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FOREWORD

The objective of the Forest Sector Project at IIASA is to study long-term development alternatives for the forest sector on a global basis. The emphasis in the Project is on issues of major relevance to industrial and governmental policy makers in different regions of the world who are responsible for forestry policy, forest industrial strategy, and related trade policies.

The key elements of structural change in the forest industry are related to a variety of issues concerning demand, supply, and international trade of wood products. Such issues include the development of the global economy and population, new wood products and substitution for wood products, future supply of round wood and alternative fiber sources, technology development for forestry and industry, pollution regulations, cost competitiveness, tariffs and non-tariff trade barriers, etc. The aim of the Project is to analyze the consequences of future expectations and assumptions concerning such substantive issues.

The research program of the Project includes an aggregated analysis of long-term development of international trade in wood products, and thereby analysis of the development of wood resources, forest industrial production and demand in different world regions. The other main research activity is a detailed analysis of the forest sector in individual countries. Research on these mutually supporting topics is carried out simultaneously in collaboration between IIASA and the collaborating institutions of the Project.

The aim of this paper is to describe the current status of the formulation of the global trade model to be employed for trade analysis. The data definition and availability have been discussed to a considerable extent as well. The work draws heavily on several earlier papers of the project as well as on comments by a number of collaborators on these papers.

Markku Kallio
Project Leader
Forest Sector Project

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A MODEL FOR INTERNATIONAL TRADE IN FOREST PRODUCT AND SOME CONSIDERATIONS OF THE INPUT DATA

Matti Kirjasniemi*, Seppo Salo**, Esko Uutela* and Markku Kallio***

1. INTRODUCTION

During the course of the Forest Sector Project at IIASA there has been a thorough discussion on key issues related to world trade in forest products and on alternatives to model it (Adams et al. 1982, Batten et al. 1983, Buongiorno and Gilless 1983, Kallio 1983, Nagy 1983). This paper has two objectives. First, to describe a model of the forest sector in global scale that has grown out from numerous discussions in the project, and second, to discuss practical questions related to getting valid input data for this model.

In principle, a world trade model calls for a regional subdivision of the world, regional component models and a linkage system between them (cf. Kallio 1983). A world trade model could be set up by constructing the regional component models yielding regional import demand and export supply as functions of regional prices. A world trade model would then just take these functions as input and calculate world trade and prices taking into account stated market imperfections. However, there would be a vast number of these excess supply functions (number of regions times number of products) each being a function of all prices. This problem may be remedied by assuming that excess demand for a given product is a function of its own price only. A resulting model can be made rather easily manageable (cf. Buongiorno and Gilless 1983).

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Another possibility to avoid introducing complicated excess supply functions explicitly is to construct a single computer model which includes all the regional component models and the linkage system. In this system the regional component models contain the excess supply functions implicitly. Doing so we do not have to make the above simplification of assuming the excess supplies independent of each other. The interdependence results from a common raw material base of round wood.

In the sequel we shall first discuss the model principles in detail, and thereafter the practical questions concerning data.

2. MODEL DESCRIPTION

The model structure is an extension of that developed recently by Buongiorno and Gilless for the pulp and paper sector of North America (e.g. Buongiorno and Gilless 1983). This extension is needed to account for the interdependencies between the forest products arising from their common raw material base. The model contains in implicit form supply functions for each of the products and for each producing region which are in principle sensitive to prices of all products considered.

The fundamental assumption underlying the model structure is that the major forces influencing production and international exchange of forest products can be represented accurately enough by a model of a competitive market and profit maximizing producers to which basic structure various market imperfections like quotas, tariffs, bilateral trade agreements, inertia of trade flow adjustments have been appended.

The basic forces driving the model are the demands for end products and production and transportation cost differences. Each producer will maximize its profits. Each region will satisfy its demand with minimum cost given the prices for all regions end products and transportation costs. Prices for each of the regions will then equilibrate the world market taking into account stated market imperfections.

The model contains five components:

- demand for end products
- supply of timber
- supply of recycled paper
- production
- world trade

These will be described in detail below.

The database follows the country groupings of Appendix 1. The trade model shall be constructed by further aggregating the world regions. This aggregation shall be up to the user of the system. In the trade scenario analysis at IIASA primarily the following aggregation shall be used:

1. Canada, West
2. Canada, East
3. USA, West
4. USA, East
5. Brazil
6. Latin America excluding Brazil
7. Finland
8. Sweden
9. Rest of Western Europe
10. USSR, European
11. USSR, Asian
12. Rest of Eastern Europe
13. Africa
14. China
15. Japan
16. ASEAN
17. Rest of Asia
18. Australia and New Zealand

The product classification adopted for the database is given in Appendix 2. Again, the user of the model system shall have the freedom to further aggregate the products. In the analysis at IIASA primarily the following product classification shall be used:

1. Coniferous Logs
2. Non-coniferous Logs
3. Pulpwood
4. Fuelwood
5. Coniferous Sawnwood
6. Non-Coniferous Sawnwood
7. Panels
8. Pulp
9. Newsprint
10. Other Printing and Writing Paper
11. Household & Sanitary Paper
12. Packaging paper & Boards

2.1 Demand of Forest Products

Eight of the products listed above considered are being used in production activities of the non-forest sectors of economy. These other sectors being exogenous we can assume regional demands to be functions of the price of the product and time only. The corresponding price functions $P_{ikt}(c)$ (of consumption level c in region i for product k at time period t) are assumed given and convex. In the sequel when considering only a certain time period we drop the time subscript t for notational convenience. These demands will be met in the world trade equilibrating process with minimizing cost.

The price functions may be defined constant or increasing and with or without strict upper bound as depicted in Figure 1.

For the remaining four products (two types of logs, pulpwood and pulp), demand is endogenously determined by production activities within the forest sector.

2.2 Timber Supply and Conversion

Trees being harvested are grouped into four categories according to their type and size

- "big" size trees (coniferous and nonconiferous)
- "small" size trees (coniferous and nonconiferous)

Supply of these trees is modeled by giving a (convex) price function $\bar{P}_{ilt}(r)$ for each region i, tree category l, and time period t. (See Figure 2.)

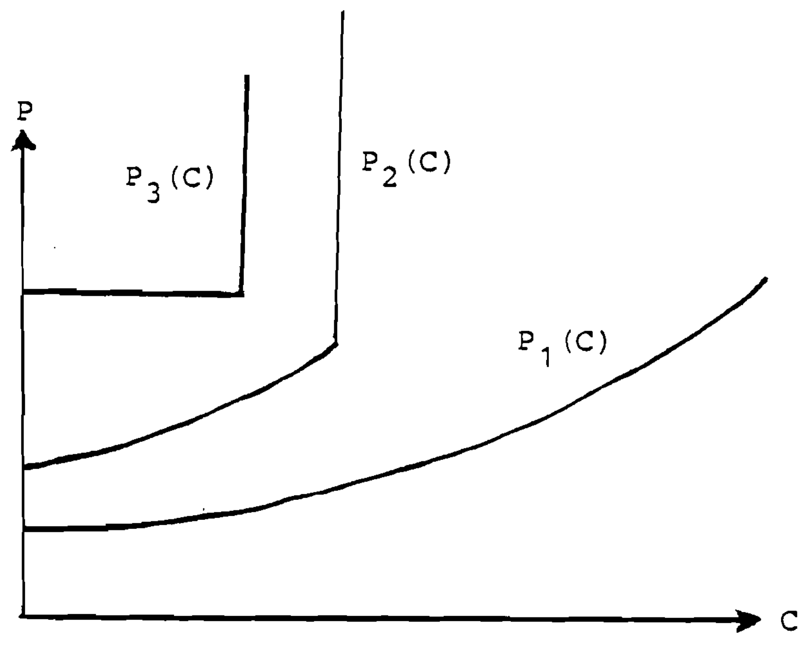

Figure 1. Examples of allowable price functions for demand.

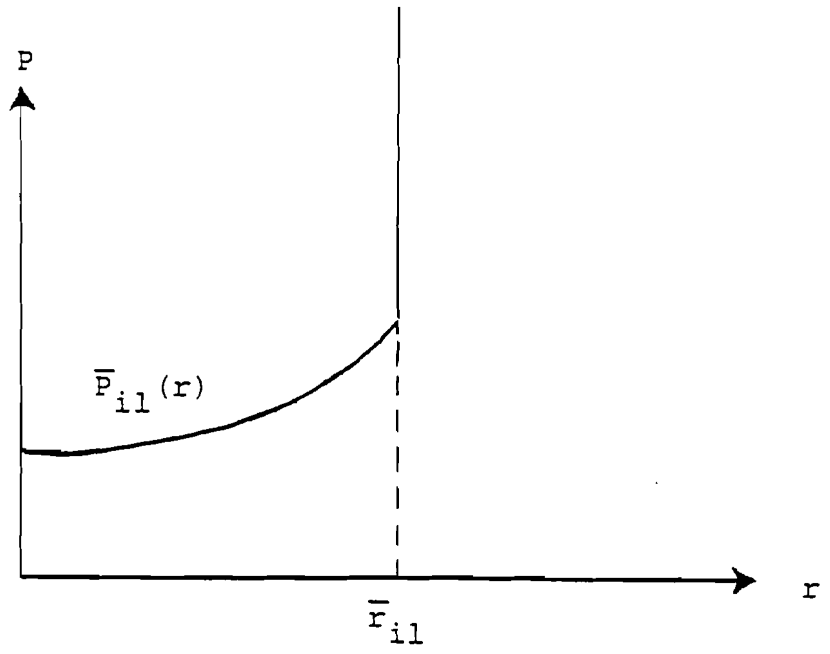

Figure 2. Price function $\overline{P}_{il}(r)$. r = volume of supply, $\overline{r}_{il}$ = maximum allowable cut, p = unit price.

2.3 Paper Recycling

The consumption $C_{in,t-1}$ of all paper in the preceding time period t-1 is taken as the potential stock of supply of recyclable paper in period t and region i. The actual recovery rate r_i is assumed to be a function of the price of the recycled paper. The corresponding price function $P_{iR}(r)$ would typically be of the form depicted in Figure 3.

2.4 Production

Production is modeled as an input-output process (Leontief substitution system) for each of the regions i:

$$S_i = A_i Y_i , \tag{1}$$

where S_i is the vector of net production in region i in time period t (one component corresponding to each product considered), Y_i is the vector of levels of production activities and A_i is the matrix of input-output coefficients for these activities.

Four of the production activities Y_{ik_l}, (l = 1,...,4), one for each timber category, refer to conversion or trees into logs, pulpwood and fuelwood. We assume that the volume of big timber has a practical maximum share of sawlogs (the rest of the volume being pulpwood and fuelwood). Small timber is pulpwood and fuelwood only. The conversion activity level Y_{ik_l} is interpreted to be the amount of timber of class l

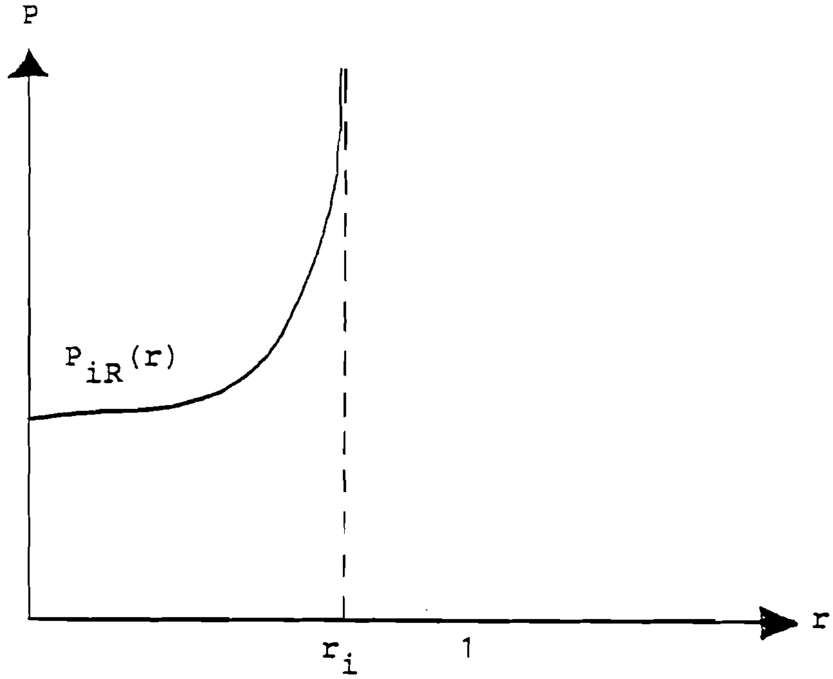

Figure 3. Price function for recycled paper. r = recovery rate, r_i = maximum attainable recovery rate in region i, P = unit price of recycled paper.

harvested. In certain regions pulpwood and logs can be used as fuelwood as well. This is technically possible in the model by defining one of the activities in vector Y_i to mean conversion of pulpwood (logs) to fuelwood.

One of the production activities Y_{ir} is conversion of recycled paper to pulp (the level Y_{ir} being the amount of input). Besides round wood conversion and conversion of recycled paper there will be several (substitute) production activity components Y_{ik} for producing a certain product. These activities represent alternative technologies on production recipes that can be applied to manufacture the product.

Integrated production (employing integrated plants) could be formulated by approximating the set of production alternatives of the integrate by a convex combination of two or more input-output production modes. Let k_I be the number of such modes. In each mode k take one of the products as the main product and K_{Ik} the capacity of the plant to produce the main product in production mode k. The input-output coefficients a_{jk} then define the output or input of product j per unit of main product in mode k. The capacity constraint for the integrated production is then (activities Ik in Y_i being the integrated activities)

$$\sum_{k=1}^{k_I} \frac{1}{K_{Ik}} Y_{iIk} \leq 1 \qquad (2)$$

The cost of production has been broken down to four parts:

— round wood cost defined by the wood price functions (a non-linear cost term)

- recycled paper cost defined by corresponding (nonlinear) price function
- input cost of intermediate products (linear)
- other production costs (linear).

2.5 World Trade

World trade flows are assumed to result from a competitive world market where regionally differing prices equilibrate regional demands and supplies subject to constant unit costs of transportation, stated trade barriers, and inertia constraints.

Let T_{ijk} denote the amount of product k transported from region i to region j. Then quota Q_{jk} set by region j for total imports of product k from a set E_{jk} of regions i can be handled by the constraint

$$\sum_{i \in E_{jk}} T_{ijk} \leq Q_{jk} \tag{3}$$

Inertia in adjustment of trade flows can be represented by the following inequalities

$$\alpha_{ijk} T_{ijk,t-1} \leq T_{ijk,t} \leq \beta_{ijk} T_{ijk,t-1} \quad , \quad 0 \leq \alpha_{ijk} \leq 1, \ 1 \leq \beta_{ijk} \leq 2 \tag{4}$$

with the non-negative coefficients α and β determining the maximum speed of adjustment.

A first order approximation for handling tariffs is be to increase the corresponding transportation costs accordingly.

2.6 Mathematical Form of the Model

Following Buongiorno (Buongiorno 1981) the problem of finding the market equilibrium for the regional profit maximizing producers and cost minimizing consumers can be cast in the form of maximizing the sum of consumers surplus and producers surplus subject to regional material balances. The resulting model takes the form

$$\text{maximize} \sum_{i,k} \int_0^{C_{ik}} P_{ik}(c)dc - \sum_{i,l} \int_0^{Y_{ik_l}} \bar{P}_{il}(r)dr - \sum_{i} \int_0^{Y_{ir}} P_{iR}\left(\frac{r}{C_{in,t-1}}\right)dr \tag{5}$$

$$- \sum_{i,m} c_{im} Y_{im} - \sum_{i,j,k} t_{ijk} T_{ijk}$$

subject to

$$C_i = A_i Y_i + \sum_j (T_{ji} - T_{ij}) \tag{6}$$

$$Y_i \leq K_i, \tag{7}$$

$$C_i, Y_i, T_{ij} \geq 0, \text{for all } i, j, m \tag{8}$$

where

i, j	indices for regions
k	index for products
m	index for production technologies (one or more for each product)
l	index for wood raw material
k_l	index for raw wood conversion activity (harvesting)
r	index for conversion activity of recycled paper
P_{ik}	product price in region i for product k
$P_{ik}(c)$	price function for demand (function of consumption c)
$\bar{P}_{il}(r)$	price function for wood raw material (function of wood consumption r)
$P_{iR}(r)$	price function for recycled paper (function of recovery rate r)
c_{im}	manufacturing costs, excluding wood
t_{ijk}	delivery costs
Y_{im}	production activity
Y_i	vector of production activities
T_{ijk}	delivery to other region
T_{ij}	vector of deliveries (product wise)
C_{ik}	total consumption of product
C_i	vector of consumption (product wise)
A_i	matrix of input/output coefficients
K_i	vector of production capacities

If integrated production is being included in certain regions then a composite capacity constraint (2) for integrated production activities for those regions should be added. If quotas of trade are analyzed then corresponding constraints (3) should be added to the above model. Market inertia, as well as certain trade agreements and policies can be handled by constraints (4).

2.7 Model Dynamics

The model described above deals with one period at a time only. It is assumed that prices equilibrate world markets for each period separately and that inventory changes may be neglected. The dynamics of the model is then determined by the dynamics of demand functions, raw material supply, capacity changes, and shift in the mix of vintages of production capacity.

Forest dynamics is exogenous in the model. It should be reflected in the price functions for round wood supply for consecutive periods. These functions can be defined separately for each time period or specific functions of time can be applied as shifters.

Updating capacities from one period to the next depends on particular investment strategies applied in different regions. Because regions may be interested in analyzing different alternative strategies, explicit rules for capacity expansion shall be left open for suggestions from those regions. A base scenario against which various alternatives could be compared, may be constructed by assuming that the capacities for current time period are not binding (i.e. relaxing the capacity constraints (7)). Production exceeding current capacity would then be interpreted as capacity expansion while constructing the base scenario. The overall regional capacity expansions would be limited by a investment budget. The size of such a regional budget relates to investment policy. In the base run we could apply a fixed share of the turnover from previous period to determine the budget.

3. DATA CONSIDERATIONS

3.1 Demand Functions

The global trade model formulation requires estimation of demand functions for eight end products, which are:

- fuelwood
- coniferous sawnwood
- non-coniferous sawnwood
- panels
- newsprint
- printing and writing papers
- household and sanitary papers
- industrial papers and boards

The other four product groups:

- coniferous logs,
- non-coniferous logs,
- pulpwood, and
- pulp,

are raw materials or intermediate products to other processes. So their demand can be derived from the production of end products by using the input coefficients in the matrix A_i of the model.

The demand functions to be estimated would be aggregate demand functions expressing the consumption/price relationship separately for each end product and region, with all non-price factors as demand shifters. Thus the total number of demand functions required for 20 regions is $8 \times 20 = 160$.

Another possibility would have been that the link between the forestry sector of a country and the rest of the world consists of simple functions describing the import demand and/or export supply for each product, as suggested by Buongiorno and Gilless (1983). This approach has at least the following weaknesses:

- import demand and export supply are artificially separated from the total domestic demand and supply. In many cases foreign trade represent only a small fraction of the total demand and/or supply. Thus any conclusions based on import demand and export supply functions only might be dangerous to be used to describe exchange relationships between nations or regions.
- the model would not allow the existence of cross-price elasticities between different forest products. Measuring own-price elasticities of imports and exports in a reliable way would obviously be difficult, and the model might be sensitive to changes in these elasticities.
- if made properly, the analysis would require description of trade flows between each separate pair of trading partners. With 20 regions and 12 products this would mean 190 net trade flow possibilities per product or 2,280 net trade flow possibilities altogether. Since each flow can be either an import or export flow, the maximum number of functions needed would be 4,560. Although this number could be reduced by ignoring the most unlikely trade flow possibility, the number of functions would still be difficult to manage.

Construction of demand functions for total demand for forest products has been dealt with in many papers of the Forest Sector Project (e.g., Demand, Supply, and Trade Group 1982, Lönnstedt 1983, McKillop 1983, Wibe 1983) and is therefore not repeated again. It must be observed that the demand functions in the objective function are simplified versions where all important demand shifters are exogenous and their effects investigated through separate analyses.

The input data for the model itself consists only of the functional relationship between price and consumption for each product and region. Normally this relationship is presented through price elasticity.

However, measuring price elasticities from the past is a complex task. If price elasticities are calculated from pure time series data, there is a problem of multicollinearity between variables measured in value terms, e.g. income (GDP per capita) and price. Therefore, it is difficult to conclude, which part of explained variation belongs to the income variable and which part to price variable. Normally, if more reliable results are needed, this is done through the use of combined cross-section and time-series analysis. Often there are also some dummy variables used to describe some special features between different data sets.

Furthermore, it is evident that the numeric values of price elasticities tend to vary over time and/or income level. This can be seen from Table 1, where the results of two different studies are compared. In both studies (Buongiorno 1978, JPI 1983) the method for calculating elasticity was based on the use of covariance analysis and dummy variables, but the time period and countries included were different. Buongiorno's (1978) study covered 43 countries and years 1963-1973, the other study (JPI 1983) 40 countries and years 1965-1980 for newsprint, as well as 14 countries and years 1979-80 for wrapping and packaging papers.

Table 1. Comparison of long-run elasticities of selected paper grades between Buongiorno's and JPI studies.

Product (study)	Long-run elasticities		
	Income	Own-price	Cross-price
Newsprint (Buongiorno)	+1.04	-0.73	+0.13
Newsprint (JPI)	+0.84	-0.30	+0.06
Printing and writing papers (Buongiorno)	+1.33	-0.55	+0.26
Other paper and board (Buongiorno)	+1.64	-0.71	..
Wrapping and packaging papers and boards (JPI)	+0.63	-0.10	-0.03

The differences between the measured elasticities, especially price elasticities, are very significant from modeling point of view. One possibility to explain the high elasticities in Buongiorno's study (1978) is the choice of deflation factors. Other results can be found in several FAO's studies (e.g. FAO 1977).

Since the results of several studies show very different price elasticities, it would be necessary to carry out a comprehensive analysis to verify a reasonable level of price elasticity for each end product. If this is not made in the Forest Sector Project, the results of the global trade model might be questionable provided that the model proves to be sensitive to elasticity changes. Any estimates from earlier studies (normally concentrating on some individual products and/or regions or countries only) do not give a sufficient ground for establishing the functional relationships needed in the global trade model.

The interpretation of price elasticities of forest products is a problem where different opinions are to be seen. Although price elasticities can be measured from the past price and consumption data, one cannot be sure whether their relationship is causal, or whether price and demand developments are two independent phenomena. This question is discussed in several early studies (e.g. FAP 1960, Sundelin 1970) with regard to income (GDP) and consumption. Some writers (e.g., Åberg 1968) have concluded that the demand for paper and paperboard is inelastic since:

- real prices of paper and paparboard did not change much before 1973
- paper and paperboard do not have cheap substitutes
- paper and paperboard are complementary products whose share of the total price of products to which they are related is very small, and therefore, even large price increases would not much affect paper and paperboard consumption

- consumption of paper and paperboard is obtained mature
- price variables include short-term variation which can even reduce the coefficient of determination in long-term consumption model (FAO 1960).

Estimation of price elasticities from the past will require a large data base. The current data base of FSP includes FAO Yearbook volume data for production, imports and exports and value data for imports (CIF) and exports (FOB) for years 1966-1980. This data base does not include, unfortunately, data on production values. From experience it can be stated that it is impossible to get data on production values systematically from any source. Therefore, the value of consumption must be estimated based on import/export prices. FAO's data forms a good starting point for the FSP data base. However, FAO's data contains a lot of errors: false data and unreliable estimates. This holds both for quantity and value data (see e.g. Nagy et al. 1983). It is suggested that before any analyses the current data base would be checked by experts in the field and the unreliable data sets replaced with data from alternative sources. These alternative sources include a.o.:

- international organizations which publish pulp and paper statistics (OECD, CEPAC, ECE, CICEPLA, PPI, UN, EPI, etc.)
- national industry associations (API, CPPA, SCPF, VDP, OPA, SAPPI, JPPA, PSF, COBELPA, ANFPC, APRPPACA, etc.)
- national customs office statistics (also for checking value data)
- national official statistics (by central bureaus of statistics)

Data checking should be made at least for the most important countries where mostly also very detailed and reliable statistics are available. A lot of this kind of work was made when establishing Jaakko Pöyry's Forest Products Market Data Bank, for instance.

There are at least three open questions relating to price data which should be solved in a reasonable way:

1) CIF and FOB prices in FAO data have been expressed in current US dollars. This causes two problems:
   a) What is the correct deflator to get constant prices?
   b) The US dollar price series are disturbed by exchange rate fluctuations. Because importers make their buying decisions based on the price in national currencies, the price elasticity measured from dollar-based prices may be biased.
2) Some of the product groups are composed of many different individual products which have different end-users, different growth prospects, etc. This is the case especially for:
   - panels (plywood, particle board, fiberboard)
   - printing and writing paper
   - industrial papers and boards

   The changing structure of these product groups will cause extra variation in price/consumption series which will affect the results of the elasticity analysis.

3) Domestic prices are in some cases clearly different from world market prices. This is the case especially if the domestic market is large and/or imports or exports play a marginal role.

Price elasticities should be measured from models which include all important demand shifters, e.g., by using covariance analysis and dummy variables as was made in Buongiorno's (1978) and JPI's (1983) studies. Otherwise the reliability and importance of price elasticities is difficult to evaluate.

The above requirement will cause further needs for data in the data base. McKillop (1983) has suggested a large number of general economic and social variables which should be included. In the following the important demand shifters on which data should be available have been listed for each of the end products. The minimum amount of economic data for demand analysis is:

Product	*Demand Shifters*
Fuelwood	GDP per capita, population, possibly share of rural population
Mechanical Wood Products (sawnwood and panels)	Level of construction activity, population
Newsprint	GDP per capita, population, grammage development
Printing and Writing Papers	GDP per capita, population
Household and Sanitary Papers	Private consumption or GDP per capita, population, possibly share of young population
Industrial Papers and Boards	Industrial production

The inclusion or exclusion of substitute prices should be studied separately, since in most cases the price of substitute materials alone is not decisive, but the costs of the whole system related to that material (e.g. use of plywood to decrease working costs in construction). Therefore, it would be worthwhile for the Project to carry out separate background studies to analyze this kind of relationships.

The general economic indicators listed above could be found in the following publications and instances:

— United Nations	— Demographic Yearbook
— United Nations	— Statistical Yearbook
— United Nations	— Monthly Bulletin of Statistics
— OECD	— National Accounts of OECD Countries
— World Bank	— World Tables
— World Bank	— World Development Reports
— World Bank	— Yearbook of Construction Statistics

— World Bank — Annual Bulletin of Housing and Building Statistics for Europe

All value data should be deflated by national deflators and only in the last phase converted into US dollars by using a "representative" exchange rate to avoid the bias caused by short-run exchange rate fluctuations in the data series. How this "representative" exchange rate can be calculated is also a problem which should be solved in the Project.

3.2 Wood Raw Material Supply Functions and Conversion Factors

Wood raw material stumpage costs should be given for four different grades.

- "Small" timber, softwood/hardwood
- "Big" timber, softwood/hardwood

In principle all small timber is pulpwood and big timber has practical maximum share of sawlogs, the rest of the volume being pulpwood. In addition, the amount of fuelwood should be given.

For plantation wood the stumpage will include the plantation costs including purchase price of land. The estimation of wood costs as a function of wood supply requires vast knowledge of regional characteristics and is strongly dependent of selected policies for forestry. The cost estimates have therefore to be the responsibility of regional research teams. However, it is essential that if any assumptions are to be made, they should be consistent between the regions. An experienced person capable for coordinating the work of regional team is therefore required. In addition, when the results of the regional teams are available, it is proposed that a meeting would be arranged where all regional teams added by selected wood costs specialists could analyze and discuss the results to arrive at wood cost estimates, which would be comparable between the regions.

3.3 Manufacturing Costs, Other than Wood and Purchase Intermediate Forest Products

The manufacturing costs will include:

a) variable costs
   - raw materials, other than wood and purchased intermediate products. (chemicals, fillers, etc.)
   - purchased energy (fuel and power)
   - packing materials

b) Fixed manufacturing costs
   - personnel costs, including fringe benefits
   - operating and maintenance materials, outside maintenance services

- general overhead costs (e.g. insurances, telecommunication costs, office supplies)

c) capital charges
- interests on total capital
- depreciation

Row wood conversion costs will include

- harvesting costs to roadside
- transport costs and overhead

Paper mills are either integrated with the pulp mills or the pulps are purchased. As 70-80% of the purchased pulp already today is bleached pulp, the market pulp in the model will be interpreted as bleached softwood and hardwood pulp, whereas mechanical, chemi-mechanical, semimechanical and unbleached chemical pulps will be calculated as integrated to paper production. Paper making costs will then exclude costs of bleached pulp but include costs of other pulp grades required.

Three different technologies will be included in estimating the cost levels of the industry for each of the products:

- total manufacturing costs for new capacity, i.e. new optimum sized mills or major expansions
- average total costs for the modern capacity of the existing industry
- average total cost for the old capacity

The division of the existing industry into modern and old is artificial as the total manufacturing costs from low cost producers to high cost producers is normally more or less a straight line without any big steps in between (see Figure 4).

The age of the mills as such does not tell whether a mill belongs to modern or old capacity due to various rebuilding activities. Therefore, a term apparent age has been developed by JPI* to express the effect of rebuilds on the modernity of a specific mill. The division of the regional capacity to modern and old capacity could be done at an apparent age of say 20 years. The effect of rebuilds on capital charges will also be taken into account as well as the degree of replacement investments as a function of the apparent age.

The cost estimation model developed by JPI* for estimating the cost range of low to high cost producers can be used to estimate fairly reliably the costs of the pulp and paper industry. The cost estimates for sawnwood and panel industry have to be based on simpler estimation methods, and the reliability of the input data will be more difficult to assess.

The cost estimates for the next time period will include the following changes:

- new capacity, decided in the previous period, will be in use in this period forming part of the modern capacity. The amount of new capacity will be a result of the optimization

* Jaakko Pöyry International

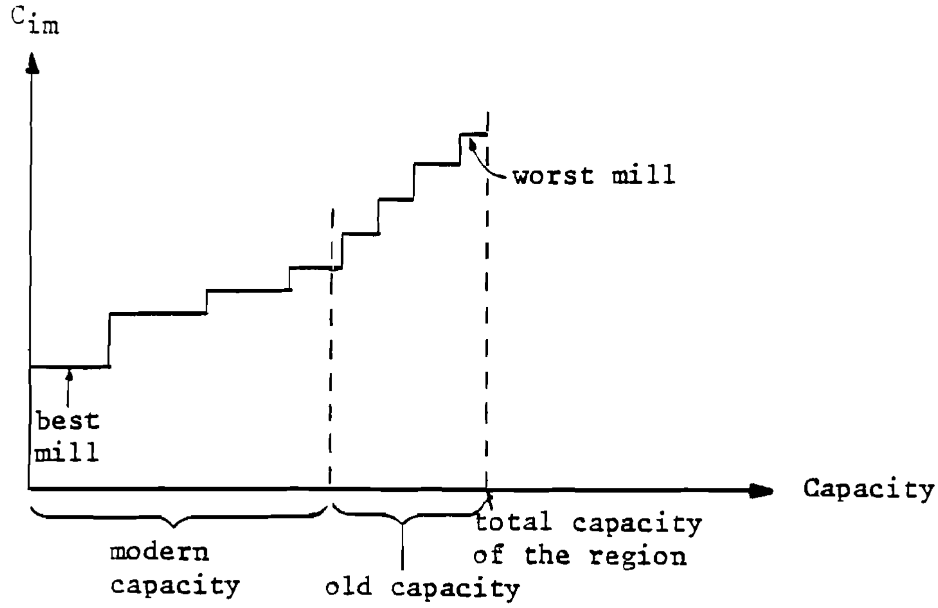

Figure 4 Typical manufacturing cost distribution in the pulp and paper industry.

- part of the modern capacity in the previous period will shift to old capacity. The amount of this capacity will be estimated by forecasting the change of apparent age of the mills in question
- part of the old capacity will be rebuilt and become modern. Also this amount of capacity has to be forecasted by analyzing the past behavior of the industry in this respect
- part of the old capacity will shutdown. The shutdown-capacity will be a result of the optimization.

To prevent the possible unrealistic results in the optimization; namely that all old capacity were replaced by more cost competitive new capacity, the following constraints should be added in the model:

- in the main production regions the investment budget will be limited to correspond to about the same investment activity as in the past, i.e., somewhere about 10 to 15% of the turnover. Investment required per unit expenditures of new capacity for each product will be given.
- the domestic production can during one time period decrease relatively little due to various inertia reasons.

The use of the JPI cost estimation model for the pulp and paper industry is based on the JPI pulp and paper mill data bank where the information on mill capacity, degree of integration, paper furnishes, amount of rebuilds and other similar technical data can be found. The unit prices of input factors, other than wood and purchased pulp is proposed to be collected by collaborating regional research teams. Such unit prices to be collected are:

a) raw material prices excluding wood, for instance,
   - filler clay
   - starch
   - alum
   - salt cake
   - caustic soda
   - chlorine
   - chlorate

b) purchased fuel (at average fuel mix)

c) purchased power (per MWh)

d) cost of labor, including fringe benefits

e) cost of salaried personnel, including fringe benefits
   - technical supervision and management
   - administration

f) interest rates.

It is proposed that the basic price information is given in local currency for the basic year, say, for 1980, and the change to USD would be done within the optimization model. In the model exchange rates can be varied.

It is obvious that the unit price information given by regional research teams will consist different price estimation methods depending on the available information sources characteristic to each region. Therefore, it is essential that the collection of unit prices is well coordinated by IIASA so that any assumptions to be made will be consistently the same in each region.

3.4 Input/Output Factors of Production Processes

These factors, when deviating from 0 or 1 are factors specifying the consumption of intermediate products, i.e., consumption of bleached pulp in paper-making, and production of by-product pulpwood in sawnwood and panel production. These factors has to be given at the same time when estimating manufacturing costs as they are interrelated.

Conversion factors standing wood to sawlogs and pulpwood could be collected by regional research teams. However, there is strong correlation between sawmilling and panel production costs and log dimensions requiring thus good coordination between the regional teams and production cost estimators.

3.5 Delivery Costs by Product

The delivery costs will include all costs from mill to CIF landed in exports. For "domestic" markets it could be assumed that the producing mills are located cost-wise equally to the import CIF point in relation to the final delivery point, and delivery costs can then be excluded.

The delivery costs include (in ocean transport):

- land transportation costs from mill to harbor
- port handling, forwarding, and loading costs
- ocean freight, insurances
- unloading costs
- commissions and other sales costs
- import duties and similar costs
- export incentives (negative cost)

Import duties may in some cases be fairly complex functions of import volume (duty-free quotas), price, etc. However, in most cases duties can be enough accurately put in the model as a fixed cost per unit imported. Similarly, export incentives could be included as a decreasing factor in delivery costs.

The ocean freight rates are in many cases more dependent on volume than distance. Therefore it is very difficult to get valid data by collecting actual freight rates from different sources. It is proposed that the freight rates be calculated as total cost estimates assuming

- big transport volumes
- optimum size vessels for different distances.

An experienced transport cost specialist can develop fairly easily these cost estimates supported by national or regional research teams giving data on regional land transport and harbor costs. Also information on import duties and export incentives could be collected by regional research teams.

3.6 Recycled Fibers

The amount of recycled fiber is globally already around 40 mill. tons/a. Calculated as equivalent round wood consumption, recycled fiber corresponds to about 10% of the total wood consumption, and about 30% of the pulpwood consumption. The possible future changes in the degree of recycling may thus have considerable effects on the forestry sector and recycling should be included in the model.

The price of recycled fibers is normally related to the market pulp price and recovery rate (= collected amount of waste paper/consumption of paper and paperboard in a country). It is obvious that the relation between waste paper price is only marginally dependent on the recovery rate up to a certain point (e.g. recovery rate reaches 45-50%). After that collection costs may grow rapidly, and waste paper price would increase exponentially.

Recovery rates of recycled fibers vary from region to region. The model would require to take on recovery rates in the initial period t_0 and also forecasts for every step t_1, t_2,..., etc. One possibility is to present price as a function of recovery rate. Other factors than price which affect attainable recovery rates are:

- population density (inh/km^2)
- share of urban population
- wood resources (ha/capita)
- GDP per capita
- paper production/consumption relationship
- grade structure of paper consumption

Against this background it is obvious that there will be different parameters in recycled fiber supply functions for different regions, possibly every region will require its own price/supply function.

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Appendix 1: Regional Subdivision for the Database

1. Canada, West
2. Canada, East
3. USA, Nort-West
4. USA, South-East
5. Mexico
6. Rest of Central America
7. Argentina
8. Brazil
9. Chile
10. Columbia
11. Peru
12. Venezuela
13. Rest of Latin America
14. Finland
15. Sweden
16. Norway
17. Denmark
18. BENELUX
19. UK
20. Ireland
21. FRG
22. France
23. Austria
24. Switzerland
25. Italy
26. Spain, Portugal
27. Greece
28. Yugoslavia
29. Hungary
30. Czechoslovakia
31. GDR
32. Poland
33. Bulgaria
34. Rumania
35. USSR, European
36. USSR, Asian
37. Africa, North
38. Africa, East
39. Africa, South
40. Africa, West
41. Australia
42. New Zealand
43. China
44. India
45. Thailand
46. Hong Kong
47. Malaysia
48. Vietnam
49. Indonesia
50. Philippines
51. North Korea
52. South Korea
53. Japan

Appendix 2: Product Classification for the Database

1. Coniferous Logs
2. Non-coniferous Logs
3. Pulpwood
4. Fuelwood
5. Coniferous Sawnwood
6. Non-coniferous Sawnwood
7. Veneer
8. Plywood
9. Particle Board
10. Fibreboard
11. Panels (aggregate)
12. Mechanical Pulp
13. Semi Chemical Pulp
14. Chemical Pulp
15. Bleached Sulphate Pulp
16. Dissolving Wood Pulp
17. Other Fibre Pulp
18. Pulp (aggregate)
19. Newsprint
20. Other Printing and Writing Paper
21. Household & Sanitary Paper
22. Packaging Paper & Boards