FINAL REPORT: ITTO ACTIVITY PCM(XI)/4

THE ECONOMIC LINKAGES BETWEEN THE INTERNATIONAL TRADE IN TROPICAL TIMBER AND THE SUSTAINABLE MANAGEMENT OF TROPICAL FORESTS

TECHNICAL ANNEXES OF THE MAIN REPORT

TO THE

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

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Executive Summary to the Main Report

The Main Report for the ITTO Activity (PCM(XI)/4) *The Economic Linkages Between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests* has been submitted by the London Environmental Economics Centre (LEEC) for review at the 14th Session of the International Tropical Timber Council in Kuala Lumpur, May 1993. The main purpose of this Activity has been to assess how the trade influences the incentives for sustainable management of tropical production forests, and to evaluate alternative trade policy options available to ITTO and its member countries to implement the Year 2000 Strategy as outlined by Council Decision 3(X).

The report examines the extent to which the tropical timber trade and policies, compared to other factors, affect tropical deforestation and timber-related forest degradation. The report also analyzes the potential role that interventions in the international tropical timber trade may have in promoting efficient and sustainable resource use in the forestry sector.

Evidence on the linkages between the tropical deforestation, timber production and the timber trade suggests that the trade is not a major source of tropical deforestation. Not only is the conversion of forests to other uses such as agriculture a more significant factor, but an increasing proportion of tropical timber harvested in producer countries is for domestic consumption and does not enter international trade. For example, only 17% of total non-coniferous tropical roundwood production is used for industrial purposes. Of this, only 31% is exported in round or product form. Therefore, only 6% of total tropical non-coniferous roundwood production enters the international trade.

Thus the volume of tropical timber production that actually enters the trade is small and declining. As tropical timber resources are depleted and domestic consumption of timber products increases in producer countries, log prices are expected to rise and exports fall. However, increased exploitation of temperate timber resources, and possibly substitution by other wood and non-wood products, will keep the prices of tropical hardwood products down. Profit margins of tropical log processors will be squeezed, and export markets difficult to expand. Thus the main link between deforestation and the tropical timber trade may be the impact of increasing scarcity of tropical timber resources, and thus tropical hardwood logs, on production and exports.

Nevertheless, there is genuine cause for concern over the excessive exploitation and rapid depletion of tropical production forests in many regions, including the indirect impacts of 'unsustainable' harvesting practices on the loss of non-timber forest values and the incentives to convert forest land to other uses (e.g. agriculture, livestock ranching). However, a more significant impact may be the role of 'unsustainable' timber production in opening up forest areas to subsequent agricultural encroachment and deforestation. These effects do not necessarily in themselves support strong statements about the relationship between timber production for the trade and tropical deforestation. As noted above, only a small proportion of tropical logs produced enters the trade directly, and in the future declining log exports are expected to be only partially offset by increased product exports.

On the other hand, the timber trade can lead to greater net returns for forestry investments and sustainable management of production forests, making this option more attractive than alternative uses of forest land such as agriculture. Unfortunately, in many producer countries the widespread prevalence of market and policy failures have distorted the incentives for sustainable management. Failures in concession and pricing systems have produced counter-productive incentives that lead to the 'mining' of production forests. Domestic market and policy failures have also had a major influence on the conversion of forest land to agriculture and other uses.

Thus the key factor in reducing timber-related tropical deforestation is ensuring proper economic *incentives* for efficient and sustainable management of tropical production forests. Appropriate forest management policies and regulations within producer countries ought to provide these incentives so that the *long run* income-generating potential of harvesting timber is maximized, and any significant external environmental costs associated with timber harvesting are 'internalized'. The starting point for ITTO's Target 2000 is therefore to tackle the problem at its source by urging producer countries to improve forest sector policies.

Current trade policy distortions in producer and consumer countries have, if anything, exacerbated the problems created by poor forestry policy and regulations in tropical forest countries. Although log export restrictions in producer countries have stimulated growth and employment in domestic processing, they have led to serious problems of processing over-capacity and inefficiency. To the extent that this is the case, log prices are artificially depressed and recovery rates fall, thus increasing pressure on timber resources. Although import tariffs on tropical forest products are generally low and declining in major developed consumer markets, non-tariff barriers may be significant and increasing. Restrictions on imports depress the global demand for tropical timber products and can feed back to reduce stumpage values in producer countries, thus discouraging the incentives for more efficient processing and better forest management. Moreover, producer countries will continue to argue that they need to compensate their domestic processing through subsidies and export restrictions.

In short, restrictions in trade are not helping to reduce timber-related deforestation in developing countries. In contrast, by adding value to forestry operations, the trade in tropical timber products *could* act as an incentive to sustainable production forest management - provided that the appropriate domestic forest management policies and regulations are also implemented by producer countries. Unfortunately, many proposed trade policy interventions to 'save the tropical forests' - such as bans, taxes and quantitative restrictions - may actually work to *restrict* the trade in tropical timber products. Such interventions may reduce rather than increase the incentives for sustainable timber management - and may actually increase overall tropical deforestation. A summary of timber trade policy options, and their advantages and disadvantages in promoting sustainable tropical forest management is provided in Table 1.

However, our study does suggest that there is a role for additional tropical timber trade policies in fostering *trade-related incentives* for sustainable management. Trade policies will be the most effective if:

i) they are employed in conjunction with and complement improved domestic policies and regulations for sustainable forest management within producer countries;

ii) they improve rather than restrict access to import markets for tropical timber products so as to ensure maximum value added for sustainably produced tropical timber exports; and,

iii) they assist producer countries in obtaining the additional financial resources required to implement comprehensive national plans for sustainable management of tropical production forests.

Based on the above conclusions from our study, and in particular on our assessment of the various trade policy options that ITTO could consider, we recommend a policy strategy whereby ITTO explores those options that *help reinforce the commitment by producer countries towards implementing sustainable management and the Year 2000 objective*. The main elements of this strategy are:

- ITTO should encourage the establishment of a *country certification* scheme. The main objective of such a scheme should be to verify that a producer country is *implementing policies, regulations and management plans that ensure substantial progress toward the Year 2000 Target*. In return to satisfying these conditions, *all tropical timber products of that country* will be certified coming from a 'Target 2000' producer country.

- As part of their policy reviews required for the certification process, producer countries should be required to review:

  i) the implications of their existing domestic forestry policies and regulations on timber-related tropical deforestation; and,

  ii) the extent to which their existing forest sector trade policies may also be affecting deforestation, either directly or through exacerbating problems caused by poor domestic forestry policies and regulations.

  In order to show progress towards achieving Target 2000 of sustainable timber management, producer countries ought to *demonstrate a commitment to correcting those policy distortions that work against the Target 2000 objective*.

- In exchange, producer countries that qualify for country certification of their tropical timber products through demonstrating progress towards achieving Target 2000 *should be allowed better access for these products in the import markets of consumer countries*. For example, the removal of specific tariff and non-tariff barriers on imports of a certified country's tropical timber products ought to take place on a case by case basis. In addition, consumer countries could actively promote, through information and market intelligence campaigns, the use of tropical timber imports from certified countries.

- Certified producer countries should also qualify for *the additional financial assistance* they require for implementing national sustainable management plans and policies. Approximate estimates of the additional resources required suggest that anywhere from US$ 0.3 to 1.5 bn will be needed annually by producer countries to sustainably manage their tropical forests, including production forests. ITTO *should take the lead in promoting additional international financial assistance for this purpose for those countries that demonstrate progress toward the Year 2000 Target and are duly certified.*

- Our study has examined several mechanisms for raising these additional funds. Our conclusions are:

  i. Although the additional resources required for sustainable management of tropical forests ought to come from sources external to the trade, in the current global and economic climate any additional funding through existing bilateral and multilateral development assistance is unlikely to be forthcoming or sufficient for the task;

  ii. As part of its Year 2000 Strategy, ITTO ought to begin working with other international fora to establish more comprehensive mechanisms and international agreements for raising revenue *external* to the trade to combat the *overall* problem of tropical deforestation. Possible mechanisms could include the establishment of a tropical forest fund or a global system of marketable forest protection and management obligations;

  iii. However, ITTO ought to explore *immediately* the possibility of raising funds more specifically targeted for sustainable management of tropical production forests in certified countries, most likely through appropriating revenue from the international trade in tropical timber products.

  iv. In our opinion, the use of a *tax or revenue transfer scheme* to redistribute the existing revenue from the trade back to certified producer countries offers the most promising option. If necessary, it could be supplemented by a *revenue-raising trade surcharge* of less than 5% - but this approach should be used cautiously to avoid any distortionary or discriminatory effects.

- Finally, as part of this strategy, there may be a need to protect individual tropical timber species that are in danger of over-exploitation. ITTO ought to work with CITES and other relevant authorities to establish a comprehensive trade mechanism that establishes sustainable offtake export quotas for endangered tropical timber species as an incentive to both producer and consumer countries to accept a controlled legal trade and to enforce it.

We believe that the recommended strategy should form the basis for further negotiations by producer and consumer countries under ITTO auspices. A comprehensive set of policies should be developed that enlist trade-related incentives as a means to assisting producer countries attain the Year 2000 Target of sustainably managed timber production.

MAIN REPORT

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ANNEX A

Tropical Forest Resources and International Trade In Tropical Timber Products

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Tropical Forest Resources and International Trade in Tropical Timber Products

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1. Introduction

The following paper consists of a synthesis of existing data and studies to provide a statistical review of forest resources and the international trade in timber products, with special emphasis given to the role of tropical forests and tropical timber products. This overview provides a background for the formulation and analysis of policy options for the international tropical timber trade to encourage sustainable forest management.

The Food and Agriculture Organization of the United Nations (FAO) plans on completing its *1990 Forest Assessment* towards the end of 1992 thereby updating the world's most comprehensive database on global forest resources. The FAO studies are an amalgamation of various primary sources ranging from case studies and national statistics to satellite data. The data on developed countries is being amassed by the FAO/European Commission for Europe (ECE) in Geneva while FAO in Rome compiles the developing country data. Some preliminary summary results on deforestation rates in tropical regions have been released (FAO 1992), and the overview of tropical forest resources and forest land use that follows is necessarily based on this, past FAO assessments as well as other secondary sources. While a number of these secondary sources, such as the World Resources Institute (WRI 1990) and Sedjo and Lyon (1990), have pieced together regional or global reviews from more up-to-date primary sources, they often end up relying heavily on the older FAO and ECE/FAO figures.

Data on the production of, and trade in, timber products is generally more accessible and reliable than that concerning forest resources and changes in land use. The FAO maintains an extensive database of information that chronicles the yearly turnover in internationally traded forest products as well as figures on domestic production. An additional source of information on tropical timber is the International Tropical Timber Organization (ITTO) which compiles statistics reported by its producer and consumer country members.

2. The Status of Tropical Forest Resources

Global Forest Resources

In the mid–1980's approximately 27% of the world's land area – or 3,565 million hectares (mn ha) – was covered by natural forests. Closed forest accounted for almost 80% (2,822 mn ha) of these natural forests. Other woodlands and plantations accounted for an additional 13% of the world's land area (1,723 mn ha).[1] Figure A.1 gives a regional breakdown of closed and open forest lands along with an indication of the percentage of total land area covered by closed and open woodlands in each region. No discernible pattern in percentage of total natural forest cover between the tropical or temperate regions emerges from the data. Around 40% of the former Soviet Republics and the Americas are forested while Europe (34%), Africa (23%), Oceania (20%) and Asia (18%) are relatively less forested. Asia, Europe and the former Soviet Republics countries maintain large tracts of closed forest relative to open forests. The only region with more open than closed forest – by a factor of two – is Africa.

Commercial harvesting of forest resources may occur in both open and closed forest. Open woodlands, for example in Africa, lend themselves more to use as sources of fuelwood and other local uses. Closed forests, on the other hand, are more likely to be subject to more intensive commercial exploitation for industrial wood products. As this study examines the environmental effects of the international trade in forest sector commodities, closed forests are of particular importance (see Figure A.2). The former Soviet Republics and Latin America hold just over one–half of the world's closed forests between them. North America follows with 21% and Asia with 13%. The remaining closed forests are situated within Africa (6%), Europe (6%) and Oceania (3%) completing the regional distribution.

Natural forests are also classified according to whether they are bamboo, broadleaved (i.e. non–coniferous or hardwood) or coniferous (i.e. softwoods) with the latter two being more prevalent in closed forest formations. Figure A.2 illustrates that softwoods predominate in temperate regions and hardwoods are found largely in tropical regions. Although there are there are substantial hardwood resources located in the temperate regions of the former Soviet Republics, the United States (US) and Canada, the reverse is not true and tropical regions have few softwood resources.

<u>Tropical Forest Resources</u>

Table A.1 depicts the status of natural tropical forest resources across ecological zones and regions using provisional data from the *Forest Resources Assessment 1990 Project* (FAO

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[1]Definitions of closed and open vary. For *temperate closed forests* WRI uses the ECE definition of areas with greater than 20% of area covered by tree crowns and the area's primary use is forestry. For *tropical closed forests* WRI uses the FAO definition of areas with a large proportion covered by trees and without a continuous grass layer on the forest floor. FAO's definition of areas with more than 10% tree cover and a continuous grass cover is taken by WRI as the criteria for *open forests*. WRI classifies temperate areas that are not used for agricultural purposes, have between 5–20% of their area covered by tree crowns, or have shrubs and stunted trees covering over 20% of their area as *other woodlands*. This is essentially ECE's definition of open forest minus the restriction that such areas be less than half a hectare in area. Finally, forest fallow and shrubs in tropical countries are also classified as *other woodlands* by WRI.

1992).[2] In 1990, the total area of natural tropical forests was estimated to be 1,715 mn ha – approximately 36% of the total land area in the tropics. Of this, tropical rainforests (656 mn ha) and moist deciduous forests (626 mn ha) constitute the largest portions (38% and 37% respectively).

On a regional level, Africa accounts for 47% of the total land area within the tropics but contains only 35% of the total tropical forest. In contrast, Asia is the smallest region within the tropics (15% of the total tropical zone area) but contains an equal proportion of tropical forest (15% of total tropical forest area). Latin America and Caribbean make up the remaining 35% of the tropical zone area, and contain the largest extent of tropical forest resources (50% of total tropical forest area). Within the tropical zone, over half of the closed forest area is concentrated within three countries, namely Brazil (347 mn ha), Zaire (103 mn ha) and Indonesia (109 mn ha) as shown in Table A.1

The extent of land under plantations[3] in the tropics is relatively small compared to that under natural forests – in 1990 total plantation area was 43.9 mn ha, less than 2% of the total tropical forest area (Table A.2a). What is more, the 'net' area (after accounting for an estimated survival rate of approximately 70%) is even lower – lying between 27.6 mn ha and 34.1 mn ha. Of the total tropical plantation area, Asia and Pacific have by far the largest share (73%), and a significant proportion (79%) of all tropical plantations are concentrated within three countries, namely India (18.9 mn ha), Indonesia (8.8 mn ha) and Brazil (7 mn ha). Industrial plantations (mainly eucalyptus, pine and teak) make up less than 35% of total plantation area, the majority of which is located in the Asia and Pacific region (58%), followed by Latin America (33%) with the remaining 9% in Africa (Table A.2b).

3. Changes in Tropical Forest Resources

Measurements of the extent of 'forest change' are heavily influenced by the definition that is employed. In this Section we look only at forest change according to the strict FAO definition of deforestation, that is 'the change of land use or depletion of crown cover to less than 10%' (FAO 1988). However, Section III of the main Report discusses in more detail the implications of using other definitions of forest change, such as degradation and modification, when analyzing the causes of tropical deforestation.

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[2] The FAO (1992) tropical forest data is based on information from 87 tropical countries which contain over 97% of the world's tropical forests.

[3] The definition of plantation used here is taken from FAO (1992) which states that "a plantation is a class of forest established artificially: (i) on land which previously did not carry forest; or (ii) involving the replacement of the previous crop by a new and essentially different species."

In recent years certain global patterns in forest land use changes have appeared. While in the temperate region as a whole forested area has remained broadly stable[4] – Sedjo and Lyon (1990) actually report a 2% gain in temperate forest area since World War II – the extent and rate of tropical deforestation has generated an increasing amount of publicity.

Tropical Deforestation

The preliminary results from the *Forest Resources Assessment 1990 Project* (Table A.1) indicate that the previously estimated total natural forest area for 1980 of 1,935 mn ha needs to be revised *downwards* to 1,882 mn ha. In addition, the research indicates that the extent of deforestation throughout the 1980's needs to be revised *upwards* from 11.3 mn ha annually to 16.9 mn ha annually. The effect of lowering of the forest area in the base year (1980) and increasing of the extent of annual deforestation leads to an increase in the estimated rate of annual tropical deforestation from 0.6% to 0.9% throughout the 1980's. The revisions are even more significant on a regional level, with the annual rate of deforestation in tropical Asia in particular being revised upwards from 0.6% to 1.2% (3.6 mn ha annually). However, Latin America (8.3 mn ha annually) and Africa (5 mn ha annually) continue to be the most significant contributors to tropical deforestation due to the sheer extent of the loss of their tropical forests. Among the main ecological regions in the topical zone, 7.3 mn ha of forests are deforested annually in the moist forest zone, 4.9 mn ha annually in the tropical rainforest zone and approximately 2 mn ha each year in both the dry and hill/montane zones, with the moist deciduous forest zone and the hill/montane forest zone suffering the highest rates of annual deforestation at 1.1%.

Of the tropical countries, Brazil (3.2 mn ha) and Indonesia (1.3 mn ha) incur the highest *extent* of annual forest loss (Table A.1). However, the *rates* of tropical deforestation are highest in those countries that have high annual losses of tropical forests combined with relatively small tropical forests, such as Ivory Coast (6.5%), Nigeria (5%), Costa Rica (4%), Paraguay (4.7%) (WRI 1992). Due to the vast extent of their forest stocks, the annual rate of deforestation in the 'Big Three' tropical forest countries remains relatively low: in Brazil it is 0.9%, in Indonesia 1.21% and in Zaire 0.2%.

Forests, of course, are not only destroyed, but regenerated naturally as secondary forests, are regenerated by human intervention or renewed naturally by human management. Reafforestation refers to three separate processes: (i) the restoration of a previously existing forests (artificial regeneration); (ii) the artificial establishment of a new forest on previously forested ground (reforestation); and, (iii) the artificial establishment of forests in previously unforested areas (afforestation). Table A.2a presents estimates of annual reforestation and afforestation in the tropics. While the reported area planted amounts to approximately 2.6 mn ha, the estimated net area planted annually (after taking account of an observed 70% survival rate) is only 1.8 mn ha. It is clear that the level of annual reafforestation (1.8 mn ha) are being dramatically outstripped by the level of annual deforestation (16.9 mn ha) in the tropics. What is more, only 35% of plantations are for

[4] Jones and Wibe (1992) point out that there are many forests within the temperate zone that are also under threat from degradation and deforestation. However, the loss of these forests has received much less attention than the loss of tropical forests.

industrial purposes, with the majority for non–industrial use, such as community tree planting and agroforestry.

It is extremely difficult to generalize about the implications of the reduction in tropical forest resources for the timber trade.[5] In some regions, the decrease in the natural tropical forest stock is constraining the availability of timber for the trade. In other regions, natural tropical forest stocks are still plentiful but economic factors, such as the cost of extraction and transportation of the timber, may constrain the supply of timber for the trade. Whilst an increase in industrial plantations may offset the reduction in supply of timber from natural forests in the future, this depends on a rapid increase in the level of investment in reafforestation over the next few years. The type of species planted, and the degree of substitutability between plantation timber (usually softwood species) and timber from natural forests (mainly hardwoods), will also influence the extent to which plantations can offset the loss of natural tropical forests. An additional concern is that some of the 'wider' economic benefits of tropical forests (e.g. non–timber forest products, watershed protection, biodiversity value, carbon store, climate regulation etc.) are being irreversibly lost through tropical deforestation.

4. Ownership, Management and Protection of Tropical Forest Resources

Poore *et al.* (1989) provide one of the most comprehensive discussions of forest management in the tropics in their book *No Timber Without Trees*. In addition, the FAO has undertaken numerous regional studies of tropical forest management throughout the 1980's (FAO 1989a, 1989b, FAO 1987). In anglophone Africa, customary rights recognized by colonial administrations in countries such as Ghana, Nigeria and Malawi have meant that although the forests are often nominally nationalized they are in fact treated as communal property. In francophone Africa, on the other hand, forests were traditionally considered property of the state – although local use was not expressly forbidden – and post–independence attempts to communalize forest lands have largely failed. In tropical Asia a large percentage (over 80%) of forests are owned, controlled and managed by the state.

One of the main mechanisms for conserving tropical forests is through the establishment of protected areas. Protected areas currently cover 5.4% of the total land area in the tropics. The level of coverage is roughly 1% higher in Latin America and Caribbean than Africa, Asia and Pacific (Table A.3). Although Africa has a much smaller number of protected areas, the average size of these areas is much greater than in other regions. The participants at the *IV World Congress on National Parks and Protected Areas* (1992) agreed to work towards ensuring 10% protection by the year 2000.

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[5] A project that is currently being undertaken for ITTO by Duncan Poore and IIED on 'Forest Accounting' should provide a greater insight on the implications of forest resources for timber production and trade.

5. Tropical Timber Products: Production and Trade

The FAO segregates timber products into 5 general categories: roundwood, sawnwood and sleepers, wood-based panels, wood pulp, paper and paperboard. The sub-category 'roundwood' is composed of both 'industrial roundwood' (i.e. sawlogs and veneer logs, pulpwood and particles) and 'non-industrial roundwood' (i.e. fuelwood and charcoal). All further processed products (such as furniture, window frames and doors) are referred to as 'higher processed products'.

While charcoal and fuelwood production is significant as a percentage of the volume of total roundwood production, especially in developing countries (i.e. 80%), only a very small percentage (less than 0.5%) of non-industrial roundwood production enters the international trade (Table A.4a). What is more, the value of imports of fuelwood and charcoal compared to the value of imports of all timber products is very small - less than 0.5% (Table A.4b). For these reasons, and because fuelwood rarely qualifies as a traded good due to its low value per unit of volume, it is excluded from further consideration in this study.

Global Timber Trade

The production of, and trade in, timber products on a global level has been expanding throughout the last few decades. The volume of industrial roundwood produced has grown steadily to reach 1,654 mn m^3 in 1990, of which around 7% enters the international trade as industrial roundwood (Table A.4a). Some of the industrial roundwood is consumed domestically in the timber processing industry, and approximately 20% of secondary processed products (e.g. wood based panels, wood pulp, paper and paper boards) are traded internationally. While the value of industrial roundwood imports has been rising steadily over time, its share of the total timber products trade fallen from a peak of around 20% in the 1970's to 10% in 1990. This reflects the increasing importance of secondary processed timber products, such as paper and paperboards and sawnwood and sleepers. In 1990 these two categories together accounted for 67% of the total value of the timber products trade. Given the focus of this study on the tropical timber trade, it is important to note that only around 30% (in volume terms) of the total global production of industrial forest products is derived from non-coniferous forests - which are mainly located in tropical regions (see Table A.5).

The global timber product market is largely dominated by developed countries, in terms of both exports and imports.[6] For example, on the export side (Table 2.6a), developing countries receive just a tiny portion (13%) of revenue generated by exports of industrial timber products. The value of Africa's exports of industrial timber products is less that 1% of the total value of exports of industrial forest products, that of Latin America less than 3%, and that of Asia only 10%. The principle exporters of timber products are North America and Western Europe who export 31% and 49% of the world industrial timber products respectively (in value terms). Developing country export figures are

[6] Note that developing countries are mainly located within the tropics and developed countries in temperate regions.

heavily influence by the trade from Far East Asia, which is responsible for 66% of roundwood exports and 91% of wood-based panels exports from all developing countries.

Differentiation by product type shows that the paper products category makes up approximately 47% of global export revenues (in value terms) from the industrial forest sector. This market is dominated by developed countries who account for 94% of the revenue raised by exports of paper products. The next largest markets are those for sawnwood (17%) and wood pulp (16%), followed by wood-based panels (10%) and industrial roundwood (9%). It is the less significant markets in which developing countries play a more active role – that is, they are responsible for 29% of exports of industrial roundwood and 42% of exports of wood based panels.

The developing countries share of the import market for industrial timber products is also relatively minor (only 27% in value terms), however this is larger than their share of the export market (13%). In 1990, the value of imports of industrial timber products to developing countries (US$ 33,005 mn) far surpassed the value of exports (US$ 12,930 mn) making them net importers of industrial timber products at a cost of over US $20,000 mn.

Tropical Timber Trade[7]

Of the total world non-coniferous tropical roundwood production (1,400 mn m^3 in 1990), only 17% is used for industrial purposes with the remaining being consumed as fuelwood and for other non-industrial uses (Table A.7a). Out of the total volume of industrial timber produced (275 mn m^3), approximately 31% (86 mn m^3) is exported in round or product form by tropical countries. Therefore, only a small percentage (6%) of total tropical non-coniferous roundwood production enters the international trade (Bourke 1992). Exports from tropical developing countries account for a modest share of the total value of world exports – US$ 11 billion (bn) out of US$ 97.5 bn, i.e. 11%.

Table A.8 lists (in value terms) the trade balance for tropical countries that currently export forest products.[8] Tropical Asia and Oceania is the major exporting region followed by Africa, with Central and South America playing a minor role in the international forest products trade. The major exporting countries are Indonesia, Malaysia, Ivory Coast, Brazil, Gabon and Congo who each exported over US$ 100 mn in forest products in 1990. Although many tropical countries export forest products only a few maintain a positive forest products trade balance due to high import levels of forest products. The forest products trade generates positive net foreign exchange earnings in only ten of the eighteen

[7] Tropical timber is defined here as non-coniferous timber coming from developing countries lying predominantly between the Tropic of Cancer and the Tropic of Capricorn. However, due to data constraints some of the following Tables are based on coniferous and non-coniferous timber data. Where this switch occurs, it is clearly indicated in the report and Table.

[8] Note that term 'forest products' includes industrial and non-industrial wood products and does not distinguish between coniferous and non-coniferous timber.

African countries, five of the nineteen Central and Southern American countries, and eight of the seventeen countries from Asia and Oceania listed in Table A.8.

Estimates (in volume terms) of the proportion of timber products that enter world trade from tropical countries compared to their apparent domestic consumption (ADC) of these products are presented in Table A.9.[9] As noted above, tropical Asia and Oceania is clearly the most important region in the forest products trade – it accounts for half of the industrial roundwood, sawnwood and wood-based panels produced by tropical countries and its exports represent over 85% of total exports of these products from all tropical countries. Tropical Central and South America produce 36% of forest products from tropical countries, but few of these products are exported as the large figure for ADC in Table A.9a indicates. Tropical Africa produces a minor share of forest products from tropical countries (14%) and exports roughly 10% of its domestic production. Whilst Africa accounts for around 15% of the ADC of roundwood in all tropical countries, its proportionate ADC of sawnwood (9%) and wood-based panels (12%) is much lower.

Table A.9b shows exports of timber products as a percentage of total domestic timber production in tropical regions between 1961 and 1990. On average in 1990, tropical regions exported 11% of industrial roundwood, 12% of sawnwood, and 69% of wood-based panels, with the rest consumed locally. The proportion of industrial roundwood and sawnwood exported relative to production has decreased from the peak around 1970, whilst in contrast the proportion of wood-based panels exported relative to production has doubled. However, this pattern is dominated by the Asian block – reflecting dramatic increase in the percentage of wood-based panels exported relative to production, from 40% in 1960-70 to 90% in 1990 – and is therefore not applicable to all regions. For example in Africa, while exports of industrial roundwood and sawnwood as a percentage of production have fallen over time, exports of wood based-panels have also fallen from 34% in 1961 to 22% in 1990. This is mainly due to the increased domestic consumption of processed wood in Africa. Similarly, in Central and South America, exports of all forest products as a percentage of production have decreased since 1961.

Real Price Trends for Tropical Timber Products

The real forest products price index has been fairly stable since 1969, although has shown a slight downward trend since the early 1980's (Figure A.3).[10] Within this broad forest products category, the real price index of tropical logs has displayed a rising trend over the 1969-88 period. However, the real tropical log price index has been fairly depressed over the past decade, and it has remained consistently below its peak value in 1979 (Figure A.4). The real tropical sawnwood price index has followed a similar trend, although with larger fluctuations and steeper decline since the mid-1980's (Figure A.5).

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[9] In Table A.9, the data refers to coniferous and on-coniferous timber products.

[10] The current prices are derived from export unit values and deflated with an index of export unit values of manufactured goods from the UN Monthly Bulletin of Statistics to obtain real prices (FAO 1990). The real forest products price index includes coniferous and non-coniferous forest products traded internationally.

The real price rises of tropical logs and sawnwood may reflect increasing scarcity due to declining inventories. Other industrial timber products (including wood based panels, pulp, and paper and paper board) have displayed a gradual increase in their real price index over the 1969–88 period as a whole. However, in contrast to tropical logs and sawnwood, the real price index of these products have continued their rise over the 1980's.

There are regional differences in the export price of tropical timber products. For example, the average unit export price of non-coniferous logs from Africa (current price US\$ 136/m^3 in 1988) is substantially higher than the average unit export price of non-coniferous logs from Asia (current price US\$ 78/m^3 in 1988) (FAO 1990). This difference in average unit export price between the two regions is explained, to some extent, by the composition of species exported.

<u>The Value of the Trade to Tropical Regions</u>

As noted above, only a small proportion of tropical timber harvested is used for industrial purposes (17%) and an even smaller proportion of total roundwood production enters the international trade (6%). The industrial forest sector and timber trade is, however, important to tropical countries for a number of reasons:

- First, the industrial forest sector makes a direct contribution the economy of producer countries – for example, in 1989 the industrial forest sector accounted for 3–6% of total gross domestic product (GDP) in Malaysia and Indonesia, 2–3% of total GDP in Ivory Coast, Gabon, Ghana, Brazil and Costa Rica. In most other tropical timber producing countries, however, the industrial forest sector represented less than 2% of total GDP in 1989 (World Bank 1992).

- Second, wood-related industries are an important source of employment generation in the manufacturing sector of many developing countries, although the level of employment in wood-related industries is extremely modest compared to the size of economically active populations in developing countries (Table A.10).

- Third, forest product exports are a valuable source of foreign exchange for a few countries. For example, forest product exports account for over 10% of the total value of exports from Central African Republic, Ghana, Indonesia, Malaysia and Papua New Guinea. However, across the tropics as a whole, exports of forest products do not generate substantial foreign exchange earnings compared to total export earnings (Table A.11).

- Finally, there are numerous wider economic and social benefits associated with timber production and trade that are also important for tropical developing countries, such as rural infrastructure development and the provision of other social amenities.

6. Future Trends in Supply and Demand in the Forest Sector

A number of studies have attempted to forecast future trends in supply and demand in the forest sector on a global and a regional level (Sedjo and Lyon 1990, Kallio *et al.* 1987, FAO 1990, Cardellichio *et al.* 1989, ECE/FAO 1986, ECE/FAO 1989, ECE/FAO 1990, USDA Forest Service 1990). A comprehensive review of many of these studies is provided in a recent paper by Arnold (1991). This Section provides a brief overview of all these studies.

A number of factors make it very difficult to estimate demand and supply projections of forest products. For example, on the demand side it is often difficult to predict the relationship between demand and trends in population growth, the level of overall economic activity and technological change. On the supply side, it is difficult to make predictions due to poor information on forest stocks, the rates of growth of these stocks and the economic feasibility of harvesting the timber resources (these are, of course, readily available proxies for *real* determinants of demand, such as construction, housing starts, furniture turnover etc). There is a particular difficultly in predicting tropical supply, mainly because it is usually difficult to obtain significant coefficient on price for many producers, therefore most models rely on exogenously determined supply (extrapolation of historical trends). For these reasons, there is often a high level of uncertainty attached to predictions about future demand and supply of forest products.

To date, most forecasting has been based on separate projections of consumption and production of forest products. There have been a few national and regional studies that have attempted to simulate market equilibrium, however in these studies trade is usually treated as an exogenous variable. Although the basis for drawing firm conclusions about the long term future of forest products supply and demand is extremely weak, it is reasonable to make a number of broad statements concerning general long term trends (Arnold 1991, Vincent 1991). The major trends in long term supply and demand of timber are summarized below.

<u>The Long Term Supply of Timber</u>

- The tropical timber trade will continue to decline in significance compared to the global timber trade due to the reduction in the stocks of tropical forest resources and an increase in domestic consumption by tropical countries. However, the trade in timber between tropical countries – especially in sawnwood – is expected to increase in significance over the next few decades. Investment in timber processing capacity, especially in Asia, will enable producer countries to export more secondary and higher processed products. To the extent that producer countries succeed in exporting a much higher volume of value-added goods in place of logs, the total volume of the tropical timber trade may fall but the drop in value of the trade will not be proportionate.

- The shift in production from old growth stands to planted and secondary forests will continue, both in tropical and temperate regions (ECE/FAO 1990). Investment in plantations in some tropical regions, especially Asia, may support a revival of timber production and trade by tropical countries in the future (although no longer in hardwoods from natural tropical forests).

- Despite the decline in tropical forest resources, expanding use of temperate resources will be more than sufficient to meet future global demands and stabilize real prices for wood products (ECE/FAO 1990, Sedjo and Lyons 1990). The projected growth in demand will be met mainly by plantations, while any 'unexpected' increase in demand could be met by additional resources in central Canada, northern Europe and eastern Russia. Western Europe will become more and more self-sufficient in timber resources, in particular Ireland, United Kingdom (UK), Portugal and Spain foresee an above average increase in their forest resource as large new plantations, mostly coniferous species, mature. North America is expected to become an increasingly important producer with appreciable long term increases in timber harvests over the period 1985–2035, with the harvest in the south of the US increasing by about 100 million m^3 (Sedjo and Lyons 1990). Exports of sawn softwood, paper and paperboard and building board are projected to increase substantially. Japan will also become increasingly self-sufficient in timber resources from maturing domestic timber supplies, and their production of pulp and paper will continue to increase.

<u>The Long Term Demand for Timber</u>

- Global demand for industrial wood is projected to grow at a rate of 15–40% over the next 15 years, and by 35–75% over the next 50 years. Developing countries will account for a substantial proportion of this growth in demand (in particular for sawnwood). The level of and growth in consumption of all major timber products by the developing region is concentrated within South America, the Far East and China – between 1986–2000 they are expected to account for more than half of the projected increase in sawnwood consumption. Although the growth in demand by developed countries will be more moderate, they will continue to dominate the global timber market.

- Hardwood consumption will grow faster than softwood consumption. However, current exports from tropical countries to developed countries will be reduced to mainly higher quality woods. The bulk of tropical hardwood will be increasingly directed to domestic consumption and to exports to other developing countries. Although the export of processed timber products has been growing, there are limited market prospects in the main user markets.

- Changes in technologies and preferences will favor an increase in the growth of demand for reconstituted products as opposed to solid products. At the global level, the demand for sawnwood is expected to grow the slowest whilst the demand for pulp and paper products the fastest. The growth in consumption of pulpwood is anticipated to be nearly three times as fast as the growth in consumption of saw logs to the year 2000 (Cardellichio *et al.* 1989).

- In North America the long run demand for all major wood products is projected to grow solidly over the next 50 years. Consumption of paper products, fuelwood and pallets is expected to grow particularly rapidly (USDA Forest Service 1990). In the mature European market the growth in demand will parallel the increases in population (ECE/FAO 1990). However, within this overall pattern of demand in Europe, the consumption of paper and paperboard and of wood based panels is expected to grow twice as fast as consumption of sawnwood between 1980 to 2000 (ECE/FAO 1986):

Growth in Consumption of Timber Products by Europe (1980–2000, %)

	LOW	HIGH
Sawnwood	0.8	1.6
Wood–based panels	1.7	2.5
Paper and Paper board	1.6	3.2

Over the next few decades, Russia and the former Soviet Republics are expected to rationalize and intensify their use of wood in order to improve the level of wood use productivity. Up until now, a much larger proportion of the wood harvest is used as fuel or in solid form (sawnwood) than in most other industrialized countries. However, the structure of wood use is now shifting to reduction of sawnwood and increase in panels and paperboard, combined with an increased use of residues as industrial raw materials and a further reduction in the use of roundwood as fuel (ECE/FAO 1989). Consumption of wood in Japan is expected to have increased by at least 15% from 1986 to 2004 (MAFF 1987, Cardellichio 1989). The projected growth in demand is for panels, paper and paperboard, reflecting a shift away from the traditionally heavy use of sawnwood in housing and other construction uses.

Market Volume and Value of Timber Trade

The projections of global timber harvests to the year 2000 are clustered around two levels (see Table A.12). The earlier projections undertaken in the late 1970's and early 1980's project the global timber harvest to lie between 2.3 billion m^3 to 2.8 billion m^3 by the end of the century. The more recent studies (Timber Supply Model (TSM) by Sedjo and Lyons 1990; the FAO Industry Working Party; and IIASA Global Trade Model) all predict a lower timber harvest, lying between 1.7 bn m^3 and 1.9 bn m^3. Attempts to project timber harvests beyond the year 2000 lead to large divergences in the estimated levels of timber supply.

The literature indicates that if demand for timber continues to grow at a rate consistent with the historic rate of growth of consumption, timber supplies are likely to respond without any substantial increase in real prices. The decline in tropical timber resources will be offset by the expanding temperate resources, other non–timber substitutes and technical improvements in efficient resource production and processing. Any increase in prices at the timber stand level is expected to reinforce the incentives for maintaining plantation programs and may enable previously uneconomical timber supplies to be considered as financially viable timber resources.

There have been few attempts to undertake price projections on a global level, with the exception of the TSM and the IIASA studies (see Table A.13). Despite similar harvest volume projections for the year 2000, the real price estimates of the IIASA study grow at almost 7 times the rate of those predicted by the TSM for the base case and twice as fast as the TSM high demand scenario. The findings of the TSM are, however, consistent with the statements made by ECE/FAO (1986) and the widespread opinion that there is no anticipated significant upward movement in real prices in the foreseeable future.

New CINTRAFOR Projections

Many of the trends described above are confirmed by more recent projections carried out for this study. New projections of supply, demand and trade in forest products were made using a model of the global forest sector, developed by the Center for International Trade in Forest Products (CINTRAFOR).[11] Baseline short term projections to the year 2000 reveal a number of significant trends concerning non-coniferous (hardwood) trade, including tropical hardwood:

- Shortages exist in tropical timber but not temperate hardwoods. Decreasing commercial inventory of tropical timber is beginning to constrain harvests significantly, particularly in Malaysia. There is no comparable shortage of temperate hardwoods, which supply large consuming country markets in the US, Europe and other non-Asian markets. Even with increased sawlog production in Indonesia and Brazil, two tropical hardwood suppliers with a large inventory, the tropical hardwood share of all hardwoods will begin to decline.

- The combination of expected strong economic growth in tropical timber producing countries, more modest demand growth in other consuming countries and declining supply of tropical hardwood logs will produce a substantial shift away from export to domestic markets by the major tropical hardwood suppliers. Declining log exports will be offset only partially by increased product exports.

- In the short-term, Japan's high-valued, end-use markets will continue to import logs to meet their needs, forcing less competitive consumer countries to reduce log purchases. High growth in other Asian consuming countries will be filled by increased processed imports, especially in Korea, which is losing competitiveness in processing. With higher log prices after the year 2000, however, Japan will decrease log imports substantially.

- Declining tropical hardwood inventory will lead to steadily rising sawlog prices, reaching levels 60 to 80% above 1990 levels by the year 2000, in real terms. Most of this price increase is anticipated to occur in SE Asia. Prices in countries with adequate temperate hardwood sources will remain more stable.

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[11] Annex K describes the results of projections and policy simulations based on the latest version of the CINTRAFOR Global Trade Model (CGTM), using data up to 1990.

- While product prices will increase with rising log prices, the availability of other supply sources in the more developed consuming countries, in conjunction with lower demand growth, will constrain product price increases which in turn will squeeze profits for processors of tropical timber. Plywood prices in Japan will rise hardly at all. Relatively small price increases will be adequate to increase Brazil's sawnwood exports considerably. Temperate region wood processors will benefit from increasing availability of wood and gain market share. While tropical hardwood processors will also face rising log prices, they at least should gain the benefit of rapid domestic demand growth. Other consuming country processors will be further squeezed by softwood and temperate hardwood substitutes. The trend in the developed consuming countries is therefore for a reduction in tropical log imports and the processing of imported logs, and increased product imports with more substitution away from tropical products.

- In the Asia–Pacific markets, scarcity of temperate hardwoods as well as softwoods will impede substitution of these sources for tropical hardwoods. One can expect significant structural changes in these markets to occur in the short–term as tropical hardwood inventory and harvests decline. Log markets in the Atlantic region are very different from those in the Asia–Pacific region. While African–European tropical log markets are not well differentiated in CINTRAFOR's model, it is still evident that the increasing availability of temperate hardwoods, both in log and product form, will temper log shortages of tropical timber from Africa to Europe. Although West African log exports have declined historically they should have an opportunity to shift away from European markets to higher prices in Asian markets. However, structural changes taking placing in Asian markets may result in the consuming countries reducing tropical log exports to the extent that African producers can not develop a market advantage in the long term.

- Long–term projections to 2040 show that the commodity in short supply continues to be tropical hardwood logs, not processing capacity. With the available tropical hardwood inventory in several countries declining rapidly by 2000, either harvest levels will be reduced quickly to more sustainable levels or they will drop even more abruptly just a few years later with the depletion of the inventory. The estimates used for the commercial timber inventory for Malaysia, show that they are near depletion of that inventory. Increased harvests by Brazil and Indonesia are not adequate to offset the other harvest declines and also service strong demand growth. Their inventories are sufficiently large that the higher prices produce increasing harvest levels in the model simulation unless harsh harvest constraint are superimposed. Their harvest levels may not be forever sustainable, but they are not close to depletion of the commercial inventory for many years.

- Tropical sawlog prices will continue their upward trend but product price increases will not keep pace. European markets show no impact of shortages in contrast to SE Asia. With a 30% reduction in supply outside of Indonesia and Brazil, log price increases of 200% above 1990 levels are projected by 2020. While consumer countries are forced to accept slightly higher prices and do change their consumption patterns with those high prices, tropical log prices are not likely to flatten out and decline much unless and until increased investment in sustainable forest management can support increased harvest levels. European markets show a tendency for temperate hardwood log substitution for tropical hardwoods.

- Higher log prices in tropical producer countries will help to motivate sustainable forest management. While it may not have been economic to manage the current harvest in such a way as to increase the yield of the next harvest given the low prices in the past, the projected price increases will greatly increase the rate of return for managing forests for more sustainable production. While much of this benefit may take 25 or more years to provide mature inventory and is therefore beyond the forecasting period illustrated, some features such as greater use of waste material and lower-valued species could occur much more quickly and dampen the price increases.

7. Conclusions and Policy Implications

There are a few key issues with important policy implications which arise from this review of forest resources and the international trade in timber products:

- The rate of tropical deforestation is significant (0.9% for 1980-90) and has increased substantially in recent years. However, the decline in the stocks of tropical timber resources is being offset by expanding temperate resources, especially from plantations and second growth forests.

- Only a small percentage of tropical non-coniferous wood (17%) is used for industrial purposes. Out of the total volume of industrial timber (275 mn m^3), approximately 31% is exported in round or product form by tropical countries. Therefore, only a modest percentage (6%) of total tropical non-coniferous roundwood production enters the international trade.

- Tropical Asia is the most important region in terms of volume of timber produced (over 50% of tropical production) and exported (over 85% of tropical exports). Asia is also taking the lead in processing timber products, and higher valued timber products account for an increasing proportion of its exports.

- Exports from tropical developing countries account for a small share of the total value of world timber exports (US$ 11 bn out of US$ 97.5 bn, i.e. 11%). However, for a number of countries (e.g. Central African Republic, Ghana, Indonesia, Malayisa and Papua New Guines) timber exports are an important source of foreign exchange earnings (over 10% of total export exrnings).

- Domestic consumption of timber by tropical countries will continue to increase due to population and income growth. Many tropical timber producers are already, or rapidly becoming, net timber importers. The level of South-South trade is expected to expand over the next few years.

- Demand for industrial timber on a global level is expected to increase up until the year 2000. Developing countries will account for an increasing share of this growth, although developed countries will continue to dominate the global timber market.

Declining tropical timber inventory combined with demand growth in producer countries will push up log prices and decrease log exports. Expanding temperate resources will prevent commensurate increases in the prices of hardwood products. Processors of tropical logs will see their profits squeezed, leading to declining imports of tropical logs into consumer countries. This is only partially offset by increased product imports from tropical countries.

Given the small proportion of tropical timber production that actually enters the international trade there appears to be little direct leverage to use the trade as a means of encouraging sustainable tropical forest management. While the value of the tropical timber trade is not particularly significant for most exporting countries, it is an important source of foreign exchange earnings and wider socio-economic benefits for a few key producer countries. The loss of the benefits associated with the timber trade may undermine incentives for tropical countries to manage and conserve their forest resources.

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Table A.1 Tropical Forest Resources: Status and Changes

	Land Area (000 ha)	% of Total Land Area	Forest Area 1990 (000 ha)	% of Land Area	% of Total Forest Area	Area Deforested Annually 1981-1990 (000 ha)	Area Deforested Annually 1981-1990 (%)
MAIN ECOLOGICAL REGIONS 1/							
Lowlands							
Tropical rain forest	912000	18.9	655500	71.9	38.2	4900	0.75
Moist deciduous forest	1461100	30.3	626400	42.9	36.5	7300	1.17
Dry deciduous forest	720500	15.0	212900	29.5	12.4	2100	0.99
Very dry forest	547700	11.4	39500	7.2	2.3	200	0.51
Desert	523800	10.9	2500	0.5	0.1	100	4.00
Uplands							
Hill and montane forest	650500	13.5	178100	27.4	10.4	2300	1.29
Total	**4815600**	**100.0**	**1714900**	**35.6**	**100.0**	**16900**	**0.99**
REGIONS 1/							
Africa	2243300	46.6	600100	26.8	35.0	5000	0.83
Asia	896600	18.6	274900	30.7	16.0	3600	1.31
Latin America & Caribbean	1675700	34.8	839900	50.1	49.0	8300	0.99
Total	**4815600**	**100.0**	**1714900**	**35.6**	**100.0**	**16900**	**0.99**
SELECTED COUNTRIES 2/							
Latin America							
Brazil	845651		347000	41.0		3200	0.92
Peru	128000		73000	57.0		300	0.41
Boliva	108439		55500	51.2		60	0.11
Venezuela	88205		42000	47.6		150	0.36
Colombia	103870		41400	39.9		350	0.85
Guyana	19685		19300	98.0		3	0.02
Suriname	15600		15200	97.4		3	0.02
Ecuador	27684		12300	44.4		60	0.49
Africa							
Zaire	226760		103800	45.8		200	0.19
Congo	34150		21100	61.8		22	0.10
Gabon	25767		20300	78.8		15	0.07
Cameroon	46540		17100	36.7		80	0.47
C.A.R.	62298		3600	5.8		5	0.14
Eq. Guinea	2805		1200	42.8		3	0.25
Asia							
Indonesia	181157		108600	59.9		1315	1.21
Malaysia	32855		18400	56.0		255	1.39
Philippines	29817		6500	21.8		110	1.69

Source: 1/ FAO (1992), The Forest Resources of the Tropical Zone by Main Ecological Regions, Forest Resources Assessment 1990 Project, Rome, Italy.
2/ R. Schmidt (1990), Sustainable Management of Tropical Moist Forests', presentation for ASEAN Sub-Regional Seminar, Indonesia.

Table A.2a Tropical Forest Plantations: Status and Changes (1990, 000 ha)

	Reported Figures				Estimated Figures 1/	
	Industrial Plantation Area	Non-industrial Plantation Area	Total Plantation Area	Area Planted Annually	Net Plantation Area	Net Area Planted Annually
Africa	1400	1600	3000	130	2100	91
Latin America	5100	3500	8600	370	6000	259
Asia & Pacific	9200	23100	32300	2110	22600	1447
Total	**15700**	**28200**	**43900**	**2610**	**30700**	**1797**

Table A.2a Plantation Area by Species (1990, 000 ha)

	Reported Plantation Area by Main Species			
	Eucalyptus	Pines	Teak	Acacias
Africa	790	610	145	250
Latin America	4074	2776	15	--
Asia & Pacific	5200	1250	2020	3150
Total	**10064**	**4636**	**2180**	**3400**

Notes: 1/ The estimated figures are derived from the reported figures after taking account of an observed survival rate of 70%.

Source: FAO (1992), The Forest Resources of the Tropical Zone by Main Ecological Regions, Forest Resources Assessment 1990 Project, Rome, Italy.

Table A.3 Protected Areas in Tropical Regions: Status (000 ha) 1/

	Total Area	Protected Areas Number	Area	Average Size	% of Total Area Protected
Latin America & Caribbean	1703900	1094	104800	95.8	6.2
Africa	2268800	484	112700	232.9	5.0
Asia & Pacific	941200	1462	48800	33.4	5.2
Total	**4913900**	**3040**	**266300**	**87.6**	**5.4**

Notes: 1/ This Table includes only tropical countries and protected areas according to IUCN Management Categories I-V. Pacific includes Fiji, New Caledonia, Papua New Guinea, Solomons and Vanatu only

Source: FAO (1992), The Forest Resources of the Tropical Zone by Main Ecological Regions, Forest Resources Assessment Project, Rome, Italy.

Table A.4a Volume of World Production and Trade in Forest Products (mn cum) 1/

	1961	1970	1980	1990
Fuelwood and charcoal				
Production	1041	1186	1480	1796
Imports	4	3	3	4
Imports as a % of Production	0.3	0.2	0.2	0.2
Industrial roundwood				
Production	1018	1278	1452	1654
Imports	38	93	118	124
Imports as a % of Production	3.8	7.3	8.1	7.5
Sawnwood and sleepers				
Production	346	415	451	486
Imports	41	56	78	95
Imports as a % of Production	11.8	13.6	17.2	19.5
Wood based panels				
Production	26	70	101	125
Imports	3	10	16	29
Imports as a % of Production	12.0	14.4	15.5	23.4
Wood pulp 1/				
Production	62	102	126	155
Imports	10	17	21	25
Imports as a % of Production	16.0	16.3	16.4	16.3
Paper and paperboards 1/				
Production	77	126	170	238
Imports	13	23	34	55
Imports as a % of Production	16.5	18.0	19.9	22.9

Note: 1/ Wood pulp and paper and paperboards in mn mt.

Source: FAO (1992)

Table 2.4b: Value of World Trade in Forest Products (US$ mn, current)

	1961	1970	1980	1990
All Forest Products (AFP)				
Imports	**6778**	**14170**	**62377**	**123360**
Fuelwood+charcoal				
Imports	31	29	122	187
as % of AFP	0.5	0.2	0.2	0.2
Industrial roundwood				
Imports	908	2693	12316	12523
as % of AFP	13.4	19.0	19.7	10.2
Sawnwood+sleepers				
Imports	1841	3020	13952	34395
as % of AFP	27.2	21.3	22.4	27.9
Wood based panels				
Imports	437	1184	5236	10391
as % of AFP	6.4	8.4	8.4	8.4
Wood pulp				
Imports	1316	2650	9777	17341
as % of AFP	19.4	18.7	15.7	14.1
Paper+paperboards				
Imports	2244	4567	20845	48252
as % of AFP	33.1	32.2	33.4	39.1

Source: FAO (1992)

Table A.5 Production of Coniferous and Non-coniferous Timber Products (mn cum)

	1961	1970	1980	1990
Industrial Roundwood Production				
Coniferous	755	911	992	1138
Non-coniferous	263	367	460	516
Non-coniferous as a % of Total	**25.9**	**28.7**	**31.7**	**31.2**
Sawlog + Veneer Production				
Coniferous	478	550	614	707
Non-coniferous	159	210	264	273
Non-coniferous as a % of Total	**24.9**	**27.7**	**30.0**	**27.8**
Pulpwood+Particle Board Production				
Coniferous	175	235	256	298
Non-coniferous	38	80	115	142
Non-coniferous as a % of Total	**17.9**	**25.4**	**31.1**	**32.2**
Other Industrial Roundwood Production				
Coniferous	101	127	122	133
Non-coniferous	67	77	80	102
Non-coniferous as a % of Total	**39.6**	**37.8**	**39.7**	**43.3**

Source: FAO (1992)

Table A.6a Exports of Timber Products by Region, 1990

	Industrial Roundwood	Sawnwood & Sleepers	Wood Based Panels	Wood Pulp /1	Paper Products 1/	Total
All Developed and Developing Countries						
1000 cum	118154	88406	31179	25027	55218	
US$ mn	8964	16920	10135	15817	45268	97104
All Developed Countries						
1000 cum	84178	78146	17840	22931	51694	
US$ mn	6378	14521	5779	14609	42887	84174
N. America						
1000 cum	31255	46991	5791	13230	17263	
US$ mn	3161	6938	1280	8380	10707	30467
Europe						
1000 cum	26699	24138	10396	7922	31582	
US$ mn	1833	6378	4050	5338	29687	47286
Oceania						
1000 cum	10520	633	379	652	499	
US$ mn	502	130	101	256	274	1264
Other developed countries						
1000 cum	686	55	199	528	1335	
US$ mn	36	27	77	267	1675	2082
All Developing Countries						
1000 cum	33976	10260	13339	2096	3524	
US$ mn	2586	2399	4356	1208	2380	12930
Africa						
1000 cum	4183	909	248	240	7	
US$ mn	493	231	104	120	5	953
Latin America						
1000 cum	5084	2084	987	1630	1323	
US$ mn	209	426	317	962	830	2743
Near East						
1000 cum	117	106	23	0	49	
US$ mn	14	20	10	0	30	74
Far East						
1000 cum	22618	7116	12074	227	2145	
US$ mn	1727	1711	3921	126	1516	9001
Other developing countries						
1000 cum	1975	45	7	0	0	
US$ mn	142	12	4	0	0	159

Notes: 1/ Wood pulp and paper products in 1000 metric tonnes

Source: FAO (1992)

Table A.6b Imports of Timber Products by Region, 1990

	Industrial Roundwood	Sawnwood & Sleepers	Wood Based Panels	Wood Pulp 1/	Paper Products 1/	Total
All Developed and Developing Countries						
1000 cum	123975	94618	29282	25333	54652	
US$ mn	12523	34395	10391	17341	48252	122903
All Developed Countries						
1000 cum	98428	82663	23360	21342	45446	
US$ mn	9639	17242	8246	15067	39705	89898
N. America						
1000 cum	6898	33961	4838	4499	12647	
US$ mn	293	3314	1306	3054	8824	16791
Europe						
1000 cum	44053	37431	14173	13380	29514	
US$ mn	3510	10511	5515	9681	27867	57084
Oceania						
1000 cum	18	1430	127	279	977	
US$ mn	7	372	66	193	949	1587
Other developed countries						
1000 cum	47316	9636	4114	3034	1598	
US$ mn	5802	2992	1274	1999	1350	13418
All Developing Countries						
1000 cum	25547	11955	5922	3991	9206	
US$ mn	2884	17154	2145	2274	8548	33005
Africa						
1000 cum	897	1802	105	139	584	
US$ mn	114	386	53	75	467	1095
Latin America						
1000 cum	112	2049	335	879	1958	
US$ mn	20	300	118	429	1504	2372
Near East						
1000 cum	1111	3400	1235	139	1052	
US$ mn	256	15490	683	93	1737	18258
Far East						
1000 cum	23425	4588	4221	2833	5588	
US$ mn	2493	953	1280	1677	4820	11223
Other developing countries						
1000 cum	2	116	26	0	24	
US$ mn	0	26	11	0	20	57

Notes: 1/ Wood pulp and paper products in 1000 MT.

Source: FAO (1992)

Table A.7a The Volume of World and Tropical Timber Production and Trade, 1990

	Production	Exports	Tropical Production as a % of World Production	Tropical Exports as a % of World Production
TOTAL ROUNDWOOD (mn cum)				
World	3450.4	120.5		
Tropical	1397	30	40.5	24.9
Industrial Roundwood (mn cum)				
World	1654.2	118.2		
Tropical	275	29.1	16.6	24.6
Saw and veneer logs (mn cum)				
World	979.8	66.8		
Tropical	149	27	15.2	40.4
SAWNWOOD AND SLEEPERS (mn cum)				
World	485.9	88.9		
Tropical	59	9	12.1	10.1
WOOD BASED PANELS (mn cum)				
World	124.9	31.2		
Tropical	19.4	13	15.5	41.7
WOOD PULP (mn tonnes)				
World	154.4	25		
Tropical	7.2	0.7	4.7	2.8
PAPER AND PAPER BOARD (mn tonnes)				
World	238.2	55.2		
Tropical	15.5	2.2	6.5	4.0

Notes: Tropical countries are all developing countries excluding China, Chile, Argentina, Turkey and S. Korea.

Table A.7b The Value of World and Tropical Timber Production and Trade, 1990

	Exports (US$ billion)	Tropical as a % of World Exports
SAW AND VENEER LOGS		
World	6.57	
Tropical	2.28	34.7
SAWNWOOD		
World	16.99	
Tropical	2.15	12.7
WOOD-BASED PANELS		
World	10.14	
Tropical	4.15	40.9
WOOD PULP		
World	15.82	
Tropical	0.86	5.4
PAPER AND PAPER BOARD		
World	45.27	
Tropical	1.5	3.3
OTHER		
World	2.68	
Tropical	0.16	6.0
TOTAL		
World	97.47	
Tropical	11.1	11.4

Notes: Tropical countries are all developing countries excluding China, Chile, Argentina, Turkey and S. Korea.

Source: Bourke (1992), Restriction on Trade in Tropical Timber, paper for African Forestry and Wildlife Commission, Rwanda.

Table A.8 Forest Products Trade Balance in Tropical Countries, 1990 (US$ 000) 1/

	Imports	Exports	Net Exports
TROPICAL AFRICA			
Cameroon	35412	99833	64421
Cent Afr Rep	468	29994	29526
Congo	4500	106087	101587
Côte d'Ivoire	27200	236147	208947
Eq Guinea	0	18700	18700
Gabon	3655	136774	133119
Ghana	5129	76526	71397
Guinea	1056	800	-256
Guinea-Bissau	310	350	40
Kenya	23594	4054	-19540
Liberia	1942	78264	76322
Madagascar	8546	534	-8012
Malawi	8058	1993	-6065
Mozambique	950	923	-27
Nigeria	33083	1680	-31403
Sierra Leone	1028	146	-882
Tanzania	15700	1539	-14161
Zaire	3666	17032	13366
Zimbabwe	5765	4169	-1596
TROPICAL C. AND S. AMERICA			
Belize	3253	2445	-808
Costa Rica	40020	21895	-18125
Cuba	193411	1847	-191564
El Salvador	21800	2725	-19075
Guatemala	69410	18326	-51084
Honduras	137921	31061	-106860
Mexico	403605	13884	-389721
Nicaragua	10566	2569	-7997
Panama	76979	3988	-72991
Trinidad & Tob	54396	458	-53938
Bolivia	4060	22160	18100
Brazil	299402	1750981	1451579
Colombia	104056	20060	-83996
Ecuador	157834	24373	-133461
Fr Guiana	1087	2169	1082
Guyana	2356	2694	338
Paraguay	13055	24971	11916
Peru	104914	2558	-102356
Suriname	9671	840	-8831
TROPICAL ASIA AND OCEANIA			
Brunei Darus	6775	30	-6745
Cambodia	100	94	-6
Hong Kong	1752273	705535	-1046738
India	290967	16337	-274630
Indonesia	330157	3069199	2739042
Laos	200	10251	10051
Malaysia	483372	3040884	2557512
Myanmar	4721	148084	143363
Philippines	173662	123119	-50543
Singapore	747548	663302	-84246
Sri Lanka	28771	600	-28171
Thailand	1002371	101551	-900820
Yemen	10499	29	-10470
Fiji	7804	22775	14971
Papua N Guinea	5504	115500	109996
Solomon Is	767	17240	16473
Vanuatu	202	1900	1698

Notes: 1/ Tropical countries taken here to be countries with the majority of their land mass lying between the tropics. The term forest products includes industrial and non-industrial wood products. Only those countries that exported forest products in 1990 are included in this table.

Source: FAO (1992)

Table A.9a Production and Trade in Timber Products by Tropical Countries, 1990 (000 cum)

	Production	Exports	Imports	ADC 1/
All Tropical Countries				
Industrial Roundwood	257587	28705	4318	233200
Sawnwood	72584	8719	4841	68706
Wood-based Panels	18483	12818	1891	7556
Tropical Africa				
Industrial Roundwood	41687	3959	40	37768
Sawnwood	6598	814	235	6019
Wood-based Panels	1108	243	66	931
Tropical C. and S. America				
Industrial Roundwood	95697	172	95	95620
Sawnwood	26641	1032	1557	27166
Wood-based Panels	4289	833	296	3752
Tropical Asia and Oceania				
Industrial Roundwood	120203	24574	4183	99812
Sawnwood	39345	6873	3049	35521
Wood-based Panels	13086	11742	1825	3169

Table A.9b Export of Timber Products as a Percentage of Production in Tropical Countries (%)

	1961	1970	1980	1990
All Tropical Countries				
Industrial Roundwood	15.6	27.1	18.2	11.1
Sawnwood	15.3	17.3	16.2	12.0
Wood-based Panels	34.0	33.0	32.5	69.4
Tropical Africa				
Industrial Roundwood	23.8	23.3	16.3	9.5
Sawnwood	32.1	28.5	12.7	12.3
Wood-based Panels	34.0	33.0	28.6	21.9
Tropical C. and S. America				
Industrial Roundwood	1.6	1.0	0.2	0.2
Sawnwood	14.7	13.6	6.9	3.9
Wood-based Panels	34.0	33.0	15.3	19.4
Tropical Asia and Oceania				
Industrial Roundwood	22.2	44.2	33.4	20.4
Sawnwood	11.9	18.5	24.5	17.5
Wood-based Panels	40.5	39.9	49.4	89.7

Notes: 1/ ADC = Apparent Domestic Consumption
Tropical countries are taken here to be countries with the majority of their land mass lying between the tropics. This table includes data on coniferous and non-coniferous timber products.

Source: FAO (1992)

Table A.10 Employment in Wood Related Industries, 1980

	Economically Active Population (EAP) (million)	Agriculture Employment as % of EAP	Industry Employment as a % of EAP	Total Manufacturing Employment (thousand)	Wood and Wood Products Employment (thousand)	Paper and Paperboard Employment (thousand)
Cameroon	3.6	70	8	48	9	na
Ghana	4.4	56	18	80	17	1
Ivory Coast	3.5	65	8	67	12	2
Madagascar	4.9	81	6	39	2	1
Nigeria	32.1	68	12	295	20	2
Bolivia	1.7	46	20	43	4	0
Brazil	44.2	31	27	3800	406	106
Colombia	8	34	24	508	13	11
Ecuador	2.4	39	20	122	10	3
Mexico	22.2	37	29	1768	144	31
Panama	0.7	32	18	30	2	1
Peru	5.4	40	18	273	17	7
Vanezuela	4.9	16	28	409	22	15
India	265.3	70	13	6801	79	125
Indonesia	56.3	57	13	963	65	12
Malaysia	5.3	42	19	557	84	7
Papua New Guin	15	76	10	20	6	0
Philippines	17.5	52	16	1053	111	21
Sri Lanka	5.5	53	14	162	7	7
Thailand	25.7	68	11	994	69	12

Source: Amelung and Diehl (1992)

Table A.11 Forest Products Trade Compared to Total Trade in Topical Countries, 1990

	Forest Products Imports (US$ 000)	Forest Products Exports (US$ 000)	Total Imports (US$ 000,000)	Total Exports (US$ 000,000)	Forest Products Imports as a % of Total Imports (%)	Forest Products Exports as a % of Total Exports (%)
Tropical Africa						
Cameroon	35412	99833	1300	1200	2.7	8.3
Cent Afr Rep	468	29994	170	130	0.3	23.1
Congo	4500	106087	570	1130	0.8	9.4
Côte d'Ivoire	27200	236147	2100	2600	1.3	9.1
Gabon	3655	136774	760	2471	0.5	5.5
Ghana	5129	76526	1199	739	0.4	10.4
Kenya	23594	4054	2124	1033	1.1	0.4
Madagascar	8546	534	480	335	1.8	0.2
Malawi	8058	1993	576	412	1.4	0.5
Nigeria	33083	1680	5688	13671	0.6	0.0
Sierra Leone	1028	146	146	138	0.7	0.1
Tanzania	15700	1539	935	300	1.7	0.5
Zaire	3666	17032	888	999	0.4	1.7
Tropical C. and S. America						
Costa Rica	40020	21895	2026	1457	2.0	1.5
El Salvador	21800	2725	1200	550	1.8	0.5
Guatemala	69410	18326	1626	1211	4.3	1.5
Honduras	137921	31061	1028	916	13.4	3.4
Mexico	403605	13884	28063	26714	1.4	0.1
Nicaragua	10566	2569	750	379	1.4	0.7
Panama	76979	3988	1539	321	5.0	1.2
Trinidad & Tob	54396	458	1262	2080	4.3	0.0
Bolivia	4060	22160	716	923	0.6	2.4
Brazil	299402	1750981	22459	31243	1.3	5.6
Colombia	104056	20060	5590	6766	1.9	0.3
Ecuador	157834	24373	1862	2714	8.5	0.9
Paraguay	13055	24971	1113	959	1.2	2.6
Peru	104914	2558	3230	3277	3.2	0.1
Tropical Asia and Oceania						
Hong Kong	1752273	705535	82495	29002	2.1	2.4
India	290967	16337	23692	17967	1.2	0.1
Indonesia	330157	3069199	21837	25553	1.5	12.0
Malaysia	483372	3040884	29251	29409	1.7	10.3
Philippines	173662	123119	13080	8681	1.3	1.4
Singapore	747548	663302	60647	52627	1.2	1.3
Sri Lanka	28771	600	2689	1984	1.1	0.0
Thailand	1002371	101551	33129	23002	3.0	0.4
Papua N Guinea	5504	115500	1288	1140	0.4	10.1

Source: FAO (1992) and World Development Report (1992)

Table A.12 Forecasts of Industrial Roundwood Demand

Organisation / Study[a]		Year Made	Projected to year	Forecast volume (bn of m^3)	Implicit growth rate[b] (%/year)
Food and Agricultural Organisation		1982 (high)	2000	2.6	3.7
		1982 (low)	2000	2.3	2.9
Food and Agricultural Organisation, Working Party.		1979	2000	1.8	1.2
SRI		1979	2000	1.9	1.6
World Bank		1978	2000	2.8	4.2
			2025	5.9	3.4
International Institute for Applied Systems Analysis (IIASA) GTM		1987	2000	1.8	1.2
		1987	2030[d]	2.6	1.2
RFF TSM	Base case	1988	2000	1.7	0.8
		1988	2035	2.0	0.6
	High demand	1988	2000	1.8	1.2
		1988	2035	2.3	0.9

Source: Sedjo, S. and K. Lyons, 1990. The Long Term Adequacy of World Timber Supply.

[a] SRI International and World Bank data form Boulter (1986). FAO data from FAO, 'World Forest Products: Demand and Supply 1990 and 2000', FAO Forestry Paper no.28 (Rome , FAO, 1982). FAO Industry Working Party Paper from FAO, 'FAO World Outlook for Timber Supply', phase V (Rome, FAO, 1989). IIASA data from M. Kallio, D. Dykstra and C. Binkely, eds. 'The Global Forest Sector: An Analytical Perspective'.

[b] From a base of 1.5 billion m^3 in 1985.

[c] based on current real prices.

[d] The IIASA GTM projections to 2030 are not reported in 'The Global Forest Sector'. They were presented, however, at numerous meetings and in working papers such as 'The Global Forest Model' (unpublished draft by Lake Popovich, May 1985).

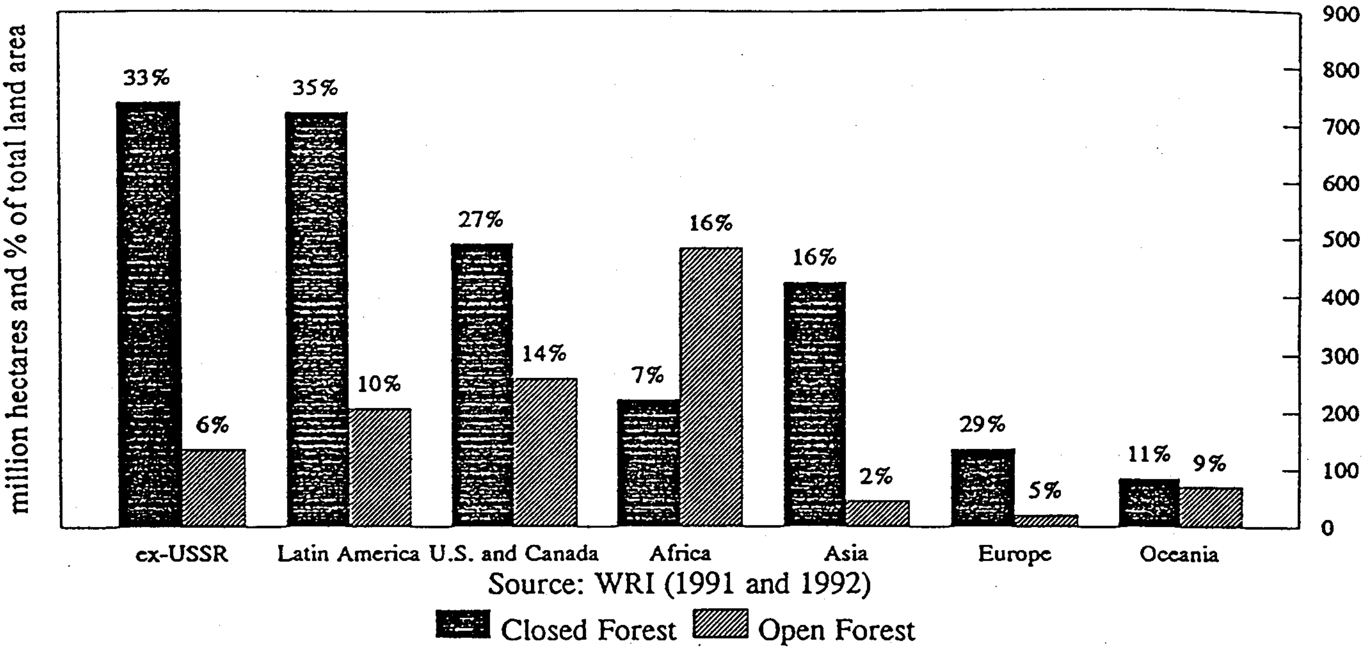
Table A.13 Projected Real Prices for Industrial Wood

Study	Year Made	Projected to year	Real Price Growth Rate (annual %) [a]
RFF TSM			
Base case	1988	2000	0.2
High demand	1988	2000	1.I2
		2035	1.3
IIASA GTM			
Eastern U.S.			
sawlogs, conifer		2000	5.9
pulplogs, conifer		2000	3.5
sawlogs, nonconifers		2000	4.7
pulplogs, nonconifers		2000	0.0
Western Europe			
sawlogs, conifer		2000	0.3
pulplogs, conifer		2000	3.2
sawlogs, nonconifers		2000	1.3
pulplogs, nonconifers		2000	1.8

Notes: a/ From 1980 to 2000.

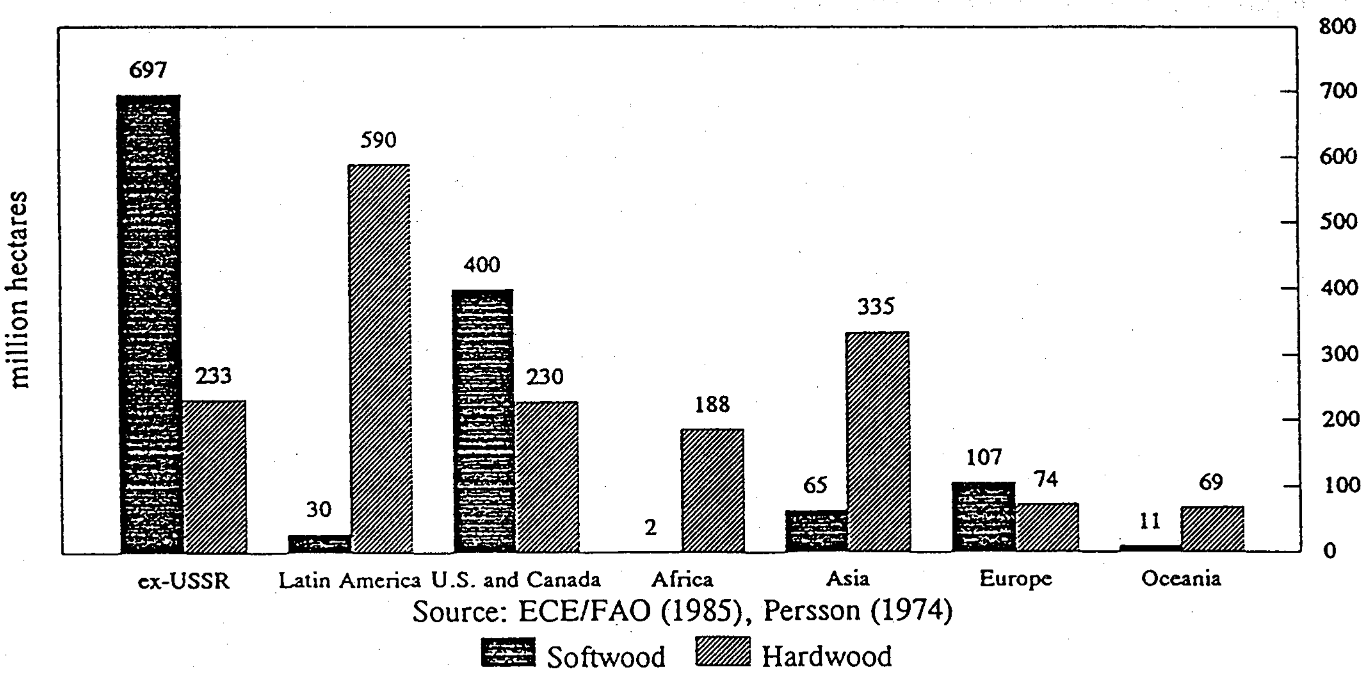
Source: Sedjo, A. and K. Lyons. 1990. The Long Term Adequacy of World Timber Supply.

Figure A.1 **World Natural Forest Resources: Closed and Open Forest Areas (1980)**



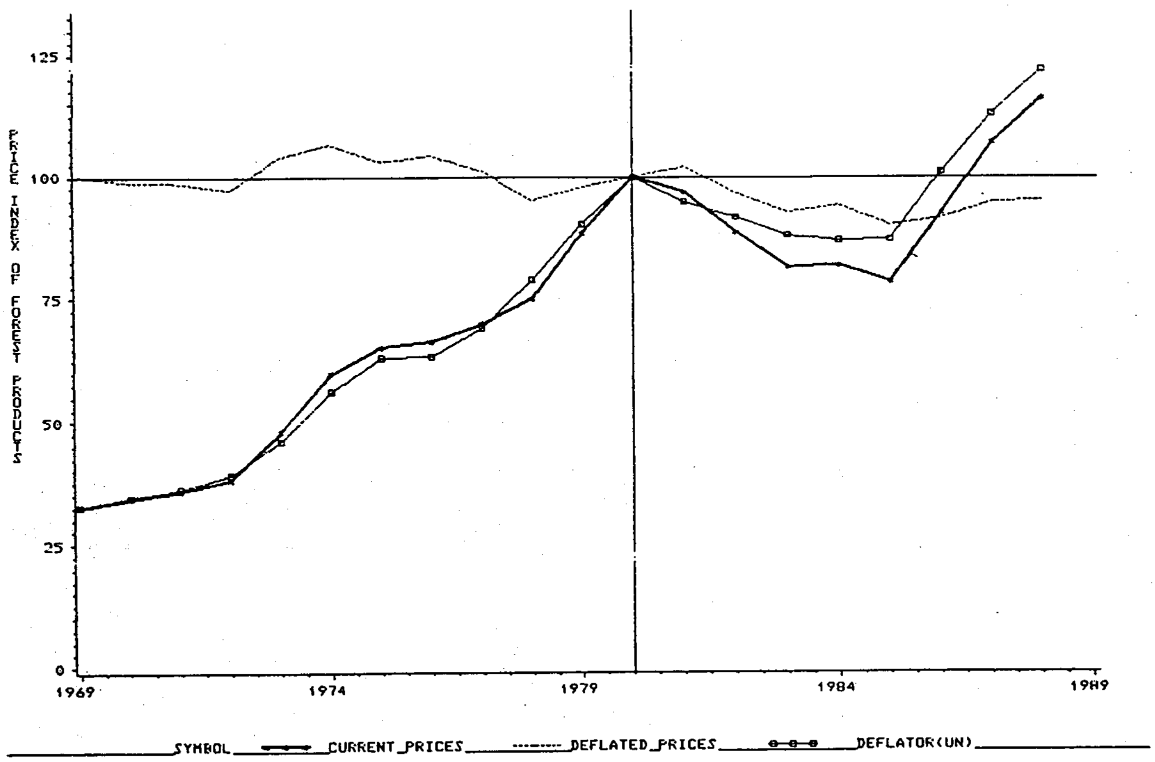
Source: WRI (1991, 1992)

Figure A.2 **World Closed Forest Resources: Land Area by Forest Formation (1970-80)**



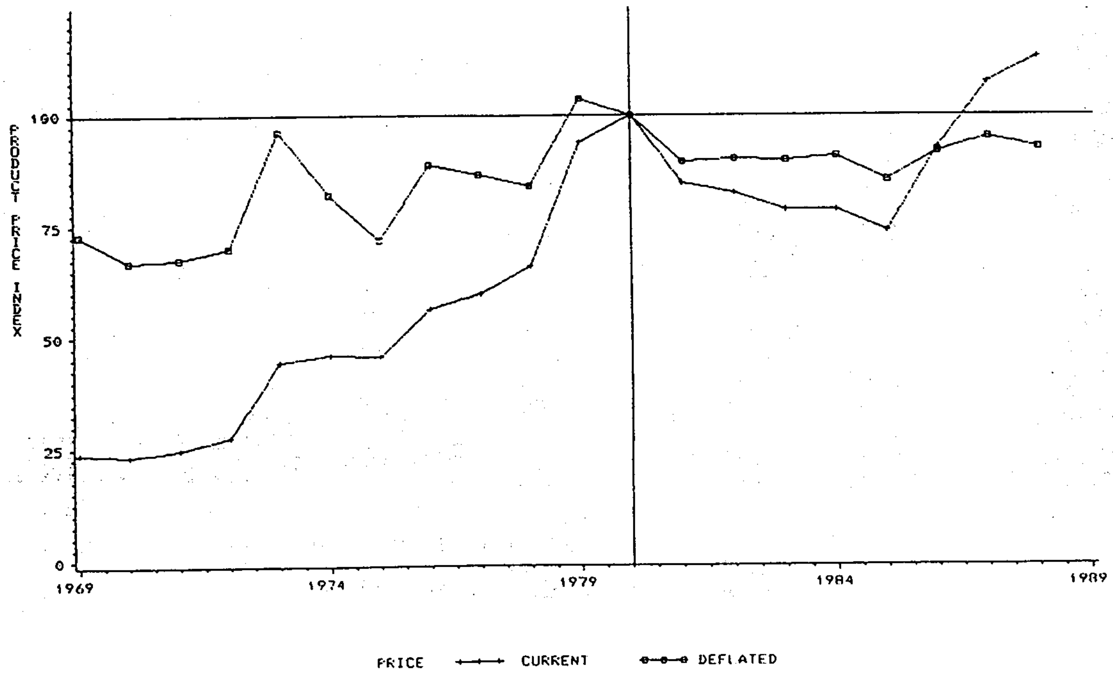
Source: ECE/FAO (1985), Persson (1974)

- **Figure A.3 Forest Products Price Index (US$/m³ 1980 = 100)**



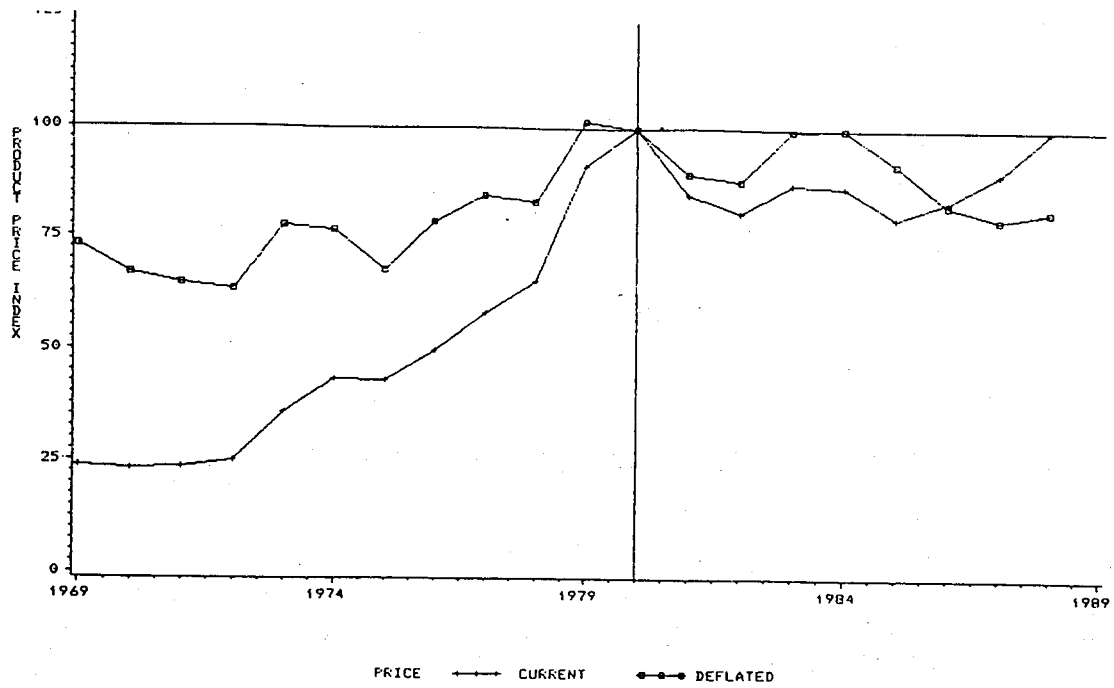
Source: FAO (1990)

Figure A.4 Tropical Logs Price Index (US$/m³ 1980 = 100)



Source: FAO (1990)

Figure A.5 Tropical Sawnwood Price Index (US$/m^3 1980 = 100)



Source: FAO (1990)

ANNEX B

LINKS BETWEEN THE TIMBER TRADE AND TROPICAL DEFORESTATION

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Links between the Timber Trade and Tropical Deforestation[1]

Joanne C. Burgess

October 9, 1992

This paper discusses the links between the timber trade and tropical deforestation. An important question to be asked at the outset is whether tropical deforestation can be considered as an economic problem. The paper then focusses on the role of the timber trade as an incentive for sustainable tropical forest management, which involves looking at alternative tropical forest land use options and the economics of land allocation. The paper draws together the literature on the direct and indirect links between timber production and tropical deforestation. Existing statistical analysis of the relationship between timber production, the trade and forest clearance in the tropics are reviewed, and a new analysis presented. Finally, the policy implications of this paper for the international tropical timber trade as a means for encouraging sustainable forest management are summarized in the conclusion.

1. Is Tropical Deforestation an Economic Problem?[2]

To answer the question as to whether tropical deforestation is an economic problem requires addressing two additional issues:

- are tropical forests an efficient form of holding on to 'wealth'?
- are the opportunity costs of tropical deforestation greater than the benefits gained?

Although apparently different, the questions are inherently related and represent two aspects of the same fundamental economic problem concerning tropical deforestation.

Like most environmental 'assets', tropical forests can be seen as a form of 'natural' capital. That is, they have the potential to contribute to the long-run economic productivity and welfare of tropical forest countries. Thus the value of a tropical forest as an economic asset depends on the present value of its income, or welfare, potential. However, in any growing economy there will be other assets, or forms of wealth, that yield income. Any decision to conserve a tropical forest therefore implies an opportunity cost in terms of foregoing the chance to invest in alternative income-yielding assets, such as man-made reproducible capital. If tropical forests are to be an efficient form of holding on to wealth, then they must yield a rate of return that is comparable to or greater than that of other forms of wealth. In other words, an 'optimal' strategy for a developing country would be to 'drawn down' its stock of tropical forests to finance economic development by

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[1] I am grateful to comments and advice from E. Barbier and I. Strand.

[2] Section 1 and 2 of this paper are drawn from Barbier (1992).

reinvesting the proceeds in other assets that are expected to yield a higher economic return. Under such circumstances, tropical deforestation is not an economic problem but is in fact economically justified; it should proceed up to the point where the comparative returns to 'holding on' to the remaining forest equals the returns to alternative investments in the economy. If the latter always exceeds the former, then even complete deforestation is economically optimal.

The idea that economic well-being, or welfare, may not be affected and may even be enhanced if the rents derived from depleting natural resources, such as tropical forests, are reinvested in reproducible capital has been around for some time in the theoretical economics literature. For example, the 'Hartwick-Solow rule' states that reinvestment of rents derived from the intertemporally efficient use of exhaustible natural resources in reproducible (and hence non-exhaustible) capital will secure a constant stream of consumption over time (Solow 1974 and 1986, Hartwick 1977). Similarly, basic economic renewable resource theory suggests that, for slow growing resources such as tropical forests, it may under certain conditions be more economically optimal to harvest the resource as quickly and efficiently as possible and reinvest the rents in other assets whose value will increase much faster. Equally, if the harvesting costs are low, or the value of a harvested unit is high, then the resource may also not be worth holding on to today (Clark 1976, Smith 1977).

However, there are obvious limits to the applications of the above rules to reality. For example, the Hartwick-Solow rule assumes that there is sufficient *substitutability* between reproducible (man-made) and natural capital over time such that they effectively comprise a single homogeneous stock. Moreover, the above rules assume that all economic values are known and reflected in the prices of resources, markets are undistorted, resource extraction is efficient and rents are reinvested in other assets in the economy. As a consequence, more recent theories now stress the limits to substitution between many forms of natural and man-made capital, even for developing countries interested in 'drawing down' their natural capital stock in favor of investing in other forms of capital (Barbier 1989, Pearce, Barbier and Markandya 1990). In particular, certain functions of a tropical forest, such as its role in maintaining micro-climates, protecting watersheds, providing unique habitats and supporting economic livelihoods of indigenous peoples, may be *irretrievably* lost when the forest is degraded or converted. Often the economic values of these and other functions of tropical forest are not properly accounted for in decisions concerning forest use. There can be a great deal of uncertainty over many of these values, such as the forest's role in maintaining biodiversity and global climate. Finally, as the main Report demonstrates, there is little evidence to suggest that tropical forest resources are currently being exploited efficiently, nor that the rents earned from activities that degrade or convert the forests are being reinvested in more 'profitable' activities. Rather, market and policy failures are often rife, and economic rents tend to be dissipated and misused.

In sum, although it is theoretically possible that the current rates of tropical deforestation are economically optimal, it is unlikely that this is the case. Too often, decisions concerning tropical forest depletion and conversion are taken without considering the opportunity cost of these decisions. In short, we do not know whether it is worth 'holding on' to the tropical forest as an economic asset because we do not know or bother to take into account the potential economic benefits that it yields. As a result, decisions will always be biased towards converting or depleting the tropical forest because the underlying assumption is that foregone benefits of maintaining the forest are necessarily negligible. If this is the case, as much evidence suggests, then current levels of tropical deforestation may not be optimal but 'excessive', and hence tropical deforestation may indeed be an economic problem.

2. The Timber Trade as an Incentive for Tropical Forest Management

Tropical Forest Land Use Options

If tropical deforestation is an economic problem, it is because important values are lost, some irreversibly, when closed forests are opened up, degraded or cleared. Each choice or *land use option* for the forest – to leave it standing in its natural state, or to exploit it selectively, e.g. for timber or non–timber forest products, or to clear–cut it entirely so the land can be converted to another use, such as agriculture – has implications in terms of values gained and lost. The decision as to what land use option to pursue for a given tropical forest area, and ultimately whether current rates of deforestation are 'excessive', can only be made if these gains and losses are properly analyzed and evaluated. This requires that *all the values* that are gained and lost with each land use option are carefully considered.

For example, preserving a tropical forest involves direct costs of preservation, in terms of setting up a protected area, paying forest guards and rangers to protect and maintain the area and perhaps the cost of establishing a 'buffer zone' for surrounding local communities. Development options, such as the use of the forest for commercial timber exploitation and of the converted forest land and resources for agriculture, mining and hydroelectricity, are sacrificed if preservation is chosen. These foregone development benefits are additional costs associated with the preservation option. Such costs are easily identifiable as they often comprise marketable outputs and income sacrificed (e.g. timber revenue, agricultural income, mineral wealth, hydroelectricity). It is not surprising therefore that governments and donors usually consider the *total costs* – the direct costs plus the foregone development benefits – of preservation in their choice of land use options for tropical forests.

But the same approach should be taken in evaluating development options of the forest. For example, if the forest is to be cleared for agriculture, not only should the direct costs of conversion (e.g. clearing and burning the forest, establishing crops) be included as part of the costs of this land use option but so must the *foregone* values of the forest that has been converted. These may include both the loss of important *environmental functions* (e.g. watershed protection, micro–climate maintenance) and *resources* (e.g. commercial hardwoods, non–timber products, wildlife).

In other words, we must determine the *total economic value* (TEV), both marketed and non–marketed, that is being surrendered through modifications of the prevailing forest land use that any development option entails.[3] These values comprise direct and indirect *use* values, *option* values and *existence* values. Direct use values include timber and non-timber products and ecotourism. Indirect use values are essentially the ecological functions of tropical forests: their watershed protection, micro-climatic and material cycling functions. All these values may have an option value component if we are interested in preserving them for future use. Finally, existence values are the values that people place on the forest 'in itself' and are unrelated to any use.

However, many of the component values in total economic value have no market - especially subsistence or underdeveloped non-timber products and the indirect use, option and existence values of forests. Choice of land use is therefore often *biased* in favor of land uses that do have marketed outputs, e.g. development options such as ranching, timber exploitation, agriculture, mining, hydroelectricity. The result is too much conversion and over-exploitation of forest and too little natural management of forest land.

The basic reason for the imbalance is that the non-market values of the natural/managed systems are not automatically reflected in the price of forested land. For example, the market value of land converted to agriculture fails to reflect the lost environmental benefits, such as watershed protection. If 'owners' (i.e. those with legal title and those who have acquired the land on a first-come basis) had to pay the full social cost of developing forested land, less land would be converted or over-exploited. Forested land is clearly *underpriced*. An important consequence is that once the land occupied has become sufficiently degraded and thus significantly less productive, the 'owners' have a strong incentive to abandon the land for new, virgin forested land which is 'cheap' to acquire and develop. The process repeats itself until it becomes difficult to get access to new forest lands, for example due to the lack of roads or waterways into a region (Schneider *et al.*, 1990, Southgate, Sierra and Brown 1989).

Although it is clearly the responsibility of governments in ensuring that the total economic value of forest land lost through conversion and exploitation is accounted for as part of the costs of these development options, most evidence suggest that public policies are often at the core of the tropical deforestation problem.[4] Too often, the pricing and economic policies of countries with tropical forests distort the costs of deforestation:

> the 'prices' determined for tropical timber products or the products derived from converted forest land *do not incorporate the lost economic values* in terms of foregone timber rentals, foregone minor forest products and other direct uses (e.g., tourism), disrupted forest protection and other ecological functions, and the loss of biological diversity, including any option or existence values.

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[3] For further details, see Barbier (1991) and Pearce (1990).

[4] For recent comparative reviews of how public policies affect tropical deforestation, see Barbier (1991); Barbier *et al.* (1991); Binkley and Vincent (1991); Hyde and Newman (1991); Repetto (1990); Repetto and Gillis (1988).

- even the direct costs of harvesting and converting tropical forests *are often subsidized and/or distorted*, thus encouraging needless destruction.

If proper economic valuation of forest losses takes place, the cost of forest conversion and degradation can often be high. For example, in Indonesia, the foregone cost in terms of timber rentals from converting primary and secondary forest land is in the order of US$ 625–750 million (mn) per annum. With logging damage and fire accounting for additional costs of US$ 70 mn, this would represent losses of around US$ 800 mn annually. The inclusion of foregone non–timber forest products, such as essential oils, honey, wildlife products, resins, bamboos, fruits and nuts, would raise this cost to US$1 billion (bn) per year. The value of exports of non–timber forest products rose from US$ 17 mn in 1973 to US$ 154 mn in 1985, comprising 12 per cent of export earnings. Exports of rattan alone were US$ 80 mn in 1985. However, the commercial potential of many non–timber products may be currently under–exploited. The foregone future value of these products may therefore be much higher than their value at present. Moreover, many of the important economic uses of non–timber products, e.g. the use of 'wild' forest foods to supplement food security and meet subsistence needs, are non–market and thus are not often properly accounted for. Consequently, both the foregone commercial and non–market benefits of non–timber products must be incorporated into any assessment of the costs of deforestation (Pearce, Barbier and Markandya 1990, ch. 5).

The total cost of the depreciation of the forest stock would include not just the cost of conversion but also the cost of timber extraction and forest degradation. One study estimated this total cost for Indonesia to be around US$ 3.1 bn in 1982, or approximately 4% of GDP (Repetto *et al.* 1987). However, this estimate must be considered a lower bound, as it does not include the value of the loss of forest protection functions (e.g. watershed protection, micro–climatic maintenance) and of biodiversity. The latter may particularly be important in terms of *option and existence values* – i.e., values reflecting a willingness to pay to see species conserved for future use or for their intrinsic worth – which could translate into future payments that the rest of the world might make to Indonesia to conserve forest lands. Similar arguments apply to the value of the forest as a *carbon store* (Pearce 1990).

The Economics of Land Use Decision Making

The decision over which tropical forest land use option to pursue depends on the relative returns to the alternative uses. The following simplified example is used to illustrate the economics of land use decision making. Consider the choice between clearing the land for agricultural production and sustainably managing the forest for timber production, some of which enters the international timber trade. If the net returns of sustainable timber production (i.e. revenues minus costs, $R_T - C_T$) exceed the net returns from converting the forest for agricultural production (i.e. $R_A - C_A$) then it will be in the direct economic interest of the individual, or society, to sustainably manage the land for timber production. The decision to convert/sustain tropical forests over time (t) depends on the present value (i.e. discounted value, where 'r' denotes the discount rate) of the stream of profits derived from the alternative options:

$$\frac{\sum(R_{tT} - C_{tT})}{(1 + r)^t} > \frac{\sum(R_{tA} - C_{tA})}{(1 + r)^t} \qquad [1]$$

Equation [1] shows that so long as sustainable forest management for timber production leads to economic rent greater than that derived from forest clearance for agricultural production, then there exists an incentive to conserve the forest for timber production.[5]

By increasing the potential value of timber production through the export of timber products this will increase the overall net returns to tropical forest management, thus making it more attractive compared to converting forest land to agriculture. Moreover, if timber production for export is done on a sustainable basis, then sustainable management of tropical forests has the chance of being an economically attractive alternative to competing forest land uses over the medium to long term.

The above example is extremely simplified and does not the reflect the full complexities of decision making in practice (such as a range of alternative land use options, other political objectives, conflicts between individual and society decisions, valuation of costs and benefits, etc) . However, it does illustrate an extremely important point – *that in order for sustainable timber management to be a viable forest land use option, it must yield net returns to developing countries that are greater than those derived from competing uses*.[6] The main Report demonstrates that trade related incentives are an important means of ensuring appropriate returns to sustainable timber management of tropical forests.[7]

3. Environmental Impacts of Tropical Timber Production

Although it is possible to manage the extraction of timber from tropical forests on a sustainable basis with minimum environmental damage, this practice does not appear to be widespread. In a comprehensive survey of management practices throughout tropical forest countries, Poore *et al.* (1989) indicated that less than 1 mn ha, out of an estimated total area of 828 mn hectares (ha) of productive tropical forest remaining in 1985, was demonstrably under sustained–yield management for timber production. This does not necessarily mean that 99% of productive forests are being degraded in the tropics through timber extraction, but is more an indication of the lack of sustainable forest management occurring in the tropics. It is the environmental problems related to the unsustainable and poorly managed extraction of timber that are of concern. These may occur:

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[5] Economic rent is the net return to a unit of land. This value is the residual, or surplus, remaining after the costs of all other factors of production are netted out.

[6] Vincent (1990) in his article 'Don't Boycott Tropical Timber' emphasizes that the forest must be used if it is to be saved. He notes "in the tropics as elsewhere, forests must out compete other land uses to remain wooded. A boycott would reduce demand and depress forest product prices. This would reduce net returns for forestry investments and make sustained timber management, a prerequisite for stabilization of forest areas in the tropics, less feasible."

[7] A study is being undertaken by Caroline Sargent and IIED for ITTO on incentives for sustainable forest management in Ghana, which should provide more information on these links.

- *directly* through the removal of trees and other damage incurred to surrounding forest during timber extraction; and

- *indirectly* through opening up and improving access to the forests which then impacts on other socio-economic factors which may degrade the environment.

Direct Environmental Impacts of Tropical Timber Production

Although the international trade in tropical timber products is well documented by the FAO it is difficult to extrapolate from such data to the direct impact of the international trade on the tropical forests for a number of reasons, including:

- uncertainty over the magnitude of forest degradation, conversion and regeneration in many tropical countries

- little information on the impact of forest management regimes and their implementation on tropical forests

- substantial methodological problems in assessing the wider environmental implications of timber extraction practices

- difficulty in determining the amount of timber extracted for domestic use as opposed to that entering international markets

In addition to depleting the resource, timber extraction can incur *external environmental costs* by degrading other tropical forest resources and functions which are of value to individuals other than timber operators. These 'external' effects may include the loss of other consumptive uses (e.g. harvesting and hunting other forest resources and recreational uses), of ecological functions (e.g. watershed protection, carbon storage and microclimatic role) and of other non-consumptive values (e.g ecotourism, genetic resource and existence values) of the forest. Much of the criticism of tropical deforestation stems from scientist's claims that closed tropical forests are estimated to hold between 50–90% of the worlds biodiversity (Reid and Miller 1989). Evidence of the importance of the sustainable uses of this biodiversity for subsistence forest products, pharmaceutical and crop breeding research, ecotourism and as a key component in global warming, local watershed protection, microclimatic functioning and other environmental functions means that timber extraction often imposes significant external costs in the tropics.

The extent of these external environment impacts from timber extraction depends largely on the type, and success, of forest management practices. Poore *et al.* (1989) notes that successful forest management depends on certain conditions being met, including the long-term security of operation, operational control, a suitable financial environment and adequate information. Although there are a few cases of successful sustained-yield management of forests for timber – for example in some regions in India, Malaysia and the Philippines (FAO 1989) – these tend to be the exception. Poorly designed and implemented management regimes for selective logging of natural forests are likely to have serious implications for the environment.

For example, on average only about 5 to 35 cubic meters (m^3) of merchantable wood are extracted per hectare of tropical closed broadleaved forests (FAO/UNEP 1981). However, these small commercial volumes relative to total standing timber can lead to disproportionate damage to the forest due to careless use of equipment and inefficient logging practices. Sometimes at least half of the remaining stock, including immature trees of potential commercial value and harvestable stocks of less desirable varieties, are damaged beyond recovery (Repetto 1990). Clear cutting the forest for the timber is likely to have even more significant environmental effects. However, measuring the wider environmental impacts and costs of forest management practices is complicated, and few empirical studies have been undertaken.

The direct impact of timber production on the environment may be offset to some extent by investments in *reafforestation*. However, even if investments to offset tropical deforestation are channelled into plantation forests then only part of the full environmental costs of timber extraction may be compensated. That is, investments in plantations may counteract the decline in stocks of timber, but may not always compensate for the wider environmental costs of natural forest degradation. Even if the compensatory investment is in management of a natural forest area, some of the environmental benefits of the degraded natural forest may still have been lost irreversibly, such as biodiversity or non-timber forest products.

Indirect Environmental Impacts of Timber Production

In addition to the direct impacts of timber extraction on the environment, tropical timber production can influence environmental degradation *indirectly*. This indirect impact may occur through the opening up and improvement of access to the forests, which may then interact with other socioeconomic factors encouraging activities that degrade the environment. However, due to the intricately interconnected relationship of the various causes of deforestation, it is extremely difficult to identify how much of the tropical deforestation process is due to timber production.

In many developing countries where there are still areas of previously unexploited forest, and there exist no formal property rights for this land, timber production may encourage open access exploitation at the forest frontier and rapid forest conversion. Timber extraction usually involves extensive road building which benefits other activities, such as agriculture and hunting, by improving access to the forest and reducing costs of transporting produce to market. In Northern Brazilian Amazon, the total road network (paved and unpaved) increased from 6,357 to 28,431 kilometers (km) over the 1975–88 period. Although the road expansion program cannot be specifically attributed to timber extraction in this case, a simple correlation between road density and the rate of deforestation demonstrates that as road density increases, the rate of deforestation increases in larger proportions (Reis and Marguilis 1991).

Timber extraction is often the first step towards opening up the tropical forest and clearing the land for agricultural production. What is more, in many developing countries, property law establishes deforestation as a prerequisite of formal claim over the land for those settling in forested areas (Mahar 1989, Pearce, Barbier and Markandya 1990). Table 1 suggests around half of the area logged in African countries is subsequently deforested, whilst there is little, if any, deforestation of previously unlogged forest land. The environmental impact of forest conversion to agriculture has grown as logging has progressively opened up more remote, hilly and ecologically vulnerable areas.

A study by Amelung and Diehl (1992) looked at the causes of tropical forest *clearance, degradation and modification* (Table 2).[8] This study clearly shows that the use of different definitions of 'tropical forest change' can lead to very different conclusions about the causes of deforestation. The more sensitive the definition to forest change, the more likely the effect of the forestry sector is to be highlighted. For example, using the strict FAO definition of *deforestation* it appears that the agricultural sector accounted for the largest share (over 80%) of total deforestation in all tropical forest countries during the 1980's, and the direct impact of forestry activities on deforestation is minimal (i.e. 2% of total deforestation). However, when the alternative, more sensitive, measures of forest degradation and forest modification are used the role of the forestry sector becomes much more significant. For example, in Indonesia the forestry sector accounts for over 40% to total biomass reduction (*forest degradation*) and for all major tropical countries it accounts for 10%. The forestry sector is responsible for the vast majority of *forest modification* (71% across all major tropical countries) by converting previously unexploited forests into productive closed forests or other forms of land use. This analysis also indicates a process of deforestation, whereby timber extraction is largely responsible for the first stages of opening up previously unexploited forest, which then enables other economic uses of the forest resources, such as agricultural cultivation, which lead to further forest degradation and then deforestation.

4. Statistical Analysis of the Links between the Timber Trade and Tropical Deforestation

A number of studies have attempted to assess the relative importance of various economic activities, including timber extraction, in causing *tropical deforestation*. However, most of the work is extremely tentative and constrained to qualitative analysis because of the problems outlined in previous Sections. For example, Binswanger (1989) and Mahar (1989) highlight the role of subsidies and tax breaks, particularly for cattle ranching, in encouraging land clearing in the Brazilian Amazon. More recent analysis by Schneider *et al.* (1990) and Reis and Marguilis (1991) emphasize the role of agricultural rents, population pressures and road building in encouraging small-scale frontier settlement in this region. The study by Schneider *et al.* (1990) also identifies the importance of logging – log production from the Amazon region increased from 4.5 mn m^3 in 1975 to over 24.5 mn m^3 in 1987 – in forest exploitation, primarily through opening access to previously inaccessible lands. Commercial timber extraction has been encouraged by both a range of public policies, increasing domestic demand and a strong international demand for tropical hardwoods.

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[8] The FAO employs a classification of deforestation to be a change of land use or a depletion of crown cover to less than 10%. Changes *within* the closed forest classification are termed forest degradation (or biomass reduction). However, there does not appear to be any clear distinction made between forest degradation and biomass reduction, although the two are not strictly synonymous.

Although the qualitative case studies provide interesting and useful insights into causes of deforestation, they do not provide a satisfactory basis for making comprehensive conclusions about the linkage between a broad range of factors (such as agricultural production, timber production, fuelwood collection, population pressure, income growth etc) and tropical deforestation. In addition, a large proportion of the studies look at the factors contributing to deforestation in a specific country rather than across all tropical countries. While country case studies are generally more focussed and able to tackle the complex, and often site-specific, process of deforestation in more detail, they are not in themselves sufficient to draw conclusions about the causes of tropical deforestation on a regional level. Given that current policy debates about intervention in the tropical timber trade are being held at an international level, it is also necessary to look at the aggregate 'tropics wide' situation. The rest of this section briefly reviews some existing relevant studies that attempt to statistically examine the linkages between tropical deforestation and provides a more comprehensive understanding between these linkages.

Review of Existing Studies

There are a number of important 'caveats' that need to be born in mind when reviewing the statistical studies of the factors thought to contribute to deforestation. Firstly, all the analyses suffer from the usual problem of reliability and accuracy of data. More importantly for the focus of this study, data limitations prevent the ability to distinguish between production forests and conversion forests across the tropics. This may lead to misleading indications about the relationship between log production and changes in forest area. That is, if log production is mainly from conversion forests, then timber extracted is essentially a precursor or by-product of agricultural conversion which is the principle factor in the resulting deforestation. The analyses are also unable to reflect the production management regime and the success of its implementation due to the lack of any suitable, and consistent set of, indicators. This was noted above as the underlying cause of forest degradation rather then the actual harvesting of timber. In addition, due to the level of aggregation required to undertake such regional level studies, the analyses are not sensitive to the different types of forests and different patterns of wood use. Finally, the studies that are selected for review, while relevant to understanding the relationship between timber production and tropical deforestation, were not designed to explicitly explore this relationship.

Allen and Barnes (1985) undertook a comprehensive cross-sectional analysis of the causes of deforestation in 39 developing countries in Africa, Latin America and Asia between 1968–78.[9] Two regression models are used to analyze the relationship between deforestation (i.e. a negative change in the forest area between 1968–78 based on FAO data) and socio-economic development, land use and wood use. The indicators for socio-economic development include gross national product (GNP) per capita and population density.

[9] This analysis includes tropical and temperate countries whose gross national product (GNP) per capita is less than US$3,000 and forest area is greater than 5% of total land area. The authors undertake an analysis of two samples: 1) all countries; and 2) Africa and Asia because the rates of deforestation have been much lower in Latin America. However, just the results of sample 1) all countries are presented here.

The potential impact of economic development (usually indicated by GNP per capita) on forest clearance is complex. On the one hand, improvements in development is associated with increasing concentration of the population in urban centers, industrialization and a reduced reliance on the natural resource base – thus reducing pressure on tropical forests. On the other hand, increasing development may be achieved by high, and unsustainable, rates of extraction and harvesting of natural resources (such as timber, agricultural crops, livestock and mining) for domestic consumption and international trade. In the latter situation, increasing GNP per capita through unsustainable extraction puts greater strain on the tropical forest.

In the Allen and Barnes (1985) model, GNP per capita is expected to impact positively on the change in forest area while population pressure is anticipated to lead to a negative impact on forest area. The land use variables include arable land and land under permanent crops and are expected to lead to a negative impact on forest area. A measure of wood use is constructed from the sum of wood fuel consumption and wood exports and is expected to be negatively linked to forest area. The 'wood use' variable reflects the demand for fuelwood as well as wood exports and it is not possible to identify what is the effect of these factors individually. The authors explain the use of this composite variable due to the sum of the two factors being more closely related to deforestation than either wood fuel production and wood exports alone. However, it is clear from the data provided in the study that the level of wood fuel production outweighs the level of wood exports (both in m^3 per 1,000 persons). Therefore, it is difficult to draw any firm conclusions from this study that are directly relevant to the links between the timber production for the trade and deforestation.

The first equation is a short–run model that estimates an *annual change in forest area* as a function of population growth, change in arable land, GNP per capita growth and change in wood production. The results of the model (Table 3a) show how a change in forest area over the 1968–78 period is related to a change in the independent variables over the same period. As anticipated, population growth has a significant and negative relationship with forest area. However, although the coefficient for change in arable land is negative, it is not significant. Further analysis of simple correlations between the changes in forest area and arable land indicate that this relationship is stronger than the multivariate coefficients, probably because the forest are being replaced by agricultural land. The authors assert that controlling for population suppresses the negative relationship between cropland and change in forest area in this model and that this relationship does in fact hold true. However, the anticipated relationship between forest area, GNP per capita and wood production per capita is not supported by this model. This may be due to the slow movement of these variables over the given time frame and a lagged impact on forest area, or simply reflect that fact that these factors do not have significant links with the change in forest area.

The second long–run model provides an analysis of the impact of the 1968 levels of forest area, wood production, per capita GNP, population density, and area under permanent crops on the change in the forest area between 1968–78 (Table 3b). This model supports the hypothesis that change in forest area over the ten year period is negatively related to wood use. That is, forest loss, or deforestation, increases with increasing wood use. The log of percent of forest area (reflecting the extent of the forest resource base) is statistically significant and positively related with deforestation. This results shows that those countries with a less than average forest resource base are more likely to lose forest area during the following decade. However, neither GNP per capita nor population density are statistically significant in this model.

An extensive cross–sectional statistical test of various factors influencing deforestation in 72 tropical countries[10] was carried out by Palo, Mery and Salmi (1987). Taking total forest coverage[11] in 1980 as the dependent deforestation variable, they tested the correlation between this and 33 independent variables which were divided into 5 sub–groups. The groups comprised:

- natural factors – soil, climate and accessibility;
- traditional factors – shifting cultivation, grazing and fuelwood gathering;
- economic development factors – permanent agriculture, industrial logging, forest management and economic development;
- political factors – land tenure, forest and other administration, market mechanisms; and,
- population factors – population pressure.

The most interesting relationships that were defined using an iterative process utilizing correlation matrices were then used to specify a basic model. There is little, if any, theoretical reasoning behind the construction of the model, other than the fact that the independent variables were found to be statistically significant through simple correlation tests. Due to strong multicollinearity in the basic model (Table 4) a number of variations of the model were tested. Both agricultural area coverage and food production per capita were significantly and negatively related to forest coverage, suggesting that increasing demands for food had mainly been met by expanding land under agriculture production at the expense of forest area. The statistical analysis also identified a strong negative correlation between total forest coverage and total population density in tropical countries, excluding 8 arid African countries. In this model, the linkages between forest coverage and forest products exports per forest area and relative industrial roundwood production were not statistically significant.

Capistrano (1990) and Capistrano and Kiker (1990) examine the influence of international and domestic macro–economic factors on the depletion of tropical forests. Drawing on data from 45 tropical developing countries during the period from 1967 to 1985, the impacts of export prices, income, international debt as well as population, arable land availability and food self–sufficiency on forest depletion are evaluated. The dependent variable used to represent deforestation is the extent of disturbance from industrial

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[10] Includes moist, semi–moist and arid African countries.

[11] Forest coverage is defined here to be the ratio of forest area to total land area and is used as a negative proxy for deforestation.

logging. The use of this variable is justified by the authors on the grounds that there is a close correlation between average area of closed broadleaved forest and industrially logged forest from 1976–80. However, it is questionable as to whether this assumption is appropriate. For example, although on aggregate the indicator may be correlated, there are many countries where industrial logging is not significant in the deforestation process. In other cases, the link between deforestation and industrial logging may have decoupled after 1980, or where plantation forests replaced the traditional supply of tropical timber. Other problems may arise, as noted by the authors, where there is under-reporting of wood removed from public forests. Given these reservations, the study can be considered more as an analysis of the relationship between various factors and the changes in the tropical timber production forests, rather than tropical deforestation *per se.*

The regression analysis was run over 4 periods: 1967–71; 1972–75; 1976–80; and 1981–85, using three different model specifications. The model was not run over the entire 1967–85 period as a whole. The impact of the explanatory variables on deforestation were expressed as elasticities – i.e. measuring the percentage change in forest depletion for every percentage change in the explanatory variable. The significance of the explanatory variables varied substantially in the four periods of the model, and only the significant variables are included in the final versions of the models presented in Table 5. This variation reflects the structural change that was occurring in tropical forest countries over the time period of the analysis.

In the first period (1967–71) the only explanatory variable that was significant was the export value of tropical wood, but this variable alone explained more than 85% of the variation in the area of productive forest logged during this period. Therefore, it can be asserted that tropical deforestation was strongly linked to timber export prices between 1967–71. However, the export value of tropical wood is not significant in any subsequent periods.

In the second and third period (1972–75, 1976–80) the cereal self–sufficiency ratio was estimated to be statistically significantly related to deforestation. A 1% increase in this ratio led to a 4.5% to 5.5% increase in forest depletion. However, this explanatory variable ceased to be significant in the fourth period, perhaps because the policy objective of food self–sufficiency was generally given less attention. Population pressure (given by total population) was only statistically significant in the second period (1972–75) at above the 90% confidence level. In this period it had a positive impact on forest depletion. In the third and forth period (1976–80, 1981–85), real exchange rate devaluations had a strong, positive statistical relationship with deforestation when a 1% devaluation of the domestic currency was associated with a 3–4%, and 1–2% increase in deforestation respectively. In the final period (1981–85) the expansion of arable lands had the strongest influence on forest depletion, although the data on arable land expansion does not indicate whether this expansion was for subsistence or export crops.

Southgate, Sierra and Brown (1989) examine the causes of agricultural colonization and deforestation in eastern Ecuador in the early 1980's. They use statistical analysis to study the relationship among land clearing, rural population pressure, local demand for agricultural commodities, infrastructure development and tenure insecurity across broad stretches of the agricultural frontier. Although the analysis does not explicitly examine the role of timber production, the relationship between road building and forest conversion is included. This is relevant to understanding the indirect impact of timber production on forest clearance through opening up forest lands.

The analysis involves a two stage approach. First, for each of the twenty cantons in Ecuador, the influences on agricultural rents (excessive economic profits) are regressed against the area's agricultural labor force (which is taken as an indication of rural population pressure). The agricultural rents are thought to be affected by:

- the scale of the urban population – which influences the local demand for agricultural commodities;

- the quality of the soil – which may constrain agricultural productivity; and

- the extent of the road network – which opens up the forest for conversion to frontier agriculture colonization and the affects the accessibility of the urban market for transporting agricultural commodities.

The second stage involves relating the extent of land clearing (deforestation) to demographic pressure (the dependent variable from Stage 1) and an index of relative tenure security. The problem of tenure security arises from excessive bureaucratic requirements claims for formal property rights take a long time to adjudicate, are costly and complex to undertake.

The regression results generally support the economic theory underlying the statistical analysis (Table 6). That is, the incentive to capture agricultural rents is the main driving force behind forest conversion, and is further induced by tenure insecurity. The study emphasizes the role of population pressure in encouraging deforestation, directly through an increasing rural labor force and indirectly through rising urban food demand, but also identifies the implications of misguided government policies over land tenure arrangements.

A more recent paper by Southgate (1991) draws on data from 24 Latin American countries to explain the causes of agricultural frontier expansion and thus forest clearance. Growth in agricultural yields from non–land inputs is expected to alleviate the pressure on frontier expansion. Population growth is expected to lead to further forest clearance and expansion of land under agriculture, although the primary relationship between population growth and frontier expansion is indirect, i.e. increasing numbers of urban consumers raises the demand for agricultural commodities and the ensuing demand for agricultural land. A further factor expected to increase the demand for agricultural land is the expansion of agricultural exports. The specific relevance of the Southgate (1991) study for this report is through the role of the land constraint variable (reflecting the physical constraints of the land). Where there is little appropriate land available for conversion then the growth in arable land, and thereby forest clearance, is significantly reduced. However, this variable is indicative of the potential role of domestic land use management regimes (including planning, monitoring and enforcement) where is government polices that constrain land use. The results of this econometric analysis are presented in Table 7 and provide strong statistical support to the basic hypotheses espoused by Southgate (1991).

The tentative conclusion that can be drawn from the statistical analyses reviewed above is that there are no clear links identified by the existing literature between timber production for the international trade and tropical deforestation. Although this may seem to be a rather unfulfilling result, it is nevertheless extremely important to show that the quantitative research conducted to date does not provide any solid ground for making sweeping statements about the links between timber production for the international trade and tropical deforestation. However, as noted at the beginning of Section 4 there are many caveats that need to be taken into account and that none of these studies were explicitly designed to explore the relationship between the timber trade and tropical deforestation.

Analysis of the Links between the Timber Trade and Tropical Deforestation

Building on the lessons learned in previous quantitative studies, and the insights provided by the numerous qualitative studies, a regression analysis to examine the role of timber production to tropical forest clearance has been developed for this study. The research is based upon an analysis of 53 tropical countries and looks at the relationship between a range of variables (i.e. timber production, agricultural yield, population density, income growth and tropical forest stock) and forest clearance.[12]

The dependent variable to represent forest clearance during this period is given by the logarithm of the forest area in 1985 minus the logarithm of the forest area 1980. The data on forest area (in 000 ha) is based on the most up to date FAO statistics (Schmidt 1988) for 1980–85 (pending the results of the FAO *1990 Forest Assessment*). The data used to capture the effect of industrial roundwood production is taken from FAO *Yearbook of Forest Products* (FAO 1992). Two variables were tested in the model: industrial non–coniferous roundwood production per capita in 1980 (m^3/total population), and industrial non–coniferous roundwood production per total land area in 1980 (m^3/000 ha). Timber production is expected to have a negative impact on the state of the tropical forest, directly through unsustainable extraction of timber and indirectly through opening up the forest by the construction of logging roads. Therefore, the higher the level of timber production the higher the level of deforestation. As noted in Section 2 of the main Report, only a small proportion of total industrial timber production actually enters the international trade. Therefore, any attempt to infer a relationship between the international tropical timber trade and tropical deforestation based on this variable needs to be undertaken with great caution. However, the industrial non–coniferous roundwood variable is a useful instrument to enable analysis of the impacts of *domestic and trade policies* on roundwood production and its implication for tropical deforestation.

The variable used to capture the effect of economic development on tropical forests is real gross national product per capita in 1980 (in US$) taken from World Bank Tables (1992). It is anticipated that across the tropics as a whole, economic development relieves the pressure on tropical forests. Therefore, the higher the income per capita, the lower the loss of tropical forests. Population pressure, given by population density in 1980 (total

[12] Tropical counties are taken to be those countries with the majority of their land mass lying between the tropics. This definition does not distinguish between moist and dry forests that lie between the tropics.

population/total land area (ha), World Bank Tables (1992)) is expected to be directly associated with higher levels of tropical forest clearance. In order to capture the effect of changes in agricultural productivity on forest clearance an indicator of agricultural yield was included, given by cereal production per unit of cereal production area in 1980 (1000 mt/1000 ha) (FAO *Production Yearbook 1992*). Higher agricultural yields are expected to offset the need to clear forests for agricultural production and thus have a positive impact on the state of tropical forests.

The status of the forest resource base in the initial period (1980) is given by the logarithm of the percent of forest area over total area (forest area in 000 ha(*100)/total area (000 ha)) (Schmidt 1988). This variable is included to show that the level of existing forest stocks may affect rate of forest clearance in the future. On the one hand one would expect that in those countries where the proportion of land under forests is lower than average then the level of forest clearance will be higher than average – mainly due to the size of the initial stock. On the other hand one may expect the value of tropical forest resources to increase as the forest becomes more scarce, and thus encourage more conservative use of the forest. However, this 'scarcity' effect is unlikely to be sufficiently large, or to be taken into account in time, to have a positive feedback on forest conservation. Finally, because deforestation rates have been lower in Latin America and exports of timber products are generally less significant for this region, a dummy variable for Latin America is included in the model.[13]

The results of the model (presented in Table 8) are fairly robust given the complexity of the problem being analyzed, the aggregate level of the analysis, the cross-sectional nature of the model and the data unreliability, especially the forest data. The model supports the hypothesis that industrial roundwood production and population pressure are positively associated with forest clearance in the tropics for the 1980–85 period, i.e. increasing levels of industrial roundwood production per capita (or increasing population density) leads to higher rates of forest loss.[14] That is, a 1% increase in roundwood production (m^3 of industrial non-coniferous roundwood produced per capita in 1980) is anticipated to increase the level of forest area cleared by 0.019%. Similarly, a 1% increase in population density would increase forest clearance by 0.02%[15]

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[13] Although there are numerous other factors that may contribute to deforestation, such as agricultural production, fuelwood harvesting, livestock production, road building or government expenditures on forestry, they are not included in this model. This is to retain the focus of the model on timber production and to keep the model relatively simple and transparent. In addition, the first three factors may be picked up to some extent by the GNP per capita and population density variables. The latter two factors are omitted due to data constraints.

[14] The model was also run using the variable industrial non-coniferous roundwood production per total area in 1980. The coefficient on this alternative explanatory variable was also negative (–0.000167) and there was little change to the estimated coefficients of the other independent variables. However, the explanatory power of this alternative variable was slightly less significant (t statistic –1.68) and the robustness of the model in general was reduced through the inclusion of this variable.

[15] The elasticities given at the bottom of Table 6.1 indicate the percentage change in forest area cleared for every 1% change in an explanatory variable (holding all other factors constant).

Economic development is seen to have a negative and significant relationship with forest clearance, i.e. improvements in economic welfare reduces forest clearance. The model also supports the hypothesis that improvements in agricultural yields can also promote more conservative rates of forest clearance – a 1% increase in cereal production (1,000 mt) per unit of cereal production area (1,000 ha) would lead to a decrease in forest clearance by 0.03%. The positive and significant coefficient for the log of percent of forest area indicates that countries with a lower average forest resource bases in 1980 are more likely to lose forest area during the next five years. This suggests that many countries with relatively small forest areas to total land area are running their remaining forest stocks down at a high rate.

It may be argued that because the causes of deforestation are location specific and extremely complicated, a cross–national study over–simplifies reality and cannot provide any useful insights useful. However, simply discarding attempts to statistically analyze these links due to their complexity undermines the potential to use econometric analysis to contribute to policy debate. This analysis suggests that higher levels of industrial roundwood production is related to higher levels of forest clearance in the tropics. However, the use of trade interventions to encourage improved tropical forest management is likely to be a blunt tool due to the limited role of the timber trade in overall timber production and consumption in the tropics.

5. Conclusions and Policy Implications

This paper has discussed the linkages between the tropical timber trade and sustainable forest management. It is extremely difficult to identify and analyze the linkages for a number of reasons, in particular due to the complexity of the linkages, the lack of data on the status of forest resources, information on the returns to forest land under alternative uses, and the difficulty of isolating the impacts on the forest of timber harvested for the trade from total timber production. However, there are several important policy implications that can be drawn from this paper:

- Current rates of tropical deforestation are excessive and tropical deforestation is considered to be an economic problem.

- In order for sustainable timber management to be a viable forest land use option it must yield net returns to developing countries that are greater than those derived from competing uses, such as conversion for frontier agriculture. Trade related incentives are an important means of ensuring appropriate returns to sustainable timber management of tropical forests and making it an economically attractive land use option.

- Although it is possible to manage the extraction of timber from tropical forests on a sustainable basis with minimum environmental damage this practice does not appear to be widespread. Timber production can degrade tropical forests directly through unsustainable forest management practices and indirectly through opening up the forests.

- A review of the literature revealed that there is no strong statistical basis for making statements about the relationship between timber production for the trade and tropical deforestation, although a study undertaken for this Report does confirm a positive linkage between timber production and tropical forest clearance. As noted in Section 2 however, only a small proportion of the total volume of industrial roundwood produced is traded internationally. Therefore, the use of trade interventions to encourage improved forest management through reducing the volume of timber production is likely to be ineffective due to the limited role of the trade in overall timber production.

This paper has highlighted a dichotomy in the linkage between timber production for the trade and tropical deforestation. On the one hand, the timber trade can lead to greater net returns for forestry investments and make sustained timber management, a perquisite for stabilization of forest areas in the tropics, more feasible in the long run. On the other hand, it appears that poorly managed and excessive timber extraction is leading to direct and indirect forest degradation in the short run. Section 6 of the main Report will look in more detail at the domestic market and policy failures that are undermining the incentives for trade to contribute to sustainable forest management.

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Table 1 **Timber Harvesting and Deforestation in African ITTO Producer Countries, 1981-85 (000 ha)**

Country	Area Logged a/	Area Logged Deforestedb/	Unlogged Area Deforested c/
Cameroon	272.0	75.0	3.0
Congo	57.0	20.0	1.5
Cote d'Ivorie	330.0	290.0	d/
Gabon	150.0	15.0	d/
Ghana	N.A.	22.0	N.A.
Liberia	104.0	44.0	d/
TOTAL	> 913	466.5	> 4.5

Notes:

a/ total average area selectively logged per annum
b/ estimated area of a/ subsequently logged
c/ unlogged area deforested per annum
d/ unknown but small

Source: E.B. Barbier *et al.* (1992)

Table 2a. Sources of Deforestation in Tropical Countries, 1981-1988 a/

	Brazil	Indonesia b/	Cameroon	All Major Tropical Countries
Forestry	2 d/	9	0	2 (10)e/
Agriculture	89	80	100	(83) f/
shifting cultivators c/	13	59	92	na
	(23)	(67)	(95)	(47)
permanent agriculture:	76	21	8	36
-pastures	40	0	0	17
-permanent crops	4	2	5	3
-arable land	32	19	3	16
Mining including related industries	<3	<0.3	0	na
Hydroelectricity production	4 b/	0	0	2 b/
Residual g/	2	11	0	(13) h/

Notes: a/ Percentage shares in deforestation refer to averages for the respective period.
b/ Data refer to the 1980-1990 period.
c/ Figures in parentheses show the results of the FAO for 1980. These data include also market oriented farmers who produce cash and export crops and engage only partly in shifting cultivation.
d/ Deforestation due to logging is due to charcoal production.
e/ The figure in parentheses refers to the estimation of EK (1990). The calculation includes only Indonesia and Brazil, since these countries account for the largest share in clear cutting by the forestry sector.
f/ This percentage rate is based on the assumption that the percentage share calculated for shifting cultivators can be taken as an average for the 1981-1988 period.
g/ This includes other industries, housing, infrastructure services and fire loss.
h/ The residual has been calculated from the data in this column which includes data from different periods.

Source: Amelung (1991)

Table 2b. Sectoral Share in Forest Degradation and Forest Modification, 1981-85 a/

	Percentage Share in Biomass Reduction (Degradation)				Percentage Share in Forest Modification			
Sector	Brazil	Indonesia	Cameroon	Total b/	Brazil	Indonesia	Cameroon	Total b/
Forestry	6	44	10	10	(100) c/	(100) c/	98	71
Agriculture d/	85	49	90	76	0	0	2	26
Others d/	9	7	0	13	0	0	0	4

Notes: a/ For the definition of modification and biomass reduction (degradation) see FAO (1982)
b/ Total refers to all major rain forest countries.
c/ Following FAO statistics, deforestation in virgin forests is 0, since clearing by agriculture and other sectors concentrates on disturbed forests. Even though some clearing occurs in virgin forests, there is reason to assume that the bulk of deforestation is due to forests that have been logged over prior to the clearing of the respective areas.
d/ These figures have been derived from Table 3.5 and reflect averages for the 1981-1988 period or, in the case of Indonesia, the 1980-1990 period.

Source: Amelung (1991)

Table 3 The Causes of Deforestation in Developing Countries, 1968–78

A. Model 1 Dependent Variable: Annual Forest Area Change, 1968–78

Independent variables	Estimated Coefficient (t values)
constant	0.0042
X1, annual population growth rate 1970–78	−0.005 (1.477)
X2, annual cultivated land change 1968–78	−0.140 (0.734)
X3, annual per capita GNP growth rate 1960–78	0.0009 (0.699)
X4, annual change in per capita wood fuels production and roundwood exports 1968–78	−0.007 (0.141)

F statistic:	1.091
Number of countries:	39
R^2:	0.113

B. Model 2 Dependent Variable: Total Forest Area Change, 1968–78

Independent variables	Estimated Coefficient (t values)
constant	−0.144
X1, log percent of forest area, 1968	0.045 (1.337)
X2, population density,1968	0.0013 (0.529)
X3, per capita GNP, 1968	0.0001 (0.932)
X4, per capita wood fuels production and exports, 1968 roundwood exports 1968–78	−0.0001 (2.204)
X5, percent of land area under plantation crops,1968 roundwood exports 1968–78	−0.016 (2.791)

F statistic:	3.614
Number of countries:	39
R^2:	0.353

Source: Allen and Barnes (1985)

Table 4 Deforestation in the Tropics

Dependent variable Forest coverage in year t (FC_t)

Independent variables	Estimated Coefficient (t values)
constant	92.62 (11.79)
FF_t, share of forest fallow	−0.10 (−4.07)
LP_t, livestock production index	0.09 (1.84)
FW_t, relative fuelwood production	−0.04 (−0.36)
AG_t, agricultural area coverage	−0.53 (−6.87)
FP_t, food production per capita	−0.14 (−2.93)
IW_t, relat. indust. roundwood production	−1.61 (−0.47)
EX_t, forest products exports per forest area	0.10 (0.10)
GN_t, GNP per land area	1.16 (0.34)
PD_t, population density	−0.12 (−4.46)
PG_t, population growth	−0.63 (−0.26)

Adjusted R^2: 0.85
F statistic: 30.76
Number of observations: 60.00
Critical t−values at 1% = 2.66, at 0.1% = 3.46

Source: Palo, Mery and Salmi (1987)

Table 5 Elasticity Of Forest DepletionWith Respect to Significant Variables

Dependent Variable	**Forest Depletion (industrial roundwood removal from broadleaved forest divided by volume actually commercialized from undisturbed closed broadleaved forest).**

Explanatory Variables	**Model 1**	**Model 2**	**Model 3**
Period 1 (1967–71)			
Log Export Value Index	1.45**	1.49**	1.50**
Period 2 (1972–75)			
Per Capita Income	2.18**	2.18**	1.96**
Agricultural Export Price Index	0.86	1.11	0.96*
Debt Service Ratio	–1.15	–1.15*	–1.46*
Cereal Self–Sufficiency Ratio	5.12**	4.84**	4.71**
Population	0.26	0.26	0.26*
Period 3 (1976–80)			
Per Capita Income	1.43	1.61*	1.29
Real Devaluation Rate	4.10**	4.67**	3.16*
Cereal Self–Sufficiency Ratio	4.61	5.41*	4.19*
Period 4 (1981–85)			
Real Devaluation Rate	1.40*	1.40*	1.02*
Arable Land Per Agric. Capita	3.74**	4.03**	2.86*

*   Significant at 0.05 level
**   Significant at 0.01 level
Others significant at 0.10 level

Source: Capistrano and Kiker (1990)

Table 6 Causes of Tropical Deforestation in Ecuador

STAGE 1

Dependent Variable **AGPOP (the canton's agricultural labour force)**

Explanatory Variables	**Estimated Coefficient (standard deviations)**
constant	469.144 (251.334)
URBPOP (canton's urban population)	0.263 (0.061)
SOILS (hectares in the canton covered with soils that do not have major limitations for crop production)	0.008 (0.002)
ROADS (kilometers of all–weather roads in the canton)	3.350 (2.527)

F = 26.856 adjusted R^2 = 0.803 number = 20

STAGE 2

Dependent Variable **DEFOR (extent of land clearing in a canton)**

Explanatory Variables	**Estimated Coefficients (standard deviations)**
constant	16,111.728 (23,977.621)
AGPOP	51.073 (6.241)
TENSEC (relative differences in formal tenure security among cantons)	26,989.394 (12,321.915)

F = 36.097 adjusted R^2 = 0.875 number = 11

Source: Southgate, Sierra and Brown (1989)

Table 7 Agricultural Frontier Expansion in Latin America

Dependent Variable **Agricultural land growth (annual 1982–87)**

Explanatory Variables	**Estimated Coefficient (t statistic)**
constant	0.463 (2.876)
POPGRO (annual population growth, 1980–88)	0.249 (3.773)
EXPGRO (annual growth agricultural exports, 1984–88)	0.031 (2.214)
YLDGRO (annual increase in crop production per unit area of crop land, 1982–89)	−0.198 (−6.000)
NOLAND (land constraint dummy set to 1 for those countries with low potential agriculture land availability)	−0.641 (−3.127)

Adjusted $R^2 = 0.699$ DW = 2.065 SSR = 3.489 F = 12.098

Source: Southgate (1991)

Table 8 The Linkages between Timber Production and Tropical Deforestation

Dependent Variable — **Five year change in closed forest area (log forest area 1980 – log forest area 1985)**

Explanatory Variables	**Estimated Coefficient (t statistic)**
constant	−0.1009 (−4.188)
X1 (log of closed forest area as a percentage of total area 1980)	0.01253 (1.609)
X2 (population density 1980)	−0.0474 (−2.695)
X3 (roundwood production per capita 1980)	−0.0849 (−2.3029)
X4 (real GNP per capita 1980)	0.000195 (1.8098)
X5 (agricultural yield 1980)	0.02301 (1.1298)
X5 (dummy Latin America)	−0.06809 (−2.4086)

Estimated Elasticities

X1 = 0.0125
X2 = −0.0285
X3 = −0.0186
X4 = 0.1870
X5 = 0.0339
X6 = −0.0216

R^{2}:	0.268
F Statistic:	2.8089
Number of Observations:	53

ANNEX C

MARKET CONDITIONS FOR TROPICAL TIMBER PRODUCTS

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Terms of Reference

For research and analysis of end use markets for tropical hardwoods

These Terms of Reference relate to a sub-contract for consultant services to be provided as part of the ITTO Activity entitled *The Economic Linkages Between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests* (Activity No. PCM(IX)/4). Under these Terms of Reference the London Environmental Economics Centre, hereafter referred to as LEEC, agrees to engage the services of the Forestry Sciences Laboratory, Pacific Northwest Research Station, Corvallis OR (Dr David Brooks, Principal Investigator), hereafter referred to as the Consultant, in accordance with the following conditions:

1. The Consultant will research and report on three broad topics related to end-use markets for tropical hardwood products, as listed in points 2 and 3, below. In each case, the focus of research by the Consultant will be to review the current state of knowledge on the particular topic and to identify important gaps in understanding. Where possible, the Consultant will supplement his review and assessment of background literature with analysis of available data.

2. Assess trends in major export markets for tropical timber products. What factors in export markets are key determinants of the demand for tropical timber products? How does (or will) consumption of tropical timber products respond to changes in prices, both own price and prices of competing products? What is the degree of and trend in substitution between tropical timber products and temperate timber or non-timber products in intermediate or end-use markets?

3. Assess trends in domestic timber markets in tropical producer countries and in other developing economies. What is known about the future growth in domestic demand for tropical timber in these countries? What information is available on the growth of timber processing industries and the export of finished wood products?

4. The whole contract period covering the tasks described above is from 15 July to 30 September 1992. During this period the Consultant will submit a detailed outline of a report to LEEC, not later than 1 August 1992. The Consultant will submit a final report to LEEC not later than 30 September 1992.

Market Conditions for Tropical Timber Products

David J. Brooks

14 October 1992

Introduction

Trade in tropical timber and its relation to management of tropical forests must be understood in the context of markets for all forest products and, of course, specific markets for industrial products from tropical forests. In this regard, at least three issues require particular attention. First, how have patterns of trade in tropical timber changed as a result of changes in the type and level of forest products consumption in major markets? Condition in major markets - Asia, Europe and North America - must be reviewed to assess patterns of consumption and the role of tropical timber products in relation to total forest products consumption and production. Of particular importance are an understanding of end uses of tropical timber, key determinants of demand, and trends in pattern use. The roles of prices, consumer preferences and prejudices, and technological developments in consumption must be taken into consideration. Because a significant volume of tropical timber products, like many primary and secondary forest products, are "consumed" in manufacturing processes (such as home construction, and manufacturing doors, windows and furniture), technological developments that lead to substitution of other products and materials can play an important role in the outlook for consumption of tropical timber.

A second issue is consumption of forest products in countries producing tropical timber. What are recent trends in consumption, and how are they likely to affect tropical timber markets as a whole? In large measure growth in domestic consumption of forest products in tropical timber producing countries is a natural consequence of economic and population growth. However, it is important to assess the extent to which the outlook for forest products consumption in tropical countries may differ from that of other developing countries. Readily available supplies of industrial forest products are likely to affect the pattern and rates of growth in consumption. To the extent that this consumption represents a significant source of demand for tropical timber, existing patterns of trade will change. In addition, with growth in domestic consumption in tropical timber producing countries, production of industrial products from tropical forests will be increasingly beyond the scope of policy instruments focusing on international trade.

Finally, the emergence of new markets, particularly those in developing countries that are not producers of tropical timber, must also be examined. The effects of the trade policies of industrialized nations on tropical timber consumption and production are obviously limited by the importance of consumption and trade that takes place outside the boundaries of such intervention.

Any one of these issues is worthy of extensive study; here, however, each is simply addressed simply through a review of recent trends and recent literature. The objective is to provide a broad-based display of issues. Definitive results, such as estimates of rates of substitution between tropical and temperate timber products in specific markets, are beyond the scope of this effort; they are, in addition, limited by the quantity and quality of available data.

1. Markets in Industrialized Countries

Table 4.1 summarizes broad patterns of consumption (net imports) of tropical timber by product and major importing countries or region. Trends and patterns for each region will be addressed in turn. Japan is the predominant market for tropical timber, followed by Europe (data are shown for the European Community (EEC) only), with North America a distant third in consumption among industrialized regions. In the last decade or so, Korea and Taiwan have emerged as significant importers of tropical timber; in 1989-90, Korea and Taiwan imported a quantity of tropical timer nearly equal to that of the EEC. For both countries, a considerable portion of tropical timber consumption is in export-oriented industries, especially furniture, with North America and Japan as the major export markets. As a result, some double counting is reflected in this table; tropical logs imported by Taiwan, for example, are used to manufacture plywood that is exported to the United States, Europe, and Japan. Therefore, in table 4.1 some portion of the volume reported for Taiwan and Korea actually appears in two places.

Japan

Japan's domestic timber resources are substantial, covering roughly 25 million hectares with a stock of 3 billion cubic meters. Roughly two-thirds of Japan's domestic timber resource is softwoods, most of which is the result of a post WW-II reforestation program. Nevertheless, Japan depends on imported raw material and timber products to meet nearly three-fourths of domestic demand. This import-dependence has increased steadily since the mid-1970's, in part because the bulk of domestic timber resources are immature or expensive to harvest, and in part as a result of explicit trade and industrial policies. In the late 1980s Japan's demand for timber reached a peak of roughly 115 million cubic meters (roundwood equivalent); domestic resources supplied less then 30 percent of this volume (Ward 1991).

Japan continues to be the world's largest importer and consumer of tropical timber as it has been for more the two decades (table 4.1). In 1990, Japan accounted for roughly half of tropical timber imports of industrialized countries, and more than one-fourth of world trade in tropical timber products. These data are only slightly changed from the mid-1980s (Nectoux and Kuroda (1989). Table 4.2 shows the distribution of Japanese timber imports by products (logs, lumber, and plywood), and species (hardwood and softwood), both temperate and tropical. Tropical logs account for nearly all hardwood logs imported, but less than half of all logs imports; tropical lumber accounts for 80 percent of hardwood lumber imports, and less than 20 percent of total lumber imports. Tropical plywood accounts for nearly all plywood imports, and about one third of Japanese plywood consumption.

Table 4.3 summarizes the importance of tropical timber in the Japanese forest sector in 1990. In terms of both value and volume (all products expressed in a equivalent basis), imports in the form of logs still account for the majority of Japan's tropical timber imports. Domestic log production in Japan peaked in the mid-1960s, and has declined steadily since. Tropical logs are used primarily in the domestic plywood industry, although their relative importance is lower than at any time in the recent past. These data for 1990 show a decline in the tropical log share of raw material for plywood production from data reported by Ward Associates (1990) for 1988. Supply restrictions in tropical timber producing countries, competition form product imports, and a slow-down in construction activity (1991-92) have all contributed to long-term decline in Japanese plywood production. Currently, production is at the lowest level since the mid-1960s (Japan Lumber Reports 1992). Plywood imports increased by a factor of 10 between 1985 and 1990.

In 1990, domestic production of logs used in lumber manufacturing was roughly 18 million cubic meters, and was composed primarily of temperate softwood species; domestic production accounted for less than 40 percnet of log supply to Japanese saw mills. Over the past 2 decades, Japanese lumber manufacturing had declined more than 30 percent in output and number of mills; employment in lumber manufacturing decreased by nearly 50 percent. As with the plywood industry, decreased availability of raw material, increasing raw material prices, and increased competition from imports have contributed to this trend.

Table 4.4 summarizes end use data for tropical timber in Japan; housing and construction account for the majority of Japanese consumption of tropical timber. Overall plywood accounts for the majority of Japanese tropical timber consumption; most plywood is used in sheathing and formwork in construction. End uses for lumber are less concentrated; housing fixtures (such as doors, windows and stairs) account for most use of tropical lumber (Ward Associates 1990). However, there are few applications in which there is not competition from temperate species (both domestic and imported) and other materials. Ward Associates (1990) reports that tropical hardwood lumber (whether imported or manufactured in Japan) lost market share in all end use markets over the period 1980-89. Total consumption of tropical lumber declined by more than 2 million cubic meters over this period.

Competition from other materials is a significant factor in the use of tropical lumber in furniture manufacturing; temperate hardwood and softwood lumber has replaced tropical lumber in a variety of applications (Ward Associates 1990). Similar patterns of substitution have occurred in packaging. Packaging accouts for less than 5 percent of tropical plywood use in Japan (table 4.4), and has maintained a steady share of wood used in this market; however, overall wood use in packaging has declined in the past decade, the share accounted for by tropical lumber has declined (Ward Associates 1990). Uncertainty concerning supply (or, at the very least, the process of changing sources of supply from domestic production to imports) likely contributed to this decline.

Changes in the mix of raw materials used are driven only in part by physical availability. For Japanese manufacturers, supplies might expand through use of non-traditional tropical species, or through use of non-tropical timber. In either case, we expect to see scarcity reflected in relative prices. Vincent and others (1990) found little statistical evidence for price-based substitution of lessor-known species (LKS) for well-known species (WKS of tropical logs. However, there was some statistical support for the hypothesis of price-based substitution of temperate for tropical species in lumber manufacturing (Vincent and other 1991). Ward Associates (1990) reports that tropical LKS are increasingly being used in both lumber and plywood manufacturing. Nevertheless, nearly all of Japan's tropical log imports continue to come from Asia; Africa and Latin America supply very small quantities of logs to the Japanese market (Ward Associates 1990). Imports of tropical products are considerably more diversified, however.

Japanese imports of value-added wood products (such as moulding, joinery, doors and windows, and furniture) are small compared to imports of primary wood products (logs, lumber and plywood). Nevertheless, the value of imports of these products has gown rapidly, and in 1989 totalled nearly $600 million dollars (Ward Associates 1990). Tropical timber producing countries account for about 100 million dollars of the total trade; importers of tropical timber that process and export products (such as Taiwan and Korea), account for an additional 150 million dollars of these imports by Japan. Japanese imports of tropical timber furniture and furniture parts more than doubled in the past decade (Ward Associates 1990); nearly all of these imports are from countries that import tropical timber to maintain these industries.

The outlook for tropical timber in Japan is a continuation of recent trends: declining imports of logs, increasing imports of lumber and plywood, and even sharper increases in imports of value-added products (Ward Associates 1990). One of the most important indicators of demand for wood products in Japan is residential construction; as in the United States, this is closely correlated with economic activity and the business cycle. Over most of the period 1970-85, total housing starts declined, as did the size of houses built and the share of new houses that are wooden. All of this contributed to slow growth in Japan's consumption of solid wood products (logs, lumber and plywood) throughout much of the 1980s. Government intervention in housing markets and product promotion by US manufacturers (focused on construction methods) gave a boost to demand in the late 1980s, but one favoring softwood consumption lumber (Ward Associates 1990). Total Japanese forest products consumption declined in 1991 and early 1992; recession in the broad economy was reflected in declines in construction adn housing starts - the two strongest determinants of Japanese consumption of solid wood products, including tropical timber products. Weakness in the Japanese economy in the early 1990s can be expected to result in slow growth in Japanese consumption of tropical timber.

Much, if not most of the decline in market share for tropical timber reflects price-based substitution. Ingram (in press) reports growth in tropical sawn wood prices in Japan in the late 1980s, after a period of declining real prices beginning in the late 1970s. According to these data, deflated prices of tropical sawn wood increased sharply at the end of the decade. Perhaps even more important than tropical sawn wood prices adjusted for inflation is the price of tropical sawn wood relative to the price of substitutes. Figure 1 illustrates one measure of relative prices. The ratio of the price of lauan sawn wood to hinoki sawn wood declined over the period 1970-78 (encouraging the use of lauan over hinoki sawn wood). While there are significant cycles in the relative price measure over the period 1978-90, there is also a clear upward trend. This is the same period over which Ward Associates (1990) reports loss of market share for tropical lumber.

Europe

Europe is considerably more self-sufficient in forest products than is Japan; taken as a whole, European countries rely on imports for roughly 15 per cent of total consumption. Tropical timber accounted for less than 20 per cent of these imports on a volume basis (ITTO 1990). Therefore, tropical timber accounts for roughly 3 percent of European consumption of industrial timber products. Tropical timber products are important in the European forest sector nevertheless, occupying niche markets of relatively high value (ITTO 1990). This, too, is in contrast to the Japanese market where relatively low-value applications (concrete formwork, for example) account for a significant share of tropical timber consumption.

Europe accounts for roughly one half of world forest products imports (all species and products) and, although second only to Japan as an importer of tropical timber products, as of the late 1980s Europe accounted for only 20 percent of world tropical timber imports (ITTO 1990); see Table 4.1. Recent trends are broadly similar to those in Japan: a reduction in imports of tropical logs beginning in the early 1970s, a relative increase in imports of processed tropical timber products, and an overall decline in total consumption. Both trends- an increase in the share of imports in processed form, and a decline in consumption (or, at least, no significance increase) of tropical timber products can be expected to continue (ITTO 1990). Table 4.5 shows the trend in consumption of temperate and tropical nonconiferous logs in the EEC. Based on data reported by Cooper (1990) and ITTO (1990, 1991) it appears that roughly half tropical log imports by the EEC is used to manufacture plywood; one-third is used to manufacture sawnwood; the remainder are used to produce veneer.

As a result of proximity and historical ties, Africa supplies the majority of European imports of tropical logs; sources of tropical sawn wood and plywood are more diversified, and include producers in Asia and Latin America. Six countries account for 89-90 percent of EEC consumption of tropical sawn wood and plywood: United Kingdom, France, Germany, Italy, Netherlands, and Belgium. Of these, the United Kingdom is the largest single consumer of tropical timber (18 percent of sawn wood, and 37 per cent of plywood consumption in 1988) (Cooper 1990).

Table 4.6 summarizes patterns of end use of tropical sawn wood and plywood in three EEC countries. These data illustrate and reflect characteristics of European tropical timber markets: first and foremost, markets and patterns of use are not homogeneous across European countries. France, Germany and the United Kingdom differ in types of imports, sources of imports, and patterns of use. The United Kingdom, for example, relies almost entirely on imports of products while France and Germany have, in the past, relied quite heavily on imports of logs. French imports (of tropical logs) are supplied almost exclusively by African producers, while German imports are primarily from Asia. Table 4.6 illustrates the importance in European consumption of tropical timber of end uses in which appearance is a critical component of suitability.

Both Cooper (1990) and ITTO (1990) suggest that the outlook for tropical timber products in Europe holds, at best, a prospect of modest growth in consumption. For a number of countries and end uses Cooper (1990) suggest static or declining markets. Competing products and, to some extent, changing tastes and preferences, will lead to loss of market share or absolute reductions in quantities of tropical timber products consumed. As they rely more heavily on log imports, tropical plywood manufacturers in Germany and France, for example, face adjustments not unlike those in Japan: reduction in domestic manufacturing (in the absence of shifts to new sources of raw material), and increases in imports of processed products to maintain existing levels of consumption and patterns of use.

North America

Although Canada and the United States are the largest importers of forest products, both countries are relatively small participants in tropical timber markets (see table 4.1). Nevertheless, North American imports of tropical logs, sawn wood, veneer, and plywood totalled nearly $600 million (US) in 1990 (see table 4.7). The United States is the primary market, accounting for 95 percent of the net imports in both volume and value terms. Tropical hardwood plywood dominates North American tropical timber imports, accounting for three-fourths of the value, and nearly 90 percent of the volume of imports. Indonesia, Malaysia and Brazil supply most North American imports of tropical timber. Imports from Africa are negligible. Non-tropical countries, such as Taiwan and Hong Kong, account for a small share of North American imports of tropical timber products.

It is important to note that North American imports of other manufactured forest products from tropical countries, including pulp and paper products, are substantial. United States and Canadian imports of all forest products from tropical countries in 1990 exceed $1 billion (US). Table 4.8 summarizes United States imports of forest products from tropical countries, and illustrates the shift in the pattern of imports similar to those noted for Japan: the importance of value added products including, in this case, pulp and paper products. Primary tropical products (logs, lumber, veneer and plywood) account for only one fourth of US imports of forest products from tropical countries.

Table 4.9 summarizes data on end uses of tropical lumber and plywood in North America. As in European markets, relatively high-value uses dominate. Nevertheless, tropical timber products face strong competition in nearly all end uses (Ward International 1992). Recent declines in construction activity (1990-91) reduced overall demand for all wood products, including tropical timber. However, temperate hardwoods, other wood-based products (such as particle-based panels), and other materials present significant competition for tropical timber (Ward International 1992). Trends in relative prices for imported hardwood plywood in the United States show patterns similar to those for tropical lumber in Japan: increasing relative prices that can be expected to discourage consumption of tropical plywood, and encourage consumption of substitutes.

2. Forest Products Markets in Tropical Countries

A summary of recent projections (FAO 1991) of consumption of forest products in developing and developed countries (table 4.10) provides background for a review of recent trends in tropical countries. For each of the broad aggregates of timber products, FAO projections of the growth in consumption expected over the next two decades in developing countries exceeds that expected in developed countries. In many cases, projected rates of growth for developing countries are double those of developed countries. Because developing countries are largely, although not exclusively, those in the tropical region, it is reasonable to use these projections to draw attention to the need to more specifically examine recent trends in forest products consumption in tropical countries.

Although the implications of the FAO projections are at first dramatic, they largely originate in two simple facts. First, when percentage change is calculated against a small base quantity, rates of increase are exaggerated. In terms of absolute quantities, for all products except fuelwood, the scale of developed country consumption is far greater than that in developing countries. In 1975 for example, consumption of industrial roundwood in developed countries was nearly 5 times that in developing countries; consumption of sawn wood in developed countries was more than 5 times that in developing countries. However, by 1990 the ratio of consumption in the two country groups was roughly 3 to 1, and in two decades the ratio is projected to be roughly 2 to 1. Nevertheless, trends in consumption by developing countries - in both the historical and projected data - must be considered in absolute terms as well as in percentage terms.

Second, the FAO projections rely in large part on projected population growth (as well as income growth) in calculating projected consumption of forest products. Higher population growth rates in developing countries - nearly three time growth rates in developed countries - lead naturally to expectations of higher rates of increase in all aspects of consumption. In contrast to the "mature" markets of Europe and North America, with relatively slow population growth rates, tropical countries generally have markets and economies undergoing rapid change and development. As a result, over the next two decades developing countries are likely to be the fastest growing markets for timber and timber products.

The implications of these trends for tropical countries, and tropical timber producers, must be more closely examined. Growth in consumption of industrial products adds pressure on tropical forests that already account for nearly half of world timber harvest. The share of roundwood removals used for fuel in tropical countries has declined steadily, but only because demand for industrial products is increasing. More than 80 percent of the estimated harvest from tropical forests is used for fuel, and the harvest for fuelwood in developing countries exceeds total industrial timber production in developed countries.

Based on both the scale of consumption, and the mix of products, it is reasonable to ask if tropical countries are capable of meeting domestic demand with domestic resources. The world's industrial timber economy is predominantly based on temperate zone coniferous species. In spite of the fact that the tropical timber share of industrial roundwood harvest has increased significantly in the past four decades, in 1990 tropical timber accounted for less than 15 percent of industrial roundwood. In 1950, tropical timber accounted for 5 percent of the industrial timber harvest (Pringle 1976). To the extent that increased consumption of forest products in tropical countries follows the pattern of the industrialized forest economies of the temperate zone, domestic resources, although abundant in many cases, will not match the mix of raw materials required by technologies in production and consumption. As a result, imports of forest products may be necessary to satisfy consumption requirements.

Table 4.11 summarizes trends in consumption in tropical countries for major categories of industrial forest products over the period 1970 to 1990. Rates of growth in consumption are consistent with FAO trends and projections (table 4.10). For all four product groups, consumption increased by a factor of 2 (wood-based panels, coniferous sawn wood) or 3 (paper and paperboard) times over the period 1970-90. Perhaps more interesting than consumption trends considered in isolation is a simultaneous comparison of production and consumption. Figures 2-5 compare trends in production and consumption for the four product groups for tropical countries taken as a whole and illustrate important aspects of the trends and outlook for forest products markets in tropical countries. Table 4.12-15 show trends in consumption (only) for each of the tropical regions (Asia, Africa and Latin America).

First, the growth in both production and consumption of nonconiferous sawn wood is not surprising (figure 2). What is interesting is the relative absence of strong cycles corresponding with global economic cycles; such cycles are more pronounced in data for industrialized countries. It is also noteworthy that net exports of nonconiferous sawn wood have changed little over the 20-year period. This is not true in the case of wood-based panels. Here (figure 3) is evidence of growth of a substantial, export-oriented industry. It is the pattern of consumption in which a strong upward trend is altered at the time of the world-wide recession in 1982 and never recovers.

Figures 4 and 5 also display interesting, but perhaps not unexpected results. Consumption of coniferous in tropical countries sawn wood grew least quickly of all four products; nevertheless, consumption growth rates were considerably higher than those in developed countries. And although growth in production was also significant, net imports are substantial (12-15 percent of consumption) and are not declining appreciably, even as domestic production increases. However, it is in consumption of paper and board products that tropical countries are most dependent on imports - for nearly 40 percent on consumption.

3. Markets in Developing Countries

Table 4.1 reflects two significant developments in world markets for tropical timber. the first, as discussed above, involves the slight decline in total volume of imports by industrialized countries, and the trend toward imports of processed products (sawn wood and plywood) instead of logs. The second change reflected in table 4.1 is the growing importance of new "consumers", in this case Korea and Taiwan and, to a lessor extent, Hong Kong and Singapore. Both Taiwan and Korea have very limited domestic timber resources, and rely on imports of both raw materials and products. All four countries have developed export-based industries, lead especailly by Taiwan, now the world's leading exporter of furniture.

As an approximation of data showing changes in patterns of trade in tropical timber products, table 4.16 shows exports of nonconiferous saw and veneer logs, nonconiferous sawn wood and plywood by developing countries. These three products aggregations, produced by developing countries, are dominated by tropical timber; therefore, in this context, "developing countries" has a reasonable correspondence with tropical timber producers. These data are similar to those used by Buttoud and Hamadou (1986) in describing emerging patterns of forest products trade between developing countries. Trends they observed - the relative importance of trade between developing countries, and the increasing importance of processed products along all trade routes - have continued.

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Table 4.1--Net imports of tropical timber products in major markets, 1990

Product	North America	Japan	Europe (EEC)	Republic of Korea	Taiwan[b]
			Thousand cubic meters[a]		
Logs	3	11,319	3,303	3,731	4,193
Sawn wood	202	1,371	3,094	587	na
Veneer	24	117	229[b]	13	-
Plywood	1,099	2,718	1,030[b]	541	433
		Thousand cubic meters (roundwood equivalent)[c]			
Logs	3	11,319	3,303	3,731	4,193
Sawn wood	364	2,468	5,569	1,057	na
Veneer	46	222	435	25	-
Plywood	2,528	6,251	2,369	1,244	996

na = not available

[a] Product basis.
[b] Data for 1989.
[c] Conversion factors (m^3 roundwood per m^3 product) are: sawn wood, 1.8; veneer, 1.9; and plywood, 2.3.

Sources: International tropical Timber Organization (1991), Stichting Bos en Hout (1991), Wood-Products Stockpile Corp. (1991), Foreign Agricultural Service (1990).

Table 4.2--Japanese imports of logs, lumber, and plywood, by temperate and tropical, and hardwood and softwood, 1990

Type	Logs	Lumber	Plywood[a]
		Thousand cubic meters	
Tropical			
Hardwood	11,300	1,371	2,718
Softwood[b]	227	308	2
Temperate			
Hardwood	1,017	343	282[c]
Softwood	16,455	7,061	50
Total			
Hardwood	12,317	1,714	3,000
Softwood	16,682	7,369	52
Total	28,999	9,083	3,095[d]

[a] Converted from square meters at 135 m^2 per m^3.
[b] Softwood volume from South Seas and "other".
[c] Hardwood plywood not classified as tropical; Indonesia is the primary supplier.
[d] Includes plywood classified as "other".

Source: Wood-Products Stockpile Corp. (1991)

Table 4.3--Importance of tropical timber in the Japanese forest sector, 1990

	Imports of tropical logs			Imports of tropical	
	Total	Used for lumber	Used for plywood	Lumber	Plywood
			Thousand cubic meters		
Volume	11,300	2,614	8,684	1,371[c]	2,718[d]
			Percent		
Share of supply[a]	24	5	88	5	26
Share of imports[b]	39	11	92	15	88

[a] Tropical share of total log supply (from domestic production and imports), and tropical share of total lumber and plywood supply.

[b] Tropical share of total log, lumber, and plywood imports (including softwood logs).

[c] Includes hardwood lumber from South Seas and a small quantity of hardwood lumber from sources other than the South Seas, North America, Russia, Chile, and New Zealand.

[d] Tropical hardwood plywood imports (WSC 1991) converted from square meters (366.9 million m2) at 135 m2 per m3.

Sources: Calculated and estimated from data reported by Japan Wood-Products Information and Research Center (JAWIC) (1991), Japan Wood-Products Stockpile Corp (WSC) (1991), and Japan Lumber Reports (1992).

Table 4.4--End uses for tropical lumber and plywood in Japan, 1989

End use	Lumber	Plywood
	Percent	
Housing and construction	37	66
Furniture	29	9
Packaging	13	4
Other	21	21

Source: Ward Associates (1991).

Table 4.5--Nonconiferous log consumption, EEC

	Temperate	Tropical	Total	Share tropical
	Thousand cubic meters			*Percent*
1965	17,963	4,759	22,722	20.9
1966	18,557	4,933	23,490	21.0
1967	18,328	4,720	23,047	20.5
1968	18,462	5,361	23,823	22.5
1969	19,139	6,689	25,828	25.9
1970	20,058	6,017	26,075	23.1
1971	18,947	6,189	25,136	24.6
1972	18,666	6,882	25,548	26.9
1973	19,992	7,942	27,934	28.4
1974	19,162	6,043	25,205	24.0
1975	17,516	4,757	22,273	21.4
1976	17,548	6,161	23,708	26.0
1977	19,347	5,795	25,142	23.0
1978	19,617	4,935	24,552	20.1
1979	19,057	5,321	24,378	21.8
1980	19,766	5,393	25,159	21.4
1981	18,988	4,112	23,099	17.8
1982	17,142	3,841	20,982	18.3
1983	17,288	3,764	21,052	17.9
1984	17,568	3,681	21,249	17.3
1985	16,992	3,400	20,391	16.7
1986	17,688	3,308	20,996	15.8
1987	17,538	3,025	20,563	14.7
1988	17,879	3,245	21,123	15.4
1989	17,915	3,381	21,296	15.9
1990	18,594	3,303	21,897	15.1

Source: original data are from ECE/FAO.

Temperate, nonconiferous log consumption is calculated as apparent consumption of all nonconiferous logs less net imports of tropical logs.

Data for former DDR are included.

Table 4.6--End uses for tropical sawn wood and plywood in selected European countries

Product and end use	United Kingdom	France	Germany
Sawn wood			
Joinery	24	39	15
Windows, doors	23	22	67
Furniture	33	25	18
Construction	11	11	
Other	9	3	
Plywood			
Shopfitting, joinery	34	33	
Furniture	17	18	15
Industrial	19		66
Construction	19	25	19
Other	11	24	

Source: Based on data reported by Cooper (1990).

Table 4.7--Value of North American forest products imports of tropical timber, 1991

Million US $

Product	Canada	United States
Logs	-	3
Sawn wood	4	94
Veneer	2	45
Plywood	20	399
Total	26	541

Source: Ward International (1992).

Table 4.8--United States imports of forest products from tropical countries, 1990[a]

Commodity category	Total	Of which tropical[b]
	Millions of dollars	
Logs	15.1	4.2
Sawn wood	116.5	82.6
Veneer	53.9	21.6
Plywood	467.3	383.7
Subtotal, primary	652.8	492.1
Other solid wood[c]	491.7	na
Pulp and paper	516.2	na
Wooden furniture	396.2	na

na = not available

[a] Tropical countries are those countries with significant land area in the tropical zone; figures do not include data for imports from Taiwan, Singapore, and Hong Kong, but do include data for imports from Mexico.

[b] Commodities identified as tropical timber; the species composition of manufactured products and furniture is not identified in trade data.

[c] Includes milled and manufactured products such as joinery, windows, doors, tools, and tableware.

Table 4.9--End uses for tropical lumber and plywood in North America, 1990

End use	Lumber	Plywood
	Percent	
Housing/construction	15	30
Furniture	35	25
Cabinets	10	15
Millwork	25	10
Containers	1	1
Other	14	19

Source: Ward International (1992).

Table 4.10--Summary of FAO World Outlook Projections for forest products

Percent per annum growth in consumption

Product	1965-75	1975-b87[a]	b87-95	1995-2000	2000-10
Developing countries					
Roundwood	3.0	2.6	2.3	2.1	2.0
Fuelwood	2.6	2.2	2.2	1.7	1.4
Industrial rndwd	5.5	4.2	3.0	3.5	3.7
Pulp wood	6.9	8.1	3.9	5.7	6.1
Sawn wood	4.8	4.5	2.9	3.2	3.3
Wood-based panels	11.5	7.7	7.3	8.2	8.2
Paper & paperboard	5.4	7.5	6.2	6.8	7.2
Developed countries					
Roundwood	0.1	1.8	1.4	1.5	1.6
Fuelwood	-3.3	4.3	0.5	0.3	0.2
Industrial rndwd	0.8	1.4	1.6	1.8	1.8
Pulp wood	3.0	2.9	2.6	2.9	3.2
Sawn wood	-0.1	1.0	1.2	1.4	1.5
Wood-based panels	6.9	2.6	2.9	3.3	3.5
Paper & paperboard	2.7	3.6	2.5	3.0	3.2

[a] The base period for these projections (b87) is the average consumption 1985-89.

Source: Food and Agriculture Organization (1991).

Table 4.11--Trends in consumption of industrial forest products in tropical countries, 1970-90[a]

	Coniferous sawn wood	Nonconiferous sawn wood	Wood-based panels	Paper & paperboard
	Thousand cubic meters			*Thousand MT*
1970	8,156	20,127	3,076	7,318
1975	10,676	26,249	4,581	8,822
1980	14,673	37,978	8,100	14,268
1985	16,414	44,945	9,016	16,861
1990	17,631	52,829	8,918	23.373
Average annual growth (percent)				
1970-90	3.9	4.9	5.5	6.0

[a] Apparent consumption for the tropical countries of Africa, Asia, and Latin America; excludes countries in those regions that are outside the tropical zone.

Source: Calculated from data reported by Food and Agriculture Organization (AGROSTAT).

Table 4.12--Apparent consumption of nonconiferous sawn wood in tropical countries, 1970-90

	Tropical countries of:				
	Africa	Latin America	Asia	Oceania	Total
	Thousand cubic meters				
1970	2,034	6,594	11,407	92	20,127
1971	2,217	7,095	11,161	62	20,535
1972	1,976	6,783	12,981	136	21,876
1973	2,114	7,146	12,645	97	22,002
1974	2,477	7,624	13,959	78	24,138
1975	2,790	8,622	14,740	97	26,249
1976	2,619	9,763	15,630	89	28,101
1977	3,000	10,158	18,018	75	31,251
1978	3,742	10,667	18,923	77	33,409
1979	3,833	10,625	18,196	77	32,731
1980	4,596	12,231	21,063	88	37,978
1981	4,854	12,908	21,632	54	39,448
1982	4,530	12,659	24,552	57	41,798
1983	4,277	12,982	24,914	58	42,231
1984	4,257	13,670	25,487	60	43,474
1985	4,676	13,689	26,521	59	44,945
1986	4,805	14,303	25,856	67	45,031
1987	5,025	14,289	28,786	70	48,170
1988	5,049	14,212	28,372	71	47,704
1989	5,142	14,595	34,600	69	54,406
1990	5,124	14,851	32,785	69	52,829

Source: Food and Agriculture Organization (AGROSTAT).

Table 4.13--Apparent consumption of coniferous sawn wood in tropical countries, 1970-90

	Tropical countries of:				
	Africa	Latin America	Asia	Oceania	Total
	Thousand cubic meters				
1970	441	6,204	1,500	11	8,156
1971	500	6,010	1,701	16	8,227
1972	457	6,293	1,742	18	8,510
1973	461	5,912	1,807	13	8,193
1974	395	6,452	1,806	12	8,665
1975	438	8,317	1,908	13	10,676
1976	431	9,267	2,716	12	12,426
1977	447	9,970	2,692	12	13,121
1978	408	10,532	2,711	14	13,665
1979	424	10,389	3,062	14	13,889
1980	505	10,771	3,343	54	14,673
1981	548	10,894	3,473	46	14,961
1982	521	10,659	3,824	46	15,050
1983	464	11,315	4,357	46	16,182
1984	528	11,985	4,375	46	16,934
1985	553	11,926	3,894	41	16,414
1986	565	11,758	3,709	41	16,073
1987	617	11,876	3,769	41	16,303
1988	666	12,249	4,019	43	16,977
1989	631	12,204	4,315	43	17,193
1990	629	12,102	4,857	43	17,631

Source: Food and Agriculture Organization (AGROSTAT).

Table 4.14--Apparent consumption of wood-based panels in tropical countries, 1970-90

	Tropical countries of:				
	Africa	Latin America	Asia	Oceania	Total
	Thousand cubic meters				
1970	264	1,265	1,521	26	3,076
1971	360	1,496	1,442	23	3,321
1972	385	1,861	1,481	24	3,751
1973	423	1,997	1,388	9	3,817
1974	499	2,131	1,319	8	3,957
1975	486	2,303	1,784	8	4,581
1976	581	2,590	2,122	6	5,299
1977	656	2,878	2,457	15	6,006
1978	692	2,957	2,622	16	6,287
1979	780	3,169	3,092	16	7,057
1980	942	3,611	3,535	12	8,100
1981	936	3,819	3,941	11	8,707
1982	980	3,782	4,871	13	9,646
1983	1,004	3,803	4,147	14	8,968
1984	903	3,763	4,294	14	8,974
1985	1,011	3,670	4,317	18	9,016
1986	1,010	3,750	4,370	24	9,154
1987	991	4,004	3,951	24	8,970
1988	1,026	3,901	4,687	29	9,643
1989	1,041	3,841	4,207	29	9,118
1990	1,040	3,784	4,048	46	8,918

Source: Food and Agriculture Organization (AGROSTAT).

Table 4.15--Apparent consumption of paper and paperboard in tropical countries, 1970-90

	Tropical countries of:				
	Africa	Latin America	Asia	Oceania	Total
	Thousand metric tons				
1970	390	4,323	2,601	4	7,318
1971	447	4,416	2,892	4	7,759
1972	397	4,803	3,002	5	8,207
1973	482	5,254	3,316	1	9,053
1974	549	6,055	3,171	1	9,776
1975	477	5,357	2,987	1	8,822
1976	516	6,137	3,473	3	10,129
1977	527	6,794	3,670	7	10,998
1978	542	7,063	4,236	9	11,850
1979	542	7,738	4,612	10	12,902
1980	554	8,967	4,734	13	14,268
1981	681	8,984	5,237	12	14,914
1982	569	9,105	5,420	8	15,102
1983	599	9,026	5,578	10	15,213
1984	529	9,872	6,148	8	16,557
1985	598	10,074	6,180	9	16,861
1986	585	11,011	6,583	9	18,188
1987	606	11,370	7,774	9	19,759
1988	614	12,690	8,528	9	21,841
1989	599	12,627	9,471	9	22,706
1990	603	12,357	10,404	9	23,373

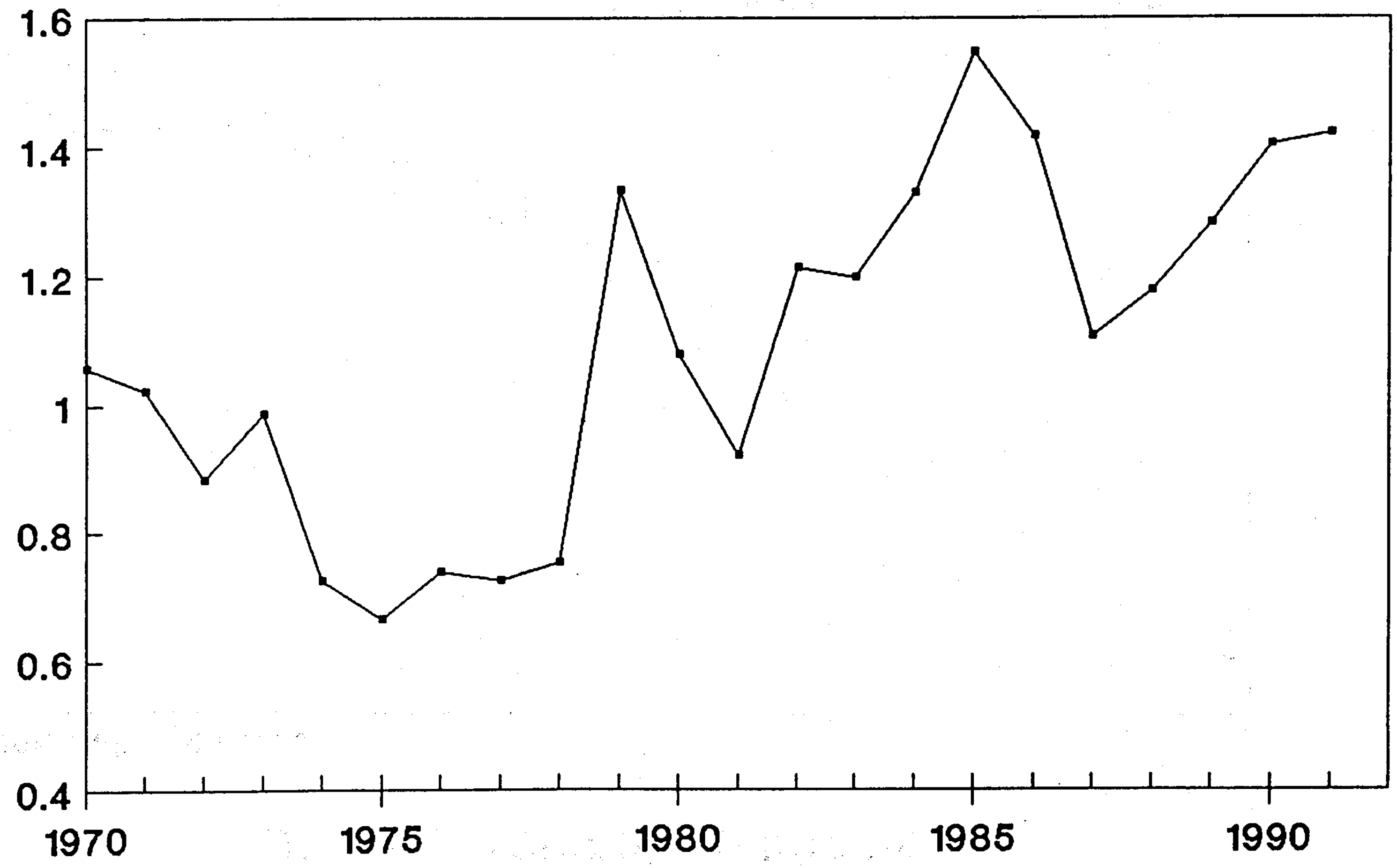
Source: Food and Agriculture Organization (AGROSTAT).

Table 4.16--Developing country exports of selected forest products, 1975-90

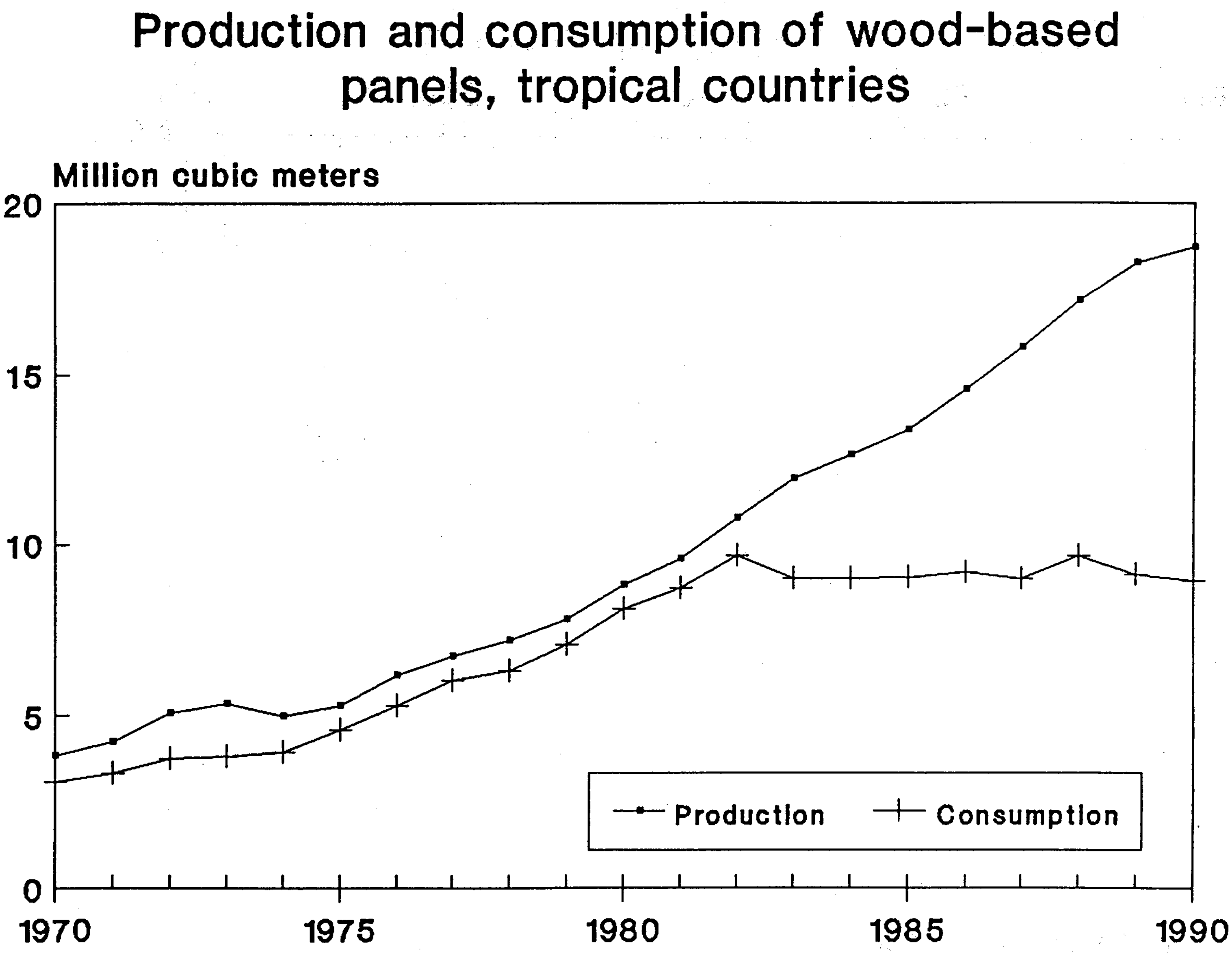
Product and destination	1975	1980	1985	1990
Nonconiferous saw and veneer logs (million cubic meters)				
Developing countries	10.1	13.7	9.2	12.0
Developed countries	24.2	24.6	17.7	14.7
World	34.3	38.3	26.8	26.7
Nonconiferous sawn wood (million cubic meters)				
Developing countries	2.0	4.2	4.0	4.9
Developed countries	2.7	4.1	3.9	4.2
World	4.7	8.3	7.9	9.1
Plywood (million cubic meters)				
Developing countries	0.4	1.5	3.4	6.4
Developed countries	2.6	2.7	2.5	5.5
World	3.0	4.2	5.9	11.8

Source: Food and Agriculture Organization.

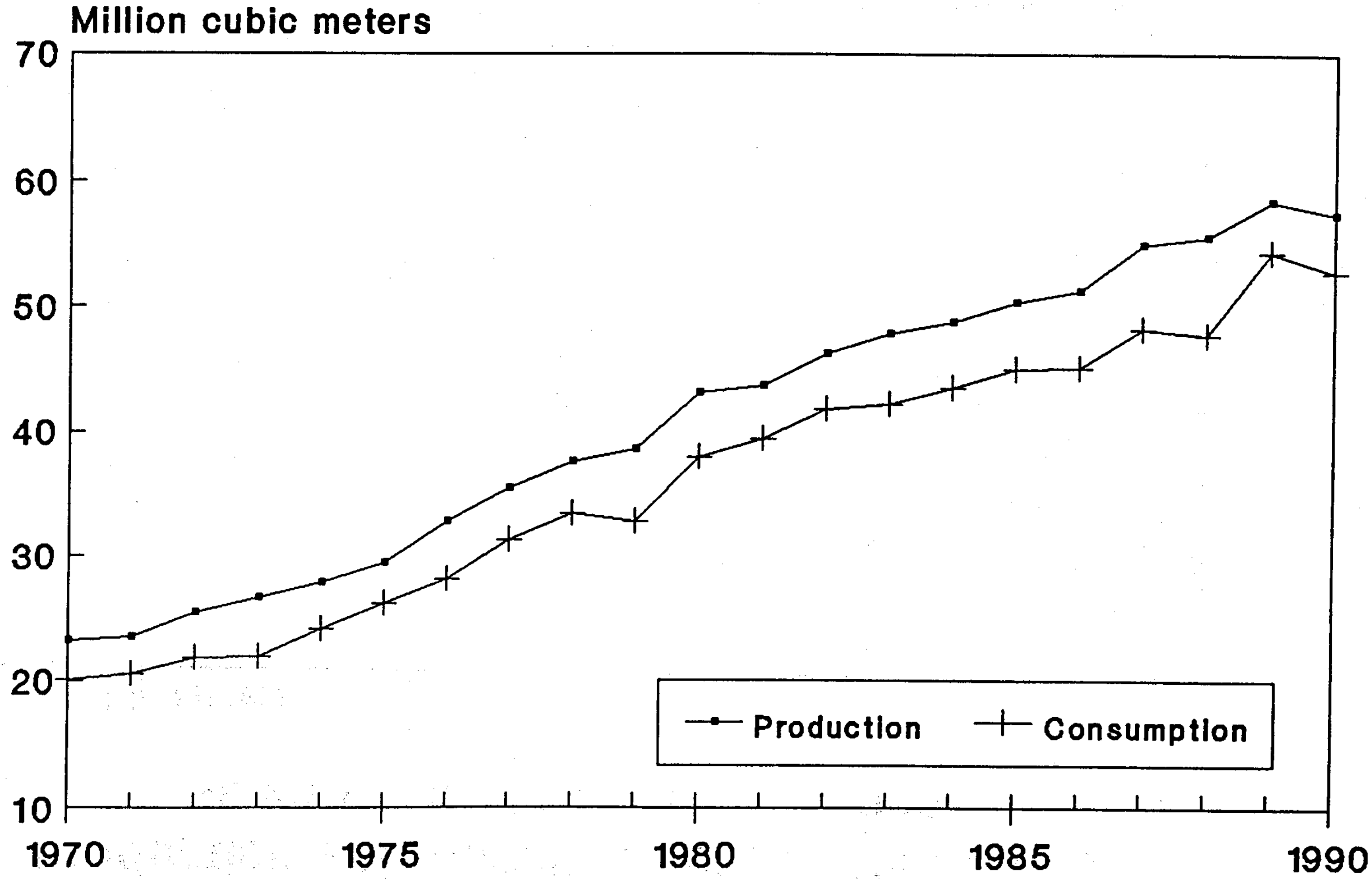
Relative prices of sawn wood in Japan: Lauan and Hinoki



Source: FAO (1990); WSC (1992)

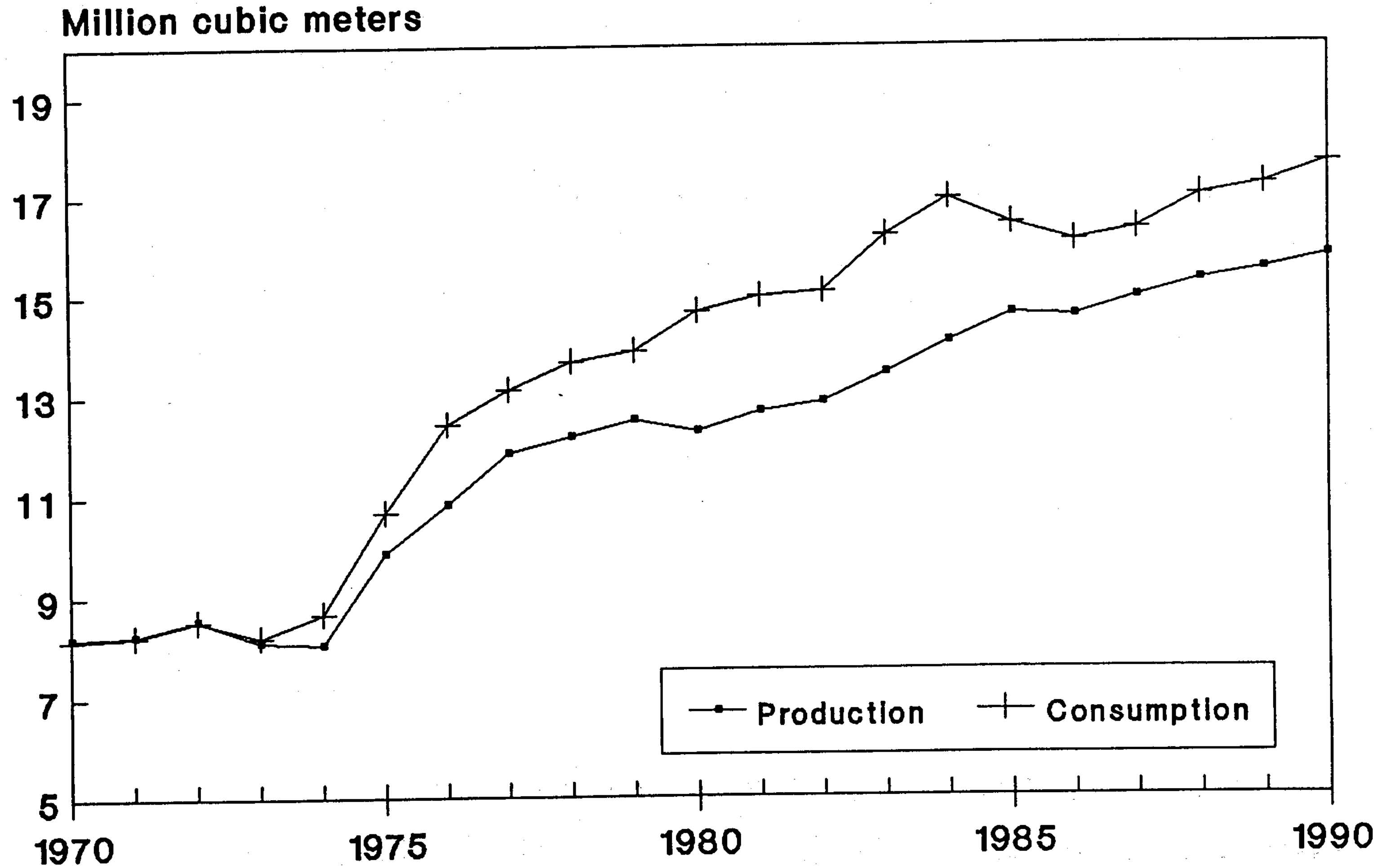

Production and consumption of wood-based
panels, tropical countries
Million cubic meters
20
15
10
5
0
1970
1975
1980
1985
1990
Production
Consumption

Production and consumption of nonconiferous sawn wood, tropical countries



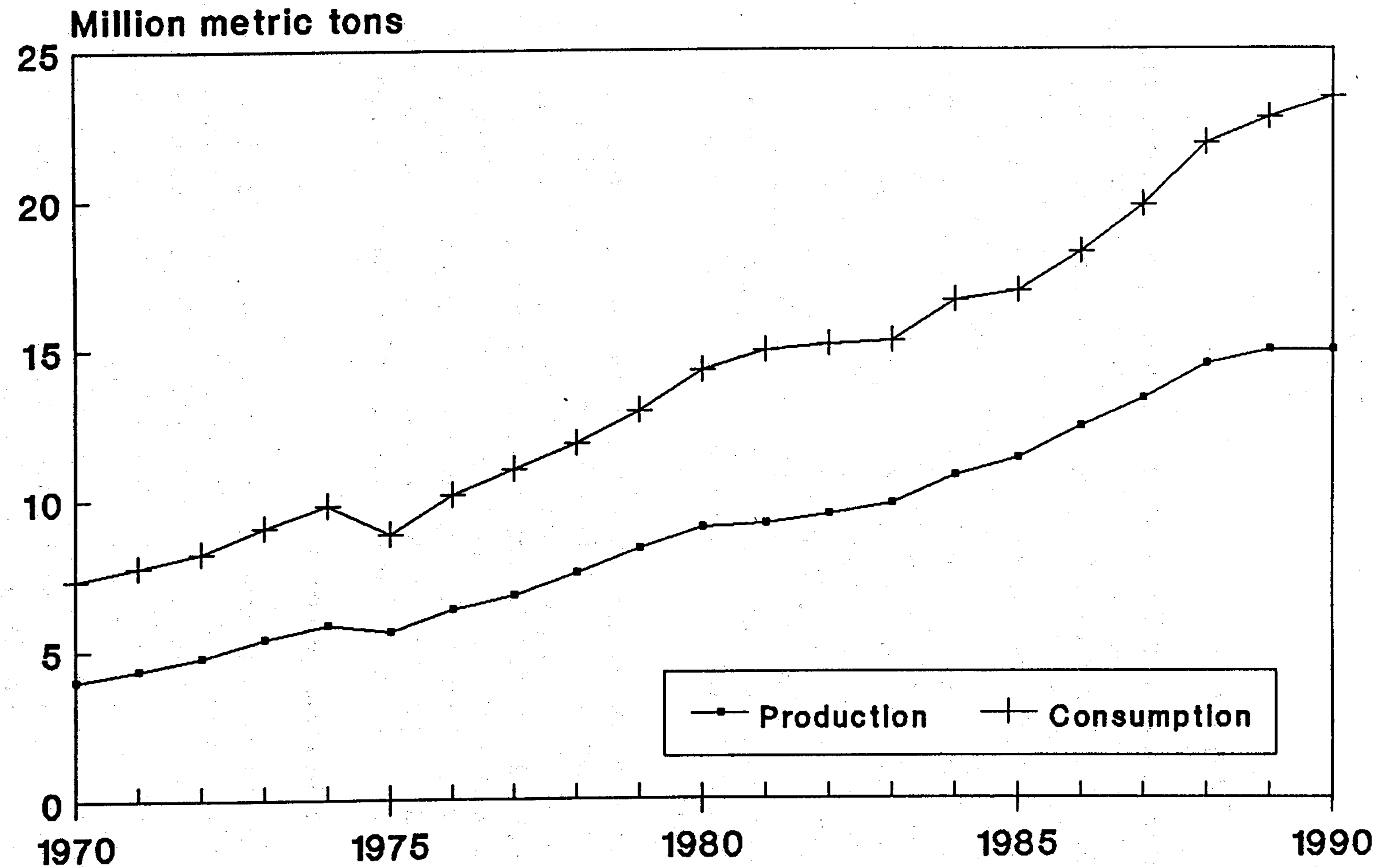
Source: FAO

Production and consumption of coniferous sawn wood, tropical countries



Source: FAO

Production and consumption of paper and board products, tropical countries



Substitution in Forest Products Consumption: Issues, Trends and Implications for Tropical Timber Trade Policy

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1. Background

Markets for tropical timber are critical in maintaining tropical forest; forest management that provides financial returns with practices that maintain ecological conditions and processes can be one of the best methods for slowing rates of deforestation in the tropics (Poore 1989). However, a sequence of as-yet unanswered questions begins in the conclusion that sustainable management of tropical forests costs more than current management approach (Oxford Forestry Institute 1991). If raw material (log) production costs production costs are increased, and these increased costs are passed through to product prices, how will markets respond? Will consumers absorb these costs as an inevitable part of sustaining tropical forests? Or will consumers respond simply to higher prices by reducing consumption of tropical timber, thereby undermining the objective of sustaining tropical forests through economic returns from timber products of tropical forests? The lack of clear knowledge of the type and rate of likely market response to higher tropical timber prices inhibits policy development and analysis. If reduction in consumption or substitution of other material and products for tropical timber occurs quickly and broadly, new policy approaches must be developed.

In fact, we do not lack general knowledge of the processes or results of material substitution, but we do not have enough information on demand for tropical timber products to broadly and definitively project the results of increased tropical timber prices. However, for some tropical timber products, in some markets, we have evidence of changes in consumption in response to changes in price and the price of substitutes. This paper briefly reviews issues of materials substitution, and experiences in forest products to provide background useful in formulating tropical timber trade and management policies. Recent studies of tropical timber markets are reviewed for specific indications of possible market responses.

2. Substitution processes

The process by which materials are consumed and substituted for each other has been extensively treated in the economics literature. Abundant materials are used to replace relatively scarce materials to maintain types and levels of economic activity. Rosenberg (1973) uses examples of the use of timber in the United States and Europe to illustrate these processes. Compared to conditions in Europe, in the 18th and 19th centuries wood was abundant in the United States and use was inefficient. Increasing real prices, increasing relative prices, and new technology lead to the substitution of other materials for wood across a wide array of activities (Rosenberg 1973).

Based on a enumeration by Tilton (1983), four types of substitution can be identified: material for material, other factors for material; quality for material; and interproduct substitution. Forest products provide examples of all four types of substitution.

Material for material: - Timber use by railroads provides a 19th century example of this process. In the United States in 1850 wood supplied more than 90 percent of all fuel-based energy, and was nearly the sole source of fuel for steam engines; by the end of the century, a shift to coal fuel was nearly complete (Rosenberg 1973). More recent examples of material-for-material substitution include the use of concrete in place of wood for railroad ties, and the use of aluminium, steel and plastic in place of wood in structural and decorative uses.

Other factors for material: - In all industries consumption of materials is reduced by increasing non-material inputs. In forest products, timber consumption in the manufacture of sawn wood and other products has been reduced through increasing the use of labour and capital. In the past few decades in the United States, technology - in the form of capital inputs - has been reduced both raw material and labour use. Examples include computer-controlled saw milling machinery, "chip-and-saw" techniques to increase total material recovery, and the development of narrow kerf blades.

Quality for material: - Altering product quality or performance standards can be used to reduce material content. A general example of this is lumber production standards in the United States and elsewhere that specify smaller minimum dimensions for products sold as having larger nominal dimensions. Other examples include reductions in acceptable dimensions of standard framing lumber to 2 x 3 inches from 2 x 4 inches, and the use of low-grade core material in place of veneer in plywood.

Interproduct substitution: - This type of substitution does not alter the manufacturing process or the mix of materials used to produce individual good; instead the composition of goods or services is changed (Tilton 1983). Thus of electronic information in place of paper is one example of (widely expected, if not actually observed). Perhaps more important are significant changes in the level and composition of demand for forest products that have resulted from the introduction and substitution of new products, some of which are themselves manufactured from wood. The introduction of plywood that replaced lumber as sheathing material is perhaps the best example; plywood also replaced lumber and shingles in siding: particleboard has replaced lumber in much furniture construction.

This broad-based approach makes clear the importance of substitution as a factor in commodity production and consumption. Forest products manufacturing and marketing are no exception. The process of substitution is fundamental and ubiquitous, and the conditions and factors that cause it are not well understood (Tilton 1983). It is not possible to state generally and categorically which among changes in relative prices, changes in market institutions and regulations, development of technology, or changes in consumer tastes and preferences is most influential in causing or controlling the rate or extent of substitution. In large measure this is because the process of substitution can only be understood in the context of specific products used in specific markets, and within a relatively short time frame.

For tropical timber all four types of substitution must be considered. Material-for-material and interproduct substitution are likely to be the most important in the near terms, but all are important. Substitution opportunities include non-timber materials, the use of non-tropical timber, and the development of products using, for example, tropical veneers glued on cores composed of other materials. Which is most likely-or dominant-will depend on end use and market.

3. A brief review of literature

Unfortunately, the forest products literature offers little information on the substitution question that is directly useful to analysis of tropical timber markets. Generally, two types of studies have been done. The first is a descriptive approach; this might be quite general (dealing with issues) or quite specific in terms of technical details. Studies of U.S. forest products markets generally have addressed broad trends in substitution (see, for example, Haynes [1990], but do not provide specific estimates of factors motivating substitution, or rates at which it may occur in the future. Alexander and Greber (1991) estimates specific elasticities of substitution between softwood lumber and nonwood materials used in construction, using relative prices as the explanatory factor. Although their results are by no means definitive, there are indications of the type and magnitude of interaction among materials in this broad end-use market.

Studies focused more narrowly provide more information on causes, processes and opportunities for substitution, but cannot be generalized. See, for example, clark (1971) Spelter (1983) and Hansen and Sinclair (1991). Studies of this second type would be ideal for current tropical timber policy deliberations. Unfortunately few studies have specifically considered tropical timber.

Vincent and others (1990 1991) approach the substitution question by examining producer decisions on choice of raw material. Vincent and others (1990) examine substitution among tropical timbers, to examine the use of well-known species (WKS) and lessor-known species (LKS) of tropical timber. Here, as with Alexander and Greber (1991), relative prices are assumed to motivate substitution; that is, the hypothesis tested is that changes in relative prices of WKS and LKS lead to substitution. Results were generally inconclusive. Weak data is one explanation; the possibility that substitution, or the lack of it, may be more strongly motivated by other considerations is another.

Vencint and others (1991) examines substitution between tropical and temperate logs in Japanese lumber production; statistically significant results are reported. That is, relative prices are found to be a statistically significant factor in explaining substitution in raw material use. However, there is an inelastic relationship between consumption (by mills) of tropical logs and changes in prices of temperate softwoods. Not surprisingly, substitution was found to occur more readily within a species group than across groups. The magnitude of response to relative prices was such that it is not an important factor (to date) in raw material choice, for Japanese saw mills.

Some models of demand for tropical timber in the US market have included substitute products as explanatory factors. Haji-Othman (1991) included the price of substitutes -

domestic hardwood lumber - in his model of US demand for tropical lumber. The price of the substitute was not a significant explanatory factor, but demand was found to be very responsive to changes in the price of tropical lumber. Cengel and McKillop (1990) estimate US demand for tropical hardwood plywood using a specification in which hardboard is a substitute product. Price of domestic hardboard was found to be a significant explanatory factor in US demand for hardwood plywood from Japan, although there was not strong evidence in response to changes in import (own) price. Chou and Buongiorno (1982, 1983) estimated statistically-significant, own-price elasticities for imported hardwood plywood, but did not include prices of commodities other than hardwood plywood as explanatory variables. Chou and Buongiorno (1983) focuses on the processes and elasticities of substitution among sources of supply of hardwood plywood.

Using a model similar to Cengel and McKillop (1990), but aggregated across all sources of supply, own-price and cross-price elasticities were estimated for US imports of hardwood plywood (see appendix 1). Over the period 1971-91, imports were found to be responsive to import price, the price of substitutes, and activity in end-use markets. Using more recent data, own-price elasticity estimates are somewhat lower than the high own-price elasticities reported by Chou and Buongiorno (1983) and Cengel and McKillop (1990). However, these results illustrate the importance of substitution - relative prices - in demand for tropical plywood in the United States, and support Ward International's (1992) description of the importance of end-use activity in US demand for tropical plywood.

4. Studies of tropical timber markets

Recent studies of timber markets in Japan and Europe provide descriptive results that contribute to our understanding of substitution as it specifically relates to tropical timber. For the most part, these studies do not provide comprehensive or conclusive information, but they do provide indications of trends in tropical markets and evidence of substitution. For example, Ward Associate (1990) discusses Japanese market conditions for all wood products, and the current and future role of tropical timber products. Changes in market conditions (reductions in log imports and increases in product imports) are assessed in terms of net revenue to tropical timber producers, and the competitive position of tropical timber is assess by broad markets.

The general assessment is that tropical timber "is doing reasonably well" (Ward Associates 1990). However, tropical lumber has decreased to less than 10 percent of the lumber market in 1989 from more than 15 percent in 1980. Because acceptability among consumers remains high (based on function and appearance), price and availability are given as reasons for reductions in market share (Ward Associates 1990). Markets for tropical plywood in Japan are expected to grow, based increasingly on imports of products rather than on domestic (Japanese) production. However, substitute materials (softwood logs and veneers) and substitute products (medium density fibreboard and oriented strand board) are identified as strong competitors in a number of key end-use markets. Nevertheless, over the next decade tropical timber consumption in Japan is expected to remain roughly constant when measured in terms of total (roundwood equivalent) volume (Ward Associates 1990). Log volumes consumed will decrease sharply and products volumes consumed are expected to increase sharply.

The market for tropical timber in the United Kingdom is described as "buoyant" by the Oxford Forestry Institute (1991), implying a relatively inelastic response to higher prices. However, Cooper (1990) and ITTO (1990) provide evidence of markets for tropical timber in Europe that, if not weak, are certainly susceptible to change resulting from changes in relative prices and changes in consumer preferences.

Cooper (1990) reviews tropical timber markets in European countries. He outlines detailed end-uses for tropical timber and discussions with decision-makers (i.e., consumers of tropical timber who are in many cases producers of consumer goods). The qualitative factors that determine the demand for tropical timber in these uses are presented. These factors include, for example product characteristics that lead to the choice of tropical timber (the basis for evaluating the existence of possible substitutes), and the strength of consumer loyalties. Quantification and statistical estimates are the next logical step, albeit one requiring considerable effort. Specific forecasts of European tropical timber markets are not developed.

ITTO (1990) estimates tropical timber's share of total sawn wood consumption for Europe as 3.9 percent in 1986, a decline from 4.5 percent in 1972. Consumption of tropical plywood is estimated to have been roughly unchanged over the period 1976-86. The outlook for tropical timber consumption for the next decade is projected to be similar to the past decade: decreasing log consumption (by European countries) and increasing product consumption with little net change in the total volume of tropical timber consumed. Consumption of all timber products is projected to increase; as a result, tropical timber is expected to decline in relative importance (ITTO 1990).

Ward International (1992) reviews North American timber markets, focusing on markets and uses for tropical timber. North America - predominantly the United States - is the largest forest products market in the world, but tropical timber and timber products account for a very small part of consumption. Trade between Canada and the United States accounts for the vast majority of North American trade in forest products; imports into either the United States or Canada from other sources are small. However, tropical timber accounts for significant proportion of imports from non-North American sources. Tropical timber accounts for half of US hardwood lumber imports, and 90 percent of US hardwood plywood imports (Ward International 1992).

Recent trends in North American markets for tropical timber are strongly influenced by the recent recession; production, imports and consumption of all forest products peaked in 1988-89, and declined 1990-91. Primary tropical timber products (logs, lumber, plywood and veneer) barely maintained their share of this declining market; for most products, consumption in the early 1990s is below levels of consumption in the early 1980s. Growth in North American consumption of tropical timber is forecast to accompany growth in total consumption (Ward International 1992), but tropical timber faces competitive pressure from low cost substitutes in a number of end use markets. Tropical timber products "are, at best, only holding their own in North America" (Ward International 1992). Competitive substitutes include forest products manufactured from temperate species, and products manufactured from non-wood materials. For example, in furniture markets - the largest market for hardwood products - reconstituted panel products such as medium density fiberboard (MDF) and particleboard compete with, and are substituted for, tropical plywood. Although in some cases, these products provide a market for tropical veneer as a survace material, the total volume of tropical timber consumed decreases substantially. Changing tastes and preferences that appear to favor temperate over tropical woods in some exposed uses also contribute to pressure on the competitive position of tropical timber (Ward International 1992).

As is the case with Japanese and European markets for tropical timber, the North American market is also characterized by a shift away from raw materials and semi-processed materials, and towards imports of value-added tropical timber products. However, because North American imports of tropical logs have never been significant, the shift is away from lumber and plywood and towards imports of manufactured products such as millwork, doors, furniture and furniture parts. Non-tropical countries in Asia (such as Taiwan) and Europe (such as Denmark) are major suppliers of furniture in which tropical timber is a component (Ward International 1992). Tropical timber remains a competitive material in these products and end uses, and value added products represent the best prospect for growth in North American imports and consumption of tropical timber (Ward International 1992). However, tropical timber producers face increased competition from a large number of potential suppliers.

Analysis of tropical timber consumption based on trade data must be done with caution, as these data can be quite misleading. First, the high degree of aggregation underlying these data can easily mask conditions that are quite different than they first appear. Second, as the consumption of trade in tropical timber changes, the choice of where consumption is measured becomes critical to an assessment of market response. For example, consumption of tropical logs has declined in every European market; in nearly every case, important of products (sawn wood, plywood and manufactured goods) have increased. Changes in the composition of trade do not necessarily indicate teh direction of change in overall consumption of tropical timber. Changes in consumption are made more difficult to measure by lack of complete current and historical consumption data that distinguish tropical from other timber. Historical data that include information on the use of tropical logs in consuming countries are needed. Efforts of tropical timber producing countries to increase processing beyond sawing lumber or manufacturing plywood further complicate teh assessment of trends. If data on specific end uses of logs, lumber, and plywood are not available, countries importing smaller quantities of sawn wood and higher quantities of joinery products or furniture may be assumed to be consuming less tropical timber than is actually used.

Summary: implications for tropical timber trade

Even in the absence of the data needed to develop detailed models of changes in consumption of tropical timber products in specific uses, price trends can be used to indicate one source of pressure for substitution. Table 1 builds on the Ward Associates (1990) analysis of the Japanese market (see their table (IX-E). Changes in preices of temperate (hinoki) and tropical (lauan) lumber clearly illustrate incentives to find substitutes for tropical timber. The real price (cost relative to an index of all commodity prices) and the relative price of lauan lumber have increased almost steadily since 1970. In contrast, the real price of hinoki lumber has fluctuated, but shows no trend over the same period (figure 1). As a result, the relative price of lauan lumber has increased in the last decade, and especially in the period 1987-91. This should be expected to lead to reductions in market share, as reported by Ward Associates (1990).

Data from the US market show similar patterns. Indexes of real prices for hardwood plywood imports, and domestic hardwood plywood (and related products) are shown in table 2. Although hardwood plywood imports include some temperate plywood, tropical hardwood plywood accounts for 90 percent of US hardwood plywood imports, and about one half of hardwood plywood consumption. In real terms (deflated by the all commodity producer price index), the price of hardwood plywood imports in the US fluctuated 1970-85, but shows no trend until the late 1980s (figure 2). Some of the sharp change in the price index 1989-90 may be anomalous - the result of changes in commodity classifications in trade data (1989). Nevertheless, increases in real prices of tropical plywood have been sustained. Perhaps even more significant, over the period 1970-88 the price of imported hardwood plywood increased relative to a composite index of hardwood plywood and related commodities that can be expected to act as close substitutes. Therefore, it is only surprising that tropical plywood has apparently maintained its share of the US market (Ward International 1992).

Ingram (in press) adds additional information to this view of price trends by examining broad trends in tropical timber imports by North America, Japan and Europe. Increasing real prices were found in all markets. Most price increases occurred in the last decade; changes in prices relative to those of current or prospective substitutes were not examined. Generally, Ingram (in press) provides additional indications of price-based inducements to seek substitutes for tropical timber. To confirm this, further work must examine prices of specific tropical timber products (a) relative to all commodities (ie real price trends), and (b) relative to actual or potential substitutes. Even without a completely developed statistical analysis we can determine the extent to which historical trends provide, or fail to provide, economic signals that would induce substitution or reduction in consumption.

Additional, more detailed, and more comprehensive studies must be undertaken to improve our understanding of tropical timber market responses to changes in prices and other factors. In addition to price changes, studies must address, for example, labelling and certification (efforts to effect consumer attitudes without changing prices) and regulatory and legal factors (such as building codes and product standards). Cooper (1990) outlines methods for studies of high value end uses of tropical timber in Europe. It is important to keep in mind the fact that the substitution decision can be made at a number of stages in the manufacturing process. Although the responses of "final" consumers typically are examined in econometric studies, manufacturers choices of inputs also should be considered. Because many tropical timber products are "embedded" in broader consumer goods (for example, as doors or window frames in houses) it will bet difficult to establish the basis for consumer choices. Finally, any analysis of consumption trends requires prices consistent with the stage of processing, and should also be based on cost in use. Prices of substitute raw materials are appropriate when examining manufacturers production decisions, but may not reflect costs of final products; choice of the price indicator must be consistent with the market and use being examined.

Although not systematic, data from a variety of markets and sources show that prices of selected tropical timber products have increased (1) relative to prices of all commodities, and (2) relative to prices of potential substitutes. Models of demand for tropical timber products generally have shown consumption to be responsive to the real price of tropical timber products, and responsive to the price of selected substitute commodities. As a result, we should expect the market responses - reductions in demand for tropical timber - that, in fact, have been observed in descriptive studies. If policy intervention results in increases in costs of production of tropical timber relative to production costs of competitive products (temperate timber, and other materials), and these costs are reflected in increased product prices, further weakening of markets for tropical timber should be expected.

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Table 1--Tropical and temperate lumber prices in Japan, 1970-91

	Lauan[a]		Hinoki[b]		
	Nominal	'80 Yen	Nominal	'80 Yen	Ratio[c]
	Thousand yen per cubic meter				
1970	42.3	87.4	40.0	82.6	1.06
1971	43.0	89.6	42.1	87.7	1.02
1972	40.8	84.3	46.2	95.4	0.88
1973	54.7	97.7	55.4	99.0	0.99
1974	73.2	99.3	100.8	136.8	0.73
1975	67.7	89.2	101.9	134.3	0.66
1976	77.6	97.4	105.0	131.7	0.74
1977	82.2	101.2	113.3	139.5	0.73
1978	79.5	100.5	105.5	133.4	0.75
1979	133.3	157.0	100.0	117.8	1.33
1980	141.1	141.1	130.9	130.9	1.08
1981	126.2	124.5	137.0	135.1	0.92
1982	135.9	131.7	112.0	108.5	1.21
1983	129.4	128.2	108.0	107.0	1.20
1984	130.6	129.8	98.3	97.7	1.33
1985	134.0	134.6	86.6	87.0	1.55
1986	130.2	144.4	91.8	101.8	1.42
1987	137.3	157.7	124.1	142.5	1.11
1988	138.4	160.6	117.5	136.4	1.18
1989	152.2	172.3	118.7	134.3	1.28
1990	167.8	186.1	119.4	132.4	1.41
1991	165.5	183.2	116.4	128.9	1.42

[a] Lauan boards, grade 1, 3.0 - 3.4 x 30 cm x 4.0 m.
[b] Hinoki square, grade 1, 10.5 cm x 10.5 cm x 3.0 m.
[c] The ratio of lauan price to hinoki price.

Sources: Food and Agriculture Organization (1990); Japan Wood-products Information and Research Center (1992).

Table 2--Hardwood plywood price indexes in the United States, 1970-92

	Import unit value index		All hardwood plywood index[a]		
	Nominal	Deflated[b]	Nominal	Deflated[b]	Ratio[c]
1970	0.344	0.933	0.566	1.534	0.608
1971	0.348	0.913	0.556	1.459	0.626
1972	0.362	0.909	0.576	1.447	0.628
1973	0.522	1.159	0.623	1.384	0.837
1974	0.591	1.105	0.719	1.344	0.823
1975	0.458	0.785	0.660	1.130	0.694
1976	0.545	0.892	0.677	1.108	0.805
1977	0.669	1.030	0.705	1.086	0.949
1978	0.698	0.998	0.774	1.107	0.901
1979	0.957	1.216	0.934	1.187	1.025
1980	1.134	1.263	0.975	1.086	1.163
1981	1.048	1.070	0.993	1.013	1.056
1982	1.000	1.000	1.000	1.000	1.000
1983	0.908	0.823	0.993	0.900	0.915
1984	0.977	0.942	0.996	0.960	0.980
1985	0.864	0.837	0.899	0.871	0.961
1986	0.879	0.877	0.910	0.908	0.965
1987	1.046	1.017	0.929	0.904	1.125
1988	1.147	1.073	0.942	0.881	1.218
1989	1.830	1.631	0.998	0.889	1.834
1990	2.256	1.940	1.034	0.889	2.181
1991	2.224	1.908	1.028	0.882	2.163
1992p	2.276	1.943	1.056	0.902	2.154

[a] Hardwood plywood and related products.

[b] Nominal index divided by the all commodity producer price index.

[c] Ratio of import unit value index and hardwood plywood composite index.

Sources: Ulrich (1990); US Bureau of Labor Statistics, US Department of Commerce.

Appendix 1--A model of United States demand for hardwood plywood imports

Some recent studies provide estimates of the own price elasticity for tropical plywood imports, but are less clear on the question of substitution--that is, the change in imports in response to changes in the price of substitutes. Chou and Buongiorno (1983) focus on substitution among sources of supply, but do not consider the price of domestic hardwood plywood, or other substitute products in the demand for imports. Cengel and McKillop (1990) estimate U.S. demand for hardwood plywood from Korea, Taiwan, and Japan, and include the price of a substitute, Type II hardboard, as an explanatory factor. Neither of these studies uses data more recent than 1979. Therefore, a simple model of U.S. demand for hardwood plywood was formulated to provide estimates of own-price elasticity using more recent data, and better estimates of the response of demand to changes in the price of substitutes.

Demand for imported hardwood plywood was modeled as a function of the import price, the price of domestic hardwood plywood and related products, and levels of activity in end-use sectors of the U.S. economy:

$$Q = \alpha P_m^{\beta 1} P_d^{\beta 2} E^{\beta 3} \tag{1}$$

Equation (1) combines Chou and Buongiorno's (1983) and Cengel and McKillop's (1990) specifications. Total import demand is estimated in a single equation. Data series chosen to represent the price of substitutes, and end-use activity differ from those used by Cengel and McKillop (1990). Equation (1) was estimated using data from 1971-91; results are shown below.

All coefficients in table 3 have expected signs, and are significant at the .01 level. These results are consistent with previous econometric results, and support Ward International's (1992) description of the importance of end-use activity in U.S. demand for tropical plywood. Estimated own price is -1.2, and the elasticity of imports with respect to the price of substitutes is 1.5; Chou and Buongiorno (1983) estimated an own price elasticity of -2.2 for hardwood plywood imports. Cengel and McKillop's (1990) estimates of own price elasticity range from -1.4 to -1.9; their estimate of the elasticity of imports from Japan with respect to hardboard price is 5.2. The results shown in table 3 confirm that demand for tropical hardwood plywood continues to be quite responsive to price; in addition, the importance of substitution--relative prices--in demand for tropical plywood in the United States is demonstrated.

Table 3--Coefficient estimates (t-statistics)

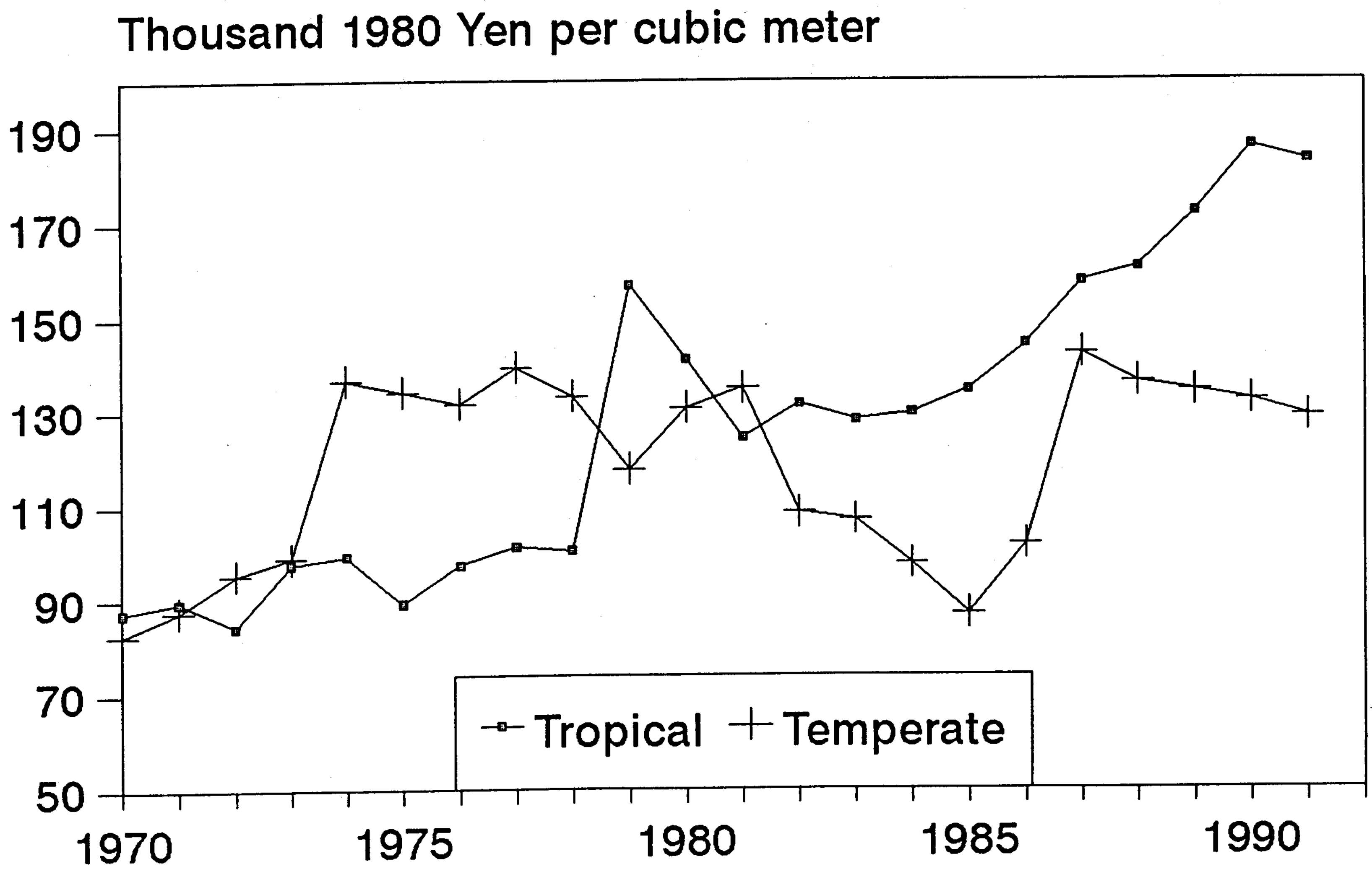
α	$\beta 1$	$\beta 2$	$\beta 3$	R^2	D-W[a]
8.0256 (144.09)	-1.1573 (-6.66)	1.4514 (5.45)	0.8293 (3.07)	0.83	1.37

[a] Durbin-Watson statistic.

Table 4--Definition of variables

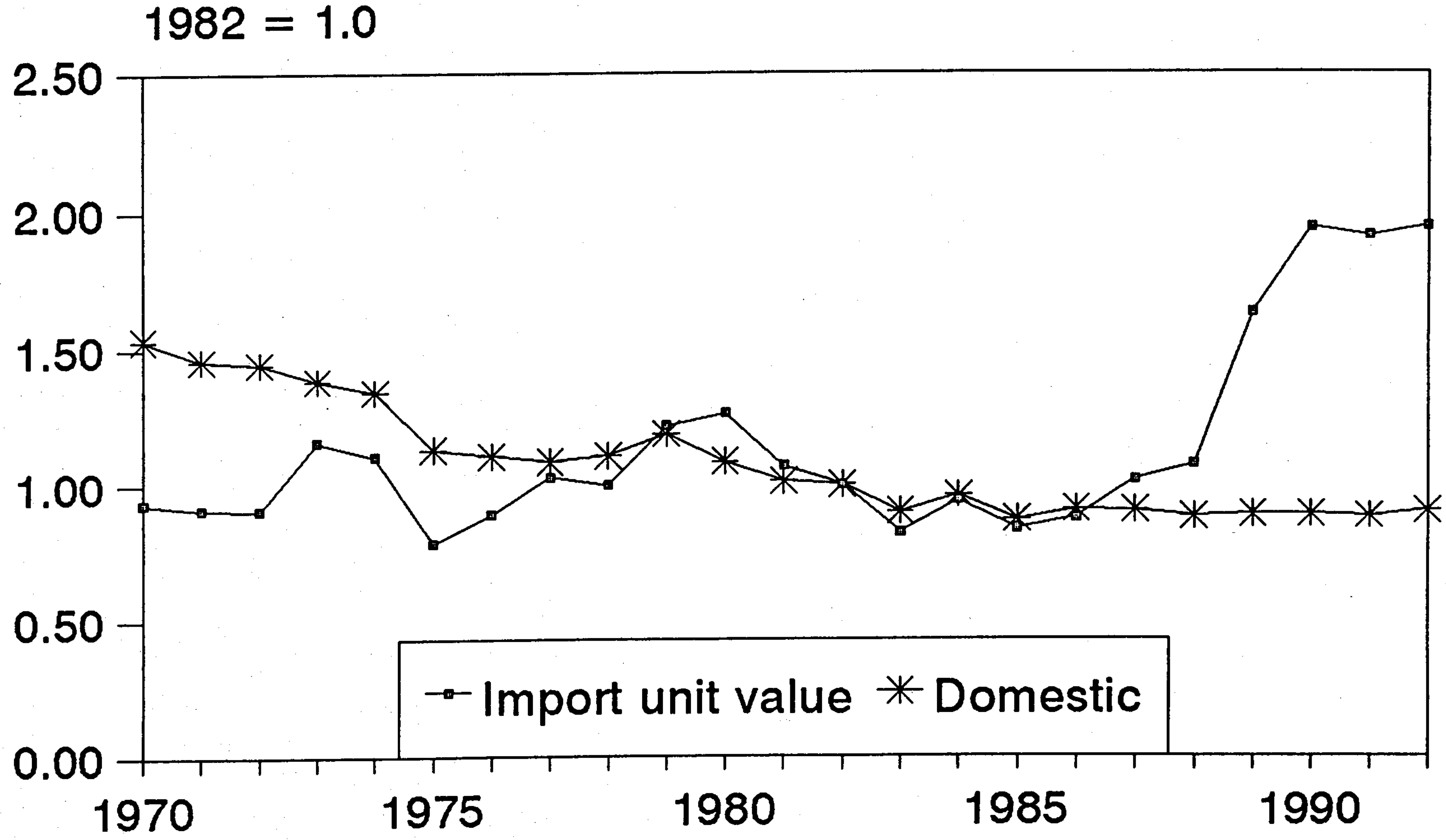
Variable	Description
Q	U.S. imports of hardwood plywood, million square feet, surface measure.
P_m	Index of the unit value of hardwood plywood imports, deflated using the all-commodity producer price index.
P_d	Hardwood plywood and related products price index, deflated using the all-commodity producer price index.
E	Index of end-use activity, constructed from an index of the real value of private construction, the index of total manufacturing production, and the index of furniture production.

Figure 1--Real prices of tropical and temperate lumber in Japan, 1970-91



Tropical: Lauan grade 1, 3.0-3.4 x 30 cm x 4.0 m
Temperate: Hinoki grade 1, 10.5 x 10.5 cm x 3.0 m

Figure 2--Indexes of real prices for hardwood plywood imports and domestic hardwood plywood, United States 1970-92



Domestic index includes related products

Data for 1992 are preliminary
Source: Ulrich (1990) and US Bureau of Labor Statistics

United States Trade in Forest Products:
Trade with Tropical Countries and Trade in Tropical Products

David J Brooks

27 January 1992

Abstract

Data on the value of United States imports and exports of forest products 1985-91 are summarized, with particular attention to imports of tropical timber and forest products trade with tropical countries. Long-term trends (1950-90) and preliminary data for 1992 are also reported. Forest products trade data is grouped in two broad categories, solid wood and pulp and paper, and sixteen commodity groups within these broad categories. Commodity groups are based on the Harmonized System commodity trade classification. Patterns and trends in the value of US forest products trade with tropical countries reveal that trade in secondary products and pulp and paper products now accounts for half of US imports from tropical countries. In addition, tropical countries represent important markets for US producers, with total US forest products exports to these countries valued at 3 billion dollars in 1992, and net trade valued at 1.4 billion.

Introduction

This report summarizes US trade in forest products, focusing on US trade in tropical timber, US trade with tropical countries, and US trade with countries that are members of the International Tropical Timber Organization (ITTO). The International Tropical Timber Agreement (ITTA) (United Nations 1984) is a multi-national commodity trade agreement whose central objectives are to support and promote conservation of tropical forests through sustainable management, utilization, and trade in tropical timber. When established a decade ago, ITTA identified countries as either producers or consumers of tropical timber, and focused attention on trade in tropical logs and primary products manufactured from non-coniferous tropical timber. Primary products include logs, sawn wood, veneer and plywood.

Renewal of the ITTA must take into consideration the complexity of forest products trade linkages among tropical developing and temperate developed countries. Issues that must be addressed include shifts in tropical country exports from primary products to "secondary" products that include a wide variety of manufactured goods, and the increasing importance of forest products imports by tropical countries. Recent data on United States forest products trade illustrates these issues.

Compared to Japan, Taiwan, Korea, and the European Community, the United States is a relatively unimportant participant in markets for tropical timber; tropical timber is a minor component of US consumption of industrial forest products. Nevertheless, US imports of tropical timber products are significant in terms of value - more than 600 million dollars in 1991. In terms of the value of trade, however, tropical countries are more important as markets for US exporters of temperate forest products than as sources of supply for US consumption. This report provides a broader context for understanding United States trade in tropical timber and forest products trade with tropical countries. Patterns and recent trends in trade reflect the increasing complexity of the United States role in tropical timber production and trade.

Data sources and methods

Official US trade data is compiled and maintained by the US Department of Commerce (USDOC); all data used in this report is taken from USDOC computer records. Data summarized in this report covers the period 1985-91; individual commodity data was aggregated by commodity groups and groupings of trade partners. For 1985-88, data is USDOC estimates of the correspondence between HS commodity codes and earlier classification of US commodity trade (TSUSA). Although this correspondence may have errors associated with individual commodities, the correspondence is reasonably accurate for broad aggregates such as those listed in table 1.

Solid wood products are defined as all commodities in chapter 44 of the HS (US International Trade Commission 1990); pulp and paper products are defined as commodities in chapter 47 and nearly all commodities included in chapter 48. Commodities in chapter 44 for which a tropical timber component is explicitly identified were selected using 6-digit HS codes and aggregated to display trends in tropical timber imports. Although tropical timber data was extracted for 1985-91, USDOC estimates of the value of tropical timber imports prior to 1989 did not appear reliable. Only data that was collected using the HS codes (1989-91) was retained.

US forest products trading partners were grouped into three categories: ITTO producer countries (those producing tropical timber), ITTO consumer countries, and all other countries. ITTO countries are shown in table 2; trade with any country not shown in table 2 is included in the "other countries" grouping. In more aggregated compilations, US trade with all tropical countries, temperate countries, and selected individual countries is also reported. Tropical countries are defined as countries with significant area in the tropical zone.

Background

Production and trade in industrial timber products is generally recognized as only one of many factors influencing tropical deforestation (Repetto and Gillis 1988). Nevertheless, trade in tropical timber has come under increasing pressure in the past decade (Vincent 1990). Changes in timber management practices have been suggested as a means of reducing impacts of industrial timber production on tropical forests; these methods, however, are likely to be more costly than current practices. Increased costs, if reflected in commodity prices (as should be expected), will limit markets for tropical timber products and, ultimately, limit the role of tropical timber in providing revenue and incentives for maintaining tropical forests (Barbier and others 1992a, 1992b). Sustainable forest sector development and trade requires integration of environmentally benign timber production, efficient processing and effective marketing.

Prospects for supporting sustainable management of tropical forests through intervention in trade are complicated by competition among producers of tropical timber, and competition between tropical timber and substitute products that include temperate timber, and non-timber materials (Barbier and others 1992b). The effects of trade policy measures on management of tropical forests can only be understood through information on trade and use of tropical timber products. In turn, developments in trade and use of tropical timber products can be understood only within the broad context of the forest sectors of both producing and consuming countries. Two specific developments that must be examined are the importance of tropical country trade in pulp and paper products, and shifts in the composition of tropical timber trade toward secondary (more highly processed) solid wood products.

Pulp and paper products represent a considerable and increasing share of the volume and value of world forest products production, consumption and trade. Although production and exports of industrial products from tropical forests is predominantly in solid wood products, tropical countries are producers - and exporters - of small quantities of fibre products. Tropical countries are also consumers of pulp and paper products, and must rely to a large extent on imports to satisfy consumption (Food and Agricultural Organization 1992). The need to satisfy domestic consumption requirements is increasing the importance of production and trade in pulp and paper products for tropical countries. At the same time, efficient production processes capable of complete utilization of harvested raw material are a requisite of global forest sector competitiveness. Integrated solid wood and pulp and paper manufacturing typically contribute to competitiveness in temperate countries, and eventually may do so in tropical countries as well. Therefore, an understanding of production, consumption, and trade in pulp and paper products is a critical component of an understanding of future industrial use of tropical forests.

Similarly, the effort to maximise economic benefits from production of industrial timber commodities has led many countries, including a number of tropical timber producers, to emphasize further processing of primary products prior to export. In fact, promotion of such efforts is included in ITTA objectives (United Nations 1984). Although the initial scope of these efforts was to promote production and export of sawn wood or plywood in place of log exports, a number of countries have progressed well beyond this stage to production of a variety of shaped, milled and manufactured products. Policy measures that began with restrictions on log exports to induce sawn wood production now include, in some cases, restrictions on exports of sawn wood. Any understanding of US trade with tropical countries therefore must include recognition of these policy measures and their impact on the mix of production and exports. Compilations that include only trade in logs, sawn wood, veneer, and plywood fail t o capture an increasingly important component of the volume - and especially the value - of industrial timber production from tropical forests.

Overview of US forest products trade

The United States is the world's leading importer of forest products, and the second leading exporter of forest products. Since 1950 trade in forest products has expanded significantly, although forest products trade as a share of all merchandise trade decreased over this period. Forest products now account for roughly 4 percent of US merchandise imports, down from more than 10 percent in the 1950s. In 1990, import of forest products were 17.7 billion dollars, up from 1.1 billion (current dollars) in 1950. Adjusted for inflation, imports increased at an average annual rate of 3.4 percent over the period 1950-90 (figure 1). As is the case for all merchandise imports, imports of forest products reflect the timing of the US business cycle. Forest products imports peaked in 1989, declined in 1990-91, and increased in 1992 (based on data through October 1992), reflecting the timing of the recent recession and recover in US economic activity.

Imports of forest products from Canada account for nearly 75 percent of all forest products imports (table 3); softwood lumber, pulp and newsprint account for three fourths of all forest products imports from Canada. Pulp and paper products account for two thirds of US imports from all sources (table 4). Unlike Japan, where tropical timber accounts for as much as 15 percent of forest products consumption, United States consumption and imports of forest products depends largely on temperate zone forests. Softwood species from North America make up the bulk of US forest products consumption. Tropical timber accounts for a negligible share of US consumption of logs and lumber, and about 4 percent of US consumption of panel products (Ward International 1992). Tropical plywood does account for half of US consumption of hardwood plywood, however.

Three tropical countries - Indonesia, Mexico and Brazil - are among the top five suppliers of forest products to the United States (based on the total value of trade), but together account for only 7 percent (1.1 billion dollars) of the value of US imports of forest products (table 3). Forest products imports from all tropical countries are 10 percent of total US imports of forest products; tropical countries account for 20 percent of US imports of solid wood products.

Imports of primary tropical products - logs, sawn wood, veneer and plywood - were valued at 670 million dollars in 1991 (table 5). These commodities account for less than 5 percent of US forest product imports (table 5), and about 10 percent of US imports of solid wood products. Imports of primary tropical timber products peaked in 1985; since 1980, imports of tropical lumber and plywood have fallen substantially (Ward International 1992). Imports of secondary ("value-added") products from tropical countries have increased since 1980 (Ward International 1992).

Although small in comparison to total forest products imports and consumption, US imports of tropical timber account for a significant share of imports of specific commodity groups. For example, tropical plywood accounts for about 80 percent of all plywood imports, and more than 90 percent of US imports of hardwood plywood. Tropical lumber accounts for half of US imports of hardwood lumber (Ward International 1992).

Over the past 40 years, US exports of forest products grew more rapidly than imports, increasing to 15.7 billion in 1990 from 190 million dollars in 1950. Adjusted for inflation, exports increased at an annual rate of 7.7 percent over the period 1950-90, and the most rapid, sustained expansion of exports has been the recent past (1985-91) (figure 1). This recent increase in US exports is largely attributable to the devaluation of the US dollar in 1985, but export promotion and efforts to have trade barriers reduced or removed have contributed to the growth in US forest products exports. Shipments to three countries - Japan, Canada and Mexico - account for half of all US forest products exports (table 6). As with US imports, trade with temperate countries accounts for most forest products exports; trade with tropical countries accounts for a somewhat larger share of exports than of imports, however. Exports to tropical countries (including Mexico) account for 18 percent of US forest products exports (table 6).

As is the case with imports, pulp and paper products dominate in US forest products exports; pulp and paper commodities account for 60 percent of the value US exports to all destinations (table 7). Five of the sixteen commodity groups - logs, lumber, pulp, packaging paper and board, and miscellaneous paper manufactures - account for more than 85 percent of total exports. Softwood logs and softwood lumber account for 30 percent of US exports, and more than 60 percent of exports of solid wood products.

In 1991, US imports and exports of forest products were roughly equal in value. Balanced forest products trade is characteristic of US recessions, and typically results from a sharp reduction in imports combined with increased exports (see figure 1). The expansion of US exports 1985-91 and the recession 1990-91 all but eliminated the forest products trade deficit. Until recently, imports exceeded exports for both solid wood and pulp and paper. In the past few years (1989-91), however, the value of solid wood product exports exceeded the value of solid wood product imports, but not by enough to offset net imports of pulp and paper products. Preliminary data for 1992 indicate an increase in net imports of forest products based on net imports for both commodity groups (see figure 1).

Trade with tropical countries

Figure 2 summarizes recent trends in the composition of US forest products trade with tropical countries. The United States is a net exporter of forest products to tropical countries; over the period 1985-91, the value of net trade in forest products with tropical countries increased to nearly 1.5 billion dollars from 300 million dollars. This trade surplus declined slightly in 1992 (to an estimated 1.3 billion dollars) as a result of increased US imports; US exports of forest products to tropical countries continued to increase in 1992 (figure 2). US exports to tropical countries more than doubled between 1985 and 1991, while US imports from tropical countries peaked in 1989, declined 1990-91, and increased in 1992. Shipments to Mexico account for nearly half of US exports to tropical countries.

Pulp and paper products comprise the majority of US exports to tropical countries, and produce a trade surplus of 2 billion dollars (figure 2). In 1991 and 1992, nearly 80 percent of the value of exports to tropical countries was accounted for by pulp and paper. Packaging paper and board, pulp, and miscellaneous paper manufactures (in decreasing order of importance) account for most US pulp and paper exports to tropical countries. In contrast, solid wood products comprise the bulk of US imports from tropical countries. Plywood is the single most important commodity group. Net imports of solid wood products from tropical countries were valued at 700 million dollars in 1991.

Imports of tropical primary products account for only one third of the value of all forest products imports from tropical countries, and half o the value of solid wood products imports from these countries. Fiber products and secondary products represent the majority of the value of US forest products imports from tropical countries. Imports from non-tropical countries (Asia and Europe) account for nearly 20 percnet of the value of US imports fo tropical primary products.

The pattern of United States trade with ITTO producer countries differs from US trade with all tropical countries. The most noticeable difference is in terms of net trade: the United States is a net importer of forest products frm ITTO producers (figure 3). Neverhteless, US export sof forest products to ITTO producer countries have grown steadily, doubling between 1985 and 1991. As with US exports to all tropical countries - and US exports to al destinatoins - pulp and paper products account for the majority of exports to ITTO producer countries (figure 3). Exports of forest products to ITTO producer countries accounted for 30 percent of US exports to all tropical countries in 1991.

Primary tropical timber commodiities account for ony half of the value fo US imports of forest products from ITTO producer countries (figure 4). Imports of pulp and paper represent a significant component of US imports from ITTO producers - about 25 percnet of the total value fo imports. Pulp imported from Brazil accounts for the most of this trade and nearly the entire value of US imports of pulp and paper from tropical countries. Seocndary solid wood products, including a variety of manufactured goods, account for about 25 percent of the total value of US imports from ITTO producers, and about one third of the value of sold wood imports. Since 1985, more than half of the growth in the value of US imports from ITTO producer countries is accounted for by secondary solid wood products and pulp and paper products.

Summary

Patterns of trade with tropical countries - and ITTO producers in particular - illustrates (1) the importance of pulp and paper products, and (2) the importance of secondary products. Imports of pulp and paper products account for about 25 percent of US imports from ITTO producer countries. Even more substantial, however, are US exports of pulp and paper to tropical cuntries; exports to these markets are now valued at more than 2 billion dollars. US forest product imports from tropical countries are still predominantly solid wood products; however, the composition of imports is changing. Secondary products now account for one third of the value of US imports of solid wood products from trpical countries; between 1985 and 1991 this commodity group's share of imports increased by 50 percent.

Commodities that were the original focus of the ITTA now account for no more than half of the value of US imports from ITTO producers and othe rtropical countries. These data do not include the value of manufactured goods, such as furniture, in which wood is a significant material. Between 1985 and 1991, the value of furniture imports from tropical countries increased five-fold, and in 1991 were valued at 400 million dollars. ITTO producer countries accounted fro more than half of this trade. Over the past decade tropical countries have significantly changed the composition of forest-based industries and exports, diminishing the importance of primary products. At the same time, the distinction between "producer" and "consumer" countries has blurred as the tropical timber producing countries have increased their imports of pulp and paper products. United States trade with tropical countries reflects these changes. The changing pattern and composition of trade requires careful consideration of the appropriate scope and structure of commodity trade agreements designed to influence resource management.

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Table 1--Commodity groups and Harmonized System codes

Commodity group	HS codes[a]
Solid wood	
Logs and chips	4401 - 4403
Hoopwood and wood wool[b]	4404 - 4405
Sleepers and sawn wood	4406 - 4407
Veneer	4408
Shaped wood[c]	4409
Particleboard and fiberboard	4410 - 4411
Plywood	4412
Frames, tools, etc.	4413 - 4417
Joinery, incl. doors	4418
Tableware, marquetry, etc.	4419 - 4421
Pulp and paper	
Pulp[d]	4701 - 4707
Newsprint	4801
Printing and writing paper	4802
Sanitary paper	4803
Packaging paper and board	4804 - 4810
Miscellaneous manufactures[e]	4811 - 4823
Tropical timber[f]	
Tropical logs	440331, 440332, 440333, 440334, 440335
Tropical sawn wood	440721, 440722, 440723
Tropical veneer	440820
Tropical plywood	441211
Other plywood	441212, 441219, 441229, 441299

[a] Each group includes all commodities with the indicated 4-digit or 6-digit prefix.

[b] Includes poles, piling, pickets, and materials suitable for further manufacturing.

[c] Includes flooring, molding, and siding.

[d] Includes waste paper.

[e] Includes coated and decorated paper, envelopes, boxes, etc., but does not include printed material.

[f] Data for these commodities are also included in the broader groups.

Table 2--ITTO member country groups[a]

Consumers (27)	Producers (23)
Australia	Bolivia
Austria	Brazil
Belgium	Cameroon
Canada	Colombia
China	Congo
Denmark	Ecuador
Egypt	Gabon
Finland	Ghana
France	Guyana
Germany	Honduras
Greece	India
Ireland	Indonesia
Italy	Ivory Coast
Japan	Liberia
Korea (South)	Malaysia
Luxembourg	Panama
Nepal	Papua New Guinea
Netherlands	Peru
New Zealand	Philippines
Norway	Thailand
Portugal	Togo
Soviet Union	Trinidad and Tobago
Spain	Zaire
Sweden	
Switzerland	
United Kingdom	
[United States]	

[a] Data for United States trade with any country not listed here is included in the "Other countries" group.

Table 3--United States imports of forest products, 1985-91[a]

Source	1985	1986	1987	1988	1989	1990	1991
				Thousands of dollars			
ITTO producers	727,243	832,961	1,076,616	1,197,695	1,088,064	1,156,178	1,098,062
ITTO consumers	11,137,510	11,564,655	13,133,578	14,374,692	15,535,192	15,393,744	14,107,447
Other countries	921,540	1,119,875	1,340,830	1,443,721	1,434,201	1,119,618	995,148
Total	12,786,293	13,517,491	15,551,024	17,016,108	18,057,457	17,669,540	16,200,657
ITTO producers							
Africa	7,752	10,529	14,065	14,744	10,531	10,687	8,672
Asia	428,354	476,557	632,419	643,563	624,974	701,848	648,321
Latin America	291,137	345,875	430,132	539,388	452,559	443,643	441,069
Subtotal	727,243	832,961	1,076,616	1,197,695	1,088,064	1,156,178	1,098,062
All tropical countries[b]	1,016,705	1,217,905	1,556,149	1,787,323	1,777,547	1,660,694	1,542,667
Temperate zone countries	11,769,588	12,299,586	13,994,875	15,228,785	16,279,910	16,008,846	14,657,990
Major partners:[c]							
Canada	9,398,918	9,704,647	10,960,842	11,895,487	13,229,832	13,030,996	12,017,119
Indonesia	272,295	342,046	442,456	432,593	407,365	455,326	388,507
Mexico	241,434	313,660	410,958	514,790	604,996	415,427	375,969
Finland	333,685	342,142	436,903	483,157	441,522	447,851	370,505
Brazil	257,236	306,171	381,309	482,191	390,904	375,330	360,852
Subtotal	10,503,568	11,008,666	12,632,468	13,808,218	15,074,619	14,724,930	13,512,952

[a] General imports, C.i.f.
[b] Incudes Mexico.
[c] The top five sources of U.S. imports in 1991.

Source: Extracted from U.S. Department of Commerce data.

Table 4--United States imports of forest products by partner group and commodity group, 1985-91

Partner group	Commodity group[a]	1985	1986	1987	1988	1989	1990	1991
					Thousands of dollars			
ITTO producers	Logs and chips	2,292	1,736	2,020	2,170	12,116	7,869	4,240
	Hoopwood and wood wool	1,524	1,303	1,283	2,372	4,325	5,227	4,543
	Sawn wood	122,791	101,994	177,102	143,154	104,732	96,056	103,874
	Veneer	35,682	40,749	47,818	54,711	44,948	46,780	35,678
	Shaped wood	35,366	36,303	47,783	53,030	56,408	64,502	45,154
	Particleboard	33,408	36,582	39,983	28,950	32,219	25,200	20,951
	Plywood	299,502	360,320	465,622	431,013	405,027	464,983	430,799
	Frames, tools, etc.	13,850	12,981	23,219	28,843	37,229	42,986	45,896
	Joinery, incl. doors	21,849	27,417	35,097	43,543	29,378	38,771	38,590
	Tableware, etc.	41,506	40,516	53,366	70,091	88,155	106,257	115,145
	Solid wood	607,770	659,901	893,293	857,877	814,537	898,631	844,870
	Pulp	74,074	99,236	122,264	201,451	233,969	208,886	196,268
	Newsprint	1,433	3,785	1,532	3,579	1,557	0	204
	Printing & writing paper	8,349	15,918	13,473	51,237	2,316	5,906	5,098
	Sanitary paper	19	61	1,229	501	3	42	127
	Packaging paper & board	5,422	13,435	9,136	23,746	6,245	4,334	4,811
	Miscellaneous manufactures	30,196	40,654	35,687	59,301	30,086	38,697	46,757
	Pulp and paper	119,493	173,089	183,321	339,815	274,176	257,865	253,265
ITTO consumers	Logs and chips	69,765	63,379	77,031	95,739	97,708	92,248	83,789
	Hoopwood and wood wool	9,518	10,573	19,129	18,719	11,471	6,395	6,820
	Sawn wood	2,888,886	2,963,626	2,974,397	2,866,000	3,062,118	2,795,515	2,747,914
	Veneer	84,917	94,563	114,374	129,414	137,607	141,101	126,028
	Shaped wood	151,722	164,574	256,571	212,340	213,276	176,403	155,337
	Particleboard	174,023	168,456	173,392	177,709	261,794	244,388	216,537
	Plywood	101,627	93,280	101,774	85,062	74,862	77,038	64,951
	Frames, tools, etc.	27,105	34,608	45,551	49,573	57,397	57,991	60,166
	Joinery, incl. doors	230,871	245,963	224,902	230,575	252,849	269,840	254,237
	Tableware, etc.	118,612	137,686	146,517	169,495	176,713	218,107	227,486
	Solid wood	3,857,046	3,976,708	4,133,638	4,034,626	4,345,795	4,079,026	3,943,265
	Pulp	1,448,941	1,490,219	1,943,122	2,382,421	2,839,600	2,721,056	2,024,530
	Newsprint	3,989,642	4,028,348	4,529,291	4,948,747	4,642,234	4,458,572	4,154,338
	Printing & writing paper	471,355	499,287	564,864	728,331	1,254,368	1,372,435	1,313,667
	Sanitary paper	28,873	31,304	33,359	41,562	57,115	80,954	55,431
	Packaging paper & board	592,012	732,542	978,137	1,213,084	1,364,555	1,496,402	1,388,750
	Miscellaneous manufactures	749,556	806,216	951,123	1,025,596	1,031,276	1,185,264	1,227,322
	Pulp and paper	7,280,379	7,587,916	8,999,896	10,339,741	11,189,148	11,314,683	10,164,038
Other countries	Logs and chips	4,682	4,047	5,707	8,491	13,055	9,927	23,935
	Hoopwood and wood wool	675	1,263	984	534	1,241	1,791	1,083
	Sawn wood	32,606	39,550	55,659	55,470	49,554	47,436	64,849
	Veneer	4,433	4,757	6,619	8,382	13,617	9,030	8,282
	Shaped wood	61,639	70,216	87,695	117,011	110,438	114,032	106,573
	Particleboard	25,734	32,795	36,089	37,341	30,705	23,284	21,408
	Plywood	133,058	143,563	157,629	141,324	119,474	89,906	49,726
	Frames, tools, etc.	51,468	54,635	61,803	65,229	64,961	62,261	60,994
	Joinery, incl. doors	48,353	60,353	72,990	68,317	45,821	42,126	43,420
	Tableware, etc.	239,927	260,970	336,521	311,046	305,509	249,106	240,902
	Solid wood	602,575	672,149	821,696	813,145	754,375	648,899	621,172
	Pulp	28,618	42,994	44,149	81,867	90,797	75,591	80,504
	Newsprint	16,953	12,656	26,746	19,976	6,982	767	746
	Printing & writing paper	21,441	42,100	42,758	77,795	51,340	40,617	13,466
	Sanitary paper	7,588	15,234	9,820	7,438	56,049	41,619	10,039
	Packaging paper & board	17,554	33,120	56,061	67,289	53,687	51,126	42,398
	Miscellaneous manufactures	226,863	301,699	339,562	376,516	420,560	260,714	226,886
	Pulp and paper	319,017	447,803	519,096	630,881	679,415	470,434	374,039
All partners	Logs and chips	76,739	69,162	84,758	106,400	122,879	110,044	111,964
	Hoopwood and wood wool	11,717	13,139	21,396	21,625	17,037	13,413	12,446
	Sawn wood	3,044,283	3,105,170	3,207,158	3,064,624	3,216,404	2,939,007	2,916,637
	Veneer	125,032	140,069	168,811	192,507	196,172	196,911	169,988
	Shaped wood	248,727	271,093	392,049	382,381	380,122	354,937	307,064
	Particleboard	233,165	237,833	249,464	244,000	324,718	292,872	258,896
	Plywood	534,187	597,163	725,025	657,399	599,363	631,927	545,476
	Frames, tools, etc.	92,423	102,224	130,573	143,645	159,587	163,238	167,056
	Joinery, incl. doors	301,073	333,733	332,989	342,435	328,048	350,737	336,247
	Tableware, etc.	400,045	439,172	536,404	550,632	570,377	573,470	583,533
	Solid wood	5,067,391	5,308,758	5,848,627	5,705,648	5,914,707	5,626,556	5,409,307
	Pulp	1,551,633	1,632,449	2,109,535	2,665,739	3,164,366	3,005,533	2,301,302
	Newsprint	4,008,028	4,044,789	4,557,569	4,972,302	4,650,773	4,459,339	4,155,288
	Printing & writing paper	501,145	557,305	621,095	857,363	1,308,024	1,418,958	1,332,231
	Sanitary paper	36,480	46,599	44,408	49,501	113,167	122,615	65,597
	Packaging paper & board	614,988	779,097	1,043,334	1,304,119	1,424,487	1,551,862	1,435,959
	Miscellaneous manufactures	1,006,615	1,148,569	1,326,372	1,461,413	1,481,922	1,484,675	1,500,965
	Pulp and paper	7,718,889	8,208,808	9,702,313	11,310,437	12,142,739	12,042,982	10,791,342

[a] See table 1 for a description of commodity groups.

Source: Extracted from U.S. Department of Commerce data.

Table 5--United States imports of tropical timber products by partner group and commodity group, 1989-91[a]

Partner group	Commodity group	1989	1990	1991
		Thousands of dollars		
ITTO producers				
	Tropical logs	5,889	3,721	1,970
	Tropical sawn wood	86,200	78,813	89,210
	Tropical veneer	15,370	21,242	16,798
	Tropical plywood	331,546	383,366	350,146
	Other plywood	73,134	81,567	80,626
	Total	512,139	568,709	538,750
ITTO consumers				
	Tropical logs	134	106	211
	Tropical sawn wood	726	503	190
	Tropical veneer	0	1,584	7,200
	Tropical plywood	5,609	3,479	2,250
	Other plywood	68,224	72,453	62,119
	Total	74,693	78,125	71,970
Other countries				
	Tropical logs	4,041	1,286	573
	Tropical sawn wood	16,268	9,686	9,039
	Tropical veneer	227	683	1,137
	Tropical plywood	50,960	39,700	18,776
	Other plywood	68,397	49,746	29,979
	Total	139,893	101,101	59,504
All partners				
	Tropical logs	10,063	5,114	2,755
	Tropical sawn wood	103,195	89,002	98,436
	Tropical veneer	15,598	23,510	25,136
	Tropical plywood	388,114	426,543	371,176
	Other plywood	209,752	203,766	172,725
	Total	726,722	747,935	670,228

[a] General imports, C.i.f.

Source: Extracted from U.S. Department of Commerce data.

Table 6--United States exports of forest products, 1985-91[a]

Partner group	1985	1986	1987	1988	1989	1990	1991
				Thousands of dollars			
ITTO producers	387,253	441,530	509,552	557,922	620,646	718,106	830,044
ITTO consumers	4,980,382	5,760,382	7,452,739	9,589,704	10,917,434	11,775,748	11,742,138
Other countries	1,428,956	1,597,637	2,081,834	2,810,052	3,191,694	3,206,980	3,580,590
Total	6,796,591	7,799,549	10,044,125	12,957,678	14,729,774	15,700,834	16,152,772
ITTO producers							
Africa	11,353	12,505	15,324	16,186	13,758	11,892	12,301
Asia	172,033	198,476	234,264	279,956	321,679	374,884	399,246
Latin America	203,867	230,549	259,964	261,780	285,209	331,330	418,497
Subtotal	387,253	441,530	509,552	557,922	620,646	718,106	830,044
All tropical countries[b]	1,298,204	1,368,984	1,713,120	2,166,290	2,429,166	2,574,334	2,951,978
Temperate zone countries	5,498,387	6,430,565	8,331,005	10,791,388	12,300,608	13,126,500	13,200,794
Major partners:[c]							
Japan	1,686,855	2,073,646	2,788,733	3,514,023	4,366,659	4,091,509	3,829,406
Canada	980,412	998,090	1,228,571	1,509,483	1,629,672	2,601,931	2,792,179
Mexico	537,630	546,431	727,143	1,015,284	1,229,252	1,255,246	1,484,557
South Korea	319,612	427,298	565,847	799,704	933,547	902,635	830,256
Germany	335,629	404,547	490,511	602,306	676,135	674,867	722,932
Subtotal	3,860,138	4,450,012	5,800,805	7,440,800	8,835,265	9,526,188	9,659,330

[a] Total exports, F.a.s.
[b] Includes Mexico.
[c] The top five destinations of U.S. exports in 1991.

Source: Extracted from U.S. Department of Commerce data.

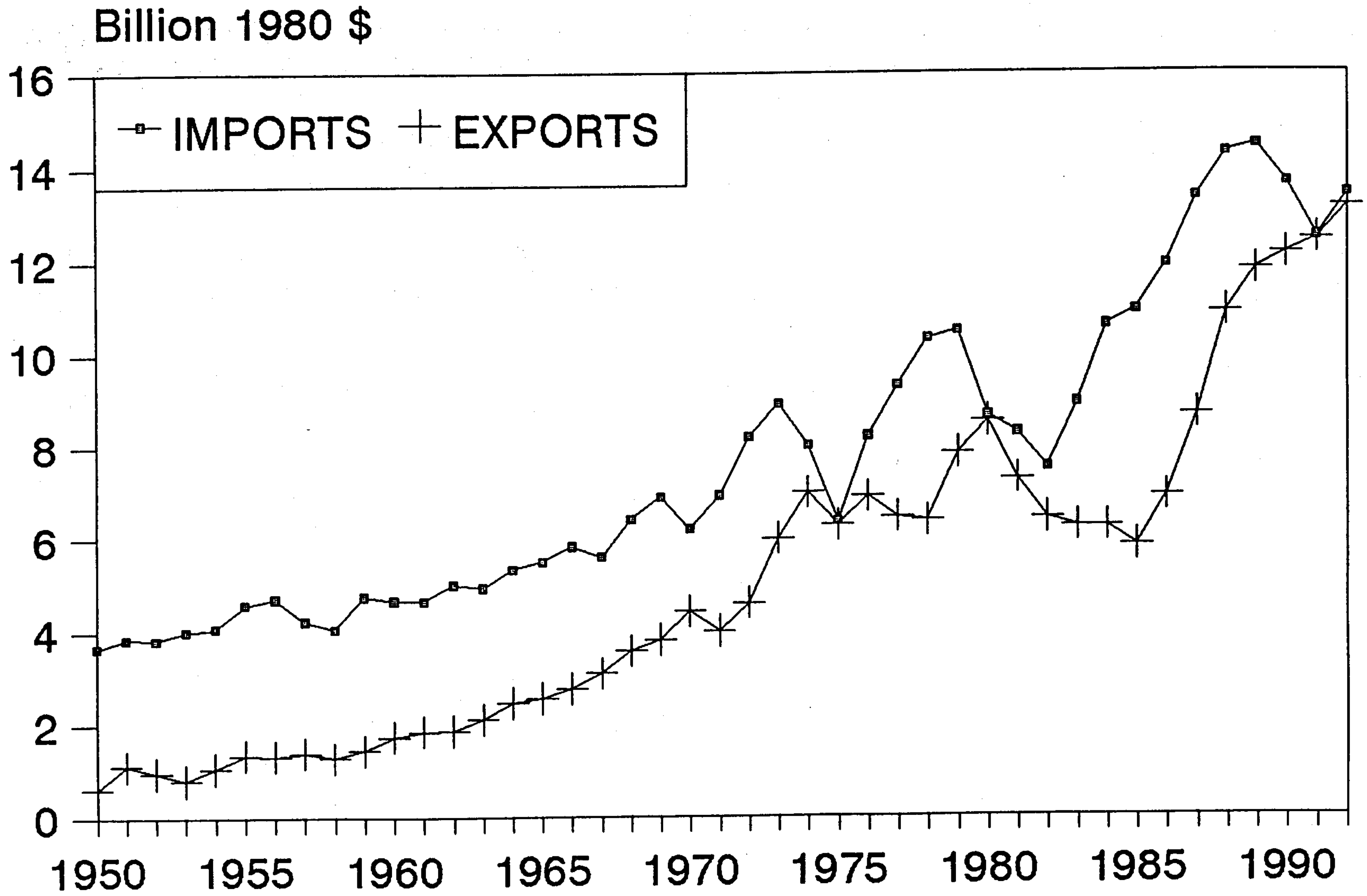
Table 7--United States exports of forest products by partner group and commodity group, 1985-91

Partner group	Commodity group[a]	1985	1986	1987	1988	1989	1990	1991
		Thousands of dollars						
ITTO producers								
	Logs and chips	8,139	7,638	5,848	9,164	10,542	24,037	15,234
	Hoopwood & wood wool	52	218	194	107	152	141	533
	Sawn wood	9,662	13,921	8,862	11,305	14,072	17,654	25,080
	Veneer	23	405	96	363	674	1,710	2,176
	Shaped wood	294	188	491	526	511	647	200
	Particleboard	1,259	1,380	1,007	1,773	2,328	4,374	2,501
	Plywood	2,888	3,375	3,252	2,797	3,106	3,201	4,697
	Frames, tools, etc.	1,490	1,474	1,813	4,414	4,068	4,457	5,060
	Joinery, incl. doors	2,065	1,664	2,853	3,923	1,471	2,599	3,084
	Tableware, etc.	2,609	2,339	2,888	2,985	3,596	4,634	3,779
	Solid wood	28,481	32,602	27,304	37,357	40,520	63,454	62,344
	Pulp	109,350	119,551	142,235	157,178	174,959	206,653	204,308
	Newsprint	22,040	29,704	24,547	28,445	36,172	30,078	56,692
	Printing & writing paper	9,755	7,496	10,764	11,817	20,995	17,456	32,664
	Sanitary paper	676	972	1,561	1,100	791	781	1,046
	Packaging paper & board	150,844	181,915	225,761	244,539	282,532	326,086	387,046
	Misc. manufactures	66,104	69,293	77,377	77,479	64,664	73,601	85,855
	Pulp and paper	358,769	408,931	482,245	520,558	580,113	654,655	767,611
ITTO consumers								
	Logs and chips	1,411,236	1,380,158	1,783,052	2,433,028	2,710,183	2,796,195	2,583,555
	Hoopwood & wood wool	7,989	9,924	13,298	17,178	9,365	6,081	6,822
	Sawn wood	603,506	793,208	1,094,678	1,482,207	1,621,375	1,763,061	1,776,003
	Veneer	63,148	80,514	114,764	141,440	150,191	190,192	193,919
	Shaped wood	17,406	19,700	34,650	44,571	66,299	118,521	128,510
	Particleboard	48,212	56,029	73,896	101,143	102,457	134,295	142,109
	Plywood	60,610	122,310	166,929	207,874	257,115	289,068	224,478
	Frames, tools, etc.	21,924	22,000	29,346	29,639	36,740	60,893	61,889
	Joinery, incl. doors	43,602	83,903	86,405	79,697	123,421	154,076	158,944
	Tableware, etc.	46,141	48,233	53,789	68,919	83,443	99,648	105,183
	Solid wood	2,323,774	2,615,979	3,450,807	4,605,796	5,160,589	5,612,040	5,381,412
	Pulp	1,301,885	1,607,055	2,120,056	2,744,657	3,312,278	3,027,927	2,667,035
	Newsprint	93,462	144,290	174,087	230,345	261,100	220,236	268,608
	Printing & writing paper	76,837	66,316	85,669	115,025	153,242	213,005	266,834
	Sanitary paper	10,780	14,519	18,786	22,719	19,061	25,129	49,966
	Packaging paper & board	596,519	705,522	861,713	974,180	1,079,745	1,369,668	1,566,629
	Misc. manufactures	578,062	607,063	741,705	897,112	931,499	1,307,812	1,542,033
	Pulp and paper	2,657,545	3,144,765	4,002,016	4,984,038	5,756,925	6,163,777	6,361,105
Other countries								
	Logs and chips	38,657	41,114	66,810	124,245	120,026	128,984	131,788
	Hoopwood & wood wool	2,136	1,693	1,850	1,064	4,313	2,168	7,317
	Sawn wood	143,365	185,165	234,225	313,784	428,939	384,643	448,823
	Veneer	9,762	16,851	14,574	20,568	22,837	20,760	25,694
	Shaped wood	3,527	5,541	5,002	7,543	7,937	7,529	10,015
	Particleboard	15,644	22,692	36,299	59,764	64,817	77,424	82,385
	Plywood	22,800	19,367	24,361	43,184	42,943	70,204	77,782
	Frames, tools, etc.	11,221	23,588	21,685	32,317	36,604	42,241	43,911
	Joinery, incl. doors	22,766	18,854	21,668	39,100	54,421	54,452	71,927
	Tableware, etc.	25,329	25,973	31,777	30,553	30,456	31,054	36,804
	Solid wood	295,207	360,838	458,251	672,122	813,293	819,459	936,446
	Pulp	377,395	433,253	641,326	826,440	878,037	834,760	758,946
	Newsprint	40,809	49,246	38,015	71,856	95,312	68,277	99,979
	Printing & writing paper	22,699	22,627	32,663	46,328	54,087	66,997	106,273
	Sanitary paper	6,863	5,925	10,611	15,533	12,103	15,583	20,181
	Packaging paper & board	284,468	319,586	428,016	530,950	561,324	631,657	730,211
	Misc. manufactures	400,524	405,790	472,919	646,696	777,500	770,168	928,271
	Pulp and paper	1,132,758	1,236,427	1,623,550	2,137,803	2,378,363	2,387,442	2,643,861
All partners								
	Logs and chips	1,458,032	1,428,910	1,855,710	2,566,437	2,840,751	2,949,216	2,730,577
	Hoopwood & wood wool	10,177	11,835	15,342	18,349	13,830	8,400	14,672
	Sawn wood	756,533	992,294	1,337,765	1,807,296	2,064,386	2,165,358	2,249,906
	Veneer	72,933	97,770	129,434	162,371	173,702	212,662	221,789
	Shaped wood	21,227	25,429	40,143	52,640	74,747	126,697	138,725
	Particleboard	65,115	80,101	111,202	162,680	169,602	216,093	226,995
	Plywood	86,298	145,052	194,542	253,955	303,164	362,473	306,957
	Frames, tools, etc.	34,635	47,062	52,844	66,370	77,412	107,591	110,860
	Joinery, incl. doors	68,433	104,421	110,926	122,720	179,313	211,127	233,955
	Tableware, etc.	74,079	76,545	88,454	102,457	117,495	135,336	145,766
	Solid wood	2,647,462	3,009,419	3,936,362	5,315,275	6,014,402	6,494,953	6,380,202
	Pulp	1,788,630	2,159,859	2,903,617	3,728,275	4,365,274	4,069,340	3,630,289
	Newsprint	156,311	223,240	236,649	330,646	392,584	318,591	425,279
	Printing & writing paper	109,291	96,439	129,096	173,170	228,324	297,458	405,771
	Sanitary paper	18,319	21,416	30,958	39,352	31,955	41,493	71,193
	Packaging paper & board	1,031,831	1,207,023	1,515,490	1,749,669	1,923,601	2,327,411	2,683,886
	Misc. manufactures	1,044,690	1,082,146	1,292,001	1,621,287	1,773,663	2,151,581	2,556,159
	Pulp and paper	4,149,072	4,790,123	6,107,811	7,642,399	8,715,401	9,205,874	9,772,577

[a] See table 1 for a description of commodity groups.

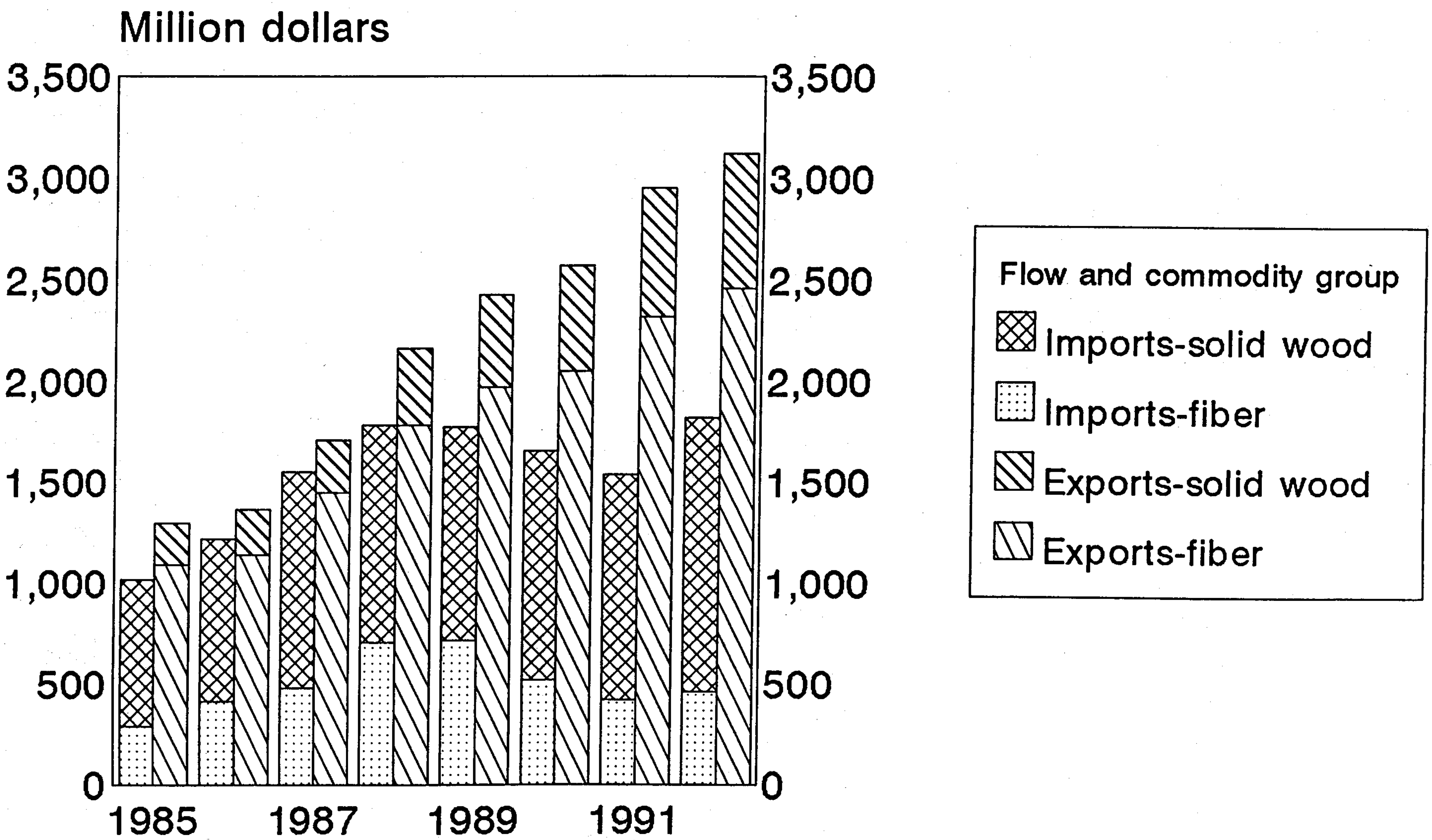
Source: Extracted from U.S. Department of Commerce data.

Figure 1--United States forest products trade, solid wood and fiber products, 1950-92



1992 data are preliminary

Figure 2--United States forest products trade with tropical countries, 1985-92



Includes trade with Mexico; data for 1992 are preliminary

Figure 3--United States forest products trade with ITTO producer countries, 1985-91

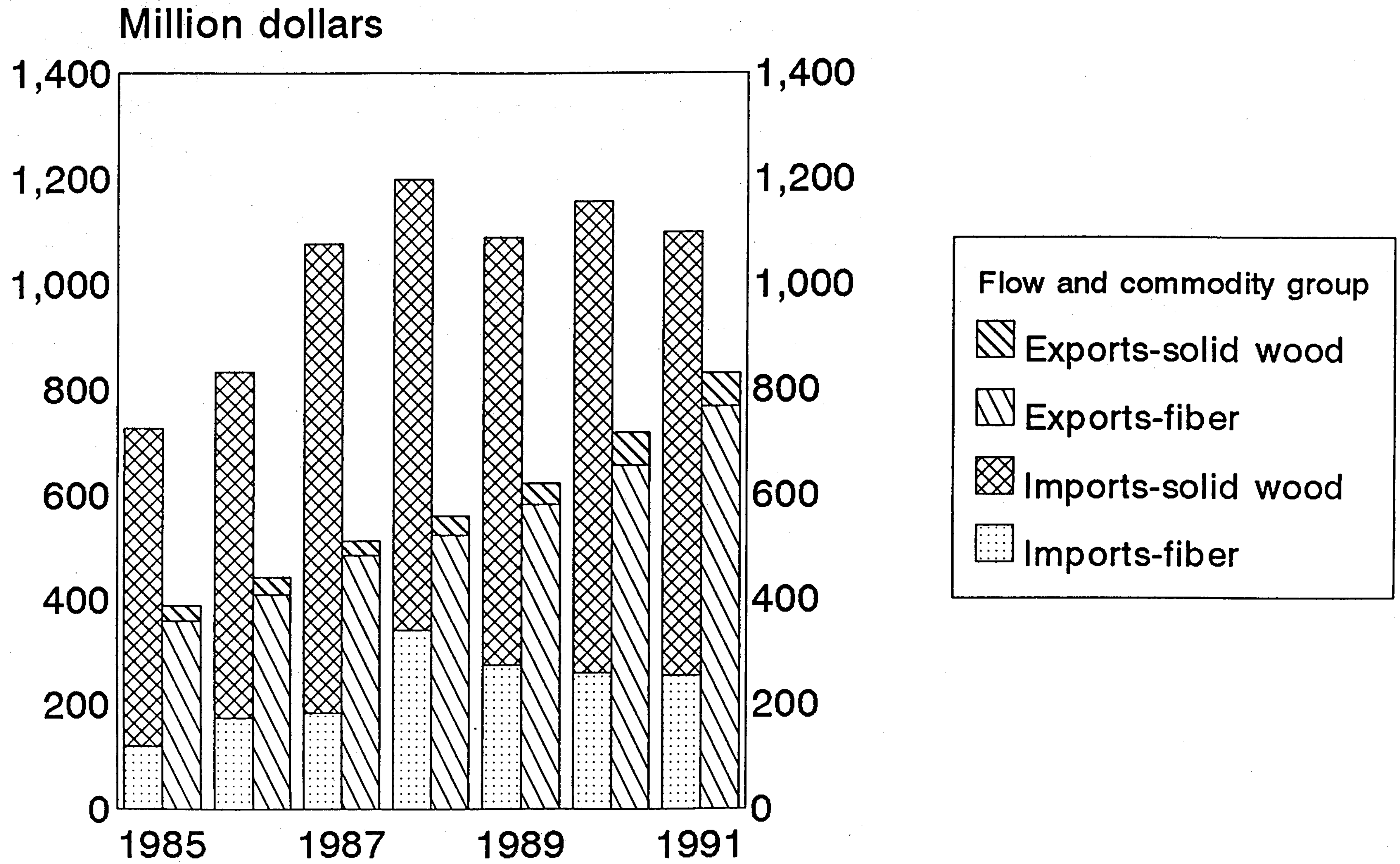
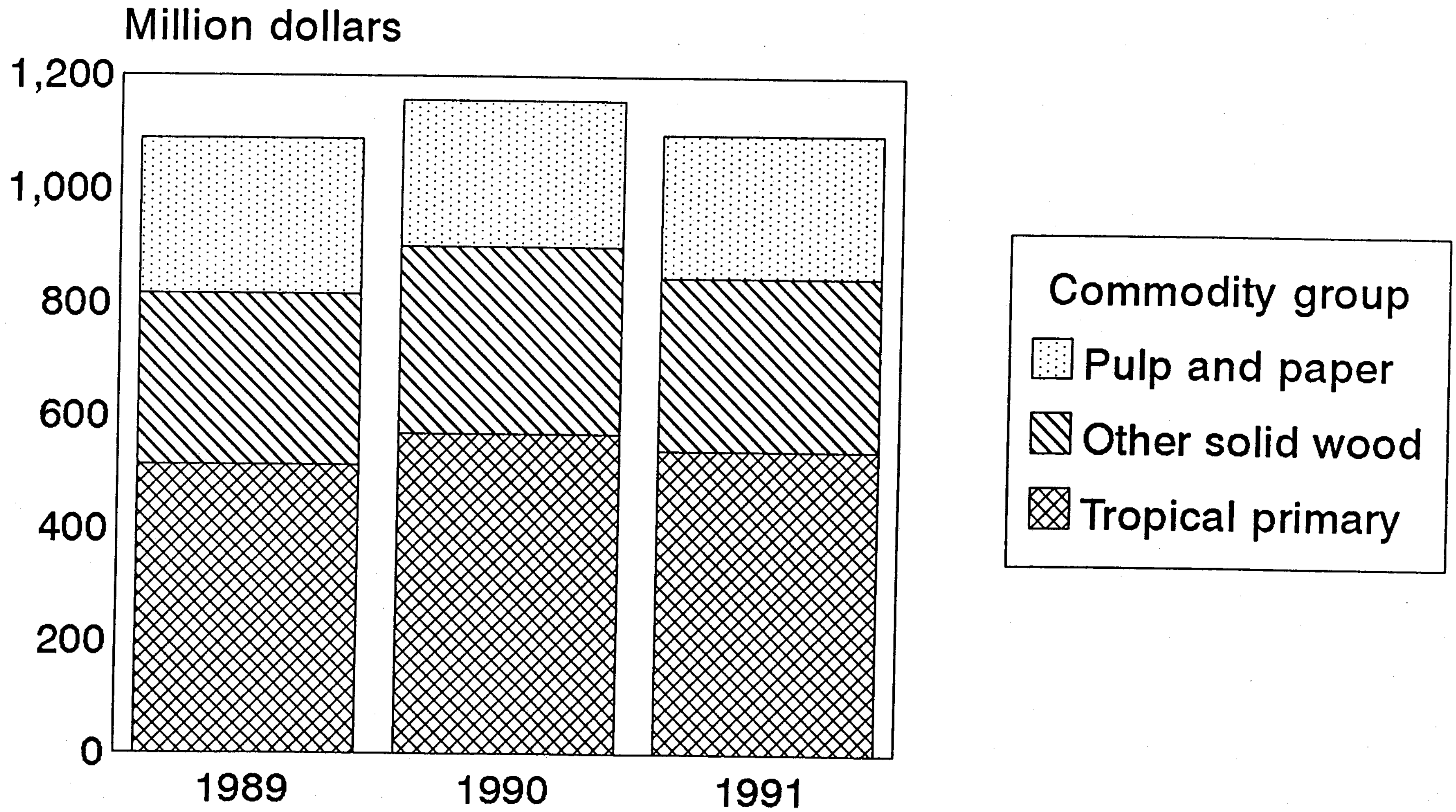


Figure 4--United States imports of forest products from ITTO producer countries, 1989-91



Tropical primary includes logs, sawn wood, veneer & plywood
Other solid wood includes manufactured commodities

ANNEX D

WILLINGNESS TO PAY FOR SUSTAINABLY PRODUCED TROPICAL TIMBER

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Willingness to Pay for Sustainably Produced Tropical Timber

Joshua T. Bishop
Camille A. Bann

October 1992

1. Introduction

Qualitative information on consumer demand for tropical timber has been obtained from recent surveys of consumers and manufacturers in the UK. These surveys also provide some information on whether and how much consumers might be willing to pay, over and above current market prices, for timber products obtained from sustainably managed tropical forests.

As part of this study, LEEC carried out a survey of timber importers in the U.K. The aim of the survey was to determine whether firms believe that their customers would be willing to pay a premium, and if so how much, for the assurance that the tropical timber products they buy originate from sustainably managed sources. The results of the survey can be compared to the results of previous surveys carried out by The World Wide Fund for Nature (WWF 1991), Friends of the Earth (FOE 1992), and Milland Fine Timber Ltd (MFT 1990), which have led to claims that consumers *are* willing to pay significantly more for tropical timber from sustainably managed forests. Preliminary results of the LEEC survey appear to contradict this assertion.

2. Methodology

All of these surveys use the contingent valuation method (CVM) to estimate the demand for sustainably produced timber. This method involves directly asking people to express their willingness to pay (WTP) for a benefit, or their willingness to accept (WTA) compensation for a loss. Estimates of demand based on CVM are therefore not based on actual behaviour but on respondents' statements of how they would react to a change in the quantity or quality of a particular good, contingent upon a hypothetical market.

The accuracy of CVM is often questioned as the method can suffer from a number of biases. 'Hypothetical bias' inherent to all survey techniques is the effect of the difference between conditions in the real market and the artificial market created by the survey. 'Information bias' arises either as a result of providing too little information about the choices offered or from misleading statements. Another frequent problem is 'strategic bias,' i.e. people may not give answers which reflect their true values but will offer instead strategic answers depending on what they think will be done with the information and how they might benefit from this. There are several ways to test for and avoid these types of bias in practice.

Notwithstanding these potential problems, properly conducted surveys using CVM can provide a great deal of information from those who would be affected by a proposed policy. While estimates based on CVM are not precise, they do provide an order of magnitude of respondents' willingness to pay for the benefit in question.

3. Previous Surveys

A number of organizations have carried out surveys of the public or of industry in attempt to determine whether and how much consumers might be willing to pay, over and above current prices, for tropical forest products originating from sustainably managed forests. A summary of the results of the different surveys is presented in Table D.1.

Milland Fine Timber (MFT) Limited, currently the sole UK distributor of the Ecological Trading Company's allegedly 'sustainable' timber, commissioned The Business Research Unit to conduct a survey in order to understand timber buyers' purchasing behaviour, the criteria used in selecting hardwood suppliers, the uses and knowledge of different hardwoods and buyers' propensity to pay more for sustainably produced hardwoods. 160 UK-based *manufacturers* operating in a variety of areas including joinery, cabinet making, and household furniture were interviewed by telephone.

65% of those interviewed were prepared to pay more for sustainably produced tropical hardwoods (73% of household and office furniture manufacturers; 50% of kitchen cabinet manufacturers); 26% were not willing to pay more and 9% did not know. Only a third of those who claimed to be willing to pay a premium were prepared to pay more than 5% above current prices. The main reasons expressed for not wanting to pay more were that tropical timber is already too expensive, that customers would be lost, that they could not afford it, and the concern that increased costs would be passed on to the customer. The sectors most likely to pay more according to this study are conservatory, household and office furniture manufacturers and cabinet makers.

The World Wide Fund for Nature (WWF) commissioned MORI to conduct a survey of public attitudes on tropical rainforests and the environment. A sample set of 2,100 representing all adults in Great Britain (excluding the Western Isles and Orkney and Shetland) were interviewed at their home. One of the main findings arising from this research was the claim that *consumers* are willing to pay on average 13.6% more for wood products if they can be shown to have come from well-managed forests. Furthermore, one in six consumers interviewed claimed to have stopped buying tropical wood products because of their fears about continuing forest destruction.

Friends of the Earth (FOE), as part of a campaign targeted at major Do-It-Yourself (DIY) retail hardware chains in the UK, conducted a national survey of over 15,000 *members of the public*. People entering one of the major DIY chainstores (B&Q, Do-It-All, Great Mills, Sainsbury's Homebase, Texas Homecare and Wickes) were questioned on their concern over rainforest destruction. 91% expressed a concern and 58% said that if they knew a timber product came from the rainforest, they would not buy it. 83% of those surveyed agreed with the phrase that shops should 'face up to their environmental responsibilities and stop selling tropical timber products which contribute to rainforest destruction.' People were not asked how much they would be willing to pay for timber from sustainably managed sources. FOE concluded from these results that the public is concerned about the rainforest and the role played by the DIY stores and that, in their own rather provocative words, 'companies cannot continue to ignore what their customers want'.

4. LEEC Survey of Willingness to Pay

For this study LEEC conducted a survey by mail of the 83 members of the U.K. Tropical Timber Federation's National Hardwood Importers Section.[1] The aim of the survey was to ask firms to estimate whether and how much their customers would be willing to pay over and above prevailing market prices for the assurance that any tropical timber they bought originated from sustainably managed forests. The LEEC survey thus differs from previous surveys in that it does not query consumers directly in order to determine WTP but rather elicits manufacturers' *perceptions* of consumer WTP. A 'single bid game' was used, i.e. survey respondents were asked to state the maximum price that they expected consumers would be willing to pay for timber from sustainably managed sources.

The survey also collected information from firms on their opinion of future trends in the trade of tropical timber and on how they are adapting to current political pressures on the trade arising from public concern about tropical deforestation. Additional information collected in this survey includes: the area of the trade the respondent was involved in; the number of employees in the firm; the type of timber imported and the percentage of each type by volume and by value; major end uses of tropical timber; the ease with which it was possible to obtain details from suppliers of the type of forest management employed in producing the timber they supplied; and whether the respondent would stock timber from both sustainable and unsustainable sources.

The number of responses received to the LEEC survey is still small and more definite conclusions must await the receipt of additional responses. Nevertheless, from the replies received so far the following preliminary results emerge: a large majority of respondants (17/24 or 75%) feel that their customers are *not* willing to pay a premium for tropical timber derived from sustainably managed forests. The main reasons expressed for this were the competitive nature of the industry and the present recession. A minority (6/24 or 25%) thought that consumers would be willing to pay between 5 and 10% more. A single respondent felt that customers would pay up to 20% more, but only for top quality tropical hardwood; any higher price would lead customers to use alternative woods. Of those who believed a premium could be levied, there was consensus that this was most likely to be achieved in the quality joinery and furniture markets and not at all within the construction industry.

Most respondents saw trade in tropical timber declining, at least in volume terms, over the coming years. A movement away from plywood towards further prepared and assembled products is anticipated. Firms see this as a way of promoting value added products in the

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[1] A copy of the Cover Letter and Questionnaire are appended. Similar forms have been sent to U.K. joinery manufacturers and U.K. cabinet manufacturers but responses were not received in time to include the results in this report.

countries of origin and thus aiding them to fund a long term forest policy and to earn income.

A number of respondents felt that the general public had been misinformed about the role of the timber trade in tropical deforestation, resulting in an adverse effect on sales. Generally respondents were sensitive to the problem of deforestation and the need to act responsibly to secure their position in the market place. Respondents claimed to be actively expressing their concern through support for the U.K. Forest Forever Campaign and ITTO guidelines for the year 2000, requesting documentation confirming sustainable supply from suppliers, issuing catalogues and mailshots on the issue, etc.

These preliminary results from the LEEC survey are at variance with previous surveys. They suggest that, in the current economic climate at least, consumers are *not* willing to pay a premium for timber products originating from sustainably managed sources. This may reflect the current recession, the fact that the survey was addressed to manufacturers rather than to consumers or the nature of the sample.

5. Conclusions

Some of the important points that emerge from these surveys of consumer willingness to pay for tropical timber products obtained from sustainably managed forests are as follows:

- Surveys in the UK indicate that consumers *may* be willing to pay significantly more for tropical timber products obtained from sustainably managed forests. Indeed, some consumers have expressed an unwillingness to purchase *any* products containing tropical timber, due to its perceived impact on tropical forests.

- Manufacturers, on the other hand, do not appear to believe that their customers would be willing to pay as large a premium as the public claims, particularly in the current recession.

- Moreover, manufacturers believe that scope for a price premium exists only in the quality joinery and furniture markets. In markets where tropical timber products compete largely on price with temperate or non–timber substitutes, such as building and construction, manufacturers see much less room for a price premium.

Table D.1 Willingness to Pay for 'Sustainably Produced' Tropical Timber

Study	Focus of Survey / Sample Set / Methodology	Results
Milland Fine Timber Ltd. 1990	Focus: propensity of manufacturers to pay more for sustainably produced tropical hardwoods Sample: 160 UK-based manufacturers Methodology: telephone interview	65% willing to pay (WTP) more 26% unwilling to pay more 9% don't know of 65% WTP more: 34% WTP 5% more 23% WTP 6-10% 5% WTP 11-15% 3% WTP 16-20% 4% WTP 21-25% 31% don't know
World Wide Fund for Nature (UK) 1991	Focus: consumer willingness to pay for tropical wood products shown to have come from well managed forests Sample: 2,100 members of the British public Methodology: personal interviews	13.6% average willingness to pay above current prices
Friends of the Earth 1992	Focus: consumer concern about rainforest destruction Sample: 1,500 shoppers entering 'Do-It-Yourself' hardware stores in the UK Methodology: personal interviews	91% expressed concern about rainforest destruction 58% claimed that if they knew a timber product came from a rainforest they would not buy it
London Environmental Economics Centre 1992	Focus: opinion of UK tropical timber importers on whether and how much their customers would be willing to pay for the assurance that any tropical timber they buy originates from sustainably managed forests Sample: 83 members of the UK Tropical Timber Federation's National Hardwood Importers Section Methodology: mail survey	71% believe that their customers are not willing to pay more 25% believe that customers are willing to pay between 5 and 10% more

30 July 1992

Dear Sir/Madam:

Consumers everywhere want to know more about the products they buy. From food to furniture, consumers increasingly demand to know where the things they use come from and how they were produced. In the case of products made of or containing **tropical wood**, this concern reflects increasing attention by the media, environmental and consumer groups to the pace of deforestation in tropical countries.

The **London Environmental Economics Centre (LEEC)** is an independent research centre, sponsored by University College London and the International Institute for Environment and Development, a registered charity. LEEC is carrying out a study on the linkages between the trade in tropical timber and the management of tropical forests. This study was commissioned by the International Tropical Timber Organization (ITTO). The ITTO is an affiliate of the United Nations; members include the governments of most countries which import and export tropical timber.

As part of the study, LEEC is carrying out a **survey of firms** which sell products made of or containing tropical timber. The aim of the survey is to determine whether consumers are willing to pay a premium for the assurance that any tropical timber products they buy originate from sustainably managed forests. This information will be used to help the ITTO and member countries to develop appropriate policies affecting the trade in tropical timber.

Your firm is one of many selected for the survey. We would be very grateful if you would take a few minutes to fill out the attached form and return it to us in the enclosed stamped, self-addressed envelope. **Any information you provide will be treated in strictest confidence**. Your cooperation is greatly appreciated.

Yours sincerely,

EDWARD B. BARBIER, PhD
Director

Questionnaire on Willingess to Pay for Tropical Timber from Sustainably Managed Forests

London Environmental Economics Centre

July 1992

NAME OF ORGANISATION:
NAME OF RESPONDENT:

A. General Information

In what area of the timber trade do you operate?
Please tick (more than one if necessary)

- Del credere agent _
- Agents acting as principals _
- Importers _
- Merchants _
- Manufacturers _

In what industry does your firm operate?

How many people do you currently employ?

B. Tropical Timber Trade

What type of tropical timber do you import? (e.g. logs, sawntimber, plywood, veneer, processed goods).

Can you give the percentage of each in volume terms if you import more than one.

From which country / specific forest area does your timber originate ?

Do you concentrate on certain species–groups or regions?

if yes, which and for what reason:

species:

regions:

What are the main end uses of the timber you buy?

What percentage of your timber, in terms of value and/or volume, is imported from tropical as opposed to temperate sources?

If you purchase direct from overseas suppliers, or from overseas through agents, do you have difficulties obtaining details of the type of forest management employed in producing timber?

What type of information is given?

Does it refer to:
Please tick

the country as a whole _
a forest region _
a specific stand _

Can you briefly summarise what your firm considers to be the main future trends in your market for tropical timber ?

C. Position on Current Political Pressures Against Tropical Deforestation

There has been increasing attention in politics and the media to the problem of tropical deforestation which has been linked to the trade and market for tropical timber. How has this affected:

your firm

your suppliers

your customers?

How has your firm responded to these concerns?

How do you expect your use of tropical timber to change in the future?

D. Willingness To Pay for Sustainable Tropical Timber Use

Do you think your customers would be willing to pay **extra** for the assurance that any tropical timber purchased from you were obtained from sustainably managed sources?

If yes, in which markets and /or for which products?

How much **more** do you think your customers would be willing to pay of the assurance that any tropical timber purchased from you were from, sustainably managed sources?

0%, 10%, 20%, 30%, 40%, 50% or more?

Would you stock timber from sustainable **and** unsustainable sources and how would you distinguish between the two?

Optional Questions:

Since it is essential to obtain as much information as possible would you be willing to provide financial information to assist our study on the value and volume of your sales of tropical timber?

If so would you please give details of:

1. Your gross turnover

2. Total turnover of timber and/or timber products

3. Total turnover of tropical timber and/or tropical timber products

We emphasis the absolute confidentiality of any information given.

If you are not able to answer in financial terms could you please answer 2 and 3 in % terms.

Please feel free to add any further comments which you consider would add value to our study on an extra sheet of paper.

References

Friends of the Earth. 1992. *Press Release*, 28th March 1992.

Milland Fine Timber Ltd. 1990. *New Business Feasibility Study,* prepared by The Business Research Unit, 5 St John's Land, London.

World Wide Fund for Nature. 1990. *Tropical Rain Forests and the Environment: A Survey of Public Attitudes*, Godalming, Surrey.

ANNEX E

ECONOMIC EFFICIENCY, RENT CAPTURE AND MARKET FAILURE IN TROPICAL FOREST MANAGEMENT

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Josh Bishop*
Edward Barbier*

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Economic Efficiency, Rent Capture and Market Failure in Tropical Forest Management

Bruce Aylward
Josh Bishop
Edward Barbier

October 13, 1992

E.1 Economic Efficiency and Rent Capture in Tropical Forest Management

As outlined by Hyde, Newman and Sedjo (1991), public policies influence the environmental effects of timber forest management through their impacts on:

- the level of *privately efficient* harvests,
- the level of *socially efficient* harvests when accounting for environmental externalities,
- alternative *royalty, contract and concessional* arrangements and their implications for trespass, high-grading and other environmental losses,[1] and
- the level of *rent distribution.*

The implications are illustrated in Figure E.1.[2] If p is the competitive price for delivered logs, V is the harvest volume and MC_1 is the short-run private marginal cost curve of the concessionaire for delivered logs, then V_1 is the optimal short-run and private harvest level. That is, the private concessionaire is concerned only with short-run financial returns from harvesting and not with the potential long-run returns from the stand or with any of the 'external' environmental effects of logging. However, this level of extraction, V_1, is not optimal from a social point of view because it excludes

- the 'user costs' of short-run harvesting, i.e. the discounted future returns from leaving the residual stand undamaged and growing, or through avoidance of high-grading and other practices that degrade the stand, and
- any 'external' environmental costs of timber extraction such as watershed degradation, downstream sedimentation, disruptions to nutrient cycling, loss of natural habitats, loss of non-timber products, etc.

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[1] *Trespass* is a forestry term that refers to losses due to logging theft, which could also be extended to included losses due to graft. *High-grading* refers to the removal of high-valued timber and leaving a degraded timber stand..

[2] This example concerns a concessionaire contracting with a forestry ministry to extract timber from public forest land. With modification, the example could easily be extended to describe a forest operation on private land.

Improved contractual arrangements between the forest ministry and the concessionaire could ensure that the latter 'internalizes' any additional user costs. Long term contracts that coincide with optimal harvesting/regrowth rotations could ensure that the concessionaire has an incentive to take account of these user costs, denoted by MC_2 in Figure E.1. Other arrangements, such as imposing provisions for continuation of short-term contracts on condition of 'sustainable' practices or even outright sale of the land, could also be applied. If successful, such contractual arrangements would ensure that the concessionaire would attain the optimal long-run harvest level, V_2, and harvest less timber. Finally, if MC_3 is the additional off-site environmental costs of timber harvesting, then these costs can also be 'internalized' by imposing a tax equal to *bd* on the concessionaire.[3] The result is that the concessionaire now harvests at the socially optimal level, V_3, which is lower than the private short or long-term level.

As indicated in Figure E.1, the concessionaire is making an economic rent equal to pap_1, or pbp_1 if all social costs are accounted for. The forestry ministry can 'capture' all or part of this rent through harvest taxes. However, an *ad valorem* (flat rate) tax or royalty that is a percentage charge on net revenues does not affect the harvest level (i.e., will not 'move' the concessionaire from V_1 to V_3) but will increase the incentive to high-grade, trespass and ignore off-site environmental costs. A uniform fixed royalty, which is a flat fee per unit of harvest, does alter the marginal harvest decision, but also increases the incentive to high-grade, trespass and ignore off-site environmental costs on the infra-marginal land. Moreover, increasing this royalty may actually *decrease* tax revenues if the elasticity of the marginal cost curve is greater than one, and could reduce harvests below the socially optimal level, V_3. To 'internalize' user and environmental costs *and* capture a greater share of rents would require a more sophisticated combination of policies of, first, sorting out long-run contractual arrangements and an environmental 'tax' equal to *bd* as outlined above, and second, charging a competitively bid lump sum fee for the right to harvest the stand, equal to pbp_1, in order to capture the economic rent generated at V_3.

E.2 Market Failure and Tropical Forest Management

As explained in the previous section improved contractual arrangements and forest management policies may improve the incentives for achieving private and socially efficient rates of timber extraction and trade. Clearly then - the opposite case applies - poor design and implementation of policy will have an adverse affect on forest management. But what is the root cause of short-run harvesting? In the absence of good or bad policy prescriptions what are the incentives that drive individuals and firms to 'mine' the forest? Neoclassical economics suggests that market systems are susceptible to a number of imperfections which - when they occur - will lead producers such as

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[3] It is possible that the forestry ministry might want to impose a single tax to cover both user and environmental costs, in which case the optimal tax would be *bc* in Figure F.1; however, Hyde, Newman and Sedjo (1991) correctly argue that such a tax does nothing to 'extend' the horizon of an operator after short-run gains, and would actually encourage high-grading, trespassing and tax avoidance, especially for infra-marginal stems and stands.

concessionaries to fail to attain private and/or socially efficient production levels. In such cases, the case for policy intervention rest with the underlying failure of the market. Policies designed to improve forest management should, therefore, be targeted at the correction of these market failures.

Market Failure

Neoclassical economic theory asserts that markets will achieve an optimal allocation of societal resources given that certain conditions are met in the marketplace. These conditions include:

- the absence of *public goods* and *common pool resources*,
- the absence of *externalities* (e.g. no non-marketed goods)
- perfect information (e.g. no uncertainty or undiversifiable risk),
- perfect competition (e.g. no market concentration),

'Market failure' is said to occur when these conditions are not fulfilled. That is, the failure to meet these conditions invalidates the basic assumptions for the market to function as an efficient allocator of societal resources. Under such circumstances the market will not achieve a *pareto-efficient* outcome - it will still be possible to make one participant in the market better off without causing another participant to be equally worse off. Thus, in the case of market failures that lead to short-run harvesting of timber, movement towards privately and socially efficient harvest levels would actually make society better off as a whole. Before indicating a few of the market failures that produce inefficient outcomes in tropical forest management a brief exposition of the theory behind each type of market failure is presented.

Inefficient allocation of natural resources often arise when the resource is a common pool resource or a public good. Both types of resources are *non-exclusive*; i.e. they are available to all who wish to consume them. Public goods are also *non-rival*; i.e. consumption by one user does not impinge on the quantity or quality of consumption by others. Public goods will be under-supplied by the market, since the costs incurred by any private producer exceed the benefits they might obtain. If one producer were to undertake to provide a public good all other potential consumers could obtain the good for free - a phenomenon called 'free-riding.' This situation leads to a stalemate of inaction as each producer waits for someone else to provide the public good. Collective action is required to overcome this free-riding that occurs in the marketplace presence of public goods. Many tasks traditionally undertaken by governments fall into the area of public goods such as the provision of defense, transport infrastructure, and basic needs support to the impoverished.

Common pool resources, on the other hand, are *rival*, i.e. exploitation by one user impairs the consumption of others. When the cost of excluding potential users or of coordinating joint use is high, common pool resources may be subject to *open access* exploitation. Open access refers to the unmanaged exploitation of a resource by multiple users. Because each user suspects that others would benefit from any self-imposed restraint, all users rush to consume the resource as fast as possible. Regulatory approaches to the open access problem stress enforcement of property rights, through limits on exploitation and use of the resource. Alternatively, management may be devolved to local user groups which are often better placed to define regulations or to administer incentives and dispute resolution schemes than central authorities.

Externalities take the form of costs or benefits arising in a process of production or consumption which are not reflected in the market prices of the relevant goods and services. Typically externalities affect third party 'victims,' who lack the means to obtain compensation for foregone benefits or imposed costs. Externalities may be positive as well, in which case a benefit is enjoyed without payment to the producer. Externalities persist due to the absence of markets in which such costs and/or benefits may be valued and exchanges made. The ideal response to an externality is to 'internalize' costs and benefits affecting third parties, so that market prices will reflect the full social costs and benefits of production and consumption. This may be achieved either by applying the *polluter pays principle* or by altering property rights or contractual agreements so that the negative impacts are incorporated directly into production or consumption decisions.

The neo-classical market model also assumes perfect information, but undiversifiable risk and uncertainty violate this assumption. Risk implies that the relative likelihood of alternative outcomes is known, while uncertainty is akin to ignorance - it is impossible to specify probabilities of potential outcomes. Market failure occurs where there are no mechanisms for diversifying or hedging risk, or if absolute uncertainty (which cannot be hedged) prevails. Under such circumstances individuals and firms will tend to curtail their investment. Society as a whole, on the other hand, can pool and diversify risk, which suggests that it will prefer a higher level of investment. Uncertainty and risk thus drive a wedge between private and social rates of time preference. Potential solutions to these problems involve investing in information generation, creating markets to hedge risk, and reducing uncertainty over property rights and their enforcement.

Monopolies, oligopolistic cartels and monopsonies violate the neo-classical assumption of perfect competition. The lack of competition typically leads to levels of production and supply below the social optimum, a transfer of welfare to the monopolist or monopsonist, and a deadweight loss to society. Monopolies or monopsonies in natural resource markets are often considered benign precisely because they lead to conservative use of resources, in order to maximize scarcity rents. Tax and regulatory instruments can be used to ensure that monopolistic scarcity rents accrue to society, although public intervention more often creates conditions of imperfect competition that dissipate resource rents.

Market Failures in Tropical Forest Management

Market failure in tropical forest management can lead to privately and socially inefficient forest management in several ways.

In the absence of an enforceable system of formal property rights and tenure, forested land becomes essentially an open access resource from which no one can be excluded. Even if an individual wanted to conserve the forest, or set it aside for future use, another individual would still be able to intervene and extract timber from the plot for personal gain. In addition, the risk and uncertainty over the future availability of timber makes it difficult for an individual to exercise restraint and creates an incentive to maximize short term returns by extracting timber immediately. Thus, the individual fails to account for the 'user cost' of timber and exploits the forest in a privately inefficient manner. With the exception of more remote 'frontier' areas of tropical forests, very little forested land exploited for timber is subject to 'pure' open access conditions. However, the failure to design appropriate concession arrangements for public forest lands and insecurity of ownership can create similar conditions as the 'open access' situation. That is, concessionaires will make harvesting decisions based on short-term profit-maximizing decisions and have little regard for the potential for greater future returns from the timber stand.

If market failures leading to privately inefficient harvest levels are not corrected the powerful incentive to 'mine' tropical forests is likely to overcome any efforts to put forest managment on a socially-efficient footing. However, assuming that these failures are corrected allows a discussion of market failures that 'cause' socially inefficient forest management - i.e the presence of public goods, common pool resources and externalities; and uncertainty over the value of alternative uses of tropical forests.

The market prices of most widely traded timber products typically do not reflect the environmental costs of their production. Market prices fail to account for the degradation or loss of non-timber forest products, indirect use values (e.g. watershed protection or nutrient cycling), as well as future and non-use values (e.g. option value or existence values), that occurs during timber harvesting. When such costs are consistently ignored throughout an industry, prevailing market prices will tend to fall below the socially optimal level, leading to excessive exploitation.

The root cause of this problem may be subdivided according to whether or not the alternative uses are primarily on-site or off-site uses. Logging companies, for example, may neglect the impact of their activities on local non-timber uses of the forest. This may occur due to a lack of information on the part of logging companies of the potential gains from these forest uses. This is in part a result of the lack of transparency of these uses due to their subsistence nature. The loss of subsistence value falls outside the private cost and benefit calculations of the timber firm. Where non-timber products (e.g. rattan) are of obvious commercial value they tend to be internalized into the production decision.

The benefits of tropical forests that are realized at a distance from the forest include watershed values, carbon sequestration, the use of biodiversity in biotechnology and the existence values of tropical forests.[4] Where forest managers lack the means to appropriate such values, they will tend to ignore them. It is extremely difficult to exert property rights over the off-site benefits of tropical forests, that is, it is these benefits are typically non-exclusive public goods or common pool resources. The appropriation problem is made even more difficult in the case of timber concessions where the operator has only use rights - not ownership rights. As a result the market provides little incentive

[4]Existence values are those benefits of a resource that are completely divorced from the physical use of the resource.

for concessionaires to internalize the social costs that may be incurred by the degradation of these off-site values.

Imperfect competition in the forestry industry can also have important effects on forest management. Barriers to entry and exit can prevent the most efficient firms from operating in the industry, thus leading the industry as a whole to extract more timber than necessary to provide a given supply of products. Inefficiencies in the processing sector are particularly damaging in this respect, as they directly impact on the scale of timber exploitation through poor log conversion rates and overexpanded capacity. Imperfect competition and information may also have implications in terms of failure to improve or adopt technologies and forest management practices that minimize forest depletion and environmental degradation.

In sum, market failure is likely to be a root cause of failure to attain private and socially efficient harvest levels in tropical timber producing countries. The existence of market failure is usually cited as the primary justification for intervention in the marketplace whether in the form of public or collective action. Intervention to redress market failure may involve regulation, economic incentives or institution-building. An important caveat, however, is that intervention is only justified if the cost of correcting market imperfections does not exceed the potential welfare benefits. In other words, policy interventions should yield net benefits or else they are not worth undertaking from an economic perspective.

References

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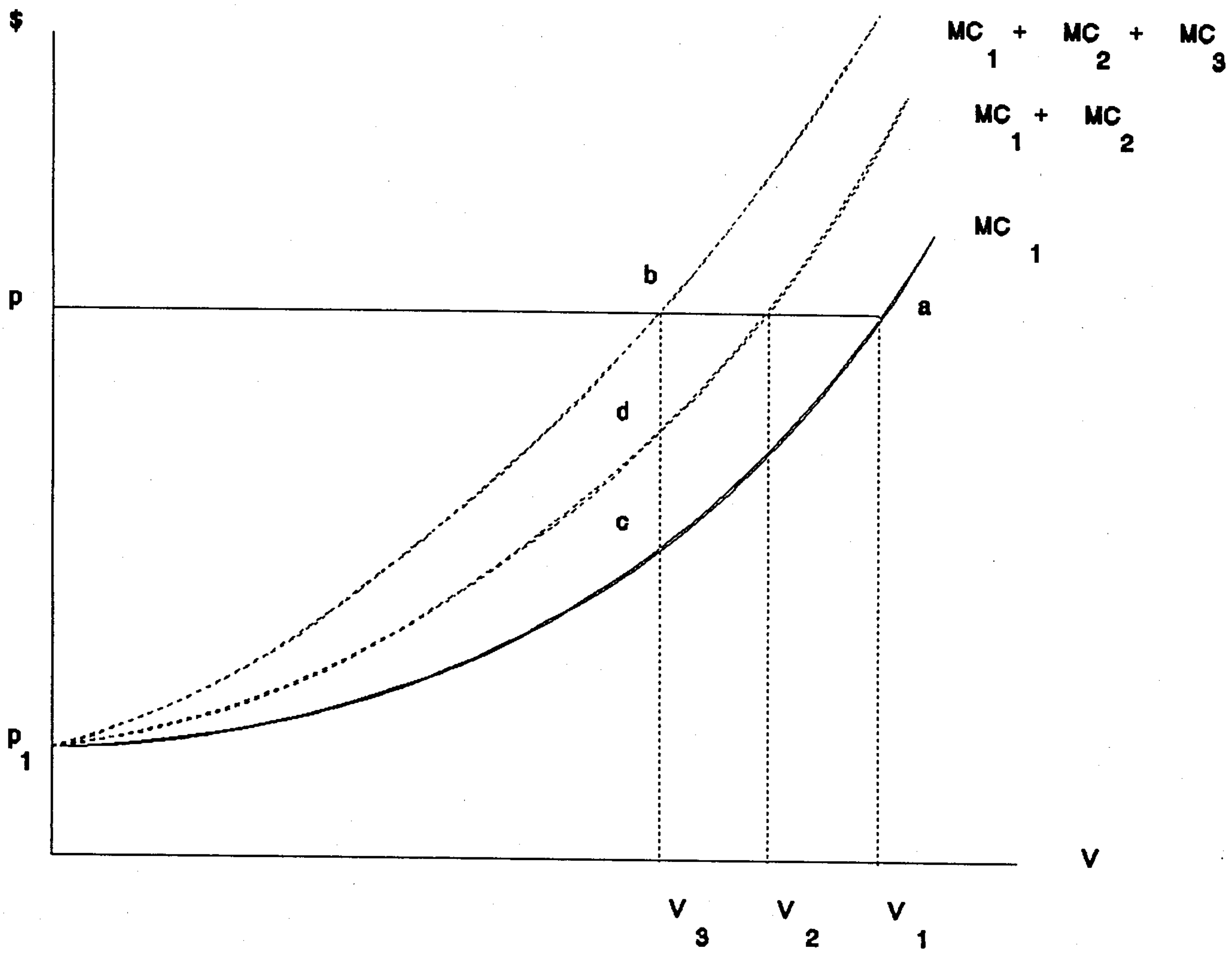
Figure E.1 Social and Private Harvesting Decisions



p = competitive price for delivered logs

V = harvest volume

MC = timber concessionaire's marginal cost curve for delivered logs

Source: Hyde, Newman and Sedjo (1991)

ANNEX F

CONGO - CASE STUDY OF CONGOLAISE INDUSTRIELLE DES BOIS

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Congo - Case Study of Congolaise Industrielle Des Bois[1]

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The following case study illustrates how a government policy - e.g. the requirement that the majority of timber produced by a concession be transformed into sawnwood - can be undermined by poor transport infrastructure and policies that make the export of sawnwood unprofitable for the concession. A particularly striking feature of this example is that the company is attempting to operate the concession following sustainable management practices, but current policies and economic conditions are hindering these efforts.

In Northeastern Congo, near the borders with Cameroon and the Central African Republic, the private foreign-owned company Congolaise Industrielle des Bois (CIB) operates a concession at Pokola of around 480,000 hectares (ha). Around 300,000 ha of the concession has been previously logged or is too swampy to use. Logging has occurred over the past 40 years, but with a comparatively small annual volume during the first 20 years. In 1992, the potential timber yield of the remaining 180,000 ha was estimated to be over 2 million m^3 (about 10 to 15 m^3/ha). CIB is attempting to operate this concession on a sustained-yield basis, following recommended management practices based on a 30-year rotation.

Annual production is currently targetted at about 140,000 m^3 of logs, of which 80% is the species *sapelli*, 10% is *sipo* and the remainder is a mix of *ayous* (mainly) and other varieties (e.g. *wengue, doussié*). However, in 1991 logging was stopped from the middle of March to the middle of July due to poor export demand (the loss of the East European sawnwood market). Total production of logs therefore totalled only 111,639 m^3, with 40,471 m^3 of the logs exported and 71,168 m^3 sawn in Pokola. Of the latter, 33,107 m^3 of sawnwood were exported and 21,613 m^3 were sold for use in the Congo.

A high percentage of the concession's log production is sawn into lumber because of the Government of Congo (GoC) regulation that a timber concession must operate a sawmill on site and that 60% of log production must be processed. However, given current export conditions, the ability of the concession to conform to this regulation and export sawnwood at a financial profit is being hindered by high transport costs. The latter arise from the poor infrastructure in the Congo for transporting timber products long distances and government-administered transportation charges and taxes (see Tables 1 and 2). Both logs and sawnwood have to be transported 900 km by river and 600 km by rail before they reach Point Noire and can be exported. Given the high cost of the government-run river transport service (ATC), the company has often found it cheaper to use their own or alternative means of transportation. However, CIB cannot avoid government river taxes

[1] I am grateful to Henry Stoll and Marc Prevost of Tropical Timber SA, Bâle and Jean-Marie Mevellec of CIB for assistance in preparing and reviewing the figures presented in this annex.

or port duties, and it must rely on the government-run railroad (CFCO) to transport sawnwood and logs to Point Noire.

Table 1a shows the actual costs and export values obtained for *sapelli* exported logs in 1991. Transport costs accounted for as much as 60-65% of the total f.o.b. costs of log production. A financial return was possible only if CIB used its own barges or transported logs as rafts. Low river water and high levels of production during the dry season often mean CIB must rely on government or private-run barges as alternative means of transport. As of January 1 1992, the GoC raised river transport taxes and freight charges, along with railroad freight fares. Table 1b shows the effects of these cost changes on CIB's returns, using 1991 average export f.o.b. unit values. By using rafts and its own barges, CIB might still manage to make some profit on exporting logs, but the margins are reduced significantly. Renting other barges becomes even more unprofitable.

In comparison, Table 2a indicates the actual costs and export prices for *sapelli* sawnwood produced by the CIB concession. Although transport costs as a proportion of total f.o.b. costs are lower (e.g. 25-30%) than for logs, this proportion is still substantial. The result is that exporting sawnwood is unprofitable for the concession. Moreover, the loss is greatest if transported downriver by the government-run service, and the least if CIB transports the sawnwood itself. The higher transport charges and taxes raise the proportionate share of transportation costs (i.e. to 30-35%) and further increase the losses from sawnwood exports (see Table 2b). For example, according to Table 2b, average export unit values would have to rise by approximately 5-15% in 1992 to make sawnwood exports financially profitable. This is extremely unlikely, as unfavourable market conditions continue to plague the concession. Log production in 1992 was targetted at 145,767 m^3. However, production has had to be suspended indefinitely due to falling demand and poor price trends that have made operations unprofitable, given the high costs involved.

In sum, the regulation requiring CIB to produce 60% of its timber as sawnwood is not financially realistic, given existing export market conditions and government transport infrastructure, charges and taxes. The regulation may backfire as a strategy to increase government revenues and stimulate value-added processing, unless transportation costs for sawnwood can be drastically reduced through increasing infrastructure investments or reducing taxes and charges. Out of the four timber concessions recently operating in Northern Congo, CIB is the only one with operations still in place. CIB may also be forced out of the export market, particularly for sawnwood, if current trends in transport costs are not reversed.

Table F.1 Congo - Costs and Taxes Incurred in Transporting Sapelli Logs from CIB's Concession at Pokola

CFA per cubic metre
(283 CFA = US$ 1)

A. Actual Costs in 1991

	Beach	River Transport Costs b/			Rail Transport Costs c/			Port Costs d/			Total Transport Costs	Total Costs	1991 Average Export Price
	Costs a/	Taxes e/	Freight	Total	Loading	Freight	Total	Loading	Tax	Total	FOB	FOB	FOB
ATC Barges f/	21,000	2,503	13,810	16,313	3,102	9,679	12,781	7,541	500	8,041	37,135	58,135	57,553
Delacour Barges g/	21,000	2,503	13,977	16,480	3,102	9,679	12,781	7,541	500	8,041	37,302	58,302	57,553
CIB Barges	21,000	2,503	7,700	10,203	3,102	9,679	12,781	7,541	500	8,041	31,025	52,025	57,553
ATC Rafts f/	21,000	2,361	6,686	9,047	3,835	9,679	13,514	7,541	500	8,041	30,602	51,602	57,553
CIB Rafts	21,000	2,361	7,700	10,061	3,835	9,679	13,514	7,541	500	8,041	31,616	52,616	57,553

B. Projected Costs in 1992 (After Price and Tax Changes)

	Beach	River Transport Costs b/			Rail Transport Costs c/			Port Costs d/			Total Transport Costs	Total Costs	1991 Average Export Price
	Costs a/	Taxes e/	Freight	Total	Loading	Freight	Total	Loading	Tax	Total	FOB	FOB	FOB
ATC Barges f/	21,000	2,656	14,589	17,245	3,102	12,218	15,320	7,541	500	8,041	40,606	61,606	57,553
Delacour Barges g/	21,000	2,656	13,977	16,633	3,102	12,218	15,320	7,541	500	8,041	39,994	60,994	57,553
CIB Barges	21,000	2,656	7,700	10,356	3,102	12,218	15,320	7,541	500	8,041	33,717	54,717	57,553
ATC Rafts f/	21,000	2,758	7,235	9,993	3,835	12,218	16,053	7,541	500	8,041	34,087	55,087	57,553
CIB Rafts	21,000	2,758	7,700	10,458	3,835	12,218	16,053	7,541	500	8,041	34,552	55,552	57,553

Notes:

a/ Costs of harvesting, transporting and loading logs at concession port (Pokola)
b/ Pokola to Brazaville, approximately 900 km.
c/ Brazaville to Point Noire, approximately 600 km.
d/ Point Noire Port
e/ River tax and port duty.
f/ Government of Congo River Transport Company
g/ Private River Transport Company

Source: Congolaise Industrielle des Bois (CIB).

Table F.2 Congo - Costs and Taxes Incurred in Transporting Sapelli Sawnwood from CIB 's Concession at Pokola

CFA per cubic metre
(283 CFA = US$ 1)

A. Actual Costs in 1991

	Beach Costs a/	River Transport Costs b/ Taxes e/	Freight	Total	Rail Transport Costs c/ Loading	Freight	Total	Port Costs d/ Fees	Tax	Total	Total Transport Costs FOB	Total Costs FOB	1991 Average Export Price FOB
Non-Container													
ATC f/	90,000	2,491	13,978	16,469	8,993	9,141	18,134	2,500	500	3,000	37,603	127,603	121,036
Delacour g/	90,000	2,396	12,094	14,490	9,173	9,141	18,314	2,500	500	3,000	35,804	125,804	121,036
Mossimbi g/	90,000	2,396	11,900	14,296	9,173	9,141	18,314	2,500	500	3,000	35,610	125,610	121,036
CIB	90,000	2,396	7,700	10,096	9,173	9,141	18,314	2,500	500	3,000	31,410	121,410	121,036
Container													
ATC f/	90,000	2,491	13,978	16,469	7,979	9,141	17,120	2,500	500	3,000	36,589	126,589	121,036
Delacour g/	90,000	2,396	12,094	14,490	7,533	9,141	16,674	2,500	500	3,000	34,164	124,164	121,036
Mossimbi g/	90,000	2,396	11,900	14,296	7,533	9,141	16,674	2,500	500	3,000	33,970	123,970	121,036
CIB	90,000	2,396	7,700	10,096	7,533	9,141	16,674	2,500	500	3,000	29,770	119,770	121,036

B. Projected Costs in 1992 (After Price and Tax Changes)

	Beach Costs a/	River Transport Costs b/ Taxes e/	Freight	Total	Rail Transport Costs c/ Loading	Freight	Total	Port Costs d/ Fees	Tax	Total	Total Transport FOB	Total Costs FOB	1991 Average Export FOB
Non-Container													
ATC f/	90,000	2,820	16,919	19,739	10,831	12,389	23,220	3,700	500	4,200	47,159	137,159	121,036
Delacour g/	90,000	2,725	12,094	14,819	11,011	12,389	23,400	3,700	500	4,200	42,419	132,419	121,036
Mossimbi g/	90,000	2,725	11,900	14,625	11,011	12,389	23,400	3,700	500	4,200	42,225	132,225	121,036
CIB	90,000	2,725	7,700	10,425	11,011	12,389	23,400	3,700	500	4,200	38,025	128,025	121,036
Container													
ATC f/	90,000	2,820	16,919	19,739	9,817	12,389	22,206	3,700	500	4,200	46,145	136,145	121,036
Delacour g/	90,000	2,725	12,094	14,819	9,371	12,389	21,760	3,700	500	4,200	40,779	130,779	121,036
Mossimbi g/	90,000	2,725	11,900	14,625	9,371	12,389	21,760	3,700	500	4,200	40,585	130,585	121,036
CIB	90,000	2,725	7,700	10,425	9,371	12,389	21,760	3,700	500	4,200	36,385	126,385	121,036

Notes:

a/ Costs of harvesting, transporting and processing at concession port (Pokola). In 1991, forest production was halted for 5 months and sawmilling for 3 months. During a normal production year, beach costs would be around CFA 85,000.

b/ Pokola to Brazaville, approximately 900 km.

c/ Brazaville to Point Noire, approximately 600 km.

d/ Point Noire Port. Fees include FOB port costs and taxes.

e/ River tax and port duty.

f/ Government of Congo River Transport Company

g/ Private River Transport Company

Source: Congolaise Industrielle des Bois (CIB).

ANNEX G

TARIFF RATES ON TIMBER PRODUCTS IN SELECTED COUNTRIES

J. Bourke*

* Forest Products Division, Food and Agriculture Organiztaion of the United Nations.

ANNEX G. IMPORT TARIFF RATES: RECENT CHANGES IN SELECTED COUNTRIES (% Ad Valorum)

CCCN Tariff No.	Description	AUSTRALIA a/ 1986 MFN	AUSTRALIA a/ 1986 GSP	AUSTRALIA a/ 1992 MFN	AUSTRALIA a/ 1992 GSP	CANADA b/ 1986 MFN	CANADA b/ 1986 GSP	CANADA b/ 1992 MFN	CANADA b/ 1992 GSP	EEC a/ 1986 MFN	EEC a/ 1986 GSP	EEC a/ 1992 MFN	EEC a/ 1992 GSP
44.03	Wood in rough (ie logs) whether or not roughly squared	0.0		0.0		0.0		0.0		0.0		0.0	
44.07	Wood sawn lengthwise sliced or peeled or planed	2,5,15	0.0	10.0 C 5,10 NC	5.0 C 5.0 NC	0.0 C 1.3 NC		0.0		4.3	[0]	0-4.9 c/	[0]
44.08	Veneer	5.0		5.0	0.0	na	na	0.0		6.1	[0]	4-6	[0]
44.09	Wood-tongued,grooved, beadings, mouldings, etc.	15.0		10.0	5.0	6.8	5.0	0.0		3.6	0.0	3,4 C 2.5 NC	0.0 0.0
44.12	Plywood and laminated wood	28.0		15.0	10.0	15.0 C 9.8 NC	10.0 C 9.0 NC	15.0 C 8,9.2 NC	10.0 C 5,6 NC	[10.4]	[0]	10.0	[0] d/
44.15	Packing cases, drums, pallets, etc.	15.0	0.0	10.0	5.0	15.0	10.0	15.0	10.0	6.9,7.5	0.0	4.9,7.5	0.0
44.18	Builders' joinery and carpentry	15.0	0.0	na	na	0-15	0-8.5	6.2-12.5	0-8	2.6-9.1	[0]	3-6	[0]
94.01/03	Furniture	30.0	[20]	15.0	10.0	15.0	12.5	15.0	10.0	5.6,6.3	[0]	5.6	[0]

Source: from Bourke (1992a) based on Country tariff schedules; Bulletin International des Douanes. Prepared June 1992.

Notes: CCCN = Customs Cooperation Council Nomenclature
MFN = Most Favoured Nation; GSP = Generalised System of Preferences
C = coniferous; NC = non-coniferous

a/ Preferential agreements exist for some countries or regions in addition to the GSP. Rates are being reduced gradually up to 1996.
b/ Lower rates for USA.
c/ For tropical genera the rate is 0-2.5%; for coniferous products the rate is 0-4.9% Finger joint is subject to a higher rate.
d/ Coniferous plywood quota = 650 000 m3. Over the quota a 10% duty applies. The quota is not allocated to specific countries.
[] Quantitative restrictions also exist.

ANNEX G. IMPORT TARIFF RATES: RECENT CHANGES IN SELECTED COUNTRIES (% Ad Valorum)

CCCN		JAPAN				NEW ZEALAND				USA			
		1986		1992		1986		1992		1986		1992	
Tariff No.	Description	MFN	GSP	MFN	GSP	MFN	GSP	MFN	GSP	MFN	GSP	MFN	GSP
44.03	Wood in rough (ie logs) whether or not roughly squared	0.0		0.0		0.0		0.0		0.0		0.0	
44.07	Wood sawn lengthwise sliced or peeled or planed	0-10 C e/ 10 NC	0.0 5.0	4.8-8 C e/ 0,10 NC f	0.0 [0]	10.0	0.0	7.5 C i/ 0-8 NC	0.0 0.0	0-2.5	[0]	0.0	
44.08	Veneer	15.0	[0,7.5]	5.0	[2.5]	30.0	20.0	7.5,16 C 7.5,16 NC	0,13 0,12	0.0		0.0	
44.09	Wood-tongued,grooved, beadings, mouldings, etc.	7.2	0.0	4.8-8 C 4.8-10 NC	0.0 0.0	20.0	10.0	8,13.5	0,10	0-2.5	0.0	0.0	
44.12	Plywood and laminated wood	15 C 17,20 NC	--	10,15 g/	--	na 35.0 NC	na 25.0 NC	12.5,16	10,13	20.0 C 3.6-9.5 NC	0.0 C 0-8 NC	20.0 C 8.0 NC	0.0 C 0.0 NC
44.15	Packing cases, drums, pallets, etc.	4.2	0.0	3.4,10	0.0	0,10	0.0	16.0	13.0	0-17	0.0	10.0	5.0
44.18	Builders' joinery and carpentry	2.5-7.2	[0]	0,3.9 h/	[0]	20.0	10.0	14.5	10.0	0-8	0.0	5.1,7.5	0.0
94.01/03	Furniture	4.8	[0]	0.0	[0]	40.0	22.5	17.0	13.5	2.8-5.8	[0]	2.5-6.6	0.0

Source: from Bourke (1992a) based on Country tariff schedules; Bulletin International des Douanes. Prepared June 1992.

Notes: CCCN = Customs Cooperation Council Nomenclature
MFN = Most Favoured Nation; GSP = Generalised System of Preferences
C = coniferous; NC = non-coniferous

e/ In contrast to other softwoods some of the main North American species are free of duty.
f/ Planed 10(0); Other 10(5)
g/ Less than 6mm rate = 15%; more than 6mm rate = 10%; laminated 15([0])
h/ Windows/doors rate = 0%; shutter rate = 3.9%
i/ Sanded, finger joint rate = 16%; some species including Radiata rate = 0%
-- No preferential rate.
[] Quantitative restrictions also exist.

ANNEX G. IMPORT TARIFF RATES: RECENT CHANGES IN SELECTED COUNTRIES (% Ad Valorum)

CCCN Tariff No.		Brazil j/	China k/	Indonesia		Korea l/		Malaysia n/	
		1991	1991	1986	1991	1986	1992	1986	1991
44.03	Wood in rough (ie logs) whether or not roughly squared	0.0	3.0	15.0	0.0	20.0 C 10.0 NC	1.5	20.0	20.0
44.07	Wood sawn lengthwise sliced or peeled or planed	10.0	9.0	15.0	15.0	20.0	[7] m/	20.0	20.0
44.08	Veneer	10.0	12-30	20.0 C 10-20 NC	20.0	20.0 C 10-20 NC	7.0	0,45	0,25
44.09	Wood-tongued,grooved, beadings, mouldings, etc.	10.0	40.0	30.0	20.0	30.0	9.0	25.0	25.0
44.12	Plywood and laminated wood	10.0	20.0	30.0	30.0	30.0	15.0	25.0	25.0
44.15	Packing cases, drums, pallets, etc.	10.0	60.0	?	30.0	?	9.0	25.0	25.0
44.18	Builders' joinery and carpentry	10.0	50.0	30.0	30.0	40.0	9.0	25.0	25.0
94.01/03	Furniture	0.0 25, 40	80.0	50.0	40.0	50.0	9.0	55,60	40.0

Source: from Bourke (1992a) based on Country tariff schedules; Bulletin International des Douanes. Prepared June 1992.

Notes: CCCN = Customs Cooperation Council Nomenclature
C = coniferous; NC = non-coniferous
Members of the ASEAN group (Indonesia, Malaysia, Philippines, Singapore and Thailand) grant special rates to other members. For example, Malaysia grants a 20% exemption from import duty on products in Categories 44 and 94, and full exemption for many items in Category 47.

j/ Many rates are programmed to fall in 1992.
k/ Additional taxes are applied to these rates - e.g. customs collects domestic taxes during importation, as follows:
PVT =(CIF+import duty/1-pvt x pvt rate)
ICCT =(CIF+import duty/1-icct x icct rate)
There are also foreign exchange controls.
l/ Programmed reductions to 1994.
m/ Above 127,000 m3 quota 9% duty applies.
n/ Some products also subject to sales tax of 10%. Countries may differ; in some cases higher rates apply.
-- No preferential rate.
[] Quantitative restrictions also exist.

ANNEX H

TROPICAL TIMBER TRADE POLICIES AND DEFORESTATION
A THEORETICAL APPROACH

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Tropical Timber Trade Policies and Deforestation
A Theoretical Approach*

1. Introduction

Concerns about tropical deforestation have led to an increased focus on the role of the timber trade in promoting forest depletion and degradation. Recent reports suggest a marked increased in tropical deforestation in the 1980s, with the overall rate doubling from 0.6% in 1980 to 1.2% in 1990 (Dembner 1991). However, the deforestation rate varies across regions, with an estimated annual rate for Latin America of only 0.9% compared with 1.7% for Africa and 1.4% for Asia.

Despite concern over the state of tropical deforestation and its implications for global welfare, several recent studies have indicated that the tropical timber trade is not the major *direct* cause of the problem - perhaps less than 10% of total deforestation - whereas conversion of forests for agriculture is much more significant (Amelung 1991; Barbier *et al.* 1992; Binkley and Vincent 1991; Hyde and Newman 1991). Nevertheless, it is clear that current levels of timber extraction in tropical forests - both open and closed - exceed the rate of reforestation (WRI 1992). Less than one million hectares, out of an estimated total global area of 828 million hectares of productive tropical forest in 1985, was under sustained-yield management for timber production (Poore *et al.* 1989). Moreover, timber extraction has a major *indirect* role in promoting tropical deforestation by opening up previously unexploited forest, which then allows other economic uses of the forests such as agricultural conversion to take place (Amelung 1991; Barbier *et al.* 1991). For example, in many African producer countries, around half of the area that is initially logged is subsequently deforested, while there is little, if any, deforestation of previously unlogged forested land (Rietbergen 1990).

Some of the environmental values lost through timber exploitation and depletion, such as watershed protection, non-timber forest products, recreational values, etc., may affect only populations in the countries producing the timber. Concerned domestic policymakers in tropical forest countries should therefore determine whether the benefits of incorporating these environmental values into decisions affecting timber exploitation balance the costs of reduced timber production and trade, as well as the costs of implementing such policies. The socially 'optimal' level of timber exploitation and trade is one where the additional domestic environmental costs of logging the forests are 'internalized' in production decisions, where feasible. Designing policies to control excessive forest degradation is clearly complex and requires careful attention to harvesting incentives. As recent reviews suggest, many domestic policies do not even begin to approximate the appropriate incentives required to achieve a socially optimal level of timber harvesting. More often than not, pricing, investment and institutional policies for forestry actually work to *create* the conditions for short-term

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harvesting by private concessionaires, and in some instances, even *subsidize* private harvesting at inefficient levels.[1] Over the long term, incentive distortions that understate stumpage values and fail to reflect increasing scarcity as old growth forests are depleted can undermine the transition of the forestry sector from dependence on old growth to secondary forests and the coordination of processing capacity with timber stocks (Binkley and Vincent 1991).

Increasingly the world's tropical forests, including their remaining timber reserves, are also considered to provide important 'global' values, such as a major 'store' of carbon and as a depository of a large share of the world's biological diversity (Pearce 1990; Reid and Miller 1989). Similarly, even some 'regional' environmental functions of tropical forests, such as protection of major watersheds, may have transboundary 'spillover' effects into more than one country. But precisely because such transboundary and global environmental benefits accrue to individuals outside of the countries exploiting forests for timber, it is unlikely that such countries will have the incentive to incur the additional costs of incorporating the more 'global' environmental values in forest management decisions. Not surprisingly, sanctions and other interventions in the timber trade are one means by which other countries may seek to coerce timber producing countries into reducing forest exploitation and the subsequent loss of environmental values. In addition, trade measures are increasingly being explored as part of multilateral negotiations and agreements to control excessive forest depletion, to encourage 'sustainable' timber management and to raise compensatory financing for timber producing countries that lose substantial revenues and incur additional costs in changing their forest policy.

However well-intentioned they may be, both domestic and international environmental regulations and policies that attempt to 'correct' forest management decisions may have high economic, and even 'second order' environmental, costs associated with them (Barbier *et al.* 1992). There is increasing concern that the potential trade impacts of environmental policies that affect forestry and forest-based industries may increase inefficiencies and reduce international competitiveness. Moreover, the trade impacts of domestic environmental regulations may affect industries in other countries and lead to substantial distortions in the international timber trade. The overall effect on the profitability and efficiency of forest industries may be to encourage forest management practices that are far from 'sustainable'. Careful analysis of both domestic and international environmental policies affecting forest sector production and trade is therefore necessary to determine what the full economic and environmental effects of such policies might be.

The following model has been developed to facilitate analysis of the impact of policy interventions, market structure and transfers on a timber-exporting tropical forest country. The main focus of the analysis is on how these impacts relate to the country's decisions to produce timber, or processed goods that are based on timber extraction, and thus the rate of tropical deforestation. The model is similar to the one developed by Rauscher (1990), but it differs in two important respects. First, timber products can either be exported or consumed domestically, and the export earnings are used to import domestic consumption goods from abroad. This facilitates analysis of the *trade diversion* effect to domestic consumption of a policy intervention in the international timber market. Second, it is assumed that the tropical forest has positive *stock externalities* in the form of watershed protection, genetic diversity, microclimatic functions, etc. which directly affect the overall welfare of the country. The analytical results derived from the model are clearly affected by this assumption that the forest stock has some direct social value in addition to its use as a timber resource.

The model is simplified in some important respects. Domestic capital accumulation and any tropical reafforestation efforts are not modelled, and no other production or trade sectors are included, as this would complicate the analysis without providing deeper insights into the role of timber trade policy interventions in tropical deforestation. Initially, it is assumed that the country is a price taker in the international timber market and that trade is balanced. Later in the analysis we relax these assumptions to allow for market power and foreign asset accumulation (or debt). We also expand the positive stock externalities to include transfrontier global 'services', such as the role of

2. The Basic Model

For the basic model, the following variables, parameters and functions are defined:

N(t)	tropical forest stock
q(t)	tropical timber logs extracted or commodities produced (log-equivalents)[2]
x(t)	tropical timber logs/products exported (log-equivalents)
q(t) - x(t)	domestic consumption of logs/products
c(t)	consumption of imported goods
g(N(t))	regeneration function of tropical forests
a	deforestation rate, per unit of (log-equivalent) timber extracted
p	terms of trade, p_x/p_c
δ	social rate of discount

Notation is simplified by omitting the argument of time-dependent variables, by representing a derivitive of a function by a prime, by employing numbered subscripts to indicate partial derivitives of a function, and by denoting the time derivitive and growth rates of a variable by a dot and hat, respectively.

The tropical forest country is assumed to maximize the present value of future welfare, W

$$\underset{q,x,c}{\text{Max}} \; W = \int_0^\infty U(q - x, c, N)\, e^{-\delta t}\, dt \tag{1}$$

subject to

$$px = c, \tag{2}$$

$$\dot{N} = g(N) - aq, \tag{3}$$

$$N(0) = N_o \text{ and } \lim_{t\to\infty} N(t) \geq 0, \tag{4}$$

$$N^{max} > N^{min} > 0,\; g(N^{min}) = g(N^{max}) = 0, \text{ and } g''(N) < 0. \tag{5}$$

The control variables of the model are q, x and c. The additively separable utility function, U, is assumed to have the standard properties with respect to its partial derivitives, $U_i > 0$, $U_{ii} < 0$ (i = 1,2,3). Equation (2) is the initial trade balance assumption. Equations (3) to (5) are the standard renewable resource constraint, which suggest that any deforestation due to timber extraction net of regeneration will lead to a decline in the tropical forest stock.

3. Optimality Conditions

The Hamiltonian of the above optimal control problem is

$$H = U(q - x, px, N) + \lambda[g(N) - aq], \tag{6}$$

where λ is the costate variable or the shadow price of the tropical forest. Assuming an interior solution, the maximum principle yields the following conditions

$$U_1 = \lambda a, \tag{7}$$

$$U_1 = pU_2, \tag{8}$$

$$\dot{\lambda} = (\delta - g')\lambda - U_3, \tag{9}$$

where $U_1 = \partial U/\partial(q-x)$, $U_2 = \partial U/\partial c$ and $U_3 = \partial U/\partial N$. Equation (7) indicates that, along the optimal trajectory, the marginal value of extracting one unit of timber (in terms of domestic consumption), U_1, must equal its marginal depletion cost, λa. Since extraction costs are zero in the model, the latter costs are *user costs*, the future stream of timber income foregone from extracting a unit today. Equation (8) indicates that, if international terms of trade are given, the relative marginal value of domestic timber to imported good consumption must be equated with the terms of trade, p. Finally, equation (9) yields a standard renewable resource dynamic condition for denoting the change in the value of the tropical forest stock when that stock also has direct value, as represented by U_3. As this condition is important for the analytical results of our model, we state its interpretation formally as

Proposition 1

The rate of change in the shadow price of the tropical forest, $\dot{\lambda}$, is determined by the difference between the opportunity cost of holding on to a unit of the forest, $(\delta - g')\lambda$, and the marginal social value of that unit, U_3.

Since the Hamiltonian is concave in (q,x,c,N), the above conditions are also sufficient for an optimum. By combining equations (7) and (9) one obtains

$$\frac{\dot{q} - \dot{x}}{q - x} = 1/\eta_1(\delta - g' - U_3/U_1), \tag{10}$$

where η_1 is the elasticity of marginal utility, U_1. Utilizing (10) and conditions (3), (4), (5), (7) and (8), one can solve for an optimal saddle path and the long run equilibrium. As the system is in equilbrium when the user costs, the felling rate, domestic and imported consumption and the forest stock are constant, the equilibrium can be characterized by the following system of equations

$$U_1 - pU_2 = 0, \tag{11}$$

$$(\delta - g')U_1 - aU_3 = 0 \quad \text{for} \quad \dot{q} = \dot{x} = 0, \tag{12}$$

$$g(N^*) - aq^* = 0, \qquad \text{for} \quad \dot{N} = 0, \tag{13}$$

where the equilbrium values of N and q are denoted by asterisks. Total differentiation of the system of equations (11) - (13) with respect to (q,x,N) can lead to characterization of the equilibrium state and trajectories leading to that state. It can be demonstrated that the determinant D of the Jacobian matrix of above system must be negative in order for there to be a unique equilibrium in (q,N) space; i.e., the requirement for the curve $\dot{q} = 0$ to be positively sloped and to cut the curve $\dot{N} = 0$ from below is that $D < 0$ (see Appendix). This implies that the equilibrium is a saddle point, and the saddle path is positively sloped. Using these results, the optimal solution is represented graphically in Figure 1. The solution suggests

Proposition 2

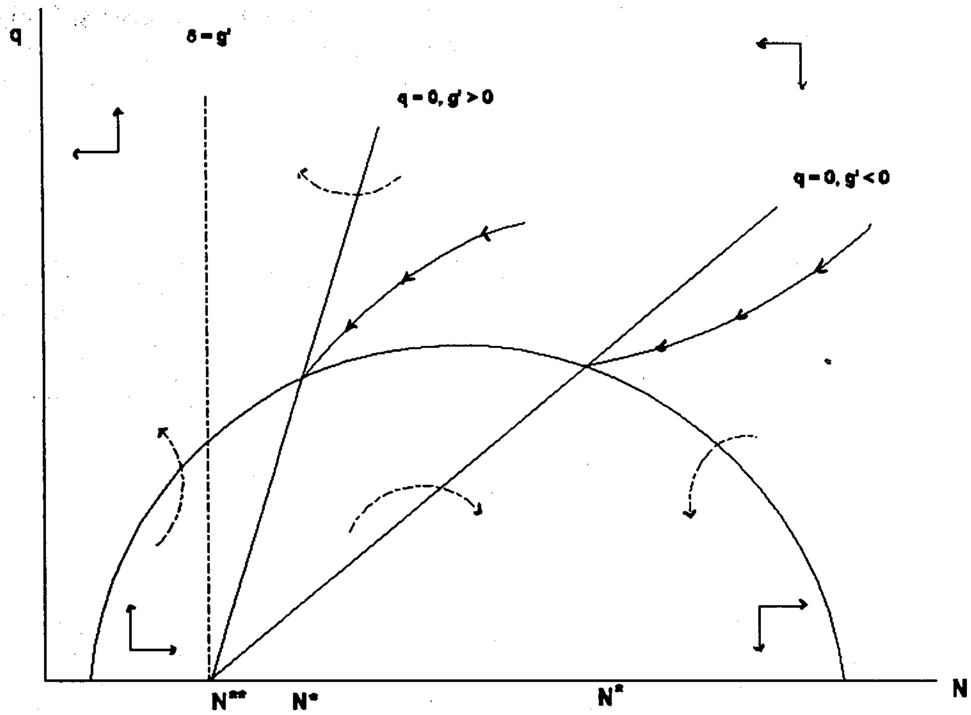
The equilibrium forest stock, N^*, is determined by the rate of return on other assets in the economy, δ, and the rate of return from holding on to the forest stock, $g'(N^*) + aU_3/U_1$. The equilibrium will occur to the left of the maximum sustainable yield (MSY) if $g'(N^*) > 0$, and it will occur to the right of the MSY if $g'(N^*) < 0$.

Thus, as depicted in Figure 1, if the initial level of the forest stock is high (i.e. $N_o > N^*$), then the economy will deforest some of this stock through timber extraction.

Moreover, equations (11) - (13) also imply

Proposition 2a

Figure 1. The Long Run Equilibrium of the Tropical Forest Economy



If $U_3 = 0$, then the equilibrium forest stock, N^{**}, is determined by $\delta = g' > 0$.

As shown in Figure 1, it must follow that $N^{**} < N^{*}$. That is, if the economy values only tropical timber then it will tolerate a lower level of tropcial forest in the long run than if it also considers the other values provided by the forest.

4. Comparative Static Analysis: Trade Interventions vs. Transfers

Comparative static analysis of the long run equilibrium can be employed to indicate what impacts that reductions in the terms of trade for tropical timber and forest products, either through import bans, tariffs or other controls, may have on the tropical forest country's decision to deforest. As noted, the model already suggests that the tropical forest has positive *domestic* externalities in the form of watershed protection, genetic diversity, microclimatic functions, etc. which directly affect the overall welfare of the country. However, the *international* externalities, such as the role of the forests as a 'store' of biodiversity and carbon and their 'macro' climatic functions, are essentially ignored by domestic policymakers. Thus it can be assumed that intervention in the global timber market is motivated by the international community - notably tropical timber importers - attempting to force the country to 'internalize' the global values ascribed to its tropical forest that are lost through the deplection arising from timber production.

A ban on tropical timber imports or the imposition of import taxes that discriminate against trade in tropical timber reduces the terms of trade. In the model, a reduction in the terms of trade, p, has the following impacts on the long run equilibrium forest stock of the timber exporting country

$$\frac{dN^*}{dp} = \frac{[1 + \eta_2]U_2 [-a(\delta - g')U_{11}]}{D}, \tag{14}$$

where η_2 is the elasticity of marginal utility, U_2, with respect to imported consumption goods. If η_2 is large, then marginal welfare in the economy is highly responsive to a change in imported consumption goods, c. We characterize this condition as 'import dependency'. The following proposition therefore results from (14)

Proposition 3

A decrease in the terms of trade, p, will actually reduce the long-run equilibrium forest stock, N^*, if the country is import dependent ($|\eta_2| > 1$).

This would suggest that the use of timber trade interventions by importing countries may under certain economic conditions be counter-productive in their effects. Timber exporting countries may not always respond by reducing exploitation of their forests; rather, as indicated in our model import dependency and other economic considerations may lead to the opposite result in the long run.

The 'second best' nature of trade inerventions can be further seen through the effects of reducing the terms of trade on the long run level of timber extraction and exports

$$\frac{dq^*}{dp} = \frac{-(U_2 + pxU_{22})g'(\delta - g')U_{11}}{D} \qquad (15)$$

$$\frac{dx^*}{dq} = \frac{[1 + \eta_2]U_2[a(g''U_1 + aU_{33}) - g'(\delta - g')U_{11}]}{D} \qquad (16)$$

Changes in timber extraction and exports will clearly depend not only on the degree of import dependency as represented by η_2 but also on the relationship of the original equilbrium forest stock, N^*, with respect to the MSY (see Proposition 2 and Figure 1). The effects are summarized in the following table

	$\lvert\eta_2\rvert > 1$	$\lvert\eta_2\rvert < 1$
$g' > 0$	$dq^*/dp > 0$	$dq^*/dp < 0$
	dx^*/dp ?	dx^*/dp ?
$g' < 0$	$dq^*/dp < 0$	$dq^*/dp > 0$
	$dx^*/dp < 0$	$dx^*/dp > 0$

If trade interventions by importing countries do not always achieve the desired effect of encouraging timber exporting nations to reduce exploitation of their tropical forest stock, then an alternative policy may be the provision of an 'international transfer' of funds to encourage exporting countries to forego the income earned from forest exploitation. Essentially, the rest of the world is 'subsidizing' tropical forest countries to conserve rather than cut down their trees. For example, Agenda 21 of the UN Conference on Environment and Development has estimated that international financing of over US$1.5 billion annually will be required by tropical forest countries to reduce deforestation (ITTC 1992).[3]

A large transfer of international funds to tropical forest countries to assist with sustainable forest management and forest conservation has the effect of 'freeing up' domestic financial resources for other purposes. In our model, an international transfer or subsidy can be represented by an increase in foreign exchange available for consumption of imported goods; i.e., it supplements timber export earnings. Thus (2) now becomes

$$px + s = c, \qquad (2)'$$

where s is the amount of the international transfer, or subsidy. The comparative statics of equation (11) in the system (11) to (13) becomes

$$U_{11}dq + [-U_{11} - p^2U_{22}]dx = pU_{22}ds. \tag{17}$$

Thus an increase in international transfers, s, has the following impact on the long-run equilibrium forest stock, N*

$$\frac{dN^*}{ds} = \frac{pU_{22}[- a(\delta - g')U_{11}]}{D} > 0. \tag{18}$$

The following proposition therefore holds

Proposition 4

A direct international transfer, s, will increase the long run equilbrium forest stock, N, unambiguously.*

In comparing Propositions 3 and 4, it is clear that the comparative statics of the long run equilibrum clearly favour international transfers as the preferred method of inducing tropical timber exporting countries to conserve their tropical forests.

5. The Large Country Exporter

The above model has assumed that the timber exporting country is a price-taker in the international market; that is, as one of many tropical timber exporters, the country is unable to affect the world price of traded tropical timber products through changing its own level of production and export of timber products.

However, currently some tropical timber exporters, particularly the major South East Asian producers (e.g., Malaysia and Indonesia), dominate the international markets in certain tropical timber products. Other countries (e.g. Brazil, Zaire and Papua New Guinea) have the potential also to become large-scale producers and exporters (Barbier *et al.* 1992). The ability of these large-country exporters to use their apparent market power to influence global prices for their timber products depends to a large exent on the availability of alternative supplies, e.g. from both other tropical and temperate forest regions, and on end-use substitution between tropical timber products from different sources, between tropical and temperate timber products and between timber and non-timber substitutes (e.g., aluminum, concrete, plastics, ceramics, etc.). Some analysts suggest that global supplies of timber are more than adequate even in the long run, and that the shift in production from 'old growth' to secondary forests could rule out the possibility of even large tropical timber producers of asserting any market power (Sedjo and Lyons 1990). Others have indicated that, while there is always scope for greater substitutibility between tropical timber and other products in the long run, substitution for some tropical timber products in major importing markets may be more problematic in the short run (Buongiorno and Manarung 1992; Vincent, Brooks and Gandapur 1991). Finally, Rauscher (1990) has shown that, at least theoretically, the 'cartelization' of a group of tropical timber exporters could lead to significant market power and greater conservation of their tropical forests.

As the possibility of a large country exporter (or group of exporters) of tropical timber products influencing international prices cannot be definitely ruled out, it is worth exploring the potential impacts further.

In our model, if a large country exporter is able to influence prices then

$$x = x(p), \quad \text{with } x'(p) < 0 \text{ and } x''(p) > 0. \tag{19}$$

(11) now becomes

$$U_2 p(1 + 1/\epsilon) = U_1, \qquad \text{where } \epsilon = x'(p)p/x. \tag{11'}$$

The Appendix indicates that the determinant D of the Jacobian matrix of the modified simultaneous system (11)', (12) and (13) is less than zero, which is again a necessary condition for a unique equilibrium. If this is the case then

$$\frac{dN^*}{d(1/\epsilon)} = \frac{pU_2(-a(\delta - g')U_{11}x'(p)}{D} > 0. \tag{20}$$

Proposition 5

An increase in market power, $1/\epsilon$, of the large country exporter(s) will increase the long run equilibrium forest stock, N^*, unambiguously.

To the extent that large country exporters can increase their market power and influence international timber prices, then they can afford to conserve more of their tropical forests in the long run. Increased monopolistic power or cartelisation of tropical timber supply appears to have a resource-conserving effect.[4]

Will increased international transfers to a large country exporter also enhance forest conservation? The effects of an increased international subsidy, s, has the following impact on the long run equilibrium forest stock

$$\frac{dN^*}{ds} = \frac{p(1 + 1/\epsilon)U_{22}[-a(\delta - g')U_{11}x'(p)]}{D} > 0. \tag{21}$$

Assuming $|\epsilon| < 1$, an international transfer to a large country exporter will increase its forest stock in the long run. Thus Proposition 4 also holds for the large country exporter.

6. Foreign Assets and Debt

An initial assumption of the model was that the trade of the tropical timber exporting country is balanced. We now relax this assumption to analyse qualitatively the effects of foreign assset (or debt) accumulation. The inclusion of a foregin capital market results in an additional condition in the model

$$\dot{A} = px - c + rA, \tag{22}$$

where $A > 0$ implies accumulated foreign assets, $A < 0$ accumulated foreign debts, and r is the interest earned (or owed). In what follows, we assumed that $A > 0$.

The Hamiltonian (6) is modified to

$$H = U(q - x, c, N) + \lambda [g(N) - aq] + \mu[px - c + rA], \tag{23}$$

with μ as the costate variable representing the shadow value of foreign asset accumulation. Assuming an interior solution, the maximum principle yields the following conditions

$$U_1 = \lambda a, \tag{24}$$

$$\mu = U_2 = U_1/p, \tag{25}$$

$$\dot{\lambda} = (\delta - g')\lambda - U_3, \tag{26}$$

$$\dot{\mu} = (\delta - r)\mu . \tag{27}$$

Conditions (24) and (26) have the same interpretation as (7) and (9) before. Equation (25) is similar to (8), although now the relative marginal value of domestic timber to imported good consumption must be equated not only with with the terms of trade, p, but with the implicit value of accumulated foreign assets, μ. Condition (27) governs the rate of appreciation in the value of foreign assets, which is is determined by the opportunity cost of holding on to a unit of these assets, $(\delta - r)$.

Conditions (24)-(27) also imply that the growth rates of the variables U_1, U_2, λ and μ are equal along the optimal path, which leads to the following relationships

$$(r - g') = aU_3/U_1 > 0, \text{ and} \tag{28}$$

$$\dot{N} = \frac{(r - g')(\delta - r)}{(aU_{33}/U_1) + g''} . \tag{29}$$

Equation (28) can be interpreted as an efficiency condition. It suggests that in order for foreign assets to be an optimal form of wealth for the timber exporting country, the rate of return on these assets, r, must equal the rate of return from 'holding on' to its tropical forests, $g' + aU_3/U_1$. Otherwise, there is no point in the country extracting and exporting timber as a means to accumulating foreign assets.

Condition (29) governs the growth (or depletion) path of the tropical forest along the optimal trajectory for the economy. If the opportunity cost of holding onto foreign assets is negative, i.e. $\delta - r < 0$, then the forest stock will be allowed to expand, i.e. $\dot{N} > 0$. Moreover, the social value of accumulating foreign assets is falling, i.e. $\dot{\mu} < 0$. Effectively, the interest rate r is so large (relative to the return on other assets in the economy as represented by δ) that the economy is better off becoming a net lender of its foreign assets and reducing its timber exploitation to hold on to more forests. However, if the opportunity costs of holding assets is positive, i.e. $\delta - r > 0$, then the country will continue to exploit its tropical forests for timber and $\dot{N} < 0$.

Moreover, due to Equations (25) and (27), U_1 grows at a rate (δ - r), and this implies that the right hand side of (28) goes to zero for small discount rates and to infinity for large values of this parameter. Therefore, the very long run solution is $N = N^{max}$ in the first case, and $g' = r$ in the latter. If the discount rate is small, then the economy will save and consumption is increasing over time. The marginal utility of consumption is reduced such that the value of the tropical forest in terms of the consumption good rises. The opposite argument applies if δ is large. Then the marginal utility of consumption is increased along the optimal path, and the relative value of the forest resource declines until the pure arbitage condition $\delta = r$ holds.[5]

Thus assuming in equilibrium that $\delta = r$ and that Condition (28) will also be valid in the long run, so long as $U_3/U_1 > 0$, then the following proposition holds

Proposition 6

With a foreign capital market and positive stock externalities ($U_3 > 0$), the forest resource will never be exhausted. Equilibrium forest stock N^* will be determined by $\delta = r = g' + aU_3/U_1$, which will always be greter than the equilibrium N^{**}, as determined by $\delta = g' > 0$ in Figure 1.

The system of equations determining the equilibrium now correspond to (11)-(13) with r inserted for δ. But the second argument of the utility function is no longer px as before but px + rA. Unfortunately A is not determined. It can be computed from the starting values of A and N, which implies

$$A_o + pN_o = A + pN \qquad \text{or} \qquad A = A_o + pN_o - pN. \tag{30}$$

Using this in the comparative statics, it follows that the first-row third-column element of the first matrix in the Appendix has to be rp^2U_{22}. Thus the sign of the determinant of the Jacobian matrix D remains negative as before. Thus we obtain as

Proposition 7

The comparative static effects on the long run equilibrium forest stock, N^*, have the same signs in the borrowing-and-lending and the previous model of the timber exporting country. The magnitude of the effects may differ.

7. Conclusion

This paper has examined several aspects of the links between the trade in tropical timber and deforestation from the perspective of an exporting country. The various versions of the model developed here have highlighted a number of important features of this linkage.

First, if the producer country values its tropical forests solely as a source of timber export earnings then it will aim for a smaller forest stock in the long run than if it also considers the other values provided by the forest. Understanding the full range of benefits accuring from their tropical forests, e.g. watershed protection, genetic diversity, tourism, microclimatic functions, etc., is important to determining the direct social value of forest conservation.

Second, if importing nations want the exporting countries to conserve more of their forests, trade interventions appear to be a second-best way of achieving this result. Under certain conditions, they may even prove to be counter-productive. In contrast, international transfers, which in our model simply reduce the dependency of the producer country on the exploitation of the forest for export earnings, are more effective in promoting conservation of the forest stock.

Third, increased market power by a large country exporter or group of exporters may actually lead to greater forest conservation. The greater the market power, the higher the reutrns per unit of output and the less need to exploit tropical forests more heavily. Nevertheless, even in the monopoly case, an international subsidy to reduce dependence on tropical timber exploitation will incite greater forest conservation.

Finally, the existence of a foreign capital market may further ensure that the tropical timber country may conserve its forest stock in the long run. If the rate of return on foreign assets is very high, the economy may switch into becoming a net lender and prefer even to increase its forest stock. However, even when interest rates are low and consequently the opportunity cost of holding on to foreign assets is high, the economy will not completely exhaust its forests.

Several recent reviews of global forest sector policies have discussed implications similar to those analyzed theoretically in our model (Barbier *et al.* 1992; Binkley and Vincent 1991; Hyde and Newman 1991). Generally, the same conclusions have been reached. However, what is of increasing concern is that domestic market and policy failures within tropical forest countries continue to distort the incentives for more sustainable management of timber production and efficient development of processing capacity, while at the same time the international community increasingly contemplates the use of bans, tariffs and other trade measures to discourage 'unsustainable' tropical timber exploitation. As our paper has attempted to show, sometimes the more simple solutions lead neither to a straightforward, nor to the desired, results.

Appendix

Comparative static solution of the simultaneous equation system (11), (12) and (13) can be represented by

$$\begin{vmatrix} U_{11} & -U_{11} - p^2U_{22} & 0 \\ (\delta - g')U_{11} & -(\delta - g')U_{11} & -g''U_1 - aU_{33} \\ -a & 0 & g' \end{vmatrix} \begin{vmatrix} dq \\ dx \\ dN \end{vmatrix} = \begin{vmatrix} U_2 + pxU_{22} & 0 \\ 0 & U_3 \\ 0 & q \end{vmatrix} \begin{vmatrix} dp \\ da \\ \ \end{vmatrix}$$

The determinant of the Jacobian matrix of the above systems D is

$$D = g'p^2U_{11}U_{22}(\delta - g') - a(U_{11} + p^2U_{22})(g''U_1 + aU_{33}) .$$

The right hand side is negative but the lefthand side is ambiguous as g' is unsigned. However, it can be shown that $D < 0$ is a requirement for the curve $\dot{q}$ to be positively sloped and to cut the curve $\dot{N}$ from below, which is a necessary (but not sufficient) condition for there to be a unique equilibrium in (q,N) space.

The implict function rule applied to the above simultaneous equation system (11), (12) and (13) yields

$$U_{11}dq = (U_{11} + p^2U_{22})dx$$

$$(\delta - g')U_{11}dq - (\delta - g')U_{11}dx = (g''U_1 + aU_{33})dN$$

$$-adq = -g'dN.$$

Substituting for dx yields

$$\left.\frac{dq}{dN}\right|_{\dot{q}=0} = \frac{(g''U_1 + aU_{33})(U_{11} + p^2U_{22})}{(\delta - g')p^2U_{22}U_{11}} > 0.$$

$$\left.\frac{dq}{dN}\right|_{\dot{N}=0} = \frac{g'}{a} .$$

It follows that

$$\left.\frac{dq}{dN}\right|_{\dot{N}=0} > \left.\frac{dq}{dN}\right|_{\dot{q}=0}$$ also implies that

$$a(U_{11} + p^2U_{22})(g''U_1 + aU_{33}) > g'p^2U_{11}U_{22}(\delta - g'),$$ and thus $D < 0$.

In the monopoly case, comparative static solution of the simultaneous equation system (11)', (12) and (13) can be represented by

$$\begin{vmatrix} U_{11} & \phi & 0 \\ (\delta - g')U_{11} & -(\delta - g')U_{11}\, x' & -g''U_1 - aU_{33} \\ -a & 0 & g' \end{vmatrix} \begin{vmatrix} dq \\ dp \\ dN \end{vmatrix} = \begin{vmatrix} U_2\, p & 0 \\ 0 & U_3 \\ 0 & q \end{vmatrix} \begin{vmatrix} dl/\epsilon \\ da \\ \end{vmatrix}$$

The determinant of the Jacobian matrix of the above system D is

$$D \quad = \quad a[g''U_1 + aU_{33}]\phi - g'(\delta - g')U_{11}[U_{11}x'(p) + \phi], \quad \text{where}$$

$$\phi \quad = \quad -U_{11}x'(p) - p^2U_{22}(1 + 1/\epsilon)^2 - U_2(1 + 1/\epsilon) + U_2p(\epsilon'(p)/\epsilon^2) \; < \; 0.$$

It follows that the condition

$$\left.\frac{dq}{dN}\right|_{\dot{N} = 0} \quad > \quad \left.\frac{dq}{dN}\right|_{\dot{q} = 0} \qquad \text{also implies that}$$

$a(g''U_1 + aU_{33})\phi \; < \; g'(\delta - g')U_{11}[\phi + U_{11}x'(p)]$, and thus $D < 0$.

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Notes

1. For example, see Barbier, Burgess and Markandya (1991); Gillis (1990); Hyde and Newman (1991); Pearce (1990); Repetto (1990) and Repetto and Gillis (1988).

2. Processed timber products are assumed to be converted to log-equivalents.

3. The proposed international financing is for, specifically, sustainaing the multiple roles and functions of all types of forests, forest lands and woodlands (US$ 860 million *per annum*); enhancement of the protection, sustainable management and conservation of all forests, the greening of degraded areas through forest rehabilitation, afforestation, reforestation and other rehabilitation measures (US$ 460 million p.a.); and promoting efficient utlization and assessment to recover the full valuation of the goods and services provided by forests, forest lands and woodlands (US$ 230 million p.a.).

4. According to Solow (1974, p. 8), "the monopolist is the conservationist's friend". Usually this holds along an adjustment path towards a steady state, which is independent of market structure. In our model, in contrast, the long run equilibrium is also affected.

5. Note that Equation (28) also implies that there is a relocation of assets at $t = 0$ such that (28) holds forever after. Thus, there is a jump in N corresponding to a jump in the opposite direction in A. The extraction rate is plus or minus infinity in this point of time. However, the long-run equilibrium remains unaffected.

ANNEX I

TIMBER TRADE AND TROPICAL DEFORESTATION - INDONESIA

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Timber Trade and Tropical Deforestation - Indonesia*

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Introduction

The following paper examines the links between the trade in tropical timber products and deforestation in Indonesia. We briefly review some of the evidence suggesting that timber production is a factor in tropical deforestation, and the role of timber trade policy in Indonesia in influencing this process by affecting forest-based industrialization. These issues are of particular concern to Indonesia, as the country has recently banned the export of sawnwood exports to encourage further rapid development of plywood processing.

We develop a partial equilibrium timber trade model of Indonesia to analyze the effects of various policy interventions on the trade and tropical deforestation. The basic timber trade model is developed as a *simultaneous equation* system determining supply and demand in the logging, sawnwood and plywood sectors of Indonesia. The system is linked to a *recursive* relationship determining tropical deforestation, which is estimated separately. We use the model to simulate several policy options, including the impacts of sawnwood export taxes/effective bans, import bans imposed by consumer countries, revenue-raising import taxes, and increased harvesting costs associated with 'sustainable management'.

The paper concludes by summarizing the results of the policy analysis, and discusses the policy options open to the Government of Indonesia (GoI) and importing countries.

The Timber Trade and Tropical Deforestation in Indonesia

South East Asia currently accounts for around 20 percent of the world's tropical moist forest (TMF). Indonesia alone has over 50 percent of the region's TMF and over 10 percent of the world's total (see Table 1). The rate of deforestation in South East Asia, measured in terms of hectares (ha) lost per year, is also fairly high - approximately 2 million ha annually - and the total area deforested is much higher than in Amazonia and Central Africa. Close to 85% of South East Asia's annual deforestation occurs in Indonesia.

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The major 'cause' of tropical deforestation in South East Asia and in Indonesia in particular is generally thought to be the conversion of forests to agricultural land. Tropical timber production, although significant in large areas of 'production' forests, is considered to be a less significant factor in overall tropical deforestation. More recently, however, attention has focused on the indirect role of timber production in 'opening up' inaccessible forest areas, which then encourages other economic uses of the forest resources, such as agricultural cultivation, that lead to deforestation on a wider scale. For example, Amelung and Diehl (1992) identify the major shifts in land use changes and the causes of deforestation in tropical countries,. including Indonesia. As indicated in Table 2.a., the direct impact of forest activities on deforestation appears to be minimal (i.e. less than 10% of total deforestation), as compared to agriculture. For Indonesia, this is partly because timber is harvested predominately by selective logging, which does not meet the 'strong' definition of deforestation that is commonly used. In contrast, the forestry sector in Indonesia is almost completely responsible for converting virgin forests into productive closed forests or other forms of land use through *forest modification*, and has a much more significant role in *biomass reduction* (see Table 2.b). In short, there are some indications that timber extraction is largely responsible for opening up previously unexploited forest, leading to further forest degradation and outright deforestation.

Other studies indicate the possible acceleration of this process, given the trends in timber production in Indonesia (Burgess 1989). With the exception of Sabah and probably Papua New Guinea, Indonesia has one of the last remaining reserves of virgin forest in South East Asia, yet well over one third of the country's tropical forests have been allocated to conversion or permanent production forest (Table 3.a). As a very large part of the production in Indonesia in the past has come from the conversion forests, which are essentially clear cut and turned over to agriculture, future supplies must depend on the permanent production forests (and any remaining virgin forest reserves allocated to them) - provided that these supplies can be maintained on a sustained basis.

Although Table 3.b suggests that Indonesia's permanent production forests are not being 'mined' to the extent of those in other South East Asian countries, there is concern that Indonesia has over-estimated the extent of its production forest, under-reported current timber extraction (e.g. there is substantial illegal felling), or both (Burgess 1989). Moreover several analysts predict a decline in South East Asia's (and Indonesia's) share of world production and trade, and some deterioration in the quality of hardwood timber produced from forests in the region (Arnold 1991; Burgess 1989; Sedjo and Lyon 1990). Thus, it is unlikely that Indonesia will be able to maintain its current dominance of world production and trade of timber products, as indicated in Table 3.c, without further and extensive exploitation of its remaining old growth reserves.

Indonesian Timber Trade Policies

The tropical timber trade has been subject to severe distortions by export restrictions imposed by log producing countries, including Indonesia. One justification often cited for these policies is that they compensate exporters for the import barriers in developed economy markets by making the price of raw logs higher to the processors in the importing country while reducing the cost disadvantage faced by domestic processors within the timber producing countries. This strategy usually has as its primary aim the creation of more export revenues and employment for the forestry sector, with a secondary objective of reducing harvesting pressure on the forests by increasing value added per log extracted.

Several authors have recently reviewed the role of export taxes and bans in encouraging forest-based industrialization and sustainable timber management in tropical forest countries (Gillis 1990; Vincent and Binkley 1991; Vincent 1992b). Initially, the preference seems to have been for export taxes, through employing escalating rates. For most countries, export tax rates on logs generally ranged between 10 and 20%. Export taxes on sawn timber, veneer and plywood have been negligible. Where sawn timber exports were taxed, rates were typically half that of logs. More recently, the use of export tax structures to promote forest-based industrialization has become largely replaced by export bans in tropical forest countries, although export taxes are still being used in certain regions and for specific timber products (see Table 4).

Tropical timber export taxes and bans have proved only moderately successful in achieving the desired results in South East Asia. For example, although expanded processing capacity was established in Malaysia, the Philippines and Indonesia, it was achieved at high economic costs, both in terms of the direct costs of subsidization as well as the additional costs of wasteful and inefficient processing operations (Barbier 1987; Gillis 1988 and 1990; Vincent and Binkley 1991; Vincent 1992a and 1992b) .

In addition, as a long-term forest industrialization strategy, ensuring export sales of processed products through denying processors in other countries access to logs may prove difficult to sustain (Bourke 1988). Importers of South East Asian logs, such as Japan, have been known to substitute other raw materials (e.g., cement, steel, plastics, fiberboard, etc.) for timber, and alternative sources of supply, such as sawlogs from temperate and other developing regions (Bourke 1988; Vincent, Brooks and Gandapur 1991).

In Indonesia, the *ad valorem* export tax on logs was doubled from 10 to 20% in 1978, while most sawnwood and all plywood were exempted. Beginning in 1980 controls on the export of logs were progressively enforced, until an outright ban was introduced in 1985 (Gillis 1988). The export tax structure created effective rates of protection of 222% for plywood manufacture, and the drop in export revenue to the government from diverting log exports was not compensated by any gain in value-added in sawmilling, resulting in a loss of US \$15 per m^3 at world prices. The consequence has been the creation of inefficient processing operations and expanded capacity, with consequences for the rate of timber extraction and forest management. Gillis (1988) has estimated that over 1979-82, due to the inefficient processing operations resulting from this policy, over US \$545 million in potential rents was lost to the Indonesian economy, or an average cost of US \$136 million annually. Moreover, as the switch from log to processed exports occurred at a time when forest product prices were falling sharply in real terms, the cost to the economy in export earnings was high. Over 1981-84, the net loss in export earnings amounted to US \$2.9-3.4 billion, or approximately US \$725-850 million annually. Additional losses were also incurred through selling plywood below production cost, which amounted to US $956 million in 1981-84, or US $239 million annually (Fitzgerald 1986).

Although the switch to value-added processing of timber initially slowed down the rate of timber extraction, the inefficiencies and rapidly expanding capacity of domestic processing may have actually increased the rate of deforestation over the medium and long term.[1] For example, by the early 1980s, the major operational inefficiencies in domestic processing due to high rates of effective protection in Indonesia led to the lowest conversion rates in Asia. As a result, for every cubic meter of Indonesian plywood produced, 15% more trees had to be cut relative to plymills elsewhere in Asia that would have processed Indonesian log exports (Gillis 1988). Thus the protection given to Indonesian mills not only increased rather than reduced total log demand, but the gross operational inefficiencies also ensured that millions more logs may have been harvested than if a more efficient policy to boost domestic processing capabilities than forced industrialization through export taxes and bans had been implemented.

More recent analysis of the impacts of the log export ban in Indonesia on the efficiency of timber processing industries confirms that the policy has not increased wood recoveries and thus reduced log consumption compared to pre-ban levels (Constantino 1990). By depressing raw wood prices, the log export ban has led to the substitution of wood for other factor inputs, with substantial wood recovery losses in sawmilling and a slower growth in wood recovery than other factor productivities in plymilling. In both industries, wood consumption has been the main source of output growth over the 1975 to 1987 period, with efficiency gains contributing very little. However, the log export ban has not affected efficiency in the plywood industry so seriously, which could arise from the much newer capital vintages in plywood milling, its export orientation that requires higher production standards, and possibly its access to better quality logs.

Despite the problems with the export restriction policy, it is still being aggressively promoted by the GoI to encourage forest-based industrialization. In Indonesia, not only does the export log ban still remain in place, but in October 1989 export taxes on sawn timber were also increased substantially to prohibit exports and shift processing activities to plywood (see Table 4). A secondary objective of the policy is to eliminate the marginal mills, leaving only the competitive ones operational, thus improving overall industrial efficiency. The implications of the policy for wood recovery, log demand and thus tropical deforestation in Indonesia is less clear.

In this paper we develop a timber trade model for Indonesia, linked to impacts on deforestation through log demand, in order to compare the sawnwood export ban with other possible trade policy options Through the various policy option simulations, we hope to investigate the relative merits of the different policy interventions in terms of production, prices, trade and deforestation in Indonesia. However, we first briefly review other models applied to the tropical timber trade in South East Asia.

Other South East Asian Timber Trade Models

Various partial equilibrium models of forest product markets and timber supply have been developed for countries in South East Asia to examine the implications of policies that restrict log exports.

Vincent (1989) employed a simulation model of the timber trade of Malaysia, other South East Asian producers and the major importers from the region to determine the optimal tariffs on intermediate and final goods for log, sawnwood and plywood products. The results of the model indicated that the large export tariffs imposed by Malaysia and other South East Asian exporters reduced domestic prices in those countries, leading to losses in producer surplus. More recently, Vincent (1992a) constructed an economic model of sawlog and sawnwood production, consumption and trade in Peninsular Malaysia during 1973-89 to examine in more detail how the log-export restrictions imposed in 1985 affected the forests products industry in Peninsular Malaysia, and whether the restrictions generated net economic benefits. Although the export restrictions seemed to stimulate growth in the processing industries and employment, the economic costs were high. On an average annual basis, Peninsular Malaysia lost US$6,100 in economic value-added, US$16,600 in export earnings, and US$34,300 in stumpage value for every sawmill job created by the log-export restrictions. No attempt was made in either of the above models to link the impacts of timber trade interventions on timber harvesting levels and tropical deforestation.

As part of the forest sector policy review of Indonesia conducted by the United Nations Food and Agricultural Organization (FAO) and the GoI, a domestic and international trade model of timber products centered on Indonesia was developed (Constantino 1988a and 1988b; Constantino and Ingram 1990). The simulation model had as its main purpose the determination of supply and demand projections for the Indonesian forestry sector, but it was also used to run policy scenarios on different trade interventions, including the implications of Indonesia's log export restrictions. The impacts of different government harvesting policies were simulated through scenario assumptions concerning the elasticity of the supply of forest land in Indonesia. For example, a small elasticity of supply was interpreted as a deliberate government policy to impose sustained yield constraints; whereas large elasticities reflected the GoI allowing expansion of forest land harvested. Using these different elasticity assumptions, the analysis could then focus on whether in response to each policy scenario the GoI should expand the area of forest land harvested, at the risk of greater tropical timber depletion and deforestation, or whether Indonesia would be better off limiting supply through greater harvest restrictions. Detailed results are provided in Constantino (1988a), which are summarized here:

- If international competitors follow conservative harvesting practices, then Indonesia should do the same in order to take advantage of greater employment, foreign exchange earnings and rent capture. On the other hand, if competing countries follow expansionary policies, it is not clear what Indonesia ought to do. Harvest restrictions will lead to a loss in international market share and to declines in employment - but also increases government revenues.

- Export restrictions on sawnwood and plywood result in a loss in international market share for Indonesia, lower foreign exchange earnings, employment, labour income, royalty revenues for logging and economic rent to forest land. On the other hand, the restrictions lead to lower domestic prices thus benefitting Indonesian consumers, to higher profits in the processing industries and to less forest land harvested. Imposing harvest restrictions as well would improve matters, as employment would decline less, even less forest land would be harvested and economic rent to forest land would increase more, thus leading to more revenues if the GoI increased rent capture.

- A 10% currency devaluation by the GoI coupled with restrictive harvesting policies will lead to the conservation of the resource and greater economic rent from forest land, but at the expense of higher domestic prices and less employment, value added, foreign exchange earnings and royalty revenues. This would suggest that some increase in forest land harvested in conjunction with a currency devaluation would be preferred.

- The impacts of a 10% US import tariff on tropical plywood is dissipated somewhat if it is imposed on all exporters and not just Indonesia, and if there is limited substitution between tropical and temperate plywood. For Indonesia, the overall effects are a decline in total plywood exports, a smaller increase in sawnwood exports, and increased domestic consumption and trade diversion to other regions for both products. If harvesting restrictions are imposed, consumer prices will fall more, but employment, capital, foreign exchange earnings and value added will decline less.

The following simulation model is an additional attempt to examine the relationship between policy interventions, tropical timber product trade and deforestation in Indonesia.

Timber Trade and Deforestation Model of Indonesia

The simulation model employed to examine timber trade and tropical deforestation in Indonesia is a static (single-period), partial equilibrium model of the production, consumption and trade of forest products that is related to the impact of log harvesting on forested area. The model is comprised of two components: a *simultaneous equation system* determining supply and demand in the logging, sawnwood and plywood sectors of Indonesia, and a *recursive relationship* determining tropical deforestation. Each component was estimated separately over the period 1968-1988, before the 1989 tax rises on Indonesian sawnwood exports. The resulting estimated relationships were linked together in the simulation model using 1988 data.[2] The model was then used to examine the varying impacts on Indonesia's timber markets and tropical forests of the 1989 sawnwood export tax policy and other policy interventions.

The simultaneous equation system of the supply and demand for Indonesia's roundwood (log), sawnwood and plywood markets was estimated using two-stage least squares employing linear functional relationships (See Table 5). As Indonesia essentially prohibits competing foreign timber product imports, supply comes solely from domestic production. In all three markets, demand is assumed to consist of both domestic consumption and foreign demand for Indonesian exports. Separate relationships for domestic production, consumption and import demand for each of the three products were then estimated. All values were based on 1980 real prices.

In the case of the log market, domestic consumption was assumed to be equal to the level of sawnwood and plywood production, multiplied by the respective wood recovery rates plus any local residual demand. Log export demand was considered to be influenced by log export unit values relative to the price of substitutes in world markets and by macro-economic factors affecting final demand in those countries importing Indonesian logs.[3] Due to insufficient data on domestic log prices, roundwood production (harvesting) was related to log export unit values, net of log royalties and export taxes, and the costs of harvesting. Domestic plus foreign log demand was therefore assumed to equal total log production. However, because the log export ban in 1985 effectively reduced Indonesian export volumes and unit values to zero, estimation of the log supply and foreign log demand relationships was only possible for the period 1968-84. As a check on the recovery rates used as coefficients in the domestic log consumption equation employed in the simulation model (see below), a regression representing this demand was run for the entire 1968-88 period.

In the sawnwood and plywood markets, domestic consumption was assumed to be a final demand, determined by the respective product prices and Indonesian macro-economic factors. Again, as domestic price and taxation time series data were scarce, plywood and sawnwood export unit values were used as proxies for domestic prices for these products.[4] Plywood export demand was considered to be influenced by its export unit value relative to the international price of a substitute (i.e. Philippine luan), but in the case of sawnwood export demand, only the export unit value alone proved significant. Both plywood and sawnwood exports were influenced by macro-economic factors affecting final demand in the main importing countries for each product.[5] Sawnwood and plywood production in Indonesia were determined by their respective prices (as represented by export unit values), processing capacity and costs - including the price of logs.[6] In the sawnwood market, domestic production and consumption was estimated for the entire 1968-88 period; however, as sawnwood was not exported significantly until after 1973, foreign demand could be estimated only for the 1974-88 period. As plywood production did not take off in Indonesia until after 1974, the demand and supply relationships for this market were estimated over 1975-88 only.

The separate recursive relationship linking tropical deforestation to log production (harvesting) was estimated using a logit equation for pooled cross-sectional and time series data across the principal tropical hardwood forest provinces of Indonesia.[7] The relationship estimated the probability of forested relative to non-forested area as a function of log production per square kilometer (km^2), population density and GNP per capita for each province and time period. A dummy variable for 1988 was also employed, as the inventory methods for provincial forestry statistics were modified in this year leading to revisions in the estimates for total forest area.

The results of the estimation of the simultaneous equation system for the three timber product markets and of the deforestation equation are presented in Table 5. The twelve endogenous variables of the timber trade supply and demand system are the prices (export unit values), production levels, domestic consumption levels and export levels for roundwood, sawnwood and plywood respectively. The remaining variables used to estimate the supply and demand equations are exogenous.[8] In Table 5, t-statistics are displayed in parenthesis under each coefficient, and other regression statistics are placed to the right of each estimated equation.

The deforestation regression indicates that increases in population density have a more significant impact than log production in terms of changes in forested area in Indonesia's forested provinces. For every cubic meter (m^3) of timber extracted per km^2, the proportionate change in forested to non-forested area is - 0.6%. For every additional person per km^2, the proportionate fall in forest area is -1.3%. In contrast, a rise in incomes of Indonesian Rupiah (Rp) 10,000 per person, approximately US$6.00 in 1988, would counteract deforestation at a rate of 0.4%.[9]

However, the deforestation equation in Table 5 may over-estimate the contribution of log extraction alone to regional changes in forest area in Indonesia. First, there is the usual problem of reliability and accuracy of data. More importantly, however, is that data limitations prevent distinguishing in the regression between log production from permanent production forests as opposed to conversion forests. If log production is mainly from conversion forests, then timber extraction is essentially a precursor or by-product to agricultural conversion, which is the principal factor in the resulting deforestation. As indicated in Table 3a, close to 50% of Indonesia's total production forests consist of conversion forests, and anecdotal evidence suggests that a good deal of the log production during the period 1973-88 came from the latter forests (Burgess 1989). To the extent that this is the case, then the deforestation equation may be reflecting mainly the impact of agricultural conversion, rather than the initial logging operations, on changes in forested area. This is supported somewhat by the evidence presented in Table 2, which shows logging much more responsible for 'opening up' the forest rather than outright forest conversion.

On the other hand, in the 1980s Indonesia's permanent production forest began contributing an increasingly larger share to overall log production - and is expected to be the main source of tropical hardwood logs in the future. Although forest regulations for this permanent forest estate are increasingly requiring concessions to harvest timber on a sustained production basis, clear cutting is allowed under certain conditions. Moreover, problems of implementing these regulations and policy failures in forestry management also contribute to over-harvesting and clear-cutting of permanent production forests, as well as illegal felling of non-production forests (Barbier 1987; Burgess 1989; Gray and Hadi 1990; Sedjo 1987; World Bank 1989). Evidence for the 1980-90 period suggest that logging damages alone contributed *directly* to just under 10% of the annual average rate of deforestation in the Outer Islands of Indonesia (Pearce, Barbier and Markandya 1990, ch. 5). Moreover, if timber operations in Indonesia are also 'opening up' permanent production and virgin forests to subsequent encroachment and deforestation, then logging may have a major role in *indirectly* furthering the deforestation process of these forested areas.

In short, it is difficult to determine the extent to which the deforestation equation in Table 5 over-estimates, if at all, the impact of log production on tropical deforestation in Indonesia. The available evidence would suggest that, at the very least, the equation is correct in indicating that this impact is significantly greater than zero and positive.

The key relationships in the simultaneous equation system of the three main timber markets of Indonesia are for price and quantity. Table 6 compares the price elasticity estimates for each of the supply and demand equations of the model with other recent estimates for the South East Asian region. In general, the elasticity estimates compare favorably. According to our estimates, the supply of timber products in Indonesia appears to be fairly price inelastic. In the case of the processed products, this may reflect the Indonesian policy of expanding sawnwood and plywood capacity over the 1968-88 period. In our regressions, export demand for sawnwood seems slightly more elastic than domestic demand, whereas for plywood the opposite seems to be the case. A similar result was obtained by Vincent (1989) for all South East Asian exporters.

The simultaneous equation system and the deforestation regression are combined to form a simulation model of timber trade-deforestation linkages, using data for 1988. The results are displayed in Table 7. Given the Indonesian policy of banning log exports, the export log demand equation from Table 5 was not included in the model. It is assumed the total log production in Indonesia supplies domestic log demand. The latter is again related to sawnwood and plywood production, although in the simulation model actual recovery rates for the mid-1980s were used as coefficients rather than those generated by the regression for the entire 1968-88 period.[10]

Table 7 compares the results of the base case scenario with the actual values of key price, quantity and deforestation variables for Indonesia in 1988. The model appears to be a reasonably good simulation of these variables. The impacts of Indonesia's forest industries and log production on the tropical forest are indicated by effects on forest cover and the annual rate of deforestation. The latter indicator was not simulated by the base case scenario; instead, the most recent FAO estimate of annual deforestation in Indonesia was used.

The following sections compares different policy scenarios to the base case, focussing particularly on the sawnwood export tax intervention, the imposition of an import ban, the use of revenue-raising import surcharges and the implementation of improved sustainable timber management practices. There are, of course, a number of important limitations on the use of the simulation model for these policy scenarios.

First, as discussed above, the linkages of the impacts of log production on tropical deforestation do not take into account changes in the type of forests being exploited (i.e. permanent production forests, conversion forests or new forest areas) or in the production management regime (i.e. selective cutting or clear cutting). The deforestation equation also cannot distinguish between the direct versus indirect impacts of logging on the forest.

Second, although the model is well suited to examining the effects of a particular policy intervention on the *internal diversion* of timber product flows in Indonesia, i.e. between export and domestic markets for sawnwood and plywood, the model does not explicitly indicate the effects of an intervention in terms of *external diversion* of timber products, i.e. between different import markets for sawnwood and plywood. That is, elasticities of substitution by product or by sources of origin in existing importing markets are not explicitly modelled, and the possibility of new import markets opening up as a result of the intervention is not taken into account. In addition, 'leakages', or the ability to avoid any restrictions imposed by an intervention, are also not shown.

Finally, the model is capable of only showing 'static', or one-period, partial equilibrium effects of a policy intervention. Many of the impacts may have economy-wide, or general equilibrium, impacts that feedback to effect the timber product markets and deforestation. In addition, the impacts may have lag, or dynamic, effects that manifest themselves over a medium or long term horizon. Some of the policy interventions themselves, such as the implementation of sustainable management practices, would realistically involve a longer process of implementation than a single period (i.e. one year).

Keeping these obvious limitation in mind, it is nevertheless useful to use the simulation model to obtain an approximate indication of the relative impacts of different trade and forest sector policy interventions on Indonesia's timber product markets and forest resource base.

Sawnwood Export Taxes

As indicated in Table 4 and discussed above, in 1989 Indonesia imposed substantial taxes on sawnwood exports in an effort to shift processing activities to plywood. A secondary objective of the policy is to improve competitiveness and overall efficiency of sawmills. However, the implications of the policy for wood recovery, log demand and thus tropical deforestation in Indonesia is less clear.

Table 8 displays the results of imposing varying levels of sawnwood export taxes in the simulation model of Indonesia's forest sector. The results compare the changes in key price, quantity and deforestation variables to the 1988 base case scenario.

In the model, the sawnwood export taxes appear to have the effect of reducing export demand for Indonesian sawnwood, thus lowering the export price received and the quantity exported. The price effects appear to be outweighed by the quantity effects. Although some sawnwood production is diverted to domestic consumption, it is not sufficient to overcome the fall in export demand. Thus overall sawnwood production falls. The impacts on Indonesia's sawnwood markets are more severe the greater the tax. As indicated in the model, a tax rate of 700% imposed in 1988 would effectively choke off sawnwood export demand. With proposed taxes of US$250- 2,4000 per m^3, actual government policy would be represented by the higher range of sawnwood export taxes shown in Table 8.

Significantly, the imposition of a tax on sawnwood exports does not appear to instigate a major shift of processing capacity to plywood - at least not in the one-period duration of the simulation model. Only at extremely high rates of taxation does this occur even slightly, and it appears that increased domestic plywood consumption is the most noticeable effect. Evidence would suggest that there are several structural factors limiting diversion of production between Indonesia's sawnwood and plywood industry in the short term, such as the much newer vintages of capital in plywood milling, and its export orientation that requires higher production and possibly access to better quality logs (Constantino 1990). The simulation model therefore confirms that, if a sawnwood export tax is to shift Indonesian processing capacity towards greater plywood expansion, then it will be a long term process. Unfortunately, the economic costs of reduced sawnwood exports and production appear to be severe from the outset.

Only at high rates of taxation does the sawnwood export tax have a modest impact on deforestation. The inability of the policy to increase plywood output in the short term means that the net reduction in sawnwood production translates into less log extraction. At higher rates of taxation, the fall in log production is much larger, thus resulting in a lower rate of deforestation. However, as noted, the economic costs particularly in terms of lost exchange earnings of a prohibitive sawnwood export tax are severe. Moreover, if the policy is successful over the long run in shifting processing to plywood production, then one would expect log demand, and thus deforestation rates, also to be revived.

In sum, a prohibitive sawnwood export tax in Indonesia appears to be a high cost strategy for shifting processing capacity to plywood production and export, which may only be successful - if at all - over the long term. In addition, the policy does not appear to be an effective approach for reducing timber-related deforestation in Indonesia. Only modest reductions in deforestation may occur, and these will be short-lived if plywood production begins replacing the lost sawnwood output.

Import Ban

Some environmental pressure groups in Western tropical timber importing countries have been urging their governments to ban the import of tropical timber, or at least imports of timber that is 'unsustainably' produced. Consumer-led boycotts against tropical timber products have also been instigated. The presumption is that an import ban is the most effective way of ending timber-related deforestation in tropical forest countries. Despite the various economic and legal implications of such a move, as well as questions about its effectiveness, an import ban on tropical timber is a realistic possibility in the near future.[11]

The first column of Table 9 indicates the effects of a total import ban, compared to the base case scenario, in the timber trade-deforestation model of Indonesia. In order to simulate an import ban in the model, large price changes were used deliberately to constrain sawnwood and plywood exports to zero. Timber product prices are therefore no longer endogenously generated by the model, and as a result, are not shown in Table 9. Also, the functional form of the deforestation equation and its estimation using regional panel data imply that the large changes in log production associated with the import ban scenario cannot be used to predict reliably the effects on forest cover and deforestation. Thus the impacts on deforestation are also not reported for this policy scenario simulation.

As shown in Table 9, an import ban would have a devastating impact on Indonesia's forest industry in the short term. Although there would be significant diversion of plywood and sawnwood exports to domestic consumption, this would be insufficient to compensate for the loss of exports. Net production in both processing industries would fall. Given its export orientation, the plywood industry would be particularly hurt - reducing its output by over 40%. Net production losses in the sawnwood industry would be closer to 10%. The overall effect is to lower domestic log demand in the short term by around 25-30%.

The policy scenario is of course assuming that the import ban is 100% effective. It is unlikely that all importers of Indonesia's tropical timber products - many of which are also newly industrializing or producer countries with processing capacities - would go along with a Western-imposed ban. In any case, one would expect that over the longer term there would be some diversion of Indonesian plywood and sawnwood exports to either new import markets or existing markets that prove to be less stringent in applying the ban. As discussed above, these effects cannot be captured in our model.

In addition, the long-term implications of an import ban on tropical deforestation are also uncertain. Even if the ban is100% effective in the short term, any resulting reduction in tropical deforestation is likely to be short-lived. There are several reasons for this.

First, as indicated in the model, diversion of timber products to satisfy domestic demand is likely to continue as Indonesian population and economic activity expands (see Table 5). Thus one can expect the wood processing industries to recover somewhat through re-orientation to meet local consumption of timber products. Moreover, past evidence suggests that domestic-oriented processing in Indonesia is less efficient than export-oriented processing, implying poorer wood recovery rates and greater log demand (Constantino 1990). Pressure on the tropical hardwood forests may therefore increase after the initial 'shock' of a ban.

However, it is unlikely that the domestic market in Indonesia will generate the same demand for higher valued timber products as the international market. Instead, domestic demand is likely to be strongest for high-volume but lower valued wood products. As a consequence, it may be difficult for Indonesia to justify holding as large a proportion of its tropical forests as permanent production forests if the expected economic returns from sustainable management decline as a result of the ban. More of the resource may be shifted to conversion forests, and timber production will become residual to satisfying the growing demand for agricultural land. In short, without the timber trade providing increased value added in the form of external demand for higher valued products, there may be less reason for Indonesia 'holding on' to these forests as opposed to converting them to an alternative use, such as agriculture (Barbier 1992; Vincent 1990).

To summarize, a total import ban would cause a major diversion of Indonesian timber products to meet domestic demand. Although in the short term net production of wood products, and thus log demand, would fall, this situation would not necessarily be sustained over the long run. Even if this is not the case, the ban may be ineffective in permanently reducing tropical deforestation because, in the first place, timber production is not the main source of deforestation in Indonesia, and secondly, as the value of holding on to the forest for timber production decreases the incentives to convert more of the resource to agriculture will increase.

Revenue-Raising Import Tax

International cooperation and compensation to assist developing countries in achieving sustainable management of timber production forests have also been discussed in recent years. For example, the International Tropical Timber Council (ITTC) unanimously adopted a "Year 2000 Target" that encourages "ITTO members to progress towards achieving sustainable management of tropical forests and trade in tropical forest timber from sustainably managed sources by the year 2000" (Decision 3(X) ITTC 1991). One suggestion for raising additional funds for this strategy is for importing countries to impose a small import surcharge on tropical timber, which is then directed to tropical forest countries that have shown "demonstrable progress" towards achieving the Year 2000 Target.

A recent study has indicated that 1-3% surcharge on the tropical timber imports (excluding plywood and based on 1986 trade levels) of the EEC, Japan and USA would raise approximately US$ 31.4 to 94.1 million with little additional distortionary effects (NEI 1989). Buongiorno and Manurung (1992) also examine the scope for a 5% revenue-raising import levy on tropical timber by the Union pour le Commerce des Bois Tropicaux (UCBT) or the EEC.[12] The results indicate that tropical timber exporters would lose around US$44.8 million in trade earnings, with Indonesia and Malaysis suffering the worse, but importing countries would earn US$87.7 million in additional revenues. Thus, if the funds raised by the tax were rebated to exporting countries, they could be made better off by over US$40 million.

The final two columns of Table 9 show the impacts of a 1 and 5% revenue-raising import tax on Indonesian tropical timber exports in the simulation model. In the case of a 1% surcharge, a total of US$23.1 million (1980 prices) in revenue would be raised, with US$5.8 million and US$17.3 million from Indonesian sawnwood and plywood exports respectively. For the 5% surcharge, a total of US$113.9 million (1980 prices) in revenue would be raised, with US$28.5 million and US$85.4 million from Indonesian sawnwood and plywood exports respectively. When compared to the revenue estimates from the NEI (1989) study, the above figures would suggest that, in the case of Indonesia, applying the import surcharge to plywood would significantly raise the total amount of financing appropriated.

The results shown in Table 9 confirm that a small import surcharge would have very little distortionary effects on Indonesia's timber product flows and prices. There would also be a negligible direct impact on deforestation. However, around the 5% level, the impacts of the surcharge on exports in particular would become more noticeable. Thus from the standpoint of minimizing additional distortionary effects, the policy scenario confirms that an import surcharge of less than 5% would be optimal.

A more pertinent issue is whether it is worth imposing an import surcharge to raise revenue for sustainable management of tropical forests. In the simulation model, the same result, and thus the same amount of revenue, could be achieved if Indonesia raised the money for its own "sustainable management" initiatives by imposing a revenue-raising export surcharge of 1-5%. The NEI study argues that the imposition of an export levy by producing counties themselves has the advantage of directly addressing the forest management systems of these countries, as well as avoiding the transaction costs involved in international transfers, but prevents obvious problems of monitoring and evaluating success in achieving sustainable management. The counter-argument is that an import surcharge not only has problems of transaction costs and administration, but that it is also possibly discriminatory if it is limited only to the *tropical* timber trade. Moreover, the import surcharge-cum-international transfer mechanism would still require the cooperation of producer countries, as well as raise similar problems of monitoring and evaluation of progress towards sustainable management and expenditures. Finally, there is the issue of whether the amount of funds raised through any trade surcharge would be adequate for the task, and whether it would be more appropriate avenue for raising additional large-scale funding *outside* the timber trade altogether (Barbier *et al.* 1992).[13]

In sum, it is possible to raise revenue through an import surcharge of less than 5% with minimal distortionary effects on Indonesia's timber trade and production. The key issue is whether this is the most efficient and appropriate means of raising financing for improved sustainable management of production forests.

Sustainable Timber Management

An alternative to the above trade interventions would be a more direct policy initiative by Indonesia to improve 'sustainable' management of its remaining production forests. As discussed above, several studies have pointed to considerable problems of policy failures in Indonesian forestry management that are contributing to over-harvesting and clear-cutting of permanent production forests, as well as illegal felling of non-production forests (Barbier 1987; Burgess 1989; Gray and Hadi 1990; Sedjo 1987; World Bank 1989). Correcting these policy failures would improve sustainable management of Indonesia's remaining tropical forests, and thus reduce timber-related deforestation, but would also mean higher harvesting costs per cubic mere of wood extracted.

Table 10 indicates the most likely effects of such a 'sustainable' management policy scenario, which is represented by an increase in harvesting costs. As there is insufficient data to determine the extent to which costs would rise if such a policy were to be implemented in Indonesia, we have arbitrarily chosen a 25% and 50% harvest cost increase for comparison.

A surprising feature of the scenario is that although log prices are affected significantly by the increased harvest costs, any resulting impacts on the rest of Indonesia's forestry sector seem to be somewhat dissipated. There appears to be several factors at work. First, the price-elasticity of log supply for Indonesia is very inelastic in our model (see Tables 5 and 6). This is not surprising given that Indonesian policy has been to devote log production solely to supplying domestic processing capacity, which of course has expanded considerably over the 1968-88 period. Second, increased log costs are only one component of the total factor costs of Indonesia's processing industries, and have increasingly become the least important component in recent years (Constantino 1990). Finally, Indonesia's sawnwood and plywood exports seem to be the least affected by the increased harvest costs, which would suggest that external demand factors exert an important counter-acting influence.

There is reason to believe that the impacts of the sustainable management scenario on reducing timber-related deforestation may be underestimated in Table 10. As discussed above, the deforestation equation in the model can only record changes in forest cover due to changes in overall log production rates. It cannot distinguish between *qualitative* changes in the management of log production that may also affect timber-related deforestation more indirectly, such as controlling residual stand damage, improved replanting and reforestation, reduced high-grading of stands, limiting trespass, improving the incentives to control stand abandonment and encroachment, and so forth.[14] These latter factors may be more important in timber-related deforestation than log extraction alone. In addition, some sustainable management techniques, such as utilizing lesser known species and improved harvesting techniques, may actually increase the amount of logs produced from a given timber stand, thus simultaneously limiting harvest costs and reducing the pressure to exploit the remaining tropical forest.

Finally, it is unlikely that the implementation of any sustainable management techniques would occur in a single year, as implied by the simulation scenario. A longer lead time for implementation would mean more time for the Indonesian forest industries to absorb the increased costs, but it would also imply a longer period before the effects on reducing deforestation would be fully felt.

In sum, Indonesia's timber industries may not be badly affected by the higher harvest costs associated with implementing sustainable forestry management policies. Although there would be some reduction in tropical deforestation due to reduced log production, this direct effect may be less significant than the improvement in forest management and protection resulting from qualitative changes in timber stand management practices and ownership.

Conclusion

The simulation model developed to examine the relationship between Indonesia's timber trade and tropical deforestation has provided some important insights into this linkage as well as the scope for the use of trade policy instruments to limit deforestation. As discussed throughout, there are obvious constraints on the use of such model to examine such dynamic, complex and pervasive effects. Nevertheless, the model and the policy simulations would suggest extreme caution in the use of broad trade policy interventions as a means to affect timber-related deforestation in Indonesia, and in some cases even as an economic tool to develop further Indonesia's timber processing capacity.

First, it is clear that timber production is not the major cause of tropical deforestation in Indonesia. Even where timber production is a factor in deforestation, most timber-related deforestation, including subsequent deforestation by agricultural encroachment, may have more to do with the management and regulation of the timber stand than with the amount of logs extracted from the stand *per se*.

Second, extreme trade interventions, such as the current GoI policy of prohibitive sawnwood export taxes and the imposition of a total import ban on tropical timber products, may have an initial 'shock' impact on tropical deforestation in Indonesia. However, this may be short-lived as dynamic factors in the economy - notably the shifting of processing capacity or the transfer of permanent production forests to conversion forests - may take hold. Both forms of trade intervention clearly impose high economic costs on Indonesia's forestry industries. Surprisingly, a high sawnwood export tax would appear to make little headway in the short run in achieving its stated objective of spurring development of Indonesia's plywood sector.

Third, an import surcharge on tropical timber imports would have minimal distortionary impacts on Indonesia's timber trade - provided that it was imposed at a level of less than 5%. A more pertinent issue is whether this policy is the correct means for raising funds for sustainable management of production forests, and whether the financing raised would be sufficient for the task.

Finally, improvements in sustainable timber forest management and regulation by Indonesia could raise log harvesting costs, but there may not be such significant impacts on Indonesia's processed products and trade. The reduction in timber-related deforestation in Indonesia resulting from the policy may not be fully captured by the model.

In sum, there seems little scope for the use of trade policy interventions as a means to reducing tropical deforestation in Indonesia. If there is concern over timber-related deforestation, a more appropriate approach may be to deal more directly with the problem by improving sustainable production forest management and regulation at the timber stand level. However, a key factor is whether the GoI has sufficient incentive to ensure that better forest management policies are implemented and enforced. By ensuring access of sustainably managed timber to import markets and by providing financial assistance for Indonesian policy efforts, the major tropical timber consumer countries could go a long way toward encouraging the appropriate incentives for action by the Indonesian government.

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Table 1. Tropical Deforestation in South East Asia and Other Regions 1/

	Total Forest Area (mn ha)	Undisturbed Operable Forest (mn ha)	Annual Deforestation ('000 ha)	Total TMF area deforested (mn ha)
SE ASIA INSULAR	167.3	72	1707	117
Indonesia	108.6		1315	
Papua New Guinea	33.5		22	
Malaysia 2/	18.4		255	
Philippines	6.5		110	
Brunei	0.3		5	
OTHER SE ASIA 3/	39.3	18	346	NA
Myanmar	31.2		102	
Thailand	8.1		244	
TOTAL SE ASIA	206.6	90	2053	>117
AMAZONIA	613.6	453	4129	100
CENTRAL AFRICA	167.1	107	325	30
OTHER REGIONS	58.4	<10	1900	177 4/
WORLD TOTAL	1045.7	652	8480	424

Notes: 1/ Unless indicated, 1990 estimates based on R. Schmidt, "Sustainable Management of Tropical Moist Forests", Presentation for ASEAN Sub-Regional Seminar, Indonesia, Forest Resources Division, Forestry Department, FAO, Rome, January 1990. Note that *tropical moist forests* are defined as broadleaf high closed tropical forests, including wetland and mangrove forests but excluding the deciduous dry forests of South Asia, sub-Saharan Africa and sub-tropical South America. In 1988, the FAO estimated the total area of all *tropical closed forests* (including deciduous dry forests) to be 1269.6 million ha.

2/ Includes forests from Peninsular Malaysia.

3/ End of 1980 revised estimates based on Forest Resources Division, Forestry Department, *An Interim Report on the State of Forest Resources in the Developing Countries*, FAO, Rome, 1988.

4/ May include estimates for Thailand and Myanmar.

Table 2.a. Sources of Deforestation in Tropical Countries, 1981–1988 a/

	Brazil	Indonesia b/	Cameroon	All Major Tropical Forest Countries
Forestry	2 d/	9	0	2 (10) e/
Agriculture	89	80	100	(83) f/
shifting cultivators c/	13 (23)	59 (67)	92 (95)	na (47)
permanent agriculture:	76	21	8	36
– pastures	40	0	0	17
– permanent crops	4	2	5	3
– arable land	32	19	3	16
Mining and related industries	<3	<0.3	0	na
Hydroelectric production	4 b/	0	0	2 b/
Residual g/	2	11	0	(13) h/

Notes: a/ Percentage shares in deforestation refer to averages for the respective period.
b/ Data refer to the 1980–1990 period.
c/ Figures in parentheses show the results of the FAO for 1980. These data include also market oriented farmers who produce cash and export crops and engage only partly in shifting cultivation.
d/ Deforestation due to logging is due to charcoal production.
e/ The figure in parentheses refers to the estimation of Enquete-Kommission zum Schutz der Erdatmosphäre, *Schutz der tropichen Wälder*, Deutscher Bundestag 11, Wahlperiode, Drucksache 11/7220, 24.05.1990, Bonn, 1990. The calculation includes only Indonesia and Brazil, since these countries account for the largest share in clear cutting by the forestry sector.
f/ This percentage rate is based on the assumption that the percentage share calculated for shifting cultivators can be taken as an average for the 1981-1988 period.
g/ This includes other industries, housing, infrastructure services and fire loss.
h/ The residual has been calculated from the data in this column which includes data from different periods.

Table 2.b. Sectoral Share in Forest Degradation and Forest Modification, 1981–85 a/

	Percentage Share in Biomass Reduction (Degradation)				Percentage Share in Forest Modification			
Sector	Brazil	Indonesia	Cameroon	Total b/	Brazil	Indonesia	Cameroon	Total b/
Forestry	6	44	10	10	(100) c/	(100) c/	98	71
Agriculture d/	85	49	90	76	0	0	2	26
Others d/	9	7	0	13	0	0	0	4

Notes: a/ For the definition of modification and biomass reduction (degradation) see FAO, *Tropical Forest Resources*, FAO Forestry Paper 30, Rome, 1982.
b/ Total refers to all major rain forest countries.
c/ Following FAO statistics, deforestation in virgin forests is 0, since clearing by agriculture and other sectors concentrates on disturbed forests. Even though some clearing occurs in virgin forests, there is reason to assume that the bulk of deforestation is due to forests that have been logged over prior to the clearing of the respective areas.
d/ These figures have been derived from Table 2.a and reflect averages for the 1981–1988 period or, in the case of Indonesia, the 1980–1990 period.

Source: T. Amelung, "Tropical Deforestation as an International Economic Problem", Paper presented at the Egon-Sohmen Foundation Conference on Economic Evolution and Environmental Concerns, Linz, Austria, 30–31 August, 1991.

3.a. Forest Areas in Major South East Asian Tropical Timber Countries (sq km) a/

	Total Land Area	Total Forest Area	Permanent Protection Forest	Permanent Production Forest	Conversion Production Forest	Total Production Forest	Remaining Virgin Forest
Thailand	513,115	142,958	NA	NA	NA	NA	NA
Malaysia							
Peninsular	131,596	63,532	10,679	34,507	9,100	43,607	9,600
Sabah	73,711	44,869	6,000	29,984	4,080	34,064	7,815
Sarawak	123,253	94,384	24,200	32,400	37,784	70,184	50,387
Philippines	300,000	63,830	16,800	44,030	0	44,030	10,420
Papua New Guinea	468,860	359,900	NA	NA	NA	NA	NA
Indonesia	1,930,270	1,439,700	490,410	338,666	305,370	644,036	524,000
Total	**3,540,805**	**2,209,173**	**548,089**	**479,587**	**356,334**	**835,921**	**602,222**

Notes: a/ Based on P.F. Burgess, "Asia", Chapter 5 in D. Poore *et al.*, *No Timber Without Trees: Sustainability in the Tropical Forest*, Earthscan Publications, London, 1989.

3.b. Production and Yield Potential in Major South East Asian Tropical Timber Countries a/

	Permanent Production Forest (million ha)	Sustained Yield at 1.5 m^3 per year	Sustained Yield at 2.0 m^3 per year	Annual Timber Harvest (m^3)
Malaysia				
Peninsular	2.85 b/	4,275,000	5,700,000	7,914,328
Sabah	3.00	4,500,000	6,000,000	11,739,262
Sarawak	3.24	4,860,000	6,480,000	11,470,000
Philippines	4.40	6,600,000	8,800,000	3,433,774
Indonesia	33.87	50,805,000	67,740,000	28,500,000
Total	**47.36**	**71,040,000**	**94,720,000**	**63,057,364**

Notes: a/ Based on P.F. Burgess, "Asia", Chapter 5 in D. Poore *et al.*, *No Timber Without Trees: Sustainability in the Tropical Forest*, Earthscan Publications, London, 1989.

b/ The author does not explain the discrepancy between Tables 3.a and b over the size of the permanent production forest in Peninsular Malaysia.

3.c. Production and Trade of Wood Products in Major South East Asian Tropical Timber Countries a/

(1989 '000 m^3)

	Products	Production	Imports	Exports	ADC b/
Indonesia	logs	23,684.0	0.0	0.0	23,684.0
	sawnwood	10,546.0	0.0	2,692.0	7,854.0
	plywood	8,500.0	0.0	8,040.0	460.0
	veneer	53.9	0.0	29.0	24.9
Malaysia	logs	38,900.0	10.0	21,100.0	17,810.0
	sawnwood	7,660.0	197.0	5,134.0	2,723.0
	plywood	1,001.0	15.0	915.0	101.0
	veneer	445.0	5.3	248.7	201.6
Papua New Guinea	logs	1,700.0	0.0	1,260.0	440.0
	sawnwood	118.0	0.0	3.0	115.0
	plywood	18.0	0.0	0.0	18.0
	veneer	0.0	0.0	0.0	0.0
Philippines	logs	2,773.0	393.5	6.0	3,160.5
	sawnwood	975.0	12.0	438.1	548.9
	plywood	341.0	3.0	130.9	213.1
	veneer	75.0	0.0	53.1	21.9
Thailand	logs	1,770.0	1,135.0	0.0	2,905.0
	sawnwood	1,160.0	744.0	30.0	1,874.0
	plywood	185.0	4.0	35.0	154.0
	veneer	60.0	2.0	5.0	57.0
Total SE Asia Producers	**logs**	**68,827.0**	**1,538.5**	**22,366.0**	**47,999.5**
	sawnwood	**20,459.0**	**953.0**	**8,297.1**	**13,114.9**
	plywood	**10,045.0**	**22.0**	**9,120.9**	**946.1**
	veneer	**633.9**	**7.3**	**335.8**	**305.4**
Total ITTO Producers c/	**logs**	**126,967.0**	**2,536.7**	**25,749.2**	**103,754.5**
	sawnwood	**48,846.0**	**1,083.5**	**9,518.1**	**40,411.4**
	plywood	**12,115.6**	**59.2**	**9,565.2**	**2,609.6**
	veneer	**1,705.7**	**42.5**	**555.5**	**1,192.7**
Total World Producers d/	**logs**	**1,677,454**	**130,230**	**124,846**	**1,682,838**
	sawnwood	**500,685**	**100,231**	**99,088**	**501,828**
	wood panels e/	**129,108**	**28,692**	**28,443**	**129,357**

Notes: a/ Based on International Tropical Timber Council, *Elements for the 1990 Annual Review and Assessment of the World Tropical Timber Situation*, Tenth Session, Quito, Ecuador, 29 May – 6 June, 1991.

b/ ADC = Apparent domestic consumption.

c/ ITTO = International Tropical Timber Organization.

d/ All tropical and temperate timber producers, derived from FAO, *Forest Products Yearbook 1989*, Rome, 1991.

e/ Includes veneer sheets, plywood, particle board and fibreboard (compressed and non-compressed).

Table 4. Export Taxes and Bans on Tropical Timber, South East Asia, 1989

Country	Tax Rate/Export Policy	Remarks
Indonesia	20% *ad valorem* on logs	Tax imposed only on some logs in inaccessible regions. Log export ban since 1985 has made the tax irrelevant for other regions.
	Specific export taxes on sawn timber, ranging from US $250–2400 per m^3.	Specific export taxes on sawn timber introduced in 1989; plywood exempt from all export taxes.
Malaysia:		
Peninsular	Log export ban since 1971.	
Sabah	No specific export tax or ban but see remarks.	The Sabah timber royalty has a strong export tax feature: the royalty rate for log exports is almost 10 times the rate for logs used domestically.
Sarawak	15% *ad valorem* of f.o.b. log values	Tax applies to one hardwood species only.
Papua New Guinea	10% of f.o.b. log values	Tax reported to have been widely evaded through transfer pricing. Log export ban proposed.
Philippines	Log exports restricted to 25% of annual allowable cut since 1979.	Ostensibly to control deforestation.

Source: Gillis (1990).

Table 5. Indonesia – Timber Trade Simultaneous Equation System and Deforestation Equation

1. Roundwood Market

$$\mathrm{QLI} = \underset{(2.43)}{30868.4} + \underset{(2.59)}{0.172}*(\mathrm{RPXLI}-\mathrm{XTLI}-\mathrm{ROYLI}) - \underset{(-1.1)}{0.433}*\mathrm{CSTLI}$$

t = 1968–84
SE = 5534.3
DW = 0.76

$$\mathrm{XLI} = -\underset{(-2.64)}{165246.2} - \underset{(-2.03)}{34562.3}*(\mathrm{RPXLI}/(\mathrm{PLTENC}*\mathrm{EXR})) - \underset{(-1.51)}{4.74}*\mathrm{YPCML} + \underset{(2.83)}{1.397}*\mathrm{POPML}$$

t = 1968–84
SE = 6131.6
DW = 0.89

$$\mathrm{CONLI} = \underset{(0.96)}{2513.5} + \underset{(2.08)}{2.09}*\mathrm{QSWI} + \underset{(1.43)}{1.43}*\mathrm{QPWI}$$

t = 1968–88
SE = 3679.5
DW = 0.86

2. Sawnwood Market

$$\mathrm{QSWI} = \underset{(1.32)}{776.3} + \underset{(2.00)}{0.011}*\mathrm{RPXSWI} + \underset{(3.94)}{0.427}*\mathrm{CAPSWI} - \underset{(-1.41)}{0.021}*(\mathrm{CSTSWI}+\mathrm{RPXLI}-\mathrm{XTLI})$$

t = 1968–88
SE = 702.8
DW = 1.53

$$\mathrm{XSWI} = -\underset{(-2.24)}{2149.3} - \underset{(-1.96)}{0.029}*(\mathrm{JEXR}*\mathrm{RPXSWI}) + \underset{(5.66)}{68.27}*\mathrm{JAPIND} - \underset{(-0.98)}{0.201}*\mathrm{YPCMSW}$$

t = 1974–88
SE = 315.5
DW = 2.13

$$\mathrm{CONSWI} = -\underset{(-0.89)}{5914.5} - \underset{(-2.43)}{0.106}*\mathrm{RPXSWI} + \underset{(1.19)}{0.000077}*\mathrm{POPI} + \underset{(2.90)}{34.6}*\mathrm{GDFI} - \underset{(-1.82)}{0.209}*\mathrm{INDVA}$$

t = 1968–88
SE = 452.8
DW = 1.63

3. Plywood Market

$$\mathrm{QPWI} = \underset{(0.73)}{537.8} + \underset{(1.41)}{0.0042}*(\mathrm{RPXPWI}) + \underset{(5.45)}{0.706}*(\mathrm{CAPPWI}) - \underset{(-1.48)}{0.008}*(\mathrm{CSTPWI}+\mathrm{RPXLI}-\mathrm{XTLI})$$

t = 1975–88
SE = 371.3
DW = 1.75

$$\mathrm{XPWI} = -\underset{(-9.45)}{43836.4} - \underset{(-2.34)}{1537.9}*(\mathrm{RPXPWI}/(\mathrm{PHIPW}*\mathrm{EXR})) + \underset{(4.71)}{0.943}*\mathrm{YPCMPW}$$
$$+ \underset{(8.33)}{0.148}*\mathrm{POPMPW} - \underset{(-6.65)}{104.2}*\mathrm{MFXUV}$$

t = 1975–88
SE = 370.9
DW = 1.97

$$\mathrm{CONPWI} = \underset{(--3.96)}{-7014.6} - \underset{(-2.59)}{0.0033}*\mathrm{RPXPWI} + \underset{(4.16)}{0.000055}*\mathrm{POPI}$$

t = 1975–88
SE = 219.7
DW = 1.75

Deforestation Equation

$$\mathrm{LN(F/A)} - \mathrm{LN(1-FA)} = \underset{(4.45)}{0.875} - \underset{(-1.98)}{5.695}*\mathrm{LOGA} - \underset{(-5.82)}{0.013}*\mathrm{POPD} + \underset{(2.84)}{0.00037}*\mathrm{GDPA} + \underset{(4.40)}{0.997}*\mathrm{D88}$$

$R^2 = 0.51$
SE = 0.82
DW = 1.57

Table 5. Indonesia – Timber Trade Simultaneous Equation System and Deforestation Equation (cont.)

Dependent Variables

QLI	Industrial roundwood production ('000 m^3)
XLI	Industrial roundwood exports ('000 m^3)
CONLI	Apparent domestic log consumption ('000 m^3)
QSWI	Sawnwood and sleeper production ('000 m^3)
XSWI	Sawnwood and sleeper exports ('000 m^3)
CONSWI	Apparent domestic sawnwood and sleeper consumption ('000 m^3)
QPWI	Plywood production ('000 m^3)
XPWI	Plywood exports ('000 m^3)
CONPWI	Apparent domestic plywood production ('000 m^3)
F/A	Forest area(F) per total land area (A), km^2

Independent Variables

RPXLI	Log export prices (unit values) in domestic currency (Rp/m^3)
XTLI	Log export taxes (Rp/m^3)
ROYLI	Log royalties and other taxes (Rp/m^3)
CSTLI	Logging and log transport costs (Rp/m^3)
PLTENC	Average world price of temperate non–coniferous logs (US$/$m^3$)
EXR	Exchange rate, Indonesian Rupiah (Rp)/US$
YPCML	Average GNP per capita of Indonesian log importers (US$)
POPML	Average population of Indonesian log importers
RPXSWI	Sawnwood and sleeper export prices (unit values) in domestic currency(Rp/m^3)
CAPSWI	Sawmill capacity ('000 m^3)
CSTSWI	Total input sawmill costs (Rp/m^3)
JEXR	Exchange rate, Japanese yen (¥)/Rp
JAPIND	Japan – industrial production index 1985 = 100
YPCMSW	Average GNP per capita of Indonesian sawnwood importers (US$)
POPI	Indonesia – population
GDFI	Indonesia – GDP deflator index 1980 = 100
INDVA	Indonesia – industrial value added, Rp billion
RPXPWI	Plywood export prices (unit values) in domestic currency (Rp/m^3)
CAPPWI	Plymill capacity ('000 m^3)
CSTPWI	Total input plymill costs (Rp/m^3)
PHIPW	Export wholesale Tokyo spot price of Philippine (luan) plywood (US$/$m^3$)
YPCMPW	Average GNP per capita of Indonesian plywood importers (US$)
POPMPW	Average population of Indonesian plywood importers
MFXUV	Average world manufactures export unit values index 1980 = 100
LOGA	Roundwood production per total area ('000 m^3/km^2)
POPD	Population density (per km^2)
GDPA	GDP per capita ('000 Rp/km^2)
D88	Dummy variable for 1988

Statistical Data

t	Time period of the regression
SE	Standard error of the regression
DW	Durbin–Watson statistic
R^2	R–squared statistic

Notes All values are in constant (1980) prices; t–statistics are indicated in parentheses under the relevant coefficients.

Table 6. **Comparative Price Elasticity Estimates for South East Asian Tropical Timber**

	Time Period	Short Run	Long Run
1. This Study			
Indonesia – log supply	1968–84		0.20
Indonesia – log export demand a/	1968–84		– 1.51
Indonesia – sawnwood supply	1968–88		0.27
Indonesia – sawnwood domestic demand	1968–88		– 0.36
Indonesia – sawnwood export demand	1974–88		– 0.68
Indonesia – plywood supply	1975–88		0.31
Indonesia – plywood domestic demand	1975–88		– 0.91
Indonesia – plywood export demand b/	1975–88		– 0.46
2. Constantino (1988a) c/			
Indonesia – sawnwood export demand d/	See note	– 0.08	– 0.21
Indonesia – plywood export demand	1975–85	– 0.26	– 0.58
Importers – elasticity of subst., tropical and temperate sawnwood	1975–85	1.30	2.11
Importers – elasticity of subst., tropical and temperate plywood	1975–85	0.75	1.23
World – elasticity of substitution, source of origin, sawnwood	1979–85	2.50	4.39
World – elasticity of substitution, source of origin, plywood	1979–85	4.56	12.3
3. Vincent (1992) e/			
Peninsular Malaysia – log supply	1973–89		1.1
Peninsular Malaysia – sawnwood supply	1973–89		1.7
Peninsular Malaysia – sawnwood domestic demand	1973–89		– 0.55
Other tropical exporters – log export supply	1973–89		2.7
Other tropical exporters – sawnwood export supply	1973–89		0.7
Importers – tropical log demand	1973–89		– 1.59
Importers – tropical sawnwood demand	1973–89		– 5.67
4. Vincent (1989) f/			
Malaysia – log supply	1960–85		0.64
Malaysia – sawnwood supply	1960–85		1.00
Malaysia – plywood supply	1960–85		1.00
Malaysia – sawnwood domestic demand	1960–85		– 0.27
Malaysia – plywood domestic demand	1960–85		– 0.94
Other SE Asia exporters – log supply	1960–85		0.46
Other SE Asia exporters – sawnwood supply	1960–85		1.00
Other SE Asia exporters – plywood supply	1960–85		1.00
Other SE Asia exporters – sawnwood domestic demand	1960–85		– 0.53
Other SE Asia exporters – plywood domestic demand	1960–85		– 0.85
Importers – SE Asian and Malaysian sawnwood demand	1960–85		– 1.22
Importers – SE Asian and Malaysian plywood demand	1960–85		– 0.46

Table 6. Comparative Price Elasticity Estimates for South East Asian Tropical Timber (cont.)

Notes a/ Export price of Indonesian logs relative to average world price of termperate non-coniferous logs.

b/ Export price of Indonesian plywood relative to export wholesale spot price of Philippine (luan) plywood.

c/ Elasticity of substitution between sources of origin is defined as the percentage reduction in the ratio of imports from two different countries if the ratio of import prices of the two countries increases by one percent.

d/ Based on Buongiorno (1979) for coniferous sawnwood.

e/ Elasticities based on Cardellichio *et al.* (1989). Note that in the latter study, Indonesian sawnwood and plywood supply are both estimated to have elasticities of 0.7, and Indonesian sawnwood and plywood domestic demand have own-price elasticities of – 0.92 and – 1.55 respectively.

f/ Elasticities for sawnwood and plywood supply were assigned a value of one in the analysis.

Table 7. **Indonesia – Timber Trade and Tropical Deforestation Simulation Model**

Base Case (1988)

Key Variables	**Base Case 1988 Values**	**Actual 1988 Values**
1. Prices (Rp/m³)		
Log border–equivalent price (unit value)	36,714	NA a/
Sawnwood export price (unit value)	333,930	262,013
Plywood export price (unit value)	458,179	464,124
2. Quantities ('000 m³)		
Log production	28,766	29,819
Log domestic consumption	28,480	28,887
Sawnwood production	9,351	10,290
Sawnwood exports	2,923	3,083
Sawnwood domestic consumption	6,427	7,207
Plywood production	7,770	7,733
Plywood exports	6,383	6,372
Plywood domestic consumption	1,387	1,361
3. Deforestation (km²)		
Total forest area	1,401,163	1,401,144
Annual rate of deforestation a/	13,150	13,150

Notes: a/ No data available
b/ Not calculated in simulation model but based on Schmidt (1990). See Table 1.

Table 8. Indonesia – Timber Trade and Tropical Deforestation Simulation Model

Policy Scenario – Sawnwood Export Tax (% Change over Base Case)

Key Variables	**10% Tax**	**50% Tax**	**100% Tax**	**250% Tax**	**700% Tax**
1. Prices (Rp/m³)					
Log border-equivalent price (unit value)	- 0.70%	- 3.35%	- 6.39%	- 14.07%	- 29.03%
Sawnwood export price (unit value)	- 0.98%	- 4.72%	- 9.01%	- 19.84%	- 40.93%
Plywood export price (unit value)	- 0.05%	- 0.23%	- 0.44%	- 0.97%	- 2.00%
2. Quantities ('000 m³)					
Log production	- 0.16%	- 0.77%	- 1.47%	- 3.23%	- 6.66%
Log domestic consumption	- 0.15%	- 0.74%	- 1.42%	- 3.12%	- 6.44%
Sawnwood production	- 0.33%	- 1.58%	- 3.01%	- 6.64%	- 13.69%
Sawnwood exports	- 2.26%	- 10.89%	- 20.79%	- 45.79%	- 94.47%
Sawnwood domestic consumption	0.55%	2.66%	5.07%	11.17%	23.06%
Plywood production	0.01%	0.07%	0.13%	0.29%	0.60%
Plywood exports	0.01%	0.03%	0.06%	0.13%	0.26%
Plywood domestic consumption	0.05%	0.25%	0.48%	1.06%	2.18%
3. Deforestation (km²)					
Total forest area	0.00% a/	0.02%	0.03%	0.06%	0.13%
Annual rate of deforestation	- 0.3%	- 1.60%	- 3.06%	- 6.73%	- 13.88%

Notes: a/ A negligible increase over the base case forest cover of 44 sq km.

Table 9. Indonesia – Timber Trade and Tropical Deforestation Simulation Model

Policy Scenario – Import Ban and Revenue Raising Taxes (% Change over Base Case)

Key Variables	Total Import Ban a/	1% Revenue Raising Import Tax b/	5% Revenue Raising Import Tax d/
1. Prices (Rp/m^3)			
Log border–equivalent price (unit value)	---	– 0.17%	– 0.82%
Sawnwood export price (unit value)	---	– 0.11%	– 0.54%
Plywood export price (unit value)	---	– 0.21%	– 1.03%
2. Quantities ('000 m^3)			
Log production	– 28.33%	– 0.04%	– 0.19%
Log domestic consumption	– 27.37%	– 0.04%	– 0.18%
Sawnwood production	– 10.64%	– 0.03%	– 0.14%
Sawnwood exports	– 100.00%	– 0.23%	– 1.12%
Sawnwood domestic consumption	30.01%	0.06%	0.30%
Plywood production	– 43.84%	– 0.04%	– 0.22%
Plywood exports	– 100.00%	– 0.10%	– 0.51%
Plywood domestic consumption	214.51%	0.23%	1.12%
3. Deforestation (km^2)			
Total forest area	---	0.00% c/	0.01%
Annual rate of deforestation	---	– 0.41%	– 0.72%

Notes: a/ Large price changes were used deliberately to constrain sawnwood and plywood exports to zero in this simulation and therefore are no longer endogenously generated by the model. Also, the functional form of the deforestation equation and its estimation using regional panel data imply that the large changes in log production associated with the import ban scenario cannot be used to predict reliablely the effects on forest cover and deforestation. Thus both price and deforestation effects are eliminated from this policy scenario simulation.

b/ A total of US$23.1 million (1980 prices) in revenue would be raised, with US$5.8 million and US$17.3 million from Indonesian sawnwood and plywood exports respectively.

c/ A negligible increase over the base case forest cover of 53 sq km.

d/ A total of US$113.9 million (1980 prices) in revenue would be raised, with US$28.5 million and US$85.4 million from Indonesian sawnwood and plywood exports respectively.

Table 10. Indonesia – Timber Trade and Tropical Deforestation Simulation Model

Policy Scenario – Sustainable Timber Management (% Change over Base Case)

Key Variables	**25% Rise in Harvest Costs**	**50% Rise in Harvest Costs**
1. Prices (Rp/m^3)		
Log border–equivalent price (unit value)	41.59%	83.06%
Sawnwood export price (unit value)	4.04%	8.09%
Plywood export price (unit value)	2.86%	5.72%
2. Quantities ('000 m^3)		
Log production	– 0.94%	– 1.87%
Log domestic consumption	– 1.37%	– 2.73%
Sawnwood production	– 1.89%	– 3.77%
Sawnwood exports	– 1.03%	– 2.05%
Sawnwood domestic consumption	– 2.28%	– 4.55%
Plywood production	– 0.87%	– 1.73%
Plywood exports	– 0.38%	– 0.75%
Plywood domestic consumption	– 3.12%	– 6.24%
3. Deforestation (km^2)		
Total forest area	0.02%	0.04%
Annual rate of deforestation	– 2.28%	– 4.23%

Notes

1. Barbier (1987) points out that much of the reported decline in log production over the initial period 1979-82 can be attributed to depressed world prices for all timber products, and therefore, was not necessarily attributable to less exploitation because of increased processing activities. Moreover, there has always been a discrepancy between officially reported harvesting levels and rates based on processing industry output. For example, official logging statistics suggested that total log production peaked, before the ban in 1985, at around 25.3 million m^3 per year and declined initially with the ban. In contrast, estimates of log demand based on processing industry output, capacity and conversion rates indicate that log demand reached 27.3 million m^3 per annum soon after the ban, and of course continues to increase as capacity and output expands.

2. The time series and cross-sectional data used in estimating these relationships and constructing the model came from a variety of sources, including World Bank, FAO, IMF and GoI publications, and previous studies on the Indonesia forestry sector cited in this paper.

3. The main importers of Indonesian logs over 1968-84 were China, Hong Kong, Japan, Korea and Singapore.

4. Given that Indonesian sawnwood and plywood are tradeables, the assumption that domestic and export prices of these product are highly correlated over time seems reasonable. This is confirmed by the limited time series data available on both export and domestic prices.

5. The main importers of Indonesian plywood over 1975-88 were China, Hong Kong, Japan, Singapore and USA. The main importers of Indonesian sawnwood over 1974-88 were China, Hong Kong, Italy, Japan, Korea, Malaysia, the Netherlands, Singapore, Thailand and UK. Given the predominance of Japan and its main South East Asian newly industrializing competitors among these importers, the Japanese/Indonesian exchange rate and Japanese industrial activity proved to have strong explanatory power in the demand for Indonesian sawnwood exports (see Table 5).

6. However, because the price of logs was represented by log export unit values, it is only included in the estimation for the period before the ban, 1968-84.

7. Twenty provinces selected, spread over the Indonesian islands of Sumatra, Kalimantan, Sulawesi, Maluku, Irian Jaya, and Nusa Tenggara. Data were available for the years 1973, 1979, 1981, 1982, 1984 and 1988.

8. As some of the instrumental variables were highly correlated, the list of instruments included in each two-stage regression was sometimes modified.

9. Indonesia's real GNP per capita in 1988 (1980 prices) was approximately US$230. A rise in income reflects economic development and may be associated with reduced pressure on deforestation in a number of ways: i) through an increasing concentration of the population in urban centers which reduces the direct pressure of rural populations on tropical forests; ii) through changing the composition of the economy from being based on primary extractive industries (i.e. timber, agriculture, etc) to industrial processing and

service based industries; and iii) through improved efficiency and management of resource use which may accompany economic development, again reducing the indirect pressure of natural resource consumption on tropical forests.

10. In the simulation model, the log domestic demand equation is therefore CONLI = 77.95 + 1.5*QSWI + 1.85*QPWI. A comparison with the regression for CONLI of Table 5 indicates that, by the mid-1980s, recovery rates for sawmills in Indonesia had improved slightly, whereas they had deteriorated somewhat for plymills. This seems reasonable intuitively, given that by the 1980s the expansion in sawmill capacity as the GoI attempted to improve efficiency and quality, whereas plymill capacity was deliberately encouraged to expand.

11. For a review of the arguments, see Barbier *et al.* (1992).

12. The UCBT countries are Belgium, Denmark, France, Germany, Luxembourg, the Netherlands and the United Kingdom.

13. One problem is that the scale of financing required may be well beyond what can be raised from either an import or export surcharge levied on the trade. For example, Agenda 21 of the UN Conference on Environment and Development has estimated that international of over US$1.5 billion annually will be required by tropical forest countries to reduce deforestation (ITTC 1992).

14. *Trespass* is a forestry term that refers to losses due to logging theft, which could also be extended to include losses due to graft. *High-grading* refers to the removal of high-valued timber and leaving a degraded timber stand.

ANNEX J

REVIEW OF ECONOMIC MODELS OF GLOBAL FOREST SECTOR TRADE

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Review of Economic Models of Global Forest Sector Trade

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October 1992

1. Introduction

One of the main objectives of this study was to evaluate alternative timber trade policy options through comprehensive analysis of the economic gains and losses for producer and consumer countries.[1] This requires the development and application of one or more formal analytical models to test alternative policy options in a consistent framework and, using standard economic criteria, to provide comparable quantitative measures.

Formal analysis of trade policy options at a *global level* is necessary for two reasons: firstly, the mandate of ITTO and the scope of this study are global; secondly, international markets for timber products are relatively well-integrated, with considerable scope for substitution among alternative species and sources. Hence virtually any intervention affecting the trade in tropical timber products can be expected to have global impacts, both direct and indirect, on the level and patterns of trade in timber products. Early work for this study therefore included a review of the leading economic models of global forest sector trade, in order to to determine their potential for analyzing broad trade flow impacts and the aggregate welfare effects of trade policy interventions.

Any modelling exercise involves some compromise between the desire to account for all relevant variables with the minimum of assumptions and the equally important need for clarity, as well as constraints imposed by data, computing power and time. One of the weaknesses of global economic models arises from the inevitable simplification and generalization of markets. Aggregation of product categories and markets can limit the sensitivity of global models, hence the reliability of results.

A specific aim of this study was to analyze alternative trade policy options in terms of the economic gains and losses for different producer and consumer countries. This implies a model with a reasonable degree of geographic detail, to distinguish major producer and consumer countries, as well as product detail to distinguish hardwoods from softwoods and raw materials from finished goods. At the same time, because international timber markets are relatively well integrated, policy interventions in one market (product or country) can be expected to affect other markets (products or countries). Hence an appropriate model must not only be able to distinguish individual countries but it must also be able to describe the economic links between them and, in particular, the role of prices in determining the patterns of trade. This is necessary in order to account for shifts in trade arising from policy-induced changes in demand or supply at a country level. Thus two criteria used to assess alternative modelling approaches were the level of geographic and product detail possible and the sensitivity of links between markets.

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[1] See ITTO *Activity Progress Report* (PCM(IX)/4, 24 October 1991).

2. Review of Existing Economic Models of the Global Forest Sector

Having determined the kind of modelling approach required to achieve the aims of this study, the next step was to identify what kind of models actually exist or are possible to construct with the available data and knowledge. An initial review of previous efforts and publications in forest sector trade modelling helped to define the analytical options and led to a number of valuable contacts. LEEC received considerable assistance in this regard from the staff of the USDA Forest Service, the United Nations Food and Agriculture Organization (FAO) and from faculty at the Universities of Melbourne, Maryland and Kiel. Based on this information, LEEC attempted to assess the strengths and weaknesses of the different types of models. The decision quickly reduced to a choice between using an existing model or developing a new model from scratch.

A good representation of the state-of-the-art in forest sector and trade modelling is contained in three CINTRAFOR publications: Cardellichio et al. (1987), Haynes et al. (1992) and Adams et al. (1992). Probably the most sophisticated model of the global forest sector that LEEC considered for use in this study is the Global Trade Model (GTM), developed by the International Institute for Applied Systems Analysis (IIASA) under the Forest Sector Project (1981-85). The GTM is a sophisticated model designed to make long-run projections of international trade in a variety of forest products (excluding pulp and paper). Although not explicitly intended for use in comparative statics exercises, i.e. the analysis of alternative trade policies, the GTM can be used to illustrate how different policy assumptions affect the industry over the long-run. A major strength of the GTM is endogenous price estimation. This means that prices will adjust to accomodate changes in costs or in demand, as they do in the real world. The market equilibrium is calculated through an iterative algorithm, based on timber harvest and delivery costs, processing costs, international transport costs, trade barriers and product demand in all regions covered.

Although LEEC did not adopt the GTM for policy simulation analysis, the model that was used eventually (see below) is itself a version of the GTM and shares many of the same strengths and limitations. Some description of the original model therefore may be helpful. The GTM is fully described in a book by Kallio et al. (1987). The following description and critique of the GTM is based largely on a paper by Cardellichio and Adams (1988).

<u>The Structure of the IIASA Global Trade Model</u>

The IIASA Global Trade Model is a *spatial equilibrium* market model. In other words, supply and demand are balanced at a global level by allocating excess demand or surplus in particular regional markets to trade. An iterative algorithm ensures that prices and trade flows will adjust so that no excess demand or supply remains in any region. The GTM is also a *partial equilibrium* model, in that it describes only the forest sector, although some information from other sectors is incorporated in exogenous variables affecting demand, eg. building and construction. The objective function of the GTM is to maximize global producer and consumer surplus, i.e. maximum producer profit and minimum consumer cost.

The GTM includes 16 forest product categories, of which 9 final, 3 intermediate and 4 primary. The entire world is divided into 18 regions. The GTM has four component modules: Timber Supply; Processing; Demand; Trade and Transport. The GTM solves for 5 year periods, and reports the following results: the annual quantity of log and pulpwood removals, the volume of trade and conversion of log and pulpwood between and within regions, the quantity of final products within each region, the volume of trade in final products, and the marginal prices of raw materials and final products. The typical planning horizon is ten periods, i.e. 50 years. The base year is 1980.

The principal exogenous variables in the GTM are: growth in per capita income, income and price elasticities (a function of per capita GDP), the population growth rate, real exchange rates, import tariffs, timber removals in the USSR and Eastern Europe (assumed to be set administratively, not market driven), pollution and climate change (assumed to have no impact in the base case).

Criticism of the IIASA Global Trade Model

Like any empirical model, the GTM suffers from many simplifications and generalizations which no doubt seemed unavoidable when the model was constructed, due to poor understanding of the economic factors which determine supply and demand for forest products or a lack of sufficiently detailed or reliable input data. This section describes some of the major weaknesses of the GTM for use in forest sector planning and policy analysis, based again on Cardellichio and Adams (1988).

In terms of the model's specification, one of the most fundamental criticisms of the GTM is an absence of optimal control features, i.e. the lack of inter-temporal optimization. In other words, the solution of the model in period t will influence the result in period $t+1$, but not vice versa. The implication is that forest product markets are completely myopic, which seems unlikely given the relatively long planning horizon inherent (at least on the supply side) to the forest industry.

Cardellichio and Adams make detailed criticisms of the timber and product supply modules in the GTM, signalling in particular problems related to the specification of investment. On the demand side, they point out that the GTM uses only very broad indicators to determine final product demand within each region, i.e. population growth and per capita GDP. However, movements in these variables may be a poor reflection of underlying factors which affect the demand for particular products, eg. housing starts and industrial activity driving demand for solid wood products. Demand equations also fail to include an interaction term (i.e. the product of population growth and income growth). Moreover, the GTM relies on a linear approximation of a non-linear (constant elasticity) demand function, which is increasingly unreliable as one moves further from the base year equilibrium, i.e. demand becomes more elastic as prices rises.

A more fundamental problem with the specification of demand in the GTM is the failure to account for substitution across product categories or between forest and non-forest products (i.e. cross-price elasticity equals zero). In other words, the model assumes that consumers confronted with a change in relative prices will neither substitute other materials (eg. metal or plastic) for timber products, nor substitute softwood for hardwood.

At the same time, the model assumes that the elasticity of substitution within product categories is infinite (eg. that all non-coniferous sawnwood is perfectly substitutable, wherever it comes from). Recent empirical studies of substitution between tropical and temperate timber, and between timber and non-timber products, indicate that these assumptions may be simplistic (see for example Vincent et al. 1991, Alexander and Greber 1991). In other words, the GTM may not be very reliable in analyzing the impact of trade policies which affect certain product categories or countries and not others.

The trade module of the GTM also suffers from a number of technical flaws. Because the model fails to reflect exchange rate fluctuations in capital and transport costs, both price and quantity predictions are susceptible to dramatic shifts. In other words, exchange rate fluctuations will have a larger impact on demand than on supply.

There are also problems with the formulation of transport costs. The omission of intra-regional transport costs results in false price estimates, since the supply price is cost at the mill while demand price is at the point of consumption. Another problem arises from the calculation of inter-regional transport costs as a declining function of the previous period's trade volume, which creates an artificial barrier to entry.

In terms of its performance, the GTM is deemed to be a relatively unreliable predictor of real bilateral trade flows. This is attributed to a high level of regional and product aggregation, a simplistic objective function (other factors influence the trade besides producer profit maximization and consumer cost minimization, eg. trading agreements, relationships, perceptions, etc.) and data problems (inadequate, unreliable, inconsistent and out-of-date (1980)).

Price predictions with the GTM are also considered unreliable, due to the failure to include intra-regional transport costs, failure to distinguish quality differences within each product category, and the fact that after period 1 the GTM uses long-run prices which include the cost of capital, thus ignoring short-term fluctuations in the business cycle (eg. temporary excess profits or variable cost pricing).

Sensitivity analysis with the IIASA Global Trade Model

The GTM includes three types of trade barrier: bans, quotas and tariffs. Many so-called bans are used to simplify computations, by setting low levels of trade to zero. Lifting these bans in model simulation runs results in little change in total output but some increased trade volume, with a few products affected significantly. However, the total effect is limited by the recursive specification of the transport cost function. Trade quotas are specified as fixed flows (eg. between USSR and Eastern Europe), or as an 'inertia' constraint to reflect short-term trade rigidity. The latter feature results in some anomalies, such as imports priced above domestic products, but has no effect on demand due to the specification of the demand function. Relaxing the inertial constraint has little effect on total output predictions, but significantly alters levels of trade.

Other sensitivity analysis carried out with the GTM included simulation of general trade liberalization (tariffs set to zero). Effects are mixed, but generally result in increased trade for final products but little impact on total output and prices, due to other non-tariff barriers (i.e. bans, inertial constraints and rigidity resulting from the transport cost function).

Simultaneous simulation of relaxed inertial constraints, elimination of trade bans and current period transport costing (but no change in tariffs) has mixed but dramatic effects: output and trade volumes are affected both positively and negatively, depending on the region, but there is an overall concentration of trade (i.e. a reduction in the total number of trading 'arcs'), and reduced price variation across regions.

3. The CINTRAFOR Global Trade Model (CGTM)

The model used in this study to analyze the global impacts of timber trade policy interventions is the CINTRAFOR Global Trade Model (CGTM). This more recent model of the global forest sector is maintained by the Center for International Trade in Forest Products (CINTRAFOR), part of the University of Washington, Seattle. The CGTM was selected largely on the strength of its coverage of tropical timber markets, including price-endogenous simulation of supply and demand for hardwood products in the major producer and consumer countries, as well as its detailed description of trade links and the relative ease of implementing policy scenarios in the model. Of course the CGTM also has some significant limitations, many of which it shares with the original IIASA Global Trade Model. These mean that the results of projections and policy simulations carried out with the CGTM must be interpreted with caution.

The CGTM shares many features with the original IIASA Global Trade Model, from which it is derived, but also incorporates a number of significant improvements. In particular, the latest version of the CGTM is based on data up to 1990. The model is described in three CINTRAFOR publications: Cardellichio et al. (1988 and 1989) describe previous versions of the CGTM while Annex K of this report describes the most recent revisions and up-dates. The following is a brief summary of how the CGTM differs from the GTM and the major strengths and weaknesses of the former.

Like the original GTM, the CINTRAFOR model has four component modules: Timber Supply; Product Supply; Product Demand and Trade. A basic structural difference between the two models, however, is the level of detail in product and market specification. CINTRAFOR reduced the number of product categories from 16 to ten. The seven separate pulp and paper categories of the IIASA GTM were combined into one while fuelwood was dropped altogether. New categories were created to distinguish coniferous from non-coniferous plywood. In addition, the number of regions was increased substantially, from 18 to 40. Most of the additional geographic detail is for countries of the Pacific Rim, especially North America and Southeast Asia.

While most regions have fully specified endogenous demand and supply equations, 16 regions are exogenously specified, due to data problems, low levels of trade and specialized products. Exogenously determined regions include all of Latin America except Chile, the USSR, E. Europe and all of Africa. For these regions the user must provide output and consumption levels; trade is allocated automatically by the model. Pulp and paper production are also determined exogenously.

Like the GTM, the CGTM objective function maximizes producer and consumer surplus and there are no inter-temporal optimization features. Timber supply is improved, conceptually, with a conventional stumpage supply model, but data limitations still require simplistic assumptions about harvest and delivery costs - in some cases CINTRAFOR had to adopt delivered log cost models, due to lack of data to distinguish stumpage values from harvest and delivery cost. As before, timber supply elasticity with respect to inventory is assumed to equal one. Thus timber age-class is not incorporated in inventory dynamics, despite considerable criticism of the original GTM in this regard. The breakdown of timber harvest between sawlogs, pulpwood and fuelwood is only partly endogenous; fuelwood is essentially ignored by the CGTM.

The product supply module is improved by using a new smooth function, instead of the IIASA 'stepped' function with three levels of technology. Product supply in the CGTM is a function of variable production costs and capacity utilization, based on statistical estimation.

The product demand module includes limited end-use influences for some products and regions but there are still no cross-price elasticities (either for other forest products or for non-forest products). The demand function uses a non-linear, constant elasticity form. In some cases CINTRAFOR use elasticities taken from other studies.

Trade calculations are simplified, as under the GTM, by 'banning' trade on many 'arcs' where there is little current or anticipated trade volume. However, there are no inertial constraints on trade and the CGTM uses a much simpler specification of transport and tariff costs than the GTM. The new model simply takes the difference between export and import prices as the gross 'transfer cost,' thereby confounding transport costs with other 'value adjustments' (i.e. tariff and non-tariff barriers).

Limitations of the CGTM

For the purposes of this study, the major limitations of the CGTM are the following:

- Lack of sensitivity to substitution across product categories or competition from non-forest products;
- High degree of aggregation across non-coniferous (hardwood) products and across tropical producer countries;
- Exogenous simulation of supply and demand for all of Africa and all of Latin America outside Chile.

The first point means that the CGTM cannot accurately predict the demand response to price changes within any given product category, since it fails to reflect the way in which consumers will substitute softwoods for hardwoods, or reconstituted panels for solid wood products, or plastic and aluminum fittings for wood equivalents, for example. The second problem has a similar effect, since the model does not account explicitly for quality differences between products obtained from different sources or other transactions costs which constrain consumers' ability to change sources of supply at will. Both of these problems arise from a poor understanding of consumer behavior and a lack of reliable information on cross-price elasticities of substitution.

The fact that many tropical producer regions are exogenously determined also undermines the reliability of the CGTM. According to the model's developers, this was unavoidable in many cases (Cardellichio et al. 1989). While there is no lack of statistical information for tropical producers, much of the available data is contradictory and unreliable. As a result, attempts to estimate timber supply functions for these regions yield price coefficients that fail to pass the test of statistical significance. A possible explanation is that timber supply from tropical countries is, in fact, not price-sensitive and that output must be explained by other factors. According to one argument, tropical timber supply may be best described, at least in the short run, in terms of the maximization of economic rents (Vincent in Adams et al. 1992). In any event, for a number of tropical regions, future timber supply and product demand in the CGTM are simply extrapolated from historical trends. The user is asked to believe that these regions do not respond to price changes and thus, while they may import and/or export timber products, they do not *compete* in any real economic sense.

Despite these weaknesses, LEEC concluded that the CGTM offered the best available framework for global trade policy simulations. Specialists in the field, with whom LEEC staff consulted, generally concurred with this appraisal. Clearly only a global model can adequately assess the long-run, world-wide impacts of multilateral policy interventions. Comprehensive coverage of world markets for forest products in the CGTM makes possible a number of important analytical tasks. Detailed geographical specification permits analysis of policy impacts on a country-by-country basis. Spatial equilibrium with endogenous price estimation means that the CGTM is particularly well-suited to tracking the effects of policy on prices and competitiveness, illustrating explicitly any resulting change in market share within product categories. In addition, a global model can help to evaluate the potential of global revenue-raising mechanisms, by illustrating the resulting distortion of trade. Most importantly, other models are even less detailed than the CGTM in their treatment of tropical hardwood producers and markets.

Policy Simulation with the CGTM

Work carried out with the CGTM for this study can be divided into two broad areas: (i) updating the underlying statistical database to incorporate information up to 1990, re-estimating structural equations and generating new baseline projections of timber production, consumption and trade in the short-run (to the year 2000) and in the long-run (to 2040); and (ii) generating and interpreting a certain number of policy scenarios over the same period, to illustrate the economic impact of policy interventions affecting tropical timber markets. This work is fully described in Annex K.

Regarding the policy scenarios implemented on the CGTM, LEEC and CINTRAFOR decided to explore policy changes *at the margin*, rather than extreme simulations, for the simple reason that radical changes tend to push the model beyond the bounds of predictive reliability. Marginal policy adjustments were also considered to be more relevant in political terms. The types of policy scenarios considered included:

- *tropical timber trade constraints* modelled as an exogenous 10% increase in the import prices of tropical products.

- *tropical timber supply constraints* in the form of an exogenous 10% reduction in the available timber inventory in tropical producer countries.

- *trade liberalization* modelled as a 10% reduction in transfer costs and elimination of log export bans

For each of these policy simulations, CINTRAFOR was asked to compare the output of the CGTM to the base case projections. The main quantitative criteria used for comparison were: volume of trade, prices, output and consumption; economic welfare and industrial competitiveness. In their interpretation of the model projections CINTRAFOR also discussed, in qualitative terms, issues involving product substitution and technological change which are not formally incorporated in the model.

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ANNEX K

MEASURING THE IMPACTS OF TROPICAL TIMBER SUPPLY CONSTRAINTS, TROPICAL TIMBER TRADE CONSTRAINTS AND GLOBAL TRADE LIBERALIZATION

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Terms of Reference

For model updating and policy simulations using the
CINTRAFOR Global Trade Model

These Terms of Reference relate to a sub-contract for consultant services to be provided as part of the ITTO Activity entitled *The Economic Linkages Between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests* (Activity No. PCM(IX)/4). Under these Terms of Reference the London Environmental Economics Centre, hereafter referred to as LEEC, agrees to engage the services of the Center for International Trade in Forest Products, hereafter referred to as CINTRAFOR, in accordance with the following conditions:

1. CINTRAFOR will provide LEEC with a microcomputer disk copy of the entire existing database used with the current version of the Global Trade Model (GTM) maintained by CINTRAFOR.

2. CINTRAFOR will inform LEEC of the additional statistical information required in order to update the existing data base used with the GTM. Where such information is presently available to LEEC, it will be provided to CINTRAFOR free of charge and in a timely manner.

3. Subject to the availability of sufficient data and barring unforeseen technical difficulties, CINTRAFOR will update, calibrate and debug a new version of the GTM based on data to 1990, generating a Base Case Scenario with projected trends in the global supply of and demand for timber products up to the year 2040 AD. CINTRAFOR will compare the results of this new scenario to projections obtained with the previous version of the GTM, based on data to 1987. Sensitivity analysis of the Base Case Scenario projections will be implemented as agreed upon by LEEC and CINTRAFOR.

4. CINTRAFOR will generate additional scenarios with the GTM to simulate the set of policy interventions outlined in points 5 to 8 below. These simulations will be implemented separately, on the existing version of the GTM, based on data to 1987, or if possible on the new version of the GTM, based on data to 1990. In each case, CINTRAFOR will compare the results of policy simulations to the Base Case Scenario in terms of regional and global changes in the resource base (inventory); shifts in forest sector output, consumption and trade flows; trends in forest product prices and competitiveness; and changes in producer and consumer surplus.

5. **Tropical timber trade constraints:** To simulate the effect of additional tariff barriers being raised against the import of "unsustainable" tropical timber products by Northern consumer countries, CINTRAFOR will estimate the impact of a marginal exogenous change in "transfer costs" between selected regions -- i.e. an increase in the wedge between export and import prices. This simulation would affect only trading arcs between regions which include major producers and importers of tropical nonconiferous timber products. As part of this scenario, CINTRAFOR will estimate the potential gross revenue which could be obtained from such intervention.

6. **Tropical timber supply constraints:** To simulate the potential effect of implementing sustainable forest management regimes or other constraints on timber harvest in tropical regions, CINTRAFOR will estimate the impact of an exogenous marginal shift in the supply curve for nonconiferous sawlogs and veneer logs and nonconiferous roundwood pulpwood from relevant regions.

7. **Global trade liberalization:** To simulate the likely effect of removing existing barriers to trade in all timber products, CINTRAFOR will estimate the impact of an exogenous reduction in price differentials for all products traded internationally, so as to reflect only average transport costs rather than transport plus value adjustments. This scenario will include removal of existing quantitative and non-tariff restrictions on exports and imports and the opening of new "trading arcs" to reflect the potential diversion of trade to new sources (eg. outside the Pacific Rim). LEEC will attempt to assist CINTRAFOR in the evaluation of existing tariff and non-tariff trade restrictions.

8. The whole contract period covering the tasks described above is from 15 June to 15 October 1992. During this period CINTRAFOR will prepare a report describing the methodology employed and results obtained in carrying out the tasks described above. This report will be submitted to LEEC not later than 1 September 1992. CINTRAFOR will revise or amend this report to reflect written comments received from LEEC within six weeks of submission.

Impacts of Tropical Timber Supply Constraints, Tropical Timber Trade Constraints and Global Trade Liberalization

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Impacts of Tropical Timber Supply Constraints, Tropical Timber Trade Constraints and Global Trade Liberalization

John M. Perez-Garcia
Bruce R. Lippke

October 10, 1992

EXECUTIVE SUMMARY

Global competitiveness determines the impact of policy alternatives: Sustainable tropical timber management is made economically possible by higher timber prices. Various trade, environmental and timber supply policies will impact regional and global wood supplies and demands affecting timber prices. To evaluate the potential impact of various policies on the setting for tropical timber management, it is necessary to evaluate the impact of changing trade flows from a number of different supply regions to consuming countries, in effect evaluating the changing competitiveness of global trade. The CINTRAFOR Global Trade Model (CGTM) for forest products was used to construct a short-term baseline projection and then examine the impacts of changes from baseline conditions by (i) constraining supply, (ii) introducing trade constraints, and (iii) reducing tariffs and trade barriers as a move toward trade liberalization. A long-term policy scenario was also constructed to illustrate possible implications for sustainable management.

Baseline conditions in the short term show:

a. Shortages exist in tropical timber, not temperate hardwoods: The decreasing inventory of tropical timber is beginning to constrain harvests significantly, particularly in Malaysia. There is no comparable shortage of temperate hardwoods which supply large consuming country markets, particularly in the US, Europe and other non-Asian markets. Even with increased sawlog production in Indonesia and Brazil, the two tropical hardwood suppliers with a large inventory, the tropical hardwood share of all hardwoods begins to decline. Tropical hardwood sawlog prices rise steadily reaching levels 60 to 80% above 1990 levels by the year 2000; most of this price increase occurs in SE Asia. Prices in countries with adequate temperate hardwood sources remain more stable.

b. Strong demand in tropical hardwood producing countries shifts markets away from exports: The expected strong economic growth in tropical timber producing countries without strong demand growth in other consuming countries in conjunction with the declining supply of tropical hardwood logs produces a substantial shift away from export to domestic markets by the tropical hardwood suppliers. Malaysia West becomes an importer; Malaysia East augments processing capacity and decreases log exports to replace markets once held by Malaysia West. Log exports trend downward and are partially replaced by product exports.

c. Japan's needs are declining but they remain competitive log purchasers: Japan's high-valued, end-use markets continue to import logs to meet their needs, forcing less competitive consumer countries to reduce log purchases. High growth in other Asian consuming countries is filled by increased processed imports, especially in Korea, which has lost much of its processing competitiveness. With very high log prices after the year 2000, Japan decreases log imports substantially.

d. Product prices are constrained in consumer countries: While product prices are pushed up with rising log prices, the availability of other supply sources in the more developed consuming countries, in conjunction with lower demand growth, constrains their product price increases which in turn squeezes the profitability for processors of tropical timber. Plywood price increases in Japan rise hardly at all. Relatively small price increases are adequate to increase Brazil's sawnwood exports considerably. Temperate region wood processors benefit from increasing availability of wood and gain market share. While tropical hardwood processors also face rising log prices, they at least gain the benefit of rapid domestic demand growth. Other consuming country processors will be further squeezed by softwood and temperate hardwood substitutes. The trend in the more developed-consuming countries is therefore for a reduction in log imports and the processing of imported logs, and increased product imports with more substitution away from tropical products.

e. Structural changes in the Asia-Pacific Region will result in the near-term as substitutes are not available: In the Asia-Pacific markets, scarcity of temperate hardwoods as well as softwoods will impede substitution of these sources for tropical hardwoods. One can expect significant structural changes in these markets to occur in the short-term as tropical hardwood inventory and harvests decline. Log markets in the Atlantic region are very different from those in the Asia-Pacific region. While African-European tropical log markets are not well differentiated in the model, it is still evident that the increasing availability of temperate hardwoods, both in log and product form, will temper log shortages of tropical timber from Africa to Europe. Even though Africa West log exports has declined historically they should have the opportunity to shift away from European markets to higher prices in Asian markets. However, the structural changes taking placing in Asian markets may result in the consuming countries reducing tropical log exports to the extent that Africa West can not develop a market advantage in the long term.

Longer-term conditions show sawlog prices continue an upward trend but at a slower rate if targeted-sustainable-harvest rates can be maintained: With the available tropical hardwood inventory in several countries declining rapidly by 2000, either harvest levels are reduced quickly to more sustainable levels or they drop even more abruptly just a few years later with the depletion of the inventory. The estimates used for the commercial timber inventory for Malaysia, show that they are near depletion of that inventory. Harvest rates, that some have suggested are sustainable, 4 mmcm for Malaysia West and 12.5 mmcm for Malaysia East still result in projected sawlog price increases of 100% by 2010 and 200% by 2020. These targeted-harvest rates may be considered an optimistic policy scenario as they require some harvest of the non-commercial inventory levels in Malaysia given the nearly complete depletion of currently defined commercial inventory. Malaysia West prices will rise higher than other countries; as they become a net importer. Malaysia East log production declines to as low as 6 mmcm by 2005 as a consequence of low inventory and then is assumed to recover to the sustainable target of 12.4 mmcm by 2010. Indonesia remains stable at 54 mmcm beyond 2010, well above the derived 1990 harvest level of 33 mmcm. Even though these harvest rates are likely to be judged as optimistic, they still result in steadily rising prices with demand outstripping supply. Increased harvests by Brazil and Indonesia are not adequate to offset the other harvest declines and also service strong demand growth. Their inventories are sufficiently large that the higher prices produce increasing harvest levels in the model simulation unless harsh harvest constraint are superimposed. Their harvest levels may not be forever sustainable, but they are not close to depletion of the commercial inventory for many years.

The commodity in short supply continues to be tropical hardwood logs, not processing capacity. European markets show no impact of shortages in contrast to SE Asia. With a 30% reduction in supply outside of Indonesia and Brazil, log price increases of 200% above 1990 levels are projected by 2020. Product price increases do not keep up with those cost increases. While consumer countries are forced to accept higher prices and do change their consumption patterns with those high prices, tropical log prices are not likely to flatten out and decline much until the results of increased investment in sustainable forest management can support increased harvest levels. European markets show a tendency for temperate hardwood log substitution for tropical hardwoods.

Much of the pressure on prices derives from the strong growth in demand for the SE Asian region. Substitution by other wood products, and other non-wood materials that may not be adequately characterized in the model, can be expected to constrain these price increases to some extent. It should be noted that the purpose for using CGTM, a global trade model is to allow trade flows to adjust shifts between supply regions and demand regions as conditions change. In comparison to models such as the USFS model of North America, CGTM shows much smaller softwood price increases in response to softwood supply curtailments, as CGTM is able to source as much as 75% of a US supply reduction in world markets. These CGTM simulations of tropical hardwood supply reductions show large increases in sawlog prices in spite of access to global supply sources. The explanation is primarily the large demand growth in SE Asia with few substitute supply regions short of substitution with softwoods which is not incorporated in the simulation.

Higher log prices should motivate sustainable forest management. The substantially higher log prices over time, even if constrained somewhat by substitutes, should make it possible to economically motivate more investment in sustainable forest management. In particular, while it may not have been economic to manage the current harvest in such a way as to increase the yield of the next harvest given the low prices in the past, these price increases will greatly increase the rate of return for managing forests for more sustainable production. While much of this benefit may take 25 or more years to provide mature inventory and is therefore beyond the forecasting period illustrated, some features such as greater use of waste material and lower-valued species could occur much more quickly and dampen the price increases. Some increase of currently non-commercial timber is already assumed in the sustainable harvest targets used for the long term projections for Malaysia.

Supply constraints primarily accelerate the timing of the impact of the declining trend in harvest. One focus of environmental policy has been to constrain supply in order to preserve tropical forests. Others want to reduce the harvests prior to exhaustion of the inventory to smooth the transition to sustainable harvest levels. In the short term these pressures, if implemented, result in a shift or constraint to supply. With supply constraints, sawlog prices increase even faster and rise to somewhat higher peaks. A 10% supply reduction causes sawlog prices to rise another 15% by 2000. For the most part, since the region is undergoing a supply reduction as the inventory is depleted, the impact of an additional supply constraint is simply to accelerate the impact of shortages and higher prices in time. A supply reduction would constitute a loss in wealth to the tropical timber supply countries to the degree that the reduction is more than required to avoid harvest rates falling below sustainable levels.

Timber trade constraints reduce the value of timber, slowing down the motivation for increased investment in sustained forest management. Since there is a shortage in tropical supply, a reduction in demand from trade constraints might be viewed as restoring a better balance. Such a policy ignores the need for higher prices to motivate sustained management policies. One focus of environmental movements has been to increase the barriers against tropical timber trade to penalize non-sustainable activities. With a 10% increase in tariffs, the CGTM simulation shows tropical hardwood sawlog prices declining by 10-20% by 2000. The largest impact is on log exports, causing consumer countries to reduce their imports more quickly. Indonesian plywood production is also off by almost 10%. While such an impact might have negotiating value, to force the producing countries to change policy, as an economic policy it is counterproductive to motivating sustainable management. The reduction in values reduces the economic return to managing for sustainable growth.

Reduced tariffs and trade liberalization increase the prices for tropical timber, a wealth gain for the region. Since higher timber prices are viewed as an increasing return for managing forests for sustained-growth, there has been concern that trade barriers that have been introduced largely by consumer countries contribute to low prices and a short-term, non-sustainable management focus. By eliminating tariffs the demand for tropical timber is increased, with increasing returns to managing the forests. While there are both non-tariff barriers and tariff barriers, eliminating the tariff barriers alone has a significant impact.

Reducing transfer costs by 10% as a proxy for reduced tariffs and also eliminating export bans on logs and products in a CGTM simulation of global trade competition results in tropical hardwood sawlog prices rising 20% by 2000. While this demand increase does contribute to a more rapid depletion of the timber inventory, there is a substantial wealth gain by tropical hardwood producers which can support increased investment in sustainable management and higher-growth forests, including the potential for much less damage to the forests from logging activities.

The benefits to consumer countries are also large, with significant declines in log prices as a consequence of open markets. Since the commodity that is in short supply is tropical hardwood logs and the hardwood producing countries have no comparative advantage in processing, they lose some of their processing to the consuming countries. The fact that the economic and product demand growth is higher in the tropical hardwood producing countries than the consuming countries shifts some of the wood flow into Malaysia West, the producing country with the greatest shortage in supply.

Overall implications: These preliminary model simulations suggest that markets will find it difficult to adjust to declining tropical timber supplies even if those countries with large inventory increase their harvest rates to partially offset declines in other countries. With very high economic growth in the tropical hardwood producing region it is doubly difficult to satisfy local demand resulting in a substantial shift away from exports to more local use of the resource. Prices should be expected to rise faster than other wood and non-wood substitutes. This will increase the chances of new forms of substitution to hold down the price increases. More directly it will cause a reduction in log flows into the developed-consuming countries and a less than offsetting increase in product imports. Even with optimistic sustainable harvest targets, substantial sawlog price increases are suggested.

Accelerated reductions in harvests to more sustainable levels, equivalent to a supply constraint would further increase price pressures. The outlook is therefore favorable that log prices will rise enough to significantly improve the motivation for sustainable management.

Decreased trade barriers would increase the demand for sawlogs, raising prices further and adding to that motivation. Increasing tariffs as a means of putting pressure on supply countries to manage forests on a more sustainable basis is counterproductive from an economic perspective, as it decreases the economic motivation for sustainable management.

IMPACTS OF TROPICAL TIMBER SUPPLY CONSTRAINTS, TROPICAL TIMBER TRADE CONSTRAINTS AND GLOBAL TRADE LIBERALIZATION

1. INTRODUCTION

As part of the ITTO Activity entitled "The Economic Linkages Between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests" the Center for International Trade in Forest Products (CINTRAFOR) at the University of Washington was asked by the London Environmental Economics Centre (LEEC) to assess the impacts of alternative scenarios on tropical timber supply constraints; tropical timber trade constraints; and the global trade liberalization of trade restrictions. These policies necessitate an evaluation of changes in trade flows from a number of different supply regions to consuming countries; in effect, evaluating the changing competitiveness of global trade. Hence, we have used a globally competitive forest products trade model, the CINTRAFOR Global Trade Model (CGTM), to examine the impacts of implementing these policy scenarios.

The three scenarios were selected to simulate the effects of trade policies available to decision makers to promote sustainable forestry practices. The scenario on tropical timber supply constraints simulates the potential effect of implementing sustainable forest management regimes or other constraints on timber harvest in tropical regions. The tropical timber trade constraints simulates the effect of additional tariff barriers being raised against the import of "unsustainable" tropical timber products by northern consumer countries. Finally, the global trade liberalization scenario simulates the likely effect of removing existing barriers to trade in all timber products.

This document reports results using CGTM with recent updates of the data through 1990. The report is organized as follows. The following section describes the methods employed to analyze trade policy impacts. It provides a brief description of the CGTM, and is followed by several sections that describe (i) the data and data limitations; and (ii) methods employed to forecast the key exogenous variables in the model. The next section then describes the reference case output, including a description of future demand for forest products and a description of the key tropical timber producing regions and how they are treated in the model. The final sections describe methods to be employed to implement the scenarios and descriptions of each scenario.

2. METHODS EMPLOYED

The CGTM is a spatial equilibrium model of the global forest sector. It is the result of 11 years of research; five years initially at the International Institute of Applied System Analysis (IIASA) in Vienna, Austria, and six additional years at the University of Washington. The present model is an updated version of the CGTM developed by Cardellichio and others at CINTRAFOR (see Cardellichio, et al. 1988, 1989). Data has been updated to 1990 with additional minor revisions to exogenous forecasts.[1] In the following sections the general modelling approach used in CGTM and the methods used to forecast the key exogenous variables in the model are described.

2.1 The CINTRAFOR Global Trade Model (CGTM)

The CGTM projects production, consumption, prices and trade of ten forest products in 43 regions which comprise the globe. Figure 2.1 presents a flow chart describing the various components of the model. Given the demand and supply for each region, bilateral trade flows between regions, as well as transportation costs, the model solves for an equilibrium price, production, consumption and trade flow. It takes the equilibrium results for a base year and uses them to find equilibrium solutions for subsequent years by considering changes in demand, production and trade levels. These changes are implemented through submodels for timber growth, production capacity, and consumption. A detailed description of the model is presented in Kallio et al. (1987) and Cardellichio et al. (1988, 1989).

2.2 A Short Description of the Model

CGTM utilizes the mathematical programming approach suggested by Samuelson (1952) and incorporated by Kallio et al. (1987) in the IIASA forest sector model. A partial equilibrium solution is found by summing consumer plus producer surplus minus transportation costs. Constraints working on the model are (i) materials balance--in each region for each commodity, consumption equals production minus net trade; and (ii) production capacity--production levels lie within the industrial capacity of each region.

Ten products are considered in the model: Coniferous and nonconiferous sawlogs; coniferous and nonconiferous pulpwood; coniferous and nonconiferous sawnwood; coniferous and nonconiferous plywood; reconstituted panels; and wood pulp. These last two products are defined in the model as inputs to account for pulpwood and processing residual usage.

The regional breakdown in the model is the most complete for a global forest sector model. There are 33 final product demand regions around the globe. A large number of these regions have estimated demand functions for sawnwood and plywood. Final product demand is specified in constant-elasticity form using one of the following equations:

$$Q/I = a*P^b \qquad \text{or} \qquad Q = a*P^b*I^d \tag{1}$$

where:

Q is the product consumption (mm m^3 of product)
I is an indicator of market activity (for example, GDP or housing starts)

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[1] Demand forecasts for all regions and timber supply constraints--mainly in the softwood producing regions of the public sector of the US West region--have been revised to reflect their most likely future development.

P is the product prices (real local currency per m^3 of product
a, b, d are estimated parameters

The product supply specification is:

$$P = C + a*U^b \tag{2.1}$$

$$C = (ST + HD)*R_1 + MVMC - CHIPS*R_2 \tag{2.2}$$

$$U = Q/K_{-1} \tag{2.3}$$

where:

P is the product price (real value per m^3 of product)
C is variable production cost (real value per m^3 of product)
U is capacity utilization
a, b are estimated parameters
ST is stumpage cost (real value per m^3 of log)
HD is log harvest and delivery cost (real value per m^3 of log)
R_1 is an input-output coefficient (m^3 of log used per m^3 of product)
MVMC is minimum variable manufacturing cost (real value per m^3 of product)
CHIPS is the price of wood chips (real value per m^3 of chips)
R_2 is an input-output coefficient (m^3 of product)
Q is product output (mm m^3 of product)
K_{-1} is production capacity at the end of the previous year (mm m^3 of product)

In most forest sector models the supply specification is fixed proportions: a unit of output requires fixed proportions of inputs. That is to say that timber is assumed to be consumed in fixed proportions to product output.

The supply specification sets the equilibrium price, P, equal to unit cost, C, plus a margin, where the margin is estimated to be a function of the slack in capacity utilization. In CGTM, changes in production capacity are made on the basis of historical profitability. A decision rule is employed to handle capacity expansion and contraction: if capacity is less than optimal, it expands; otherwise it contracts. The optimal capacity level is determined by defining a target capacity utilization.

In CGTM, log cost is defined as the sum of two components: i) the cost of stumpage, or standing timber; and ii) the cost of harvesting the timber and delivering it to a mill. Not all regions have both the stumpage and the harvest and delivery cost structure. The decision on whether to model stumpage or harvest and delivery prices separately depends on their shares of delivered log prices, the availability of data, and the success of estimation.

Stumpage supply is modeled as:

$$P = a(Q/I)^b \tag{3.1}$$

where:

P is the stumpage price (real value per m^3 of wood)
Q is the stumpage quantity (mm m^3 of wood)
I is the growing stock volume (mm m^3 of wood)
a, b, are estimated parameters

Timber supply in the public sector of the US West is modelled as:

$$P/P_s = a(Q/U)^b \tag{3.2}$$

where:

P_s is a 3-year moving average of past stumpage sales prices
U is uncut volume in public forests.

As expressed in the stumpage supply equation, it is assumed that changes in inventory levels result in a one to one change in stumpage supply (*i.e.* the inventory elasticity is equal to one).

The timber supply dynamics include an update of the inventory term using a growth-drain relationship:

$$I_{t+1} = I_t + G_t - H_t \tag{4}$$

where:

G is timber growth (mm m^3 of wood)
H is timber harvest (mm m^3 of wood)

These dynamic elements of CGTM allow model solutions to be linked between time periods, but do not imply an optimal inter-temporal market equilibrium solution. The dynamic structure in the model, although a simple procedure, captures many of the important adjustments that would be expected in a more complete representation of the forest sector.

3. DATA REQUIREMENTS AND LIMITATIONS

Data are required to estimate the supply and demand equations (1) through (3). Behavioral equations of demand and supply were not re-estimated, having been developed with the historical period ending in 1987. In addition, since timber demand is represented by recovery ratios and the production of finished wood products, data are required for the input/output coefficients associated with sawmilling/plywood processing, pulp and reconstituted panel manufacture. Finally, one needs information on transportation cost measures and prices. Trade data are necessary to account for additions and subtractions to the available timber used in processing finished products and the consumption of these finished products.

In accumulating the data needed to estimate the equilibrium conditions in the model, several data problems became evident. Data problems with timber harvest occur when under/over-reporting of harvest levels are recorded, and perhaps less seriously, when inventory measures is poor or not available. Problems also exist with timber trade data and production data on sawnwood and plywood.

These data problems have an impact on the equilibrium solution. Errors in the measurement of timber production and trade affect the equilibrium production, consumption, trade and prices of both the timber and finished products. Measurement errors in inventory have an effect on future levels of production. Trade data problems also have been identified during the process of calibrating the model solution to 1990. Net trade affects the available timber supply for a region. Hence, measurement errors in net trade, either in imports or exports, also affect the model solution for the production, consumption, trade and prices for the period. Errors in the measurement of the production of the finished products have similar consequences. In constructing the data sets for the model, we have developed a data checking procedure to identify where data reporting inconsistencies occurred.

As an example of the data checking procedure, consider the following example. Define apparent consumption as the sum of timber harvests and net trade of timber products. For Japan, harvest of nonconiferous sawlogs in 1990 was reported as 2.063 million cubic meters (mmcm)(FAO, 1991). Imports of hardwood sawlogs were 12.5 mmcm as reported by import data. Apparent consumption, therefore,is 14.563 million cubic meters.

Actual consumption of coniferous logs is calculated by multiplying the production of hardwood sawnwood and plywood by their respective recovery ratios. In the case of Japan, recovery of sawnwood from nonconiferous logs was 70%; for plywood it was 65%. Production of nonconiferous sawnwood was estimated to be 3.361 mmcm and 6.738 mmcm for plywood. Actual consumption of logs is estimated at 15.196 mmcm. There is a difference of 0.633 mmcm.

Since supplemental information on the Japanese data is available through various sources, it is possible to check these data inconsistencies. In this manner, where the data exists, we have proceeded to check it for consistencies in reporting timber production and net trade of timber products.

In practice, there are a number of inconsistencies in the real historical data that must be resolved to avoid inconsistencies in the projections. Reconciling these inconsistencies in favor of one historical data series versus another is not always possible or practical given limited time. It is frequently less damaging to allow the inconsistency to remain and understand the implications in the projections. Otherwise we may be increasing the inaccuracy of the projections by making arbitrary adjustments in the data. Most inconsistencies will impact the balance of supply and demand and therefore impact prices, resulting in a potential step shift between historical data and projected data. We always show the last historical data point as an overlap with the first projection point to demonstrate such differences.

To make the price series transfer smoothly from the historical period to the projection period, it is customary in many models to add a constant so that no step shift between history and the projection is observed. That is, the rate of change of prices is linked to the historical series, either to the last historical data point or some average of the last several data points or alternatively, an autocorrelation adjustment is provided to smooth out the transition. Both of these procedures mask the reality of data inconsistencies and calibration problems.

We have not attempted to correct the historical data for inconsistencies except where there was at least strong evidence to support the adjustment. Any adjustment to the historical data can appear to an analyst familiar with that data to be an inconsistency in the model. Similarly, not making an adjustment will make the projected price series show a shift between the historical period and the projection that would appear to be a model inconsistency instead of a data problem.

One may choose to disregard a step shift in prices by concentrating on the rate of change in projected prices. Whether or not any step shift in prices beyond the rate of change should be considered may depend upon the nature of the inconsistencies in the historical data. The same can be said for historical versus projected volumes.

4. FORECAST OF KEY EXOGENOUS VARIABLES

4.1 Timber Harvest Levels

Two large tropical timber producers Brazil and West Africa are modeled exogenously. These two regions are treated differently in the model. Brazil, with its vast inventory of timber, is able to expand its marginal frontier unconstrained--*i.e.* , there is no constraint placed on harvesting timber in Brazil. Brazil does not become the major producer of logs for the globe however, because log demand is constrained to its domestic needs, *i.e.* , the log trade is not a significant economic activity. The ability for Brazil to provide sawnwood exports to other markets allows it to expand its domestic production--constrained by profitability, rather than its supply of logs. Brazil does increase sawnwood exports as other suppliers are constrained.

West Africa, on the other hand, with significant log trade has production projections of timber harvest levels. These projections were made based on historical production trends while reflecting expected increases from plantations after 2000. Data on the timber harvests for these and other regions are provided in Appendix 1. The lack of structural detail for these regions limits the information that can be gained about their future behavior under the various policy scenarios. One could test the sensitivity of the assumptions or attempt to more fully structure these regions in the model. Either approach requires extensive effort and time beyond the scope of this study.

4.2 Exogenous Forecasts of Product Demands

Consumption of sawnwood and plywood products for exogenous regions are also reported in Appendix II. Forecasts for the exogenous regions are provided in Appendix III. Consumption of sawnwood products were forecast using GDP per capita estimates and measures of income elasticities. Plywood consumption for these regions were determined by noting the trend in plywood to total wood-based panel consumption (which also includes reconstituted panels) and forecasting the total wood-based panel consumption, again based on GDP per capita and income elasticities.

4.3 Demand Shift Forecasts

Demand shifts for those regions with endogenous demand functions were projected using forecasts of end-use indicators (see Appendix II). For the Southeast Asian regions, the more important end-use indicators were GDP per capita, housing starts, and construction activities. These demand shift forecasts were implemented for the following countries as follows:

For Malaysia, Indonesia and the Philippines, the demand forecasts were based on GDP per capita growth and an income elasticity measure. Forecast of GDP per capita are presented in the following table. An income elasticity measure of 2.50 was used to reflect the changes in demand associated with per capita income growth.

Table 4.1: GDP per capita forecasts for Malaysia, Indonesia and the Philippines
(in percent per year)

Period	Malaysia	Indonesia	Philippines
1990-1994	3.63	3.63	3.00
1995-1999	4.13	4.13	3.51
2000-2005	5.05	5.05	4.41

Demand growth in hardwood products is projected to double for Malaysia East, Malaysia West, and Indonesia and 65% for the Philippines for nonconiferous sawnwood by 2000. Plywood consumption is also expected to double in Indonesia by 2000. Hardwood sawnwood consumption is expected to increase by 10% in Europe West by 2000. The file UPDMD presented in Appendix 2 lists the percentage shift of the demand curves for the various regions and products.

For Japan, Korea, Taiwan-Hong Kong and West Europe, end-use indicators were total floor area for housing starts (HSA), total floor area for all construction starts (BSA), and real value of furniture production (FRN). Table 4.2 gives the region, the end-use indicator by product and the assumed elasticity for these regions. Demand growth for Europe West was estimated using a GDP per capita forecast of 1.99 for the forecast period and an elasticity measure of 0.63.

A list of the most notable demand growth assumptions might include: (i) demand for wooden homes in Japan stops declining although at the lower levels experienced over the last several years. Wooden homes have lost market share, an important loss in demand for a major consumer, given a stable housing outlook. (ii) demand growth in the tropical hardwood producing countries is very strong, especially for SE Asia with substantial growth in Africa. (iii) with little population growth, demand in Europe is weak. Collectively these provide a shift in demand away from the historically strong economically developed-consuming countries to the developing-producing countries.

Table 4.2: End-use indicators for demand and elasticities for Japan, Korea and Taiwan-Hong Kong and West Europe

Region	Product	Indicator	Elasticity
Japan	nonconiferous sawnwood	HSA	1.00
Japan	nonconiferous plywood	BSA	1.00
Korea	nonconiferous sawnwood	BSA	1.00
Korea	nonconiferous plywood	BSA	1.00
Taiwan-HK	nonconiferous sawnwood	FRN	1.00
Taiwan-HK	nonconiferous plywood	BSA	1.00
West Europe	nonconiferous sawnwood	GDP	0.63
West Europe*	nonconiferous plywood	GDP	0.63

* Demand forecast for West Europe for nonconiferous plywood is exogenous. Projected consumption levels were determined based on GDP growth and the income elasticity measure of 0.63.

5. BASE CASE REFERENCE FOR THE SHORT TERM (TO THE YEAR 2000)

The short term here is defined as the ten-year period from the first projection year of 1990 to the year 2000. For periods so short, assumptions on inventory growth can be assumed to be relatively independent of price performance, *i.e.* , there will be little feedback between prices and the consequences of forest management. Since the model does not directly incorporate feedback between sawlog prices and the growth of inventory, the analysis of short term projections has been separated from longer term projections where such feedback as well as other assumptions become more difficult. Another reason for separating the discussion on long term projections is that the declining inventory of commercial timber in several producing countries becomes acute beyond the year 2000 requiring additional policy and technological assumptions regarding sustainable harvest rates. Short-term projections of the behavior of the hardwood forest products markets for key regions have been developed. The following subsections discuss these projections.

5.1 Timber Producers in the Southeast Asia Region are an Important Source of Raw Materials

Hardwood sawlog production for the regions of Malaysia East (MAE, includes Sarawak and Sabah), Malaysia West (MAW, includes Peninsular Malaysia), Indonesia (IDN) and the Philippines (PHL) are depicted in Figure 5.1. With the exception of Indonesia, the model predicts the historical harvest levels well.[2] For Indonesia, forecast harvests for

[2] Preliminary analysis of the data revealed several discrepancies in hardwood production, trade and consumption data. See the section on Data and Data Limitations for a discussion of these problems. For Indonesia, one can estimate the harvest levels by converting sawnwood and plywood production into sawlog requirements. Sawnwood and plywood

1990 (the first projection period) are nearly 23% greater than the historical level of 27 million cubic meters (mmcm). This is largely a data problem which will be discussed in more detail. Both Indonesia and Malaysia East show an increase in harvest levels in the short term; with harvest levels declining in the latter part of the decade for Malaysia East. Harvest levels for Malaysia West decline during the short term. The Philippines maintains a harvest level of about two mmcm per year. By 2000, these regions provide over 40% of the tropical hardwood harvest (see Table 5.1). India's production, while significant, serves domestic markets only

Table 5.1: Harvest projections for the year 2000 by major tropical hardwood producing regions (million cubic meters)

Malaysia East	22.0
Malaysia West	8.3
Indonesia #	36.6
Philippines	2.2
Papua New Guinea	2.6
Indochina	6.1
India	41.1
Africa West	15.0
Brazil	23.1

unadjusted harvest level

Since we have some confidence in the log-to-product recovery ratios used to compute the hardwood sawlog production projection for Indonesia, the projected harvest volumes should be more reliable than history. We have not chosen to scale the historical data up to be consistent with the projection as the historical data is the international published series. Such a step increase is evident in Figure 5.1.

The harvest projection trends reflect a growing scarcity of timber in each region. Indonesia, with a growing stock of nearly 3 billion cubic meters of commercial timber, reduces its inventory by 375 mmcm in the short term, a 13% reduction. Given the large timber stock, Indonesia may be expected to maintain its harvesting trend into the future. Malaysia East, with a stock of commercial timber estimated at 326 mmcm reduces its inventory by 40% during the first half of the decade--a period of somewhat expanding harvests--and 67% during the remaining half of the decade, when timber harvest rates decline. Inventory in Malaysia East drops to 65 mmcm by 2000, approximately 17% of the 1990 growing stock level. Continued harvests at historical levels will quickly eliminate any available inventory. Reduced timber inventories in Malaysia West force timber harvest levels to decline in the short term. An estimated 116 mmcm of hardwood growing stock is reduced by three-quarters by 2000.

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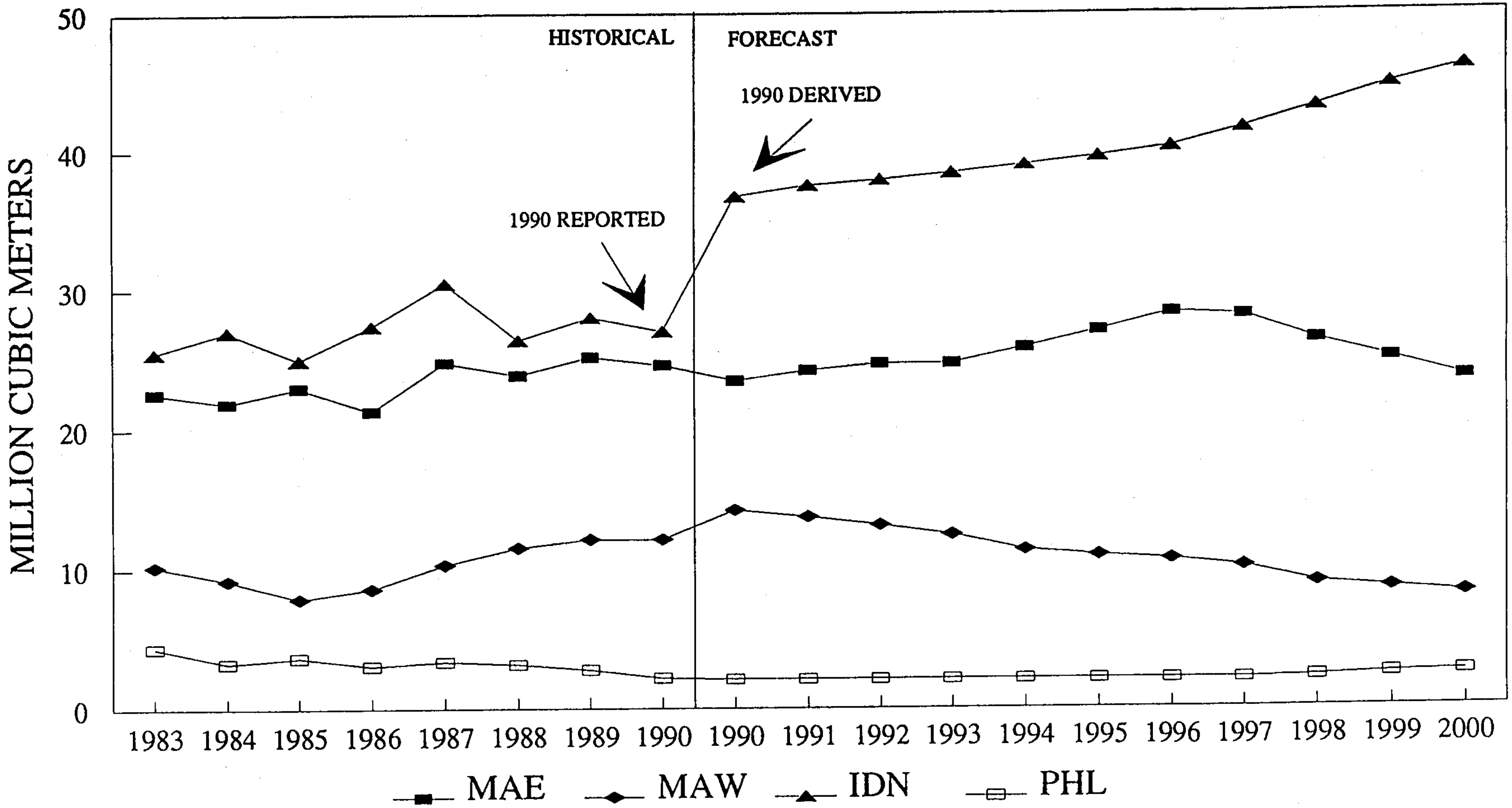
production are estimated at 9.000 and 9.306 mmcm in 1990. Recovery ratios for sawnwood and plywood are 50 and 48 percent respectively. Sawlog consumption is equal to sawlog production since net trade is very small (about 0.2 mmcm of log exports): 37.356 mmcm. Reported harvest levels are 27.000 mmcm (FAO, 1991). This step increase between the historical data and forecast is evident in Figure 5.1.

FIGURE 5.1: HARDWOOD SAWLOG PRODUCTION



The projections provide a reasonably consistent view of the regions' potential for the short-term. Planning authorities may choose to reduce the harvest to sustainable levels more quickly, or to maintain a high harvest level in the short - term. This last option, however, will cause an abrupt fall in harvest as the inventory declines more quickly. Substantial changes in prices could induce structural changes that might alter harvesting techniques and the amount of volume removed per acre, thereby increasing the volume removed in comparison to the historical experience, which would result in some downward pressure on prices. Such a structural change is not characterized directly in the model but could be juxtaposed based on technological considerations.

Harvest levels in Brazil are unconstrained by a large inventory and increase 21 % over the decade. Harvest levels in Africa West were assumed to remain at historical levels, rising in trend after 2000 (an exogenous assumption, not a model driven supply response).

5.2 Timber Consumption in the Southeast Asia Region Depends on Trade

Trade of hardwood sawlogs in the region and across the globe is heavily restricted by trade barriers. There are log export bans in place in Indonesia, the Philippines, Malaysia West and several African countries. The effect of these bans is to increase the consumption of logs in those domestic markets. In Southeast Asia, only Malaysia East provides a significant amount of hardwood logs to the international market, choosing not to impose any log trade barrier. The share of East Malaysian timber in international markets is displayed in Figure 5.2. Figure 5.2 also illustrates the amount of log exports originating from Malaysia East and the total export of hardwood logs (both temperate and tropical) in the world. There is a decline in the level and share of the hardwood log export market for Malaysia East. Log exports decline from 20.8 in 1990 to 15.1 in 2000. Export logs from Malaysia East decline due to decreasing timber inventories and increased domestic sawnwood production. The world demand for sawlogs remains strong with world hardwood production growing 10% by 2000. In contrast, log exports decline by 4%.

Timber consumption in major Southeast Asian consuming markets relies heavily on log imports from Malaysia East. Figure 5.3 illustrates the trend in log imports for Japan (JPN), Korea (KOR), China (CHN) and Taiwan-Hong Kong (THK). Log imports for these regions show a declining trend with the exception of Taiwan-Hong Kong, which shows a constant level of imports. Without a suitable substitute source of hardwood logs, these regions are forced to consume fewer logs in their sawmilling and plywood manufacturing processes.

Figure 5.4 illustrates hardwood sawlog consumption for the major regions in the area. Hardwood log consumption declines in Japan and Korea, while consumption levels are maintained in Taiwan-Hong Kong and consumption increases in China. Higher domestic production to meet demand requires China to increase its consumption of hardwood logs and sustain imports.

Hardwood suppliers outside of Southeast Asia include Brazil and Africa West. Brazil's production increase is channeled to sawnwood exports, since their log export levels have been small. Africa West's declining trend in exports results from weak demand and

FIGURE 5.2: HARDWOOD SAWLOG EXPORTS

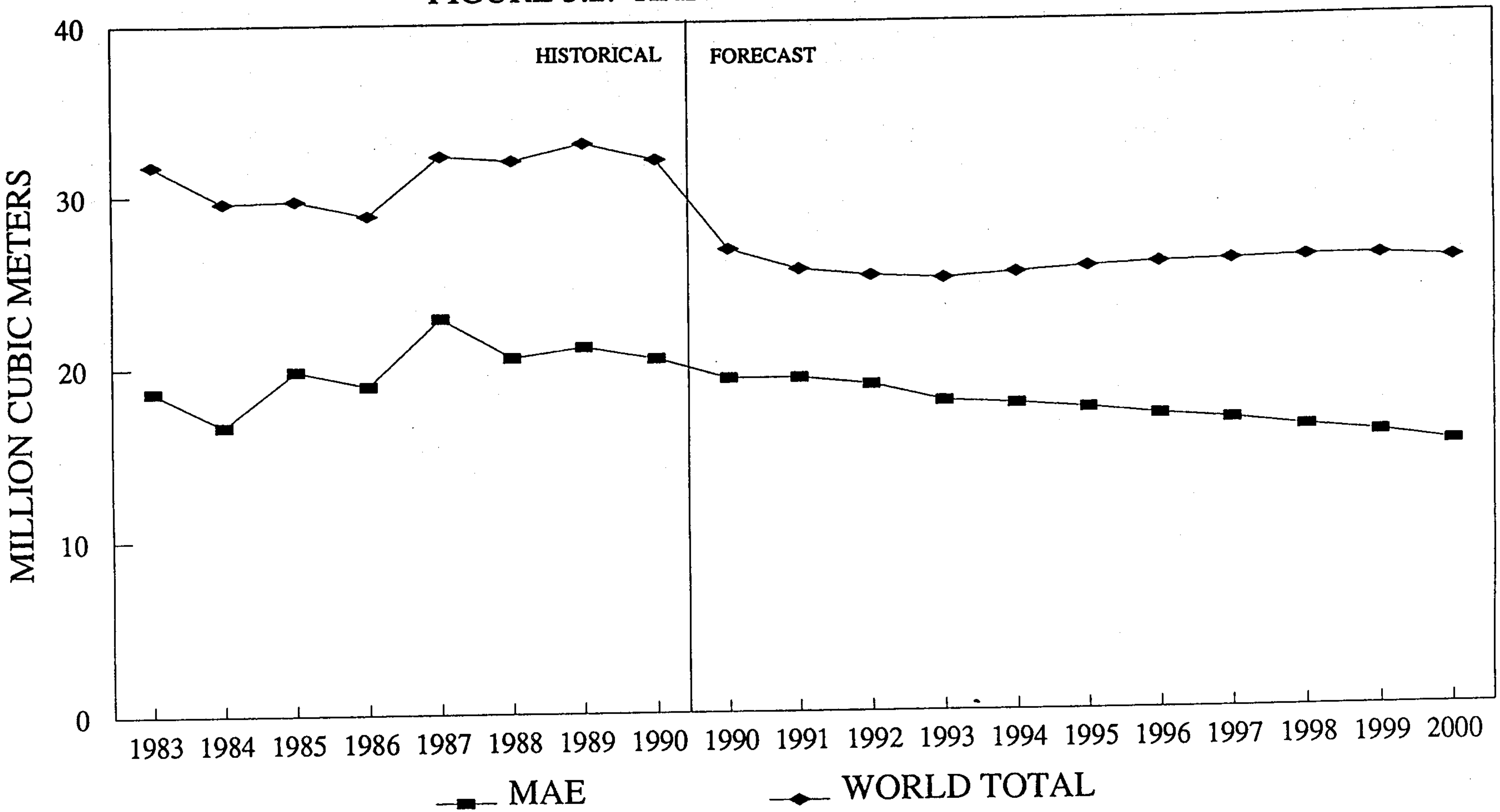


FIGURE 5.3: HARDWOOD SAWLOG IMPORTS

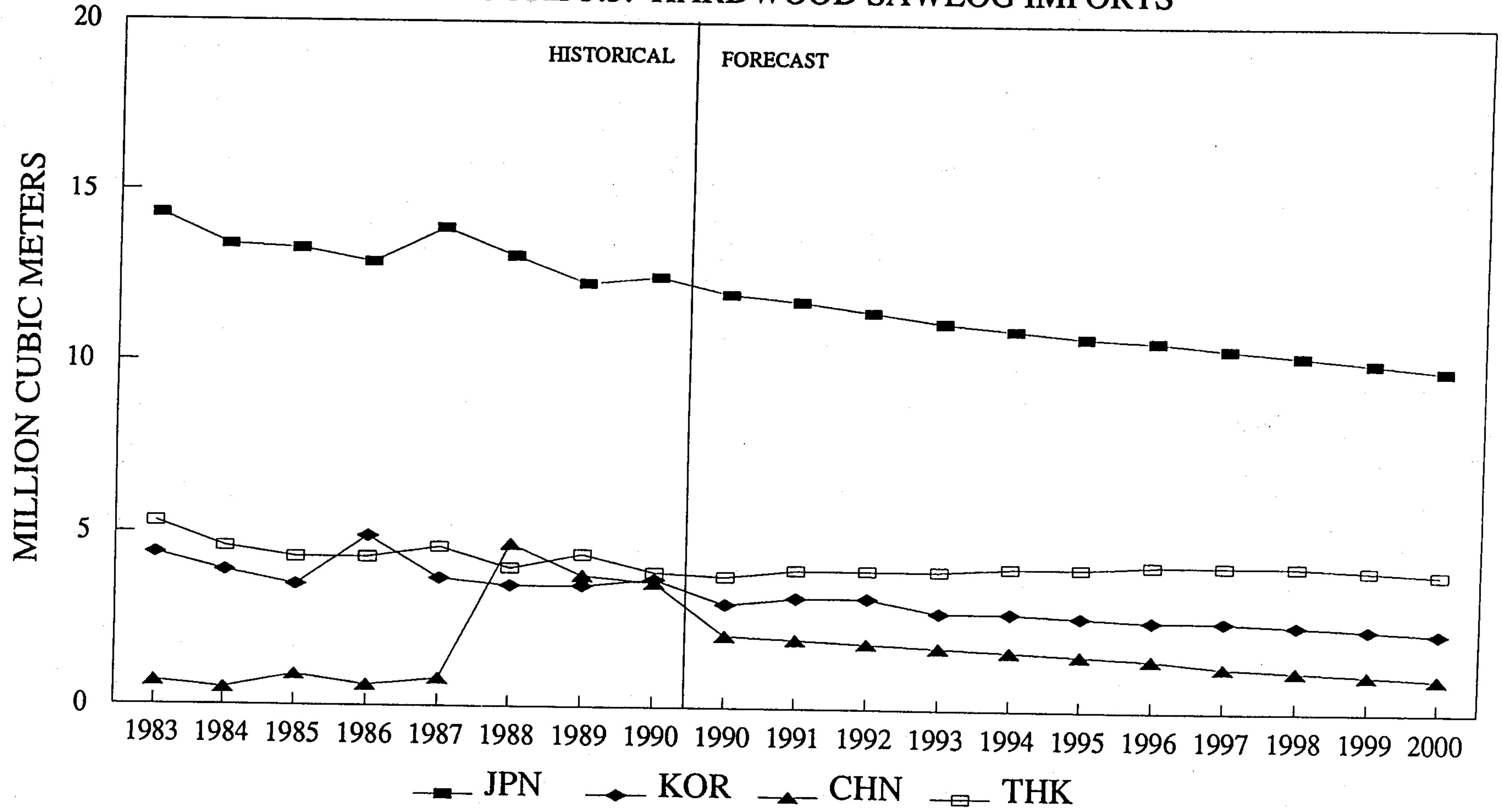
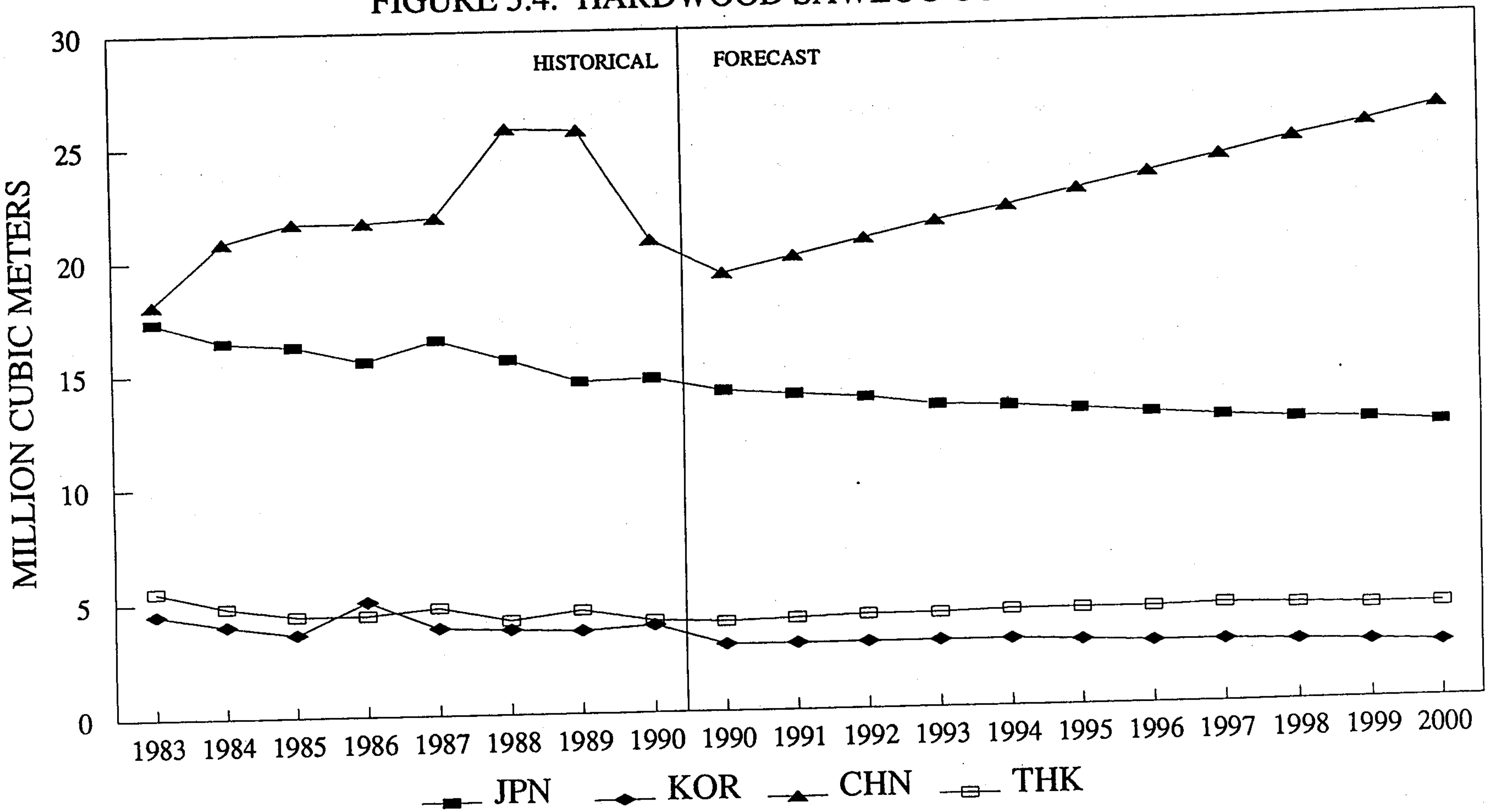


FIGURE 5.4: HARDWOOD SAWLOG CONSUMPTION



declining prices in Europe. In addition US temperate hardwood suppliers are competitive in European markets. Given the shortage in Asian markets the assumed downward trend in their log exports might be reversed by a shift away from European markets to Asian markets. Since Africa West production is an input, a detailed analysis of distribution costs would be required to determine their export potential to SE Asia (see Appendix 1 for table of all country exports).

Given the greater scarcity of tropical hardwood logs in the consuming markets of Japan, Korea, and China, and the limited number of potential suppliers, the possibility exists for greater substitution of softwoods for hardwoods, especially in the large Japanese plywood market, which might allow a more rapid decline in Japan's hardwood sawlog imports. While some might argue that this shift should be defined as a certainty and part of a BASE CASE, others have pointed out that the curtailments of softwood harvest already underway in the US Pacific Northwest and future declines expected in Canada are so large that they could easily counteract much of the potential substitution of softwood for hardwood plywood.

5.3 Temperate Hardwood Sources Reduce the Impact of Tropical Hardwood Producing Countries Marketing in Europe

Unlike the Southeast Asian region, log markets for tropical Africa and their connections to Europe are not well differentiated in the model. It is difficult to distinguish the temperate and tropical log uses directly without knowledge of bilateral trade flows. Even with access to such information, it would be hard to estimate the amount of temperate-tropical log substitution that would take place. Such a detailed analysis of substitution is beyond the scope of this study. Temperate-tropical substitution is assumed by the model where both sources exist. With the lower demand growth in Europe and the US, and the increasing inventory in temperate forests, there is no scarcity of hardwoods in these countries. While countries like Africa West might be expected to shift their exports to Asian consumers, their assumed production levels eventually fall short of local demands. Brazil, however, does increase its exports in sawnwood.

5.4 Hardwood Sawlog Prices Increase as Log Scarcity Grows

Log price behavior plays a critical role in sustainable forest management. All other things being constant, rising log prices imply increasing returns to stumpage, which should allow for higher levels of forest management investments. Figures 5.5-5.7 depict log price behavior in the major producing countries of Southeast Asia. The full world (temperate and tropical) weighted average price for all hardwood sawlogs is shown as FWA. The log shortage and rising prices being experienced in tropical hardwood countries is not shared by temperate hardwoods which as a consequence, show a much slower rate of price increase. The weighted average price for hardwoods in temperate regions is lower and not increasing compared to the increasing trend of tropical log prices in S.E. Asia.[3]

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[3] As a consequence, there is an increase in substitutes in European markets where temperate hardwoods are more readily available.

FIGURE 5.5: HARDWOOD SAWLOG PRICE PROJECTIONS

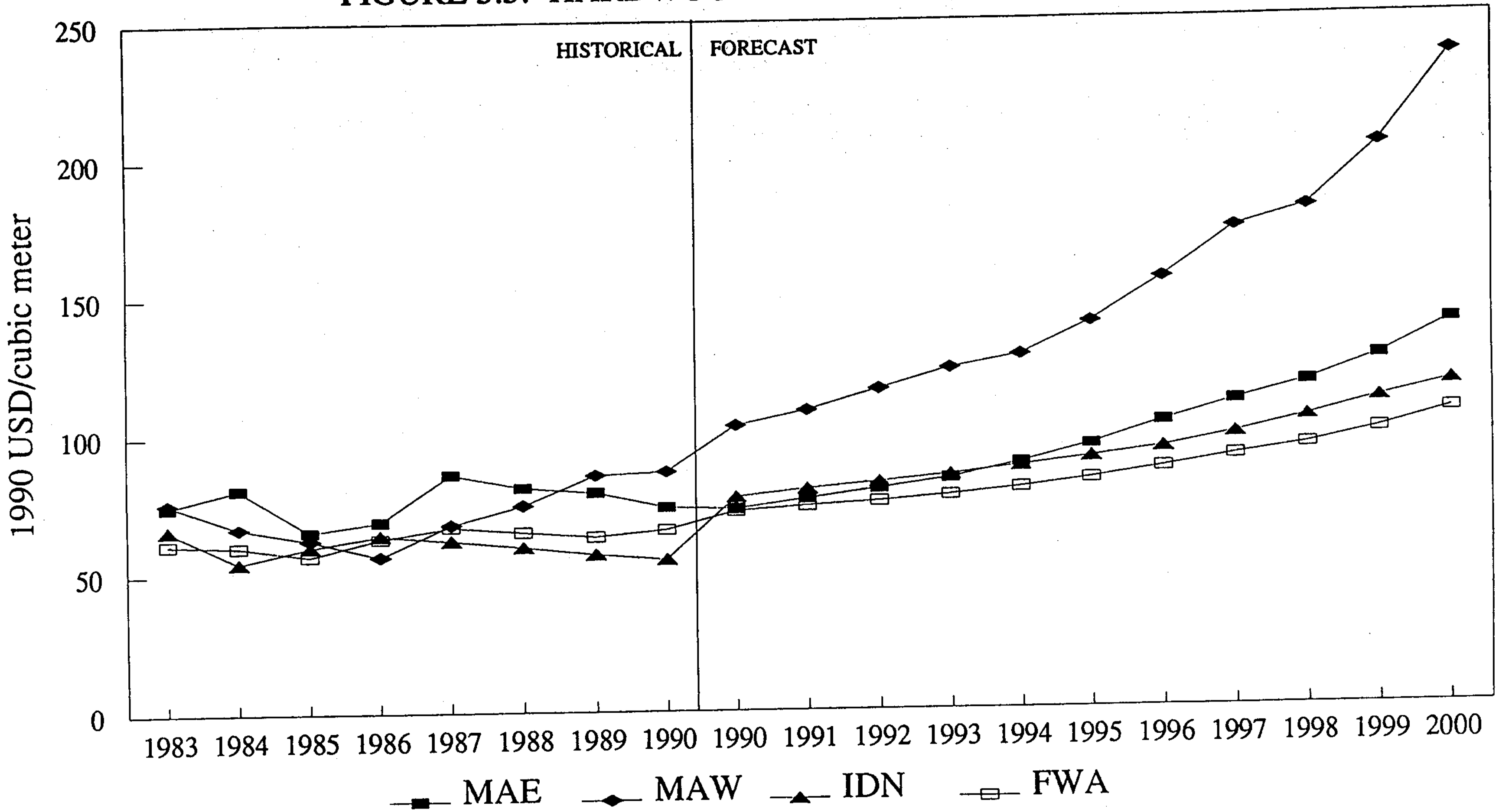


FIGURE 5.6: HARDWOOD SAWLOG PRICE PROJECTIONS

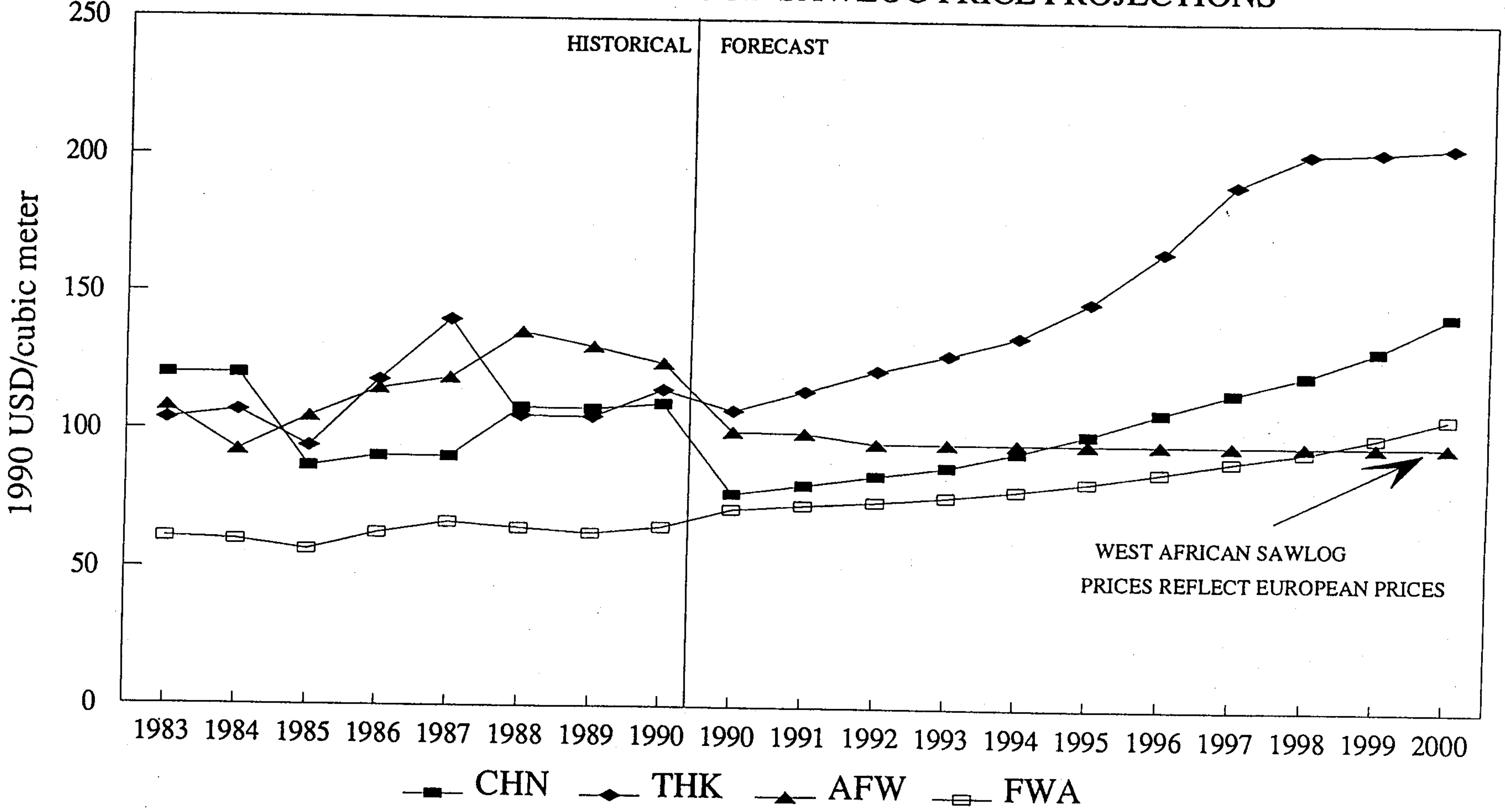
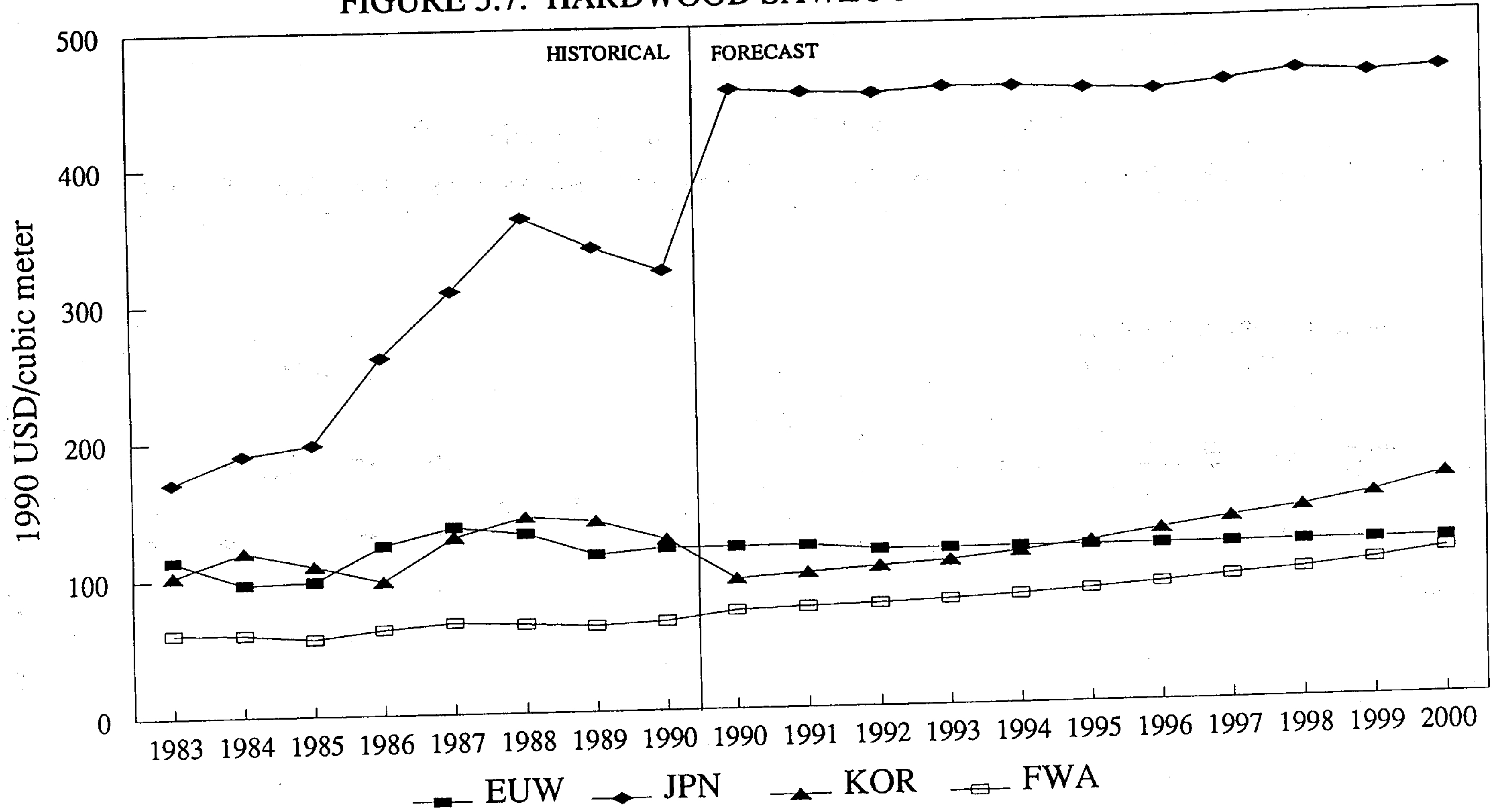


FIGURE 5.7: HARDWOOD SAWLOG PRICE PROJECTIONS



Growth rates of log price vary from 3.22% per year for the first half of the decade for Indonesia to 10.32% for the second half of the decade for Malaysia West. These projections imply a steady increase in the log price, and hence returns to stumpage. Table 5.2 reports the rate of price increase for several producing and consuming regions. Log price increases are greatest in Malaysia West, where severe log shortages occur. A portion of the price increase for Indonesia in Figure 5.5 can be related to the data discrepancies on volume that were described earlier. These show up as a substantial price increase from 1990 historical to 1990 projected. The price rate of change Table 5.2 excludes this discrepancy. Since there is probably not a comparable error in the historical price data, one could apply the rate of change projection for prices to the last 1990 price data point for an alternative price projection at least partially adjusting for the data discrepancies. These price projections have been provided as Figures 5.8 to 5.10, "Adjusted ... price projections."

Table 5.2: Rate of hardwood log price growth for selected regions (in percent)

Region	1991-1995	1996-2000
Europe West	-6.60	0
Japan	-0.15	0.25
Korea	3.86	6.57
China	4.64	7.59
Taiwan-Hong Kong	6.74	7.04
Malaysia East	4.91	7.93
Malaysia West	6.28	10.32
Indonesia	3.22	4.81
Philippines	0.09	3.42
Africa West	-0.78	0

The extreme price increase for Malaysian West derives from rapidly rising demand for logs in international markets related to its rapidly declining inventory. Alternative trade channels might be developed to diffuse such a large price increase, such as log or product imports from countries other than Malaysia East. However, effective trade restrictions in place for Indonesia have reduced substantially the available quantities of logs on the international market. The model depicts the Malaysian West market as almost closed, with rapidly declining supply. In reality, prices will not rise as rapidly as projected, consequent to the need to make structural changes that open up the channels of trade.

Log prices in consumer countries increase in those Asian countries especially dependent upon tropical hardwoods. Much lower price increases occur in Europe with rising inventories of temperate hardwood substitutes. As a consequence there would be little upward pressure on tropical hardwood log prices from Africa West (AFW).

China sawlog prices increase in response to their steady growth in demand and sawlog consumption. Taiwan-Hong Kong's somewhat higher-priced and probably higher-quality logs also move up rapidly in price with nearly flat consumption. Japan's sawlog prices remain flat with declining consumption. Korean prices rise somewhat more than in Japan with smaller declines in consumption. Since all prices are reported in US dollars, the

FIGURE 5.8: ADJUSTED HARDWOOD SAWLOG PRICE PROJECTIONS

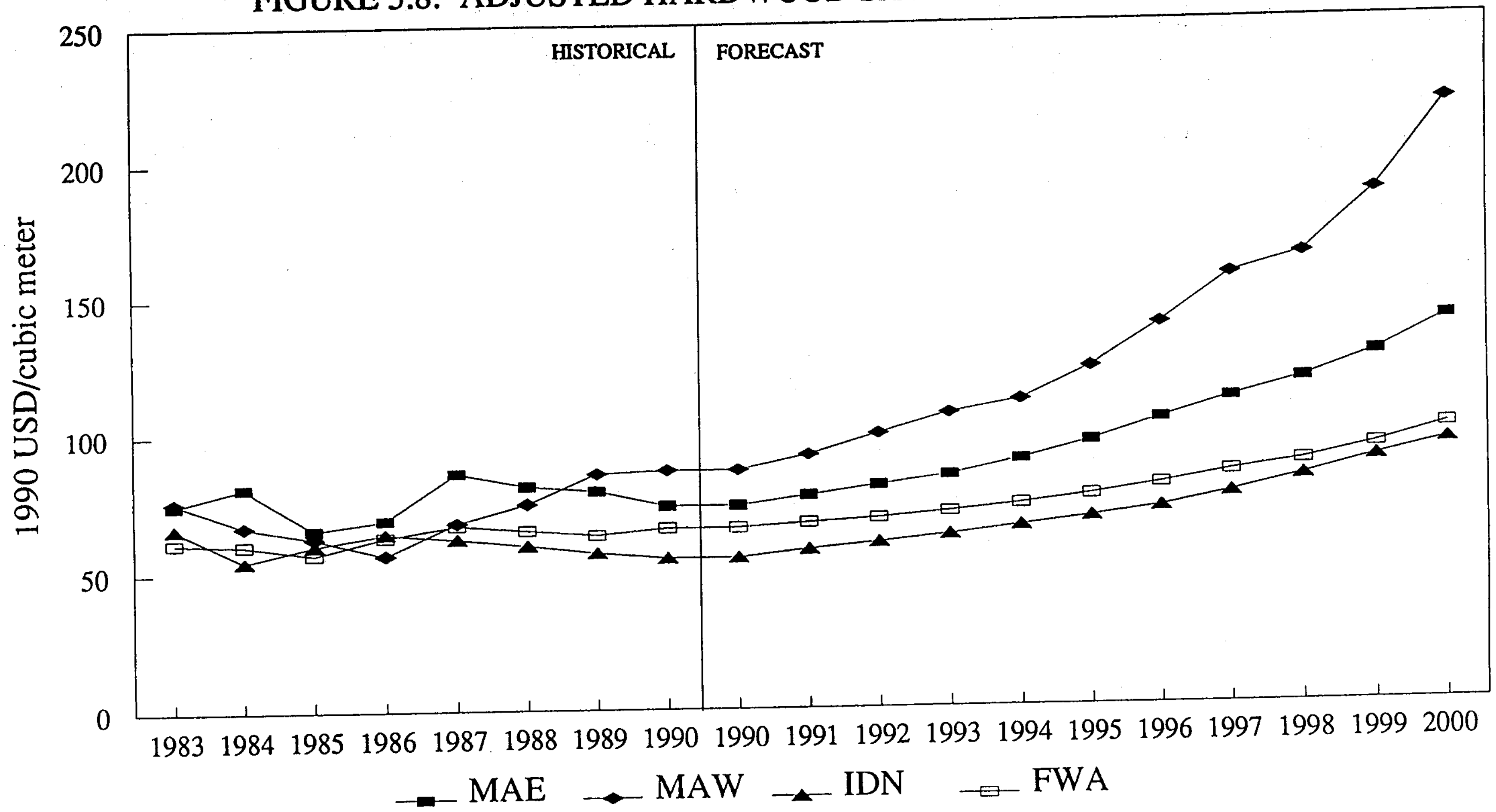


FIGURE 5.9: ADJUSTED HARDWOOD SAWLOG PRICE PROJECTIONS

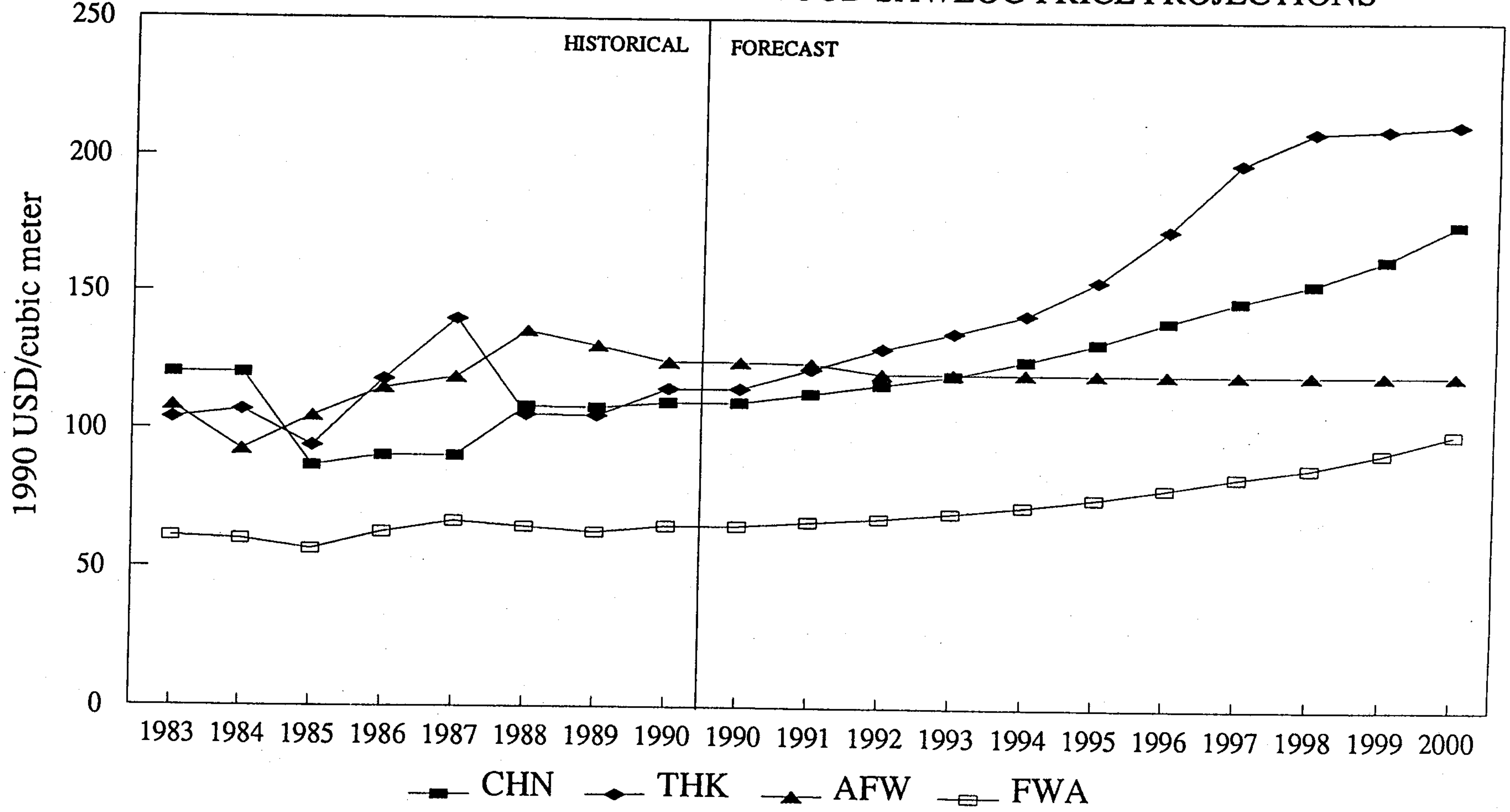
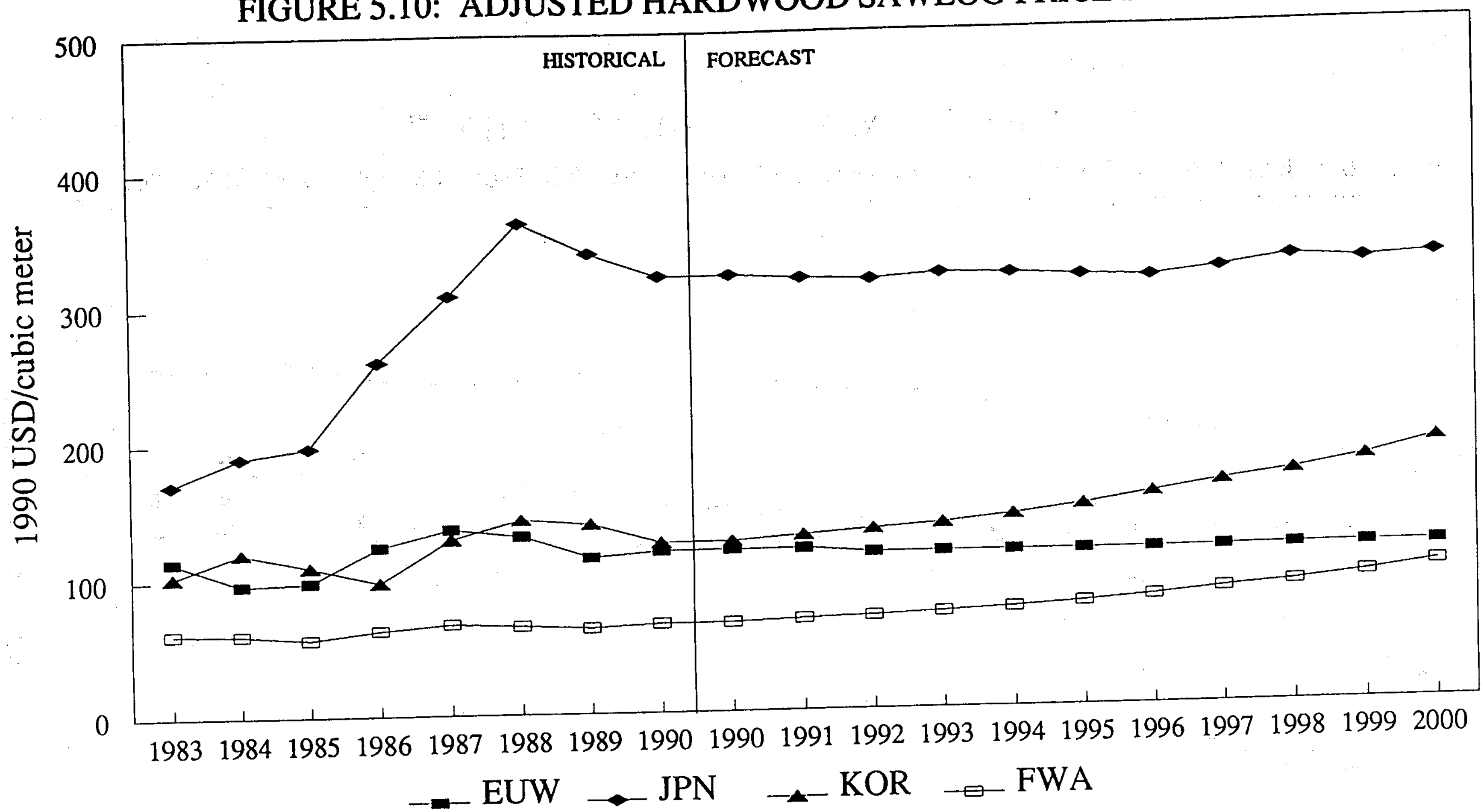


FIGURE 5.10: ADJUSTED HARDWOOD SAWLOG PRICE PROJECTIONS



cross-country price differences include the impacts of potential currency biases as well as quality differences and distribution channel differences.

These price increases have an implication for sustainable forest management investments. First, if harvest and delivery cost increases are comparable to the historical period and rise more slowly than log prices return to stumpage should also increase. With constant real harvest and delivery costs, stumpage prices would grow with log prices. Thus, there is an opportunity to increase the rent capture from higher log prices through the application of higher royalty fees, or change the contractual arrangements to pay for more expensive logging in order to support sustainable forest management production agreements.

5.5 Production of Finished Products

5.5.1 Plywood

Production of hardwood sawnwood and plywood occurs in both the timber producing countries--such as Indonesia--and major timber consumers, such as Korea and Japan. Indonesia has been able to substitute exports of plywood for its earlier export logs. Indonesia now surpasses the production levels of Japan as the major producer of hardwood plywood. Figure 5.11 illustrates hardwood plywood production forecast for Indonesia, Japan and Korea under the BASE CASE. Hardwood plywood production levels remain relatively constant throughout the short term, with Korea showing a decline in production.

With no domestic source of wood, declining competitiveness from increases in labor costs, and a strong currency, Korea is faced with a more severe erosion in processing competitiveness and a greater dependence upon product imports. Figure 5.13 shows their rapid shift from plywood surplus to shortage made up by imports. Through log export bans, Indonesia has become the major exporter of hardwood plywood. Figure 5.12 demonstrates no discernable change in the level of plywood exports for the short-term forecast. This figure also illustrates the nature of trade data inconsistency problems. Total world exports for plywood in 1990 are reported as 14.2 mmcm whereas importers report a total of 20.4 mmcm in 1990.

The forecast for growth in the demand for plywood in Japan indicates a drop in plywood consumption. Demand declines by 13% by 1993 and remains constant to 2000 in Japan. With a sufficient supply of tropical logs, mainly from Malaysia East, Japan reduces its imports of plywood to zero in the short term as domestic production is able to fill demand.

Projections of increased construction activity in Korea, on the other hand, show the demand for hardwood plywood increasing by 50% by 2000 (see Appendix II). Since there is no growth in log imports into Korea, a projected increase in the consumption of hardwood plywood is met by increased levels of imports. These trends in hardwood plywood imports are illustrated in Figure 5.13. Import levels of Taiwan-Hong Kong and China are also illustrated but do not show a comparable increase. Korea is shown as the major importer of finished product as a consequence of its declining competitiveness in

FIGURE 5.11: HARDWOOD PLYWOOD PRODUCTION

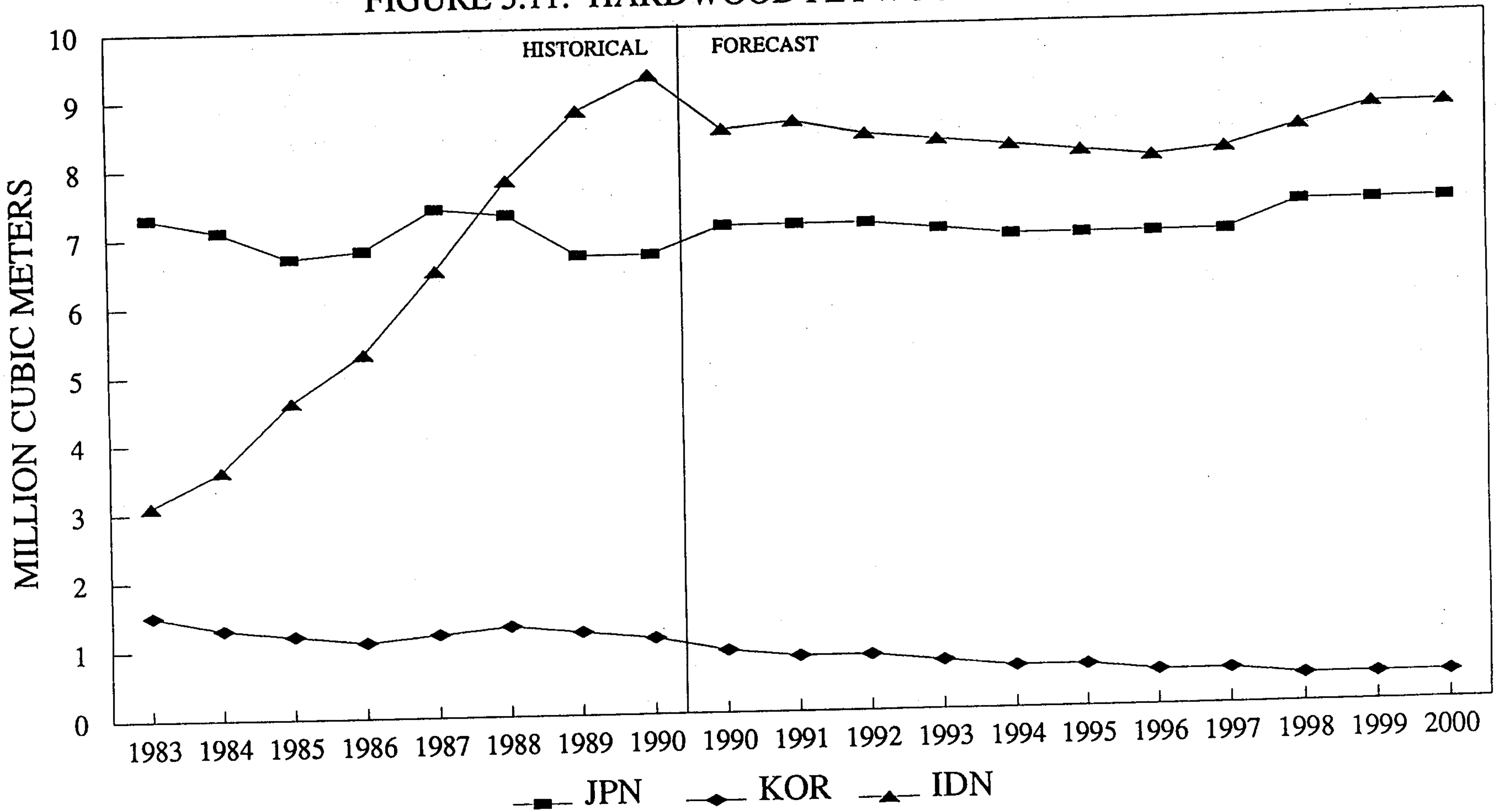
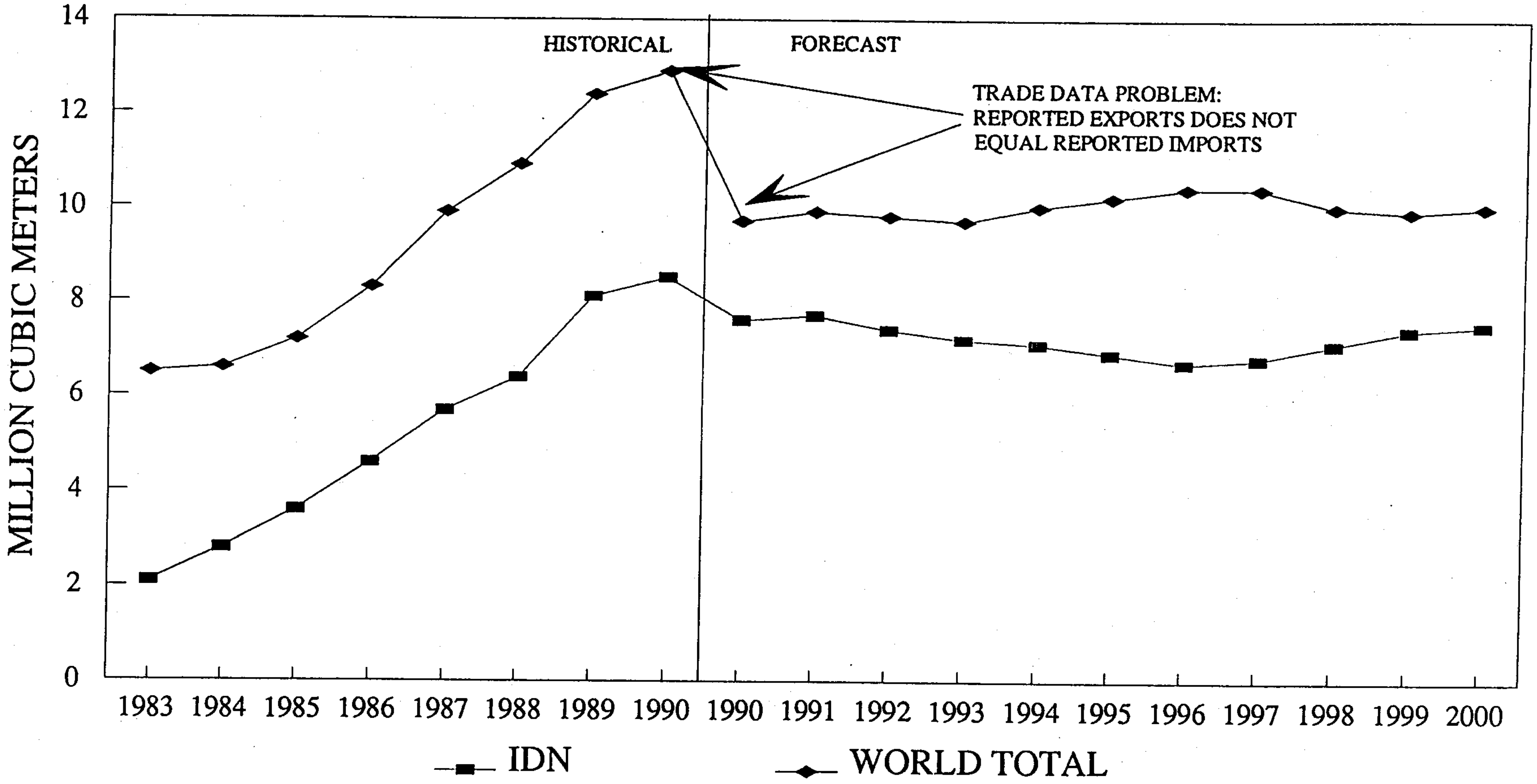


FIGURE 5.12: HARDWOOD PLYWOOD EXPORTS



processing. Taiwan-Hong Kong maintains its level of log imports and does not need to increase plywood imports. Demand growth in China supports some increase in plywood imports as well as active log imports.

There are problems with the historical price series for plywood, which was derived from export value and volume data. We have not attempted to resolve the discrepancy but do believe the price changes in the projection period are still reflective of changing supply and demand conditions.

Price behavior for the plywood markets is illustrated in Figures 5.14-5.16. With the exception of Malaysia West, there is only a modest gain in the price for plywood in the various markets. The rapid rise of plywood prices in Malaysia West occurs because demand growth is much greater than supply; hence there is no way for Malaysia West to substitute supply from other regions for its domestically produced plywood. Allowing imports would reduce the Malaysian plywood price increase and constrain sawlog price increases as well. It should be noted that imports to Malaysia West are zero under the BASE CASE. The rate of changes in prices is listed in Table 5.3.

The fact that plywood prices are not rising rapidly and production levels are flat suggests that the sawlog price increases are largely driven by declining supply. Plywood mill margins are therefore under great pressure with a shift in profits from the processing stage to timber production in the forest.

Table 5.3: Rate of hardwood plywood price growth for selected regions
(in percent per year)

Region	1991-1995	1996-2000
Europe West	0.41	2.43
Japan	0.14	0.40
Korea	0.44	2.64
China	0.48	2.83
Taiwan-Hong Kong	0.24	1.49
Malaysia East	0.44	3.72
Malaysia West	4.50	7.70
Indonesia	0.57	3.32
Philippines	0.50	2.95

5.5.2 Sawnwood

Sawnwood markets behave differently than the plywood markets. First, domestic sawnwood production in Indonesia and the Philippines is primarily used to meet domestic demand. Only Malaysia West and Malaysia East export any significant amount of sawnwood; exports of sawnwood from Indonesia have dropped significantly by 1990 due to the imposition of an export tax in 1989. Second, Malaysia West has been the primary exporter of sawnwood in the past, through the imposition of a log export ban. Nevertheless, with decreasing timber harvest levels and increasing domestic demand for

FIGURE 5.13: HARDWOOD PLYWOOD IMPORTS

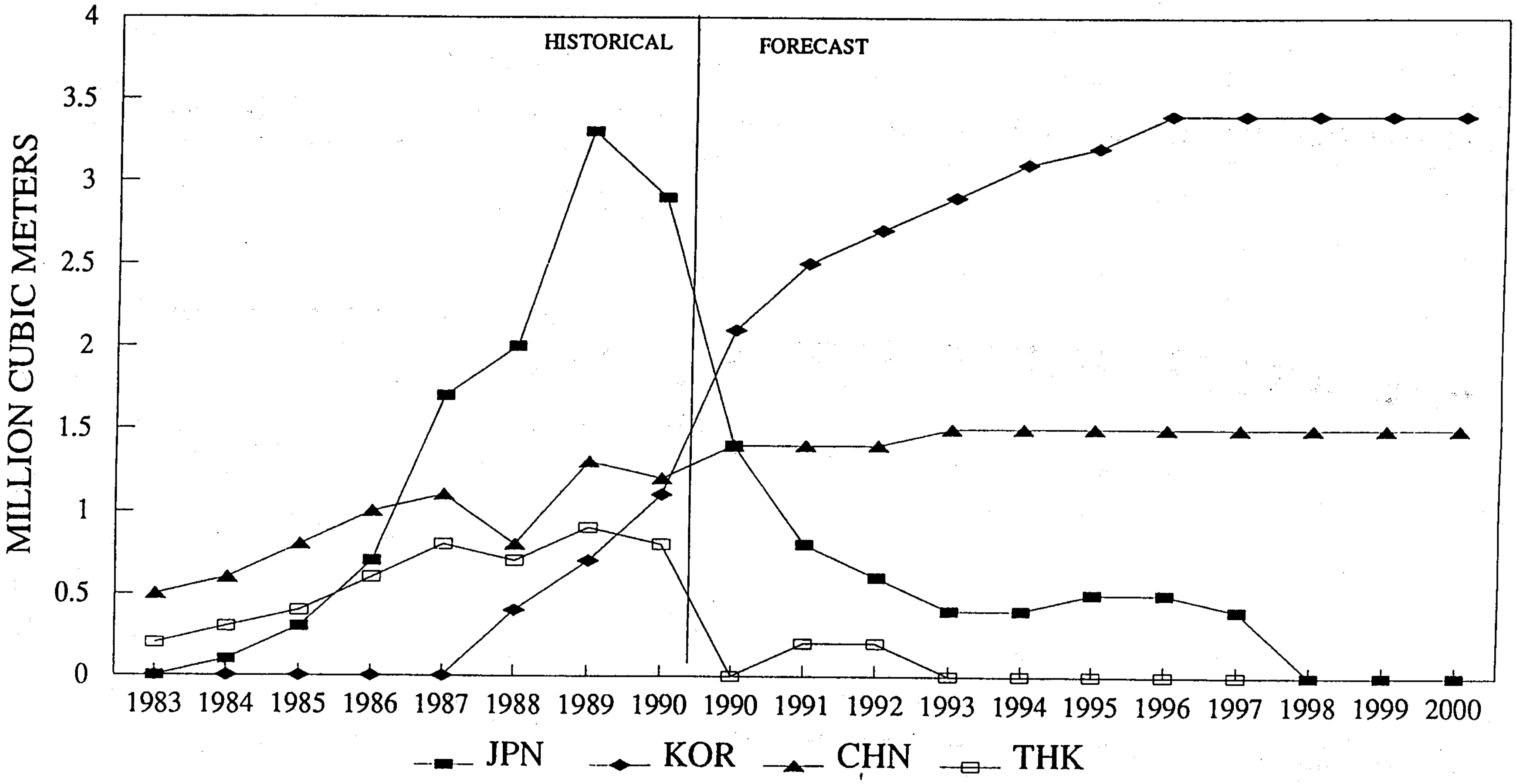


FIGURE 5.14: HARDWOOD PLYWOOD PRICE PROJECTIONS

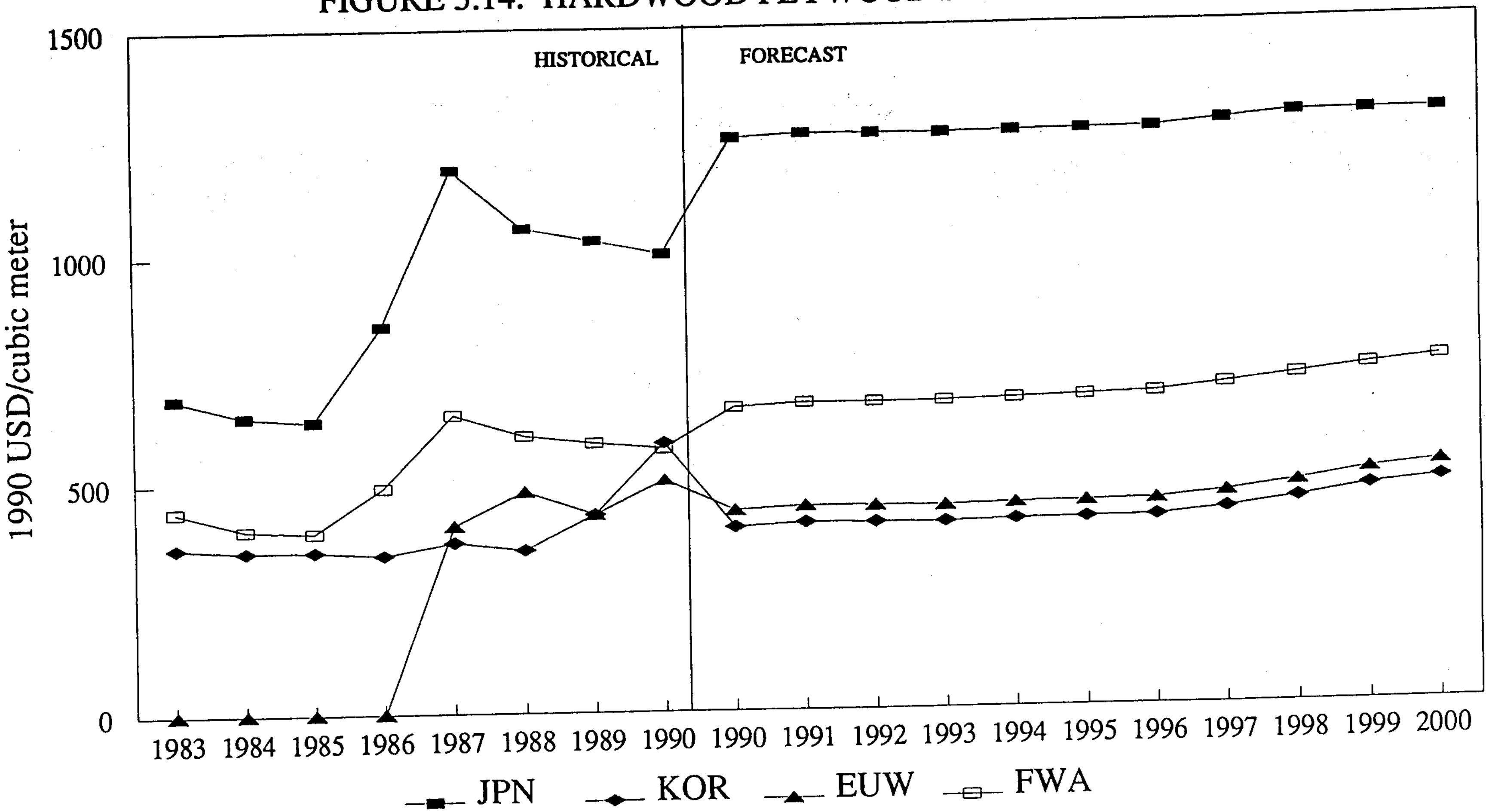


FIGURE 5.15: HARDWOOD PLYWOOD PRICE PROJECTIONS

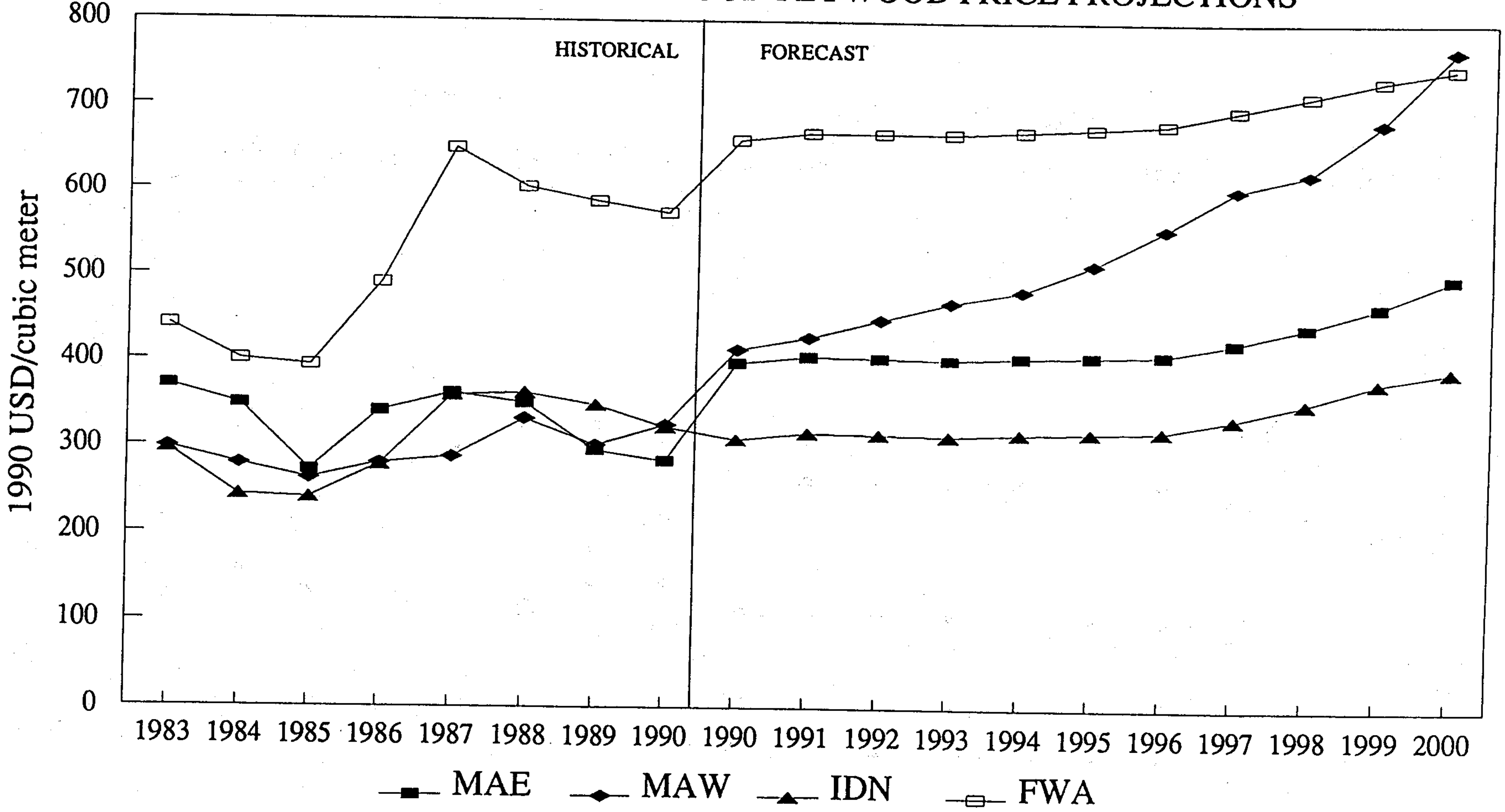
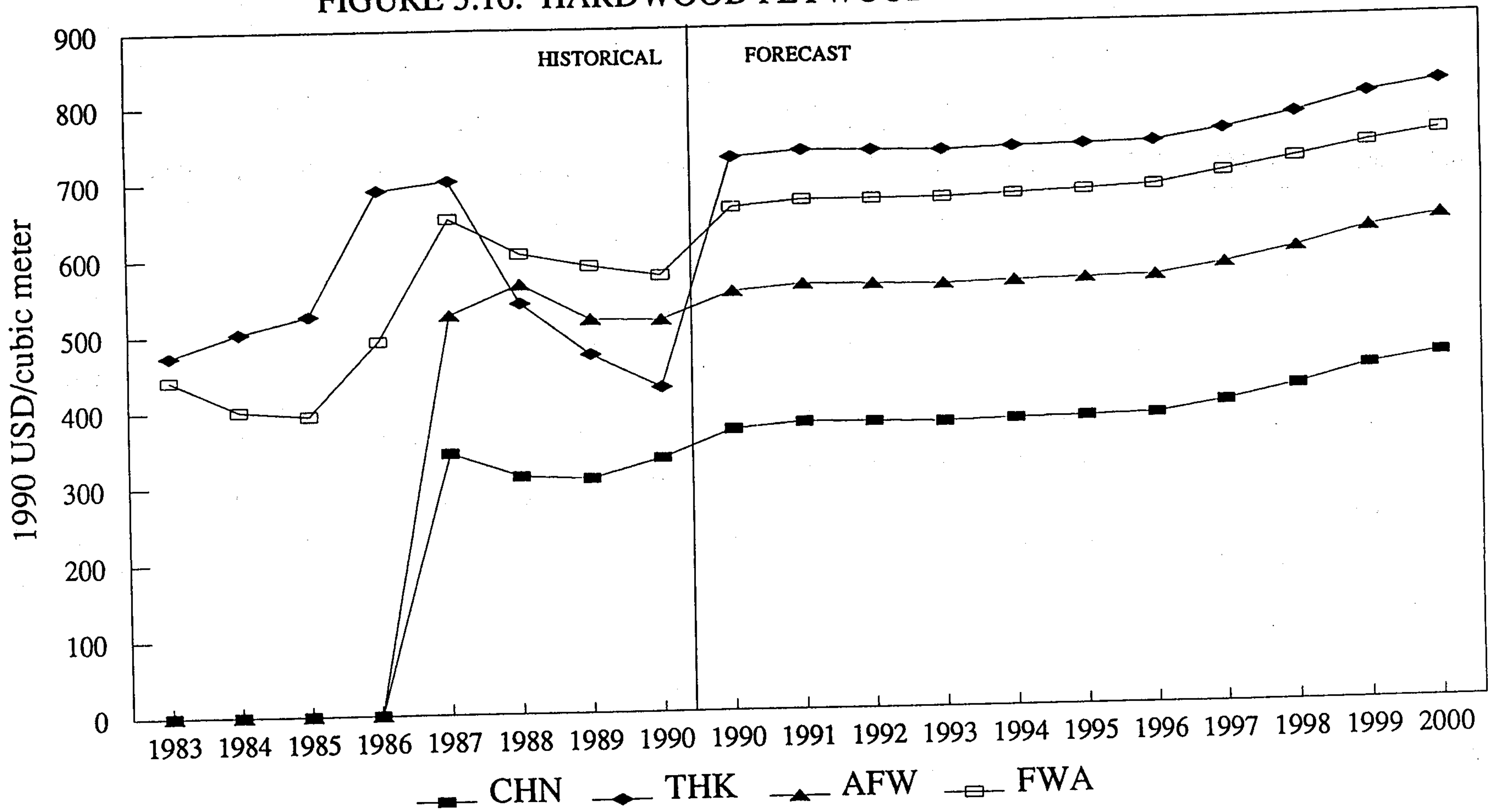


FIGURE 5.16: HARDWOOD PLYWOOD PRICE PROJECTIONS



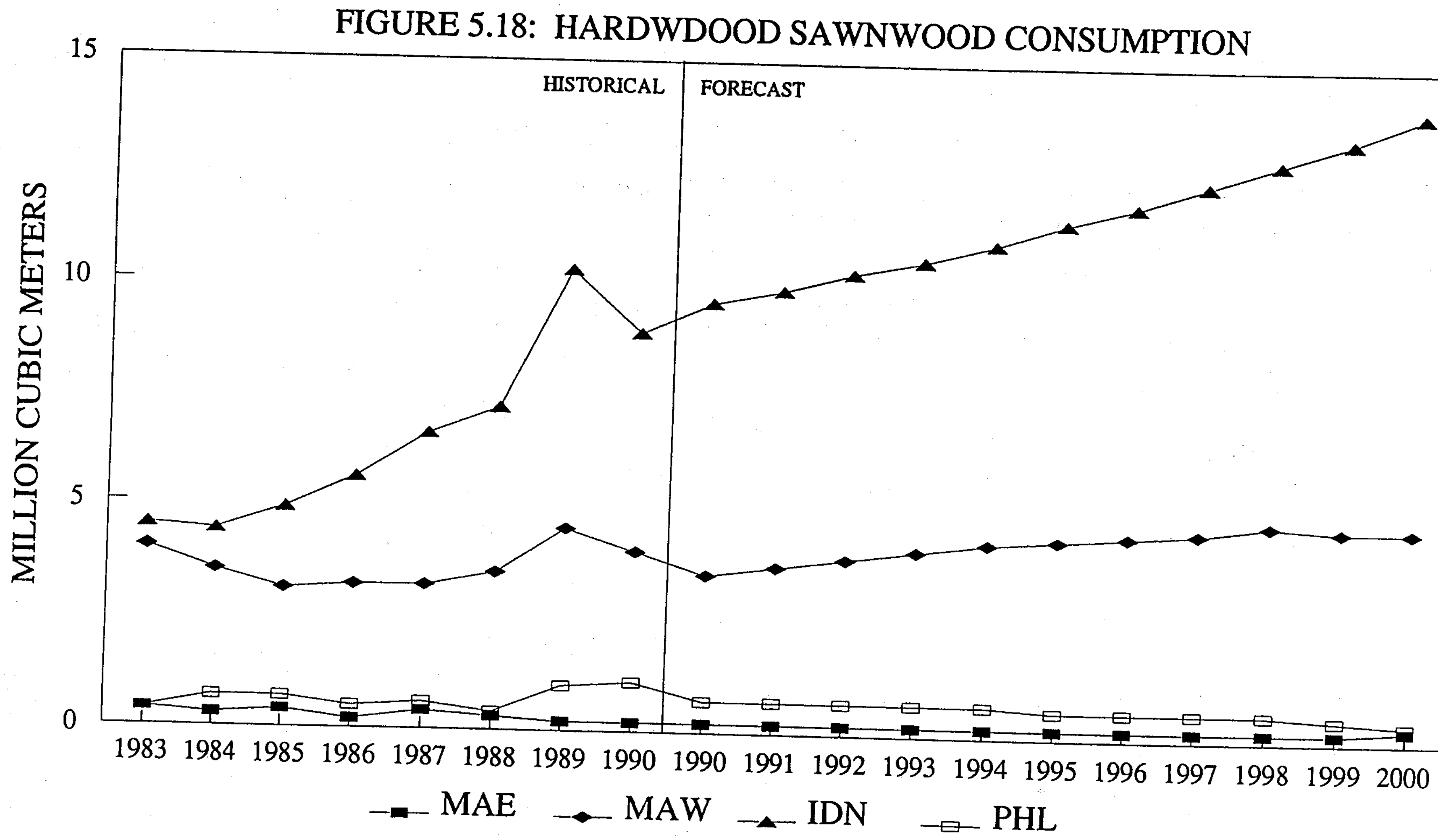


FIGURE 5.18: HARDWDOOD SAWNWOOD CONSUMPTION
15
10
5
0
MILLION CUBIC METERS
HISTORICAL
FORECAST
1983 1984 1985 1986 1987 1988 1989 1990 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
MAE
MAW
IDN
PHL

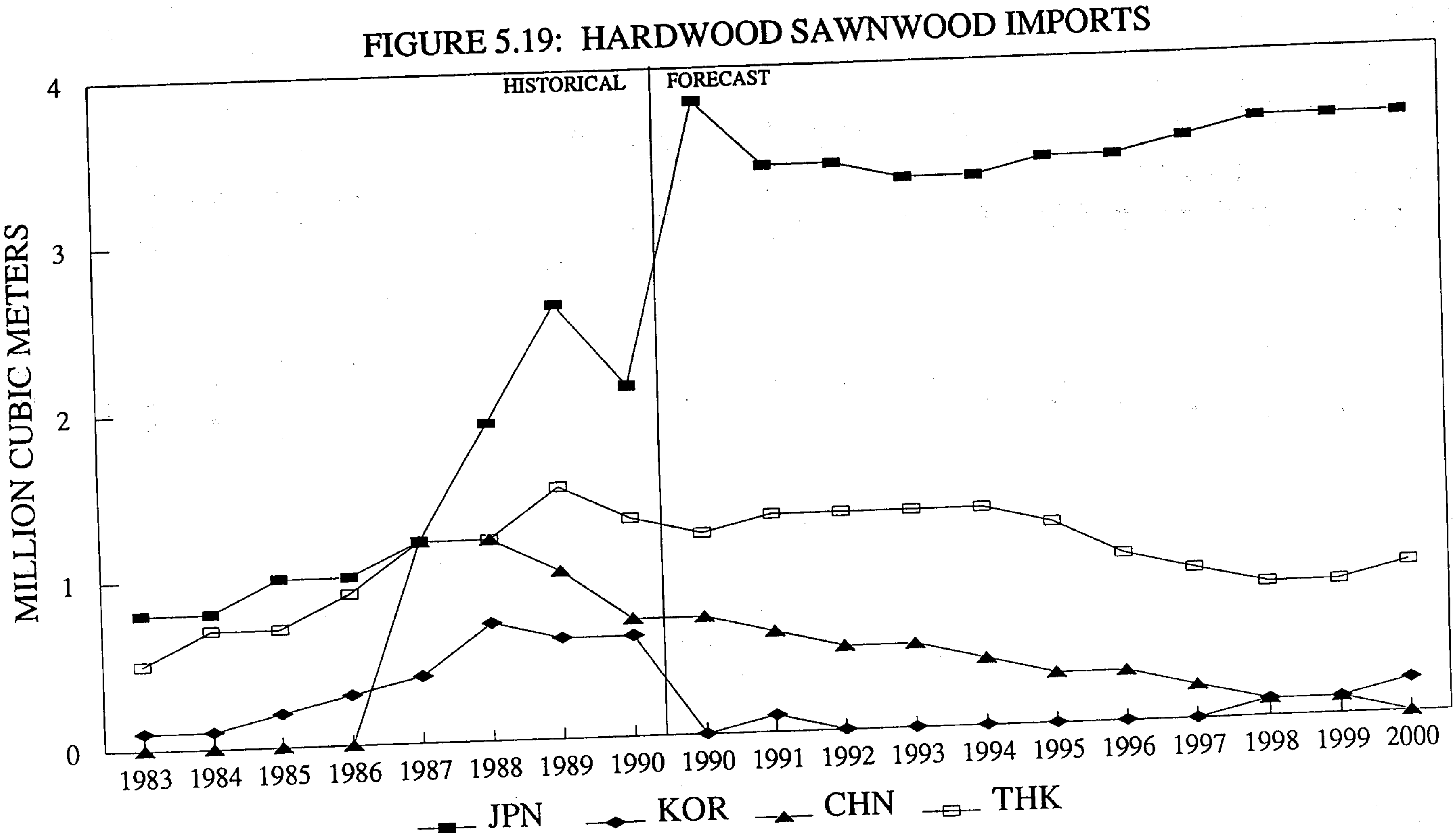


FIGURE 5.19: HARDWOOD SAWNWOOD IMPORTS
HISTORICAL
FORECAST
MILLION CUBIC METERS
0
1
2
3
4
1983 1984 1985 1986 1987 1988 1989 1990 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
JPN
KOR
CHN
THK

sawnwood, Malaysia West steadily reduces its exports of sawnwood from 4.2 mmcm in 1990 to only 0.1 mmcm by 2000. Malaysia East, with sufficient log supplies, increases its exports of sawnwood to capture the market previously held by Malaysia West. In total, however, exports drop from 6.0 mmcm in 1990 to 4.2 mmcm. These trends are illustrated in Figures 5.17 and 5.18 for hardwood sawnwood production and consumption. Brazil provides 1.6 mmcm of increased exports by 2000 making up for a portion of the Asian deficit.

Japanese import levels of sawnwood, however, are maintained in the short term. Imports are maintained at about 3.5 mmcm. Imports by Korea, China and Taiwan-Hong Kong decline as a consequence of reduced availability. These trends for the short term are illustrated in Figure 5.19.

Price projections for sawnwood increase steadily in Malaysia East and Indonesia. As in the plywood market, sawnwood prices in Malaysia West increase at a very rapid rate. These price projections for the three regions are shown in Figure 5.21. Similar trends in the price projections for the Japanese, Korean and European markets are illustrated in Figure 5.20. Finally, rates of price growth are provided in Table 5.4. It takes little price growth in Brazil to support increased exports. Africa West price growth is largely dictated by stable European markets.

Table 5.4: Rate of hardwood sawnwood price growth for selected regions
(in percent)

Region	1991-1995	1996-2000
Europe West	2.53	0.74
Japan	0.38	0.32
Korea	1.55	1.61
China	3.60	3.60
Taiwan-Hong Kong	5.45	5.56
Malaysia East	3.49	0.99
Malaysia West	5.23	9.05
Indonesia	4.41	2.62
Philippines	3.91	7.38
Africa West	3.06	0.88
Brazil	1.20	0.01

The higher price structure of Japanese sawnwood allows Japan to maintain its volume of imports at the expense of other countries. In reality, if they do not accept a broader range in quality their share of imports may not increase as rapidly, since the lower - quality wood might continue to flow to other countries. The model does not distinguish these quality differences directly.

FIGURE 5.17: HARDWOOD SAWNWOOD PRODUCTION

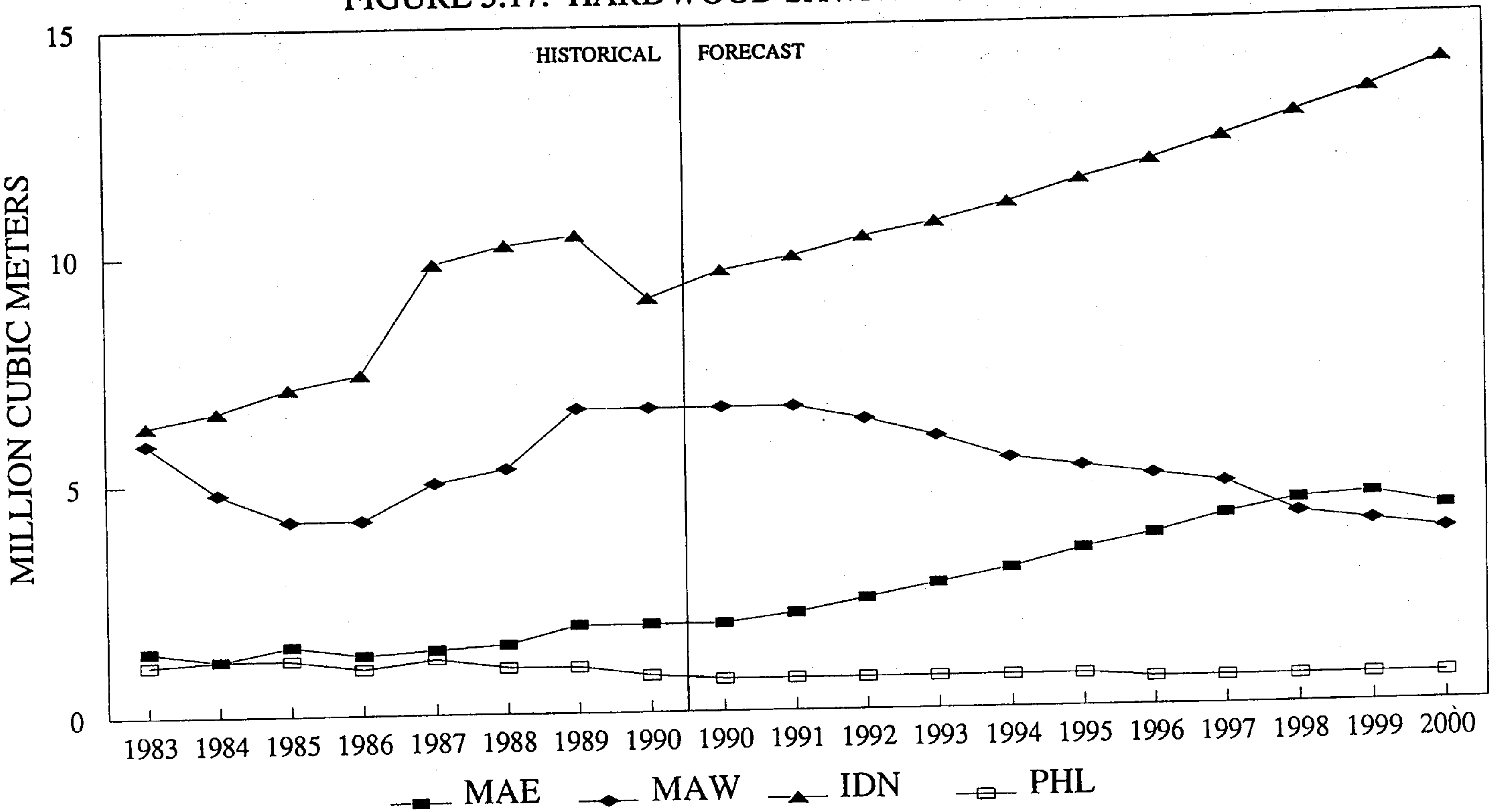


FIGURE 5.20: HARDWOOD SAWNWOOD PRICE PROJECTIONS

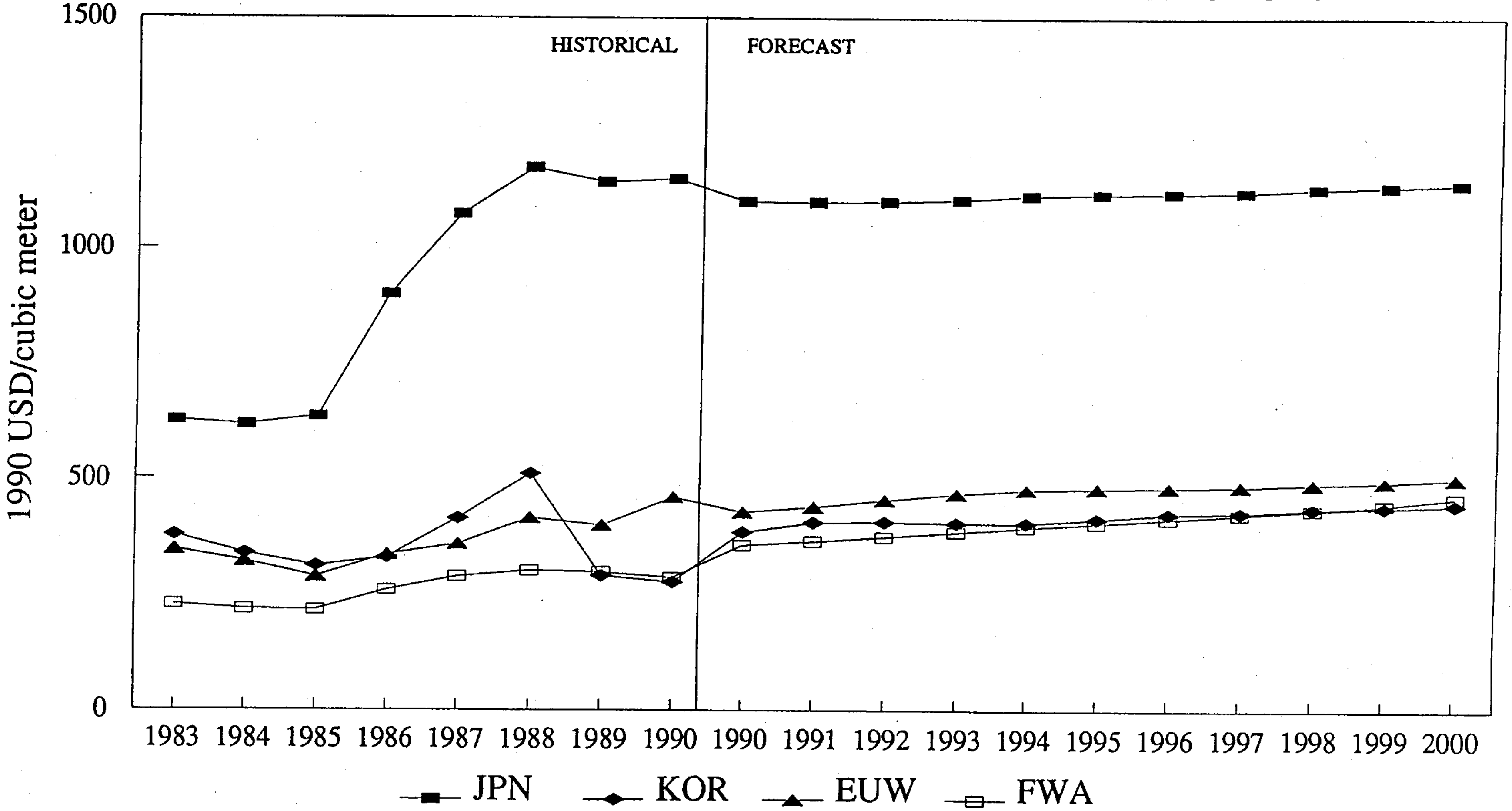
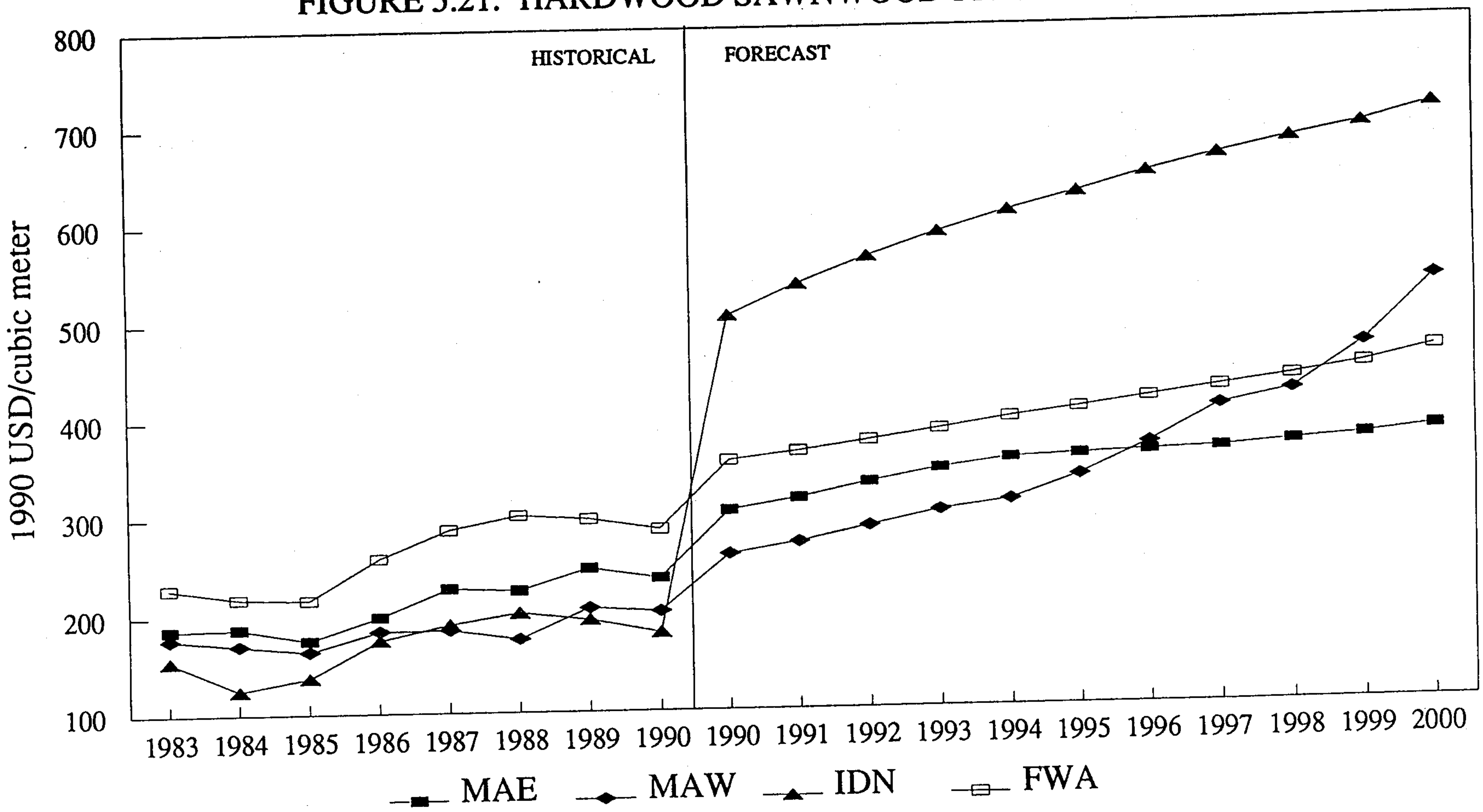


FIGURE 5.21: HARDWOOD SAWNWOOD PRICE PROJECTIONS



5.6 Summary of BASE CASE:

Shortages exist in tropical timber, not temperate hardwoods: The decreasing inventory of tropical timber with declining harvests in Malaysia, Indonesia and the Philippines dominates the projection period to the year 2000. There are not sufficient alternative sources of tropical timber to offset these declines. Africa West's declining trend in log exports was assumed to continue even though the shortages projected in Asian markets would suggest that they could reduce exports to Europe and increase exports to Asian consumers. There is no shortage of temperate hardwoods, allowing the substitution of temperate hardwoods for tropical hardwoods, particularly in the US, Europe and other non-Asian markets.

Strong demand in tropical hardwood producing countries shifts markets away from exports: With a strong growth in domestic demand in the tropical hardwood supply countries, and without a strong growth in demand in the other consuming countries, there is a substantial shift from exports to domestic consumption of tropical sawnwood and declines in log exports. The supply reductions are greatest in Malaysia West resulting in Malaysia East lumber production increasing as their log exports decline in order to help fill markets once held by Malaysia West.

Japan's needs are declining but they remain competitive log purchasers: The highest-valued end-use markets in Japan continue to import even as demand declines. Improving domestic supply and continued losses in the share of wooden housing reduces the Japanese need for products. Japan's ability to sustain its imports drives down Korea's and China's imports, given the limited excess supply. Korea's high growth in demand can only be made up by increasing their product imports such as plywood. If Japan's strong preference for quality does not decline somewhat, they might not purchase most of the available logs, leaving somewhat more for Korea, Taiwan and China.

Southeast Asian sawnwood exports also decline: Brazil increases sawnwood exports to offset a portion of the shortage experienced by Asian producers.

Plywood prices are constrained in consumer countries: Plywood prices only increase substantially late in the decade after timber prices have risen considerably. Without strong overseas demand for plywood the squeeze will be on mills for profits as their profits are shifted back to the timber resource, the resource in shortest supply. This of course is not so in temperate forests where supply is more plentiful, hence temperate processing will grow while the economic signals for tropical production will favor the tropical forest plantation rather than processors.

Malaysia West supply limitations are most severe, requiring new channels for imports: The shortage of supply in Malaysia West is so severe that their prices tend to rise much faster than other regions. New import channels are likely to be developed that would prevent the full price lift for West Malaysian logs. The BASE CASE does not assume substitute sources beyond the immediate hardwood producing region, East Malaysia. Indonesia maintains and even increases harvest levels and production for part of the period but barely keeps up with domestic needs.

International data problems remain significant: Several significant data problems are apparent. Indonesia's historical harvest appears to be understated given the usual assumption that the production of products data is more reliable and the analysis of recovery data is reasonably accurate. The step shift increase in volume from the historical reported data period to the computed demand for logs in the projection period is therefor unlikely as is the step increase in prices that corresponds with that volume increase. But these data problems are probably not seriously affecting the projected rate of change in prices.

Higher timber values will support more sustainable forest management: Overall there is a much improved outlook for tropical timber prices. These higher values for timber should go a long way toward motivating more investments in the sustained management of timber, which in the longer term could support increases in supply. While there is the risk of substitution of softwoods, yield increases from technological advances and other new sources not included in the model to provide enough supply to dampen the projected price increases, these structural changes would likely occur as a response to rising prices rather than to prevent rising prices.

6. LONG-TERM POLICY PROJECTIONS: HARVESTS DECLINE TO SUSTAINABLE LEVELS

The objective of including long-term forecasts is to observe how resource markets behave given a demand outlook and a deteriorating supply outlook. Of particular interest are the shifts in harvest levels and subsequent effects on available inventory for the tropical timber producer. The Southeast Asian tropical timber producers are likely to experience large structural changes within the next two decades. These will have direct impacts on forest products markets. This scenario provides some insight into how these changes might develop, driven by the changing resource availability.

Projecting both a demand future for the globe and resource outlook is a risky task, however. Any model outcome will be quite sensitive to the future outlook in demand, excess production of other regions, and inventory growth. We have made no direct attempt to adjust inventory levels for possible feedbacks from more intensive management in sustainable production. However, as the available commercial inventory has approached depletion, we have modified the harvest levels to reflect targets that have been described as potentially sustainable. Given the low level of commercial inventory remaining in several countries at that point in time, one can infer that some of the targeted-harvest would have to derive from either what is considered the currently non commercial inventory or other technology improvements.

At the demand end, it is also difficult to project substitution effects directly. With these cautions in mind to constrain the framework of what information can be gained from long term projections, the assumptions for demand and resource development are described first, followed by a brief analysis of the scenario results.

6.1 Key Exogenous Forecasts

6.1.1 Demand

Demand forecasts are greatly simplified for the period 2000-2040 by observing GDP per capita growth and projecting product consumption. The results of this procedure are summarized in Appendix III.

6.1.2 Resource Development

As described in the BASE CASE, the inventory of commercial timber in Malaysia is approaching the zero level given harvest rates that are based on historic supply response behavior. The inventory level for commercial timber used in the BASE CASE is almost 1/2 of the total inventory estimated in these countries. Specifically it was noted that estimates of the commercial inventory being used in the World Bank study (*Tropical Deforestation in Asia and the Market for Wood*) were only 1/2 of the inventory data that had been developed in the research phase of the development of the model. Hence, the inventory was redefined to be a commercial inventory for the BASE CASE projection. Depletion of the commercial inventory does not imply depletion of all wood in the forest. But since the non-commercial inventory is largely left behind after harvesting of the commercial inventory, depletion of the commercial inventory appeared to be the more consistent modeling approach.

As the commercial inventory becomes depleted a problem develops. Will the harvest decline to levels no greater than the estimated growth per acre, or will a portion of the non-commercial inventory become commercial. And at some point will more sustainable management techniques and technology contribute some increase to the sustainable harvest rate.

While there may not be adequate data to develop a highly reliable basis for projections, some insights on the transition from harvesting the remaining commercial inventory to potential sustainable harvest targets can be gained. If the inventory is simply depleted and the harvest levels decline to near zero, the model behavior would produce results much like those observed for Malaysia West in the BASE CASE as it approaches very low inventory with harvest rates declining rapidly. Prices rise dramatically as supply falls short of even domestic demand and prices rise to keep the production out of the export markets. Since there will be structural changes in the markets given such extreme shortages, this long term projection assumes a conversion to lower harvest levels that have been suggested by others as potential targets for sustainable harvests. The sustainable harvest levels are phased in between the year 2000 and 2005.

Given the continued increase in the harvest levels of Malaysia and Indonesia, what is the impact of imposing sustainable levels of harvests in these two regions? Recent efforts by ITTO to implement sustainable timber harvest levels for Malaysia and Indonesia have yielded estimates of sustainable log productions. Log production levels for Malaysia West are expected to decline from 11.0 mmcm to 4.7 mmcm per year by 2000. Log production levels decline from 27.6 mmcm to 12.4 mmcm by 2000 in Malaysia East. Indonesian sustainable log production has been suggested to be around 25 mmcm, down from an estimated 30.5 mmcm in 1990. This long term projection assumes these sustained harvest levels are implemented for Malaysia between 2005 and 2010. Harvest levels prior to that time are driven by the available inventory. Malaysia falls below the sustainable harvest levels, implying some degree of over-cutting. The sustainable harvest level also exceeds estimates of forest growth suggesting some of what has been defined as non-commercial inventory is being harvested. Since the suggested sustainable target for Indonesia implied a harvest of only 1% of the commercial inventory per year it did not seem appropriate to force a large reduction in the harvest rate for Indonesia. Instead it was prevented from further increases in harvest levels after 2010 even if prices increase. This projection therefore primarily demonstrates the impact of declining harvest levels in Malaysia East and West until 2005 when sustainable levels are phased in reaching the target levels of 4 mmcm for Malaysia West and 12.5 mmcm for Malaysia East by 2010.

6.2 Long Term Outlook Issues

6.2.1 Sawlog prices continue an upward trend

Figure 6.1 illustrates the sawlog price projections for tropical hardwood suppliers beyond the year 2000. The shortage of wood in Malaysia West becomes virtually complete by 2005. The price increases are essentially unlimited although with very low volume, but are capped in the simulation as harvest is increased to the targeted sustainable harvest levels after 2005. This issue was already identified in the short term outlook. Alternative import channels will no doubt be developed to relieve the Malaysia West shortage including non-wood substitutes.

Of greater importance is the continued upward trend in sawlog prices in all regions, which will provide even greater support for sustainable forest management. Malaysia East log prices move up more rapidly by the year 2000 as their production drops with depletion of the timber inventory. By 2005 prices are $20/cubic meter above the world price and the Indonesia price. By 2010 their production has increased to sustainable levels, which are above the low point; thus, price increases slow down and fall below the increases shown for Indonesia. By 2020 the Indonesia price is about $50 above the world price and the Malaysia East price. The slowdown in price increases after 2005 results from the harvest to the targeted sustainable levels that are higher than the low harvest point just prior. If the harvest transition was less abrupt, without a dip, the price lift prior to 2005 would have been muted. If the sustainable harvest level has been overestimated, prices would be expected to continue to increase with lower harvest rates.

The higher prices begin to change the usage of wood in other countries. With declining wood demand in Japan, for example, the higher prices by 2005 cause imports of logs to decline. Figure 6.2 shows this decline in Japan's log imports as prices peak. Figure 6.3 shows consumer countries' log prices peaking as imports start to decline.

6.2.2 Plywood prices in producer countries rise slightly faster than world prices

International plywood prices do not rise as rapidly as do the prices in tropical producer countries with weaker demand and alternative supply sources. Tropical producer prices are therefore pushed up by log prices, squeezing plywood processor margins. The

FIGURE 6.1: HARDWOOD SAWLOG PRICE PROJECTIONS

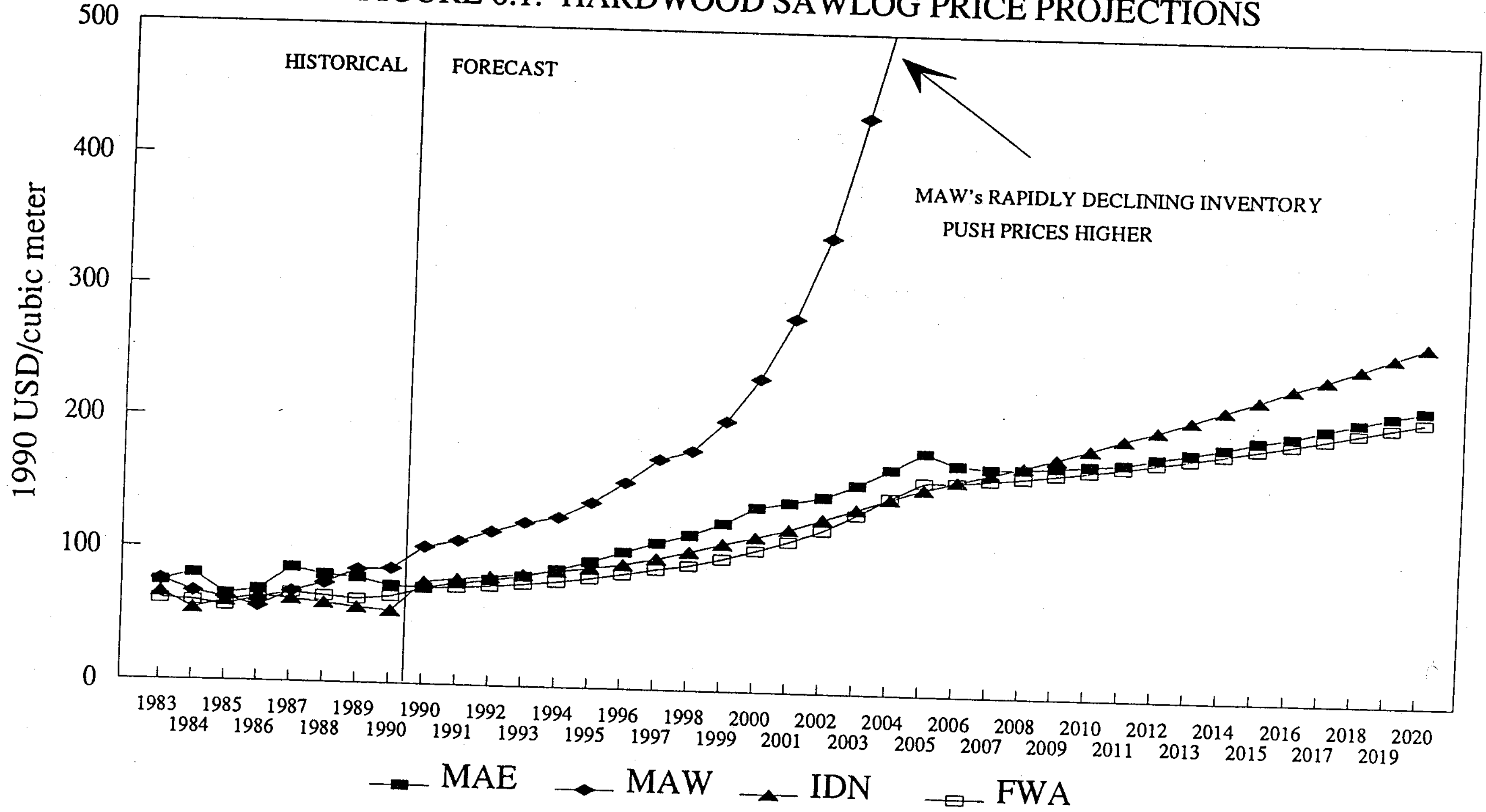
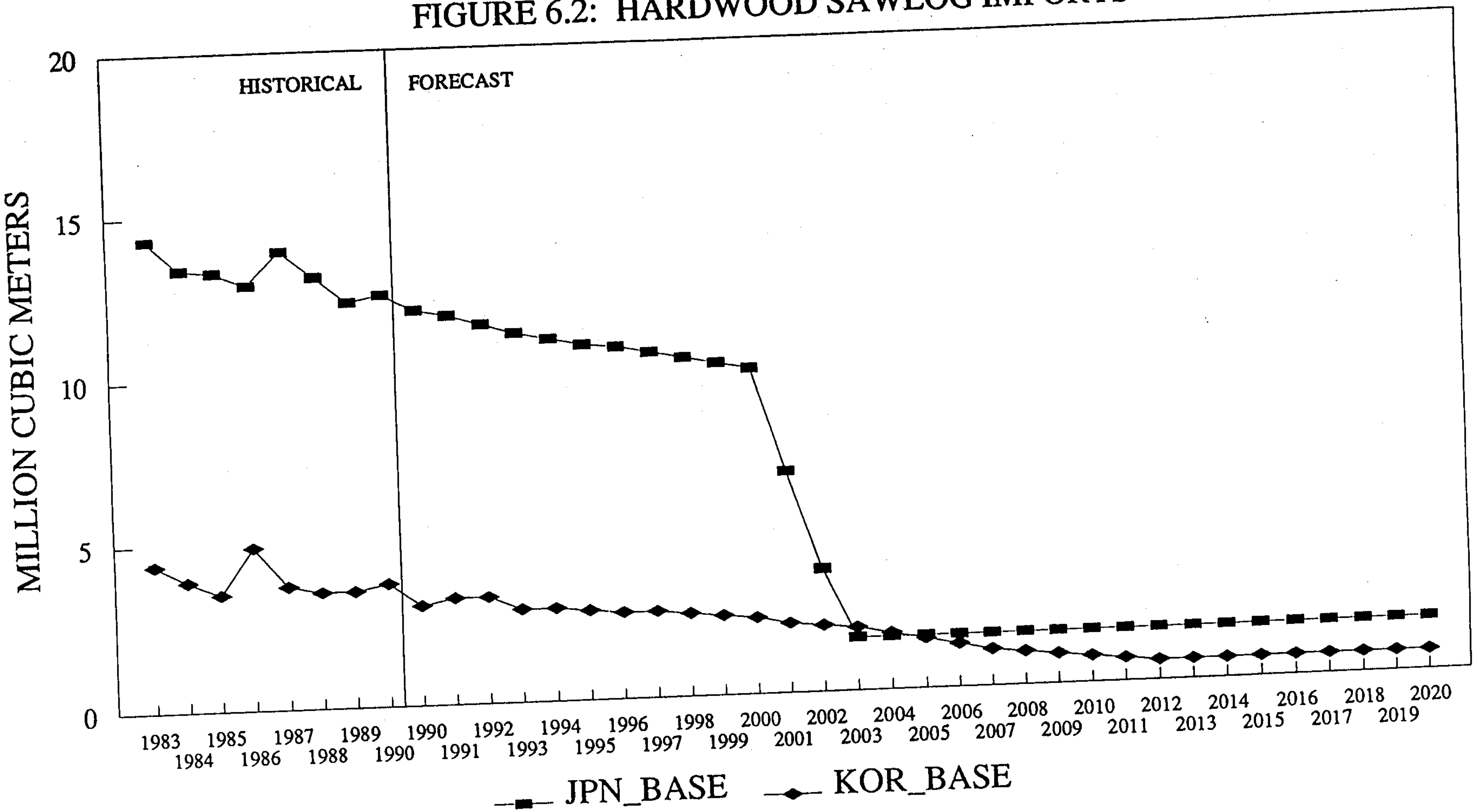


FIGURE 6.2: HARDWOOD SAWLOG IMPORTS



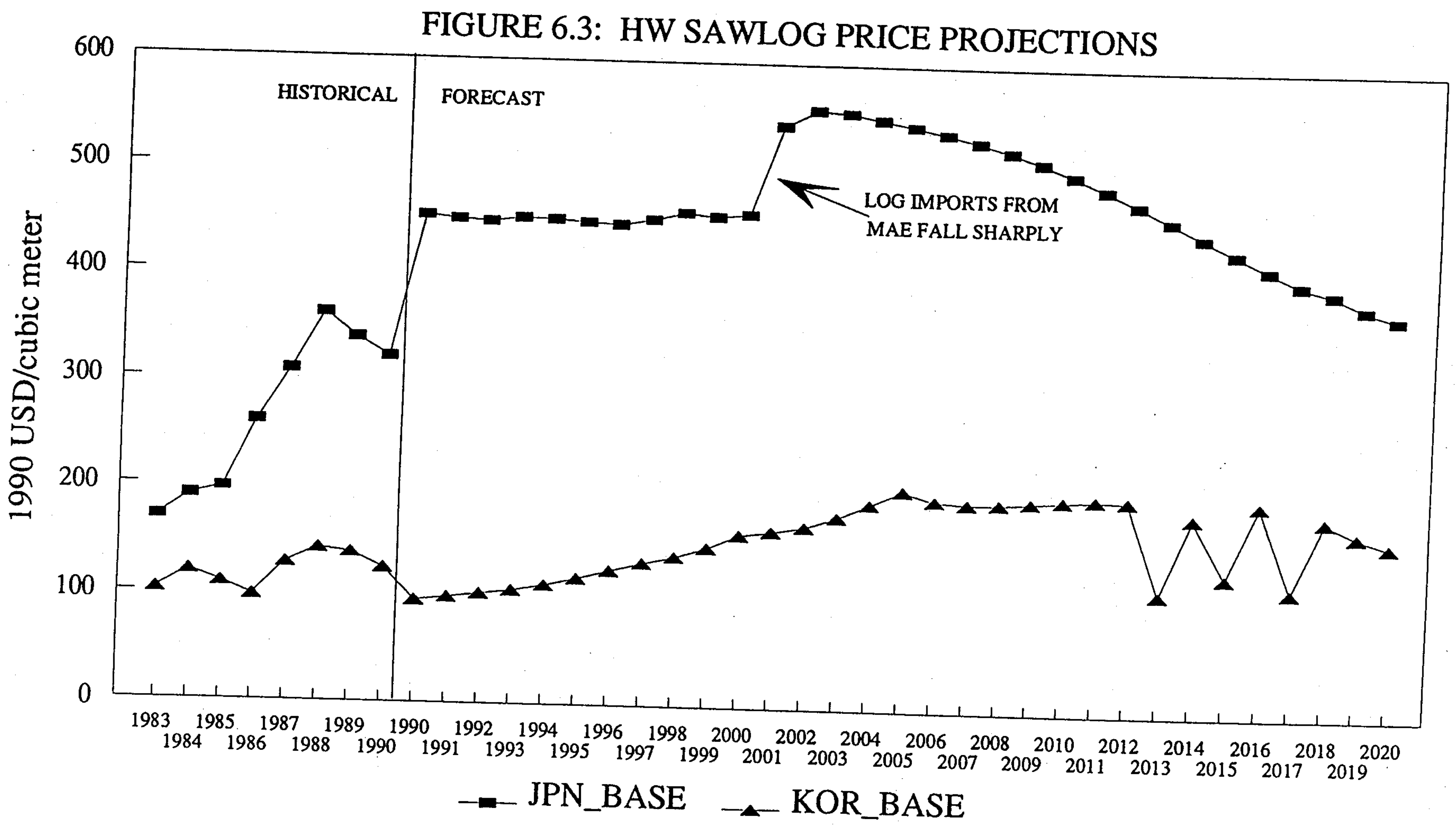


FIGURE 6.3: HW SAWLOG PRICE PROJECTIONS
HISTORICAL
FORECAST
LOG IMPORTS FROM
MAE FALL SHARPLY
1990 USD/cubic meter
600
500
400
300
200
100
0
1983 1984 1985 1986 1987 1988 1989 1990 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
JPN_BASE
KOR_BASE

Malaysia West wood scarcity shows up again as an out of control price spiral in order to keep all volume for domestic consumption. The impact is capped by 2005 with the introduction of sustainable harvest levels as described above. These price trends are illustrated in Figure 6.4.

The decline in plywood price trends in other regions after 2005 is largely the result of shifting to sustainable harvest levels, reversing the declines in harvest.

6.2.3 Sawnwood prices rise more slowly than log prices unless domestic demand exceeds capacity

While the data problems with Indonesia supply and sawnwood prices are severe, the trends in sawnwood prices are evident. Malaysia West sawnwood prices spiral out of control for the same reasons described above for plywood. Without an alternative supply, prices attempt to keep the declining supply for domestic consumption.

Malaysia East, with a surplus in wood above domestic needs, shows a continuing upward price trend in sawnwood but slower than world markets and more importantly, slower than log prices. These price trends are illustrated in Figure 6.5.

6.3 Summary of key long term issues: The commodity in short supply is tropical hardwood logs, not processing capacity

Log prices rise faster than product prices. The highest value return is for logs. Processing margins will be squeezed until there are increases in harvest from investment in sustainable forest management. This outlook scenario does not attempt to characterize what time frame will be required to see that impact. The sustainable harvest levels imposed after the year 2010 do not include the impact of improved management but they do infer harvesting more than what has currently been defined as commercial inventory for Malaysia. While consumer countries are largely forced to accept higher prices, they do begin to change their usage to reduce the impact of price increases. Japan, the major importer, reduces its imports of logs. There are many other substitutes not characterized in the model that might be expected to increase their share, reducing the rate of price increases. The domestic demand in the tropical hardwood producing countries becomes a much more important part of their overall market.

Even with sustainable harvest target rates that might be considered optimistically high sawlog price projections rise by 100% over 1990 levels by 2010 and almost 200% by 2020. While there are many possible impacts not considered in this simulation to slow the increase in prices, such as increased supply from new sources, substitution with softwoods and technology impacts, these will all occur as a result of high prices and merely slow down the price increase, not eliminate it. These price increases should go a long way to motivating sustainable management investments to reduce the damage from harvesting in order to gain the benefits from the second growth harvest with much higher rates of return than in the past.

FIGURE 6.4: HARDWOOD PLYWOOD PRICE PROJECTIONS

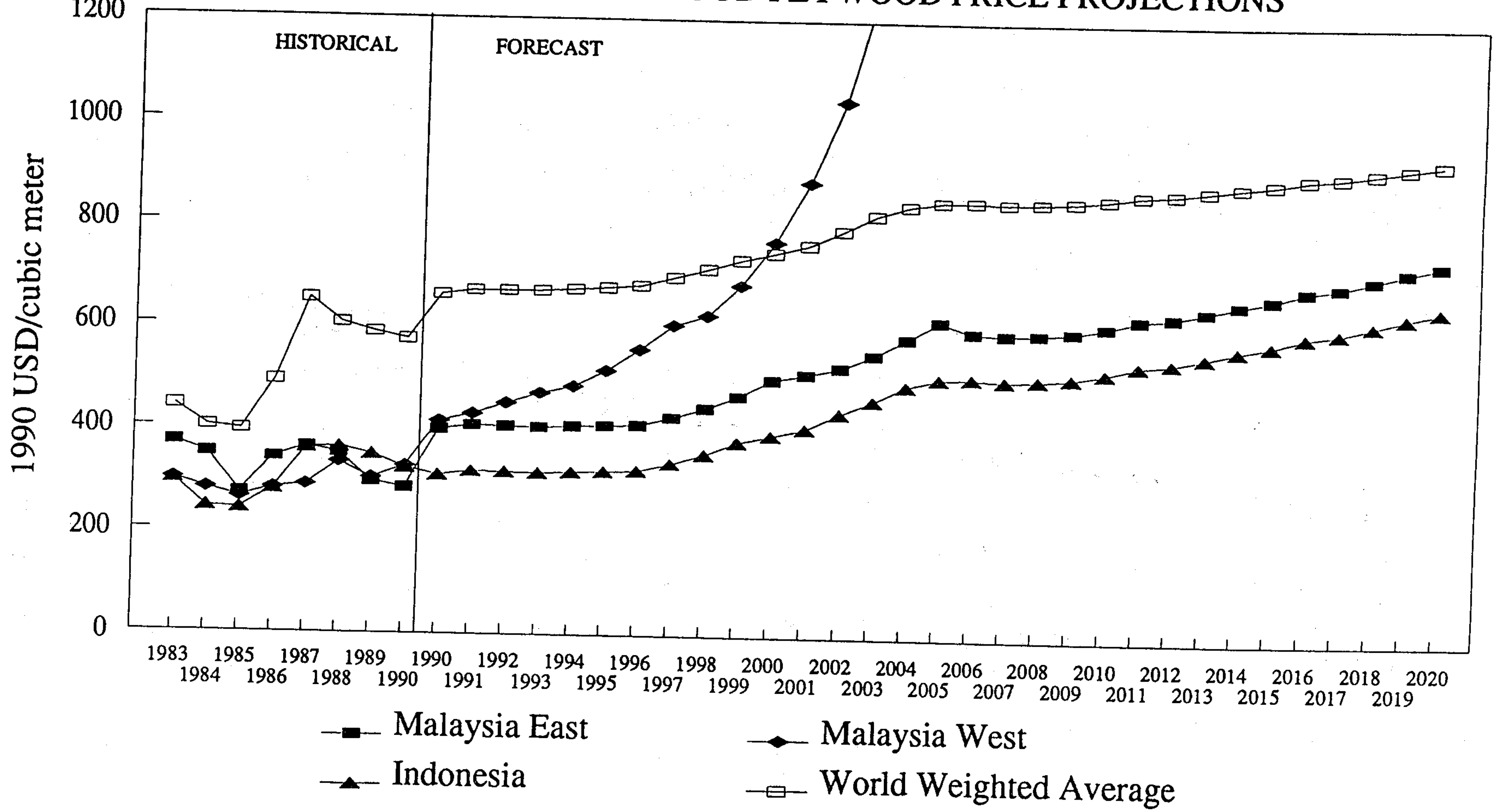
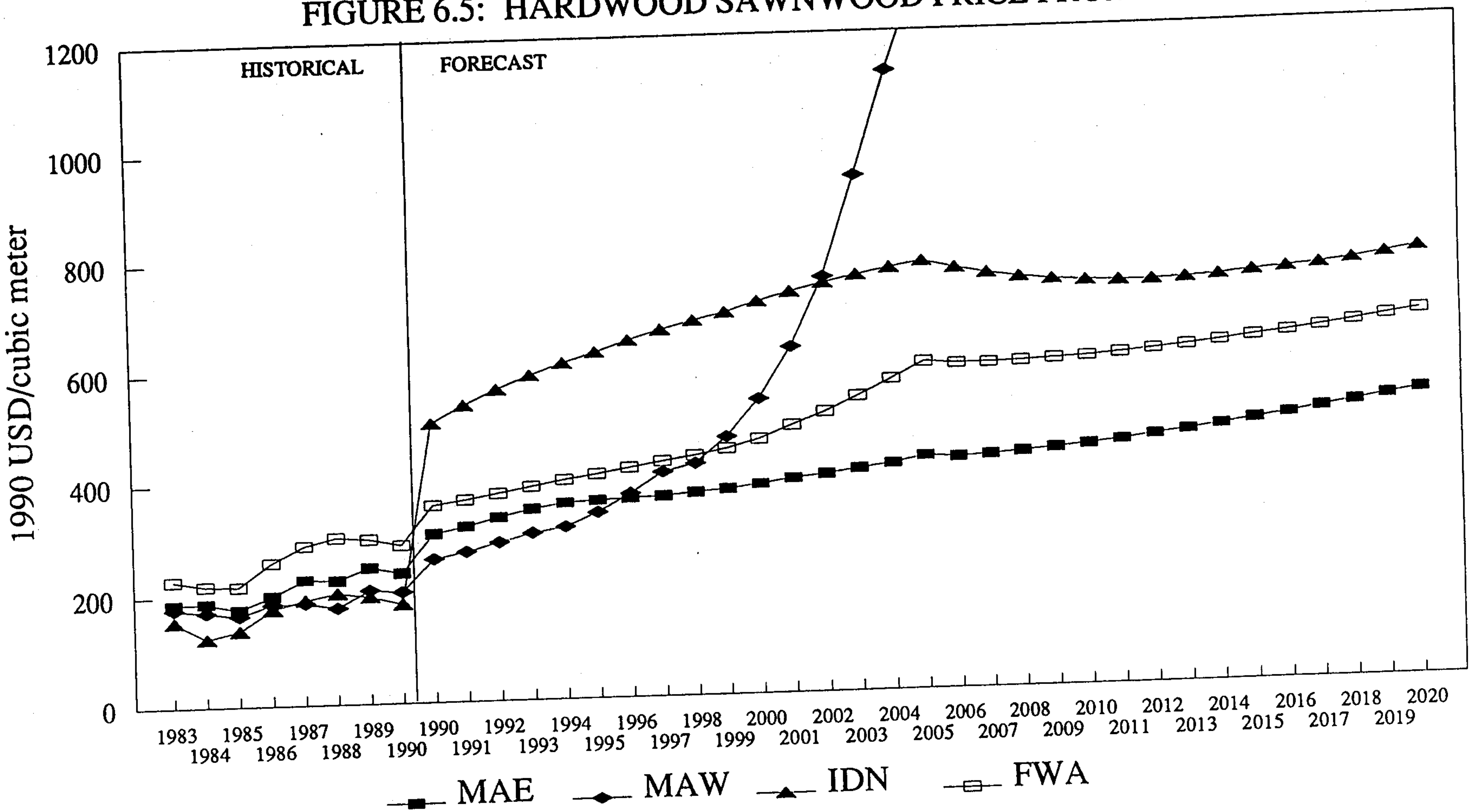


FIGURE 6.5: HARDWOOD SAWNWOOD PRICE PROJECTIONS



7. TROPICAL TIMBER SUPPLY CONSTRAINTS

There are two thrusts toward reducing the supply of tropical hardwoods. One recognizes that the rapid liquidation of the inventory will require lower harvests sooner or later. If the harvests are reduced sooner, sustainable levels can be reached without falling below those levels to wait for the inventory to rebuild. Alternatively, set-asides may be mandated to preserve natural stands. During the first few years there will not be much apparent difference between these two approaches. Over the longer-term, permanent set-asides would not support as high a level of sustainable harvest.

The reduced supply scenario merely shifts the supply curve back 10% for all tropical hardwood regions much like set-asides. Inventory is reduced by 10% to cause the harvest to reduce by 10% as though it was set aside and no longer available. Timber supply curve shifts were implemented by reducing inventory in Malaysia East, Malaysia West, Indonesia, Philippines and Papua-New Guinea by 10%. These shifts are provided in Table 7.1.

Table 7.1 Inventory Shifts in Tropical Hardwood Producing Countries (mmcm)

Region	Base Inventory	Reduced Inventory
MAE	325.7	293.1
MAW	116.5	104.8
IDN	2955.3	2659.8
PHL	347.1	312.4
PNG	846.4	761.8

7.1 Short term impacts of 10% supply reduction

As summarized in Figure 7.1, sawlog prices increase even faster than in the base scenario. Malaysia East production declines several years sooner. Figure 7.2 shows sawlog production declining rapidly, falling below the previously identified sustainable target levels before recovering. The impact on consumer countries is felt more in the countries that were noted in the BASE scenario to be somewhat less competitive. Korea reduces log imports even more.

7.2 Long term impacts of 10% supply reduction

Generally there is little that could be considered surprising in that a 10% supply decrease is simply a movement forward in time of the trend supply reductions expected in the base scenario. By reducing the available supply, harvest levels fall more rapidly in Malaysia East, falling to levels of only 20% of the previous trend by 2002. As such, the major impact of a supply reduction is felt before 2010. Volumes are returning closer to base scenario levels by 2020 only because the same transition to sustainable targets defined in the previous case was assumed after 2010.

FIGURE 7.1: HARDWOOD SAWLOG PRICE PROJECTIONS SCENARIO: 10% SHIFT IN TIMBER SUPPLY CURVE

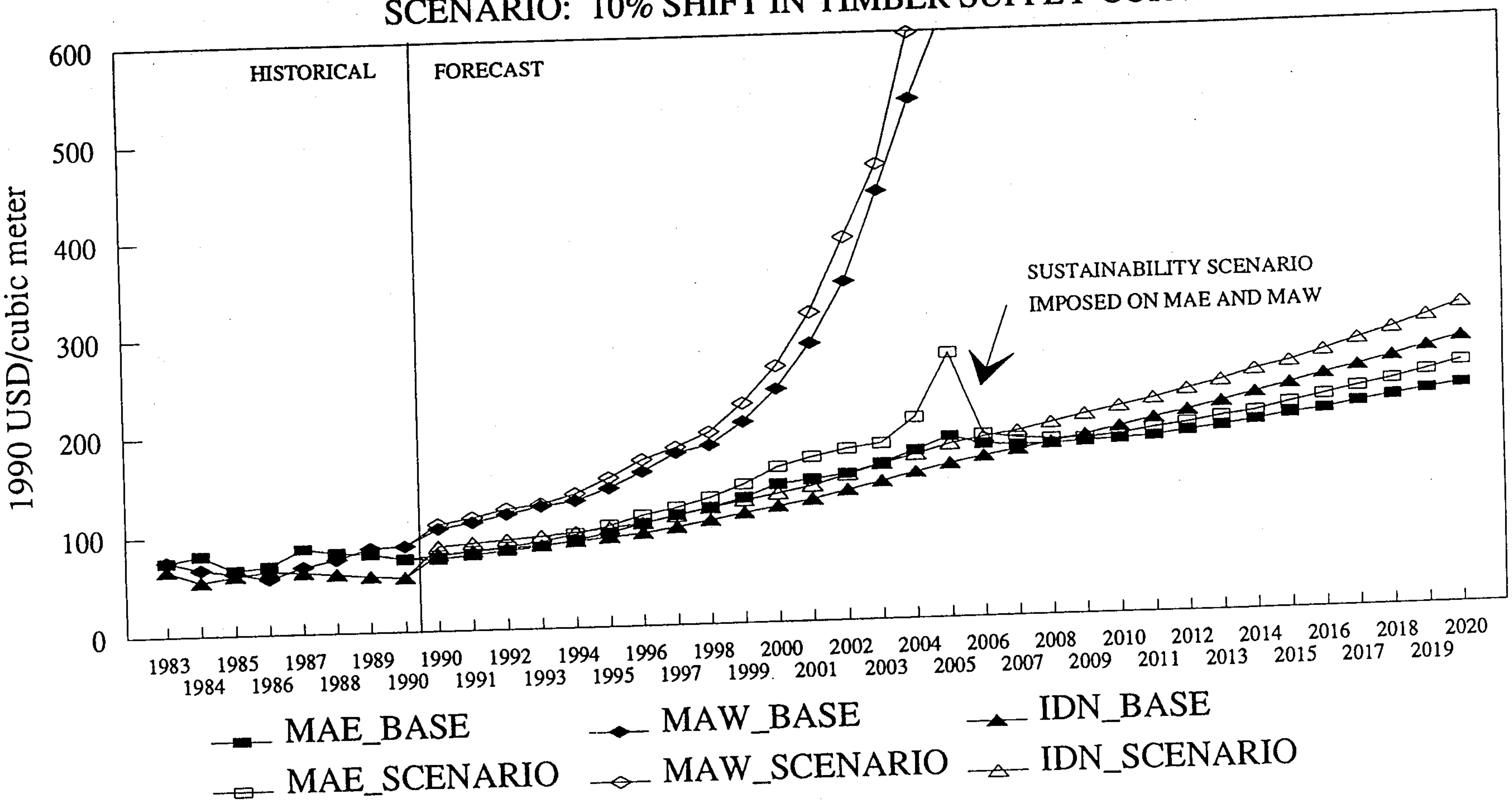
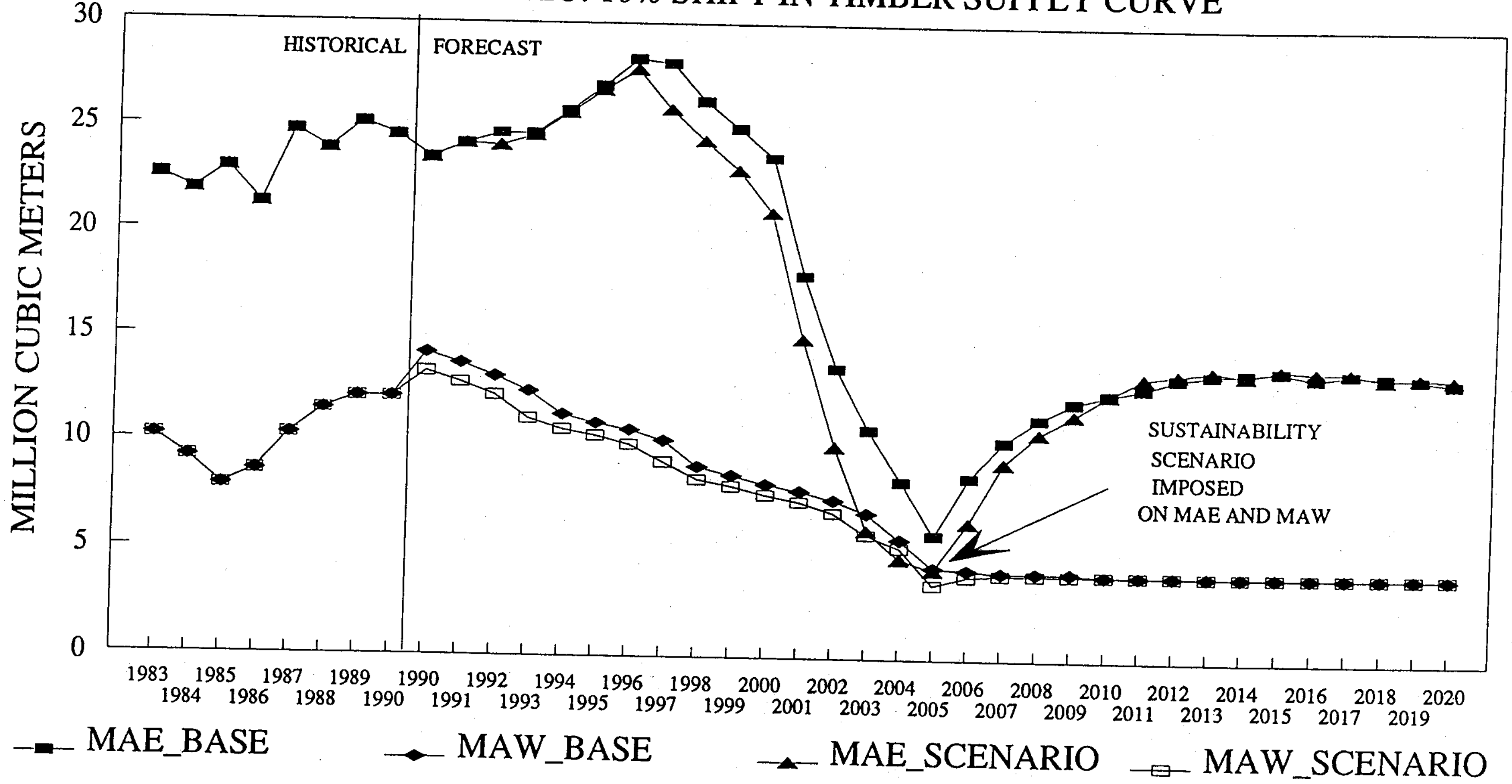


FIGURE 7.2: HARDWOOD SAWLOG PRODUCTION
SCENARIO: 10% SHIFT IN TIMBER SUPPLY CURVE



In the longer term, after Malyasia's inventory is largely depleted, and targeted sustainable harvests are used as in the long term simulation discussed in section 6, there is no way to shift the supply curve for Malaysia. Hence the long term portion of this simulation does not reflect a supply shift, especially for Malaysia.

8. TROPICAL TIMBER TRADE CONSTRAINTS

8.1 Key Assumptions in Increasing Trade Constraints

The environmental movement is pushing tropical hardwood import bans and tariffs as a policy to penalize non-sustainable tropical harvesting, with the goal of reducing the harvest of tropical forests. Trade barriers have also been erected by developed countries to protect their domestic processing. The economic impact of increasing such trade constraints has been simulated by applying a 10% increase to product prices for products reaching destination countries in the CGTM. Some product exports can be expected to be driven out in competition with domestic supplies. Table 8.1 summarizes the revenue generated from increased tariffs.

8.2 Sawlog Production Declines

All tropical hardwood suppliers suffer a decline in production. Indonesia production declines up to 2 million cubic meters as shown in Figure 8.1. Malaysia East declines by as much as 4 million cubic meters prior to 1996 as shown in Figure 8.2 but, because of the rapid decline in harvest forced by inventory depletion, they are able to make up for some of that decline between 1995 and 2005. Since most log exports were already non-economic after the year 2000 under baseline conditions, the impact of increased tariffs is not as great beyond the year 2000.

8.3 Log Trade Declines

As a consequence of the tariff, consumer countries such as Japan and Korea reduce their import of logs from Malaysia as shown in Figure 8.3. There is a 3-4 million cubic meter reduction in log exports from Malaysia East prior to the year 2000. With the decline in harvest near the year 2000 which produces higher prices, most log imports by Japan are curtailed.

8.5 Sawlog Prices Decline

Sawlog prices decline by as much as 20% for Malaysia East reducing to less than 10% declines after 2005. Indonesia sawlog prices decline less than 5%. These price impacts are illustrated in Figure 8.4. In the consumer countries, especially Japan, log prices are driven up by the reduced availability by about 10% as shown in Figure 8.5. After the year 2000 with a much reduced level of log exports the impact on sawlog prices is much smaller.

Table 8.1 Revenues Associated with Transfer Cost Increase Scenario

Product [a/]	Region [b/]	Tariff [c/] (US$)	Imports (mmcm) 1990	Imports (mmcm) 2000	Revenue (US$ mm) 1990	Revenue (US$ mm) 2000
Logs	West Europe	11.81	3.5	0.0	41.4	0.0
	Japan	45.32	14.5	12.9	657.1	584.6
	Korea	9.71	2.9	2.5	28.1	24.3
	China	7.97	2.1	1.0	16.7	8.0
	Taiwan/Hong Kong	10.77	5.1	4.2	54.9	45.2
Sawnwood	US West	44.42	0.3	0.3	13.3	13.3
	US South	20.26	0.1	0.1	2.0	2.0
	US North	20.06	0.3	0.3	6.1	6.1
	Canada	39.51	1.0	1.9	39.5	75.1
	West Europe	42.74	4.7	8.4	200.9	359.0
	Japan	111.01	3.8	3.9	421.9	433.0
	Korea	38.35	0.0	0.2	0.0	7.7
	China	38.82	0.7	0.0	27.2	0.0
	Taiwan/Hong Kong	24.75	1.1	1.2	27.2	29.7
Plywood	US West	48.02	0.2	0.2	9.6	9.6
	US South	40.00	0.8	0.6	32.0	24.0
	US North	41.63	0.3	0.0	12.5	0.0
	Canada	42.75	0.1	0.1	4.3	4.3
	Central America	49.18	0.1	0.1	4.9	4.9
	West Europe	44.13	1.8	1.8	79.4	79.4
	Japan	126.29	1.4	0.0	176.8	0.0
	Korea	40.49	2.1	3.4	85.0	137.7
	China	36.85	1.4	1.5	51.6	55.3
	Taiwan/Hong Kong	72.74	0.0	0.0	0.0	0.0
TOTALS		na	48.3	44.6	1,992.5	1,903.0

a/ Non-coniferous (hardwood) from tropical producer countries.
b/ Regions as defined in the CGTM.
c/ Tariff equals 10% of baseline product price in destination regions.

FIGURE 8.1: HARDWOOD SAWLOG PRODUCTION
SCENARIO: 10% INCREASE IN TRANSFER COSTS

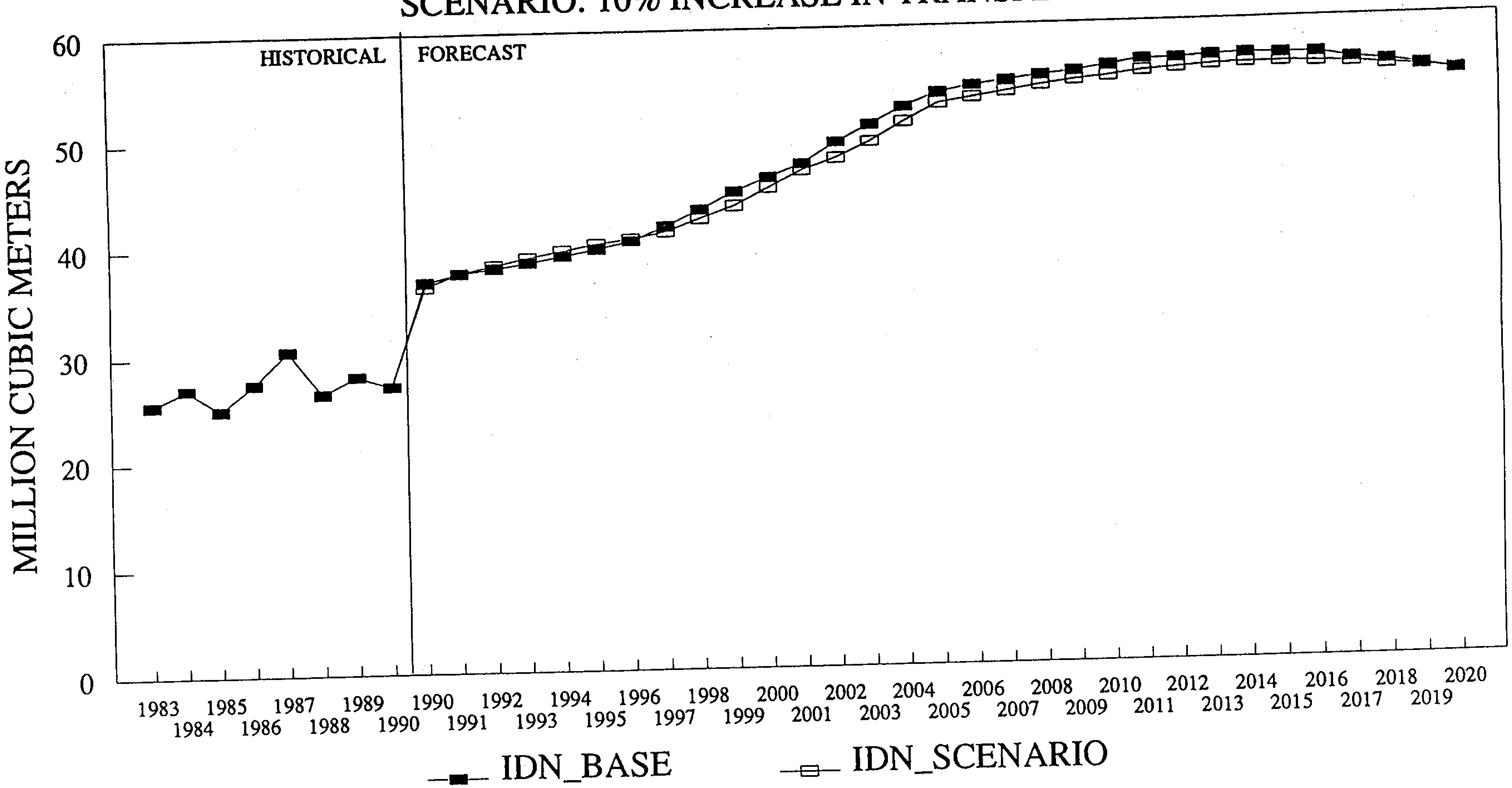


FIGURE 8.2: HARDWOOD SAWLOG PRODUCTION
SCENARIO: 10% INCREASE IN TRANSFER COSTS

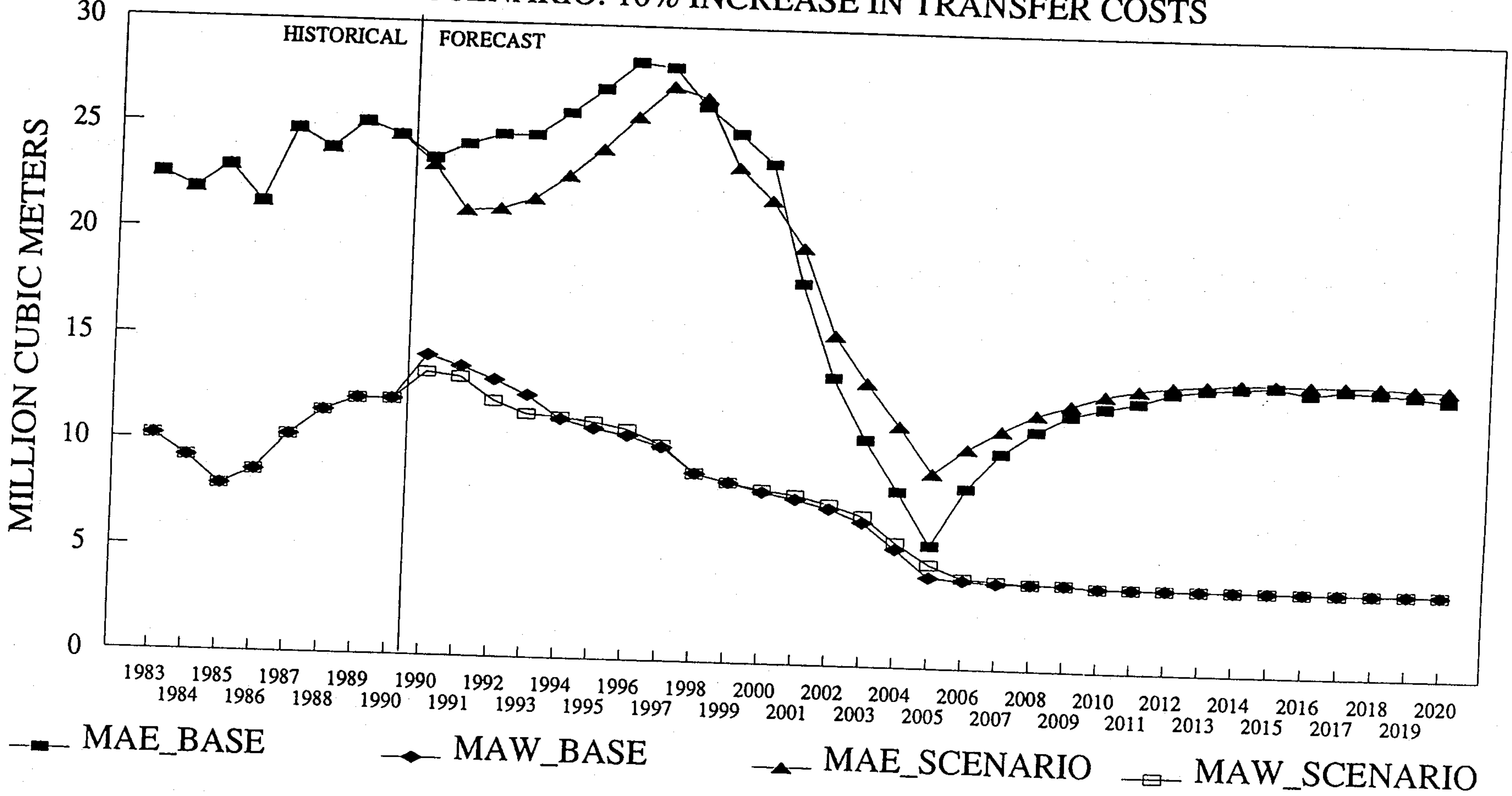


FIGURE 8.3: HARDWOOD SAWLOG TRADE
SCENARIO: 10% INCREASE IN TRANSFER COSTS

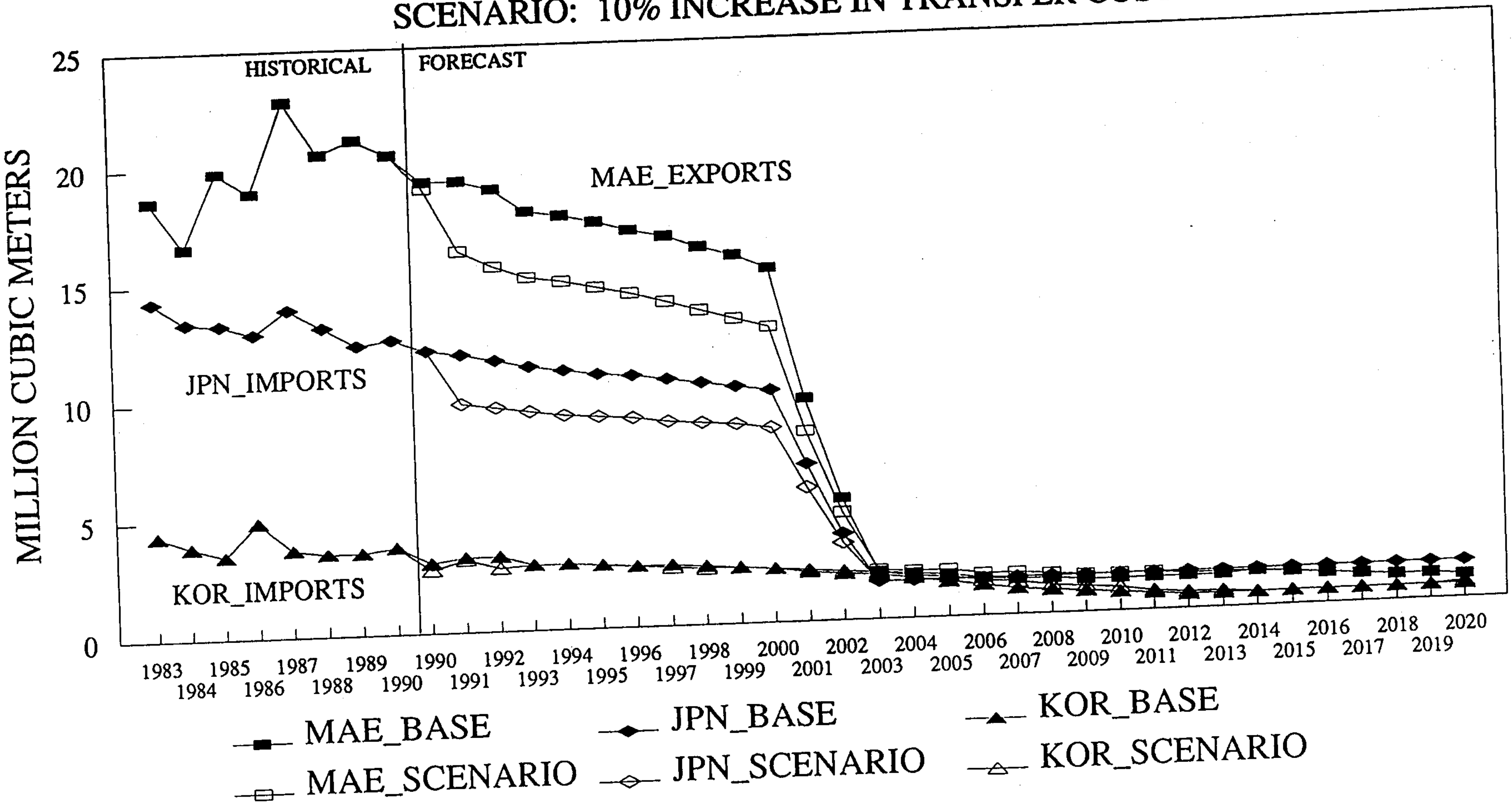


FIGURE 8.4: HARDWOOD SAWLOG PRICE PROJECTIONS
SCENARIO: 10% INCREASE IN TRANSFER COSTS

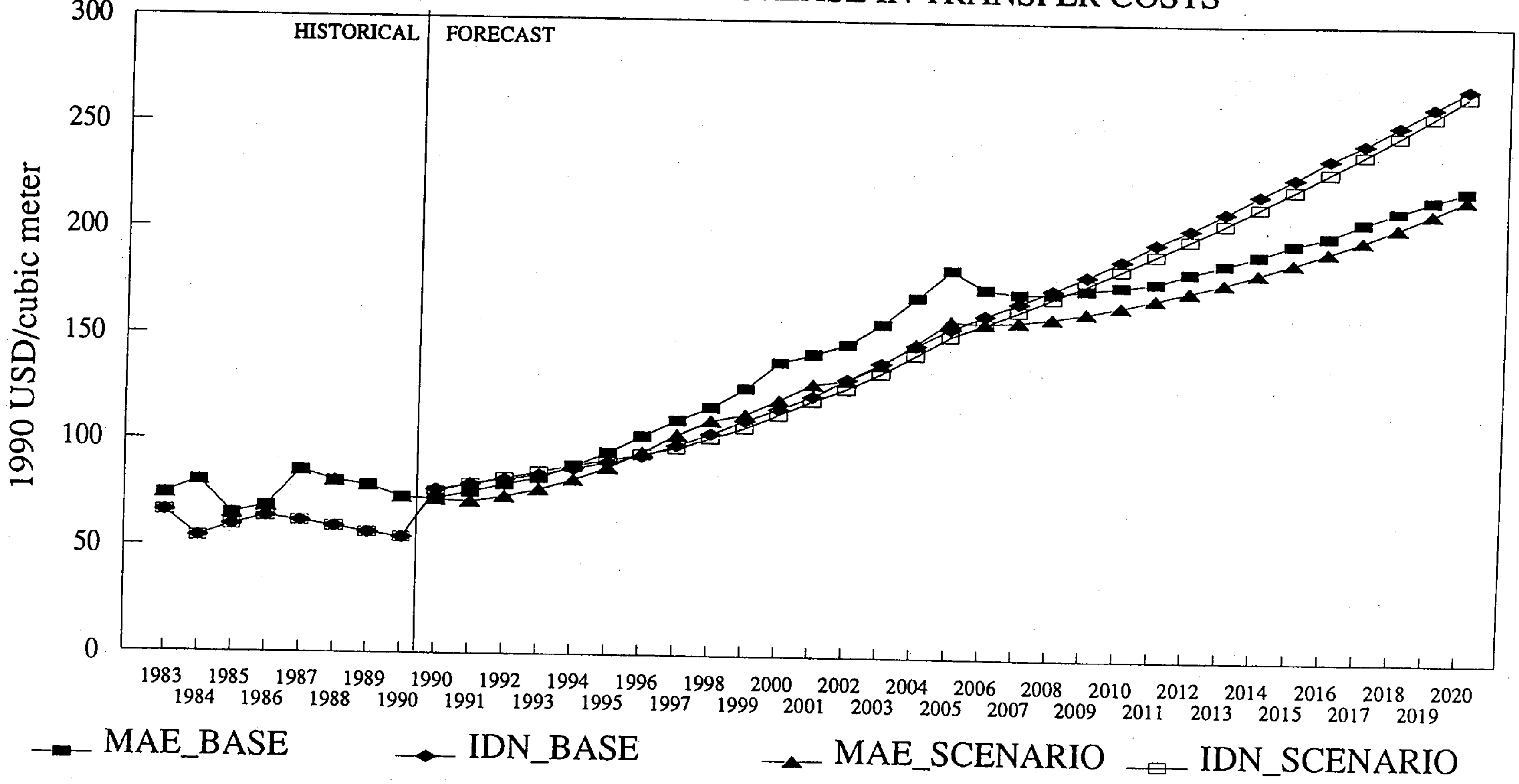


FIGURE 8.5: HARDWOOD SAWLOG PRICE PROJECTIONS
SCENARIO: 10% INCREASE IN TRANSFER COSTS

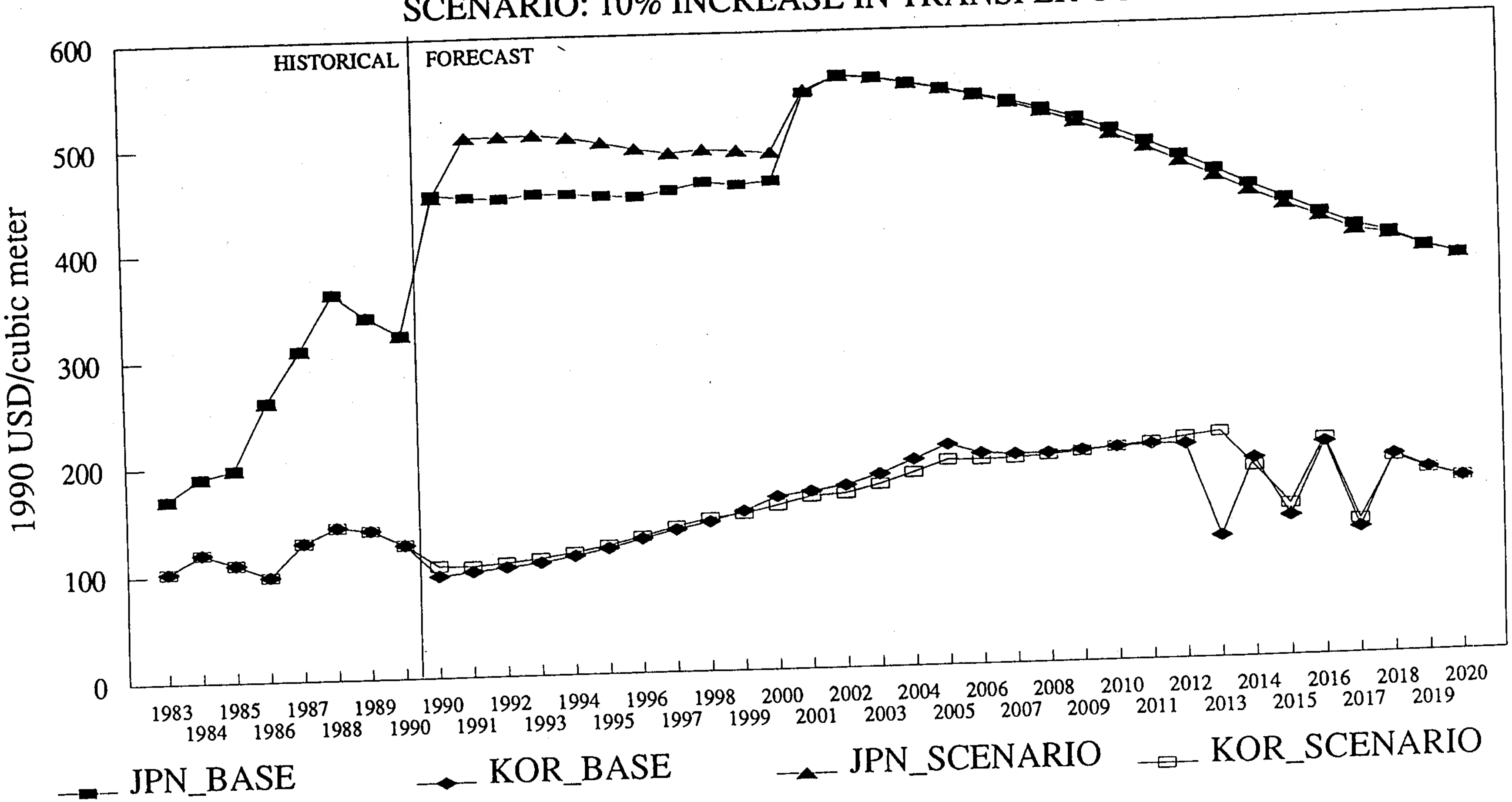
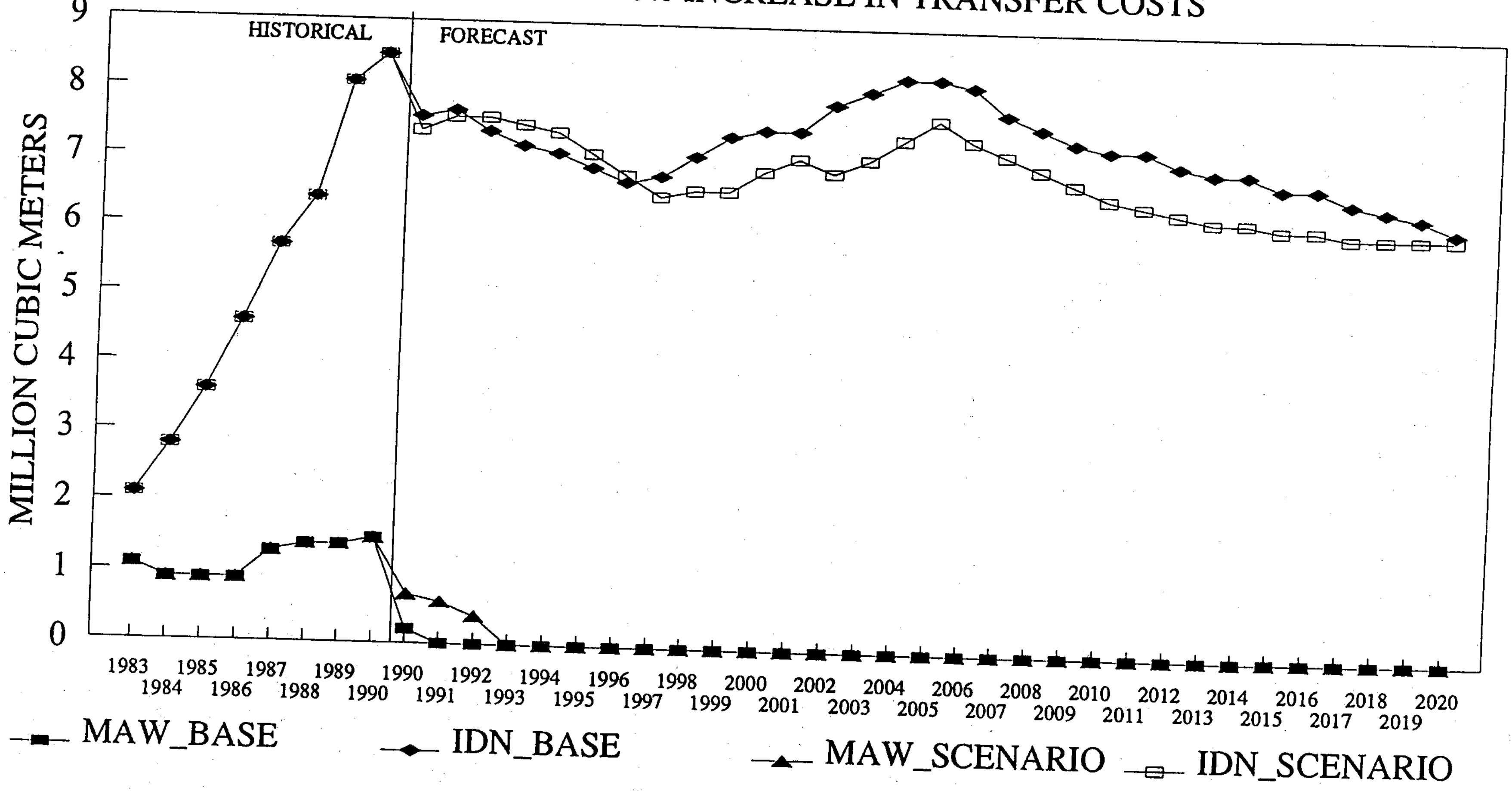


FIGURE 8.6: HARDWOOD PLWOOD EXPORTS
SCENARIO: 10% INCREASE IN TRANSFER COSTS



8.6 Product Distribution Changes

Product distribution is also impacted. Plywood exports from Indonesia are off almost 10% after 1995 as shown in Figure 8.6. In the early period prior to 1995 when there was a decline in log exports, plywood exports were slightly increased. With such a large impact on log exports, the consuming country needs for products increases, resulting in a small increase in plywood exports. In the first few years, Malaysia West increases its share of plywood exports before being constrained by log scarcity.

8.7 Summary of Impacts from Increased Trade Constraints

This scenario demonstrates the expected impacts from imposing trade barriers. Sawlog production declines in producing countries, log trade declines as transfer costs increase, and sawlog prices fall. There will be less motivation to manage the forests given the lower prices and there is a reduced revenue from which to consider such investments.

9. GLOBAL TRADE LIBERALIZATION

9.1 Key Assumptions in Reducing Trade Barriers

Trade barriers exist in consumer countries to protect their processing industry. The demand for tropical timber increases by eliminating tariffs, with increasing returns for sustainable management of the forests. While there are many non-tariff barriers as well as tariff barriers, eliminating the tariff barriers alone would have a significant impact.

Tropical timber producing countries have introduced log export bans and even primary processing product export bans in order to encourage more high valued domestic processing. While these policies may increase processing employment, many studies have shown that they also result in income and wealth losses to the region (see list of references under Literature Cited). That is, they reduce the economic welfare of the producing countries, rather than increasing it. They are largely designed to counteract the impact of consuming countries' tariffs which are designed to protect processing operations in consuming countries.

Trade liberalization in this scenario includes both the reduction of product tariffs and the removal of export bans. Most products have tariffs of 10% or more. The trade liberalization scenario reduces transfer costs by 10%. The scenario also includes lifting the restriction on log exports from Malaysia West, Indonesia, Philippines, Paupa New Guinea, and West Africa. Several routes for which there existed no log exports were opened, including log exports from Indonesia to Japan and Korea.

9.2 Sawlog Production Increases

With trade liberalization, Indonesia and Malaysia West increase sawlog production significantly for a number of years. Indonesia's harvest is up almost 5 million cubic meters until 2000 and then runs just slightly below the base projection. Malaysia East also increases harvest by over 5 million cubic meters, which accelerates the depletion of their inventory resulting in harvest levels below the base from 1996 to 2000. Malaysia West's remaining inventory is so low and their domestic needs so high that they reduce harvest and import logs of lower cost from Malaysia East. These sawlog production changes are illustrated in Figure 9.1.

It should be remembered that even in the base projection, and the long term policy simulation the rapid reduction in Malaysian East inventory resulted in a decline below the targeted-sustainable levels for a few years just after the year 2000 before settling down with the targeted harvest levels. The increased demand from trade liberalization accelerates the inventory decline with harvest levels dropping below the base projection in just 5 years. During the periods of shortest supply in Malaysia East their prices will rise significantly.

9.3 Sawlog Prices Increase

The increased demand on tropical hardwood suppliers increases sawlog prices for the producers even as log prices decline considerably in the importing consumer countries. The availability of import logs that had been banned drives down prices in the consumer countries. The reduction in prices in consumer countries are considerably larger than the increases in tropical hardwood supplier countries.

As illustrated in Figure 9.2 sawlog prices in both Indonesia and Malaysia increase by 20% during the first few years when they are both producing more than they were under baseline conditions. Once the Malaysia East inventory is near depletion their prices rise substantially, remaining about 25% higher than in the baseline projection. As Indonesia production falls back beyond the year 2000, just as in the baseline projections, their prices return to levels not much above the baseline. However because the markets are more open under trade liberalization, the Malaysia West price level converges with the Indonesia price level instead of staying below it as was the case in the baseline projection. In effect a large part of the cross-country price differences is a consequence of barriers in trade flows.

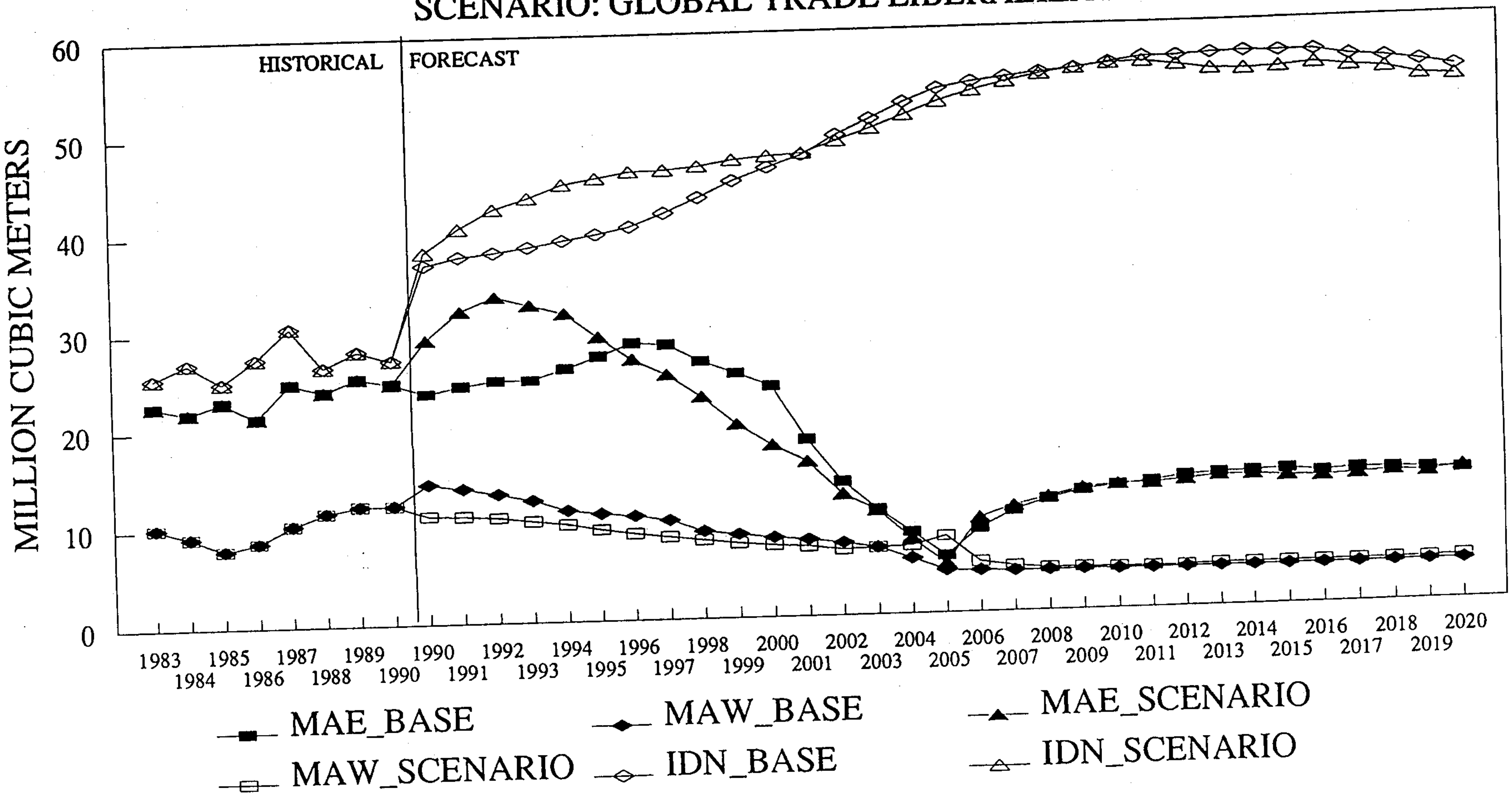
Under the baseline, Japan, Korea and other consumer countries were denied access to log imports from many countries. With the removal of these barriers their log prices decline by 20 to 40% as illustrated in Figure 9.3. In dollar amounts the decline in consumer country log prices is much larger than the gain by producer countries due to the much higher cost structure in these countries which includes freight and distribution as well as higher cost domestic timber.

9.4 Product Distribution Changes

As shown in figure 9.4, Malaysia East and Indonesia both increase their log exports significantly although in the longer term domestic demand with high sawlog prices brings an end to Indonesian log exports.

With these lower log costs, Japan imports 2 million cubic meters more in logs for the first 10 years and does not stop importing by 2000, in contrast to the baseline when they were forced out of the market once Malaysia East harvest levels declined from inadequate

FIGURE 9.1: HARDWOOD SAWLOG PRODUCTION
SCENARIO: GLOBAL TRADE LIBERALIZATION



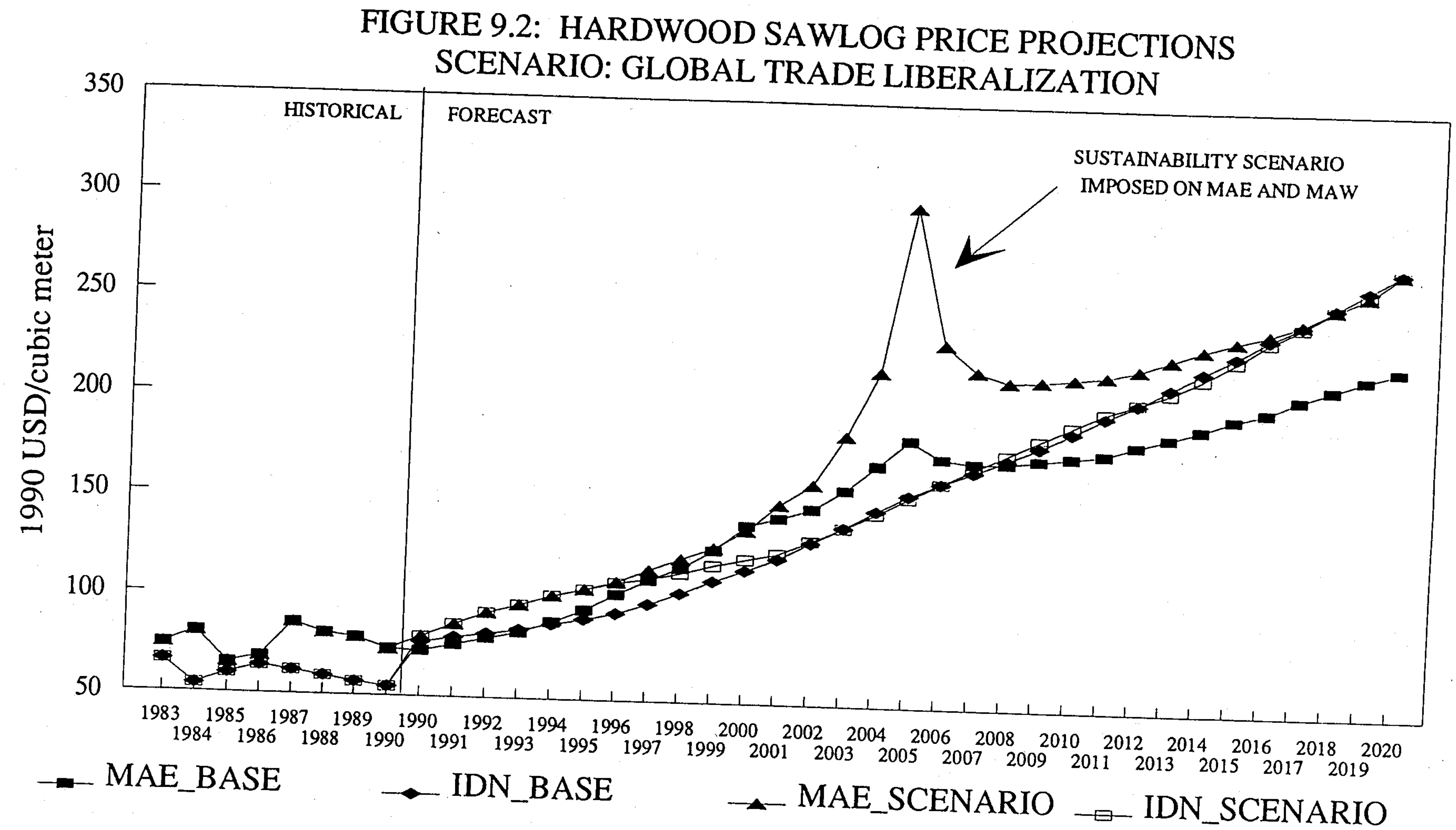


FIGURE 9.2: HARDWOOD SAWLOG PRICE PROJECTIONS
SCENARIO: GLOBAL TRADE LIBERALIZATION
HISTORICAL
FORECAST
SUSTAINABILITY SCENARIO
IMPOSED ON MAE AND MAW
1990 USD/cubic meter
350
300
250
200
150
100
50
1983 1984 1985 1986 1987 1988 1989 1990 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
MAE_BASE
IDN_BASE
MAE_SCENARIO
IDN_SCENARIO

FIGURE 9.3: HARDWOOD SAWLOG PRICE PROJECTIONS
SCENARIO: GLOBAL TRADE LIBERALIZATION

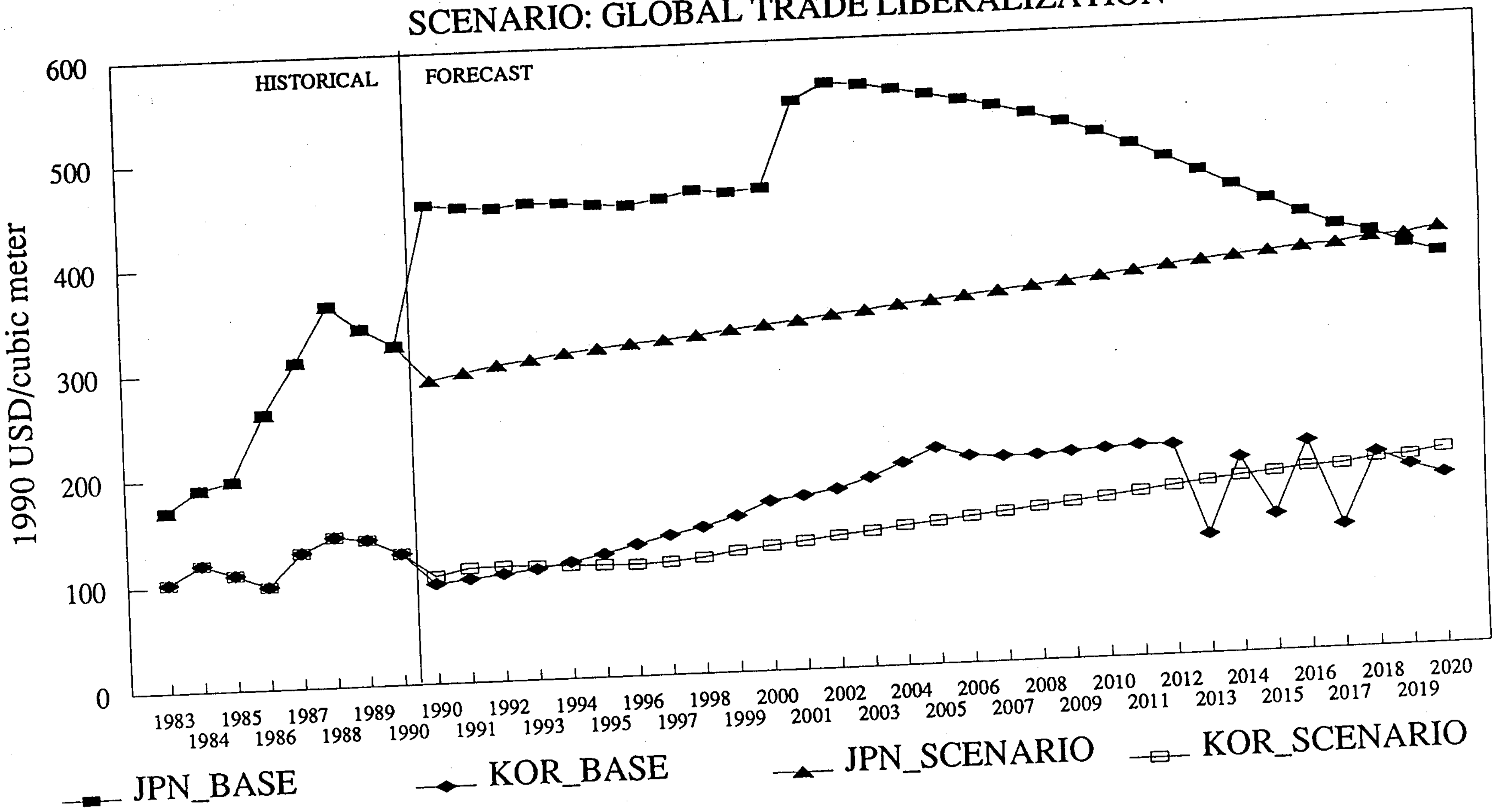
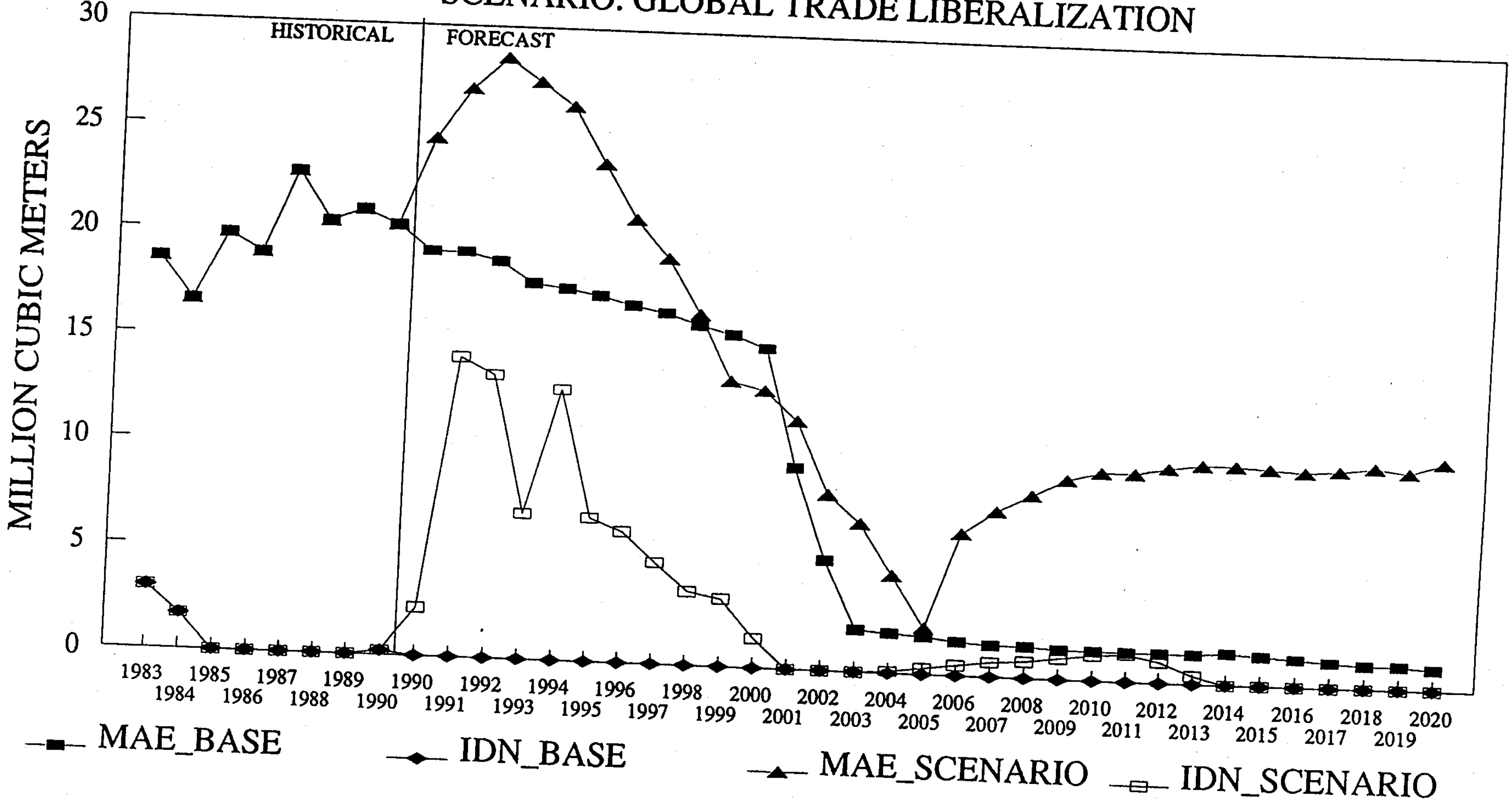


FIGURE 9.4: HARDWOOD SAWLOG EXPORTS
SCENARIO: GLOBAL TRADE LIBERALIZATION



inventory. By 2010 they are importing almost 10 million cubic meters more in log form with trade liberalization. While log exports remain on a declining trend in all consumer countries as log prices rise, they are at considerably higher levels under trade liberalization conditions, substituting for product imports. These results are illustrated in Figure 9.5.

Malaysia West, the tropical hardwood supplier with the greatest imbalance between growing domestic demand and supply, becomes a substantial log importer.

With lower log prices, Japan reduces plywood imports more quickly as illustrated in Figure 9.6 while at the same time Malaysia West exports more plywood processed from its log imports and Indonesia exports less plywood. Indonesia plywood exports remain about 10% lower with trade liberalization as shown in Figure 9.7

9.4 Trade Liberalization Conclusions

The reduction of tariffs and elimination of bans increases the demand on tropical hardwoods. As expected their is a significant producer log price increase of about 20%, an important contribution to motivate higher-growth-sustainable-forest-management.

The benefits to consumer countries are also large with significant declines in log prices as a consequence of open markets. Since the commodity that is in short supply is tropical hardwood logs and the hardwood producing countries have no comparative advantage in processing, they lose some of their processing to the consuming countries.

The fact that the economic and product demand growth is higher in the tropical hardwood producing countries than the consuming countries shifts some of the wood flow into Malaysia West, the producing country with the greatest imbalance.

FIGURE 9.5: HARDWOOD SAWLOG IMPORTS
SCENARIO: GLOBAL TRADE LIBERALIZATION

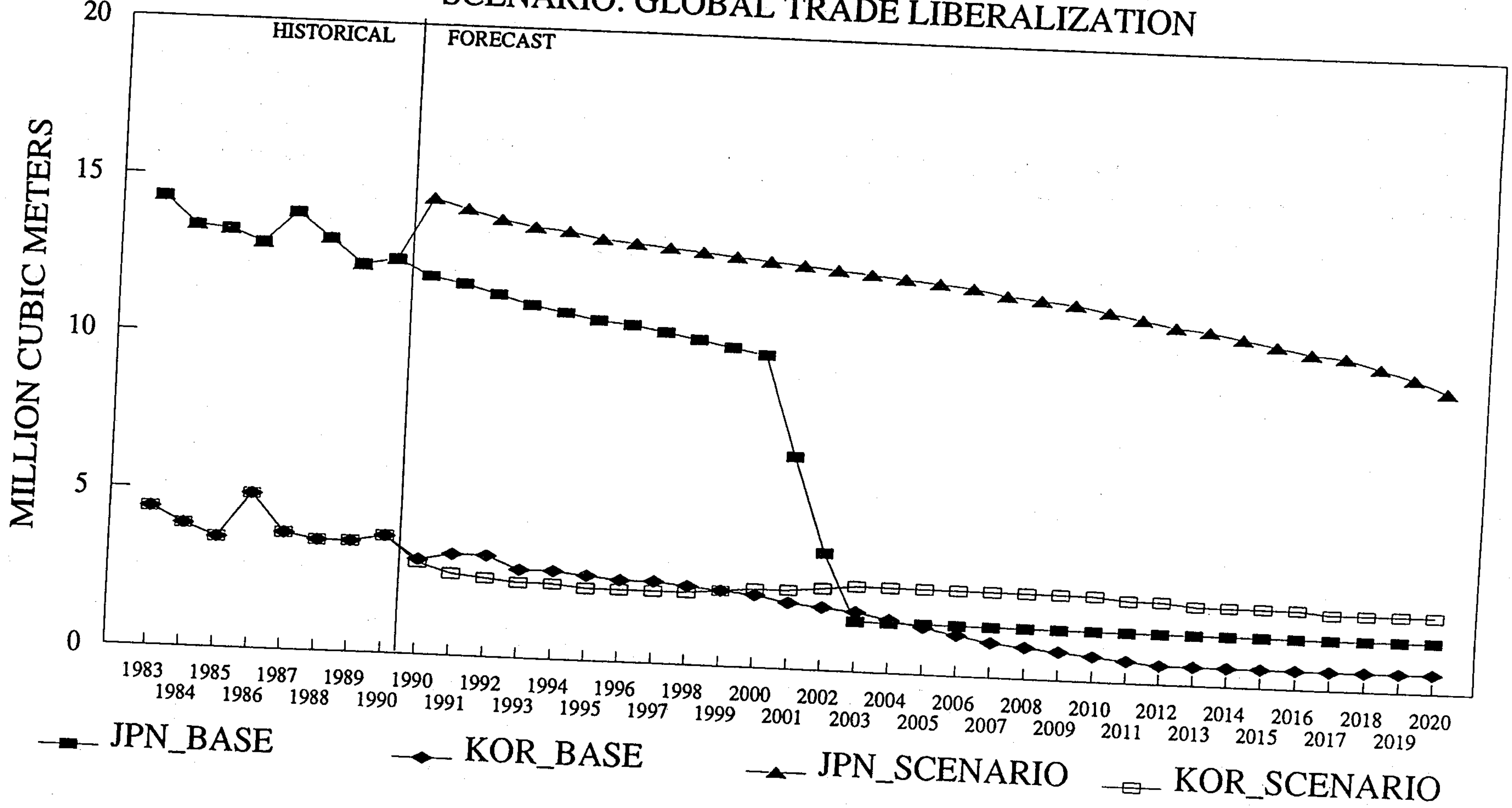


FIGURE 9.6: HARDWOOD PLYWOOD IMPORTS
SCENARIO: GLOBAL TRADE LIBERALIZATION

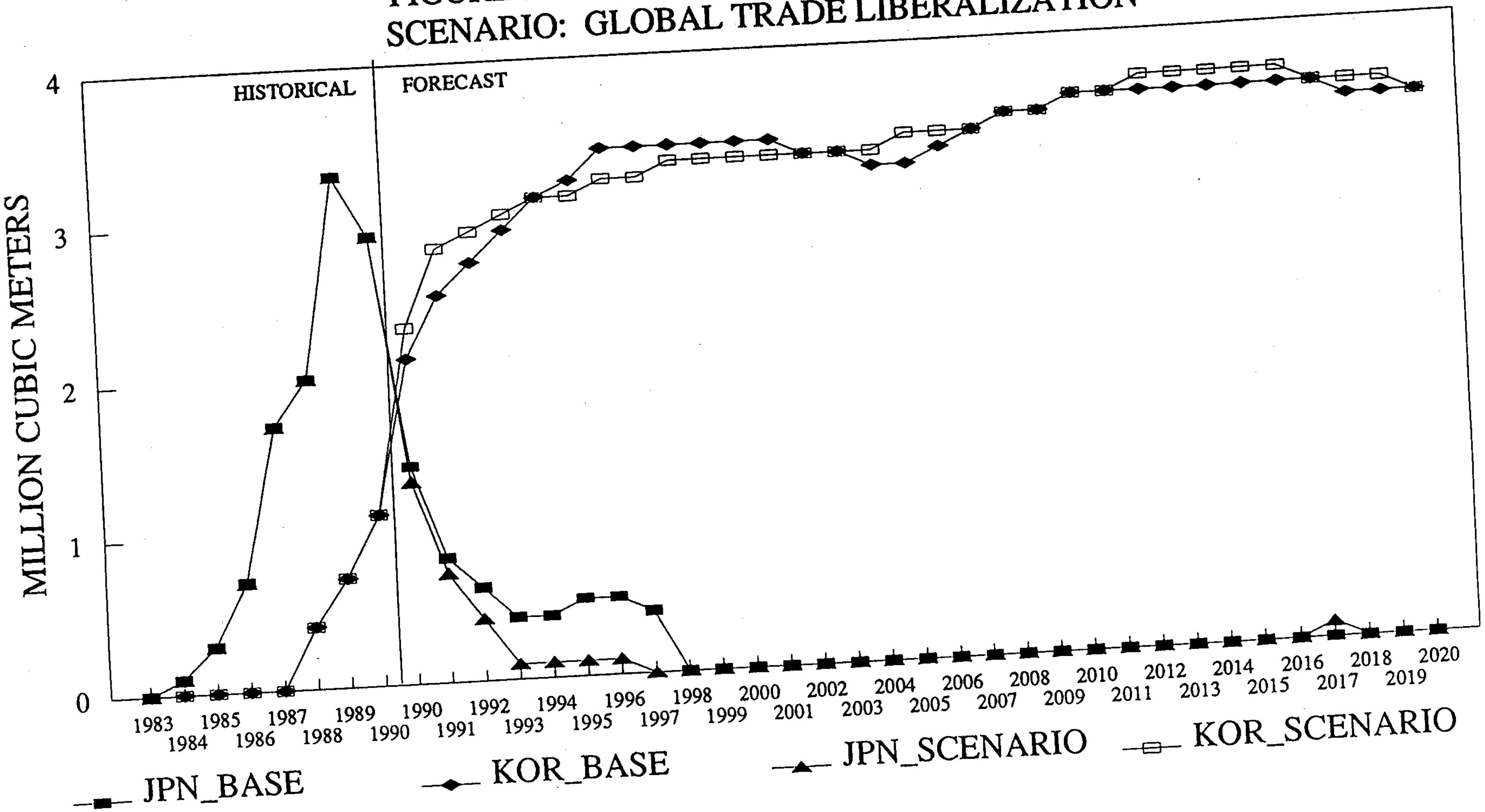
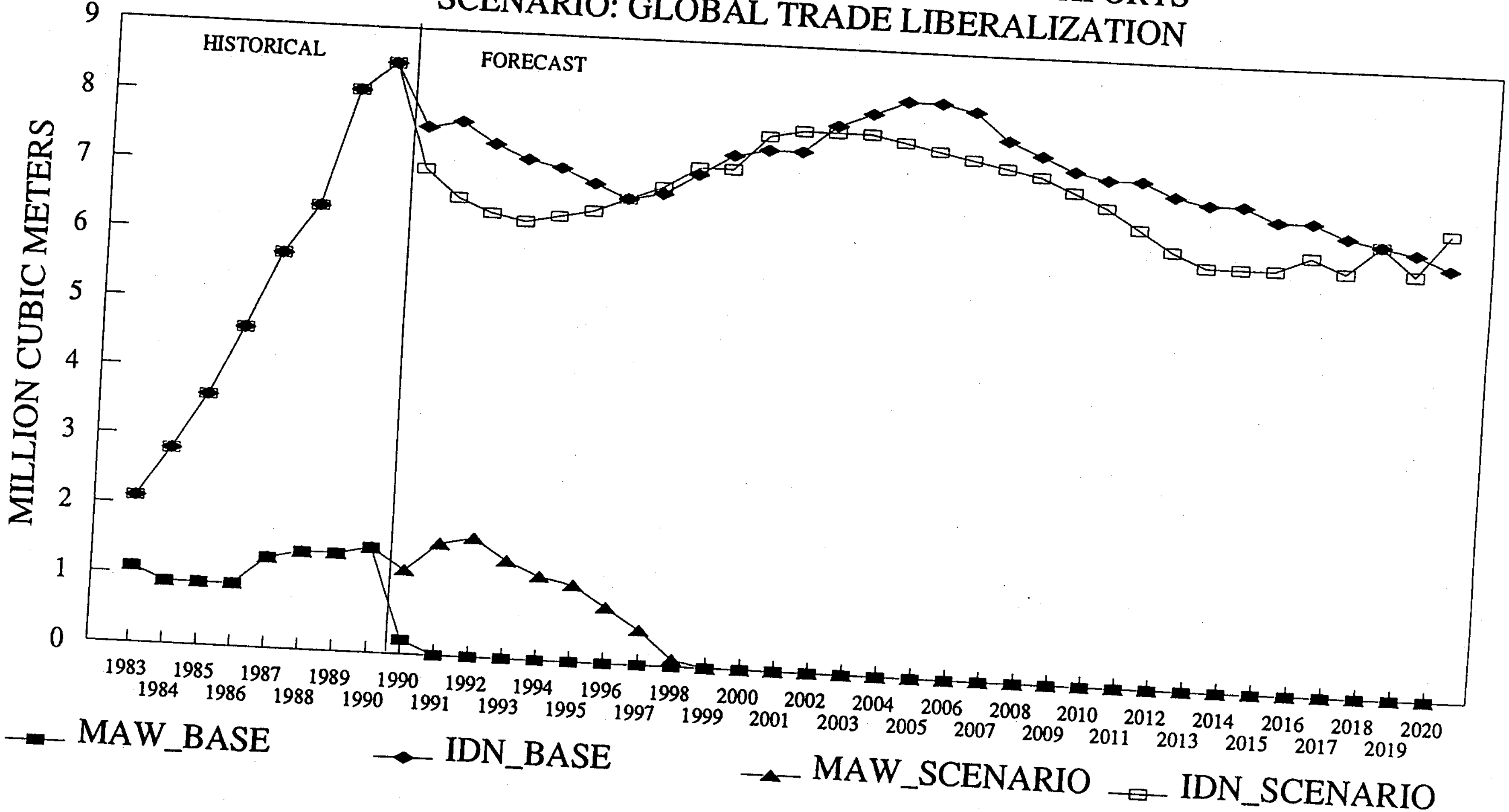


FIGURE 9.7: HARDWOOD PLYWOOD EXPORTS
SCENARIO: GLOBAL TRADE LIBERALIZATION



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