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CONSIDERATIONS IN FUTURE DEVELOPMENT OF THE IIASA FOREST SECTOR PROJECT: MODEL STRUCTURE, PRODUCT DEMAND MODELS, PRODUCT CATEGORY DEFINITION, GEOGRAPHICAL AGGREGATION, AND DATA AVAILABILITY

Demand, Supply, and Trade Group

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PREFACE

This working paper is the result of a joint working group during the Summer 1982. A first version of the paper was prepared by:

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This first version of the paper was the basis for discussion and critique by the following persons during a one-week seminar; 26-30 July, 1982:

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INTRODUCTION: OBJECTIVES OF WORKING PAPER

The Forest Sector Project at IIASA has advanced to the stage of producing an embryonic prototype model (Loennstedt 1982). The prototype is intended to serve as a guide for development of detailed individual or multi-country models of the forest sector, which is one of the principal objectives of the Forest Sector Project. The current prototype model is intended as a first approximation and therefore lacks detail within any given module. Further, no firm decisions have been made on the procedures to be employed in pursuit of the Project's second major objective, the analysis of global trade in forest products. It is appropriate at this stage, therefore, to begin a more detailed consideration of some of the fundamental decisions which must be made in the future development of the Project. This paper is intended to serve as a stimulus for further discussion, and ultimately decisions, on options for modeling the forest sector at the national and global levels. It addresses four broad topics thought to be crucial at this stage of project development: (1) the overall direction and organization of the Forest Sector Project at IIASA, (2) definitions of product categories and the specific degree of geographical aggregation to be employed in the analysis of global trade, (3) alternatives for modeling the critical elements of demand for forest products in both detailed country and global trade studies, an (4) problems of data availability and consistency which will likely be encountered as work on the Forest Sector Project proceeds.

1. RECOMMENDATIONS FOR FUTURE PROJECT DEVELOPMENT

1.1 Basic Project Objectives and Recommendations

Under its current research program, the Forest Sector Project will concentrate on two main tasks (Seppaelae, 1982):

- Forest Sector Analysis (national level) —Task A
- Analysis of World Trade in Forest Products —Task B

For both tasks the primary effort will be to build models for use in policy analysis. The policies of interest are those which may be adopted by individual countries, or perhaps by country groups, to accommodate, adapt to, or preclude "structural changes" in the forest sector over the next two to three decades (Seppaelae 1982).

Within this statement of objectives, the definition of "structural change" is crucial, since it will determine in large part the scope of the modeling effort at both the national and global levels. A broad definition would suggest the need for more detailed models with more options for policy intervention and simulation, while a narrower definition might allow more aggregative models designed to accommodate a relatively smaller class of policy instruments. Based on comments in the several regional and international meetings conducted by the Forest Sector Project to date and on the deliberations of the Demand, Supply, and Trade Group, however, it is clear that no single definition of structural change is possible. What is a critical shift or trend from the perspective of one individual or country may be of little consequence from the perspective of another. Further what may appear to be of significance today may or may not be crucial over the course of the next two to three decades.

In an effort to provide some guidance for the Project in this matter, the Demand, Supply, and Trade (DST) Group conducted the following exercise. A detailed scenario of prospective developments in world forest products markets was developed from an array of public and private sources covering the period to the year 2000. DST Group members were then asked to note which developments they considered to be "structural changes" in the forest sector. The resulting list of structural changes is given in the following tabulation. To provide a frame of reference and to give some indication of the model structure that might be required to consider this array of changes, the list has been organized by current prototype module (Loennstedt 1982). Also a notation has been made to indicate what aspect of the current prototype could be modified, if possible, to simulate the specific change.

Key elements of structural change organized by IIASA prototype module.

(n) = represented as an endogenous variable in the current prototype
(x) = represented as an exogenous variable in the current prototype
(p) = represented as a parameter in the current prototype

1. ***Product Demand Module***
   - income and end-use activity development over time (x)
   - prices of substitutes (x)
   - changing tastes and preferences (x)
   - development of new types of competing products (e.g., electronics)
   - inflation rates (general price level) (x)
2. ***Product Market Adjustment Module*** (see also linkage module)
   - changing price and inventory decision structures (p)
   - changes in market structure (p,x)
3. ***Product Supply Module***
   - investment subsidies (could be modeled through x variables)
   - capital availability and costs (n,x,p)
   - financial integration (both within the forest sector and outside)
   - interest rates (x)
   - inflation rates (general price level) (x)
   - technological change as it influences factor use efficiency, e.g., wood, labor, energy, and other materials consumption per unit of product output (x,n)
   - pollution regulation (x,p)
   - labor costs (x)
   - residue utilization (x,n,p)
   - scale economies
   - alternative investment criteria or decision-making processes (x,n,p)
4. ***Roundwood Demand Module***
   - fuelwood use (x)
   - technological change as it influences wood use efficiency (x)
   - new uses for forest biomass (could appear as a new forest product at the product demand level or be introduced directly as a separate demand for roundwood with no detail at the product level)
   - utilization of recycled fibers
   - uses of non-wood fibers
5. ***Roundwood Market Adjustment Module***

6. *Roundwood Supply*
   - utilization of standing timber and logging residues (p,x)
   - willingness to harvest by private owners
   - forest land ownership composition
   - rates of harvest from public timberlands
   - prices or pricing mechanisms for timber sold from public lands
   - sustained yield levels (as regulated by law or public policy) (x)
   - regulation of cutting or logging methods on private/public lands
7. *Forest Inventory Projection Module*
   - management intensity on public and private lands (silvicultural investments)
   - regulation of cutting methods
   - changes in the forest land base (losses to agriculture or other uses, additions through reversion from other uses)
   - catastrophic losses of growing stock or growth due to pests, fire, etc.
8. *Public Regulation and Control Module* (see all other modules)
9. *Linkage Module* (not a formal prototype module)
   - exchange rates
   - trade barriers and restrictions (tariffs, quotas, etc.)
   - transportation costs
   - capacity of transport system

This list is lengthy and complex. It suggests that, if the policy analysis needs of potential users are to be met, forest sector models must involve considerable detail. Such broad scope models are certainly feasible at the individual country level, as illustrated by work in the Nordic countries and the US. But at the global level great detail is burdensome. Indeed, in the view of the DST Group, it seems quite unlikely that a set of highly detailed national models could be successfully linked in a system to explain global trade patterns. As a consequence, we recommend that Tasks A and B of the Forest Sector Project Research Program be viewed as separate efforts, requiring two different, but compatible, types of models. Task A should proceed to develop individual country models with whatever degree of detail is required to meet the needs of user countries. Task B, employing simpler and more aggregate models, should develop a system for simulating international trade in forest products.[1] A new, final phase of the Project should be added in which methods are developed for conducting joint simulations with both model types.

Details of this recommendation and a suggestion for organization of the research effort are given in the following sections.

1) It should be noted that this general approach has also been suggested in an earlier paper by Grossmann, Loennstedt, and Seppaelae (1981).

1.2 Recommendations for Organization of the Forest Sector Project

To accomplish the objectives of the Forest Sector Project, and particularly to facilitate the development of an operational global trade simulation system, organization of work in the Forest Sector Project along the lines shown in Figure 1 is recommended. Research and development has been broken into several components (or sub-tasks). Figure 1 suggests the appropriate sequencing and linkage of these components.

(1) At the earliest possible time, agreement should be reached among participating countries on a specific list of product categories and countries or country groups *for use in the global trade analysis*. From the deliberations of the DST group, the divisions and aggregations shown in Table 1 are proposed as a first step in developing a global model. These groupings set broad limits on the scope of the trade analysis problem and provide essential information for consideration of the trade linkage mechanism and trade model prototypes discussed in items (2) and (3) below. Although both divisions are critical, the most important for the immediate progress of the Project is the product list.

(2) In the current Forest Sector Project Research Program (Seppaelae 1982), work on what will be called hereinafter "detailed country models" or *DCM*'s is organized under Task A. Development of the world trade analysis, what shall be called the "global trade model" or *GTM*, is organized under Task B. Since these two tasks address distinct and clearly separate needs among the various participating countries, this division of work is a useful and appropriate one. It is important to recognize, however, that the results of the two tasks are complementary and at the conclusion of the Project will provide a comprehensive structure for analysis of the forest sector. As noted above, the basic presumption is that the DCM's will contain considerable detail on market and resource elements as deemed appropriate by the individual participating countries, while the GTM will contain less detail and be more aggregate both in terms of products and countries. Our perception of the interaction of the two types of models is shown in Figure 2. Operating through an "interface," the GTM will provide broad world market price, production, consumption and trade flow information to the DCM's. The DCM's, in turn, provide information to calibrate, limit, and drive world trade simulations. The nature of the "interface" is discussed below.

Consistent with this overall view of the Project, the following subtasks within Task B are proposed *for initiation in the general order listed.*

Sub-task B-1. ***Linkage Mechanism***. The first step in development of the GTM must be some basic decision on the form and nature of the trade linkage mechanism. Of course, not all details need be, or can be, determined at the outset, but some critical aspects must be fixed. These would include whether the system will provide static (equilibrium) or dynamic partial adjustment solutions and (in the latter case) whether solutions will be of a simple competitive spatial equilibrium form or some variant. In any case, what is needed in this initial step is a statement of what information must be provided to the linkage mechanism to enable its solution process and any restrictions on the form of this information. This statement in turn will provide the basis for structuring the "regional

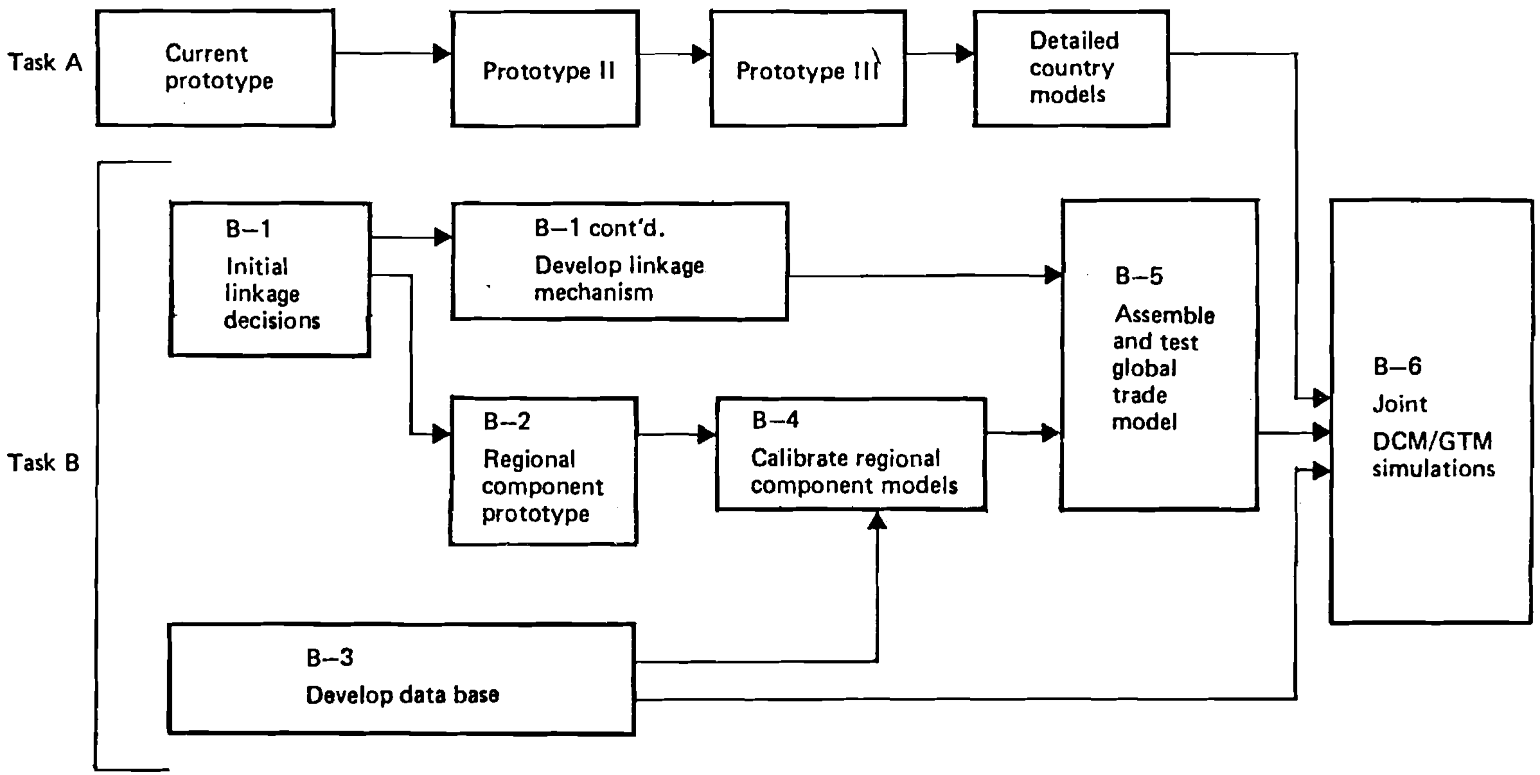

Figure 1. General plan of proposed organization for IIASA Forest Sector Project by task and sub-task

Table 1. Proposed product categories and country groupings.

	Product Categories		*Country groupings*
1	Coniferous logs	1	Africa
2	Non-coniferous logs	2	Canada
3	Pulpwood	3	US
4	Fuelwood	4	Brazil
5	Coniferous sawnwood	5	Latin America excluding Brazil
6	Non-coniferous sawnwood	6	China
7	Panels	7	Japan
8	Pulp	8	ASEAN
9	Newsprint	9	Asia excluding China, Japan and ASEAN
10	Other printing and writing	10	Finland
11	Other paper and board	11	Sweden
		12	Western Europe excluding Finland and Sweden
		13	Hungary
		14	Eastern Europe excluding Hungary
		15	Australia
		16	Oceania excluding Australia
		17	USSR

component models," or RC models, that will be tied together by the linkage mechanism. In Figure 2 these RC models are shown clustered about the linkage system within the GTM. These are the basic elements of the GTM. *There will be one RC for each country or country group in Table 1.*

Sub-task B-2. ***Regional Component Prototype Model*** Given the basic linkage requirements established in Sub-task B-1, a prototype RC model should be developed as a pattern for individual country and regional contributions to the GTM. Depending on the specific form of the linkage mechanism, some aspects of the prototype may be fairly flexible while other parts may be quite rigid to insure the feasibility of linkage. This sub-task should be completed by IIASA staff as soon as possible after the initial decision in Sub-task B-1. In some cases these regional component prototype models can be substituted by information from detailed country models, which are directly plugged into the Linkage Mechanism (sub-task B-1). Examples of such a substitution, considering the list of country groupings, are US, Japan, Finland, Sweden, Hungary and Australia.

Sub-task B-3. ***Database for Global Trade Model.*** Concurrently with the commencement of work on the linkage mechanism, plans should be layed for, and work begun on the assembly of, a basic database for the GTM. At a minimum the base should contain data aggregated by the product and regional categories noted in Table 1. Since data originate from individual country reports, the basic data storage structure may be most easily organized on a country basis, but the ability to aggregate to Table 1 levels must be a feature of the retrieval system.

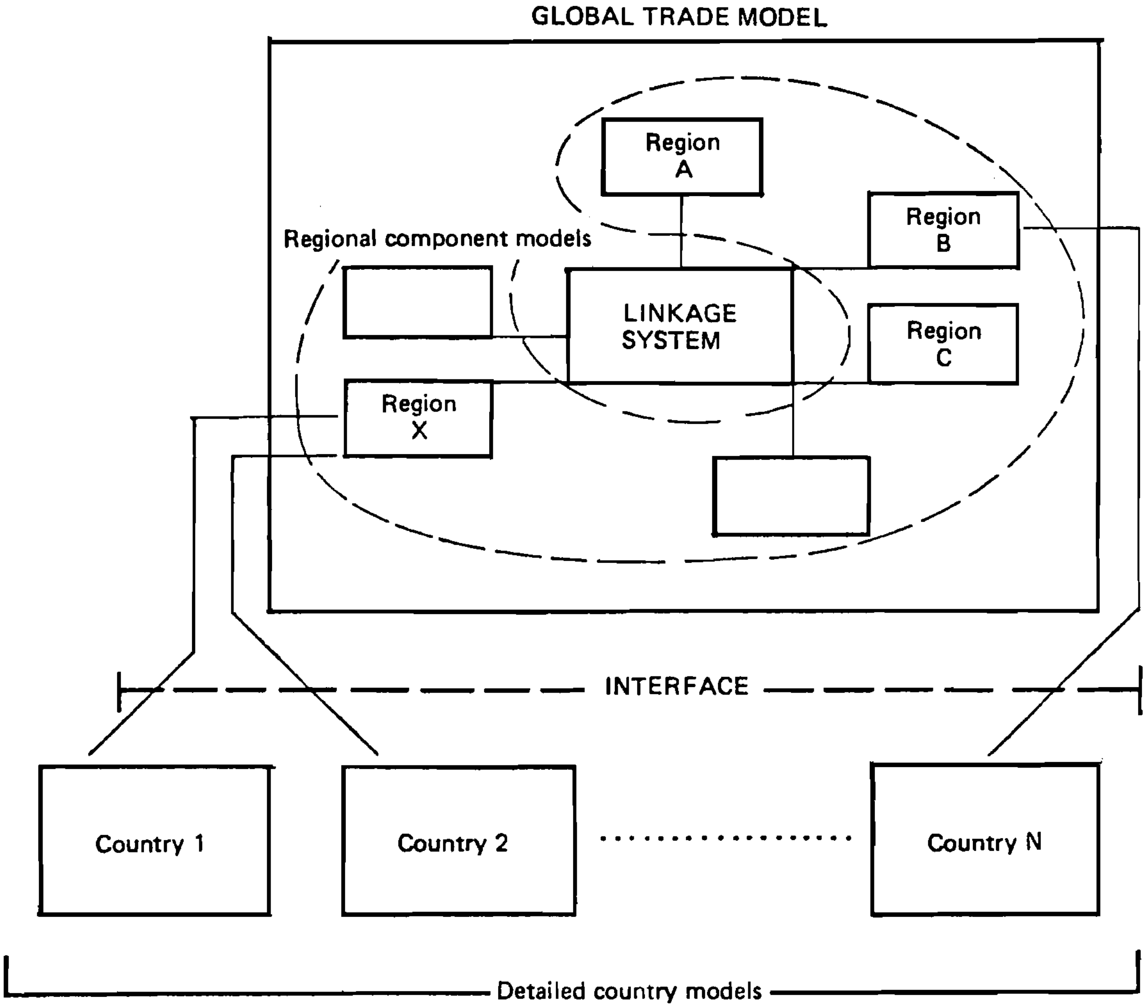

Figure 2. Interaction of Global Trade Model and Detailed Country Models in final phase of Forest Sector Project.

This database will be useful in the construction and calibration of country or regional contributions to the GTM, in the development of DCM's in Task A, and will be essential in the final assembly and de-bugging of the GTM in Sub-task B-5. The base should be located on, or readily accessible by, IIASA computer facilities and its development overseen by a permanent IIASA staff person. It is important to stress that the database has to be built at a as detailed level as possible from the beginning. the constraints in building the database at a detailed level are generated from the physical availability of detailed data on products and for countries. The detailed database can then be aggregated to the level which corresponds with the first step of the development of the global model.

Sub-task B-4. ***Construct and Calibrate Regional Component Models***. Given the RC prototype of Sub-task B-2, this sub-task involves the application, modification, and calibration of the prototype to specific countries and country groups as given in Table 1. It is proposed that this work be conducted by one or more country group representatives, working in close coordination with permanent IIASA staff. While every option for flexibility in meeting specific country/region conditions should be available at this stage of modeling, it is nonetheless essential that the calibrated RC's meet linkage requirements. It would seem most desirable to conduct this work at IIASA through secondments of researchers from participating countries. This would minimize problems of computer adaptability and enable close cooperation between the RC model builders and researchers working on final development of the linkage mechanism.

Sub-task B-5. ***Assembly and Final Construction of the Global Trade Model***. This sub-task involves the assembly and completion of the GTM. Although it cannot be finished until all RC's are calibrated, preliminary testing and experimentation can, and should, be initiated as soon as the structure of the linkage mechanism is reasonably clear. Experiments with "joint" simulations involving the GTM and any available DCM's should also proceed at the earliest possible date, both to help anticipate problems in Sub-task B-6 and to provide guidance for RC calibration in Sub-task B-4.

Sub-task B-6. ***Joint Simulations with Detailed Country Models and the Global Trade Model***. In this final sub-task, a number of "joint" simulations will be made using the Global Trade Model and the available Detailed Country Models. The objectives of the sub-task are (i) to develop efficient methods for interfacing the aggregate input and output of the GTM with the more detailed DCM's, and (ii) to construct a set of scenarios depicting future development of world trade which are of value to the participating countries.

The best means for joint use of the two classes of models (objective i) is not clear *a priori*. Two problems exist: (a) how to disaggregate results from the GTM to individual countries (where there are several countries in a country group) or regions within a country (where single countries are employed in the GTM, e.g., Canada or USSR); and (b) how to obtain consistent results in joint runs of the two types of models. To illustrate, consider a single country with an operational DCM which is represented in the GTM as part of a multi-country aggregate. GTM simulation results for production, consumption, prices, and for multi-country aggregate must somehow be disaggregated so that single country's share of these totals can be determined.

To illustrate these problems further, consider the following possible solution. Since world demand and market prices are likely to be exogenous to DCM's, one obvious approach might be as follows:

(i) develop a scheme for disaggregating GTM results, e.g., by proportions or averages;

(ii) conduct a GTM simulation, disaggregating results using (i);

(iii) conduct a DCM simulation using world market and other appropriate information from (ii) as input;

(iv) compare country and other appropriate results from (ii) and (iii). If results are "close enough", stop. If results are not sufficiently similar, return to step (ii) modifying exogenous inputs to, or parameters of, the GTM based on results from the DCM simulation.

Obviously many factors would influence the speed of convergence of this process, and, of course, there are many alternative approaches. In any case, it is envisioned that this process would take place on a country-by-country basis, and that experience gained in solving the interface problem would be cumulated and communicated to users by the IIASA staff.

For the final objective (ii) in this sub-task, individual user countries would employ the GTM, their own DCM, and the available interface knowledge to develop simulations on issues of specific concern to each user. IIASA staff would assist in this process.

1.3 Timetable and Resources

Figure 3 gives an approximate timetable for the accomplishment of the several elements and sub-tasks in both Tasks A and B of the Forest Sector Project. In the nearly three years that remain in the Project, the most critical stages are those proposed for initiation up to January 1983.

To provide some idea of the scope of the project and its feasibility in terms of resources required from internal IIASA and external sources, Table 2 has been developed. From internal funds IIASA would have to support approximately 80 man-months of researcher and staff time (excluding project leader and secretaries) over the next 36 months. Roughly 22 man-months would be required in secondments from participating countries.

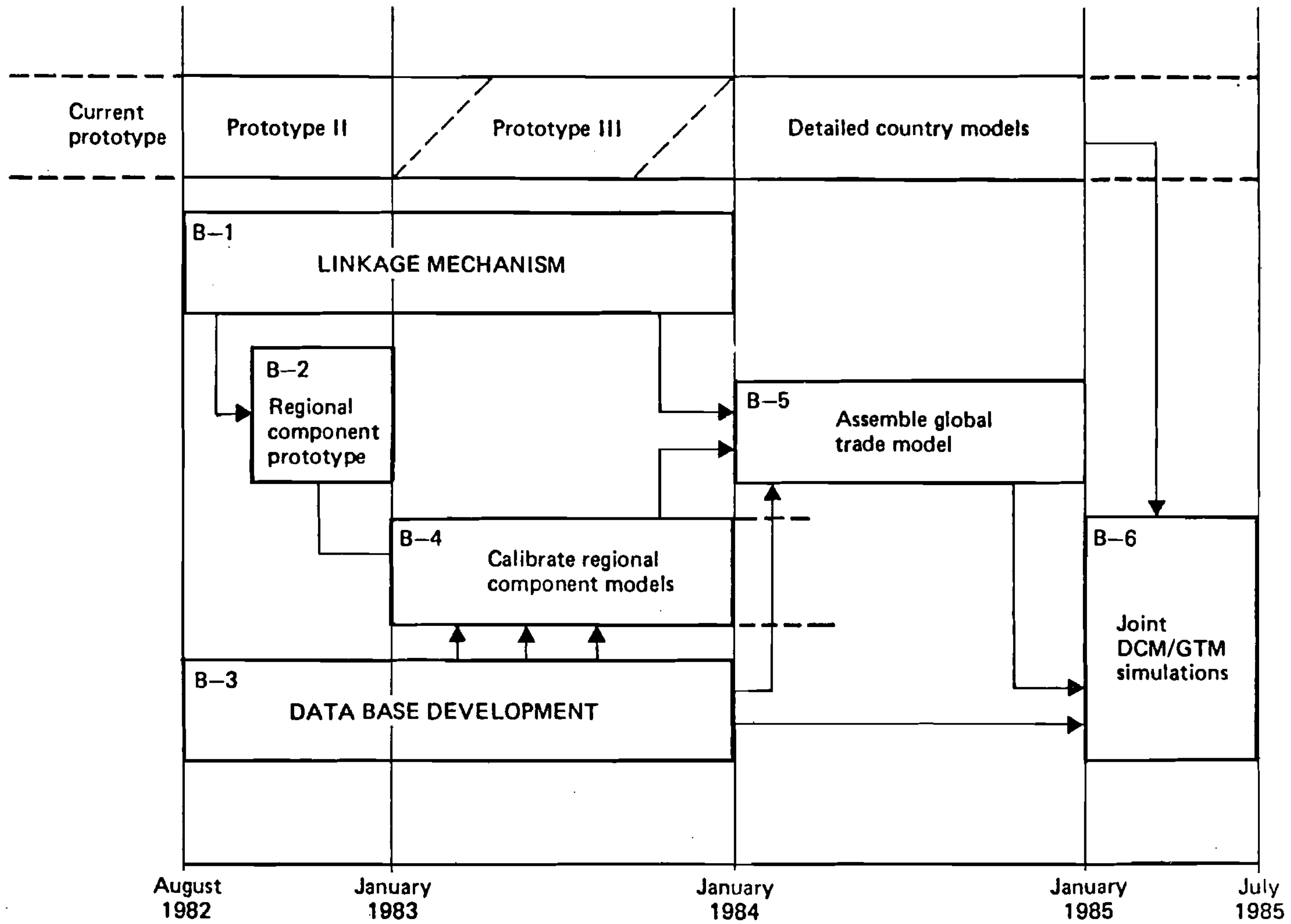

Figure 3. Timetable for initiation and completion of tasks and sub-tasks per recommendation.

Table 2. Personnel resources requirements for completion of Forest Sector Project per recommendation.

Task/Sub-task		IIASA +internal	External (Secondments, other)
		(man-months)	
B-1	Linkage mechanism	3-12	+[a)]
B-2	Regional component models prototype	4	
B-3	Database	6	22
B-4	Calibrate regional component models	27	
A	Further development of Detailed Country Model prototype	24	+
B-5	Assembly Global Trade Model	6-12	
B-6	Joint simulation	3-6	+
	Totals	73-91	22+

a)+ = additional personnel involved from participating countries

2. PRODUCT DEMAND MODULE

As an aid in further development of both individual country and global demand modules, this section presents: (1) a brief discussion of general considerations in demand modeling, (2) a survey of past studies of forest products demand, and (3) a critique of demand modeling approaches viewing the demand module in isolation and as a part of a larger forest sector model. Time has not permitted an exhaustive treatment but, we believe, all of the major considerations have been addressed.

In this section, attention is restricted to the demand for products such as lumber (sawnwood), plywood, reconstituted wood-based panel products (particleboard, flakeboard, etc.), paper, paperboard, fuelwood, posts, poles, ties, cooperage, and so forth. There is, of course, a demand at a "lower" market level for logs or roundwood for processing into the above listed products, but this demand is treated in another module. Demand is further restricted here to mean the demand by end-users for immediate consumption in a given country or region. The inventory-holding behavior of market intermediaries is not discussed nor are processes by which end-use demand and inventory adjustment are translated into "new orders" received by producers.

It goes without saying that the general structure of a demand module will depend on the objectives of the modeling process. In the IIASA Forest Sector Project, concern for objectives arises in two ways. First, the primary concern in the Project is with market and resource developments in the long-term rather than short-term cyclical issues. Thus demand structures may, *in some cases*, ignore certain market elements which are of strictly short-term importance, e.g., inventories held by consumers and market intermediaries. Second, in the development of individual national models, participating countries may chose to incorporate great detail in the product demand module. For the models which are to be linked in the global trade analysis, however, much less detail will be possible (given concerns for computational feasibility) and fairly specific model forms may be required to accommodate the global linkage mechanism adopted. As a consequence, the discussion here tends to emphasize "long-term" models, but little can be said (except in very general terms) about compatibility with the linkage mechanism.

2.1 Basic Demand Modeling Philosophy

2.1.1 Market Characteristics as Guides to Modeling Approach

The basic point of departure in modeling the markets for industrial commodities such as forest products is a consideration of the degree of competitiveness of the market. Where the market lies in the continuum between full competition and monopoly has significant implications for the approaches used to model consumption, production, and prices. The basic classification criteria include:

(1) the number and size of buyers and sellers and the degree of market influence of each,

(2) the costs or physical requirements for entering the market as either a buyer or seller, and

(3) the degree of homogeneity of the product and the ability (or leaving) of producers to differentiate their products from those of other producers.

Where the number of market participants is large and their individual influence is small, barriers to entry are limited, and product differentiation minimal, markets resemble the competitive model of economic theory in their behavior. Where participants are few, market power concentrated, entry costs high, and product differentiation substantial, markets resemble the oligopolistic or monopolistic structure of theory.

Given what is known about forest products markets in most countries of the world, some generalizations can be drawn.

(1) No single competitive classification suitably describes the markets for all forest products. Some product groups seem to be more competitive while others are much less so. Even within a given product category, e.g., paper, the situation may vary substantially from one product grade to another.

(2) No product category displays all of the elements required for fully competitive behavior. Some form of oligopoly seems to be the prevailing structure, although roughly speaking sawnwood and panel products markets tend to be more competitive than those for paper and paperboard, while (qualitatively) pulp markets seem to fall somewhere between these two groups.

A second point, of particular concern in modeling demand for forest products, is the role of forest products in their various end-uses. For the most part forest products are "producer goods"; they are employed in additional production activities to yield goods or services which are in turn marketed to final consumers (fuelwood maybe an exception to this classification in developing countries). Thus demand for most forest products may be viewed as a derived demand for a productive factor or input. Furthermore, in these secondary production processes, forest products generally account for a very small fraction of total production costs. Thus, for example, kraft linerboard is employed to produce corrugated packaging which is used in shipping applicances, food, and a vast array of other products. The cost of the box, and of the liner used to make it, represent a very small fraction of the total delivered price of the good. Even newsprint, which represents the bulk of the physical substance of a newspaper, accounts for only a small part of total publication costs. Similar observations can be made for sawnwood employed in construction, manufacturing, furniture, and repair and alterations. In the U.S., for example, where sawnwood is extensively employed in housing construction, wood inputs represent less than 15 percent of total housing unit construction costs and an even smaller fraction when land and financing costs are included.

As a consequence of these characteristics, the short-term price elasticity of demand for forest products tends to be quite low. Large changes in forest products prices have only limited impacts on total production costs and hence consumption in the short-term changes very little. In the long-term, however, the price sensitivity of demand may be substantially higher. Sustained differentials in the *costs per unit of end- use activity* between forest and substitute products present opportunities for more less permanent cost-saving shifts in production techniques. Simple product-for-product substitutions in the same production process, e.g., the use of reconstituted wood-based panel products in place of plywood, may occur quite rapidly. In other cases, e.g., the substitution of plywood for lumber in housing construction or of plastics for paper in packaging, a basic change in the end-use production method may be involved. Such changes require some time to accomplish. Producers must learn new production methods, existing laws or institutions may require modification, and new production facilities must be established (or old ones adapted). The resulting shifts in consumption may be quite substantial, once the full set of short-term rigidities is worked out.

2.1.2 Examples of Demand Modeling in Different Market Structures

Since markets for many forest products cannot be considered competitive in the classical economic sense, simple supply-demand models with simultaneous quantity and price adjustment are likely to be of relatively limited value in depicting market behavior. Further, the relative insensitivity of forest products demand to short-term price movements, but the potential significance of longer-term cost based substitution, suggest the need for demand models that focus on the details of forest products consumption activity in end-use markets. Specifically, it seems reasonable to attempt to disaggregate the demand process into parts which are dependent on forest products prices and those which are not. In this way it may be possible to more accurately identify the actual sensitivity of aggregate demand to price while at the same time providing a clearer picture of the causes of consumption movements. Two examples, from markedly different forest product markets, will clarify these notions.

2.1.2.1 Newsprint demand

A simplified outline of important determinants of newsprint demand is shown in Figure 2.1. There are four basic groups of factors:

(a) *newspaper demand* which depends on newspaper price and various elements of national income;

(b) *number of pages per newspaper* which depends in turn on the volume of newspaper advertising, prices of alternative advertising media and of newspaper advertising, industrial production, and national income;

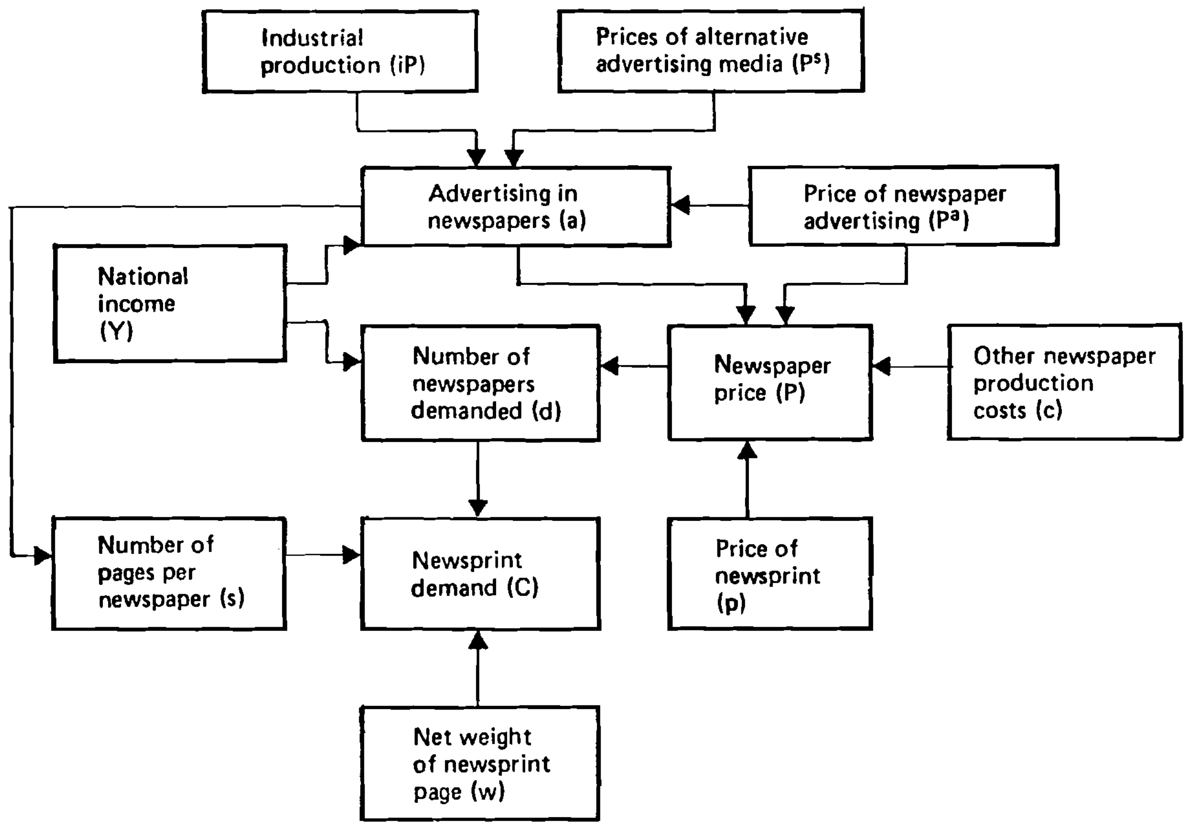

Figure 2.1. A tentative model structure for newsprint demand.

(c) *net weight of a newsprint page*, taken here as exogenous, though it might be considered a function of relative paper and non-paper costs since the basis weight (grammage) of the newsprint can be varied; and

(d) *newspaper price* which depends on newsprint and other input costs and revenues from advertising.

The following system of equations can be employed to represent this demand structure:

newspaper demand:

$$d = f_1(Y, P) \tag{2.1}$$

newspaper advertising volume:

$$a = f_2(P^a, P^s, iP, Y) \tag{2.2}$$

Number of pages per newspaper:

$$s = f_3(a) \tag{2.3}$$

newspaper price:

$$P = f_4(P^a a, p, c) \tag{2.4}$$

newsprint demand:

$$C = w \cdot s \cdot d \tag{2.5}$$

where newspaper advertising price is taken as exogenous. The newspaper pricing mechanism in equation (2.4) might be viewed as a "mark up" process, with price being set as some multiple of newsprint and other costs net of revenues from advertising. In any case, it is through this cost/price relation that newsprint price enters the model.

Though one may aim at a system such as (2.1)-(2.5), data may be unavailable on certain of the key variables such as P^a, d, a, or s. In this case, one may be forced to employ a more aggregative model, which at the most extreme would appear as:

$$C = f(p, P^s, w, Y, iP) \tag{2.6}$$

In fact this is the general model form most commonly applied. Note, however, that if (2.1)-(2.5) is the true model, the influence of newsprint price on consumption may be quite difficult to determine in (2.6) since, in fact, it enters the system indirectly via newspaper price.

2.1.2.2 Sawnwood demand in housing construction

The market for sawnwood (lumber) provides an example of a somewhat different market structure. Lumber is consumed in a wide range of durable end-use categories: housing, non-residential construction, manufacturing, furniture, repairs and alterations being among the most important. In many countries lumber markets approach the competitive structure in that there are numerous producers and consumers, there is relatively little product differentiation, and barriers to entry are limited. The general end-use categories, however, are far from homogeneous in terms of basic demand determinants, responsiveness to price, and rates of technical progress. As a consequence, models of lumber demand are commonly broken into segments corresponding to the several identifiable end-use categories. Total lumber demand is obtained by summing demands across end-uses.

Figure 2.2 outlines some of the significant considerations in a model of lumber demand for use in new housing. There are three basic elements: the number of new housing units produced, the average size of these units (floor area per housing unit), and lumber consumption per square foot of floor area in the average housing unit. New housing production depends in turn on two major groups of factors: the basic "demand" or requirement for new housing and consumers' ability to purchase new housing units. Housing requirements are derived from a subsidiary model which projects the rate of net household formation, replacements and removals from the housing stock, and the housing vacancy rate as functions of basic demographic factors and the inventory of existing housing. Physical housing requirements are then adjusted in light of the average cost of a new housing unit relative to consumers' disposable income. This model element might be written in functional form as:

$$H_t = h\left[H_t^D, \sum_l u_l\left[C_{t-l} / Y_{t-l}\right]\right] \tag{2.7}$$

where H_t = new housing production in period t, H_t^D = new housing demand or "requirements", and $\sum_l u_l\left[C_{t-l} / Y_{t-l}\right]$ = a distributed lag in the ratio of housing cost to disposable consumer income. Lumber prices enter as a part (albeit a fairly small one) of housing cost.

Average housing unit size depends heavily on consumer preferences and desires for use of the housing unit and on the average cost of the unit. It may be represented as:

$$\left(\frac{A}{H}\right)_t = s\left(d_t, \sum_k w_k C_{t-k}\right) \tag{2.8}$$

where $\left(\frac{A}{H}\right)_t$ = average size per housing unit, d_t = a qualitative dummy variable representing consumer preferences, and $\sum_k w_k C_{t-k}$ = a distributed lag in housing cost.

The final element, lumber use per unit of house size (floor area in this case), is in effect the housing producer's derived demand relation for lumber. It depends on the relative prices of lumber and its substitutes in housing construction and, in some formulations, on the relative price of lumber and the price of the completed housing unit (i.e., the "product" price). Functionally, this can be written as:

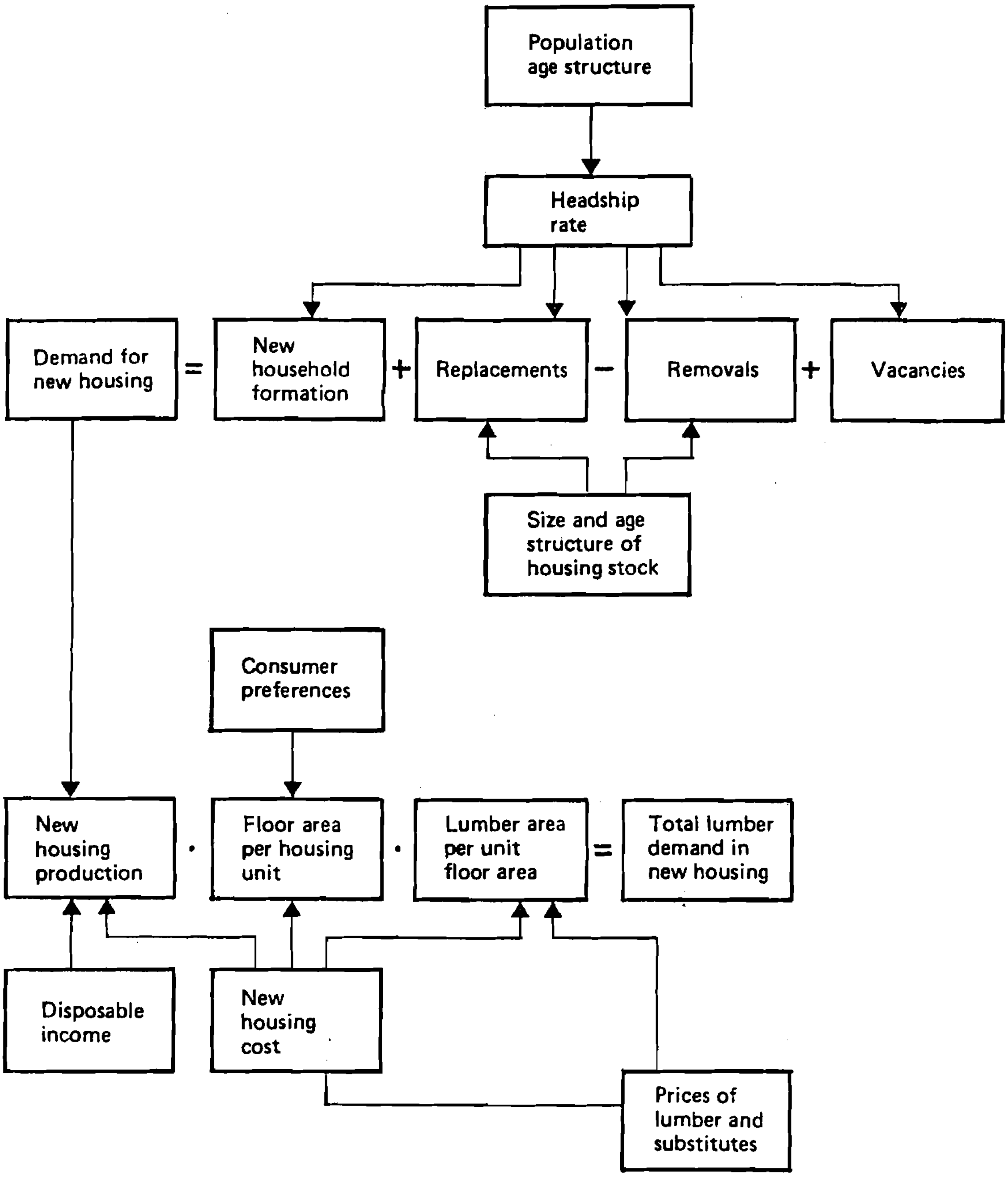

Figure 2.2. Basic structure of a model of lumber demand for use in new housing construction.

$$\left[\frac{C}{A}\right]_t = c\left[\sum_i v_i\left[P_{t-i} / C_{t-i}\right], \sum_j n_j\left[P_{t-j} / P^s_{t-j}\right]\right] \tag{2.9}$$

where $\left[\frac{C}{A}\right]_t$ = is the average lumber use per unit housing size, $\sum_i v_i\left[P_{t-i} / C_{t-i}\right]$ = is a distributed lag in relative lumber and housing prices, and $\sum_j n_j\left[P_{t-j} / P^s_{t-j}\right]$ = is a distributed lag in relative prices of lumber and substitutes.

Total lumber demand for use in housing, D_t, is then

$$H_t\left[\frac{A}{H}\right]_t\left[\frac{C}{A}\right]_t = D_t \tag{2.10}$$

Where data are available, equations (2.7), (2.8), and (2.9) may be estimated separately. In other circumstances it is often necessary to attempt to estimate (2.10) directly, e.g., as:

$$D_t = D\left[\sum_j n_i\left[P_{t-j} / P^s_{t-j}\right], \sum_i v_i\left[P_{t-i} / C_{t-i}\right], H_t, d_t, \sum_k w_k C_{t-k}\right] \tag{2.11}$$

This, of course, would lead to precisely the same problems as noted in the case of equation (2.6). While possible in theory, it may prove an empirical impossibility to disentangle all of the many separate influences represented in aggregate equations of this sort.

2.2 An Overview of Approaches to Demand Modeling

Past studies of forest products demand have been grouped, in the following discussion, into four categories based on the form of the dependent variable and the treatment of price-based substitution. These are:

(1) *consumption models without prices*, in which total product consumption is related to lagged values of itself, (directly or indirectly) to a time trend variable, and/or to some distributed lag in national income (or a similar measure of aggregate economic activity);

(2) *direct demand models*, in which total product consumption is related directly to product price and other relevant variables, in multi- or single- equation systems, with or without distributed lags;

(3) *end- use models with exogenous processes of price- based substitution* in which consumption per unit of end-use activity is identified but is not linked to prices in a formal relation;

(4) *end- use models with endogenous processes of price- based substitution*, in which consumption per unit of end-use activity is identified and linked to prices and other relevant variables in multi- or single-equation systems, with or without distributed

lags.

Within each of these categories models have been further identified based on the type of data set employed (cross section, time series), multi- or single equation system, and static or dynamic model structure.

2.2.1 Consumption Models Without Prices

The general model of this class can be written as

$$C(i,t) = f\left[Dl(A(i,t)),\ Dl(C(i,t))\ e(i,t)\right] \tag{2.12}$$

where $C(i,t)=$ consumption of a specific forest product in country i at time t either total or per capita; $A(i,t) =$ some measure of national income or aggregate economic activity either total or per capita; $Dl(\ ) =$ a distributed lag operator; and $e(i,t) =$ the disturbance term.

From the standpoint of economic theory, equation (2.12) might be viewed as a "dynamic Engel curve." If relative prices of the forest product and its substitutes have been constant in the past, and are expected to remain so in the future, then one can ignore the demand function *per se* and concentrate solely on non-price demand shifters, in this case A. Distributed lags in C and A may be introduced to represent shifts in the taste and preference structure of users over time. The notation of (2.12) is such that both models of cross-sectional and/or time series type are included in it.

The simple static time series form of (2.12)

$$C(t) = f\left[A(t), e(t)\right] \tag{2.13}$$

is often used as a tool for forecasting (see, for example, BIS 1980, Hair 1967, Resources for the Future 1960, and US Forest Service 1980). The advantages of the model are simplicity in structure and availability of data. The disadvantage of the approach is that in terms of causality it has very little to contribute to the understanding of the factors that influence consumption. The simple static cross section form of (2.12),

$$C(i) = f\left[A(i), e(i)\right] \tag{2.14}$$

has also been employed in studies of forest products demand, for example, in the study by Buongiorno and Grosenick (1977) where per capita measures of consumption and income were used.

The study by Sundelin (1970) employs equation (2.12) in a combined (static) cross section/time series approach. Sundelin argues that although the predominate pattern of a cross-sectional curve at a specified time period seems to be close to a logistic function, individual countries do not tend to follow the growth curve as their GDP increases. He then suggests a combined cross section/time series approach where individual country patterns (specific trends) as well as other factors unique for the country are considered. Subsequent studies of Jaakko Poyry (1972) generally follow this approach.

In the studies by FAO/ECE (1976) and Buongiorno (1977) equation (2.12) was employed in its most general form. As one might suspect, strong serial correlation in the series C led to the result that the distributed lag in past values of C was the most important explanatory variable.

2.2.2 Demand Models with Total Quantity a Function of Price

Models of this type may be denoted in general as

$$C(i,t) = f\left[\sum_j \omega_j P(i,t-j), \sum_k \mu_k A(i,t-k), \sum_l \nu_l Z(t-l), e(i,t)\right] \quad (2.15)$$

where i refers to the country or region, and demand (C) is a function of distributed lags in past values of the forest product and substitute prices (P), measures of general economic or end-use activity (A), population, qualitative dummy variables, etc. (Z), and an error term (e). This is the ordinary neoclassical derived demand function for a factor of production. Note, however, that while theory suggests that the *price* of the end-use product (the product manufactured from the lumber, paper, etc.) should appear in (2.15), the level of the end-use *activity or output* (A), appears instead. This substitution is justifiable using so-called "partial reduced form" equations and has been adopted in all existing forest products demand studies that have employed (2.15).

The form (2.15), or some variant, is the most commonly used approach to demand modeling in the forest sector. The major functional forms and examples from the literature are:

(a) simple static time series models of the form

$$C(t) = f\left[P(t), A(t), e(t)\right] \quad (2.16)$$

Holland (1958) and Chatterjee (1976);

(b) simple static time series models of the form

$$C(t) = f\left[\sum_j \omega_j P(t-i), \sum_k \mu_k A(t-k), \sum_l \nu_l Z(t-l)\right] \quad (2.17)$$

Eklof (1978), Adams and Blackwell (1978), Baudin (1977), McKillop (1967), and Adams (1979);

(c) combined cross section/time series dynamic forms, i.e., equation (2.15),

Aberg (1968), Buongiorno (1978).

Although this category of models is broad and includes an heterogenous array of studies, some common problems can be identified.

(1) Price data is notoriously difficult to obtain, and for many types of forest products and geographical regions available data is of questionable quality.

(2) Models in this category are often employed to represent demand for fairly broad product groups, e.g., all softwood lumber or all paper. These groups are not at all homogenous either in terms of the specific products included or in terms of the various end-uses in which they are employed. This gives rise to two further difficulties.

   (a) Different product subcategories or end-uses often have quite different demand price elasticities. There is no guarantee that the use of a single "average" price term (P) will yield anything like the "average" price elasticity for the entire group.

   (b) Since the product is employed in several end-uses, it is reasonable to wish to include several end-use activity indicators (A) in the model. This often leads to serious statistical problems (multicollinearity) and to unrealistic estimates of the independent impacts of the various end-use indicators.

(3) Since demand for forest products tends to be quite inelastic with respect to short-term price movements (for the reasons noted in Section 2.1), estimation of the several distributed lag structures in (2.15) or its variants becomes a major concern. This is, of course, a difficult statistical problem even in the best of circumstances but is made worse here by the points noted in (1) and (2) above.

2.2.3 End- Use Models with Exogenous Estimates of Price Elasticity

Models in this and the following category (2.2.4) can be described by the equations:

$$U(e,t) = C(e,t)/A(e,t) = f\left[DL(P),DL(PS),DL(PP)\right] \qquad e = 1,\ldots,E \tag{2.19}$$

$$C(t) = U(1,t)A(1,t) + \ldots + U(E,t)A(E,t) \quad . \tag{2.20}$$

where $U(e,t)$ = end-use factor, consumption of some forest product per unit of activity in end-use e in period t; $C(e,t)$ = consumption of some forest product in end-use e, time t; $A(e,t)$ = measure of activity in end-use e, time t; $DL()$ = a distributed lag or delay operator; P = price of forest product; PS = price of substitutes; PP = price of end-use products; E = total number of end-use categories; and $C(t)$ = total consumption of the forest product.

This set of relations would be developed for some specific forest product, e.g., softwood lumber or newsprint. Similar sets would be developed for each product category being studied.

The distinction between the present and subsequent model categories is that equations (2.19) are not estimated by any statistical means in the present category. Indeed, there is no formal "fitting" process to historical data at all. Rather it is assumed that if historical trends in the relative prices of forest products and substitutes were to continue into the future, the general historical trends in end-use factors $[C(e,t)/A(e,t)]$ will continue as well. The product of projected end-use factors and (exogenously) projected end-use activity indicators $[A(e,t)]$ gives the projected demand volume at trend price. The result is a set of individual price-quantity points one for each of the time points in the projection period. Demand functions, to assess demand levels at other than "trend prices," are determined by applying demand elasticity estimates, derived from other sources, to each of the several price-quantity points under some specific assumption about the form of the demand function, e.g., linear or constant elasticity.

This approach has been applied extensively by the U.S. Forest Service (1952, 1962, 1972, 1975) and most recently by Adams and Haynes (1980) and the U.S. Forest Service (1980). These applications have been restricted, however, to sawnwood and panel product categories. Computation of the use-factors C/A may, for some end-uses, involve more than one step (for example, see the sawnwood-housing example in section 2.1). The basic consideration in defining the use-factor is to isolate that aspect of end-use consumption that is price sensitive from the (one or more) parts that are not. The primary advantage of this approach is the reduction or disaggregation of the total consumption of some forest product into a set of end-use categories each of which has relatively homogenous behavior. In this way, price and other influences on demand are more readily and (it is thought) more accurately identified. Since little or no statistical processing is involved the approach may be useful as a means of obtaining rough estimates of consumption, demand, and price impacts where more detailed efforts are impossible or unwarranted.

As it has been traditionally applied, this approach requires a substantial amount of detailed data. The essential data element, time series of product consumption by end-use category, are not widely available and must, in most cases, be constructed from a few sample points and an array of related data series. Acceptable measures of end-use activity (e.g., housing starts, manufacturing activity, etc.) must also be available. If the number of end-use categories is quite large and diverse, projection of the several end-use activity indicators may itself become burdensome.

Beyond data problems, the approach has numerous flaws. Since the end-use factors are not explicitly linked to relative prices, it is impossible to distinguish between the impacts of changing relative prices and other determinants such as shifting user preferences (lumber use in furniture is an important example of the influence of non-price factors). Thus, the actual location of the "trend" price-quantity pairs in price-quantity space is highly suspect. Similarly the application of exogenously determined price elasticities to establish demand functions is strictly *ad hoc* since the elasticity is arbitrarily assumed to apply to the trend points.

2.2.4 End- Use Models with Endogenous Estimates of Price Elasticity

As previously noted, equations (2.19) an (2.20) comprise a mathematical description of this final category of demand models as well. In this case, however, the coefficients of the distributed lags in equations (2.19) are estimated by statistical means from historical (time-series) data. This method has been employed by Robinson (1969) in an early exploratory paper on lumber markets and extensively by Data Resources, Inc., (Cardellichio and Veltkamp, 1980; Veltkamp, Young, and Berg 1981) in models of lumber, plywood, other wood-based panel products, and pulp, paper, and paperboard markets in the US, Canada, Japan, and parts of western Europe.

In this approach demand elasticity estimates are derived directly from the statistical fitting process and need not be applied in the *ad hoc* fashion of the models in section 2.2.3. Efforts have also been made, particularly in the Data Resources models, to disentangle price and non-price effects on end-use factors through the inclusion of time trends and qualitative dummy variables in the specification of equations (2.19). Use of statistical estimation techniques, of course, entails an even greater burden of data collection and development.

Where data on end-use disposition of products is unavailable, as is the case for most paper products, this approach may still be employed by identifying as the end-use activity indicator (A) some measure of activity in the most important end-use category. For example, Cardellichio and Veltkamp (1980) report an analysis of demand for coated two-side printing papers in which the end-use activity for this product group is measured by the book publishing and commercial printing component of the U.S. industrial production index. It is known, of course, that some portion of the product in question is consumed in uses other than book publishing and commercial printing. In this case, use of equation (2.19) is equivalent to the demand relation (2.15). Advocates of this approach argue that most of the advantages of end-use analysis are preserved even through the activity indicator does not cover all end-uses. It should also be noted that this method has generally been applied with very narrow product category definitions.

2.3 Critique of Modeling Approaches

2.3.1 Summary of Model Characteristics

Based on the survey in section 2.2, the following advantages and disadvantages of the several modeling approaches can be summarized, *viewing the demand module in isolation.*

2.3.1.1 Non- price consumption models

Advantages

— may be only feasible approach where data is limited

- may be a reasonable representation of demand for some classes of products in some regions where market exchange is limited (e.g., fuelwood in developing countries)
- ease of construction and projection

Disadvantages

- highly abstract representation of causal mechanisms
- clearly inappropriate where relative prices of forest products and substitutes have or are expected to fluctuate.

2.3.1.2 Models with total quantity as a function of price

Advantages

- somewhat more detailed representation of causality than non-price models
- requires less data than end-use factor models (for some product categories)

Disadvantages

- price data often of poor quality
- when used to model aggregate product categories, often impossible to distinguish price effects or separate effects of several activity measures

2.3.1.3 Use-factor models with exogenous price elasticity estimates

Advantages

- simple to apply, allows input of qualitative information in use-factor projections and elasticity estimates

Disadvantages

- use-factor projections and elasticity adjustments strictly *ad hoc*

2.3.1.4 Use-factor models with endogenous price elasticity estimates

Advantages

- demand behavior more homogenous by end-use category
- end-use factors afford convenient means of representing changes in technology and consumer preferences
- for some products, end-use factor models allow isolation and more realistic modeling of price sensitive elements of demand.

Disadvantages

- requires considerable data, not widely available for all products or regions
- where consumption cannot be broken out by end-use category and use factors are formed as the ratio of total consumption to some measure of activity in the *principal* end-use category—not clear that this is an advantageous approach (e.g., most paper grades)

2.3.2 Integrating Demand Models into Forest Sector Models

Consideration must also be given to the interaction of the demand and other modules in a larger model of the forest sector. The basic question is whether the structure of the demand module necessarily influences the form or properties of other parts of the forest sector model.

The most likely elements of the overall model (either a detailed country model or global trade model) to require some adaptation to the structure of the demand module are the product market (price/quantity) adjustment module and the (intercountry) trade linkage mechanism.

Given the state-of-the-art in model solution methodology specific functional forms employed in the demand module (e.g., linear or non-linear) should present only limited difficulties. Of greater concern are the dynamics of demand adjustment over time and the presence and form of linkages among demands for different products. In the case of a detailed model of a single country or region, where "rest of the world" market behavior is taken as exogenous, the product market (price/quantity) adjustment mechanism would clearly have to be structured to accommodate the presence or absence of: (1) any contemporaneous sensitivity of product demand to current period market price; (2) any inventories held by consumers or market intermediaries, since these represent another element of adjustment feasibility; and (3) any contemporaneous interdependence of demand for different products (e.g., lumber and plywood as substitutes in housing construction or other end-uses). For a global trade model, presuming that its structure would be somewhat more aggregated and simplified than an individual country model, product inventories may not be considered. Whether or not current period own price and cross-price demand elasticities are zero, however, remains an important issue for the structure of the linkage mechanism.

2.3.3 Conclusions

The foregoing discussion in this section admits of some generalizations and broad conclusions regarding the structure of, and modeling methods appropriate to, the demand module.

(1) In both detailed country models and more aggregate global trade models, the basic point of departure in demand module construction is a consideration of the competitive structure of the market(s) under study.

(2) Specific market conditions and availability of data will constrain the final demand modeling method selected. But where some discretion is possible, the end-use factor model with endogenous estimates of price elasticity (see 2.2.4) would appear to be the most desirable modeling approach for individual country models. Ideally, demand modules for global trade models might then be developed by aggregating results from the country models. Realistically, demand in global models is more likely to be modeled independently using the standard neoclassical demand functions discussed in section (2.2.2).

(3) Demand modules influence the structure of the remainder of the forest sector model via the trade linkage and/or product market (price/quantity) adjustment mechanisms. The most important concerns relate to the presence or absence of inventories at the consumer level and whether contemporaneous own and cross-price elasticities are zero. It should be noted that while these attributes will influence the form of linkage and adjustment mechanisms they should not be considered as "handicaps," since numerous approaches are available to accommodate them.

3. DATA PROBLEMS

3.1 Data and Model Building

A model is a simplified picture of reality. In most cases a model can be either complex or simple according to the problem studied and the model builder's filtering of reality—his ideas, experience, and knowledge of the problem area.

The degree of simplification depends on:

- objectives of the study
- aggregation of products and regions
- time horizon
- availability of data
- available analytical techniques
- the complexity of "reality", i.e., the model builder's conception of the area to be analyzed.

Normally, it is appropriate to give the model a mathematical-statistical form. The data on which the analysis is based are an important issue in most economic statistical applications. The data problem can be separated into three blocks:

(1) availability

(2) quality aspects

(3) the use of data

Availability of data will be taken up as a separate question in section 3.3. The importance of getting access to the appropriate data for the analysis must, in this context, be emphasized.

Quality aspects of data (item 2) is in most situations related to availability in the sense that if data are of low quality there are in effect only limited data available. Quality, in this context, means that data are defined in a precise way, that data for one period are compatible with data of other periods, and that we can find data which are defined in line with the model. This means that there is an obvious relation between the model outlined and the data to be used.

Even more related to the model is the question of *what to do with the data* (item 3). Shall we transform data, e.g., log transformations? Should the data be adjusted in terms of differences, etc.? If the model is dynamic, there are obvious reasons for considering differences or other devices for achieving stationarity.

All these data aspects have an impact on the model building process. The availability of data influences the hypothesized model which might, in turn, have implications for the objectives of the study, the definition of the observation period, forecast period, product groups, and countries/regions to be analyzed. The adjustment of data has implications for the definition of the model to be estimated. There is also a feedback from the model control to data adjustment and availability. The relation between the model building process and data is summarized in Figure 3.1.

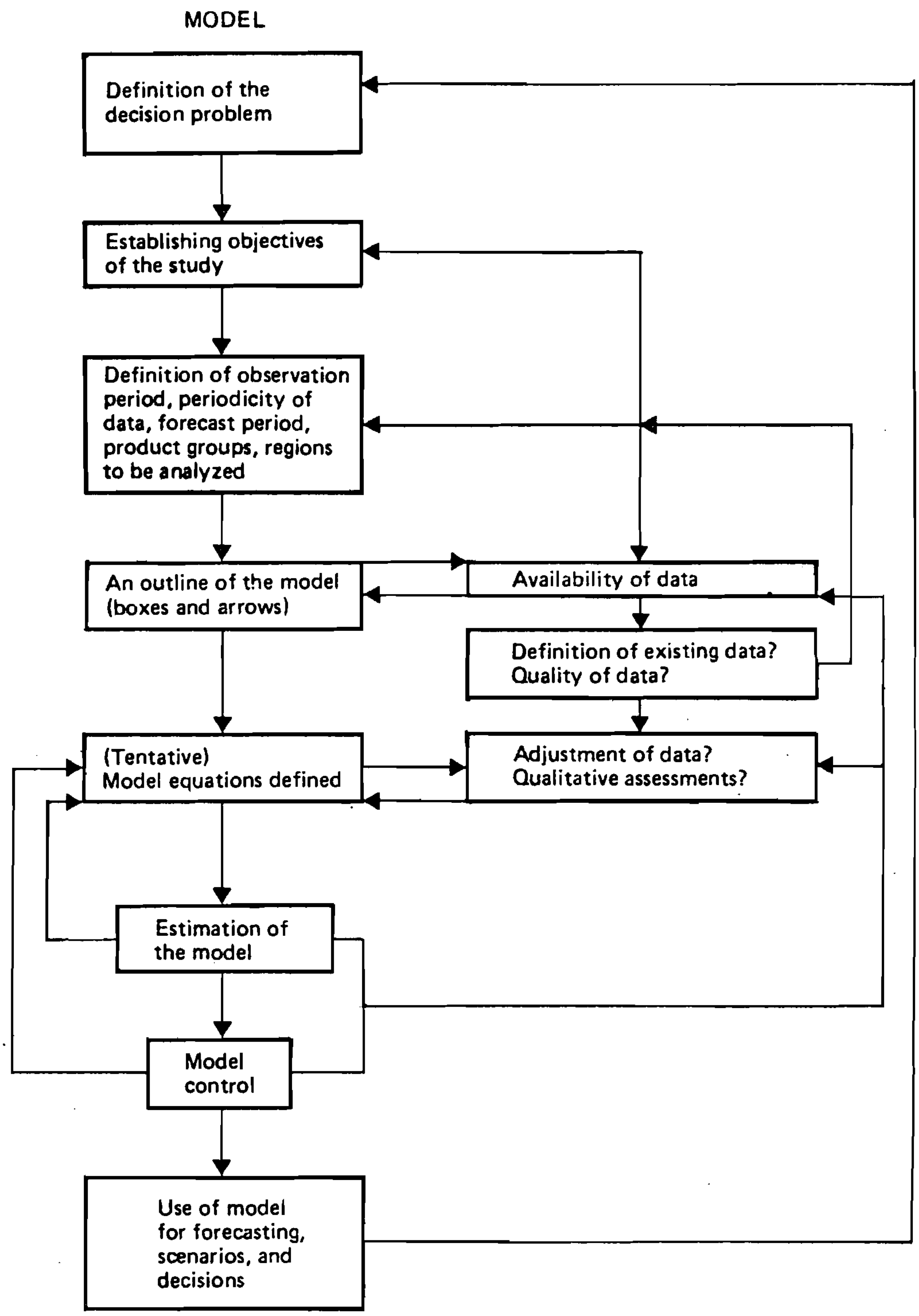

Figure 3.1. Model building and data.

3.2. Broad Types of Data Needed

In the section "Basic Modeling Philosophy" two examples are described: sawnwood (lumber) demand and newsprint demand. In these two cases the broad types of data needed in the actual analysis are also outlined. In these examples it is also possible to imagine the difficulties involved in obtaining the relevant input data for structural analysis of the forest sector.

3.3 Availability of Data

As discussed in section 1.1, one of the main objectives of the Forest Sector Project is to build a global model for analysis of demand, supply and trade with a time horizon of 20-30 years. In supplying this model with data many different data sources must be employed. Very often one specific data source will cover only a few geographical areas or economic activities. In Table 3.3.1 is a list which illustrates some of the major sources of data, the area covered, and the degree of availability. These sources cover both general economic data and more specific forest sector data which will be needed in developing a global model.

When using different data sources, problems of quality and compatibility in data will arise. Therefore it would appear to be essential that a databank will be established at IIASA (as proposed in section 1.2) for the purpose of compiling and storing consistent data for the global model. This databank can also service collaborating institutions with data as required in the construction of individual country models.

Many of the forces leading to structural change are generated by factors which are difficult to model or collect from the sources listed above. This data has the characteristics of "soft" information — experience, contacts in the trade, insights based on proprietary analysis, and so forth — as opposed to the "hard" data which are available from the sources in Table 3.3.1 above and which can be built into a formal model. To be successful in analyzing structural changes in the forest sector, it is necessary to work with both "hard" and "soft" data. The most effective way to get this "soft" information into IIASA's modeling process is through the establishment of a reference group of top level decision makers in the forest sector. The DST Group strongly recommends the establishment of such a group to provide the Project with "soft" information through periodic meetings and reviews with the core staff of the Project.

3.4 Division into Regions and Products

The division into regions and products for the global model at IIASA must start from a consideration of the historical and anticipated future patterns in demand, supply, and trade. A second important concern is the physical availability of data for regions and products. A third factor is that the grouping must be homogenous with respect to demand and supply factors. But a fourth, and very important, factor is the feasibility of constructing and solving a global model at a disaggregated versus aggregated level. The relation of aggregation level, modeling feasibility, and information generated at a global level is illustrated below.

Table 3.3.1. Availability of data

Source	Area	Degree of availability
FAO	Demand, Supply, End-use info	Free
European Timber Committee	Demand, Supply, Trade	Free
EEC (Luxembourg)	Demand, Supply, Trade, End-use info, Production costs	Restricted?
World Bank	Demand, Supply, End-use info, Trade	Free
Asian Development Bank	Demand, Supply, End-use info	Free
OAS	Demand, Supply, End-use info, Trade	Free
ASEAN	Demand, Supply, End-use info, Trade	Free
Economic Organization of African States	Demand, Supply, End-use info, Trade	Free
UNDP	Demand, Supply	Free
UNIDO	Demand, Trade	Free
National Industry Associations	Supply, Prices, Trade, Inventories, Production costs	Restricted
National Official Stations	Demand, End-use info, Trade Prices, Inventories	Free
OECD	Demand, Supply, Trade, Inventories	Free
European Paper Institute	Demand, Supply, Prices, Trade, Inventories, Production costs	Restricted
English China Clay	Demand, Prices, Production costs	Restricted?
Big consultant firms like: - SRI - DRI - Jaako Poyry - Bis Marketing Research	Demand, Supply, End-use info, Prices, Inventories, Production costs	Restricted
Individual companies	Supply, Prices, Inventories, Production costs	Restricted
GATT	Trade, Trade barriers	Free

	Disaggregated level	Aggregated level
Fraction of important information needed by decision-makers in the forest sector	large	small
Product and regional details	high	low
Modeling feasibility	low	high

Finally, for the grouping into regions a fifth criteria has also been used. The DST group has studied the countries which are collaborating with the Forest Sector Project at IIASA and made an estimate on the individual countries which can provide the global model with specific national data today and in the future. This criteria has influenced the choice of individual countries in the regional list. The basis for this estimation has been the DST group's judgment of the possibilities to set up national forest sector teams in different countries.

In the view of the DST Group, the global model must have a highly aggregated level as a starting-point. Using the five criteria noted above, we suggest the following initial grouping into regions and products for the global model.

Regional Grouping for Global Analysis

1. Africa
2. Canada
3. US
4. Brasil
5. Latin America excluding Brazil
6. China
7. Japanindivi
8. ASEAN
9. Asia excluding China, Japan and ASEAN
10. Finland
11. Sweden
12. Western Europe excluding Finland and Sweden
13. Hungary
14. Eastern Europe excluding Hungary

15. Australia
16. Oceania excluding Australia
17. USSR

Grouping of Products for Global Analysis

1. Pulpwood
2. Sawlogs-softwood
3. Sawlogs-hardwood
4. Fuelwood
5. Coniferous sawlwood
6. Non-coniferous sawlwood
7. Panels
8. Pulp
9. Newsprint
10. Other printing and writing
11. Other paper and board

These gropings would be used both for demand and supply elements of the model. Probably, decision-makers in the forest sector will find these groupings too aggregative. It is the opinion of the DST Group that the Project must start from this aggregated level and, in a stepwise fashion, expand to a more disaggregated level in the future development of the global model.

In the development of individual national models, it will be possible to work with a more disaggregated list of products from that shown above. The specific degree of disaggregation will depend on the specific country. The level of disaggregation chosen in different national models must, in any case, be aggregatable to the groupings presented above for the global analysis.

Another subject which is related to the issue of product groupings is the definition of products in demand, supply and trade-descriptions (data). When studying existing data sources it is revealing that different sources use different definitions. Therefore it is necessary to use an international standard for definition of different products in future analysis of demand, supply and trade. The standard which is recommended by UN organizations to their member countries is the Standard Industrial Trade Classification (SITC) code. The DST Group recommends that product definitions in models of demand, supply, and trade both at global and national levels follow the SITC code definitions as much as possible.

REFERENCES

Aberg, C.J. 1968. *The Demand for Paper and Paperboard in Western Europe 1950 - 1962.* Stockholm: Almquist & Wicksell.

Adams, D.M. 1977. Effects of National Forest Timber Harvest on Softwood Stumpage Lumber and Plywood Markets: An Econometric Analysis. Research Bulletin 15. Corvallis, Oregon: Oregon State University, Forestry Research Laboratory.

Adams, D.M. and R.W. Haynes. 1980. The 1980 Softwood Timber Assessment Market Model: Structure, Projections and Policy Simulations. *Forest Science Monograph* 22.

Adams, F.B., and J. Blackwell. 1973. An Econometric Model of the United States Forest Products Industry. *Forest Science* 19:82-96.

McKillop, W.L. 1967. Supply and Demand for Forest Products, an Econometric Study. *Hilgardia* 38:1-132.

Baudin, A. 1977. On the Application of Short-term Causal Models. Ph.D. thesis. Umea: Institute of Mathematics and Statistics.

BIS, 1980. *Business Opportunities in West European Softwood Markets.* London: BIS Marketing Research Limited.

Box, G.E.P and G.M. Jenkins. 1971. *Time Series Analysis Forecasting and Control.* San Francisco: Golden Del.

Buongiorno, J. 1977. Long-term Forecasting of Major Forest Products Consumption in the Developed and Developing Economies. *Forest*

Science.

Buongiorno, J. 1978. Income and Price Elasticities in the World Demand for Paper and Paperboard. *Forest Science*.

Buongiorno, J. and G.L. Grosenick. 1977. Impact of World Economic and Demographic Growth on Forest-products Consumption and Wood Requirements. *Canadian Journal of Forest Research*.

Cardellichio, P. and Veltkamp, J. 1980. Forest Policy Project. Study Module 2A. Technical Appendix. Documentation of FORSIM and Pulp and paper models. Draft Final Report. Massachusetts: Forest Products Division, Data Resources Inc.

Chatterjee, N. 1976. The Long-term Implied Income Elasticity of Demand of Forest-based Products in International Trade. *The Indian Forester*.

Eklof, J. 1978. Langsiktiga prisprognoser pa blekt bjorsksulfatmassa. SCA Teknik AB.

FAO, 1972. Outlook for Pulp and Paper Consumption, Production and Trade to 1985. Rome.

FAO/ECE. 1976. European Timber Trends and Prospects 1950 to 2000. Suppl. 3 to vol. XXIX of *Timber Bulletin for Europe*.

FAO, 1977. World Pulp and Paper Demand, Supply and Trade. Rome.

Grossmann, W.-D. L. Loennstedt, and R. Seppaelae. 1981. IIASA's Forest Sector Model — A Prototype Approach. Unpublished draft. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Hair, D. 1967. The Use of Regression Equations in Projection of Consumption of Pulp, Paper, and Paperboard. U.S. D.A. Forest Service, Forest Resources Report. Washington, DC.

Loennstedt, L. 1982. Mathematical Formulation of the Forest Sector Prototype Model —The First Step. WP-82-xxx. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Resources for the Future. 1960. *Resources for America's Future*. Baltimore: Johns Hopkins Press.

Seppaelae, R. 1982. Forest Sector Project. A Research Programme. WP-82-xxx. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Sundelin, A. 1970. *Paper and Paperboard Consumption Patterns and Development Trends of OECD Countries 1950 - 1967*. Paris: OECD.

US Forest Service. 1980. An Analysis of the Timber Situation in the United States, 1952-2030. Review Draft. Washington, DC.

Veltkamp, J., R. Young and R. Berg. 1981. The Data Resources, Inc.

Approach to Modeling Demand in the Softwood Lumber and Plywood and Pulp and Paper Industries. Paper presented at the North American Conference on Forest Sector Models, Williamsburg, US.