

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[1] It has been shown that total exports, about 80 per cent of which consist of forest products, are the principal factor responsible for business cycles in Finland (see *e.g.* HALME 1955; NIITAMO 1958; RIIHINEN 1962).

setting procedure itself in the old German, and in the more recent Anglo-Saxon, thinking takes place at different institutional levels. On the other hand, forest policy measures are supposed to reach all institutional levels — from an individual forest owner to their national aggregates.

The setting of a goal as understood by the old German school was a special group of tasks in the business economics of forestry. Essential problems of goal setting (selection of rotation, felling maturity, *etc.*) were dealt with in forest management and valuation. However, the complex of problems characteristic to goal setting was most appropriately referred to forest statics which, by means of pre-calculated return rates, strives towards maximum profitability. Forest statics, however, was not a special subject in the economics of forestry, but a branch of business management. In fact, forest statics was just an addition to forest valuation, which tried to solve some of the fundamental problems of goal setting by mathematical methods. This manifests itself most clearly in the use of Faustman's formula employed in assessing the land expectation value — *i.e.* in an »ever-lasting» maximum net return for a stand or management unit (see *e.g.* ENDRES 1911, p. 182; DIETERICH 1941, p. 151).

DIETERICH'S (1941, pp. 156—158) criticism against forest statics in goal setting is concentrated in his argument that forest statics deals merely with methods of calculation; management techniques used should, in his opinion, be considered in the calculations. He does not, however, seem to assume that alternative techniques should be considered in the sense of a marginal analysis in determining an optimum goal. There is perhaps some confusion between long and short run analyses.

Considering the purely economic principles in the methods of setting a goal as suggested by the advocates of forest statics on the one hand, and by DIETERICH on the other, certain fundamental principles are of interest. They seem to regard forestry as an aim in itself. Profitability calculations are made from the standpoint of the forest and not the forest owner, although it is the owner's preferences that ought to viewed in the light of the calculations. The forest owner, after all, sets the goal for his forestry. The task of the economist is to assist in evaluating alternative goals and in avoiding inconsistency between aims and means.

DIETERICH (1941, p. 197) does not recommend money as a measure of economic values in goal setting because it brings about a considerable uncertainty factor in the calculations. However, it is difficult to see how the absence of price could increase reliability, there being no other common denominator for magnitudes expressed in different units of measurement. The classification of different aspects of goal setting (DIETERICH 1941, p. 187) does not relieve this difficulty unless we are willing to set a goal on an entirely conventional basis. Any economic goal must be measured in monetary units because it is the only measure of economic values. This can be done most conveniently in terms of the purchasing power of money in a given base period.
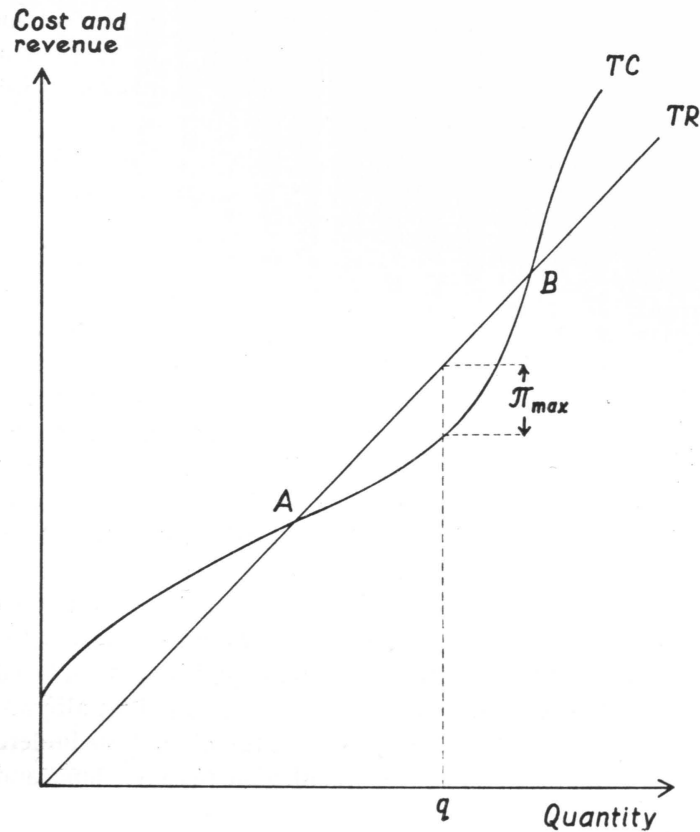
Figure 4.

The use of mathematical formulas such as Faustman's is a rather cumbersome way of approaching maximum profitability. While an economist would prefer to do this employing the classical concepts of marginal cost and marginal revenue, certain serious difficulties arise as soon as the calculations are extended over a long span of time. The purely methodical differences in these two major approaches may be illustrated with reference to Fig. 4.

In both of the methods the aim is to determine the output (q) which maximizes the profit (π_{max}) *a priori*. In order to do this using Faustman's formula or similar means, we would have to perform enough calculations to enable us to map out, in adequate detail, the area between the two intersections (A and B) of the total revenue (TR) and total cost (TC) curves. (Total revenue is here represented by a rising straight line corresponding to a horizontal demand curve.)

While Fig. 4 was drawn in terms of total revenue and total costs, with a view to illustrating the relationship between the different methods, it is perhaps more

convenient to work with the corresponding marginal concepts, marginal revenue and marginal cost. The intersection of these determines the desired output. Marginal revenue coincides with average revenue where the latter is represented by a horizontal straight line.

In both of the methods one is bound to deal with revenue and cost items generated at different times. These are not commensurate without a discount procedure, although we may be interested in a proper sequence of different alternatives rather than absolute expexted net returns.

5. Concluding Remarks

There are two types of economic models according to their purpose. One type can be used for explaining or forecasting the consumers' behaviour with no intension to affect the economies to be gained from the alternative patterns of behaviour explained. Others are meant to serve as guideposts which by means of normative forecasts point out the programme to be followed in order to attain certain aims. The former may be referred to as marketing models, while the latter are called policy models. Forestry offers a good deal of room for economic-theoretical development to find the means by which the welfare function of all concerned can be maximized.

A majority of the policy models used in forestry are static. These are of considerable value in designing policy measures, but they do not lend themselves easily to determining a production goal. Forests are a renewable resource which makes it necessary for the economist to consider several dynamic alternatives in changing the supply conditions. These, in turn, affect demand through price changes. Changes in demand are in part permanent as a result of altered preferences and the consequent adoption of substitutes; in part they are also price-induced, but temporary, following the pattern of a slowly moving cobweb phenomenon. A dynamic model can, at least in principle, be used to explain the course of events during the adjustment period required to achieve a production goal.

Forestry is often referred to as a special field of production (*cf.* SAARI 1928) in which the application of classical economic models meets with difficulty. It is special in the sense that the production plant and the product are practically the same, the period of production is long, and many of the values in forestry are not determined by the market (*cf.* DUERR and VAUX 1953, pp. 17—18). The market for forest products represents a wide variety of degrees of competition, complicating the theoretical framework to be analysed before specifying a model. Most often the competition aspects suggest the adoption of a dynamic model which is based on the temporal sequence of decisions made in the economy concerned. In a model which is supposed to explain long term influences in the

first place, the determination of lags is a special problem. The same regards the choice of time unit in general so that it is long enough to account for certain slow movements of forestry phenomena, but not so long as to make it impossible to provide enough degrees of freedom.

A rational measurement of both physical and monetary magnitudes in forestry also encounters a high degree of difficulty. It has not been able, to date, to control the flow of goods, money and services with such a precision as to enable a continuous enumeration of changes in the growing stock and other relevant variables to be effected. The only exception to this rule is the so-called control method of GURNAUD and BIOLLEY, used in Switzerland. Continuous forest inventories, or those repeated with short enough intervals, are carried out in few countries. And a high degree of precision is required for the observations to reveal significant periodic differences in solving the parameters for a production goal model. Very few countries have been able to gauge the total removals in such a way that timber volumes cut in different periods are not confused. Similarly, the composition of the removal by diameter classes is unknown, thus making it necessary for one to work on random assumptions about the diameter distribution in both the removal and the remaining growing stock.

The magnitudes of investments in forestry are not easily available from statistics, if at all. There is always some improvement work done by the forest owner that never comes into the statistics. Moreover, even if they were available, they cannot be used as such. They include a large quantity of wages and salaries which have changed with time. A rather complicated computation procedure is required to construct a critical indicator of the amount of investments. It would be desirable here, as well as in respect to other variables in forestry, to develop a practical method of assembling data for a volume index to be computed with changing quantity weights. All indexes computed with constant weights in forestry are likely to lose much of their significance because of the strong variation of the quantity, prices, composition, and area of origin of the timber cut each year.

It is conceivable that in forestry, indices computed with constant weights lead to situations in which economic and physical volumes are incompatible in the light of what is otherwise known about trends in prices (or costs) and quantities. Thus it may be difficult to deduce whether a change in an index is due to changes in prices or in quantities of different timber assortments, etc. This handicap may be overcome by computing sub-indices with a fairly constant composition and adding these up with their percentage shares of the main index as weights.

A suitable starting point for developing appropriate index series in forestry is the Divisia-Törnqvist price index used by TÖRNQVIST (1955) to study trends in tariffs and economy of the Finnish Post and Telegraph Office. The same index is employed by the Finnish State Railway in describing trends in the price of costs (FRANSSILA 1960, p. 280). This index is determined by the following formula:

$$\log P_{v+1} - \log P_v = \frac{\sum\limits_{i} c_{i,v,v+1}(\log p_{i,v+1} - \log p_{i,v})}{\sum\limits_{i} c_{i,v,v+1}}$$

in which P_v = value of the group index in period v;

P_{v+1} = value of the group index in period $v+1$;

$p_{i,v}$ and $p_{i,v+1}$ = values of the subindices corresponding to the above group indices;

$c_{i,v,v+1}$ = weight measuring the importance of subindex i at the moment of the change.

The subindices can be computed according to e.g. Laspeyres' index formula.

The group index computed as indicated above can be used in decomposing value series assembled as such into their components (quantity and price).

The provision of data for testing economic models in forestry is still poorly developed. However, statistics are likely to develop once the necessity of certain series will have been proved by theoretical enquiries.

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SELOSTUS:

METSÄPOLIITTISTEN OHJELMIEN PERUSTANA OLEVAT TALOUDELLISET MALLIT

TUTKIMUS PÄÄMÄÄRISTÄ JA KEINOISTA

Tässä tutkimuksessa analysoidaan metsäpoliittisten päätösten perustaksi kehitettyjä taloudellisia malleja. Ensin abstrahoidaan eräissä tutkimuksissa käytetyt staattiset mallit ja tarkastellaan, missä määrin nämä soveltuvat tarkoituksiinsa. Erikseen tarkastellaan tuotannon tavoitetta selvittäviä taloudellisia malleja, joista komparatiivisen statiikan keinoin on Yhdysvalloissa pyritty kehittämään kysynnän ja tarjonnan pitkäjänteiseen kilpailutasapainoon perustuvaa, dynaamisuuden vaatimukset täyttävää mallia. Kun tarkastelu on jäänyt tälle asteelle, ei mallin soveltamismahdollisuuksia ole voitu tähän mennessä edes harkita. Tässä tutkimuksessa (s. 28) esitetään lähinnä Yhdysvaltojen oloja ajatellen rekursiivinen malli. Tätä dynaamista mallia tuskin voidaan soveltaa pitkään aikaan, koska se edellyttää epätavallisen pitkiä aikasarjoja useista muuttujista. Tutkimuksessa selvitetään myös muita mallin soveltamiseen liittyviä käytännöllisiä ongelmia. Sillä on kuitenkin merkitystä pelkkänä spesifiointina, joka täsmentää eräiden keskeisten metsätaloudellisten muuttujain merkityksen ja tuo dynaamisen teorian sisällön näkyvästi esille.