The global forest products model (GFPM): users manual and guide to installation

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THE GLOBAL FOREST PRODUCTS MODEL (GFPM):
USERS MANUAL AND GUIDE TO INSTALLATION

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FOREWORD

The Food and Agriculture Organisation of the United Nations (FAO) carries-out periodic reviews of the forestry sector and produces long-term forecasts of wood and wood product supply and demand. The production of reliable and timely forecasts is seen as an important aid to planning and decision making in the forestry sector at a national, regional and global level, which FAO will continue to strongly support in the future.

Most projections of future supply and demand are based on a variety of statistical or econometric techniques. Such techniques examine historical trends and changes in supply and demand and attempt to explain these trends by identifying relationships with other variables, such as: forest product prices; the availability of forest resources; and economic growth. Assumptions about future changes in these variables are then used to make projections of future supply and demand.

A major challenge in this type of analysis is always to identify and understand the complex interlinkages between the supply and demand sides of the forest products market. For example, when growth in forest products demand exceeds growth in the availability of resources (and, consequently, supply), the resultant scarcity usually leads to upward pressure on forest product prices. This can, in turn, encourage increased production from existing areas, an expansion of the areas of forest used for wood supply or, in the global context, increased imports of wood products from other countries. However, although the role that prices play in helping to balance supply and demand within and between different parts of the world is well understood in theory, the way in which prices change in response to changes in supply and demand are often very difficult to model in practice and even more difficult to project into the future.

Until fairly recently, most models of forest products supply and demand usually treated the two sides of the market quite separately. This avoids the problem of having to specify the mechanism by which prices change in response to changes in supply and demand. Rather, price is treated in such models as an explanatory variable (rather than as a dependent variable) and projections can be made under a range of assumptions about future prices. The approach used in the current FAO forest products outlook study however, has been to use a price-endogenous model. In such a model, changes in price are determined internally by the model in response to predicted changes in supply and demand (rather than the other way around). This is a more complex way of modelling supply and demand, but is a much better representation of the actual way in which forest products markets work. It also has the advantage that, at the global level, the model will give supply and demand projections that are always in balance.

The use of the price-endogenous modelling framework is not particularly new, but may be unfamiliar to many analysts in the forestry sector. Therefore, this working paper has been produced to try to explain some of the details of what is quite a complex model. By demystifying the model, it is also hoped that this will increase the understanding of how the forecasts presented in GFPOS Working Paper 1 were produced and generate a broader interest in the methodology used in this study.

The paper is also a basic instruction manual for the model. Any researcher who wishes to use the model can request a copy (which will be supplied without any warranty or guarantee) from
FAO. The model also requires various other pieces of commercial software, which would have to be purchased from the usual suppliers.

The Global Forest Products Model (GFPM) is the result of a considerable amount of research over several years, by Professor Joseph Buongiorno and his team of researchers at the Department of Forest Ecology and Management at the University of Wisconsin (Madison). FAO would like to express its gratitude to the team, for the way in which they have developed the model to meet the specific needs of FAO. In particular, special thanks must go to David Tomberlin, who came to Rome twice in 1998, to install the model on FAO computers and train staff in the use of the model.

FAO will continue to explore ways in which the quality of future supply and demand projections can be improved through improvements in the collection of forest product statistics and the models used to make such projections. In this respect, we would welcome comments on all aspects of this study from professional analysts and users of this study (contact details can be found on page v of this working paper).

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INFORMATION NOTE ON THE GLOBAL FOREST PRODUCTS OUTLOOK STUDY

In considering the role of FAO in the sustainable management of forests and in the follow-up to the UN Conference on Environment and Development (UNCED), the 107th session of the FAO Council (1994) agreed that there was a need for FAO to improve the quality of its forest sector information and analysis. In response to this and other similar demands, FAO has increased the prominence of outlook studies in the programme of work of the Forestry Department.

A provisional global forest products outlook was produced early in 1997 which concentrated on forecasts of future supply and demand, based on econometric modelling of past trends in forest products markets. This study highlighted the need for more detailed research in two areas: the supply and demand for fuelwood; and the potential for wood supply from non-forest sources (including trees outside the forest and secondary sources). In addition to this, subsequent discussion of the provisional outlook, suggested that greater attention should be given more generally to the supply-side of future outlook studies.

The current Global Forest Products Outlook Study is the fifth in the series of FAO's global supply and demand studies which have been produced approximately every five years since 1982. The study attempts to respond to those needs identified above. However, it also attempts to go beyond the scope of previous outlook studies, by presenting much more interpretation of the future supply and demand forecasts from the point of view of forestry policy development and forest management. Thus, it attempts to go beyond answering the simple question of how much wood will be needed in the future, to cover issues such as where will the wood come from, who will produce it and how will it be produced and utilised. This, inevitably, leads to questions about how forestry policies and institutions should be shaped in the future and the study attempts to answer some of these questions.

Working papers have been commissioned on a few topics which have been considered as most important for the future wood product market outlook, including: likely future changes in the nature and type of wood and fibre supplies; trends in processing; and the future outlook for fuelwood supply and demand. Working papers are being produced and issued as they arrive. Some effort at uniformity of presentation is being attempted but the contents are only minimally edited for style or clarity. FAO welcomes from readers any information which they feel would be useful to the study on the subject of any of the working papers or on any other subject that has importance for the forest products outlook. Such material can be mailed to the contacts given below from whom further copies of these working papers, as well as more information on the Global Forest Products Outlook Study can be obtained:

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ABSTRACT

This manual provides documentation for users of the GFPM. The GFPM is a microcomputer-based economic projection model. The version of the GFPM described here projects the consumption, production, manufacturing capacity, imports, exports, and prices of 14 commodity groups (ranging from fuelwood to newsprint) in 180 countries, for the period 1994-2010. For every year, the model computes the demand, supply, trade and prices that clear markets for every commodity and country. Thus insures a global balance between final product requirements and raw material availability world-wide. Year-to-year changes reflect economic growth, changes in raw material supply, and technological change. This manual has a detailed description of the computer software needed to run the GFPM, of the steps in preparing the input data and of the procedures used to run existing or modified GFPM models. It contains a complete directory of the GFPM computer files and of its country and commodity codes, together with practical notes on how to use the GFPM, change its assumptions, and obtain new projections.
GLOSSARY

Capacity: Maximum possible production given current facilities.

Chemical Wood Pulp: Includes kraft and soda and sulphite wood pulp, except dissolving grade, bleached, semi-bleached, and unbleached.

Consumed Commodity: A commodity for which demand is represented by a demand equation, giving quantity as a function of price.

Consumption: Production plus imports minus exports.

Demand Region: A region in which consumption of a commodity is modelled by a demand equation, giving quantity as a function of price.

Elasticity: Percentage change in one variable (e.g., demand) due to a 1% change in another (e.g. price), other things being equal.

Fibreboard: A panel manufactured from fibres of wood or other ligno-cellulosic material.

Fuelwood: Includes charcoal; wood in the rough to be used as fuel for purposes such as cooking, heating an power production.

GDP: Gross domestic product at purchaser value is the sum of GDP at factor cost and indirect taxes, less subsidies.

Industrial Roundwood: All industrial wood in the rough except other industrial roundwood; includes sawlogs, veneer logs, and pulpwood.

Input Mix: A specific combination of inputs and cost used to produce a commodity.

Manufacturing Coefficient (or Input-Output Coefficient): The amount of an input commodity required to produce an output commodity.

Manufactured Commodity (or Output Commodity): A commodity production of which is modelled as a process.

Manufacturing Cost: The cost of a process in manufacturing a commodity, excluding the cost of input commodities explicitly recognized in the model.

Manufacturing Region: The region in which the production of a commodity, and the corresponding consumption of required input commodities, are modelled as a process.

Mechanical Wood Pulp: Wood pulp obtained by grinding or milling wood into fibre.

Newsprint: Uncoated paper, unsized, containing at least 60% mechanical wood pulp, usually weight between 40 g/m² and 60 g/m².
Other Fibre Pulp: Pulp of fibrous vegetable materials other than wood, including straw, bamboo, bagasse, esparto, other reeds, grasses, cotton, etc.

Other Industrial Roundwood: Roundwood used for tanning, distillation, match blocks, gazogenes, poles, pilings, posts, pitprops, etc.

Other Paper and Paperboard: Includes construction paper and paperboard, household and sanitary paper, special thin paper, wrapping paper and packaging paper and paperboard.

Particle Board: A panel manufactured from small pieces of wood or other ligno-cellulosic materials.

Plywood: A panel made of glued veneer sheets, includes also core plywood, blockboard, laminboard, and battenboard.

Primary Raw Material: An input commodity the supply of which is modelled by a supply equation, giving quantity demanded as a function of price.

Printing and Writing Paper: Suitable for printing and business purposes, writing, sketching, drawing, etc., excludes newsprint.

Process: A technology for producing an output commodity, represented by the manufacturing coefficients and the corresponding manufacturing costs.

Recovery Rate: The ratio of waste paper collected to total paper consumption.

Region: A country in each regional model, or a region (e.g. Africa) in the world model.

Sawnwood: Sawnwood and railroad sleepers.

Shadow Price (of capacity): The marginal value of one additional unit of capacity.

Supply Region: A region in which the production of a commodity is modelled by a supply function, giving quantity supplied as a function of price.

Veneer Sheets: A thin sheet of wood of uniform thickness for use in plywood, laminated construction, furniture, etc.

Waste Paper: Recycled paper and paperboard.
1 INTRODUCTION

1.1 What is the Global Forest Products Model?

The Global Forest Products Model (GFPM) is an economic model of production, consumption, and trade in forest products at the global level. It was developed as part of FAO's on-going work on forestry sector outlook studies. The GFPM is one of a series of spatial equilibrium forest sector models that have developed from the work of Gilless and Buongiorno (1987). Other international applications of the same modelling framework include ITTO (1993, 1995), FAO (1997), and Zhang et al. (1997).

The GFPM uses historical information and exogenous assumptions in a market equilibrium model to produce forecasts of global forest products market developments to 2010. The model is calibrated using 1994 as its base year and allows for the projection of consumption, production, capacity, prices and trade in forest products for 180 countries and territories and 14 different forest products categories. The purpose of this guide is to provide potential users with the information necessary to apply the model, to perform sensitivity analyses by altering the model’s assumptions, to update the input data and to understand how changes can be made to the model's structure.

Implementation of the model requires three basic sets of data:

- data on prices and quantities produced, consumed, imported, exported for each product and country in the base year;
- estimates of production capacity for each product and country in the base year; and
- estimates of future economic growth rates and technology changes for each product and country.

The parameters used in the model include: demand elasticities for final products; supply elasticities for industrial roundwood; manufacturing costs; production capacity parameters; wastepaper recovery rates; and trade inertia coefficients. Each of these parameters are defined below.

1.2 Model theory and structure

The GFPM is based on price endogenous linear programming. This is a method of combining and utilizing regional information on supply and demand curves, manufacturing technologies and transportation costs in spatial sector models. Variants of this method have previously been used to model a number of agricultural and energy-related sectors (see, for example: Kennedy 1974; McCarl and Spreen 1980) as well as the forest sector (Adams and Haynes 1980; Kallio et al. 1987; Zhang et al. 1996).

The GFPM has both static and dynamic phases. In the static phase, it computes the quantities and prices that match demand and supply of all commodities in all countries in a given year. In the dynamic phase, it predicts the evolution of this spatial equilibrium from year to year. The
The static phase of the GFPM solves a generalized version of Samuelson’s (1952) spatial equilibrium problem to find the production and trade flows that match demand and supply in different regions and the corresponding market clearing prices.

The GFPM generalizes this problem to represent the production, transport, transformation, and consumption of 14 commodities (i.e. forest products) in 180 countries and territories in the world, referred to as regions\(^1\) in the model. A commodity may be either a primary raw material (such as industrial roundwood), a manufactured commodity (such as wood pulp) or a consumed commodity (such as newsprint). Fuelwood and “other industrial roundwood” are both primary raw materials and consumed commodities since they are consumed without further processing. The product flows in the GFPM are described in Appendix A.

In the GFPM, there are 181 demand regions and supply regions, in which the demand (supply) of a commodity is described by an equation that gives quantity demanded (supplied) as a function of price. These regions correspond to the 180 countries and territories used in the model and the world region. All countries and territories export to the world region and import from it.

The GFPM also has manufacturing regions, where the production of a commodity is modelled as a process described by activity analysis (as in Takayama and Judge 1964). Each process has a limited capacity. Within a process, a commodity is made with a particular input mix, defined by manufacturing coefficients (also called input-output coefficients) which specify the amount of each input needed per unit of output. Each input mix has a corresponding unit manufacturing cost.

The solution of the static phase of the GFPM is obtained by price endogenous linear programming (Hazell and Norton 1986). Figure 1 gives a simple example of how the model arrives at equilibrium prices and quantities of production, consumption, and trade for one commodity and two countries only. In countries A and B, the competitive market solution is the price-quantity combination that maximizes the value of the product to consumers minus the cost of supplying it (i.e. the area under the demand curve less the area under the supply curve). Without trade, in country A, this solution is the price \(P_a\) and quantity \(Q_{a1}\), while in country B the corresponding solution is price \(P_b\) and quantity \(Q_{b2}\). These are the competitive market solutions in the absence of trade. However, given the opportunity for trade, producers in country B can obtain a higher price in country A, while consumers in country A can buy more cheaply from country B. Trade will therefore have the effect of driving prices in both countries towards each other. The resultant global equilibrium price will be the one that maximizes the value of the product for consumers in both A and B, minus the cost of production for producers in A and B. If, for example, this price turns out to be \(P_e\), then the associated equilibrium quantities supplied and consumed in country A would be \(Q_{a1}\) and \(Q_{a3}\).

\(^1\) Terms in italics are defined in the glossary.
with the difference between these two amounts being imports from country B to A. Similarly, in country B, the equilibrium quantities supplied and consumed would be $Q_{b3}$ and $Q_{b1}$, and the difference between these two amounts would be exports from B to A.

**Figure 1. Equilibrium price and quantities between two countries in the GFPM**

The GFPM calculates global equilibrium prices and quantities for all countries and commodities simultaneously, by maximizing the difference between the value of products to consumers and the cost of production for suppliers throughout the world. The solution to this calculation is obtained using a linear programming algorithm which solves the multi-country, multi-commodity problem given in Appendix B.

The demand equations of the GFPM express consumption in a region as a function of gross domestic product (GDP) and price. These were estimated econometrically from international data, supplemented with other information. Industrial roundwood supply is represented in the GFPM as an upward-sloping curve, the price elasticity of which was selected with reference to the academic literature on this subject and expert opinion. Supply of other raw materials (fuelwood, other industrial roundwood, non-wood fibre, and waste paper) is represented as perfectly elastic up to an upper bound. For some countries upper bounds are also placed on the supply of industrial roundwood, to reflect physical or legal limits on production.

The input-output coefficients used in the GFPM (e.g., the amount of roundwood needed to produce one unit of sawnwood) were based on the academic literature on this subject and expert opinion. Manufacturing costs were then derived from roundwood and product prices using the input-output coefficients (see Appendix C). All costs and prices are expressed in the GFPM in US$ at 1994 prices and exchange rates. Estimates of manufacturing capacity were based on production data, available capacity data and expert opinion.

The above is a complete list of the information necessary to calculate equilibrium prices and quantities of production, consumption, and trade in the base year. The model, was calibrated by calculating the global market equilibrium for the base year and checking the model’s results against the input data. The model’s output was close to the input data for 1994. However,
data limitations and inconsistencies make discrepancies inevitable, particularly for smaller countries.

1.2.2 Dynamic phase

The dynamic phase of the GFPM is a succession of static phases, one for each year in the forecast. The calculation of the short-term equilibrium in each year depends on the position of the demand, supply and cost curves and capacity availability in each year. Each year is linked to the next years by exogenous and endogenous variables. Exogenous trends include changes in manufacturing technologies, waste paper recovery rates and shifts in demand and supply curves (which are, in turn, driven by exogenous changes in GDP and timber availability, respectively). The GFPM simulates the rational behaviour of sub-optimizing agents who forecast the future imperfectly, based on past information. This approach is different to the assumption of inter-temporal optimization used in some other studies (see, for example: Sedjo and Lyon, 1990).

Global manufacturing capacity is projected in the GFPM as a function of past production and thus, past demand and prices. The share of global capacity increase going to each country depends on each country’s shadow price of capacity. The shadow price is the increase in profit that producers in each country would get by increasing their capacity. If country A has a higher shadow price of capacity than country B, new capacity is more profitable in A than in B and, therefore, the GFPM projects that a greater share of the global increase in capacity would go to A than to B. Appendix B presents the mathematical formulation of the static and dynamic phases of the GFPM, including the capacity change equations used in the model.

1.2.3 World and regional models

The GFPM consists of one WORLD model, which is solved first, and four regional sub-models (Figure 2). The WORLD model has the same commodity detail as the regional models, but only four demand and supply regions: Africa, America, Asia, and Europe. The four regional models include country-level detail, with constraints to ensure that aggregate exports and imports of the region are equal to those predicted by the WORLD model.

The WORLD model must be solved first, to give projections of regional production, consumption, imports, exports and prices. These WORLD model results, which can be obtained quickly, have inherent interest, as they quickly give projections of aggregate global trends and can be used to explore the effects of different assumptions.

The WORLD model produces an essential input to the regional models in that export and import flows calculated in the WORLD model determine the aggregate trade flows in each of the regional models. For example, the aggregate Asian exports in the ASIA model must be equal to exports from Asia in the WORLD model. Similarly, total imports by Asian countries in the ASIA model must be equal to the WORLD model projections of Asian imports. This
insures that the projections of trade for each country in Asia are consistent with demand and supply in the rest of the world.

**Figure 2. Structure of the WORLD Model**

In practice, this consistency is accomplished by having separate entries in the regional models for world demand (i.e. exports from the region to the world) and for world supply (i.e. imports from the world to the region). Within the regional models then, the levels of total regional exports and imports change exogenously, according to the projections given in the WORLD model.

The countries and territories and commodities used in the GFPM are listed in Appendix A. Major data sources used in the GFPM (mostly from FAO databases) are shown in Table 1.

**Table 1. Data sources for the GFPM**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production, Exports, Imports, Unit Values (used to calibrate the base year)</td>
<td>FAO Forest Products Yearbooks and FAO Forestry Statistics</td>
</tr>
<tr>
<td>Estimates of timer supply potential (used to shift the industrial roundwood supply curve between years)</td>
<td>FAO background papers</td>
</tr>
<tr>
<td>GDP growth rate estimates (used to shift the product demand curves between years)</td>
<td>FAO projections</td>
</tr>
</tbody>
</table>
2 INSTALLATION AND CONFIGURATION

2.1 Hardware and software requirements

The GFPM requires a PC with a Pentium processor, at least 8 megabytes of RAM and a Windows 95 or Windows NT operating system. Running on a 233 megahertz Pentium processor with 32 megabytes of RAM, the WORLD model requires about 5 minutes to produce projections to the year 2010. Each regional model requires from 20 minutes to 50 minutes depending on the model size.

The GFPM uses the Price Endogenous Linear Programming System (PELPS) software (Zhang et al., 1993), a general economic modelling system. PELPS itself uses the LINDO linear programming solver (Schrage 1991) to find the solution to each year’s global equilibrium. The GFPM is designed to run with LINDO version 6.0 or better. Data input and output are handled using Microsoft Excel workbooks (MS Office 1997 or better).

To summarize, the GFPM requires the following software:

- Windows NT or Windows 95 operating system;
- LINDO version 6.0 or better;
- Microsoft Excel (MS Office 1997 or better); and
- the input and output workbooks and DOS batch and executable files listed in Appendix C.

2.2 Installing the Global Forest Products Model

There are five basic stages to installing the GFPM:

1) Install Windows NT or Windows 95.
2) Install LINDO version 6.0 or later in the root directory of your C: drive.
3) Install Microsoft Excel (MS Office 1997 or better).
4) Before installing the GFPM files, make sure that LINDO is in the DOS path. This can be done by adding “SET PATH = C: \ LINDO;” in the C: \ autoexec.bat file. Reboot the computer after doing this. The command.com file should also be in the root directory of the C: drive.
5) Create three directories: C: \ pelps, C: \ pelps \ gfpm, C: \ pelps \ pelps, then copy the proper files (see Appendix C) to these directories from the GFPM diskettes.

2.3 Files residing in the user’s working directory

Although the GFPM has a large number of files, only a few need ever be viewed by the user and these are all located in C: \ pelps \ gfpm directory; the others are automatically generated and used by the model. Files must reside in the proper directories. The only files that the user will need in the course of ordinary model construction and analysis are the following:
1) The batch file C:\PELPS\GFPM\GFPM.BAT, which launches the model. The GFPM may be started either by double-clicking on this file in a window or by creating a shortcut to it. Explanation of model execution is in Section 4, “Running the GFPM”.

2) Five master input files (which must be called:

   C:\PELPS\GFPM\WORLD.XLS;
   C:\PELPS\GFPM\AFRICA.XLS;
   C:\PELPS\GFPM\AMERICA.XLS;
   C:\PELPS\GFPM\ASIA.XLS; and
   C:\PELPS\GFPM\EUROPE.XLS.

   these contain all the data required to define the GFPM model. The user may modify these Excel input files for scenario analysis to change assumptions or basic data.

3) The input preparation file: C:\PELPS\GFPM\INPUT.XLS which contains a macro to convert the Excel files to text files (see Section 4, “Running the GFPM” for more detail on input files).

4) The master output file: C:\PELPS\GFPM\OUTPUT.XLS, which contains the model solution and macro commands to generate a series of output files containing tables and graphs of trends for prices, production, consumption, trade, and capacity (see Section 4, “Running the GFPM” for more detail on output files).

5) The file: C:\PELPS\GFPM\TREND.XLS, which is used with the WORLD model only. In addition to the GFPM solution for the WORLD model, this file also contains the historical statistics (1965-1994) and thus allows the user to compare past trends with model projections.

6) The summary file: C:\PELPS\GFPM\SUMMARY.XLS, which contains:

   • Detailed tables of production, consumption, imports and exports, by country, formatted for import in Microsoft Word.
   • Summary tables of consumption, production, imports, exports and net trade, by region.
   • Summary charts of consumption, production and net trade, by region.
3 PREPARING THE GFPM INPUT

3.1 Preparing or altering the input file

The GFPM uses Microsoft Excel (MS Office 97 or better) for manipulating input and output data. All input data are in the five Excel files WORLD.XLS, AFRICA.XLS, AMERICA.XLS, ASIA.XLS, and EUROPE.XLS. The file names must not be changed.

Data relating to different parts of the model are on nine main worksheets within each workbook:

1. demand;
2. supply;
3. manufacture;
4. capacity 1;
5. capacity 2;
6. recycling supply;
7. transportation cost and tax;
8. exchange rate; and
9. exogenous change.

The first eight worksheets mostly contain the data required to calculate market equilibrium in the base year. The exogenous change worksheet contains all the exogenous trend data required to calculate market equilibria in subsequent years (i.e. in the dynamic phase of the model).

Other sheets (TechChange, GDP, RECYCLE) facilitate changes in the models. In each additional sheet, there is a corresponding macro to distribute the data between the main sheets. Each of the main worksheets is described below using the example of the ASIA model. The differences between a regional model such as the ASIA model and the WORLD model are noted as well.

It may be helpful to read through the following descriptions while examining a GFPM file on the computer.

3.1.1 Demand

The GFPM has a demand equation for each country, territory or region and for each consumed commodity (fuelwood, other industrial roundwood, sawnwood, veneer/plywood, particle board, fibreboard, newsprint, printing and writing paper, and other paper and paperboard). The Demand worksheet (see Table 2) contains the data that define each demand equation: the quantity consumed in the base year, the corresponding price, and elasticities with respect to price and GDP.
Table 2. Data for demand equations

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
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Table 2 above presents some of the first and last lines of the GFPM demand sheet. Line 19, for example, indicates that in country 01 (Afghanistan), for commodity 80 (fuelwood), the base-year price is $US45.2 per m$^3$ and the base-year quantity is 5,617,000 m$^3$. The price elasticity is −0.10, which along with the price and quantity data fixes the position and slope of the demand curve for the base year. The elasticity with respect to GDP is 0.40, which represents the way in which the demand curve will shift from year to year in response to changes in GDP (defined in the “Exogenous Change” worksheet). Column N, consumption in the year before the base year, is needed to simulate recycling; for this purpose base year data are adequate. Other columns in the demand sheet are not used and should be filled with 0s.

Lines 23-25 appear at the bottom of the Demand sheet, but are shown here in order to show how they differ from the other lines of the sheet. Region 97, which represents world demand for Asian exports, demonstrates the trade link between the WORLD and the regional models. Here, it specifies that the countries of Asia should export at least 2,179,000 m$^3$ of fuelwood to other countries in the region and the rest of the world. This export demand constraint is updated from year to year according to the solution of the WORLD model (see Exogenous Change, below).

Note that entries in the Demand sheet must be arranged in ascending order by country or region and then by commodity. Country and commodity codes must also have two digits, even though the first one may be zero. Price and income elasticities of demand are sometimes both set to zero. If the quantity in column D is 0, the price elasticity in column E must also be 0, otherwise a runtime error will occur.

---

2 The figure in the demand worksheet is 5617.0, because all the quantities in the model are in thousands (the convention used in the Forest Products Yearbook) but this doesn’t have to be the case as long as the same units are used throughout the model.
The Global Forest Products Model: Users manual and guide to installation

The GFPM does not use all of the capabilities of the PELPS system. In some cases the omission of these elements requires that a 0 or other placeholder (as designated on the appropriate worksheet) is included I the worksheet. When entering new data, the best way to be sure of using the correct format is to type new data into an existing GFPM spreadsheet without altering the format. This will ensure that the input file’s contents are properly read by the program. Deleting blank columns, for example, will cause errors.

3.1.2 Supply

The GFPM has a supply equation for each country or territory and raw material (fuelwood, industrial roundwood, other industrial roundwood, other fibre pulp, and waste paper). The Supply worksheet (Table 3) contains the data that define the supply equations: the quantity supplied in the base year and the corresponding price, plus elasticities with respect to price and an upper bound on supply (where necessary). The supply curves and upper bounds shift over time at a rate specified in the Exogenous Change sheet.

For each raw material in each country, the GFPM represents the supply of industrial roundwood with a price-responsive supply curve, defined by price, quantity, and elasticity of supply with respect to price. Supplies of fuelwood, waste paper, other industrial roundwood, and other fibre pulp are perfectly elastic up to an upper bound. For waste paper the upper bound is endogenous and is a function of the previous year’s paper consumption.

Table 3. Data for supply equations

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<td>B: Commodity Number (01 to 99, in ascending order within each region)</td>
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<td>4</td>
<td>C: Base period price in common currency</td>
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<td>D: Base period quantity supplied at price C</td>
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<td>6</td>
<td>E: Price elasticity (&gt;0, enter 0.00 for horizontal supply)</td>
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<td>F: Elasticity of supply with respect to the first shift variable (optional, enter 0.00 if omitted)</td>
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<td>H: Elasticity of supply with respect to the third shift variable (optional, enter 0.00 if omitted)</td>
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<td>J: Elasticity of supply with respect to the fifth shift variable (optional, enter 0.00 if omitted)</td>
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<td>K: Elasticity of supply with respect to the sixth shift variable (optional, enter 0.00 if omitted)</td>
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<td>13</td>
<td>L: Elasticity of supply with respect to previous-period supply (optional, enter 0.00 if omitted)</td>
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<td>M: Lower bound on the quantity supplied (optional, enter 0.00 if omitted)</td>
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<td>N: Upper bound on the quantity supplied (optional, enter 0.00 if omitted)</td>
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<td>16</td>
<td>O: Quantity supplied in the period before the base period</td>
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The example in Table 3 indicates that the price of industrial roundwood (commodity 81) in Afghanistan (country 01) in the base-year is $US97.8 per m³, while the corresponding quantity supplied is 856,000 m³. The elasticity of supply with respect to price is 0.4. The number 1 in column F causes the supply curve to shift at a rate specified in the exogenous change sheet. The upper bound on supply in the base year is 941,600 m³. In PELPS, a value of zero for the
elasticity of supply and for the upper bound of supply is used as a proxy for infinity, so in Afghanistan, for example, the supply curve for other fibre pulp (commodity 89) is horizontal and has no upper bound.

Line 23 in Table 3 is the import link between the ASIA and WORLD models. It specifies that the countries of Asia must import at least 1,419,000 m$^3$ of fuelwood from other countries in the region and the world. This import supply constraint is updated from year to year according to the solution of the WORLD model (see Exogenous Change, below).

In the GFPM, fuelwood and other industrial roundwood are the only commodities to appear on both Demand and Supply sheets. Demand for industrial roundwood and other fibre pulp, the two other commodities that have explicitly defined supply curves, is determined via input-output coefficients (i.e. the amount of industrial roundwood which is required to produce one unit of a downstream product such as sawnwood; panels; and pulps) which are specified in the Manufacture sheet (see below).

In contrast, final products have explicitly defined demand curves, but their supply is defined using input-output data specified in the Manufacture sheet (except for fuelwood and other industrial roundwood, which are both raw materials and final products).

As with the Demand sheet, entries in the Supply sheet must be put in ascending order by country or territory and then by commodity.

### 3.1.3 Manufacture

The Manufacture worksheet contains data that define the manufacturing costs (in $US) and manufacturing coefficients (input required per unit of output) in the base year.

Manufacturing costs are called M records and manufacturing coefficients are called P records. M records must be entered first, followed by P records. The current version of the GFPM does not use the by-products option (record type B).

Each type M record must be ordered so that the data is in ascending order by country and then by commodity within the same country. Records for a given country and commodity must also be placed in ascending order by manufacturing process and then by product mix for a given process. the current version of the GFPM uses only one process and product mix for each country and commodity, but product mixes and manufacturing costs vary by country.

Each type P record, must also be ordered so that the data is in ascending order, firstly by country, then by input commodity and then by output commodity. Multiple records for any given output commodity must also be ordered by process then by product mix.
For example, line 29 in Table 4 indicates that in Afghanistan (country 01), the manufacture of 1 \text{m}^3 of sawnwood (commodity 83) by process 31 and input mix 1 costs $27 per \text{m}^3 in the base year. This is the cost of manufacturing excluding the cost of raw material inputs (i.e. industrial roundwood). In the current version of the GFPM, the manufacturing cost in the base year is computed as the world price of the output minus the cost of the inputs. The cost of inputs are, in turn, calculated as world price of each multiplied by each input’s input-output coefficient and summed over all input commodities (see Appendix C).

Line 33 indicates that, in Afghanistan (country 01), the production of 1 \text{m}^3 of sawnwood (commodity 83) using process 31 and input mix 1 requires 2.13 \text{m}^3 of industrial roundwood (commodity 81).

Table 4. Data for manufacturing costs and input-output coefficients

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<td>4: Commodity (secondary) number (01 to 99, in ascending order within each region, and leave blank if not applicable)</td>
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<td>6: Input mix number (1 to 9, in ascending order with each process)</td>
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<td>7: Net manufacturing cost in common currency</td>
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<td>8: Record type P (manufacturing coefficients)</td>
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<td>13: Input mix number (1 to 9, in ascending order with each process)</td>
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<td>14: Amount of input commodity per unit of output commodity</td>
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<td>15: Record type B (by-product coefficients)</td>
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<td>16: Region number (01 to 99, in ascending order)</td>
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<td>17: Primary commodity number (01 to 99, in ascending order within each output commodity)</td>
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<td>18: Secondary commodity number (01 to 99, in ascending order within each region)</td>
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<td>19: Process number (01 to 99, in ascending order within each commodity)</td>
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<td>20: Input mix number (1 to 9, in ascending order with each process)</td>
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<td>21: Amount of secondary commodity per unit of primary commodity</td>
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</table>

3.1.4 Capacity—1

The Capacity—1 sheet contains the data required to predict the net change in total manufacturing capacity (i.e. the total net change in all countries of the world, or of the specific region considered), from one year to the next, for each manufactured commodity. It is needed to generate multi-period when with the accelerator model of capacity expansion is used in the model (option 4 of the PELPS main menu). This model, which is used in the

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\(^3\) Note that in type M records, output commodity records are placed in column D, while in type P records, they are in column E.
The current version of the GFPM estimates the total net change in capacity as a linear function of the three previous changes in total production, i.e. as:

$$\text{Net Capacity Change from } t \text{ to } t+1 = b_1(\text{production change from } t-1 \text{ to } t) + b_2(\text{production change from } t-2 \text{ to } t-1) + b_3(\text{production change from } t-3 \text{ to } t-2)$$

where $b_1$, $b_2$, $b_3$ are expansion parameters, which are put into columns E through G of the worksheet. Columns B to D in the worksheet contain the production level for each commodity in the three years preceding the base year of the model.

For example, line 11 in Table 5 indicates that total production of commodity 83 (sawnwood) in all countries in the ASIA model was 107,726,000 m³ in 1993; 103,010,000 m³ in 1992; and 105,379,000 m³ in 1991. The base year (1994) production is computed endogenously by the model. The corresponding expansion parameters of the capacity function are 0.40 for 1993-94 production change, 0.33 for 1992-93 production change, and 0.37 for 1991-92 production change.

**Table 5. Data on past production and expansion parameters for capacity**

<table>
<thead>
<tr>
<th></th>
<th>A: Commodity number (01 to 99, in ascending order)</th>
<th>B: Production of one period before the base period</th>
<th>C: Production of two periods before the base period</th>
<th>D: Production of three periods before the base period</th>
<th>E: First expansion parameter</th>
<th>F: Second expansion parameter</th>
<th>G: Third expansion parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>******* CAPACITY -- 1 *******</td>
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<tr>
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<td>83</td>
<td>107726</td>
<td>103010</td>
<td>105379</td>
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<td>0.37</td>
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<td>25776</td>
<td>24325</td>
<td>22786</td>
<td>0.40</td>
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<td>5494</td>
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<td>4123</td>
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<td>11</td>
<td>91</td>
<td>44152</td>
<td>40552</td>
<td>38464</td>
<td>0.40</td>
<td>0.33</td>
<td>0.37</td>
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**3.1.5 Capacity--2**

The Capacity—2 sheet contains data on the level of manufacturing capacity by country and commodity. The data must be listed in ascending order, country and territory, then by commodity and then by manufacturing process (where applicable). The current version of the GFPM does not use the other parameters, which are set to 0, 1 or -1. Capacity growth for each country and territory and commodity depends, on the current level of production and the shadow price of capacity, both of which are computed endogenously (see Appendix B).
For example, line 18 in Table 6 indicates that in Afghanistan (country 01), the capacity to produce sawnwood (commodity 83) by process 31 (defined on the Manufacture sheet) is 460,000 m$^3$. The cost of capacity and expansion parameters are not used in the model, and must be set to 0 or 1 as shown in Table 6. The 999,999 in column F is a proxy for infinity, reflecting the assumption that manufacturing capacity for this commodity in this country is effectively unconstrained. In the current version of the GFPM, this is done only for pulp, because the pulp statistics contained within the model are inconsistent with the paper statistics. In this case, capacity constraints are applied to paper and paperboard production and pulp consumption is derived in the model using the input-output coefficients. Base-year capacities are assumed to be 115% of base-year production for sawnwood and panels, while for paper they are assumed to be 110%.

Table 6. Data on base-period capacity and country-specific capacity change

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<th>M</th>
<th>N</th>
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<tbody>
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<td>A: Region number (01 to 99, in ascending order)</td>
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<td>4</td>
<td>C: Commodity number (in ascending order in each region)</td>
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<td>D: Process number (leave blank if not applicable)</td>
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<td>E: Process number (01 to 99, in ascending order within each commodity)</td>
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<td>7</td>
<td>F: Manufacturing capacity of base period</td>
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<td>8</td>
<td>G: Capacity depreciation rate</td>
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<td>9</td>
<td>H: Cost of new capacity in common currency (&gt;0)</td>
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<td>I: First expansion parameter</td>
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<td>L: Fourth expansion parameter</td>
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<td>14</td>
<td>M: Manufacturing capacity one period before the base period</td>
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<td>N: q ratio in period before the base period (non-negative, enter &quot;-1.00&quot; if not available)</td>
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<td>O: Ratio of overtime capacity to regular capacity</td>
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3.1.6 Recycling (supply)

The Recycling (supply) sheet contains the data that define the potential recovery of waste paper from consumed paper and paperboard. For each paper type, this sheet specifies the potential recovery rate of waste paper in the base year. The consumption of waste paper in a particular year is a function (expressed by input-output coefficients) of the production of paper in that year, while the supply of waste paper is horizontal and bounded by the coefficients in the Recycling (supply) sheet, giving the minimum and maximum percentages of the previous year's paper consumption that can be recovered as waste paper.

The user must provide upper bounds on the supply of the recovered waste for the base year (column H in Table 7) and then the data must appear in ascending order by region, then by recycled commodity and then by consumed commodity.
For example, line 10 in Table 7 indicates that in country 01 (Afghanistan), the maximum proportion of commodity 91 (newsprint) recoverable as waste paper (commodity 90) is 34%. The minimum recovery rate is 0% in all countries. The 1 in column F simply indicates that the demand and supply regions are identical (i.e. no demand region contains two supply regions or vice versa), as is the case of all regions in the GFPM.

Table 7. Data on waste fibre recovery

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<th>A</th>
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<td>3</td>
<td>A: Region number (01 to 99, in ascending order)</td>
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<td>4</td>
<td>C: Recovered waste number (01 to 99, in ascending order within each region)</td>
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<td>5</td>
<td>E: Consumed Commodity number (01 to 99, in ascending order within each recovered waste)</td>
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<td>6</td>
<td>F: Fraction of commodity consumed in each region</td>
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<td>7</td>
<td>G: Minimum fraction of recovered waste from consumed commodity</td>
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<td>8</td>
<td>H: Maximum fraction of recovered waste from consumed commodity</td>
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</tbody>
</table>

3.1.7 Transportation cost and tax

The Transportation Cost and Tax worksheet contains information on the direction and quantity of international trade. Data must appear in ascending order by origin region, then by destination region and then by commodity. In the current version of the GFPM, all countries export to and import from a single region, (the World). Because prices are set equal to world prices in all regions, the transportation cost is set to zero for all countries and commodities, as are import and export taxes. Transportation costs are instead reflected in manufacturing costs, which are derived from world prices (Appendix C) and in the demand and supply curves, which are also positioned by world prices inclusive of transport cost. The trade inertia constraints in column J are set to 0, indicating that trade is fixed at its observed value in the base year solution.

For example, line 12 in Table 8 indicates that Afghanistan (country 01) exported 2000 m\(^3\) of industrial roundwood (commodity 81) to the world (region 97) in the base year, 1994.
### Table 8. Data on trade

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>***** TRANSPORTATION COST AND TAX *****</td>
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</tr>
<tr>
<td>3</td>
<td>A: Origin region number (01 to 99)</td>
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<tr>
<td>4</td>
<td>C: Destination region number (01 to 99, in ascending order within each origin)</td>
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<td></td>
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<tr>
<td>5</td>
<td>E: Commodity number (01 to 99, in ascending order within each origin-destination)</td>
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<tr>
<td>6</td>
<td>F: Freight cost of shipping one unit of commodity from origin to destination</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>7</td>
<td>G: Import ad-valorem tax rate</td>
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<tr>
<td>8</td>
<td>H: Export ad-valorem tax rate</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>9</td>
<td>I: Base period quantity shipped from origin region to destination region</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>J: Trade inertia parameter (greater than or equal to 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| 12 | 01 | 97 | 81 | 0.00 | 0.000 | 0.00 | 2 | 0.00 |
|13 | 05 | 97 | 81 | 0.00 | 0.000 | 0.00 | 2 | 0.00 |
|14 | 06 | 97 | 80 | 0.00 | 0.000 | 0.00 | 28 | 0.00 |
|15 | 06 | 97 | 81 | 0.00 | 0.000 | 0.00 | 301 | 0.00 |
|16 | 06 | 97 | 83 | 0.00 | 0.000 | 0.00 | 171 | 0.00 |
|17 | 07 | 97 | 80 | 0.00 | 0.000 | 0.00 | 137 | 0.00 |
|18 | 07 | 97 | 81 | 0.00 | 0.000 | 0.00 | 2410 | 0.00 |
|19 | 07 | 97 | 83 | 0.00 | 0.000 | 0.00 | 737 | 0.00 |
|20 | 07 | 97 | 84 | 0.00 | 0.000 | 0.00 | 339 | 0.00 |
|21 | 07 | 97 | 85 | 0.00 | 0.000 | 0.00 | 15 | 0.00 |

### 3.1.8 Exchange rate

All prices and costs in the GFPM are expressed in $US, so they do not require conversion into a common currency. The Exchange rate sheet therefore contains only a column of 1s for all countries (Table 9).

### Table 9. Exchange rate data

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>***** EXCHANGE RATE *****</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>A: Region number (including demand, supply and production, 01 to 99)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>4</td>
<td>B: Exchange rate (expressed as the ratio of regional currency to U. S. dollar)</td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>01</td>
<td>1.00</td>
<td></td>
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<tr>
<td>7</td>
<td>02</td>
<td>1.00</td>
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</tr>
<tr>
<td>8</td>
<td>03</td>
<td>1.00</td>
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</tr>
</tbody>
</table>
3.1.9 Exogenous changes

The Exogenous Change sheet contains data that describe the evolution of production, consumption, trade, and prices as a function of the following exogenous factors:

1) shifts of the demand curves (record type D)
2) shifts of the supply curves (record type S)
3) changes in input-output coefficients, reflecting technological change (record type P)
4) changes in waste recovery coefficients (record type W)
5) changes in trade inertia constraints (record type T).

The data are organized by period (see Table 10), headed with the name PERIODt where t (between 1 and 16, the year 16 being the year 2010 in the current model) is the period when changes are to be made. There must be no blank line between periods. PERIOD1 must always be present for multi-period forecasts, whereas PERIODt is optional for t of 2 or more. If PERIODt is absent, the changes at time t are the same as those at time t-1. In particular, the GFPM assumes that the trade inertia constraints are the same (in percent terms) for every year through to the end of the forecast period. Thus, record type T entries appear only in period 1 in the current version of the GFPM, although this can be modified if changes in future trade inertia constraints are desired.

In the GFPM, demand curves shift with exogenous changes in real gross domestic product and supply curves shift with exogenous changes in timber supply. Rates of change of GDP are in record type D, while annual percentage shifts in supply curves are in record type S. Manufacturing coefficients for paper and waste recovery coefficients, in record types P and W, change throughout the projection period.

Table 10 is a greatly truncated example of the data in the Exogenous Change sheet. Line 47 in Table 10 indicates that the rate of change in GDP (the only shift variable for the demand curves of the GFPM) is .0840 in 1995 in Afghanistan. The model uses this information to shift the demand curve for fuelwood (commodity 80) from 1994 to 1995.

Line 49 links the regional model, here ASIA, to the solution of the WORLD model. Solutions from the WORLD model determine the total exports from and imports to all countries in ASIA model for each year of the projection. Line 49 reflects the fact that according to the WORLD model, total exports of fuelwood from the Asia region increased by 2% from 1994 to 1995. In the ASIA model, then, the world (region 97) minimum demand for fuelwood is increased by 2% from 1994 to 1995. The “LinkGfpm” macro (see Appendix G) enters these data automatically after running the WORLD model.

Line 51 indicates that the growth rate in the upper bound of supply (i.e. maximum supply potential) for fuelwood in Afghanistan is 2.01% from 1994 to 1995. The supply curve for fuelwood shifts outward at this rate between the base year and first period (since this entry appears in the "Period1" section of the sheet).

Line 53, is analogous to line 49 and shows that the WORLD model had predicted a decrease in Asian imports of fuelwood (commodity 80) from the world (region 98) of 4% between 1994 and 1995.
The manufacturing coefficient giving required mechanical pulp per ton of newsprint in period 1 (0.60), is given in line 55. Changes in these manufacturing coefficients over the projection period represent exogenous trends in technology.

Table 10. Data on exogenous changes

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
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<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
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<tbody>
<tr>
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<td>***** EXOGENOUS CHANGE *****</td>
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<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
</tr>
</tbody>
</table>

Line 57 gives the updated recovery rate of waste paper from newsprint consumption. Updating these coefficients simulates exogenous technological changes and different recycling policies.
Line 59 indicates that the maximum allowable rate of change in exports of industrial roundwood from Afghanistan between 1994 and 1995 is 25%. These trade inertia parameters, based on historical changes in year-to-year trade levels, are meant to reflect the fact that imports and exports adjust gradually to changes in economic conditions. They define the largest relative change that could occur during one year.

3.2 Saving the input file

If you change the input data files, you must save the changes in Excel in the usual way (i.e. by choosing Save under File).

4. Running the GFPM

After loading all the input data files in the C:\PELPS\GFPM subdirectory. You can launch the GFPM by clicking the GFPM icon or by typing GFPM at the C:\PELPS\GFPM\ prompt. This brings up the GFPM main menu (Figure 3).

Figure 3. The main menu of the GFPM model

Because of the hierarchical structure of the GFPM, the steps from “1) Create input files” to “5) Get output”, must be executed for the WORLD model before any regional model.

The six options have the following functions.
4.1 Create input files

This option breaks the master input files into a set of working files. This operation has no visible output, and lasts about half a minute. This step needs to be executed only after constructing or loading a new master input file for the first time.

For users of Windows NT, this option brings-up the menu shown in Figure 4 and users can create the input files for a model by clicking a save button of the appropriate name in the menu. Users of Windows 95 must access the menu shown in Figure 4 manually, before selecting option 1 in the GFPM menu. This is done by opening the file C:\PELPS\GFPM\INPUT.XLS and clicking on the save button(s) of the appropriate name(s) to save input data set(s) as described above.

Figure 4. The save input menu

<table>
<thead>
<tr>
<th>Save Input Menu</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If you do not want to prepare new input data files, click QuitExcel</td>
</tr>
<tr>
<td>(2) Make sure that you have the following master input files in C:\pelps\GFPM\ directory:</td>
</tr>
<tr>
<td>C:\pelps\gfpm\World.xls</td>
</tr>
<tr>
<td>C:\pelps\gfpm\Africa.xls</td>
</tr>
<tr>
<td>C:\pelps\gfpm\America.xls</td>
</tr>
<tr>
<td>C:\pelps\gfpm\Asia.xls</td>
</tr>
<tr>
<td>C:\pelps\gfpm\Europe.xls</td>
</tr>
<tr>
<td>(3) Click the Save... button to prepare the input data files for PELPS.</td>
</tr>
</tbody>
</table>

SaveWorld  SaveAfrica  SaveAmerica  SaveAsia  SaveEurope

4.2 Define run-time parameters

This option allows a choice of three run-time parameters of PELPS: solution range, number of steps, and projection length. The current version of the GFPM has already defined the run-time parameters which do not need to be changed. In order to run new versions of the GFPM, the parameters are described below:

**Solution Range:** This parameter controls the range (in quantity) over which supply and demand curves are approximated in a stepwise manner. For a given number of steps, a larger solution range decreases the precision of the stepwise approximation, but reduces the chance that a solution will lie outside the range of the stepwise approximation, where the curves are flat (Zhang et al. 1993). In the GFPM, the default solution range is 0.10, i.e. ±10% around the previous year’s equilibrium quantity.

**Number of Steps:** This parameter defines the number of steps in the linear approximation of demand and supply curves. There is a trade-off between precision and model size.
More steps increase precision, but also increase the likelihood of memory failure. Therefore, the GFPM is set to 12 steps for the world model and 6 steps for the regional models, high enough for adequate precision.

*Projection Length:* The default projection length of the GFPM is 16 years, but may be changed.

### 4.3 Run base-period

This option solves for equilibrium prices and quantities (production, consumption, imports and exports) by country and commodity in the base year only. Running the base-period provides a way to check whether the model solution replicates observed market outcomes in the base year with reasonable accuracy (see Appendix C on calibration).

### 4.4 Run multi-periods

Option 4 prompts the GFPM to project production, consumption, imports, exports and price by country and commodity over the number of years specified in Option 2.

### 4.5 Get output

For Windows NT users, choosing this option will automatically produce the Get Output menu (Figure 5). Windows 95 users must generate the Get Output menu manually, by opening the file C:\PELPS\GFPM\OUTPUT.XLS.
After running a model, the model’s results can be organized and placed in the C:\PELPS\PELPS\OUTPUT directory by clicking the corresponding button in the above spreadsheet, e.g., by clicking “GetAmerica” after running the “AMERICA” regional model. However, in order to avoid overwriting old files, the OUTPUT directory can be renamed, but the user must create another directory named OUTPUT for the subsequent run.

After running the WORLD model and clicking the “GetWorld” button, the user can click the “AnalyzeWorldModel” button to produce the file C:\PELPS\GFPM\TREND.XLS, which shows the historical and projected trend of consumption and net trade for the four regions in the WORLD model (Africa, America, Asia, and Europe).

To link the regional models to the WORLD model, click the “LinkGfpm” button after running the WORLD model and before running a regional model (for details, see Appendix G: Linking the WORLD and regional models).

Results for each regional model are in seven files: consumption, production, imports, exports, net trade, capacity, and prices. These files include numerical and graphical results, and they are initially placed into the C:\PELPS\PELPS\OUTPUT directory. These files are useful to judge the results of a regional model, before proceeding to another region.

The raw country tables for the whole GFPM model (i.e. which include the results for all the commodities and countries in one sheet), are in the “output” sheet in C:\PELPS\GFPM\OUTPUT.XLS. This can be updated as the model is re-run region by region by saving the OUTPUT.XLS file after retrieving the result for each regional model.
The final results of the GFPM are in file C:\PELPS\GFPM\SUMMARY.XLS. This file contains:

- Charts of projections (1995 to 2010) and past trends (1965 to 1994), for Asia, Africa, America, and Europe, as in Figure 6, 7.
- Charts of real world prices, historical (1965 to 1994) and projected (1995 to 2010), as in Figure 8.
- Detailed table by commodity, country, and activity, observed (1980 and 1994), and projected (1995 to 2010), as in Table 12.

The historical data in OUTPUT.XLS and SUMMARY.XLS files is contained in hidden columns. This data has been copied from the FAOSTAT database. The data can be updated, but the format should be changed because the macros in the two workbooks are only designed for having the data in its current format.

### 4.6 Quit the GFPM

This option allows you to exit the GFPM.

*Figure 6. Example of graphical results in the GFPM model (consumption)*

![Graph showing ind. roundwood consumption over years for Africa, America, Asia, and Europe](image)
Figure 7. Example of graphical results in the GFPM model (net trade)

Figure 8. Example of graphical results in the GFPM model (real world price)
Table 11. Example of numerical results in the GFPM model (summary table)

<table>
<thead>
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<th>D</th>
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</table>

Table 12. Example of numerical results for ASIA region in the GFPM model (detailed country table)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Table B1. Roundwood consumption (thousand m3).</td>
<td></td>
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**APPENDIX A: PRODUCTS AND COUNTRIES**

*Table A1: Products in the GFPM*

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Note: E indicates that the demand /supply relation is represented with an econometric equation; I indicates that the relation is represented with input-output coefficients.
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</tbody>
</table>
APPENDIX B: MATHEMATICAL FORMULATION OF THE GFPM

The Global Forest Products Model (GFPM) simulates dynamic market equilibrium for the global forest sector. Every year, demand, supply, trade and prices are computed that clear markets for all products and in all regions (static phase). Then, the model parameters are updated to reflect exogenous and endogenous changes from one year to the next (dynamic phase). Exogenous changes include economic growth, technical change, potential timber supply and trade inertia, they are assumptions. Endogenous changes include capacity growth and availability of recycled fibres, they are determined by the model. The model then computes the quantity-price equilibrium next year as shaped by the intervening changes. It reiterates the static and dynamic phases for every year until the end of the projection.

Static phase

The equilibrium for each year of the projection is obtained with an optimization model that simulates world markets. It finds the production, consumption and trade that maximize the total value of consumption minus the total cost of production for all products in all countries, in a given year. All the variables refer to that year.

Objective function:

\[
\begin{align*}
\text{max } Z &= \sum_i \sum_k \left( \int_0^{D_{ik}} P_{ik}(D_{ik}) dD_{ik} - \int_0^{S_{ik}} P_{ik}(S_{ik}) dS_{ik} - \sum_i \sum_k Y_{ik} m_{ik} \right)
\end{align*}
\]

where:

- \(i,k\) = country, commodity,
- \(P\) = price in US dollars,
- \(D\) = final product demand,
- \(S\) = raw material supply,
- \(Y\) = quantity manufactured,
- \(m\) = cost of manufacture.

Demand for final products:

\[
D_{ik} = a_{ik} P_{ik}^{\sigma_{ik}} X_{i}^{\alpha_{ik}} D_{i,k-1}^{\eta_{ik}} \]

where:

- \(D_{ij}\) = demand in the previous year,
- \(X\) = gross domestic product, in real US dollars,
- \(\sigma, \alpha, \eta\) = elasticities with respect to price, GDP, and past demand.
Wood supply:
\[ P_{ik} = P^0_{ik} \]
\[ S_{ik} \leq S^u_{ik} \]  \[ \text{where:} \]
\[ P^0 = \text{cost of production.} \]
\[ S^u = \text{potential supply.} \]

Material balance:
\[ \sum_j T_{jk} + S_{ik} + Y_{ik} - D_{ik} - \sum_n a_{ikn} Y_{in} - \sum_j T_{jk} = 0 \quad \forall i,k \]  \[ \text{where:} \]
\[ a_{ikn} = \text{input of commodity } k \text{ per unit of } n. \]
\[ T = \text{trade flow. Each country exports to and imports from a “world market”,} \]
\[ T^u, T^l = \text{upper and lower bounds on imports and exports.} \]

Manufacturing capacity:
\[ Y_{ik} \leq K_{ik} \quad \forall i,k \]  \[ \text{where:} \]
\[ K = \text{current capacity of production.} \]

Waste paper recovery:
\[ S_{ir} \leq S^u_{ir} \quad \forall i,r \]  \[ \text{where:} \]
\[ r = \text{recycled paper,} \]
\[ S^u = \text{upper bound on recycled paper supply.} \]

**Dynamic phase:**

Yearly changes in the market equilibrium conditions are brought about by:
1) shifts of the demand curves, due to changes in X at the projected GDP growth rate.
2) shifts of the upper bounds on wood supply, S, at the assumed rate of growth of potential supply.
3) changes of manufacturing coefficients m to reflect technical change, especially increasing use of paper recycling.
4) changes of capacity, determined as follows:
At global level, capacity change is a function of changes in production during the past three years:

$$\Delta K_k = b_{1k} \Delta Y_{k,-1} + b_{2k} \Delta Y_{k,-2} + b_{3k} \Delta Y_{k,-3}$$  \[7\]

then, global capacity change is allocated to each country in proportion of its production level and the marginal value of capacity revealed by the shadow price of capacity in the static phase.

$$\Delta K_{ik} = \frac{Y_i^0 \pi^i}{\sum_j Y_j^0 \pi^j} \Delta K_k$$  \[8\]

where:
\(\Delta\) = yearly change,
\(\pi\) = shadow price of capacity (endogenous, from constraint (5)),
\(b, \theta, \sigma\) = parameters.

5) Changes in waste paper recovery:

$$S_{ir}^U = \sum_k w_{ikr} D_{ik,-1}$$  \[9\]

\(w_{ikr}\) = maximum possible recovery rate (exogenous).

6) Trade inertia:

$$T_{ijk}^u = (1 + \varphi) T_{ijk,-1}$$
$$T_{ijk}^{ul} = (1 - \varphi) T_{ijk,-1}$$  \[10\]

\(\varphi\) = upper bound on relative change in trade flow (exogenous).
APPENDIX C: MODEL CALIBRATION

Raw material supplies

GFPM models the flow of wood from roundwood through intermediate products to final products such as paper and sawnwood, as shown in Figure C1.

Figure C1. Wood/non-wood material flows

Every effort was made to use FAO data in the development of the model. However, in some cases these data are not consistent across products, e.g., where the data on the volume of commodities produced from industrial roundwood imply (based on the model’s input-output coefficients) that not enough industrial roundwood is produced in the region to support the given production of downstream commodities.

In calibrating the current version of the GFPM for the base year, priority was given to having plausible input-output coefficients. When adjustments in data were needed, changes were
made to the data considered least reliable. Relative data reliability was assessed as follows (from highest to lowest reliability):

1. trade data for all commodities
2. production data for newsprint, paper and paperboard
3. production data for sawnwood, plywood and veneer, particle board, and fibreboard
4. production data for industrial roundwood.

Input-output coefficients were set according to industry experts’ judgement, seconded by official statistics. Attention was also given to the effect of the input-output coefficients on manufacturing costs, which are the costs of non-fibre inputs in different regions.

Some of the largest adjustments in production were required for woodpulps. Accordingly, the capacity data for wood pulps in the Capacity--2 sheet of the model was set to be at least equal to estimated production and a large number, such as 999999 was entered as an upper bound, as a reminder that there are problems with the official statistics for these commodities. For other fibre pulp and waste paper (which are supply commodities), production was estimated without an upper bound in the Supply sheet.

In order to check the reliability of production statistics, estimated production was derived from product production. Consumption of different pulp types was derived from the production of paper and the input-output coefficients. Consumption of industrial roundwood (sawlogs and pulpwood) was then derived from the production of solid wood products and pulp. Finally, production of industrial roundwood was computed as:

\[ \text{PRODUCTION} = \text{CONSUMPTION} + \text{EXPORTS} - \text{IMPORTS} \]  

For example, Table C1 shows how fibre inputs are estimated from data on paper production and input-output coefficients. Then, in Table C2, pulp production is obtained from estimated pulp consumption and data on imports and exports. Thirdly, industrial roundwood consumption is estimated in Table C3 from estimated data on pulp production and statistics on sawnwood and panel production. Finally, the production of industrial roundwood is estimated in Table C4 from the consumption estimate and import-export statistics.

Estimates of industrial roundwood production derived in this way were compared with production statistics for all countries in the Asia-Pacific region and the major producer countries elsewhere. Where large discrepancies occurred, the input-output coefficients were re-examined or the production estimates were used in preference to the production statistics, until a reasonable compromise between the recorded statistics and the internal consistency of the model (with sensible input-output coefficients) could be found.
### Table C1. Fibre needed for producing paper in Asia in 1994

<table>
<thead>
<tr>
<th>Input Code</th>
<th>Output Code</th>
<th>Manufacturing Coefficient</th>
<th>Output Quantity (000MT)</th>
<th>Required Input (000MT)</th>
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<tr>
<td>87</td>
<td>91</td>
<td>0.08</td>
<td>727</td>
<td>58</td>
</tr>
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<td>88</td>
<td>91</td>
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<td>0.58</td>
<td>727</td>
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<td>90</td>
<td>91</td>
<td>0.45</td>
<td>727</td>
<td>327</td>
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<td>0.59</td>
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<td>4,563</td>
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<td>0.34</td>
<td>7,734</td>
<td>2,630</td>
</tr>
<tr>
<td>87</td>
<td>93</td>
<td>0.02</td>
<td>18,442</td>
<td>369</td>
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<tr>
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<td>93</td>
<td>0.09</td>
<td>18,442</td>
<td>1,660</td>
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<td>93</td>
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<td>18,442</td>
<td>12,909</td>
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<tr>
<td>90</td>
<td>93</td>
<td>0.35</td>
<td>18,442</td>
<td>6,455</td>
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</table>

Note: Bold characters = input data.

### Table C2. Required production of pulp in Asia in 1994

<table>
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<th>Input code</th>
<th>Input Used (000MT)</th>
<th>Imports (000MT)</th>
<th>Exports (000MT)</th>
<th>Production (000MT)</th>
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</thead>
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<td>659</td>
<td>93</td>
<td>0</td>
<td>566</td>
</tr>
<tr>
<td>88</td>
<td>3,221</td>
<td>1,384</td>
<td>15</td>
<td>1,852</td>
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<tr>
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Note: Bold characters = input data.

### Table C3. Consumption of industrial roundwood in Asia in 1994

<table>
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<tr>
<th>Input Code</th>
<th>Output Code</th>
<th>Manufacturing Coefficient</th>
<th>Output (000MT)</th>
<th>Required Input (000CUM)</th>
<th>Input Used (000CUM)</th>
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</thead>
<tbody>
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<td>1.75</td>
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<td>1,852</td>
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<td>92,190</td>
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</table>

Note: Bold characters = input data.

### Table D4. Production of industrial roundwood in Asia in 1994

<table>
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<tr>
<th>Input Code</th>
<th>Consumption (000CUM)</th>
<th>Import (000CUM)</th>
<th>Export (000CUM)</th>
<th>Production (000CUM)</th>
</tr>
</thead>
<tbody>
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<td>92,190</td>
<td>4,587</td>
<td>2410</td>
<td>87,612</td>
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</tbody>
</table>

Note: Bold characters = input data.
Estimation of manufacturing cost

The manufacturing cost of each commodity in each country and territory is calculated from its price, the prices of its constituent commodities, and the input-output coefficients. In the GFPM model, the following input-output relations represent the manufacturing activities (see Figure C1 above):

- Industrial roundwood is used to produce sawnwood, veneer/plywood, particleboard, fibreboard, mechanical pulp, and chemical pulp.
- Mechanical pulp, chemical pulp, other fibre pulp and waste paper are used to produce newsprint, printing & writing paper, and other paper & paperboard.

Fuelwood and other industrial roundwood are not manufactured and thus, are not present in the manufacture worksheet.

The formula for calculating manufacturing cost is:

\[ C_{\text{manufactured-good}} = P_{\text{manufactured-good}} - \sum_i P_i \alpha_i \]  

where \( C_{\text{manufactured-good}} \) is the manufacturing cost per unit, \( P_{\text{manufactured-good}} \) is the price of manufactured good, \( P_i \) is the price of the \( i \)th input good, and \( \alpha_i \) is the \( i \)th input-output coefficient (the amount of input-good \( i \) to produce one unit of output). Input goods can be other manufactured goods (e.g., pulp) or raw materials (e.g., industrial roundwood).

Table C5 shows the calculation for manufacturing costs of newsprint paper, printing & writing paper and other paper & paper board in the Asia region in 1994. Prices of inputs and outputs are world averages of unit values of imports and exports, obtained from FAO statistics.

Table C5. Example of manufacturing cost computation in Asia in 1994.

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</thead>
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<td>0.44</td>
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<td>118</td>
<td>735</td>
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</tbody>
</table>

Note: Bold characters = input data.

It is important to note that, as currently specified, the GFPM uses world trade prices for the calculation of the value of outputs and the cost of inputs. Consequently, because all countries
and territories face these same costs, it is purely the difference between input-output coefficients which lead to differences between manufacturing costs in different countries and territories.
### APPENDIX D: DIRECTORIES AND FILES

The following files are needed to run GFPM. Only those in C:\PELPS\GFPM need to be examined by the user.

<table>
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<tr>
<th>Subdirectory</th>
<th>File Name and Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
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<td>World.xls (Excel)</td>
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<tr>
<td></td>
<td>Africa.xls (Excel)</td>
<td>master input file</td>
</tr>
<tr>
<td></td>
<td>America.xls (Excel)</td>
<td>master input file</td>
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<tr>
<td></td>
<td>Asia.xls (Excel)</td>
<td>master input file</td>
</tr>
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<td>Europe.xls (Excel)</td>
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<td>output.xls (Excel)</td>
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</tr>
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<td></td>
<td>gfpm.bat (DOS batch)</td>
<td>launches GFPM menu</td>
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<td>Summary.xls (Excel)</td>
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<td>trend.xls</td>
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<td>raw output file</td>
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APPENDIX E: PRACTICAL NOTES ON THE BASE-YEAR SOLUTION

The base-year is the first in a series of spatial equilibrium solutions, one for each year of the projection period. For a thorough treatment of spatial equilibrium models, see standard texts such as Hazell and Norton (1986) or Thore (1992).

The GFPM framework is a primal representation of the market equilibrium, i.e. its variables are quantities (production, consumption, and imports and exports). Prices emerge from the optimization problem (see Appendix B) as shadow prices. Both prices and quantities given by the base-year solution should be close to the input data. Calibration consists of adjusting model parameters so that input data and model output in the base year match. Calibration is important to check for data consistency and to check how reasonable model parameters are. For example, it is often the case that, when plausible manufacturing coefficients are used to derive the required consumption of industrial roundwood in a country, this amount is far greater than the level of consumption reported in official statistics. The current version of the GFPM was built by relying more on statistics for manufactured products and input-output coefficients than on raw material statistics. Consequently, when the base-year is updated it should be remembered that:

- Using the macros (see Appendix I) will speed us model preparation.

- For many countries, industrial roundwood data are inaccurate. In calibrating the base year, it is important to make sure that there is enough wood to support reported production of downstream products (see previous appendix).

- Because the WORLD model output is an input to the regional models, it is wise to have a good WORLD model before investing much energy in fine-tuning the regional models (though some going back and forth is inevitable). See Appendix G for details on the links between the WORLD and regional models.

- Changing the manufacturing coefficients in the base year of the GFPM also results in changes to the manufacturing costs and raw material supply as well.

More accurate price computations can be obtained by increasing the number of steps (menu option 2) in the demand and supply equations. However, this increases the model size and the difficulty of getting solutions. The current GFPM set-up of 12 steps in the WORLD model and 6 steps in the regional models has proven from experience to be a good compromise.
APPENDIX F: PRACTICAL NOTES ON THE PROJECTIONS

The GFPM creates projections by setting up a new spatial equilibrium problem for each year of the projection period. The positions of the demand and supply curves, the manufacturing coefficients for paper, and the waste paper recovery rate change over time according to exogenously specified trends (see Exogenous Change sheet). Manufacturing capacity is updated endogenously from period to period, as a function of past demand and the shadow price (profitability) of capacity.

This simple description of the dynamics of the GFPM suggests a number of considerations in making forecasts. Assumptions on GDP growth and timber supply shifts are the most important drivers of model results. One sure way to get dramatic price increases is to impose very high GDP growth with low rates of wood supply increase. Also, excessively tight or loose trade inertia constraints can have important effects on market trajectories. Historical changes in trade can help to set these constraints.

Wastepaper supply is different from the other commodity supplies because it is limited by a function of the previous year's consumption. No upper bound for wastepaper is explicitly entered into the Supply sheet, but the Recycling (Supply) sheet coefficient for the maximum recovery rate, multiplied by total paper consumption in the previous period, creates this bound endogenously. If the maximum recovery rate is specified at 50%, and the previous period's consumption of paper was 400,000 MT, then the upper bound on waste paper supply in this period is implicitly 200,000 MT.

Prices can rise quite sharply if the manufacturing capacity limit is reached. Total capacity change in a model (WORLD or regional) is a function of total past production. This total change in capacity is distributed to regions or countries according to the profitability of additional capacity. The current version of the GFPM has coefficients that insure a long-term ratio of capacity to production of about 1.10 for the paper industry, in agreement with historical data, and 1.15 for solid wood industry. Experience has shown that lower ratios can lead to binding capacity constraints and sharp price increases.

Price divergence among countries is a result of trade inertia constraints, without which prices should equate everywhere. However, loosening trade inertia constraints by too much can lead (particularly smaller) countries to import most of their needs and a projection showing a collapse of their domestic industry. The trade inertia parameters should be based as much as possible on observations of historical trade movements.

Divergence between the WORLD and regional model generally result from improperly aggregated regional data entered into the WORLD model. Experience has shown that this problem is minimized by building the WORLD model parameters as weighted averages of country parameters, with national production or consumption levels serving as weights.
APPENDIX G: LINK BETWEEN THE WORLD AND REGIONAL MODELS

The GFPM consists of a central WORLD model and four regional models (AFRICA, AMERICA, ASIA, and EUROPE), plus a dummy region (05) to absorb the statistical discrepancy between world imports and exports. The link between the WORLD model and the regional models is through trade. The world model generates projections of total imports to and exports from each of the four regions. For each regional model, these projections of total regional imports and exports are incorporated as sources of external demand (i.e. exports) and external supply (i.e. imports).

To make projections with the GFPM, the WORLD model is run first, generating forecasts of aggregate exports and imports for each of the four regions (the dummy region is invariant). From the point of view of a particular region, its aggregate exports are treated as demand by the world. Similarly, aggregate imports to a particular region are treated as supply from the world. Therefore, aggregate regional exports in the base year appear in the Demand sheet as demand by region 97 ("the world") and aggregate regional imports in the base year appear in the Supply sheet as supply from region 98 ("the world"). In projection years, the GFPM changes aggregate regional exports or imports by shifting demand and supply curves at the same rate as the changes in aggregate exports and imports projected by the WORLD model. For example, for each year of the projections, the GFPM calculates the percentage change in aggregate exports and imports as projected by the WORLD model and enters these by period in the Asia model's Exogenous Change sheet, through the “LinkGFPM” macro (see Appendix I).

Given this link between the WORLD and regional models, changing the WORLD model can have significant effects on the regional models, and vice versa. If the WORLD model is changed, aggregate trade flows of the regions will almost certainly be affected, so it is necessary to run the regional models again. Similarly, changing the regional models may have implications for the WORLD model (and through it, for the other regional models). For example, the GDP growth rates of countries in Asia are changed, then the GDP growth rate of the Asia region in the WORLD model should also be changed and the WORLD model run again.

The sum of the country forecasts obtained from regional models does not usually exactly match the regional forecasts of the WORLD model. However, experience has shown them to be sufficiently close if parameters of the WORLD model are weighted averages of the individual country parameters, as in the current version of the GFPM.
APPENDIX H: TROUBLESHOOTING

The following error messages have been observed in building the GFPM. They should not occur in normal use of the model, but only if extensive changes are made.

**BAD ROW:** This message may appear when the solver encounters a bad row in the MPS file. This is the file LINDO, called “matin.dat”; see the LINDO manual for a description of MPS files. The problem may occur as a result of incorrectly formatted or missing information in the file input file (WORLD.xls, AFRICA.xls, etc.).

**INFEASIBILITY:** This problem arises as a result of constraints binding too tightly, so that no solution satisfies all the constraints. Loosen any recently imposed constraints until a solution is found.

**RUN-TIME ERROR:** Pascal, the programming language of the GFPM, is unable to read numbers larger than 11 digits. It may be necessary to reduce the size of some parameters if this problem occurs. For example, an unreasonably high rate of GDP growth will lead to huge demand in large countries in future years, which may cause a run-time error.

**UNBOUNDED SOLUTION:** The LINDO solver maximizes the areas between the demand and supply curves less manufacturing costs. This occurs when the demand and supply curves are incorrectly specified, so that the area between them can be infinite.
APPENDIX I: MAIN MACROS IN THE GFPM

Using the GFPM macros will speed up input-output tasks. There are about 50 macros dealing with the input and output of the GFPM model. The main macros listed below, usually call other macros, which may call other macros again.

In file C:\PELPS\GFPM\INPUT.XLS, the main macros are called “Africa”, “America”, “Asia”, “Europe” and “World”. They correspond to the macro buttons: “SaveAfrica”, “SaveAmerica”, “SaveAsia”, “SaveEurope” and “SaveWorld”.

In file C:\PELPS\GFPM\OUTPUT.XLS, the main macros are “Africa”, “America”, “Asia”, “Europe”, “World”, “AnalyzeWorldModel”, “LinkGfpm” and “Summary”. They correspond to the macro buttons: “GetAfrica”, “GetAmerica”, “GetAsia”, “GetEurope”, “GetWorld”, “AnalyzeWorldModel “, “LinkGfpm” and “Summary”.

All of the master input files contain three useful macros that make the modification of the model much easier: “gdp”, “recycle” and “techchange”.
APPENDIX J: POSSIBLE EXTENSIONS OF THE GFPM MODEL

The PELPS framework offers a number of options that have not been used to date in the Global Forest Products Model. This is by design, to keep the model as simple as possible. Any change should be made cautiously, though it is relatively easy to add further shifters of supply or demand, to introduce by-products and to make other changes. A good way to learn about all the capabilities of the PELPS system is to study the descriptions for data entry at the top of each sheet in the master input files.

Changes in the data are readily implemented by following the general guidelines for data entry. For example, dividing industrial roundwood into sawlogs and pulpwood would require using different codes for these wood types; making the appropriate price, quantity, elasticity, and bound entries in the supply sheet; making any changes needed in the manufacturing sheet to reflect the role of these log types in the manufacturing process; and making further entries to simulate trade inertia.

Trends in the global forest sector environment are captured in the Exogenous Change sheet in the input data file. The default treatment of this sheet is that, for each year t, the parameters governing year t-1 continue to apply unless they are overridden by a new entry in the Exogenous Change sheet. That is, if no entry has been made in the Exogenous Change sheet, PELPS continues to use parameters from the previous period. For example, in the current version of the GFPM, changes in trade inertia constraints appear only in Period 1, and PELPS therefore assumes that the same constraints apply in every future period. A complete list of all the types of exogenous trends that may be introduced in the model is available in the descriptions at the top of the Exogenous Change sheet.

The model currently has the capability to represent endogenous capacity expansion in two different ways. The accelerator model currently used is simpler and less data intensive. The Tobin Q model representation would require data on the marginal cost of capacity expansion.

The current version of the GFPM uses only derived data on manufacturing costs, calculated as the residual of product price less input costs. Including cost data from external sources is simply a matter of typing in new numbers. Similarly, product prices could be derived from sources other than international trade data. The main consideration in pursuing this path is how it might affect the relative profitability of manufacturing in some countries (i.e. how it might affect the relative shadow price of capacity), and how this in turn might reallocate the distribution of changes in manufacturing capacity across countries.

A related issue is the use of bilateral trade flows in the model. It is conceptually straightforward to include bilateral (country-to-country) trade flows, however, this seems practical only for models with a small number of countries (Zhang et al. 1997).
APPENDIX K: REPRISE: RUNNING THE MODEL STEP-BY-STEP (WINDOWS NT USERS)

1) Open the world.xls or other input files in C:\PELPS\GFPM directory to make changes, then save them with the Excel save function. Invoke the PELPS menu by clicking the C:\PELPS\GFPM\GFPM.BAT icon or a GFPM shortcut. Choose option 1 and the input.xls file will be loaded automatically.

2) Click the appropriate button(s) in the Save Input Menu to prepare the input files. The run-time parameters may also be adjusted at this point by choosing option 2. Otherwise options 3 or 4 (solving the base-year only or producing projections) can be selected.

3) The user would observe the model while it runs to make sure there are no run-time errors, bad rows, or other problems. LINDO displays a message referring to poor scaling, which has to do with the relative magnitudes of the largest and smallest values in the model; the resulting inaccuracies are acceptable.

4) After completing stage 3 above choose option 5 to prompt the Get Output Menu. Click the appropriate button to retrieve the results (see the instruction in the spreadsheet). The macro will automatically generate charts and graphs of the results in several files, each labelled according to its contents: production, consumption, prices, imports, exports, net trade, and capacity. Be sure to save these under different names or copy the whole directory before using the Get Output Menu again, to avoid overwriting results of old models. The detailed tables by country for the whole GFPM model are stored in the “CountryTable” sheet of the C:\PELPS\GFPM\SUMMARY.XLS file.

5) When running the WORLD model and a regional model, it is necessary to follow all the above steps twice: first run the WORLD model, then link the WORLD model and the regional model before running it (see the instruction in the Get Output Menu).

6) The final stage is to quit PELPS III by choosing option 6.
APPENDIX L: REPRISE: RUNNING THE MODEL STEP-BY-STEP (WINDOWS 95 USERS)

1) The first stage is to make any desired changes, to the WORLD or regional model input file and save this in the C:\PELPS\GFPM directory. The next stage is to open C:\PELPS\GFPM\INPUT.XLS and click the appropriate button(s) to prepare the input file. When the macro is finished, it automatically closes Excel.

2) Invoke the PELPS menu by clicking the C:\PELPS\GFPM\GFPM.BAT icon or a GFPM shortcut. If changes have been made to the input file since the last time the model was run it will be necessary to run option 1 to prepare the new input file. The run-time parameters may also be adjusted at this point by choosing option 2. Otherwise options 3 or 4 (solving the base-year only or producing projections) can be selected.

3) The user should observe the model while it runs to make sure there are no run-time errors, bad rows, or other problems. LINDO displays a message referring to poor scaling, which has to do with the relative magnitudes of the largest and smallest values in the model; the resulting inaccuracies are acceptable.

4) After completing stage 3 above, the user can quit PELPS (menu option 6). The file C:\PELPS\GFPM\OUTPUT.XLS should then be opened to get the Get Output Menu Click on the appropriate button to retrieve the results (see the instruction in the spreadsheet). The macro will automatically generate charts and graphs of the results in several files, each labelled according to its contents: production, consumption, prices, imports, exports, net trade, and capacity. Be sure to save these under different names or copy the whole directory before using the Get Output Menu again, to avoid overwriting results of old models. The formatted detailed tables by country for the whole GFPM model are stored in the “CountryTable” sheet of C:\PELPS\GFPM\SUMMARY.XLS file.

5) When running the WORLD model and a regional model, it is necessary to follow all the above steps twice: first run the WORLD model, then link the WORLD model and the regional model before running it (see the instruction in the OUTPUT.XLS file).
List of Working Papers to be released

GFPOS/WP/01: Global forest products consumption, production, trade and prices: global forest products model projections to 2010
GFPOS/WP/02: The global forest products model (GFPM): users manual and guide to installation
GFPOS/WP/03: The outlook for future wood supply from forest plantations
GFPOS/WP/04: The potential for technological change to influence future wood supply and demand
GFPOS/WP/05: Past trends and future prospects for the utilisation of wood for energy
GFPOS/WP/06: The potential contribution of trees outside of forests to future wood supplies