International Institute for
Applied Systems Analysis
IIASA www.iiasa.ac.at

The Analysis of World Trade in Forest Products: Part 1 - Conceptual and Empirical Issues

Batten, D.F., Johansson, B. and Kallio, M.J.

IIASA Working Paper

WP-83-050

May 1983

WORKING PAPER

THE ANALYSIS OF WORLD TRADE IN FOREST PRODUCTS: Part 1 - Conceptual and Empirical Issues

David Batten
Börje Johansson
Markku Kallio

May 1983
WP-83-50

IIASA
International Institute for Applied Systems Analysis

THE ANALYSIS OF WORLD TRADE IN FOREST PRODUCTS: Part 1 - Conceptual and Empirical Issues

David Batten
Börje Johansson
Markku Kallio

May 1983
WP-83-50

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

PREFACE

One of the central tasks of the IIASA Forest Sector Project is the *Analysis of World Trade in Forest Products.* The objectives of this task encompass several dimensions such as: (i) analyzing the structure and mechanisms of world trade in forest products in retrospect, as revealed in historical data, (ii) formulating a flexible linkage system which can interact with various regional component models, and (iii) generating alternative long-term scenarios of world trade of forest products in conjunction with various adjustment assumptions and regionally specified levels of production and consumption of the same products. Since the linkage system will interact with a variety of regional component models which specify regional supply and demand potentials, the need for flexibility points to a composite methodology which is capable of satisfying pertinent requirements emanating from various countries.

The present paper has been written with the purpose of raising significant conceptual and empirical issues pertaining to the analysis of trade flows in forest products and identifying the criteria that the global trade model must satisfy. It serves as a foundation for the development of the more detailed methodologies which are pertinent to the model as a whole, and will undergo revision as further suggestions on these issues evolve. The formal discussion of formulations for the Linkage System and the Regional Component Models, and the family of scenarios which the model can generate, will appear in companion papers.

This paper has resulted from a collaborative effort between the Forest Sector Project and the Regional and Urban Development Group at IIASA.

Markku Kallio
Leader
Forest Sector Project

Börje Johansson
Acting Leader
Regional and Urban
Development Group

CONTENTS

THE ANALYSIS OF WORLD TRADE IN FOREST PRODUCTS: Part 1 - Conceptual and Empirical Issues

David Batten, Börje Johansson and
Markku Kallio

1. INTRODUCTION

The purpose of this paper is to define and discuss the substantive conceptual, methodological and empirical issues pertaining to the development of a Global Trade Model (GTM) for IIASA's Forest Sector Project (FSP). A major goal of the FSP is to analyze the long-term adjustment process within the international market for forest products. An analytical tool in the form of a computer model which is capable of generating alternative scenarios of future trading patterns and prices based on a range of trading assumptions can be a powerful aid in this regard. In this paper, various issues which are pertinent to the development of such a tool are examined.

We begin by defining the scope and objectives of world trade analysis. The desired outputs of the Global Trade Model are outlined. The need for policy relevance emphasizes the advantages of a scenario approach. Then the joint problems of product classification and regional subdivision are addressed, and the process of *aggregation* is emphasized to provide an important element of flexibility with respect to the linkage process.

In Section 4, the empirical database (FTDB) which is currently being established is outlined, and historical aspects of structural adjustment in the trading patterns of certain forest products are examined. These empirical hindsights include an exploration of the speed of the adjustment process and the influence of inertia, by examining the predictability of historical changes in the patterns of trade flows and prices over one, five, and ten year intervals. Skewed patterns of trade dispersion are also identified.

The substantive determinants of world trade adjustments in the long-term are discussed in Section 5. This section begins with a decomposition of structural change into three components which influence future patterns of trade: (i) supply-related factors (ii) demand-related factors, and (iii) link-related factors. The first category includes the dynamic process of forest sector development in various regions, which is largely influenced by the dynamics of the forests themselves, technological changes in related forest industries, and their changing capacities. Demand-related factors, which include both intermediate and final consumption, respond mainly to changing consumer preferences or purchasing power and product developments which introduce new competing substitutes. Factors related to the linkage process include changes in trade preferences, trade barriers, transportation costs and capacities, other costs contributing to trade prices, and the overall mechanism determining trade flows.

It is concluded in Section 6 that in order to develop a Global Trade Model which is capable of addressing each of the determinants of world trade adjustments outlined in Section 5, a set of Regional Components and a Linkage System will be required. The choice of a suitable Linkage System must not only be consistent with observed trajectories of structural change in the trade patterns, but also be flexible enough to generate a wide range of scenarios based upon alternative assumptions concerning the future relevance of each of the substantive determinants. These criteria suggest a *composite* methodology, the details of which will appear in a companion paper (Batten, Johansson, Kallio: The Analysis of World Trade in Forest Products, Part 2, 1983).

2. SCOPE AND OBJECTIVES OF WORLD TRADE ANALYSIS

The Global Trade Model aims to provide a quantitative tool for the long-term analysis of structural changes in the pattern (flow volumes) and competitive terms (value and conditions) of worldwide trade in forest products. The words "forest products" are intended to define logs, pulpwood, fuelwood, sawn timber, pulp, paper, panels and various converted wood products. Thus the scope of the GTM encompasses all the primary and secondary products of the entire forest sector (forestry and forest industries). The word "long-term" implies a time horizon of at least twenty years.

The GTM will not be designed to forecast one single trajectory of structural change in the pattern of future trade flows. Rather it will be capable of generating a wide range of alternative scenarios based upon different opinions and assumptions concerning future trading possibilities. The generation of these scenarios will not be limited to the traditional area of sensitivity analysis. Instead, the scenario capability will be extended to the theoretical structure of the model itself and the actual mechanisms by which trade patterns may adjust over time. These additional dimensions of conceptual and methodological flexibility will allow a much richer range of trade policy alternatives and sensitive decision areas to be assessed. They will also ensure that a much wider audience will be able to participate in the specification and evaluation of alternative scenarios. In the face of limited information about various trading options for the future, such flexibility can improve markedly our understanding of the most appropriate policies needed in order to adapt to changing circumstances in the global forest sector.

The major scenario outputs from the model will consist of the most probable interregional pattern of physical trade flows for each forest product which are consistent with the chosen linkage assumptions, price-determining mechanisms, and appropriate supply and demand potentials in each region. These trade patterns will be computed at five-yearly intervals over the total time horizon. Secondary outputs which may also be of interest are the conditional supply and demand potentials of each region and a set of traded prices which are consistent with the chosen price adjustment mechanism.

Of major importance in determining the real scope of the GTM will be its policy implications and limitations. To gain some appreciation of these, it is useful to ask ourselves the question:

What are the type and range of structural change issues which could be addressed by the global trade model?

An illustrative sample of these issues will be outlined in Section 5, when we discuss the decomposition of structural change.

Before we can analyze recent patterns of change in world trade, or fruitfully discuss the decomposition of structural change within the global system into various components, we must define the boundaries of our multi-regional system and decide upon an appropriate classification of forest products. These fundamental questions of aggregation are quite strategic and cannot be left entirely to the discretion of model users.

3. AGGREGATION STRATEGIES

In the social and economic sciences, the seminal work on aggregation is that of Theil (1967, 1972) who has made extensive use of information theory for comparing data sets at different levels of aggregation. Theil's concern centred on the understanding that whenever data sets are aggregated in some way there is usually a significant loss of information. In regional science, however, there has been more concern recently about the comparison of formal models and their performance at different levels of aggregation. The fact that any model could generate different predictions depending upon the way in which the regions or industries have been subdivided has inspired a variety of work on the problem (see, for example, Masser and Brown, 1978; Batten, 1982a; Batty and Sikdar, 1982; Roy, Batten and Lesse, 1982; Lesse, Batty and Batten, 1983).

The two problems introduced above are of paramount significance in the development of any trade model at the global level. Aggregation must be regarded as a special form of model transformation which alters the number of variables. In this respect, it is important to understand the effects of product classification and regional subdivision on the performance and reliability of the GTM.

3.1 Product Classification

Of fundamental importance in the product classification system for the GTM is that each traded product be reasonably *homogeneous*. Multisectoral systems (such as input-output models) usually suffer from the fact that their sectoral representations combine heterogeneous products. In reality, we observe values and quantities referring to a product class. In principle, such a class consists of a finer set of components. If these components appear in constant proportions over time, the product class is a "composite commodity". With this background we may identify three dimensions of homogeneity:

(i) The producer/exporter may regard a class as homogeneous if the production and transportation characteristics of its components are identical;

(ii) The consumer/importer may regard the class as homogeneous if its components are perfect substitutes;

(iii) Price homogeneity obtains for a composite commodity if the relative prices of its components are largely time-invariant.

If the "quality" changes for a significant component in a product class, all three conditions may be severely violated.

The basic classification of forest products available for the establishment of our Forest Trade Database (FTDB) is given in Appendix 1. Each of these products is quite homogeneous in the physical sense, and they appear to conform approximately to our three homogeneity requirements. To satisfy these criteria one may sometimes have to analyze certain exporter-importer links in separation; two different trade links may represent different composite commodities which contain the same components but in different proportions (compare Figure 7).

Although the different users of the GTM may wish some freedom to aggregate these products in various ways, it must be emphasized that significant aggregation problems of the type discussed above will arise if this process is carried too far (see, for example, Buckingham et al, 1983). In the GTM work at IIASA, the following product classification system is regarded as reasonably homogeneous and computationally manageable, and will therefore be the most aggregate representation adopted in the simulation studies:

1. Coniferous Logs
2. Non-coniferous Logs
3. Pulpwood and Woodchips
4. Fuelwood
5. Coniferous Sawnwood
6. Non-coniferous Sawnwood
7. Panels[1)]
8. Pulp[2)]
9. Newsprint
10. Printing and Writing Paper
11. Other Paper and Boards

3.2 Regional Subdivision

When it comes to the choice of nations or groups of nations to be represented in the GTM, much more serious difficulties arise. The global economy can be partitioned in many different ways; each model so produced will generate a different scenario of the future depending on the manner in which the geographical subdivision is carried out. This multiplicity of model representations arises not just from the delineation of spatial boundaries, but is also influenced by the size of each zone (i.e. the scale at which the trade pattern is to be analyzed). These two

1) The "composite commodity" known as *Panels* does not exhibit satisfactory homogeneity with respect to any of the three definitions. In particular, the relative export prices of the four elementary products (namely veneer, plywood, particle board and fibreboard) were in the ratios 10:2:1:1 in 1965, but had converged more closely to the ratios 3:2:1:1 by 1980. This classification may therefore require some revision.

2) The category *Pulp* excludes all mechanical pulp which is an intermediate product used in newsprint production; mechanical pulp is largely a local input which is rarely traded.

compatibility problems can be synthesized as the *regional aggregation problem* for global trade models. To properly ascertain whether different zoning systems are compatible, we need to construct the appropriate class of model transformations (see Lesse, Batty and Batten, 1983).

For the GTM, certain compromises are inevitable. Because we are focusing on a process of exchange, it is at least essential to identify the major trading routes which have already been established for each product, and to represent the major trading partners involved. Unfortunately, the major trading partners in one forest product differ markedly from those trading in another product. For example, two-thirds of all trade in coniferous logs is from the USA and USSR to Japan, whereas half of all trade in non-coniferous sawnwood occurs within the ASEAN group of nations (Indonesia, Malaysia, Philippines, Singapore and Thailand) or from this group to Western Europe. These major differences are summarized in Table 1, which has been derived from statistics in FAO (1982) and Byron (1980). In this table, the percentages in parentheses indicate the total share of those major regions mentioned.

The basic regional subdivision of trading nations for which data can be ascertained and assembled in our FTDB is given in Appendix 2. This is quite a coarse subdivision which certainly allows all major trading routes and partners to be clearly identified. For the purposes of the GTM, however, further aggregation will be necessary to ensure computational feasibility and to allow a smaller set of regional component submodels. The following regional subdivision will form the basis of our initial simulations:

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. Hungary
13. Rest of Eastern Europe
14. Africa
15. Taiwan and Korea[3)]
16. Japan
17. ASEAN group
18. Rest of Asia
19. Australia
20. Rest of Oceania

Although the above subdivision scheme may be useful for many simulations, there may be certain instances where it would be preferable to return to a more detailed representation of the global pattern of trade in a particular product. For such cases, the GTM will require an additional capability: the estimation of detailed flow patterns between individual nations based upon detailed historical data and aggregated forecasts. Such a facility can be constructed quite easily using information theory (see, for example, Snickars and Weibull, 1977; Webber, 1979; Batten, 1982a,b) and available algorithms (Eriksson, 1981), and will be included in the GTM. The usefulness of this methodology for predicting trade flows of forest products has already been demonstrated (Anderstig, 1982).

An important comment on the regional subdivision issue concerns Western Europe. Table 1 verifies the extensive trade occurring *within* this region in at least six products (namely fuelwood, panels, pulp, newsprint, printing and writing paper, and other paper and boards), and thereby emphasizes two other important aspects of the trade modelling work:

(i) the need for the GTM to record *intra*regional as well as *inter*regional trade flows, since the former may exceed the latter in certain instances; and

---

3) Although FAO practice is to include Taiwan in the People's Republic of China for statistical purposes, trade in forest products by China is negligible compared with that in Taiwan and South Korea (Ferguson, 1978). We may therefore conclude that published data on China's trade is largely that of Taiwan.

Table 1. Principal forest products and trading regions in world trade; 1980

FOREST PRODUCT	UNIT	PRODUCTION	TRADE	MAJOR TRADING REGIONS
<u>Raw Materials</u>				
1. Coniferous logs	Mill. m^3	600	28	Exporters: USA, USSR (75%) Importers: Japan (67%)
2. Non-coniferous logs	"	241	42	Exporters: ASEAN (74%) Importers: Japan, Taiwan, Korea (70%)
3. Pulpwood & chips	"	341	39	Exporters: E. Europe, Australia, USA (65%) Importers: Japan, W. Europe (80%)
4. Fuelwood	"	1627	3	Exporters: ASEAN, W. Europe (90%) Importers: W. Europe, Japan, ASEAN (80%)
<u>Mechanically Processed Products</u>				
5. Coniferous sawnwood	"	322	66	Exporters: Canada, NORDIC (65%) Importers: USA, W. Europe (70%)
6. Non-coniferous sawnwood	"	103	13	Exporters: ASEAN (50%) Importers: W. Europe, ASEAN (60%)
7. Panels	"	102	16	Exporters: W. Europe, ASEAN (57%) Importers: W. Europe, USA (75%)
<u>Reconstituted Products</u>				
8. Pulp	mill. tons	127	21	Exporters: Canada, NORDIC, USA (75%) Importers: W. Europe, USA (70%)
9. Newsprint	"	26	12	Exporters: Canada, NORDIC (84%) Importers: USA, W. Europe (75%)
10. Printing & Writing paper	"	42	7	Exporters: W. Europe (80%) Importers: W. Europe (62%)
11. Other Paper & Boards	"	106	16	Exporters: W. Europe, USA (77%) Importers: W. Europe (56%)

SOURCE: FAO (1982) and Byron (1980) REMARK: The NORDIC countries are included in W. Europe.

(ii) the need for a more detailed analysis of trade in all wood products within Western Europe.

Before we leave the issue of aggregation, it is wise to mention that despite our best efforts and intentions with respect to regional subdivision, there will still be considerable variations with respect to export and import prices of the same type of product at each origin and destination region. These do not merely reflect transportation costs, but are also indicative of qualitative differences in each traded product. In many instances, the latter are much more significant than the former.

4. CHANGING PATTERNS OF TRADE IN FOREST PRODUCTS: SOME EMPIRICAL HINDSIGHTS

An important aspect of the trade modelling work is the establishment of the Forest Trade Database (FTDB). This work involves the reconciliation of trade statistics from two different sources, namely the Food and Agriculture Organization (FAO) and the United Nations Statistical Office (UNSO). Although the trade data collected by each agency emanate from different sources, there is a certain wisdom in paying some attention to both. Once the FTDB handling program has been completed, it will be very simple to generate a variety of tables such as (i) region by region trade flow matrices for each forest product; (ii) export and import flow tables by region; (iii) export and import shares; and (iv) trade balance tables.

In the meantime, the following brief analysis of changing patterns of trade in forest products is designed to be illustrative but far from exhaustive. By necessity, we concentrate mainly on one or two forest products and the impact of major trading regions. Further empirical hindsights can be found in Francescon (1983), and an extensive report on the historical analysis of global trade in forest products will appear shortly.

4.1 Historical Patterns of Adjustment

At the aggregate level, the world consumption of forest products has been growing annually by just over three percent since the early fifties. In terms of its productive contribution to the global economy, the forest sector does not belong amongst the most expansive sectors, but nor is it a member of the stagnating elements. The growth path of most forest products has been extremely consistent until the middle seventies, so much so that a linear trend can provide an amazingly accurate explanation of this expansion prior to the onset of the oil crisis with its various ramifications. Figures 1 and 2 depict this trend for two particular products, but the pattern is very similar for the whole forest sector.

In the same period, the level of trade in forest products has increased annually by about five percent. This more rapid escalation of exchange between countries is partly symptomatic of declining timber availability in certain traditional regions. It is also related to the changing structure of the complete forest sector.

Table 2 presents the total export volumes (in millions of cubic metres or millions of metric tons) and export earnings (in millions of U.S. dollars) of all eleven forest products traded in 1965 and 1980. Unit values are also recorded to give some indication of average export prices in the world market. Figure 3 depicts the changing structure of export earnings in the forest sector.

In this twenty year perspective, the following products have experienced a growth rate in excess of the average rate of growth in traded products for the forest sector as a whole: pulpwood and chips, panels, printing and writing paper, and other paper and boards. The two major export earning sectors in the fifties and sixties, namely pulp and coniferous sawnwood, have relinquished some of their earlier market share. With the exceptions noted above, the overall structure of the forest sector has not altered dramatically over the last twenty years. This apparent structural inertia may be qualified significantly when we come to examine longer patterns of change in the forest sector.

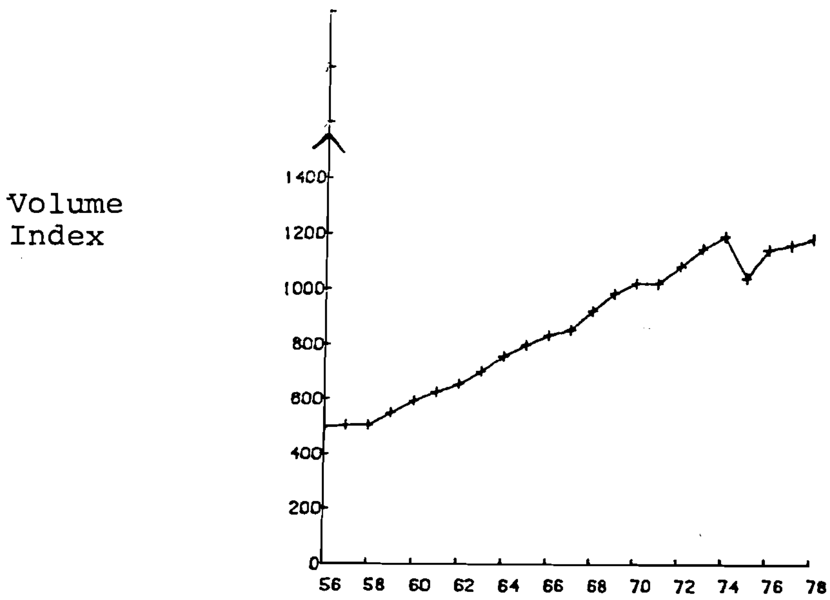


Figure 1. World consumption of wood pulp 1956-1978.
SOURCE: Johansson and Andersson (1981)

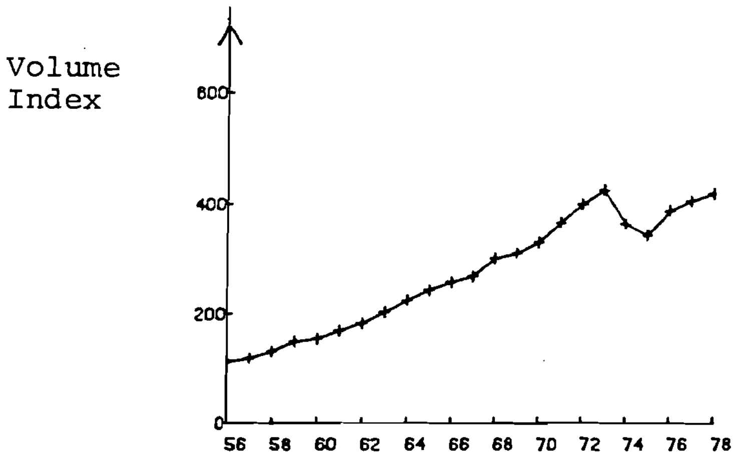


Figure 2. World consumption of plywood 1956-1978.
SOURCE: Johansson and Andersson (1981)

Table 2. The changing export volumes and values in the global forest sector.

FOREST PRODUCT	1965			1980		
	VOLUME	VALUE	UNIT VALUE	VOLUME	VALUE	UNIT VALUE
Raw Materials						
1. Coniferous logs	11.6	200	18	27.9	2492	89
2. Non-coniferous logs	21.2	517	24	41.9	4037	96
3. Pulpwood and chips	16.8	185	11	39.9	1368	34
4. Fuelwood	2.3	20	9	2.2	75	34
Mechanically Processed Products						
5. Coniferous sawnwood	44.0	1702	39	65.2	9024	138
6. Non-coniferous sawnwood	5.5	345	63	12.7	2984	235
7. Panels	5.8	689	119	16.0	4899	306
Reconstituted Products						
8. Pulp	12.5	1598	128	21.2	9370	442
9. Newsprint	9.0	1125	125	12.4	5326	430
10. Printing & Writing Paper	1.8	420	233	7.0	5135	733
11. Other paper & boards	5.7	1141	200	15.7	9295	592

SOURCE: FAO (1982)

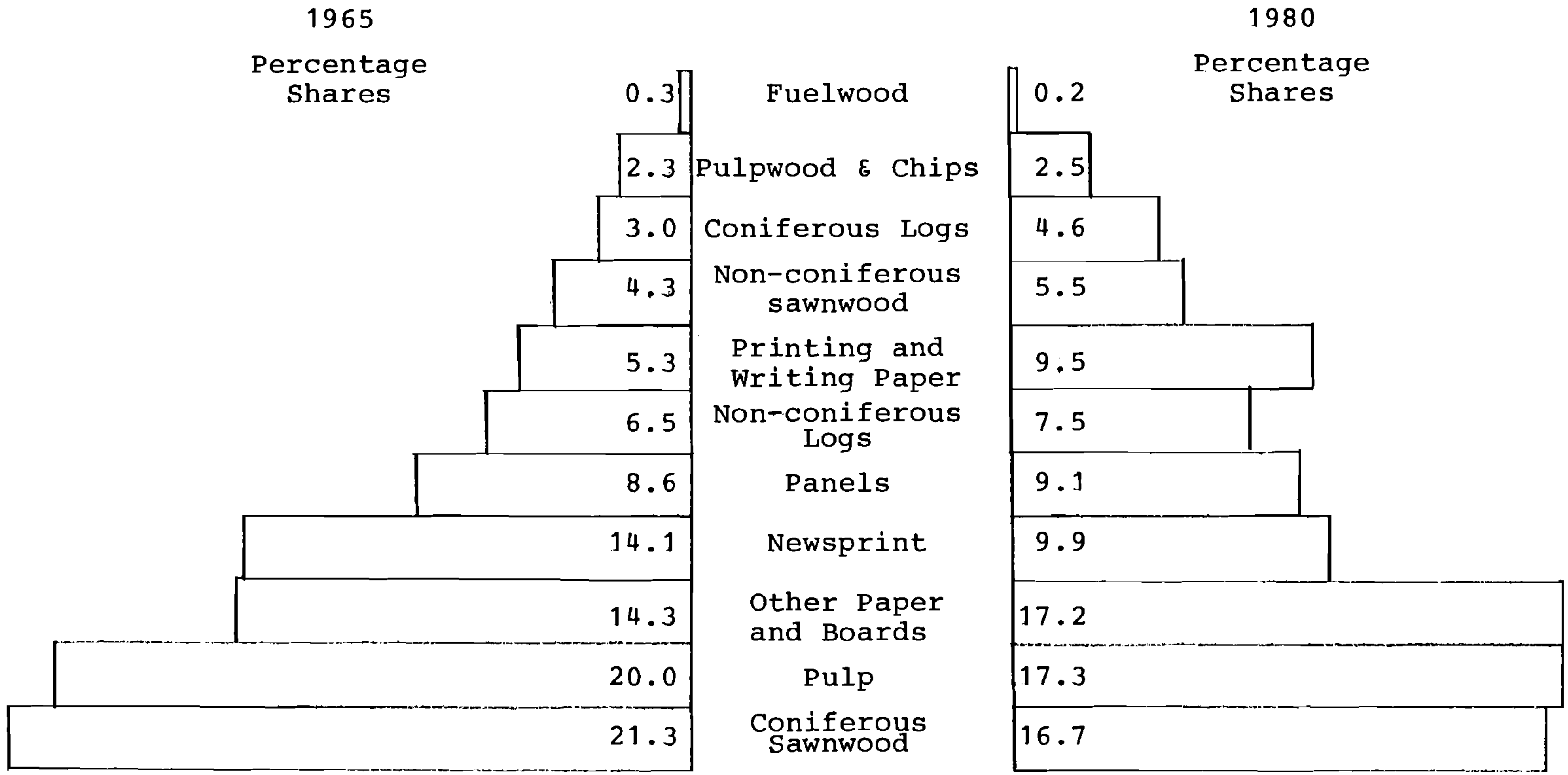


Figure 3. The changing export earning structure of the forest sector.

SOURCE: FAO (1982)

To focus briefly on the relationship between production and trade, we have plotted (see Figure 4) the annual global production and exports of sawnwood (coniferous and non-coniferous) over the period 1965-1980. As might be expected, the peaks and troughs in export volume follow closely the trajectory of production. The marked slump which occurred in all areas of forest production between 1973 and 1975 due to the oil crisis and its ramifications was accompanied by a corresponding fall in exports. This initial evidence points to a close relationship between production and trade, in terms of both supply potential and timing.

Since the middle fifties, one can also observe a gradual transition process which has taken the focus of industrial production away from North America to other parts of the world. In 1950, two-thirds of all production in the industrialized market economies emanated from the USA and Canada. Twenty-five years later, this figure had dropped to 45 percent. Such a transition may also reflect a simultaneous shift in the purchasing power within this group of countries. But the major change in this period has been the emergence of other regions outside the group considered above.

In terms of world trade, industrialized market economies in general, and North America in particular, have increased their dependency on other trading nations. The decline in overall relative purchasing power within North America, the UK and Ireland, together with the complementary increases elsewhere, have led to important restructuring patterns of trade. Table 3 depicts the changing consumption of forest products in various parts of the world. Demand has increased by its largest increment in the world outside North America and Western Europe, growing only at a medium pace in the latter region and very slowly in North America. This overall pattern of adjustment has persisted into the eighties.

At the more detailed level of individual nations, some striking changes in the spatial patterns of trade have occurred. Some of these appear to contradict the general trends discussed above. For example, Figures 5 and 6 depict the trade shares of major exporters and importers of coniferous sawnwood in five-yearly increments from 1965 to 1980. Canada has increased its

Table 3. World market adjustments in the consumption of Forest Products 1956-1978.

Products	Growth according to linear trend in percent of the level in 1978		
	Rest of the world	Western Europe	North America
Plywood	8.1	4.1	4.7
Fibreboard	7.8	4.7	4.0
Printing & Writing	7.2	5.7	-4.6
Other Paper & Boards	6.7	4.5	2.8
Pulp	6.5	3.9	3.2
Newsprint	5.3	2.7	2.4
Fuelwood	3.2	-4.9	-6.6
Logs	3.0	2.9	0.9
Industrial Roundwood	2.5	1.8	1.5
Sawnwood	2.3	1.8	1.1

SOURCE: Johansson and Andersson (1981)

ever-dominant position as the major exporter, largely at the expense of the USSR and Sweden. The USA has also improved its share, while Finland and Austria have maintained their proportions. On the import side, the USA has lifted its intake substantially, whereas the UK has experienced a compensating decline. West Germany, Italy and Japan have now converged to each import between 7 and 8 percent of the world market, but Japan's share is still climbing.

An interesting characteristic of this trade in coniferous sawnwood is revealed in Figure 7. The average import and export prices (in U.S. dollars per cubic metre) of each major trader are shown at the origins and destinations of each trade flow. The thickness of the flow line indicates approximately the share of total trade held by the two nations involved. Dominating this global exchange pattern is the trade within North America. Note that the average export price from Canada ($\$96/m^3$) and the average import price to the USA ($\$80/m^3$) are both significantly lower

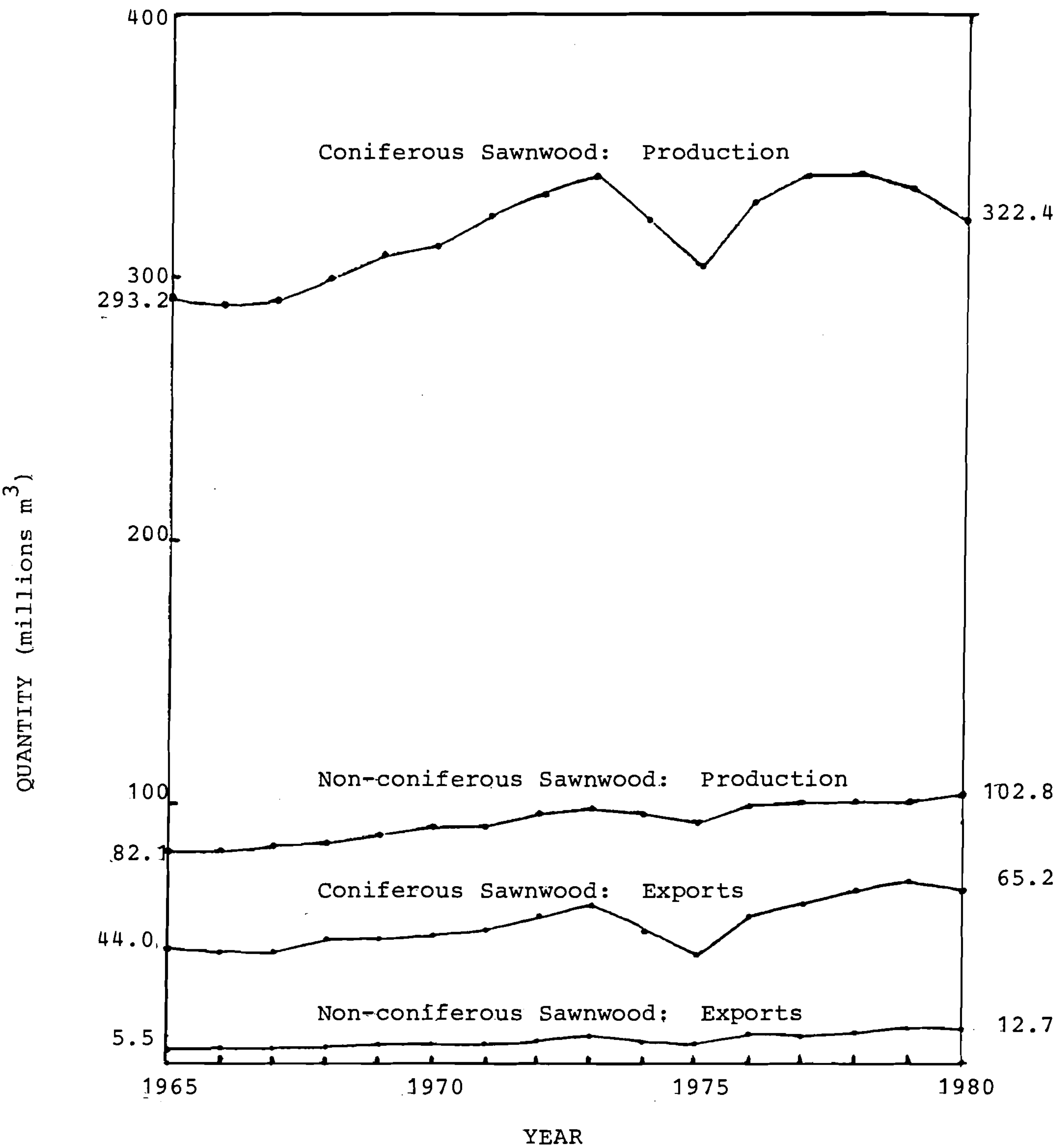


Figure 4. World production and exports of sawnwood, 1965-1980.

SOURCE: FAO (1982)

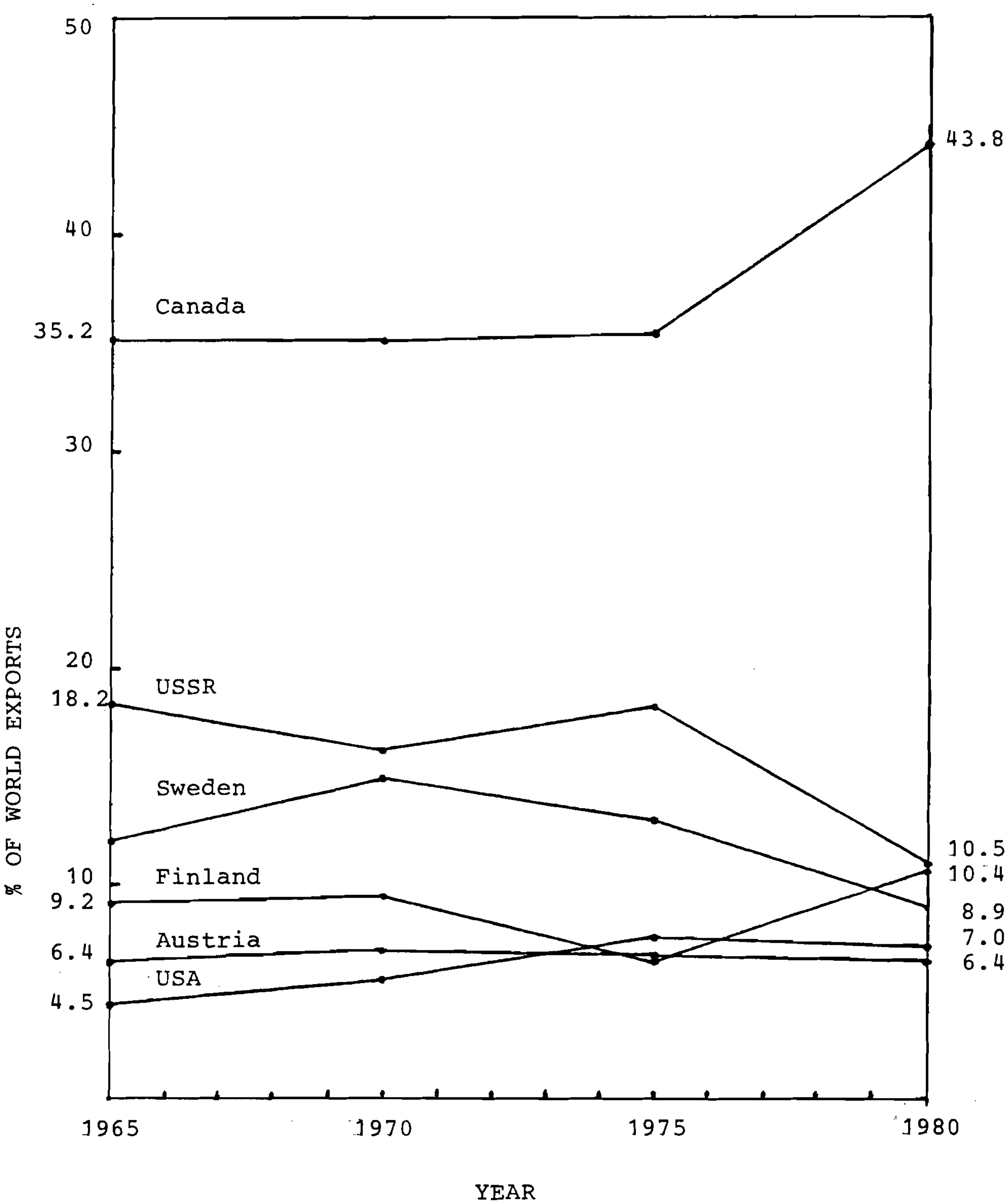


Figure 5. Major exporters of coniferous sawnwood, 1965-1980.

SOURCE: FAO (1982)

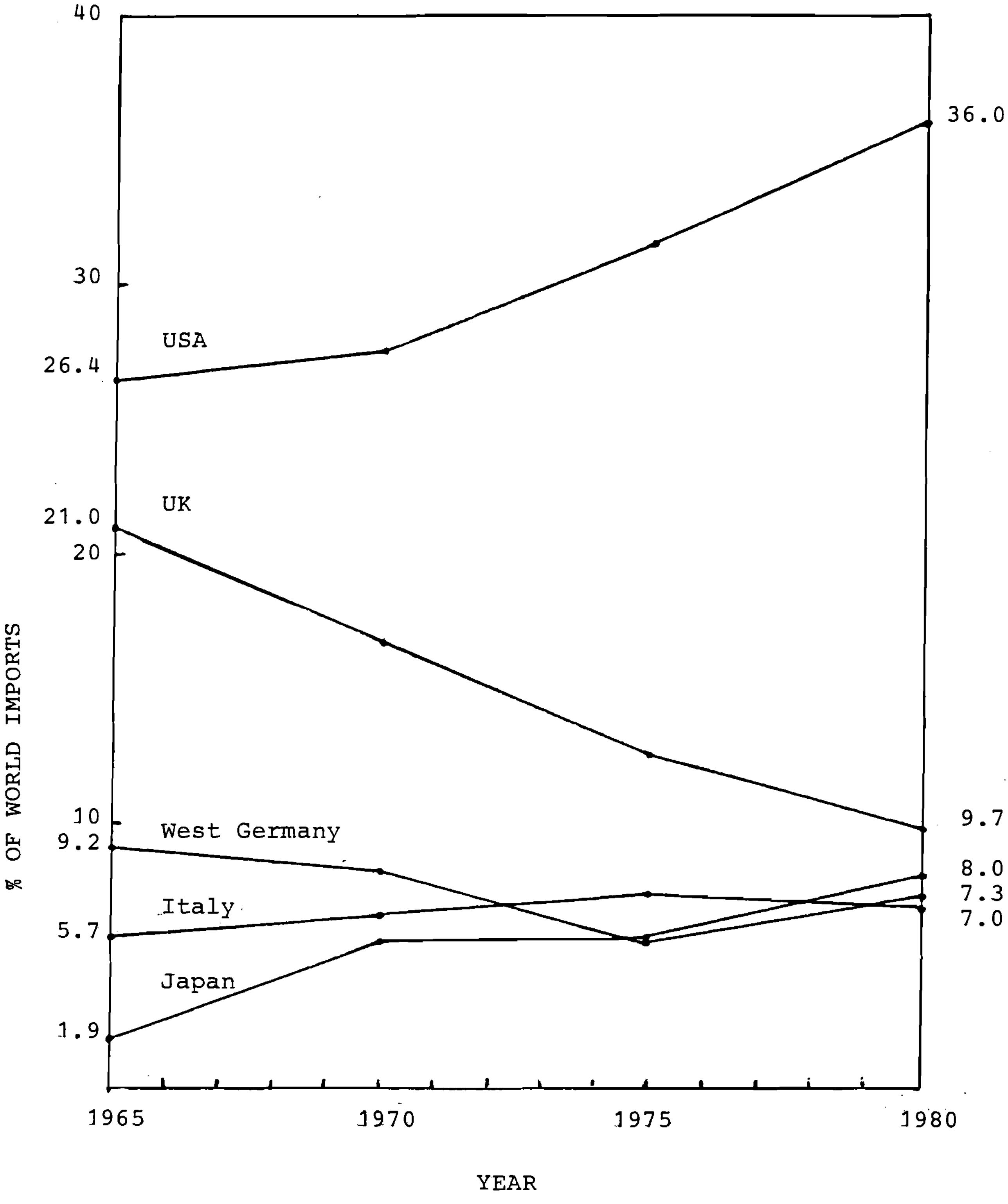


Figure 6. Major importers of coniferous sawnwood, 1965-1980.

SOURCE: FAO (1982)

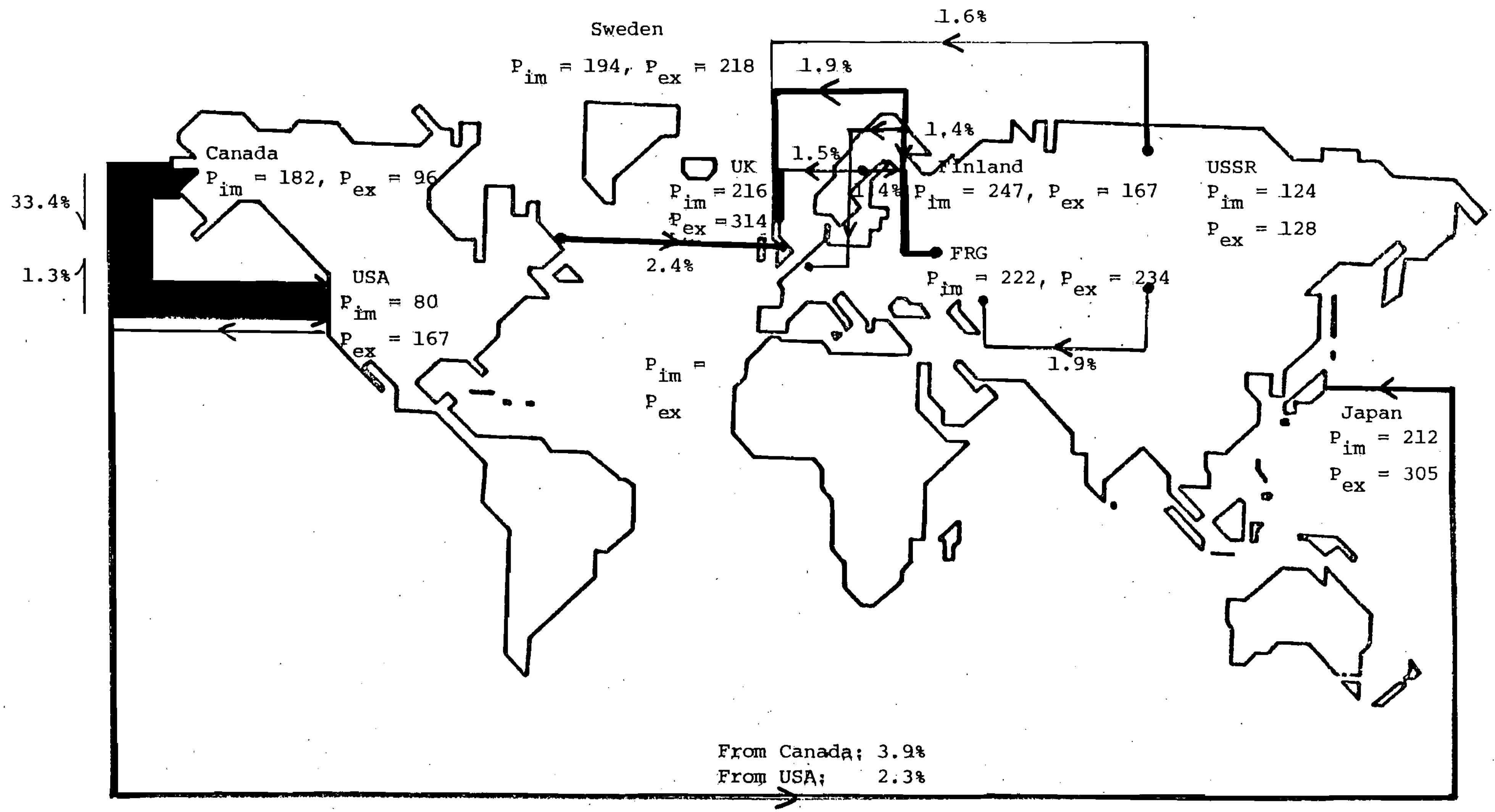


Figure 7. Major trade flows in coniferous sawnwood during 1980.
(with percentages of total trade; P_{im} = average import price;
P_{ex} = average export price).

SOURCE:

lower than those of their rivals. Although various qualitative differences exist between classes of coniferous sawnwood, the traded price set by Canada for sales to the USA appears to be lower than to the rest of the world. Although lower transportation costs undoubtedly contribute to this situation, such marked price differences also emphasize the influence of geographical, cultural and other less visible bilateral trade preferences on the terms of trade. We shall return to the question of trade preferences a little later.

The foregoing insights are merely illustrative and by no means reveal the many emerging patterns of change within the global exchange system. They are nevertheless sufficient to emphasize a need to address the fundamental time dimension of structural change more rigorously. In the following section, the time element will be examined directly by measuring the degree of inertia which exists in historical trade patterns. The speed of this adjustment process relates to various cyclic influences which are recurring at different frequencies. Some results of recent studies using spectral analysis can be instrumental in identifying a pertinent *time interval* for the trade analysis within which fluctuations of major significance rarely occur, but between which longer cycles prevail.[4)]

4.2 Inertia and the Speed of Structural Change

In the following, we shall examine the degree of inertia or resistance to change which manifests itself in patterns of trade which alter slowly in terms of variations to earlier trade intensities and multilateral trade shares. A simple means of assessing the extent to which trade inertia has existed historically involves the use of earlier trade patterns as the *a priori* determinant of trade shares for some later period. Let the actual trade flow of a particular forest product from region i to region j in period t be given by $x_{ij}(t)$, the total exports from region i be $x_{i.}(t)$, and the total imports to region j be $x_{.j}(t)$. The flow pattern τ years earlier is then given by $x_{ij}(t-\tau)$.

---

4) Anderstig, C. (1983), Spectral Analysis of Sweden's export of Forest Products 1961-1979, mimeo, Umeå University (in Swedish).

If the degree of inertia is a significant determinant of trade flow patterns, then the simple adjustment of our earlier flow pattern, $x_{ij}(t-\tau)$, to satisfy the new export and import totals, $x_{i.}(t)$ and $x_{.j}(t)$, using any one of a family of updating procedures [5] should serve as an accurate prediction of $x_{ij}(t)$. We shall label this prediction $\hat{x}_{ij}(t)$. If $x_{ij}(t)$ and $\hat{x}_{ij}(t)$ are reasonably close for periods of τ such as 5 or 10 years, then we can conclude that considerable inertia exists in earlier trade patterns.

Formally, we simply minimize the following function:

$$I = \sum_{i=1}^{n} \sum_{j=1}^{n} \hat{x}_{ij}(t) \log [\hat{x}_{ij}(t)/x_{ij}(t-\tau)] \qquad (1)$$

subject to the following constraints:

$$\sum_{j=1}^{n} \hat{x}_{ij}(t) = x_{i.}(t) \qquad , i=1,\ldots,n \qquad (2)$$

$$\sum_{i-1}^{n} \hat{x}_{ij}(t) = x_{.j}(t) \qquad , j=1,\ldots,n \qquad (3)$$

and all $x_{ij}(t) \geq 0$. A number of algorithms are available to perform this routine task.[6]

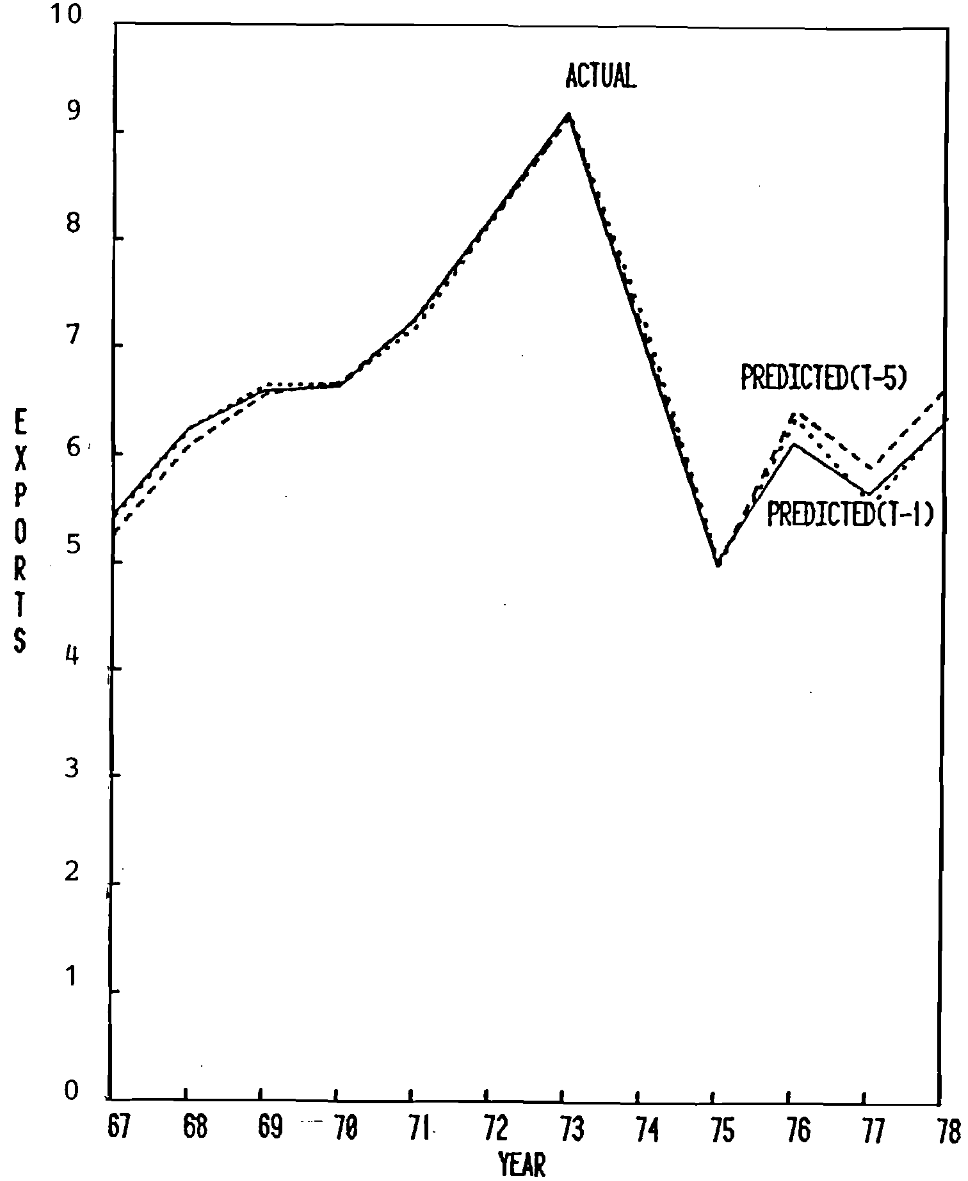
Figure 8 depicts the actual exports of sawnwood from Sweden to Europe over the period 1967-1978, together with the predicted exports, $\hat{x}_{ij}(t)$, based on export patterns recorded one and five years earlier. Figure 9 depicts similar results for trade in sawnwood from North America to Europe. These results are taken from Anderstig (1982).

In the case of Sweden, knowledge of the historical pattern of trade flows and the current total of Swedish exports is sufficient information for an extremely good prediction of the actual export pattern. The predicted exports using $x_{ij}(t-1)$ are

---

5) Techniques such as the RAS method, Cross-Fratar analysis, entropy-maximizing with non-uniform prior probabilities, and the minimum information principle can all produce the desired forecast. For a synthesis of these approaches, see Batten (1982a).

6) For a more detailed discussion of the use of information theory to simulate inertia effects in trade flow patterns, see Batten (1982b).



.Figure 8. Actual and predicted exports of sawnwood from Sweden to Europe 1967-1978 (millions tonnes)

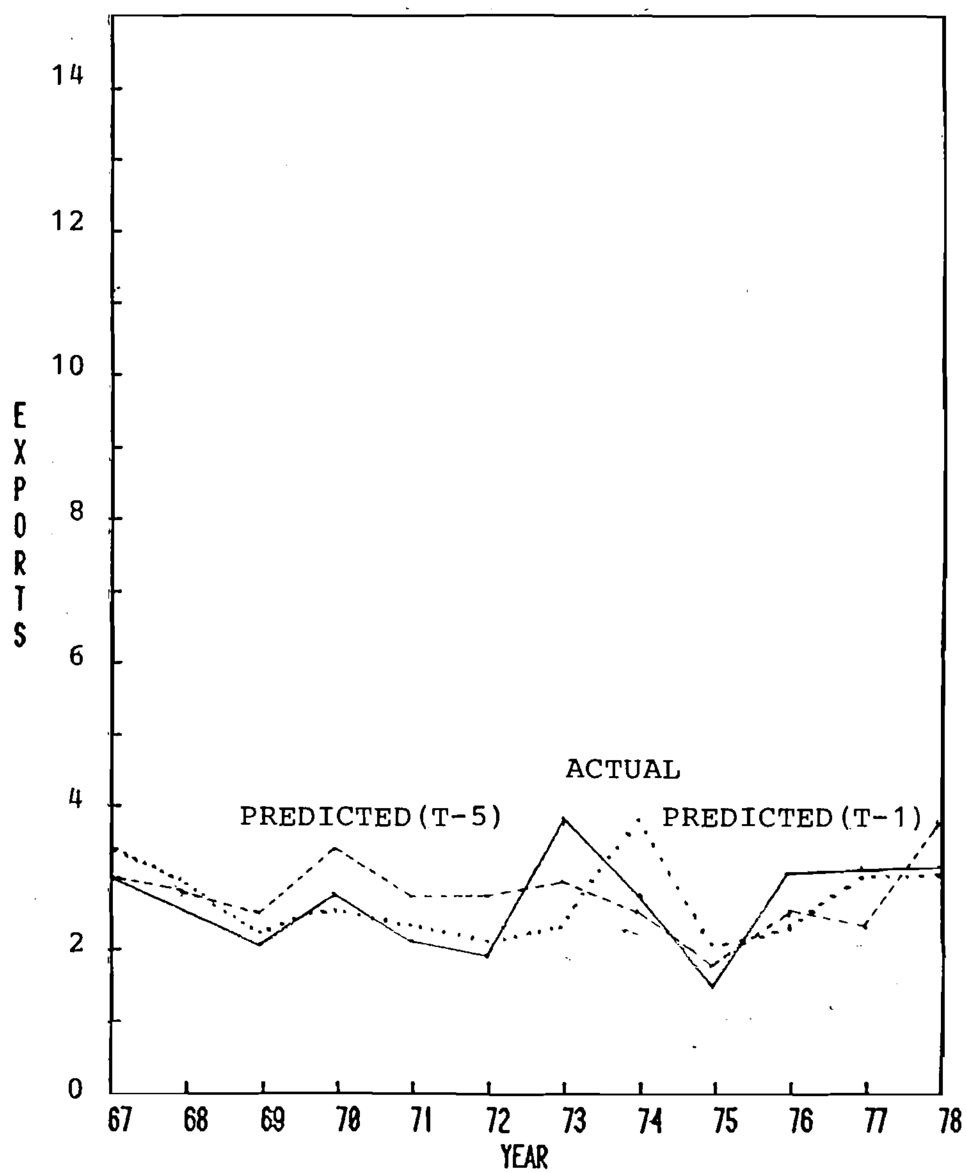


Figure 9. Actual and predicted exports of sawnwood from North America to Europe 1967-1978 (millions tonnes).

SOURCE: Anderstig (1982)

almost coincident with the actual flows, and those using $x_{ij}(t-5)$ are almost as good. Since Europe is Sweden's major market for sawnwood exports, perhaps this result is not so surprising.

Contrary to Sweden, North America has a very large share of the world market (see Figures 5 and 6) and much of this trade is *intraregional*, that is between Canada and the USA. The divergences between the actual and predicted flows of sawnwood from North America to Europe are greater in this case. This may not be so surprising if we recall that the degree of regional aggregation is much coarser in this case. It is much more informative to deal with individual trading nations whose embodied trade preferences can be clearly identified.

Turning to another forest product, Figures 10 and 11 depict actual and predicted exports of pulp from Sweden and North America to Europe over the same period. In this case, there is an additional prediction based upon the actual pattern of trade ten years earlier. Figure 10 reveals that all three export predictions from Sweden to Europe are quite close to the actual level of exports. The divergence between all three predictions is also quite small. There is clearly a good degree of inertia embodied in Sweden's export pattern to Europe.

Divergences between the actual and predicted flows of pulp from North America to Europe are, once again, relatively large and less consistent. Furthermore, the predicted exports based upon patterns displayed ten years earlier turn out to be lower than actual exports throughout the seventies. Aside from the aggregation problem, this result indicates that the intensity of trade from North America to Europe shifted during the last ten years to a higher level. Such shifts are an important determinant of the most appropriate time interval which should be used for our analysis of structural change.

Summarizing what we have just learnt:

(i) there is ample evidence to suggest that a considerable degree of inertia is embodied in the trade pattern of various nations exporting forest products;

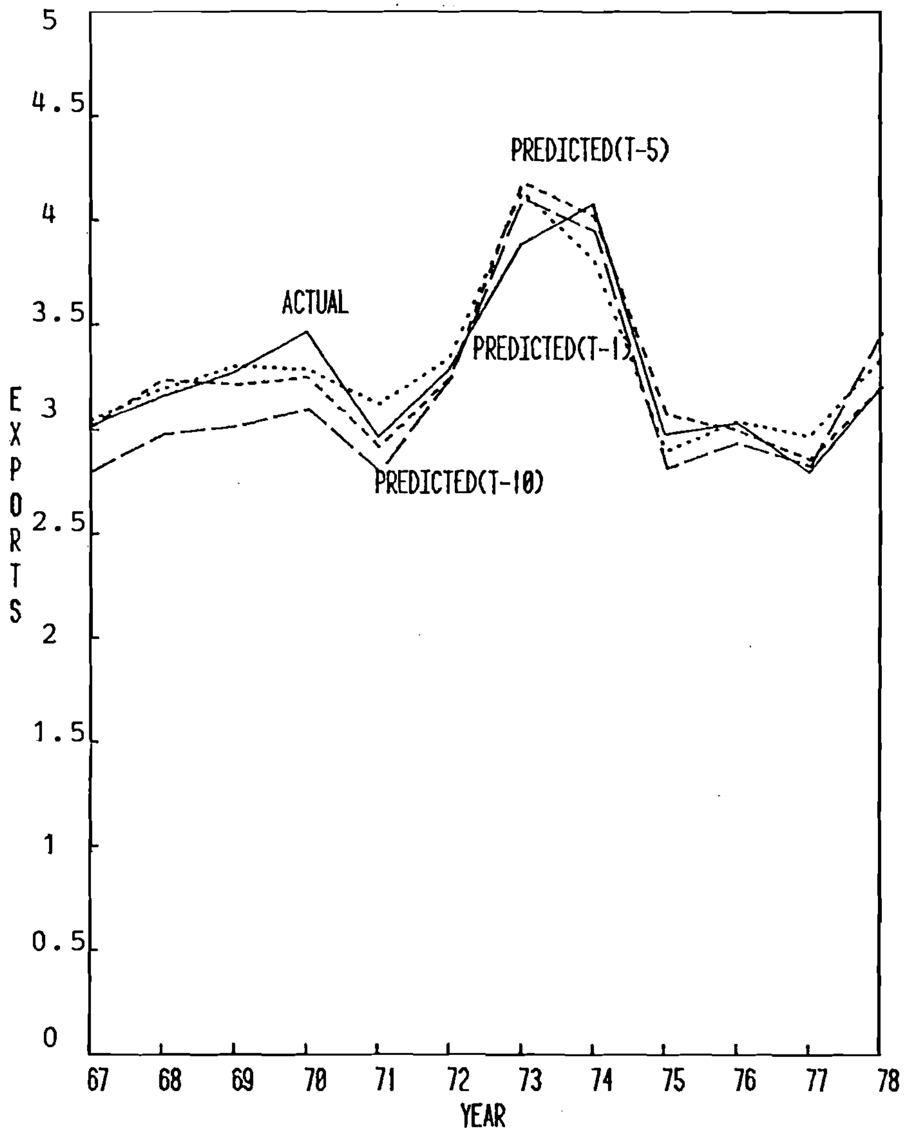


Figure 10. Actual and predicted exports of pulp from Sweden to Europe 1967-1978 (millions tonnes)

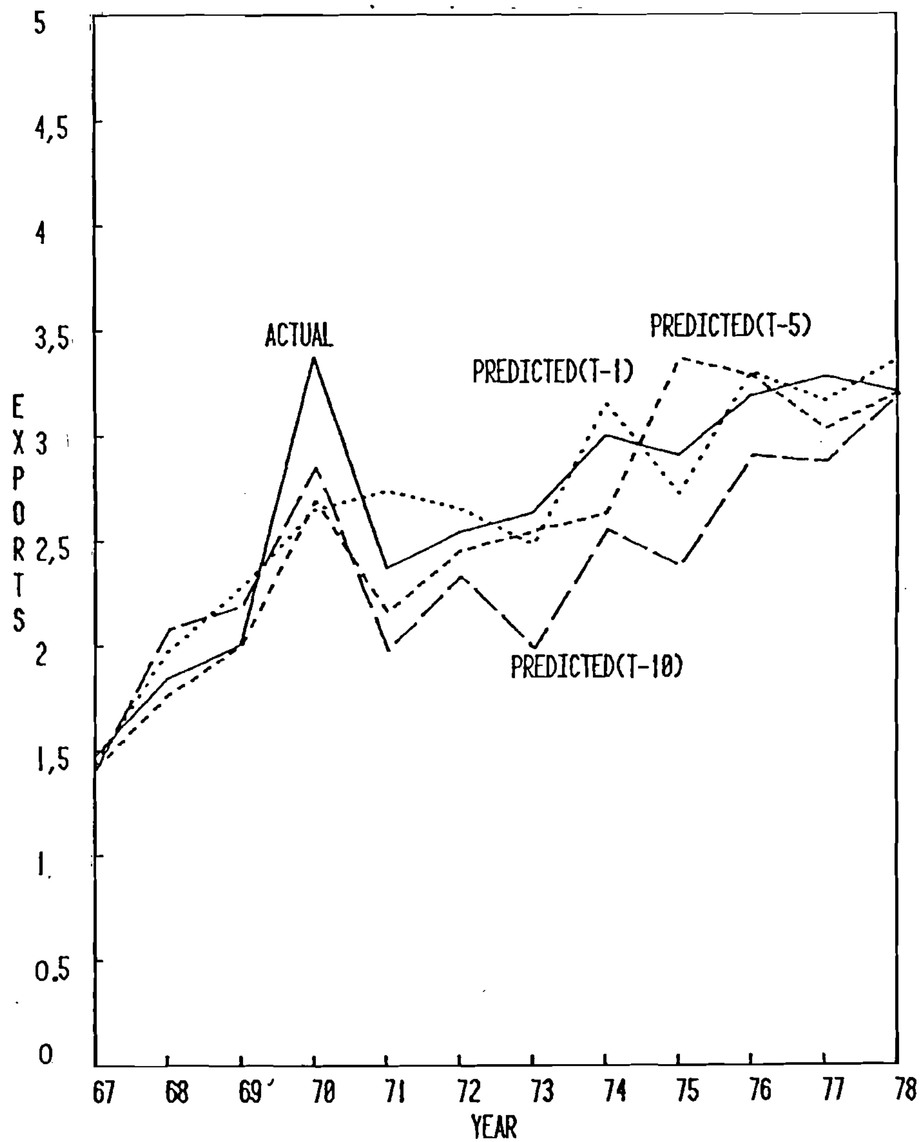


Figure 11. Actual and predicted exports of pulp from North America to Europe 1967-1978 (millions tonees)

SOURCE: Anderstig (1982)

(ii) to identify such forces accurately requires a regional subdivision into individual exporting nations, since only then can pertinent factors such as geographical location and trade preferences be properly taken into account; and

(iii) significant shifts in the trade intensity pattern are an important determinant of the basic time increment for the modelling process, since within this time interval such shifts should not be prevalent but between two or more such intervals more pronounced patterns of cyclic behavior should be discernable.

One may also add that the comparison between North America's and Sweden's exports to Europe indicates that increasing distance and transportation costs make the trade pattern more unstable and sensitive to shorter term disturbances. For Sweden, Europe is the most important market and as a consequence Swedish exporters are anxious not to destroy established trade "partnerships". For North America, Europe is more of a market on which it sells its excess supply as the domestic markets are cyclically dampened.

4.3 Cyclic Patterns

On the question of time increments for the modelling of structural change, the results of a recent spectral analysis of export patterns for forest products over a twenty year time period contain valuable insights (see Anderstig, 1983). Spectral analysis is a useful statistical tool for identifying the significant components of cyclical behaviour in the long-term development of any phenomenon. In the Swedish case, Table 4 summarizes some of the more pertinent results. The figures in the two columns of the normalized spectrum indicate the relative importance of one and five year cycles. The larger the number the more significant is the cycle. In all cases, the 5 year cycle dominates shorter patterns of fluctuations, although the shorter cycle is of certain importance for some products like raw logs and pulpwood. However, the results indicate that the business cycle is significant. Hence, a sequential model with five-yearly intervals can provide scenarios from which the business cycle has been eliminated. For longer term scenarios this is a desirable property.

Table 4. Spectral analysis of Swedish export patterns in forest products: 1 and 5 year cycles between 1961 and 1979.

FOREST PRODUCT	Relative importance*	
	1 year cycle	5 year cycle
Raw logs & pulpwood	0.2114	0.2802
Chips	0.0265	0.6048
Sawnwood for construction	0.0513	0.6451
Sawnwood for other uses	0.2841	0.4018
Veneers	0.1687	0.3233
Particle boards	0.1306	0.3679
Fibreboard	0.0585	0.4344
Pulp	0.0866	0.5538
Newsprint	0.0916	0.4906
Printing & writing paper	0.0334	0.6421
Other paper and boards	0.1000	0.5839

SOURCE: Anderstig (1983)
* Relative importance is formally measured by a normalized spectrum.

Figure 12 provides some additional insights. The frequency scale is graduated in half-yearly increments so that frequency 1 relates to the 10-year cycle, a frequency of 2 to the 5-year cycle, and at the limit a frequency of 20 to a half-year cycle. Since the cyclic elements of 10-year and longer period movements dominate the shorter patterns, a sequence of connected 5-year solutions should be able to capture the most essential patterns of long-term change.

Such a model would generate paths along which the medium-term dynamic pattern has been averaged out. In this sense the cycles which are five years or shorter will be embedded in the longer-term change processes.

Having chosen a time increment of 5 years for the model scenarios, we have now completed our discussion of all the preliminary decisions concerning the classificatory attributes

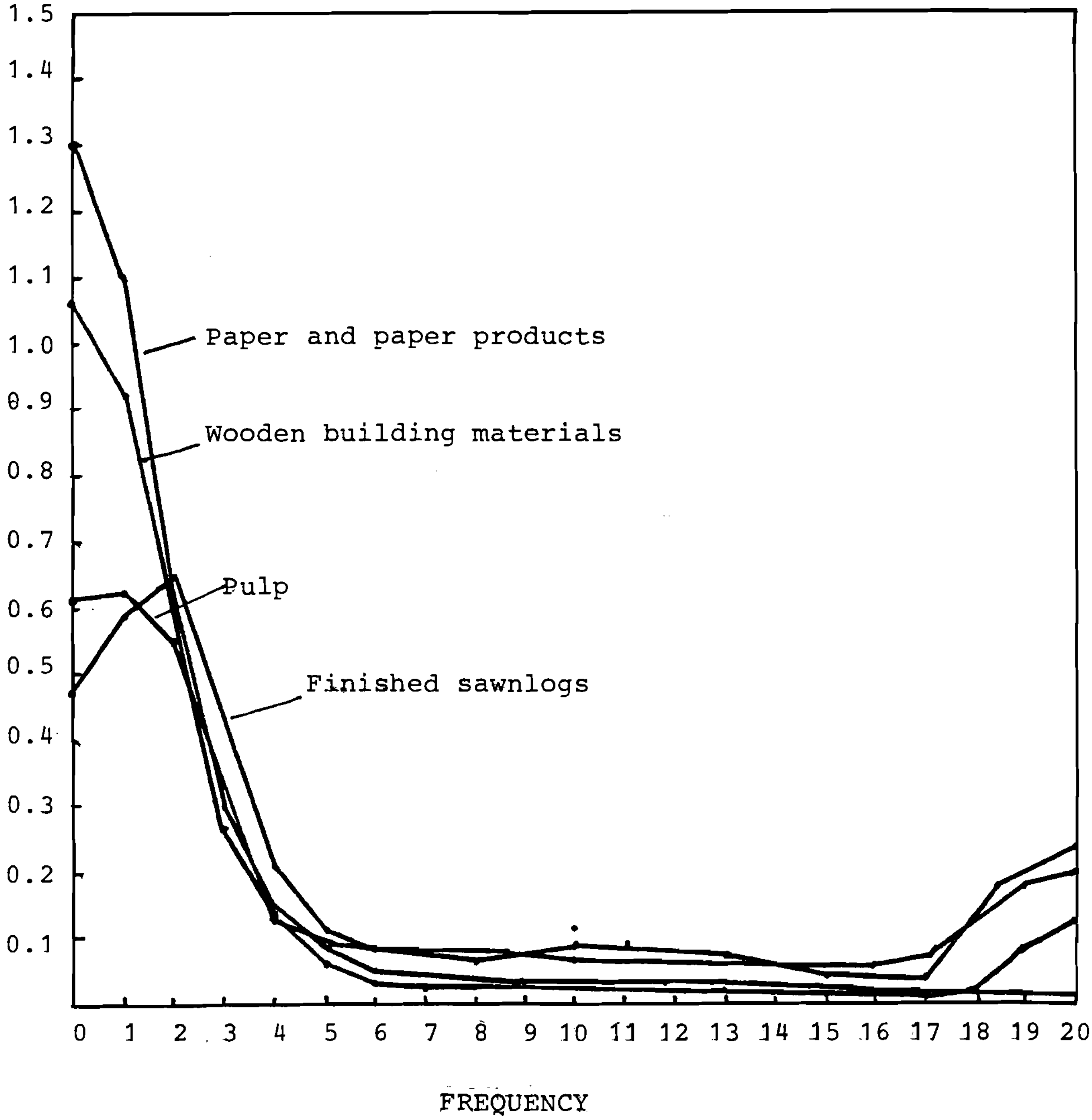


Figure 12. - Normalized spectrum for Swedish export patterns of forest products between 1961 and 1979.

SOURCE: Anderstig (1983)

of the model and the relevance of empirical hindsights. It is therefore time to summarize the substantive determinants of world trade trajectories in terms which permit us to translate each of the major factors into elementary components of our scenario generation capability. We begin with a strategic scheme for the decomposition of structural change.

5. DETERMINANTS OF WORLD TRADE SCENARIOS

5.1 Components of Structural Change

Of major importance in determining the real scope of a trade model are its policy implications and limitations. Illuminating in this respect is to ask ourselves the question: What are the range and nature of structural change issues which can be addressed by a Global Trade Model? The following sample is merely illustrative and by no means exhaustive; it is strategically subdivided into issues which are (i) supply-related, (ii) demand-related, and (iii) link-related.

Supply-related factors

What structural changes to the pattern and terms of trade would result from

(a) *Ecological difficulties* in certain countries, such as poor rotation management, inappropriate mix of species, conflicting land uses, or natural hazards;

(b) *Technological changes* in certain countries, such as new processing techniques, substitution of capital for labor, new products with less timber content, or less energy-intensive production techniques;

(c) *Capacity changes* in certain countries caused by escalating production costs and/or reduced selling prices, fluctuations and shifts in interest rates and investment allowances and depreciation of old equipment, which is eventually replaced by new capacities embodying more advanced production techniques.

Demand-related factors

What structural changes to the pattern and terms of trade would result from

Table 5. Decomposition of factors affecting structural change.

	SPEED OF ADJUSTMENTS		
	FAST	MEDIUM	SLOW
SUPPLY RELATED FACTORS	Labor inputs Intermediate inputs	Capacity changes and investments; associated changes in productivity and technique	Technological change Forest dynamics Ecological balance
DEMAND RELATED FACTORS	Purchasing power	Changing consumer preferences Product substitution	Product development Population development
LINK RELATED FACTORS	Trade flows Transportation Artificial barriers	Freight capacities Trade barriers	Trade preferences
	Market and other exchange mechanisms		

(a) *Societal changes* in certain countries, such as changes in consumer preferences, less emphasis on product advertising, eroding or expanding purchasing power, and more leisure time or recreational forestry;
(b) *Interindustry changes* in certain countries, such as greater use of telecommunications, less timber in dwellings, or greater use of synthetic materials.

Link-related factors

What structural changes to the pattern and terms of trade would result from

(a) *Changes in trade preferences* between certain countries, such as more bilateral trade agreements, contracts based on political or ideological expediency, or historical alliances;
(b) *Changes in trade barriers* between certain countries, such as tariff adjustments, embargoes, quota relaxations or penalties for geographical location;
(c) *Changes in transportation conditions* between certain countries, such as escalating freight costs, excessive handling capacities, and investments in infrastructure associated with transportation;
(d) *Price fluctuations* between certain countries, such as price discounting or fluctuating exchange rates;
(e) *Different flow-determining mechanisms* between certain countries, such as bilateral bargaining and negotiation, regional cartel formation and other variations in the degree of competition on the world market. Also a country or a region may shift from being a price-setter (price-leader) to a price-taker, and prices may be more or less strongly import-determined or export-determined (e.g. import or export revenue maximization).

To some extent, each of the issues raised above falls within the scope of the Global Trade Model since each will influence the trajectory of structural change. The task of addressing such a broad range of issues may appear immense, but their decomposition into three basic groups is a convenient simplification. There are other system-analytic representations which may also be useful, but we shall not dwell on these here. Table 5 summarizes our decomposition approach. We shall now discuss each group of factors in more detail.

5.2 Supply-Related Factors

5.2.1 Forest Management and Ecological Balance

In any international discussion of the forest sector and its products, the logical place to begin is in the forests themselves. The supply or availability of the raw forest material is an extremely important issue because of the multiplicity of uses which forests can provide. The forest system can satisfy various needs which can be broadly classified as basic resources, economic goods and societal needs. Ecological problems and conflicting land-uses are additional complexities which emphasize that any forest is a complex interactive system (see Grossmand & Lönnstedt, 1983).

The forest resource and forest-based activities form a system, which is developing dynamically and is confronted by a wider dynamic system in which other socio-economic activities take place. The forest system supplies various resources and services which have traditionally been important sources of life support for many people. During the last two centuries, however, technological changes have decreased the importance of the forest system as alternative resources such as coal, oil, metals, plastics and concrete became available. Although the global production and consumption of fuelwood is still greater than that of industrial wood, the latter now dominates in terms of trade potential.

About one-fifth of the global land area is covered by forests, but the distribution and management of this forest system is quite uneven in various respects. Firstly, forest area per capita is much lower for developing countries than for the developed nations. However, Brazil has about thirty times as much forest area per capita than the South-East Asian countries. Secondly, forest characteristics such as density, species diversity, productivity and sustainable yield differ greatly. The supply potential of developing countries is severely restricted in the medium term by clearfelling and deforestation practices which lack management foresight. To ensure a steady, long-term supply of raw materials from these countries will require a transformation to more efficient long-term rotation management of plantation forests with a more unified biological structure and more highly developed transportation capacities (Andersson, 1982). Thirdly, harvesting and rotation management policies differ widely depending on the species of forest, its ownership, and the role which the forest is expected to play. Plantation programs in both developing and developed nations could mitigate the pressure on virgin forests and yet vastly improve the overall supply of forest resources. Finally, in highly developed nations institutional factors pay an even more important role. The current high proportion of small ownership forests in the USA suggests that careful investment could increase the productivity of these forests substantially.

The above observations are designed to emphasize the diversity of issues which relate to forest dynamics and ecological balance, and the differing perspectives which must be taken on these issues by different nations. In many large geographical areas such as the USSR, the USA, Canada, the Nordic countries, and South America, there is an obvious need for dynamic regional forest management models. The above issues suggest that the optimal development trajectory and management strategy for the supply and use of forests in these countries will differ greatly. Because of these marked differences, it is clear that detailed trajectories of forest dynamics in various regions will need to be treated outside the core of any Global Trade Model. Nevertheless, the need for interdependency between the growth and availability of forest resources in various parts of the world and the corresponding trade potential is fundamental. In this way, large-scale plantation programmes which may shift the location of major forest industries and therefore alter the patterns of future trade can be assessed.

5.2.2 Technological Change in Forest Industries

Industrial innovations result from efforts to implement new technological ideas. One means of measuring this innovative effort is to calculate the ratio between R & D investments and the value added by an industry. The development of technological knowledge is usually the outcome of more general research, and as such is less directly related to the industry itself.

In most industrialized countries, the forest industry has attributed a low priority to investment in R & D. With regard to basic research, more resources have usually been allocated to foresty-related issues than to problems of the forest industries. In a long term perspective, forest industries must compete with a variety of other industries which presently allocate 3-4 times more of their value added to research and development. The expected outcome of this process is a gradual increase of potential substitutes which will firstly force the forest sector to adjust by further reducing production costs and might finally squeeze an increasing number of forest industries and their products out of the market. This is a bleak scenario which has enormous ramifications for trading opportunities in the long-term.

In view of the observations made above, it is essential to distinguish between process and product innovations. During the post war period, the paper and paper products industries have secured their markets primarily by means of cost reducing process innovations implying increased production scale and a growing capital intensity. For this segment of the industry, the process seems to have reached a stage of maturity in terms of production technique. However, the gap between the technical level in various countries was pronounced in the beginning of the 1980's. As a consequence, one may foresee structural changes altering the regional distribution of supply capacity and productivity.

Similar changes may be anticipated with regard to the wood products industry. This sector is characterized by small scale production techniques which have not changed in any fundamental way during the twentieth century. In this case, there is an immature gap between the techniques which are currently in practice and potentially available technologies.

The future of forest-based products is threatened by competition from product developments in a spectrum of other sectors. The electronics industry, new systems for communication and transmission of information, industries producing plastic and synthetic fibres, and metal industries producing building and construction materials are but a few. At the same time, we must not ignore potential technological break-throughs which may unearth new products based on cellulose molecules. Within the wood products industry, there is scope for substantial changes both with regard to new production techniques and products with more elaborate features.

New technological processes of the type outlined above complicate the analysis of world trade by introducing new product mixes into the system and jeopardizing old patterns of trade. Scenarios of such transiton paths may involve drastic changes in both the supply capacity and the demand structure in various regions of the world. For similar reasons to those expressed concerning the dynamics of the forests themselves, these issues are fundamental to the interdependencies which must be addressable using the Global Trade Model, but they are too complex to be treated inside the linkage system itself.

5.2.3 Investment and Changing Capacity

In the preceeding section, we emphasized the pronounced contrast between the historical development of production techniques in the two major segments of the forest industry. As a result of this dynamic pattern, the paper and pulp industry has an extremely high capital/output ratio which may reach a level that is 6-7 times as high as the average level in the wood products industry. This capital-intensity also means that investment costs per unit of capacity will vary between the sectors over similar orders of magnitude.

In the longer term, the total capacity of the forest industry is determined by the slow growth process of available forests. Therefore, an evaluation of alternative ways in which the limited forest resources can be used is the most important decision problem for many of the productive nations. In other regions (e.g. South America and the ASEAN region), the supply capacity depends on investments in harvesting capacity and associated infrastructure. For these regions with potential growth in supply capacity, different scenarios will correspond to alternatives regarding the availability of (foreign) capital, investment risk evaluations, etc. Moreover, it should be recognized that such infrastructure developments constitute *slow* processes of change.

Conditions for expanding production capacity are quite different in the two main segments of the forest industry. The capital intensive part of the industry, with integrated paper mills as an extreme example, is characterized by a time consuming investment process. In this case, new plants require a design and construction period extending beyond the five-year scale. In model terms the capacity may change between five-year periods but rarely within them. The wood products industry, with significantly smaller capital coefficients and design complexity, is changing at a much faster rate. For this industry, capacity adjustments do occur within five-year periods. Moreover, in the paper and pulp industry we observe that capacity contractions in the form of plant shutdowns occur at a slow pace. Much of the production structure in Europe has this feature of delayed shutdown. One consequence of this is that the difference between the best-practice technique and techniques still operating in old plants is considerable.

For certain groups of countries, capital formation is a variable with macro-economic significance. In such countries forest industries may use up more than one-quarter of the total investment budget available for the industry as a whole. This is illustrated by Table 6. In those countries, the forest sector plays a dominating role. Since new production techniques are brought about through capital formation, technological change and increased competition may cause severe tensions in the capital markets of such regions. Therefore, the financing of new investments constitute a fundamental problem, not only for countries which are currently trying to develop and augment their capacity, but also for some of the traditional forest industry regions.

Table 6. The percentage ratio between forest industry investment and total investments in manufacturing industries 1965-1975, and 1976-1980.

	Wood Products		Paper and Paper Products		Forest Industry as a whole	
	65-75	76-80	65-75	76-80	65-75	76-80
Finland	8	9*	23	28*	31	37*
Sweden	8	8	17	18	25	26
Canada	7	6	15	14	22	20
Norway	7	7	8	11	15	18
Philippines	7	-	6	-	13	-
Austria	6	4	6	7	12	11
USA	3	3*	6	7*	9	10*
Czechoslovakia	4	4	5	4	9	8
Australia	4	4	4	4	8	8
France	4	5	3	3	7	8
FRG	3	3*	3	3*	6	6*
Japan	2	1	4	4	6	5
Hungary	2	2	3	2	5	4
England	2	2*	3	3*	5	5*
Netherlands	2	2	3	4	5	6

SOURCE: UN Yearbook of Industrial Statistics
* denotes incomplete series 1976-80.

Remark: Wood products also include furniture (which is a significant component only for France and Austria).

Decisions about capacity change may sometimes be influenced by objectives adhering to overall industrial policies of a country. However, in general the incentives to create new capacity are based on expectations about future incomes and profits associated with the investment. One may therefore identify a potential interplay between capacity creation in regional component models and price patterns generated by the world trade analysis. Decisions to reduce supply capacity, remove obsolescent plants, and abandon non-profitable harvesting areas are affected by the relation between costs and prices. However, one should be careful to distinguish between the continuation of production in already established production units and the decision to build up new capacity. The latter process can only be captured if the scenario capability takes into account the interplay between capacity decisions, productivity and cost differentials, and world market prices.

One may observe that the options for less industrialized countries to enter into competition with the traditional forest industry regions differ considerably between different types of production. This is illustrated by the following two examples. For modern, integrated paper mills the capital intensity (capital per employee) is presently reaching levels exceeding US$300,000. For some types of saw mills the capital intensity will be less than 10 percent of the above value.

5.3 Demand-Related Factors

The demand for forest products in various regions of the world is also the focus of major structural changes. In this context, our discussion is restricted to the demand by end-users either for intermediate or final consumption in a certain country or region. The most pertinent factors shaping structural change appear to be (i) changing consumer preferences and a nation or region's fluctuations in purchasing power, and (ii) product innovations and competitive substitution. Often it is also useful to distinguish between inputs to investment processes (e.g. building and construction) and other production inputs (e.g. chips).

5.3.1 Consumer Demand

It has been suggested that a widespread future belief in resource conservation within one or more of the major trading nations in paper products (e.g., Canada or the USA) would propagate a drastic reduction in total consumption and trade. In reality, the use of paper is related to the whole structure of the production and consumption of various commodities where packaging and freight play an important role. But the conservation question highlights the fundamental role which changing consumer attitudes can play in determining future demand patterns and the structure of trade. Any forecast of long-term developments on the demand or consumption side must not only account for income and price adjustments, but also the changing location of consumers and their total pattern of life.

The variations which occur in the case of paper demand are extremely illustrative of this point. In the middle seventies, the average paper consumption per capita in the OECD group was about 150 kilograms. At this time, Sweden was actually consuming about 220 kilograms per person whereas Austria's per capita consumption was less than 100 kilograms. Regression analyses based on comparative incomes or prices as the explanatory variables can only explain a limited amount of this variance. Table 7 illustrates some of the deviations from the expected consumption levels. These deviations emphasize the role which different consumer attitudes can play in various nations. They may also partly reflect the relative purchasing power of these nations, which are subject to the vagaries of aggregate monetary and economic policies of a more general type.

5.3.2 Substitution and Product Development

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 each market lies in the continuum between full competition and monopoly has significant implications for the approaches used to model substitution and industry development. The basic market 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 of producers to differentiate their products from those of other producers.

Models of pure competition usually refer to situations in which the numbers of producers and consumers are large, few barriers to entry exist, and the degree of product differentiation is small. Monopolies and oligopolies may prevail when the number of buyers and sellers is small, entry costs are high, or substantial

Table 7. Deviations from the expected consumption (+ or -) of paper in different OECD-countries in 1974.

Higher consumption countries	Deviation from regression value	Percent deviation
Great Britain	+ 56 kg/capita	+ 65 percent
USA	+ 82	+ 41
Japan	+ 29	+ 26
New Zealand	+ 27	+ 23
Sweden	+ 17	+ 8
Lower consumption countries		
Germany	- 19 kg/capita	- 27 percent
Switzerland	- 49	- 24
Australia	- 44	- 24
Norway	- 36	- 21
France	- 27	- 19
Denmark	- 19	- 11
Austria	- 18	- 15

SOURCE: Andersson (1982).

differences exist between products.

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

(1) No single competitive classification 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 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. Most forest products are intermediate goods; they are employed in additional production activities to yield goods or services which are in turn marketed to final consumers (fuelwood may be 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. Even newsprint, which represents the bulk of the physical substance of a newspaper, accounts for only a small part of total publication costs.

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 cost-saving shifts in production techniques. Innovative 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 more 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 have eased.

For a more detailed discussion of the general factors involved in demand modeling, a survey of past studies of the demand for forest products, and a critique of various modeling approaches, see the work of IIASA's Demand, Supply and Trade Group (1982).

5.4 Trade-Related Factors

Supply-related and demand-related factors are essentially a reflection of the state of the forest sector in individual nations or regions of the world. To this extent, they can be regarded as *intra*regional issues. Link-related factors necessitate the simultaneous consideration of forest sector developments in two or more nations. They are therefore describing *inter*regional issues. The major link-related factors which affect the international pattern of trade can be classified as trade preferences, trade barriers, transportation costs and freight capacities, traded prices, price formation, and flow-determining mechanisms. Each of these factors has an important role to play in the Linkage System for the GTM, and therefore warrants some discussion.

5.4.1 Trade Preferences

In Section 4.2, we discovered ample evidence to suggest that a considerable degree of inertia is embodied in the trade pattern of various nations exporting forest products. This inertia manifests itself in patterns of trade which alter quite slowly in terms of variations to earlier bilateral trade intensities or multilateral trade shares. Our analysis of future trade flows must therefore reflect the establishment and continuation of certain rigidities such as bilateral trade agreements, channels of communication and specific contacts between particular buyers and sellers in different regions. These particular forces of attraction or alliance may be loosely grouped under the heading of *trade preferences*.

Political, cultural, religious or economic alliances generally create certain zones of preference within which trade between members is substantially greater than might otherwise have been expected. These zones may have former colonial links (such as the British Commonwealth), they may be bound by close cultural, geographic or historical ties (such as the Nordic countries or Canada and the USA), or they may be areas of economic cooperation (like the European Economic Community and the Organization for Economic Cooperation and Development). In many instances, these zones of preference are formalized by the establishment of bilateral or multilateral trade agreements. It is important to emphasize that for certain trade links such preferences appear to be extremely strong.

5.4.2 Trade Barriers

The pattern and terms of trade are also a function of certain impedance factors and frictional effects which may be conveniently grouped under the heading of *trade barriers*. These barriers are of two types:

(i) *natural* barriers such as distance, terrain, and climate; and

(ii) *artificial* barriers such as tariffs, import duties, quotas and embargoes.*)

The latter group may be further subdivided into price-related (tariffs, import duties) and non-price-related (quotas, embargoes) barriers.

Tariffs and quotas have probably been more thoroughly analyzed than any other factors affecting trade flows (Sève, 1983). Examples of work in this area include some analyses of USA-Canada lumber trade restrictions by Adams and Haynes (1980), an econometric simulation of a log export ban by Haynes, Darr and Adams (1980), and Radcliffe's (1980) examination of the trade barrier question with respect to several products on a "composite commodity" basis. Very little attention has been paid to the influence of natural barriers such as location and distance. One may also point out that in a certain sense barriers constitute forces which counteract the influence from trade preferences.

---

*) For certain products there exist country-specific standards with regard to technical and quality features of the products (e.g. building materials delivered by the wood products industry). Such standards have the same effect on trade as artificial barriers.

5.4.3 Transportation Costs and Freight Capacity

Transportation cost is a convenient means of quantifying the effect of relative location and distance on trade flows. Calculations carried out by Jaakko Pöyry suggest that the costs of transportation account for between 6 and 15 percent of average production costs for similar classes of paper production units. These transportation costs are highly variable because of their dependency upon energy prices. For example, the possible concentration of trade in certain forest products to the central European market would automatically gain some comparative advantage for the Nordic countries over the USSR, Asia, or the Americas if any large increases in energy and transportation costs were to occur.

An illustration of how much transportation costs may differ between various exporters is provided in Figure 13. It shows the distribution costs for three different origins with the same destination, i.e. Rotterdam.

Limitations also exist on the freight handling and carrying capacity of certain exporters to ship heavy timber products. In some cases, inappropriate or insufficient cargo carriers are available. In other cases, there is simply a long delay caused by lengthy round trip times. These differences in delivery capabilities are also an important determinant of comparative advantage.

5.4.4 Market and Other Exchange Mechanisms

The development of world trade may be modeled as the outcome of an interaction between regional component models and a linkage system. The latter reflects the exchange mechanisms which determine trade flows and corresponding prices.

Among different exchange mechanisms we may identify a broad class of market type of mechanisms, but also processes of negotiation and bilateral bargaining which may deviate more or less strongly from market principles. Various adjustment processes adhering to a system of exchange mechanisms will generally operate at different speeds, and they will relate to different aspects of the exchange system. One may distinguish between at

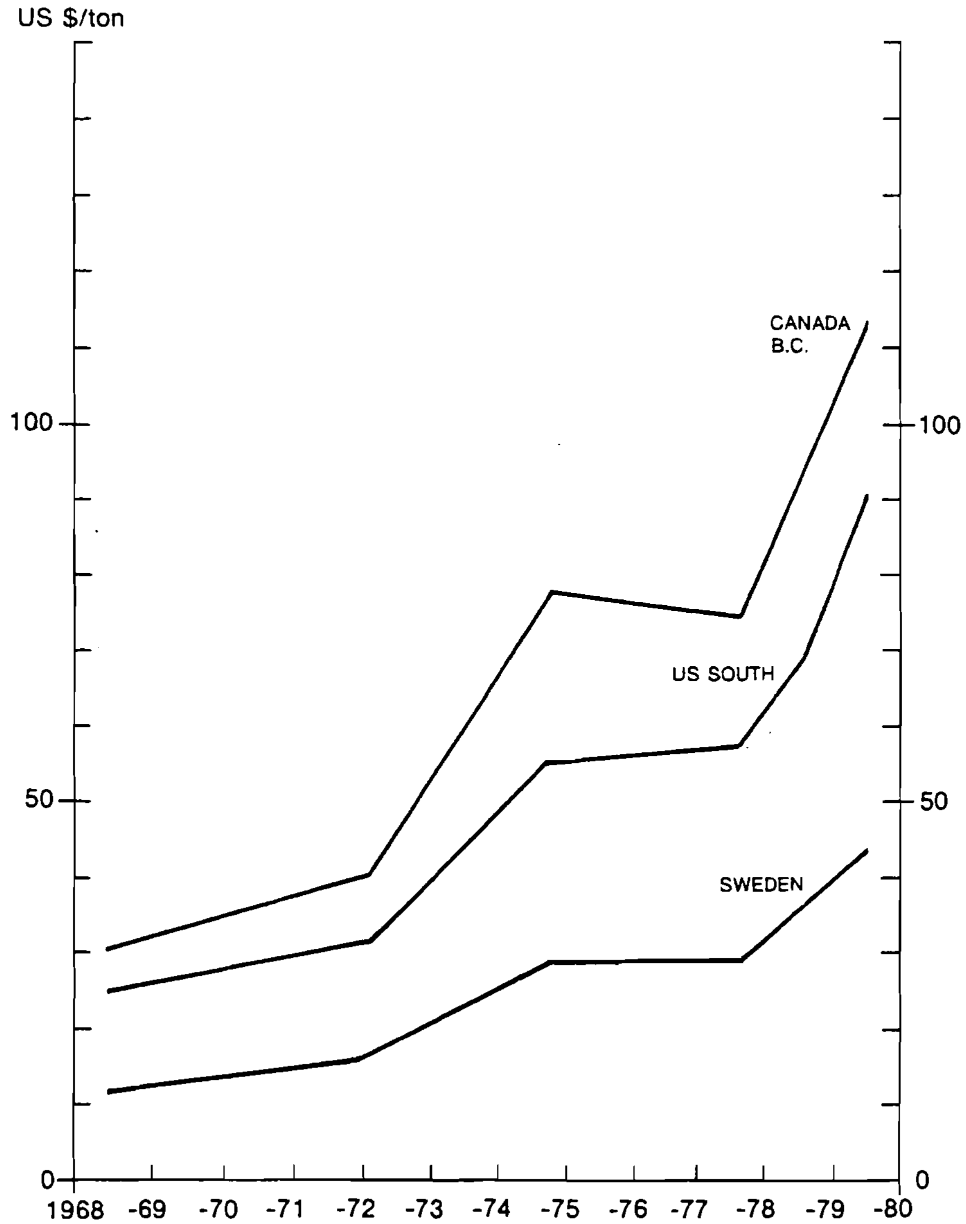


Figure 13. Distribution costs for bleached sulphite pulp delivered to Rotterdam.

SOURCE: SCA Shipping and SCA-T.

least four such aspects (i) macro-relations, (ii) system-wide relations, (iii) relations with regard to one specific product class, and (iv) relations referring to one specific exporter-importer link between two regions.

An example of a macro-relation is the development of trade balances and corresponding re- and devaluations of national currencies. In recent years this problem has been accentuated by strong tendencies towards a sustained state of disequilibria in global trade, escorted by disturbances in the international currency and credit systems. Phenomena like OPEC's pricing policy, exchange rate fluctuations and discounting strategies have contributed to disequilibria also in the global market for forest products. Macro-phenomena like this must be catered for in the development of the Global Trade Model.

System-wide phenomena include the relation and substitution between different types of products, relative prices and the specialization of regions as regards which products they export and import.

In general, the trade of a specific product class is influenced by an exchange mechanism which varies in character over the set of different links. Those variations depend partly on differences in how trade contracts are made and how fast established patterns change. In a medium-term perspective such differences will be reflected by trade preferences and barriers as well as other forms of inertia prevailing over several years in sequence. Established trade channels with prevailing affinity between distinct pairs of exporting and importing regions make the pattern of trade flows rigid and the adjustment process slow. An obvious example is the trade between different firms belonging to the same multinational corporation. Similar rigidities are caused by long-term agreements and contracts. Inertia in these different forms may be very strong for certain trade links and much weaker for others.

With regard to a given product class the exchange system will usually be segmented to some extent; certain parts of the trade will be influenced by oligopolistic behavior orchestrated by cartel formations, tacit and open collusions aiming at controlling the price level on different links and safeguarding established market shares. Other parts of the trade flows may share certain characteristics of competitive behavior, e.g., in the sense that exporters are price-takers. Still other parts of the trade flows may be regulated by bilateral bargaining between countries. The Global Trade Model should allow for exercises which assess the effects on future trade patterns of alternative scenarios (assumptions) with regard to the development of trade segmentation in the sense outlined above.

A basic feature of the Global Trade Model must be its ability to use varied assumptions about different market type mechanisms, and to assess the effects of such alternatives. It should be recognized that also for cases in which distinct trade policies play an important role, the market environment in which they are applied still affects the nature of such policies and the consequences they have.

At this instance it is necessary to clearly distinguish between the regional component models and the linkage system. Let us first note that for each time period the linkage system will receive two types of inputs from the component models:

i) Regional supply of a product class; in principle, this supply will have the form of supply behavior or supply strategies in each region such that the supply depends on the regional cost structure, the selling price and adopted (prevailing) trade and industrial policies. This means that the supply from different regions (and on different trade links) may vary considerably as regards the price sensitivity, i.e., on certain links the supply may not vary at all in the medium-term as the world market price pattern varies.

ii) Regional demand; also in this case we have to recognize that the price-sensitivity will vary between regions (and on specific trade links).

The nature of the regional supply and demand behavior will strongly affect the world trade pattern. In addition to this one should observe that the price sensitivity may vary in the linkage system itself. This statement may be interpreted in several ways. First, when the trade flows in the linkage system represent imbalances the link-related prices may adjust too slowly to instantaneously resolve the imbalances. Second, the adjustment of the flow pattern on the link network may adjust fast or slow to price differences on different links. This example illustrates that the price-sensitivity or the degree of competition must be evaluated on two levels: (i) for the regional component models which refer to the behavior in different countries, and (ii) for the linkage system itself which refers to the exchange mechanism of the world trade market.

As regards price formation, the Global Trade Model may have to cater for various features such as (i) a certain region is identified as a price leader, (ii) exporters are price-setters and importers are price-takers, (iii) importers are price-setters and exporters are adjusting to given prices. Equally important features of the model mechanisms relate to the way in which trade or exchange solutions are defined:

i) How does the exchange mechanism adjust trade flows as a response to imbalances, and how are trade flow balances defined?
ii) How does the exchange mechanism adjust the associated price structure, and how are price structures and flow patterns associated?

Let us first note that a trade solution will be defined by the specified solution conditions. It is necessary to adopt a methodology which is flexible enough to allow for alterations of these conditions. Moreover, such conditions must be specified for the two levels of the trade system--the regional and the global level. The trade flows may, for example, be balanced (or in equilibrium) on the global level with corresponding regional disequilibria and vice versa. Also, one may consider groups of regions, each constituting a trade pool which is balanced (in a solution) while regional and global disequilibria prevail in the medium-term perspective. Finally, the solution concept adopted for the medium-term perspective will affect the way in which a sequence of medium-term periods have to be linked together.

Examples of alternative market mechanisms are provided in Johansson and Persson (1982). One such assumption is that sellers are price-takers. In this case, all exporters (including domestic or intraregional deliveries) are behaving according to a price-sensitivity rule which induces them to adjust their trading pattern in accordance with changes in relative prices. This type of import-determined price mechanism is most appropriate in a buyer's market.

The contrasting assumption would be that buyers are price-takers, so that the price-sensitivity of importers is of central interest. This type of export-determined price mechanism corresponds to a seller's market. A closer examination of the price adjustment processes for each forest product would enable us to distinguish between mechanisms which generate prices which are import or export competitive. For some products, neither the net import price from each origin region nor the net export price from each destination region may be constant.

The importance of the above type of considerations is obvious if we note that when a seller (exporter) evaluates the various options to deliver his output, the following facts are important: (i) the production cost may depend on the level of output, (ii) the transportation cost varies between links, and (iii) the artificial barriers (e.g. tariffs) varies similarly. This means that the seller may have to adapt the price charged (obtained) to the conditions pertaining on each separate link. The net income or profit will depend on how the link-related prices vary. An analogous situation obtains for the buyer (importer).

In summary, different assumptions about market and other exchange mechanisms should be allowed for in the Global Trade Model. Moreover, the linkage system of the model must be flexible enough to include mechanisms which are appropriately designed to reflect the varying conditions for specific exporter-importer relations. For various countries (and regions) those conditions may include bilateral bargaining and negotiations, the formation of regional cartels, and other variations in the degree of competition on the world market. A country or region may shift from being a price-setter (price-leader) to only a price-taker, and prices may be more or less import-determined or export-determined. The latter pair correspond to the underlying assumptions of import or export revenue maximization.

6. SUMMARY AND FUTURE DIRECTIONS OF RESEARCH

The Global Trade Model (GTM) will consist of a set of Regional Component Models (RCM) and a Linkage System. The interface between these submodels is depicted schematically in Figure 14. Operating through this interface, the GTM will provide information on world market prices, trade flows, and production and consumption potentials within each region. A more detailed picture of the relationship between the Forest Trade Database (FTDB), the Regional Component Models and the Linkage System is given in Figure 15. It is evident that the decomposition of structural change into supply-related, demand-related, and link-related factors is consistent with the chosen structure of the GTM. The supply and demand-related factors will be treated in the Regional Component Models whereas the link-related factors will be addressed in the Linkage System.

Operationally, the Regional Component Models will provide information on the supply and demand potentials of their respective regions. This may be in the form of supply and demand functions which are sensitive to prices on the world market, or just simply a price-sensitive net supply function for each region. Then for any set of world market prices proposed by the Linkage System, the Regional Component Models can compute consistent levels of export and import activity.

The Linkage System will be designed to compute a price vector which is consistent with the set of bilateral trade flows calculated using a particular flow-determining mechanism. Since this latter mechanism will itself be flexible to allow various theoretical assumptions to be explored, we do not intend to elaborate any further on the Linkage System at this stage. It will be the subject of detailed discussion in the companion paper (Andersson, Batten, Johansson, Kallio, 1983).

In this first paper, we have concentrated instead on the substantive conceptual and empirical issues pertaining to the development of a Global Trade Model (GTM) for IIASA's Forest Sector Project. We began by defining the major objective of the GTM exercise as the provision of a quantitative tool for the

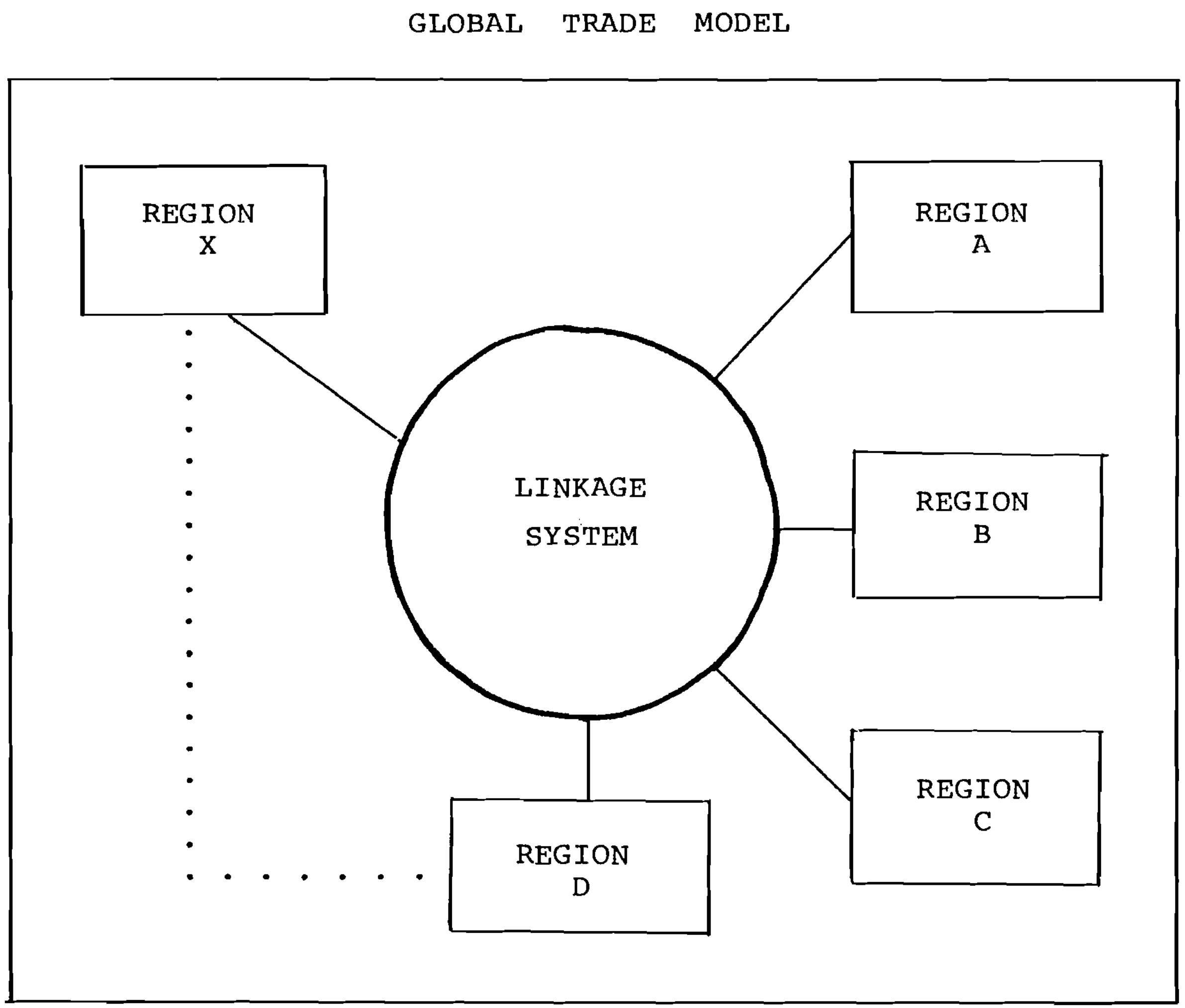


Figure 14. Interface between Regional Component Models and the Linkage System.

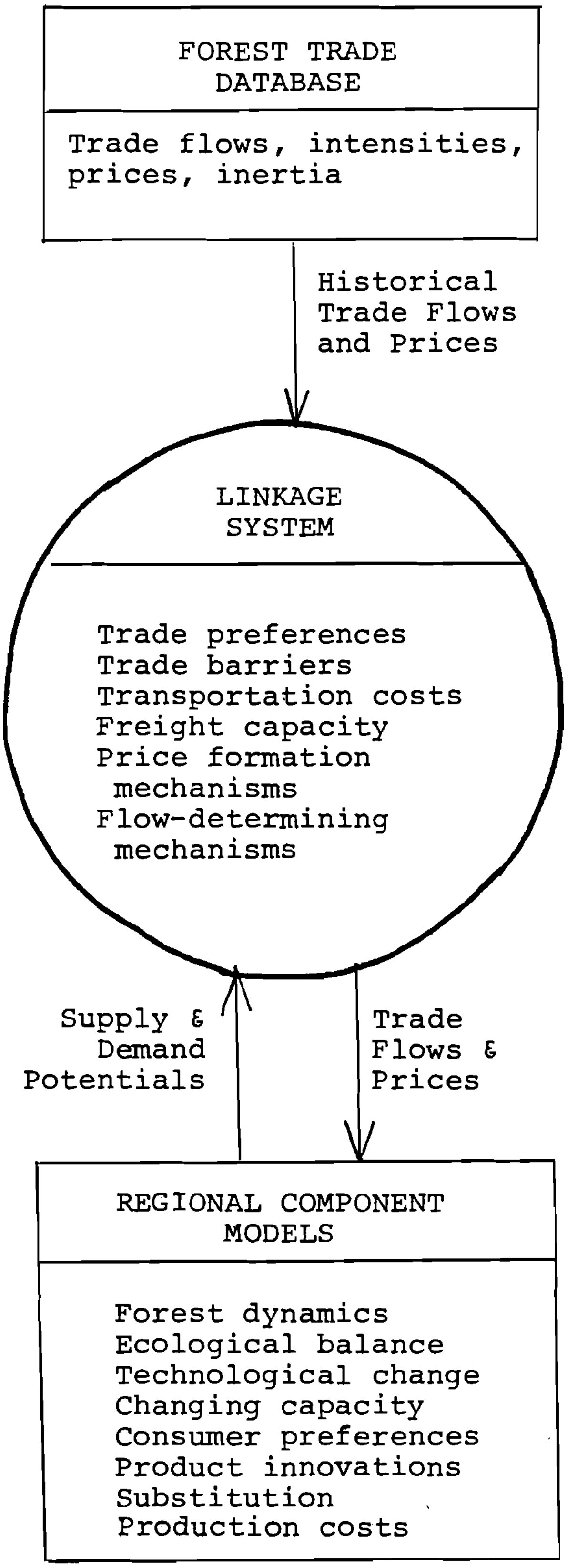


Figure 15. The interdependencies of the GTM.

long-term analysis of structural changes in the pattern (bilateral flow volumes) and terms (value and conditions) of world-wide trade in forest products. The scope of the GTM encompasses all the primary and secondary products of the entire forest sector, namely forestry and forest industries.

The need for policy relevance emphasizes the advantages of a scenario approach. Problems of product classification and regional subdivision have been addressed, and the notion of strategic aggregation has been introduced to provide an important element of flexibility with respect to the linkage procedure. Historical aspects of structural adjustment in the trading patterns of certain forest products have been examined, and ample evidence points to the embodiment of a considerable degree of inertia in the trade patterns of various exporting nations. The results of recent spectral analyses of export patterns in forest products over a twenty year period suggest that a sequential model with 5-yearly intervals can provide scenarios from which the business cycle has been eliminated. To retain this desirable property, 5-yearly intervals have been adopted for the GTM. It is important to observe that all available evidence indicates that also in cases where shorter-term fluctuations are not insignificant, they do not affect the longer-term pattern of change.

The substantive determinants of world trade adjustments in the long-term have been decomposed into three components, namely (i) supply-related factors, (ii) demand-related factors, and (iii) link-related factors. It is concluded that in order to develop a GTM which is capable of addressing each of these determinants of structural change, a set of Regional Components and a Linkage System will be required. The former will address the factors related to supply and demand potentials, whereas the latter will accommodate the link-related information.

The choice of a suitable Linkage System must not only be consistent with observed trajectories of structural change in the trade patterns, but also be flexible enough to generate a wide range of scenarios based upon different opinions and assumptions concerning future trade possibilities. The generation of alternative trade scenarios will not be restricted to the traditional type of sensitivity analysis, namely the specification of certain upper and lower bounds for key exogenous or endogenous variables. Instead, the scenario capability will be extended to the theoretical structure of the model itself and the actual mechanisms by which trade patterns may adjust over time. This additional flexibility will allow a much richer range of trade policy alternatives to be assessed, and implies a *composite* methodological structure for the Global Trade Model.

ACKNOWLEDGMENTS

The authors wish to acknowledge valuable contributions to this paper in the form of creative comments or useful material from Åke Andersson, Christer Anderstig, Ann Francescon, Wolf-Dieter Grossmann, Lars Lönnstedt and the former Demand Supply and Trade Group at IIASA (Darius Adams, Anders Baudin, Sten Nilsson, and Uno Zachrisson).

REFERENCES

Andersson, A.E., D.F. Batten, B. Johansson and M. Kallio (1983), The Analysis of World Trade in Forest Products: Part 2 -Methodology and Linkage System. (Forthcoming working paper), Laxenburg, Austria: IIASA.

Adams, D.M., and R.W. Haynes (1980) US-Canadian Lumber Trade: the Effect of Restrictions, *Proceedings, Workshop on Issues in US International Forest Products Trade,* Resources for the Future, Washington, D.C.

Andersson, Å.E. (1982) The Swedish Forest Sector: Problems, Methods, Models. In Å.E. Andersson, L. Lönnstedt and M-O Olsson (eds). *Proceedings from a Nordic Workshop on Models for the Forest Sector.* Research Report 1982:1. Umeå: Swedish College of Forestry, University of Umeå.

Anderstig, C. (1982) Actual and Predicted Trade Flows of Forest Products. Umeå: Department of Economics, University of Umeå.

Anderstig, C. (1983) Spectral Analysis of Swedish Exports in Forest Products, 1961-79. Umeå: Department of Economics, University of Umeå (in Swedish).

Batten, D.F. (1982a) *Spatial Analysis of Interacting Economies.* Boston: Kluwer-Nijhoff.

Batten, D.F. (1982b) Modeling Interregional and International Trade using Information Theory. Paper presented at the 19th Annual Conference of the Japanese Regional Science Association, Takamatsu, Japan.

Batten, D.F. (1983) International Conflict Management via Adaptive Learning and Multistage Compromises. *Conflict Management and Peace Science,* forthcoming.

Batty, M., and P.K. Sikdar (1982) Spatial Aggregation in Gravity Models: An Information-Theoretic Approach. *Environment and Planning A.* 14.

Buckingham, S., J. Koonce, M. Staley and C. Walters (1983) FSP/ARP Forest Trade Model: Model Structure, Submodel Descriptions and Policy Interventions. Draft, Laxenburg, Austria: IIASA.

Byron, N. (1980) Forest Products Trade in Newly Industrializing Asia. Seminar Paper. Canberra: Bureau of Agricultural Economics.

Demand, Supply and Trade Group (1982) Considerations in Future Development of the IIASA Forest Sector Project: Model Structure, Product Demand Models, Product Category Definition, Geographical Aggregation and Data Availability. WP-82-108. Laxenburg, Austria: IIASA.

Eriksson, J. (1981) Algorithms for Entropy and Mathematical Programming. PhD Thesis. Linköping, Sweden: Dept. of Mathematics, University of Linköping.

FAO (1982) *Yearbook of Forest Products, 1969-1980.* Rome: Food and Agriculture Organization of the United Nations.

Ferguson, I.S. (1978) International Trade in Wood Products in the Asia-Far East Region. *Proceedings Conference on Forest Policy and Forest Products in National Development and the Role of Foreign Aid,* ANU, Canberra.

Francescon, A. (1983) Historical Analysis of International Trade Flows in Forest Products: A Preliminary Paper. Draft. Laxenburg, Austria: IIASA.

Haynes, R.W., D. Darr and D.M. Adams (1980) US-Japanese Log Trade-Effect of a Ban. Proceedings, Workshop on Issues in US International Forest Products Trade, Resources for the Future, Washington, D.C.

Johansson, B. and Å.E. Andersson (1981) World Markets for Forest Products, in Johansson, B (1981), *Requisites for Industrial Development in Värmland during the Eighties,* Värmlandsläns landsting, Karlstad (in Swedish).

Johansson, B. and H. Persson (1982) Inertia and Change in World Trade: a Multiregional Linkage System. WP-82-00. Laxenburg, Austria: IIASA.

Kallio, M. (1983) An Approach for Analyzing World Trade in Forest Products. Draft. Laxenburg, Austria: IIASA.

Lesse, P., M. Batty and D.F. Batten (1983) A Theory of Model Evaluations: Spatial Invariance, Transformations and Aggregations. *Environment and Planning A.*

Masser, I. and P.J.B. Brown (1978) *Spatial Representation and Spatial Interaction.* Leiden: Martinus Nijhoff.

Nagy, A. (1983) The Treatment of International Trade in Global Models, WP-83-25. Laxenburg, Austria: IIASA.

Radcliffe, S.J. (1980) US Forest Products Trade and the Multilateral Trade Negotiations. *Proceedings, Workshop on Issues in US International Forest Products Trade,* Resources for the Future, Washington, D.C.

Roy, J.R., D.F. Batten and P.F. Lesse (1982) Minimizing Information Loss in Simple Aggregation. *Environment and Planning A,* 14:973-980.

Sève, J.E. (1983) Information Needs for Forest Products Trade Strategies. *Symposium on World Trade in Forest Products,* University of Washington, Seattle.

Snickars, F. and J.W. Weibull (1977) A Minimum Information Principle: Theory and Practice. *Regional Science and Urban Economics.*

Theil, H. (1967) *Statistical Decomposition Analysis.* Amsterdam: North-Holland.

Theil, H. (1972) *Economics and Information Theory.* Amsterdam: North-Holland.

Webber, M.J. (1979) *Information Theory and Urban Spatial Structure.* London: Croom Helm.