Global Forest Products Model Software Design & Implementation (GFPM version 2014)

by

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Contents

This manual describes the structure of the GFPM software and of the programs to update and calibrate the GFPM with new data.

1 GFPM software

An overview of the GFPM software structure is given in Section 1.1 in terms of the overall processing flows and the main components of the GFPM. Section 1.2 describes the role of batch files in controlling the execution of the GFPM programs, and details of the sequence of program execution corresponding to each of the "Main Menu" options of the GFPM. Next, each component is described in detail in Sections 1.3, 1.4, and 1.5, including the main programs in that component, the control mechanism, and the data flow.

The description of individual programs, procedures, or functions, focuses on their functionality, input/output, and processing mechanism. It does not go through the program code line by line. The manuals on using the GFPM and calibrating and updating the GFPM should be read before this manual.

1.1 Overview of GFPM software structure

Fig. 1 shows the main components of the GFPM: data preparation, data processing, and output retrieval. The data preparation is done with Microsoft Visual Basic Application macros in INPUT.XLSM, and the user interface is the Excel spreadsheet WORLD.XLSX. Users enter the demand, supply, trade and other data in the formatted spreadsheets in WORLD.XLSX and run the macros via a graphical user interface in the INPUT.XLSM workbook. These macros convert the data in WORLD.XLSX into .DAT files (Table 1). These are ASCII files, which are then read by the data processing component.

The data processing component is qPELPS, an improved version of PELPS III (Zhang et al. 1993), which reads data in ASCII format to construct an MPS file. The MPS file is an industrial standard input file for linear programming systems. The MPS file is then read by the BPMPD software to solve the economic equilibrium problem, which is equivalent to an optimization. The optimization problem is first solved for the base year. For succeeding years, the MPS file is updated based on last year's solution and exogenous changes. The core of the data processing component is constructing the MPS input file for BPMPD and updating it from year to year.

The output-retrieval component consists of Visual Basic Application macros, which convert the ASCII output files from the data processing component to figures and tables in Excel spreadsheets such as SUMMARY.XLSM.

1.2 Control Programs and Program Execution

Each of the three components of the GFPM software consists of a number of programs, the execution of which is controlled by a DOS batch file control program. The batch files switch control from one program to another, making programs written in different languages work together. Some batch files, however, simply delete unused files or change the current working directory. Table 2 lists the main files in the GFPM.

The batch file GFPM.BAT in C:\PELPS\GFPM launches the GFPM by calling WELCOME.BAT in C:\PELPS\PELPS\, which starts WELCOME.EXE and then switches control to PELPS.BAT, which starts the MENU.EXE program, which generates a BATCHFIL.BAT file, the central controlling batch file.

For each main menu option MENU.EXE generates the corresponding DOS batch code in BATCHFIL.BAT to control the execution of programs to perform that option. The most complex menu option is “4) Run multi-periods” for which BATCHFIL.BAT launches Pascal, C++, and Java programs and BPMPD to make multiyear projections.

Another DOS batch file is INPUT.BAT in C:\PELPS\, which launches the INPUT.XLSM workbook and then deletes unused files. The batch file OUTPUT.BAT in C:\PELPS\ backs up the old output data and launches the OUTPUT.XLSM workbook to retrieve the GFPM output.

The following programs correspond to each of the “Main Menu” options and are controlled by the BATCHFIL.BAT batch file. The programs are described in detail in Sections 1.3 to 1.6.

1) **Calibrate GFPM model** Choosing this option launches the Calibration.xlsm workbook, calibrates the base year model with historical data and parameters, creates World.xlsx for the base year, updates the base output, and optionally adds bilateral trade flows in the World.xlsm.

2) **Run base-period** Choosing this option first launches the BASE_REC.EXE program that calculates the lower and upper bounds on recycled paper supply. It then launches BASEYEAR.EXE to generate the different parts of the MPS file for the base year. Next BASEMAT.EXE is launched to combine these parts as an MPS file. It then launches the BPMPD optimization program to find the base year solution. CHECKSIGN.EXE checks the sign of output data to delete negative signs on shadow prices in the output files. BASEEQLM.EXE processes output files to generate ASCII files containing production, demand, trade, and other results (Table 3).

3) **Compare base-period solution with data** Choosing this option launches ValidateBaseyear.xlsm, compares the base year solution with input data in demand, supply, manufacture, capacity, transportation, and net trade.

4) Run multi-periods Fig. 2 shows the processing flows for this option. The steps of the "2) Run base-period" option are first carried out to generate the base year results. UPDATE-A.EXE then applies the parameters describing exogenous changes stored in UPIN.DAT to update demand, supply, capacity bounds, trade bounds, etc., from one year to the next. The ITERCAP.EXE program updates the capacity data file DEPOUT.DAT. The ITEROUT.EXE program generates ASCII output files for each aspect of the solution, such as demand, supply, production, manufacturing, capacity, and transportation. These files contain the final solution of GFPM in text format. These files are used to produce summary figures and tables in the output retrieval component. ITER_REC.EXE calculates the supply bounds for recycled paper. T_RATIO.EXE updates GDP growth rates for each period, which are used for trade bounds updating in ITER-A.EXE, since the bounds on trade depend on past trade and economic growth. ITER-A.EXE generates the separate sections of the MPS file used by BPMPD for periodical iteration. ITERMAT.EXE combines these sections into a single MPS file, which is used by BPMPD to construct the optimization problem for each projected period. SORT.EXE sorts the capacity output by country code and commodity code from BPMPD, and CHECKSIGN.EXE deletes negative signs on shadow prices in the output files.

After generating the projection output for year *t*, UPIN.(t+1) is copied as UPIN.DAT. Along with other output files from year *t*, UPIN.DAT is used by UPDATE-A.EXE to update intermediate files for the generation of next period's MPS file, via ITER-A.EXE.

5) Get output Choosing this option launches the OUTPUT.XLSM workbook for output retrieval.

6) Quit GFPM Choosing this option simply exits from the GFPM.

1.3 Data preparation

The data preparation component of the GFPM involves converting data in the WORLD.XLSX worksheets to ASCII input files for qPELPS. Data preparation is performed by Excel macros in the INPUT.XLSM workbook, and Pascal programs.

1.3.1 Data preparation programs

The main Excel macro in C:\PELPS\GFPM\INPUT.XLSM (referred to as INPUT.XLSM) is "SavePelps". It saves each spreadsheet in WORLD.XLSX as a text file. The main Pascal program in data preparation is TRANSFER.EXE, which creates separate files for each year's exogenous change data from the "ExogChange" worksheet in WORLD.XLSX.

1.3.2 Processing flows in data preparation component

Figs. 3 and 4 show the processing flows from entering data to generating ASCII data files for the processing component. Users enter the GFPM data and parameters in the Excel file C:\PELPS\GFPM\WORLD.XLSX. The detailed format of the input data in the WORLD.XLSX worksheets is described in the “Using the Global Forest Products Model” manual.

To allow further processing the WORLD.XLSX worksheets are converted to text file (.PRN files) by the “SavePelps” Excel macro in INPUT.XLSM. These .PRN files are then converted to .DAT files via C:\PELPS\INPUT.BAT and are stored in the C:\PELPS\PELPS directory. Table 1 shows the WORLD.XLSX worksheets and corresponding .DAT files in the C:\PELPS directory.

The “ExogChange” worksheet in WORLD.XLSX containing inter-period exogenous changes is saved as the text file UPIN.DAT. This file is then split into separate text files for each year’s exogenous changes by TRANSFER.EXE. Each year’s exogenous change data are saved as an UPIN.I file, where “I” corresponds to the year number.

1.4 Data processing and problem solving

The data processing component contains programs and data files for converting input text files to an MPS file from which BPMPD constructs the optimization problem. There are also programs and data files for saving the last solution from BPMPD to output text files and for updating next period’s MPS file using output files and exogenous change data. All executable programs and data files reside in the C:\PELPS\PELPS directory, unless otherwise specified.

1.4.1 Data files for data processing

The two main data files used in data processing are MATIN.QPS and REPORT.DAT. MATIN.QPS contains the optimization problem to be solved by BPMPDin MPS format. It is described in more detail in the next section. REPORT.DAT is the output file from BPMPD containing the results of the optimization. Additional data files contain input data from users, which are combined to produce MATIN.QPS, or output data derived from REPORT.DAT. Other .DAT files are intermediate files used to temporarily store information between periodic iterations.

After the optimization problem is solved byBPMPD, the results in REPORT.DAT are diverted to different files according to the result type.

A particular code is used to identify each row in the .DAT files. It consists of a type code, a country code, and a commodity code. For example, in UPIN.DAT, “D 11 80” represents demand of commodity ‘80’ in country ‘11’; “T 11 zz 80” represents trade of commodity ‘80’ from exporting country ‘11’ to importing country ‘zz’.

1.4.2 The MPS File

The Mathematical Programming System (MPS) is a common format for describing linear programs. In this format the linear program forming the optimization model for the GFPM is described in terms of five components:

1. a ROWS section, which gives the name and the equality or inequality type of each row of the linear program;
2. a COLUMNS section, which lists each nonzero in the objective function and constraints along with the row in which it appears;
3. a RHS section, which lists each nonzero on the right-hand side along with the row in which it appears; and,
4. a BOUNDS section, which lists simple upper and lower bound constraints on variables.
5. a QMATRIX section recognized byBPMPD, which is similar to COLUMNS section except that the first two columns on each line correspond to a pair of variables for which their product appears as a term in the quadratic of the objective and the third column on the line corresponds to the coefficient of the product.

The MPS file describing the GFPM optimization problem for a given period is MATIN.QPS, and is the center of the model. Fig. 5 shows a sample section of this file. Table 4 shows the naming conventions for the MPS file in GFPM.

In Fig 5 the row label “Ch183” represents country *h1* and product *83* (United States sawnwood) and the row label OBJFUNC represents the objective function. The column label “Yh1833311” represents production of product “83” in country “h1” with process “31” (United States sawnwood production). The column labels “Th1zz83” and “Tzzh183” represent exports and imports, respectively, of commodity “83” between country “h1” and region “zz” (United States sawnwood exports (imports) to (from) the world). Column labels “Dh183A” and “Dh183B” represent United States demand for sawnwood (first and second step of the step-wised demand). The section of the MPS file shown (Fig 6) corresponds to the United States material balance for sawnwood:

$$T_{h1,zz,83} + Y_{h1,83} - D_{h1,83} - T_{h1,zz,83} \geq 0 \,,$$

where: $T_{h1,zz,83}$ is United States sawnwood imports (exports), $Y_{h1,83}$ is United States sawnwood production and $D_{h1,83}$ is United States sawnwood demand. The MPS file also contains information relating to a portion of the objective function:

$$\max Z = ... + 0.5(b_{h1,83} D^2_{h1,83} - d_{h1,83} Y^2_{h1,83}) + D_{h1,83} p_{h1,83} - Y_{h1,83} m_{h1,83} - c_{h1,83} T_{h1,zz,83} - ...$$

where: $m_{h1,83}$ = 114.56 is the cost of manufacturing sawnwood in the United States, $c_{h1,83}$ = 28.14 is the cost of transportation for United States imports of sawnwood, and $b_{h1,83}$ = 0.01157771634458 and $d_{h1,83}$ = 0.01269931119243 are coefficients of demand and manufacture quadratic forms in the objective function.

To construct the MATIN.QPS file five separate files, corresponding to each section of the MPS file, are first created: ROWLIST.DAT, COLLIST.DAT, RHSLIST.DAT, BONLIST.DAT, and QMATLIST.DAT. These files are then combined to form MATIN.QPS.

1.4.3 Data processing programs

The executable files for carrying out data processing are located in the C:\PELPS\PELPS directory, and the corresponding programs written in the Pascal or Java language are listed in Table 2. Fig. 6 shows the main programs and data files, and their relationships, in the data processing component of the GFPM.

The key programs are BASEYEAR.PAS, ITER-A.PAS, and UPDATE-A.PAS. These Pascal programs are compiled into the executable files, BASEYEAR.EXE, ITER-A.EXE, and UPDATE-A.EXE. The program BASEYEAR.PAS organizes the data to create the MPS file MATIN.QPS for the base period. ITER-A.PAS organizes the data to create MATIN.QPS for the iteration periods. UPDATE-A.PAS updates the output from iteration *t* with the exogenous changes for that iteration to generate the input for iteration *t+1*. With the updated input, ITER-A.PAS generates a new MPS file.

Baseyear.pas

The main output from the BASEYEAR.PAS program are the text files COLLIST.DAT, ROWLIST.DAT, BONLIST.DAT, and RHSLIST.DAT. The most important procedures in BASEYEAR.PAS are *DemandAndSupply* and *Matdat*.

DemandAndSupply uses data from input files DEMIN.DAT and SUPIN.DAT to build the quadratic terms to approximate the area under the demand and supply curves. The results are formed into five lists corresponding to the MPS input format: Row, Column, RHS, Bounds, and Qmatrix.

The main sub procedure of *DemandAndSupply* is Qmatrix, which build the quadratic matrix from initial price, quantity, and price elasticity[1].

Matdat takes input from MATDAT.DAT, DEPIN.DAT and TRAIN.DAT to form three lists: Row, Column, and RHS. The main sub procedures of *Matdat* are

[1] The *CrossPriceElasticity* and *RecycleDemand* procedures are not used in the current version of the GFPM, so the worksheets in WORLD.XLS corresponding to the data handled by these procedures are empty.

ManufacturingCost, *ActivityCoefficient*, *ManufacturingCapacity*, and *TransportationCost*[2].

The *ManufacturingCost* sub procedure builds Row, Column, and RHS lists for each manufacturing cost. The *ActivityCoefficient* sub procedure builds Row, Column, and RHS lists for each input-output coefficient. The *ManufacturingCapacity* sub procedure builds Row, Column and RHS lists for each capacity constraint. The *TransportationCost* sub procedure builds Row, Column, and RHS lists for each trade flow, including its trade inertia constraints.

Iter-a.pas

This program is similar to BASEYEAR.PAS, but it produces an additional output file TRALIST.DAT that contains the column data relating to trade variables. When solving the base year trade volumes are fixed, thus there are fewer trade variables than in subsequent years. Therefore, during iterations the column list is broken into TRALIST.DAT for trade variables and COLLIST.DAT for all other variables. The intermediate output files COLLIST.DAT, ROWLIST.DAT, BONLIST.DAT, RHSLIST.DAT and TRALIST.DAT, are combined to produce the MPS file MATIN.QPS.

The major procedures in ITER-A.PAS are *DemandAndSupply*, *CapacityExtension*, and *ManufacturingAndTransportation*.

DemandAndSupply is very similar to the *DemandAndSupply* procedure in BASEYEAR.PAS.

CapacityExtension uses data from MANPAR.DAT, PRODOUT.DAT, CAPAOUT.DAT, UPIN.DAT, and DEPIN.DAT and writes results into MANPAR.OUT and MATIN.QPS. MANPAR.OUT receives the updated global production estimates (from equation [3.9]) and lagged production values. MATIN.QPS receives the updated estimate of manufacturing capacity for each commodity and country (from equation [3.10]). Capacity is represented as a record, which contains the capacity name, production, old capacity, new capacity, etc. Capacity records form a linked list[3], mainly to facilitate sorting. For each commodity, the global level capacity change is first calculated, and then it is distributed to each country according to equation [3.10].

ManufacturingAndTransportation first updates the exchange rates based on the exchange rates specified in EXCIN.DAT, then updates the penalty for exceeding the trade inertia bounds based on the previous periods' export prices according to equation [3.30]. The trade inertia bounds are also recalculated based on equation [3.13]. Based on the current UPIN.DAT, exogenous changes to manufacturing costs and input-output coefficients are applied and the results stored in COLLIST.DAT and VARIOUT.DAT.

The *Trade* sub procedure sets the name and inequality type of each row of the linear program corresponding to the trade inertia constraints [3.27] and [3.29]. Four lines

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[2] The *ByProduct* sub procedure is not used in the current version of the GFPM.

[3] A linked list is a data structure that contains smaller data structures, such as records, which are linked together, so that a record can easily be inserted or deleted while maintaining the list order.

for each trade activity are written to MATIN.QPS in the ROWS section. Two for the lower and upper bounds on trade, with row names begin with an L and U. The other two lines represent the penalty for trade volumes moving from the previous year's volume and their row names begin with A and F.

Upate-a.pas

The main function of the UPDATE-A.PAS program is to update the intermediate data files from one year to another. ITER-A.PAS then uses these intermediate data files to update the MPS file MATIN.QPS.

FindString* and *ChangeRecBound are two procedures to find a particular region-commodity string and change the bounds for recycled product supply for that region and commodity.

ChangeTaxin updates the freight costs in TAXIN.DAT from year to year, based on the exogenous change parameters in UPIN.DAT and data in TAXOUT.DAT.

ChangeDemin updates the demand data from period to period based on exogenous change parameters in UPIN.DAT, such as changes in demand elasticities, demand lower bounds, recycling content, etc. The previous year's demand data are in DEMIN.DAT, while the current year's are in DEMAND.DAT.

ChangeSupin is similar to the *ChangeDemin* procedure. It updates supply information, using exogenous change data in UPIN.DAT and the previous period's supply information from SUPIN.DAT, and temporarily stores it in SUPTEMP1.DAT.

Update is the main procedure in UPDATE-A.PAS, and performs updates on supply, demand, exchange rate, capacity, recovery rate information from year to year based on the exogenous change information stored in UPIN.DAT.
First, the procedure calls the *ChangeDemin* and *ChangeSupin* procedures to update the demand and supply data in DEMIN.DAT and SUPIN.DAT.

The minimum and maximum recovery rates for recycled products are updated based on the exogenous changes specified by "W" type records in UPIN.DAT. The previous period's recovery rates are in RECOUT.DAT and the updated recovery rates are written to RECIN.DAT.

Trade information in TRAIN.DAT is updated based on the exogenous changes specified by "T" type records in UPIN.DAT. The updated trade information includes the volume of trade, freight cost, transportation cost (freight plus import tariffs), import tariff rates, trade inertia, etc. Trade information in TRAIN.DAT is updated using equilibrium price estimates from CONSTOUT.DAT, freight cost estimates from TAXOUT.DAT, and trade volumes from TRANSPOR.DAT. The previous year's trade data are stored in TRAOUT.DAT, and the updated trade data are written to TRAIN.DAT. The *ChangeTaxin* procedure updates the transport cost data.

The minimum and maximum supply of recycled paper is updated based on exogenous changes in the recycling rate from UPIN.DAT and the previous period's consumption of paper and paperboard from SOLUTION.DAT. The necessary data are obtained from RECIN.DAT, SUPTEMP1.DAT, SUPTEMP2.DAT, and DEMIN.DAT. The updates are written to SUPOUT.DAT file.

1.5 Output retrieval [4]

Table 5 lists the major output retrieval Visual Basic Application (VBA) programs and their function. The programs are all in the OUTPUT.XLSM Excel workbook, and are run as different options from the "Get Output Menu" (in Using GFPM manual). This section briefly describes the VBA programs for each "Get Output Menu" option, and their general purpose. The main procedure, *MainTables,* used to perform output retrieval in the GFPM is then discussed. Figs. 7 and 8 show the processing flows of the output retrieval component of the GFPM.

RetrieveOutput The VBA program associated with the *Retrieve Output* option is "World". Choosing this option creates a set of Excel workbooks in the C:\ GFPM\OUTPUT directory containing tables and figures of projected consumption, production, trade, price, capacity and product value over the projection period, by performing the following steps.

First, the *MainTables* procedure reads the GFPM output files into the Excel workbooks in the C:\ GFPM\OUTPUT directory (i.e., CONSUMPTION.XLSX, EXPORT.XLSX, etc.). Next, the tables and figures of consumption, production, import, export, net trade, price, capacity, capacity price, and product value are created. Last, these tables are combined into a single worksheet in the OUTPUT.XLSM workbook by the *Combine_tables* program.

Under the Alternative Scenario, the *RetrieveOutput* option creates a new set of Excel workbooks in the C:\GFPM\OUTPUT directory. Before adding these files, the original Excel workbooks are saved as _BASE files. This permits the calculation of welfare change between the base and alternative scenarios.

Summary Under the Base Scenario the associated VBA program is "BaseSummary". It calls the "Summary" program in SUMMARY.XLSM and the "getBaseSummary" program in SUMMARYCHANGE.XLSM. Under Alternative Scenario, the associated VBA program is "AlternativeSummary". It calls the "Summary" program in SUMMARY.XLSM and "getATLSummary" in SUMMARYCHANGE.XLSM.

ValueAnalysis The VBA program associated with this option is "ValueAnalysis". This program runs the *value_analysis* procedure, which calls the various procedures and functions to calculate value change. The main function is *ValueChange*. It calculates value change for fourteen commodities, five aggregated commodities, and the total of all

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[4] Most of the VBA programs are specific to the countries and commodities in the GFPM applications described earlier. Users may have to modify them or write others to meet their own output retrieval needs.

commodities. This function has an argument “filename”, to calculate either consumers’, producers’ or total value change.

Data in PRODUCTION.XLSX, CONSUMPTION.XLSX, PRICE.XLSX, CAPACITYPRICE.XLSX, VALUE_TOTAL.XLSX, VALUE_CONS.XLSX, VALUE_PROD.XLSX for the two scenarios are used to calculate the value changes. The Excel workbooks, VALUECHANGE_TOTAL.XLSX, VALUECHANGE_CONS.XLSX, and VALUECHANGE_PROD.XLSX, in C:\GFPM\OUTPUT contain the results of the value change calculations.

MainTables This procedure is the link between the data processing component and the output summary (Fig 7 and 8). The procedure reads fifteen .DAT files (all files, except TRANCOST.DAT, listed in Table 3) and generates seventeen Excel workbooks, used to create summary output. The *MainTables* procedure combines data from different .DAT files into a single Excel workbook, or splits data from a single .DAT file into several Excel workbooks. SOLUTION.XLSX is used to temporarily store data during processing. The resulting Excel workbooks are in the C:\GFPM\OUTPUT directory. Each workbook’s filename indicates its content, e.g., NETTRADE.XLSX contains net trade data. The *MainTables* procedure performs the following tasks:

1. Open the seventeen .DAT files in Excel workbooks, and determine the number of countries.

2. Combine the data in SUPPLY.DAT and PRODUCTT.DAT as production data, and sort them by country and commodity.

3. Split the trade flow data in TRANSHIP.DAT into export and import data. Sort them by country and commodity.

4. Calculate consumption from import, export and production data.

5. Combine PROPPRICE.DAT, SUPPRICE.DAT, DEMPRICE.DAT, and OTHPRICE.DATA into a single price data set, and sort by country and commodity.

6. Get capacity and shadow price of capacity data from CAPACITT.DAT and CAPPRICE.DAT respectively, and sort them by country and commodity code;

At each step, the results are stored as single sheets in SOLUTION.XLSX. The last step of the *MainTables* procedure is to copy these individual worksheets from the SOLUTION.XLSX workbook, paste them to their corresponding workbooks, and save these in the C:\ GFPM\OUTPUT directory.

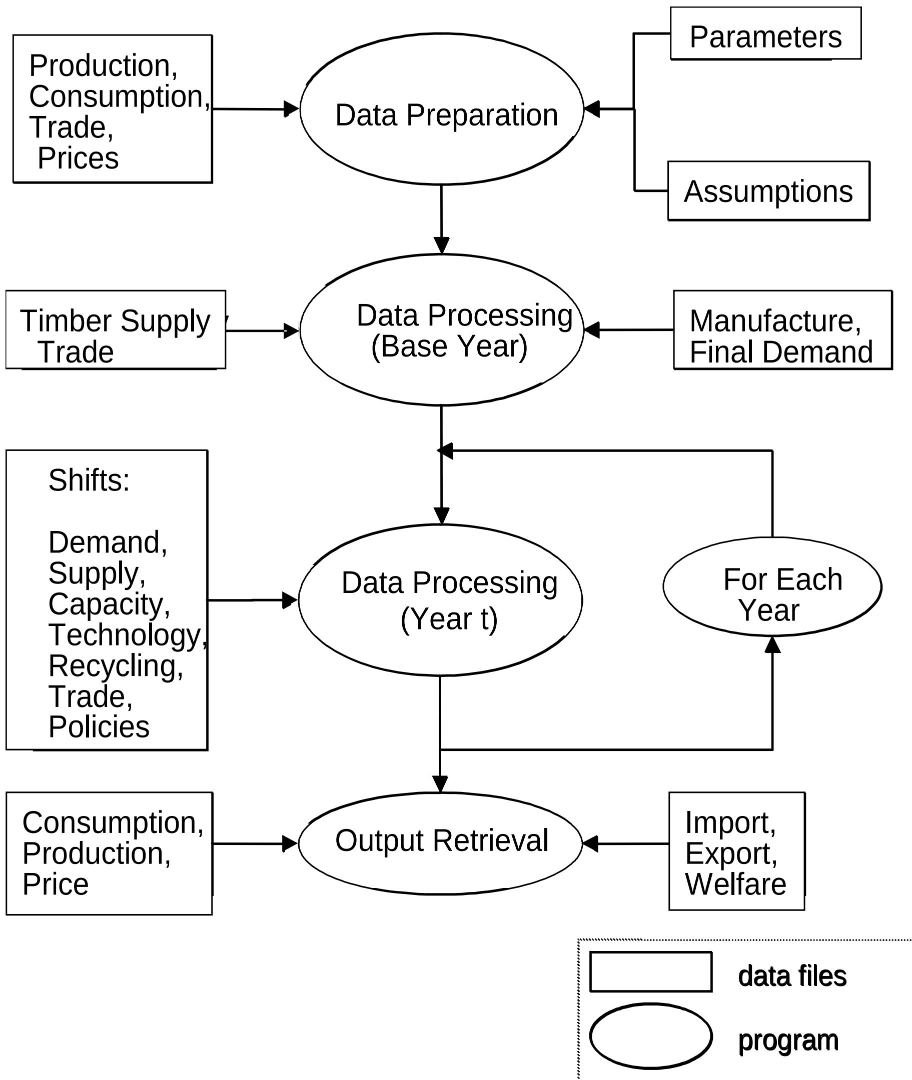


Fig. 1 Implementation components in GFPM model.

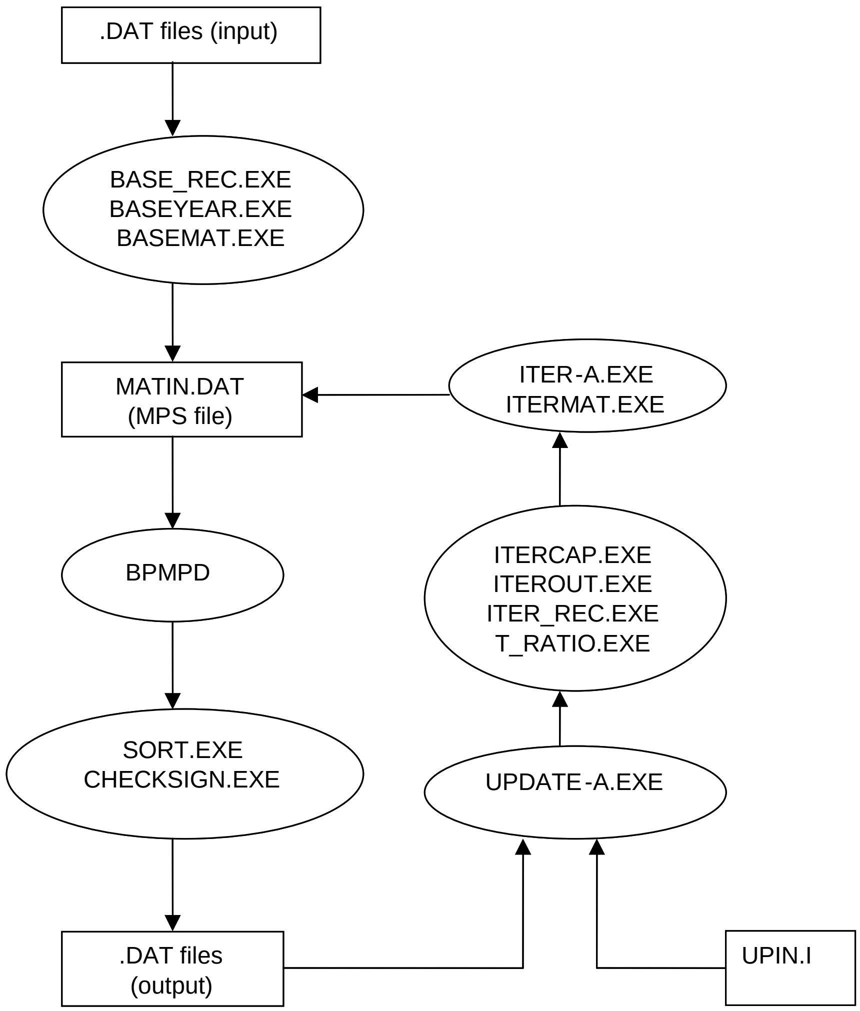


Fig. 2 Processing flows in option "4) Run multi-periods"

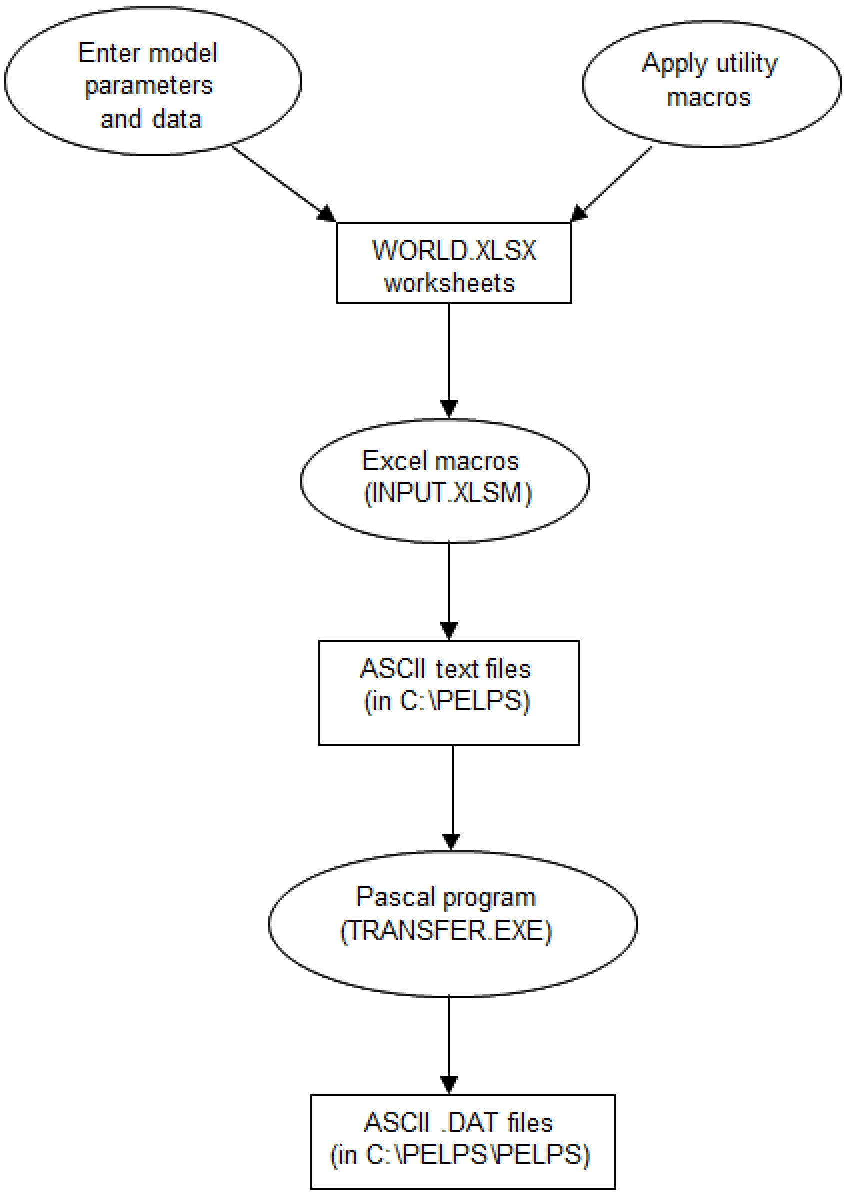


Fig. 3 Processing flows in data preparation component.

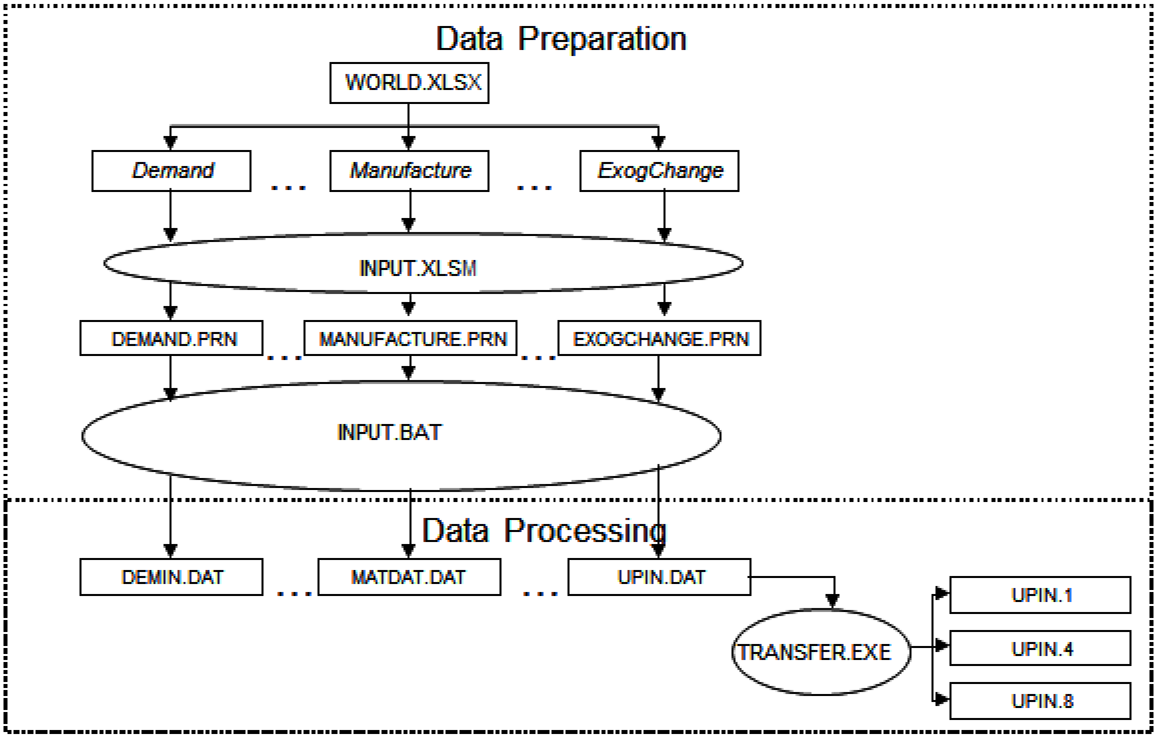
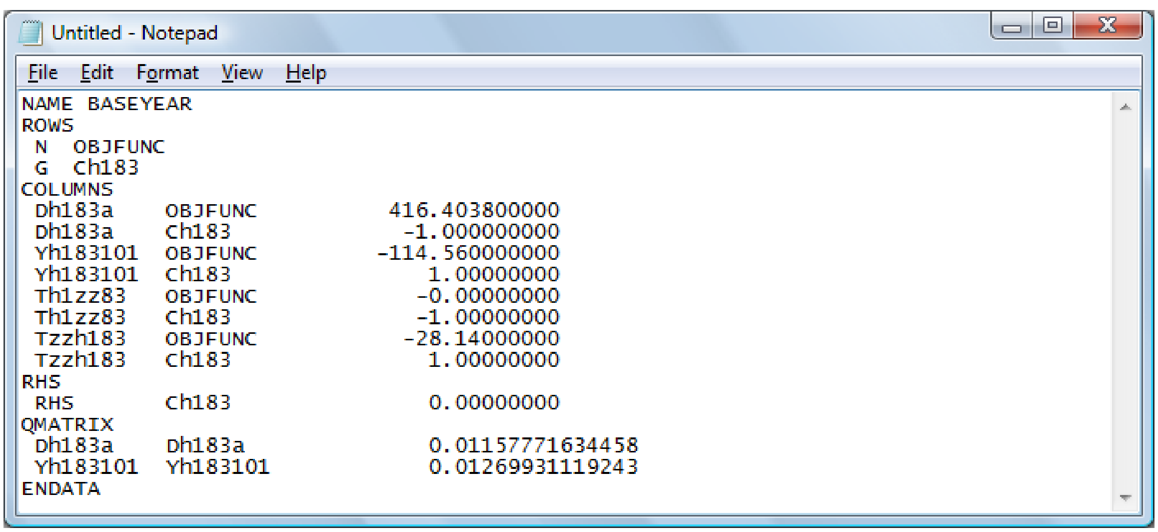


Fig. 4 Data files and programs used in the data preparation component of the GFPM.




```
NAME  BASEYEAR
ROWS
 N   OBJFUNC
 G   Ch183
COLUMNS
 Dh183a      OBJFUNC          416.403800000
 Dh183a      Ch183             -1.000000000
 Yh183101    OBJFUNC         -114.560000000
 Yh183101    Ch183              1.00000000
 Th1zz83     OBJFUNC           -0.00000000
 Th1zz83     Ch183             -1.00000000
 Tzzh183     OBJFUNC          -28.14000000
 Tzzh183     Ch183              1.00000000
RHS
 RHS         Ch183              0.00000000
QMATRIX
 Dh183a      Dh183a             0.01157771634458
 Yh183101    Yh183101           0.01269931119243
ENDATA
```

Fig. 5 Example of a section of the MPS file MATIN.QPS

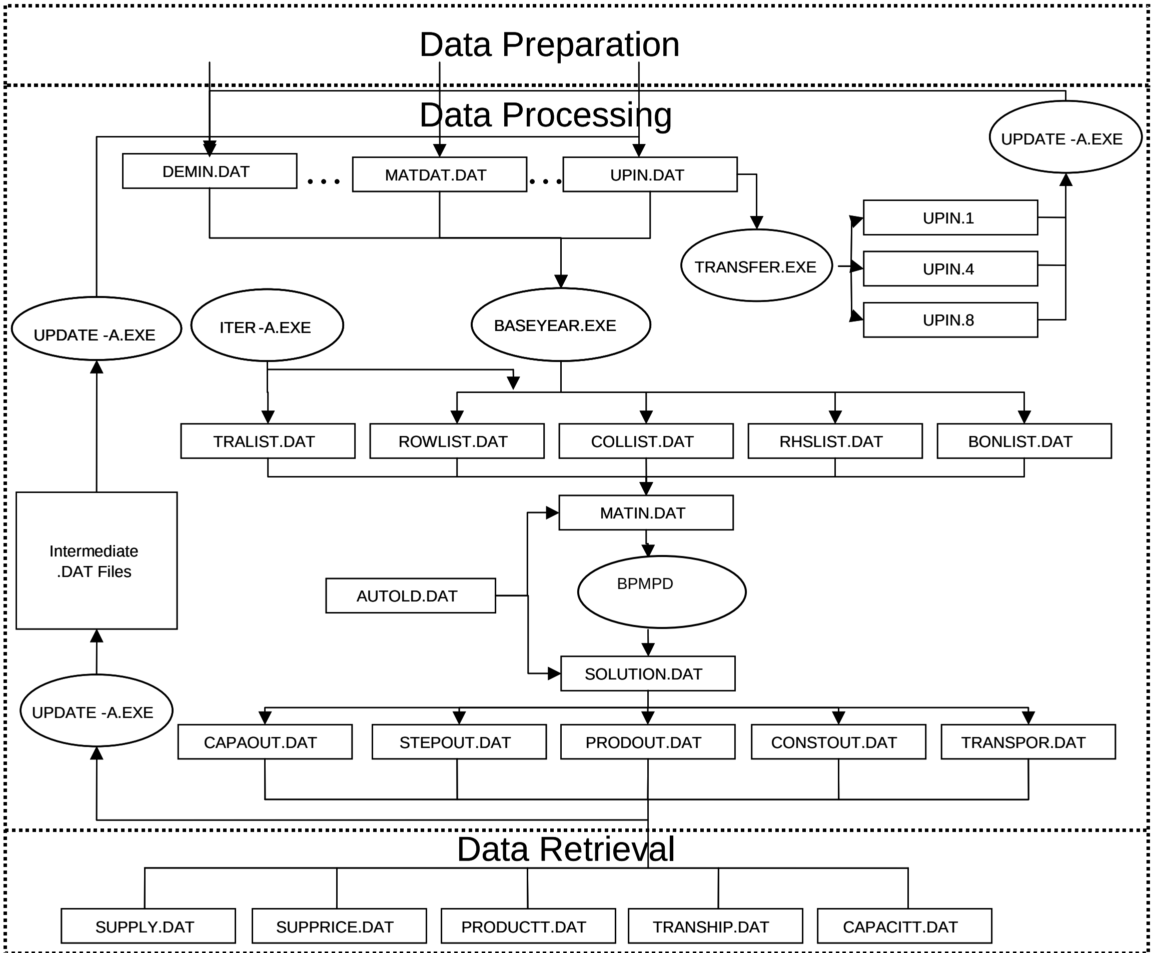


Fig. 6 Data files and programs used in the data processing component of the GFPM.

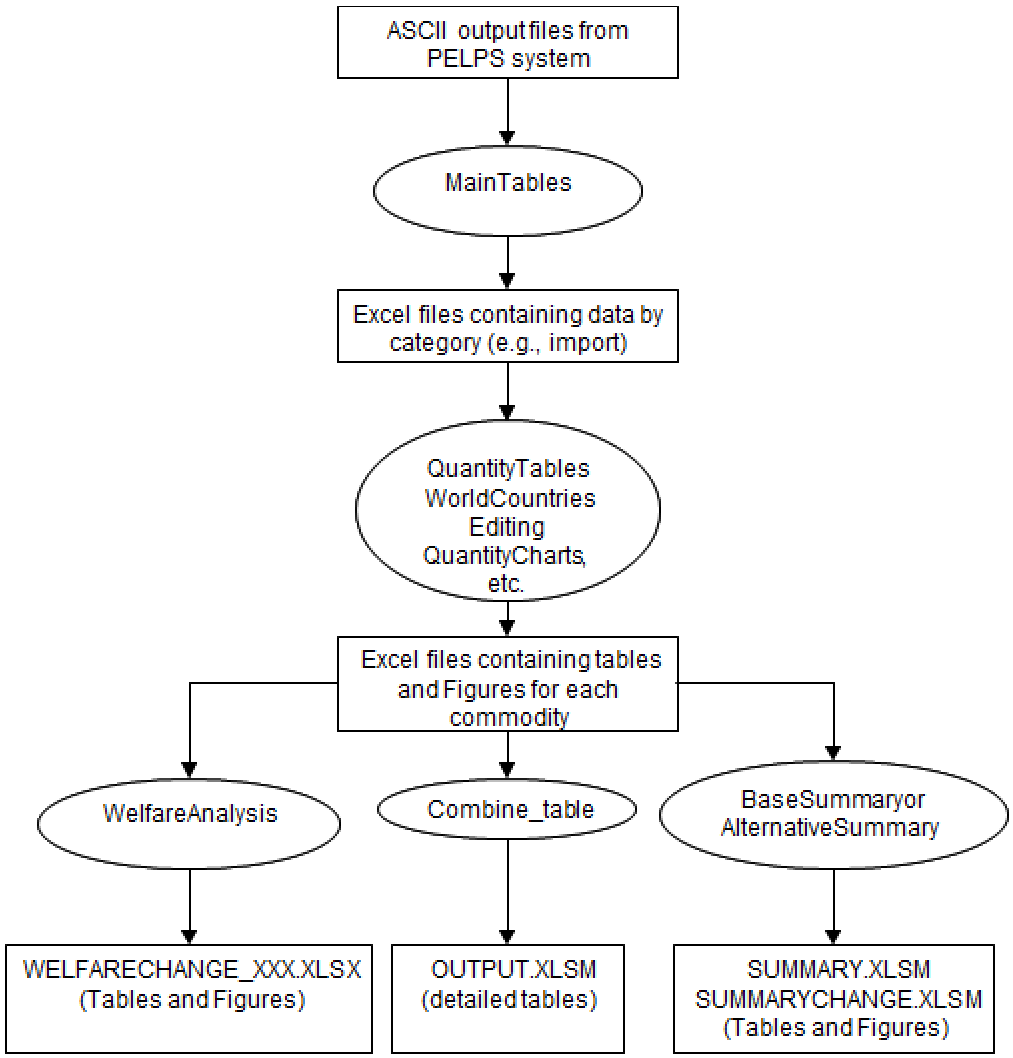


Fig. 7 Processing flows in the output retrieval component of the GFPM.

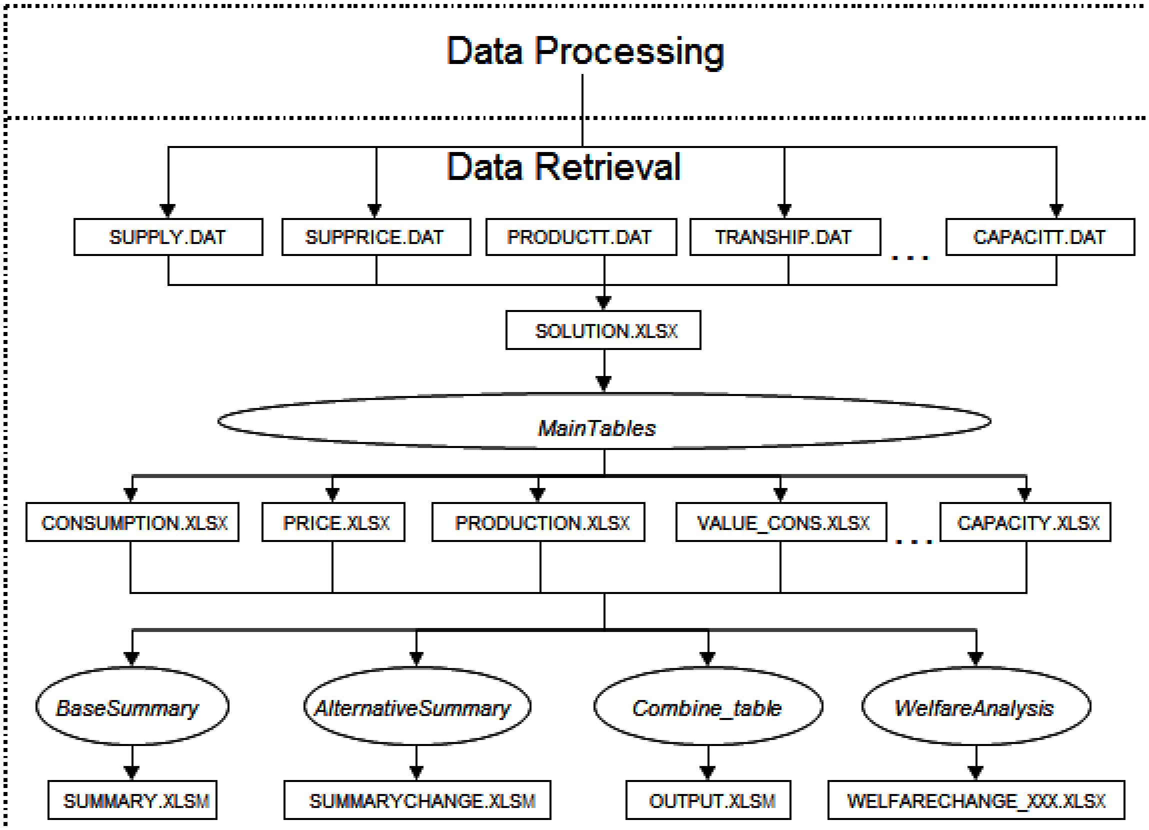


Fig. 8 Data files and programs used in the data retrieval component of the GFPM.

Table 1 The correspondence between WORLD.XLSX worksheets and .DAT files.

WORLD.XLSX worksheet	.DAT file
Demand	DEMIN
Supply	SUPIN
Forest	FORESTIN
Crossprice	CROIN
Manufacture	MATDAT
Capacity1	MANPAR
Capacity2	DEPIN
RecyclingD	REDIN
RecyclingS	RECIN
Transportation	TRAIN, TAXIN
ExchRate	EXCIN
ExogChange	UPIN

Table 2 GFPM program files.

Pascal files	C++/Java files	DOS batch files	Excel workbooks
Basecap.pas	Basemat.java	Batchfil.bat	Input.xlsm
Baseeqlm.pas	Itermat.java	GFPM.bat	Output.xlsm
Base_rec.pas	Job.java	Input.bat	Summary.xlsm
Baseout.pas	ListEmptyException.java	Output.bat	World.xlsx
Baseyear.pas	NoNextElementException.java	Pelps.bat	CheckInputData.xlsm
Chksign.pas	Queue.java	Welcome.bat	ValidateBaseyear.xlsm
Editout.pas	SortedList.java		SummaryChange.xlsm
Findfile.pas			Calibration.xlsm
Iter_rec.pas	parse_rpt.cpp		
Iter-a.pas	check_mps.cpp		
Itercap.pas	launch_bp.cpp		
Iterout.pas			
Menu.pas			
Sort.pas			
T_ratio.pas			
Transfer.pas			
Update-a.pas			
Welcome.pas			

Table 3 The main ASCII output files from the GFPM.

.DAT file	Content
AREA	Forest area of in each country
CAPACITT	Capacity of each produced commodity in each country
CAPPRICE	Shadow price of each produced commodity in each country
DEMAND	Demand of each final commodity in each country
DEMPRICE	Price of each final commodity in each country
MANUCOST	Manufacture cost of each produced commodity in each country
OTHPRICE	Price of pulp in each country
PRODUCTT	Production of each produced commodity in each country
PROPRICE	Price of each produced commodity in each country
STOCK	Forest stock in each country
SUPPLY	Supply of each raw material in each country
SUPPRICE	Price of each raw material in each country
TRANCOST	Transportation cost of each traded commodity in each country
TRANSHIP	Import and export of each traded commodity in each country
WDPRICE	World price of each commodity

Table 4 Naming conventions used in the MPS file (MATIN.QPS) of the GFPM.

C	Each commodity for each country
D	Demand
K	Capacity
L	Lower bound for trade inertia (with large penalty)
S	Supply
T	Trade
U	Upper bound for trade inertia (with large penalty)
Y	Production
ZY	Dummy region
ZZ	World market

Table 5 The major Visual Basic Application (VBA) programs in the OUTPUT.XLSM workbook and their function.

VBA programs	Function
AggregatePrice	Calculate the weighted average price for aggregated products
AlternativeSummary	Control program associated with "Summary" button for alternative scenario
BaseSummary	Control program associated with "Summary" button for base scenario
Combine_table	Combine tables of different commodities and categories into one sheet in output.xlsm.
Commodities	Filter data for each commodity based on commodity code
Editing	Copy tables from different sheets to one sheet
MainTables	Process the ASCII output data and format them for further processing
PriceCharts	Create price charts for each commodity
PriceTables	Calculate the world weighted average price (by consumption)
QuantityCharts	Create charts (consumption, production, import, export) for each commodity
QuantityChartsLine	Create charts (net trade) for each commodity
QuantityTables	Calculate the totals for each commodity
Welfare_analysis	Calculate welfare changes (total, consumer, and producer)
WelfareAnalysis	Control program associated with "WelfareAnalysis" button
WelfareChange	Calculate welfare change for each commodity
ProductValue	Estimate value of products consumed, produced and their sum to scale welfare changes
World	Control program associated with "GetWorld" button for both Base and Alternative scenarios
WorldCountries	Add country names and calculate regional sub totals for each commodity

2 Updating and Calibrating GFPM Data

Updating GFPM data involves modification of base year and exogenous change data (Figure 9). Updating base year data, for example using more recent Food and Agriculture Organization (FAO) data on forest products trade and production, requires calibration of the data to ensure material balances. Updating exogenous change data, for example modeling different tariff schedules or economic growth projections, requires consistency checks to ensure data updated during forecast periods is logical.

Figure 9: GFPM data updates and processes.

2.1 Calibrating the Global Forest Products Model

The structure of the Excel workbooks, and Visual Basic Modules involved in the process of updating and calibrating GFPM data is shown in Figure 10. The three modules; *Smooth*, *Calibrate* and *Update*, corresponding to the two steps in the calibration of the GFPM base year data, are run from the CALIBRATION.XLSM workbook (the first two modules are run during the Calibrate step and the third one is run during the Update World.xlsx step). The *Smooth* module moves FAOStat and World Bank production, trade, population and GDP data from *.csv files to the Excel workbook INPUTDATA_BLANK.XLSX and smoothes the data based on user specifications.

The *Calibrate* module calibrates the production data in INPUTDATA.XLSX via CALIBRATE.XLSX. The CALIBRATE.XLSX workbook contains the "InputOutput" worksheet in which the goal programming (GP) problem for estimating IO coefficients, manufacturing costs, etc. is formulated. The GP problem is solved using the optimization software,BPMPD. The "InputOutput" worksheet gets data from INPUTDATA.XLSX and returns the results of the GP solution to INPUTDATA.XLSX using the routines in the *Calibrate* module. The *Update* module copies the calibrated production, trade, consumption, manufacturing coefficients and costs, and transportation costs from INPUTDATA.XLSX to WORLD.XLSX, thus setting up the GFPM base year data. An additional module, *AddBilateralTrade*, copies bilateral trade flow data from BILATERALTRADE.XLSX to WORLD.XLSX.

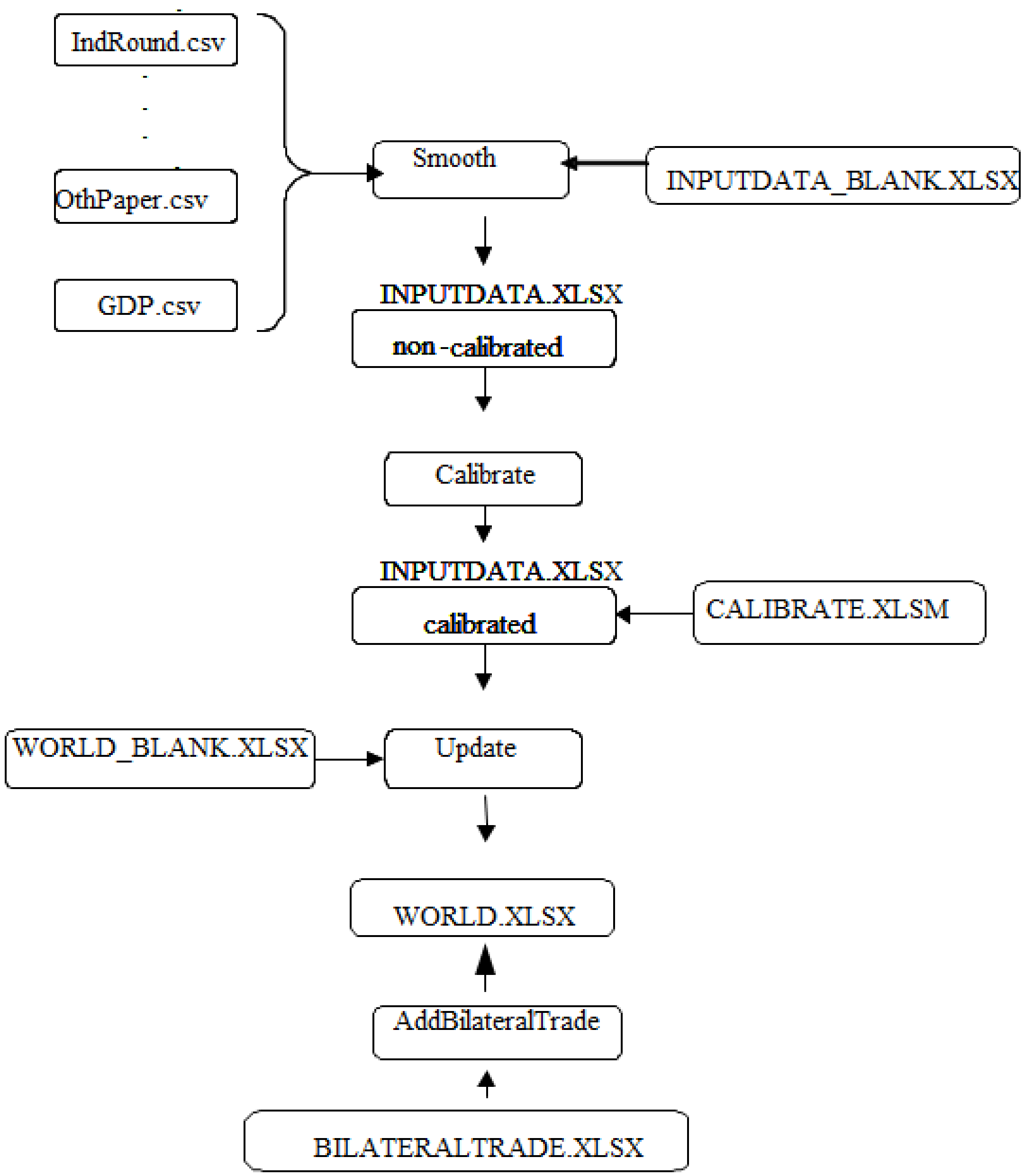


Figure 10: Structure of Excel Workbooks and Visual Basic Modules used to calibrate the GFPM base year data.

2.2 Processing FAO and World Bank Data

Data from the FAO and World Bank on country forest product production, trade and prices, population and GDP are converted from their raw downloaded format (i.e., comma separated text files in the case of FAOStat data) to a well-formed format for further processing. The multiple years' data set is smoothed with smoothing algorithm into SMOOTHEDDATA.XLSX, and the smoothed data are copied to INPUTDATA_BLANK.XLSX, and saved as INPUTDATA.XLSX.

Previously, the GFPM used a single year's FAO data to calibrate the base year. For some commodities in some countries, due to many reasons, the FAO statistical data vary unrealistically from year to year and when these data are used to calibrate the GFPM base year model, some model parameters vary dramatically among different base years. This causes large inconsistencies among GFPM models with different base years and reduces model accuracy.

The idea is to smooth the FAO data using historical data, and then use the smoothed data to calibrate the base year model. The smoothing reduces data variation, improves data accuracy, and makes the base year models more consistent from year-to-year.

Two smoothing algorithms are incorporated in the calibration program, and are invoked as part of calibration during processing each year's data. Users can specify the smoothing parameter used to smooth the raw FAO data in the field below the *Calibrate* button. The smoothing will only be done when multiple years' data are included in the input data files under C:\GFPM\INPUT\INPUTFILES. After finishing the smoothing process, the smoothed data for the current year along with the applied raw FAO data are listed in an Excel file RAWDATA.XLSX, and the smoothed data are copied to INPUTDATA.XLSX to be used for base year calibration. The smoothing is performed on production, import, export, exports value, population, and GDP data. After calibrating the GFPM, the year-by-year smoothed data are stored in SMOOTHEDDATA.XLSX and the year-by-year calibrated manufacturing cost and I-O coefficients are stored in TECHTREND.XLSX. Both files are in the same C:\GFPM\INPUT folder as other calibration files.

The exponential smoothing algorithm is:

$$S_t = \alpha R_t + (1-\alpha) S_{t-1}$$

Where S_t is the smoothed data at t, R_t is the raw data at t, α is the smoothing parameter (default value is 0.75 and could be specified as others by users).

The n year's moving average smoothing algorithm is:

$$S_t = (R_t + R_{t-1} + ... + R_{t-n+})/n$$

The program, *Smooth*, to process FAO and World Bank data in INPUTDATA_BLANK.XLSX is in the CALIBRATION.XLSM workbook. The program modules and files and their relationship to each other are shown in Figure 11. A description of each module and the procedures (and functions) in each module are presented in Table 6.

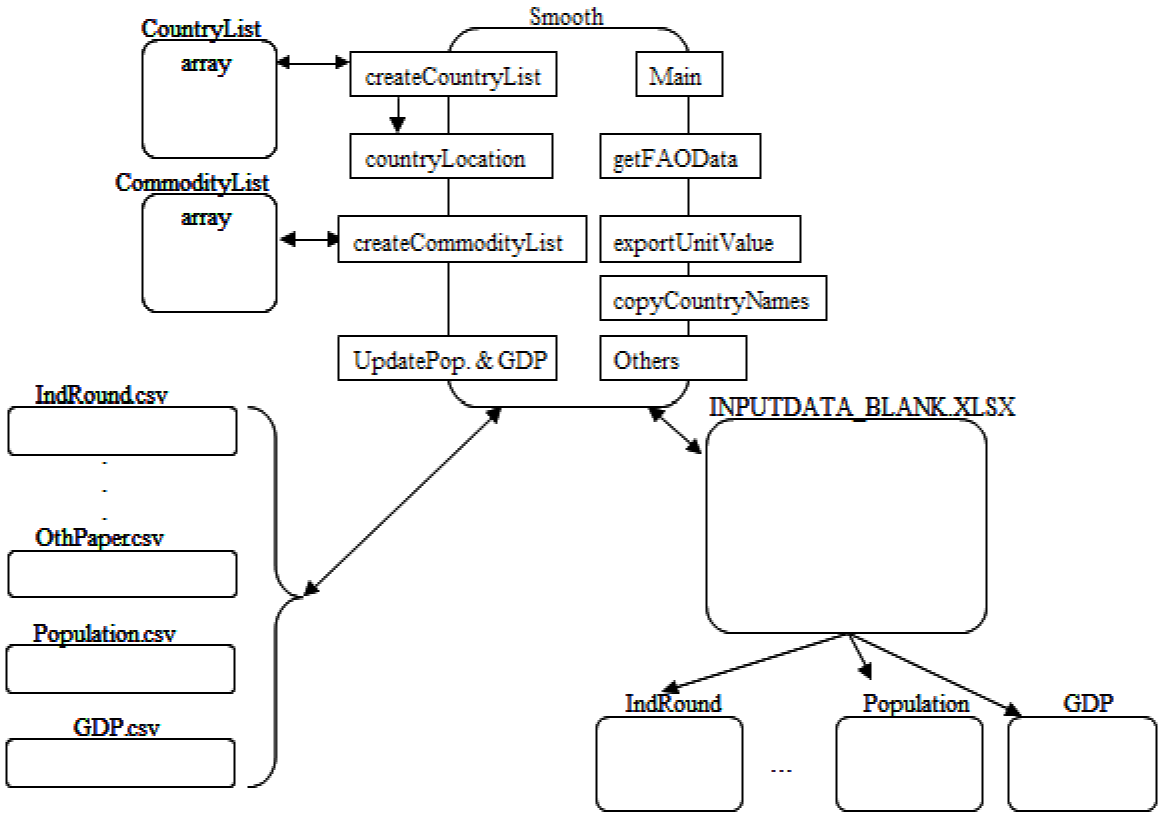


Figure 11: Smooth Module Design

Table 6: Files and Visual Basic modules used to smooth FAOStat and World Bank data to the FAODATA.XLSX format.

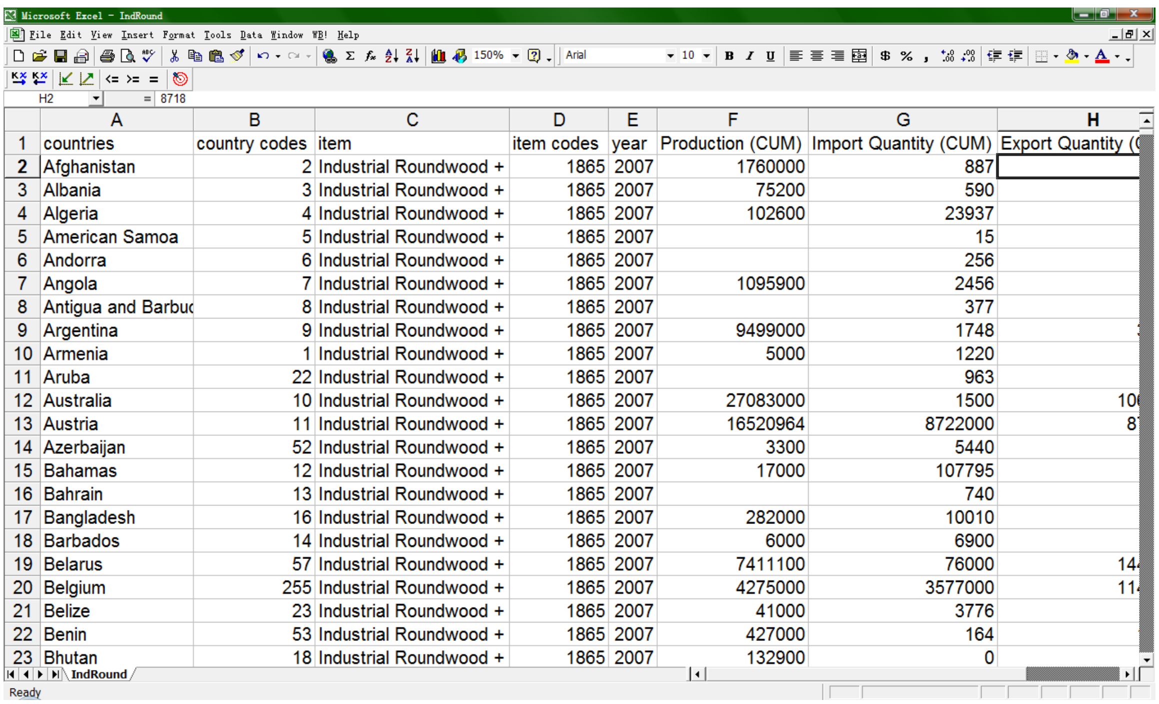
Module	Purpose
IndRound.csv	Text file containing FAOStat total industrial roundwood production, import and export data by country. Data is stored in the format shown in Figure 12. The data formats may change from year to year, and GFPM handles these formats automatically.
Population.csv	Text file containing FAOStat population data by country
GDP.XLS	Excel file containing World Bank GDP data by country
CountryList	Array giving the FAO country code, GFPM name and code for each country in the GFPM database. Used to identify country data to be calibrated and updated.
CommodityList	Array giving the commodity abbreviation, description,

	and code for each commodity in the GFPM database. Used to identify commodity data to be calibrated and updated.
RAWDATA_BLANK.XLSX	Excel workbook formatted to hold smoothed and raw FAO data.
INPUTDATA_BLANK.XLSX	Excel workbook to which FAO and World Bank data is copied.
CALIBRATION.XLSM	Contains all modules needed to calibrate the GFPM base year data. Also includes worksheets listing GFPM countries and commodities.
RAWDATA.XLSX	Excel workbook containing smoothed and raw production, import, export, export unit values for countries in the GFPM.
INPUTDATA.XLSX	Excel workbook containing production, import and export, export unit values, population and GDP data for countries in the GFPM. Data for each commodity is stored in a separate worksheet. Data is stored in the format shown in Figure 7.
Smooth	Visual Basic module with procedures and functions to process raw FAO and World Bank data to SMOOTHEDDATA.XLSX and INPUTDATA.XLSX.

Module: Smooth

Procedure/ Function	Purpose
Main	Main method for processing raw FAO and World Bank data to SMOOTHEDDATA.XLSX and INPUTDATA.XLSX
copyDataByCommodity	Copy raw FAO data to SMOOTHEDDATA_BLANK.XLSX and format for further processing.
smoothDataByCommodity	Smooth the multiple years' FAO data based on smoothing algorithm.
updateInputDataByCommodity	Update INPUTDATA_BLANK.XLSX with smoothed FAO data.
createCommodityList	Creates the CommodityList array from the commodity listing in the "CommodityList" worksheet of CALIBRATION.XLSM
createCountryList	Creates the CountryList array from the country listing in the "CountryList" worksheet of CALIBRATION.XLSM.
countryLocation	Function which when given a country name from the CountryList array searches for that country in the appropriate text file and returns the index for the line in which this country's data is stored.
getBaseYear	Identifies the year for which FAO data was downloaded and sets this year in the top left hand corner of each worksheet in INPUTDATA_BLANK.XLSX

getFAOData	Sets the value of country production, exports and imports from appropriate text file (*.csv) in SMOOTHEDDATA_BLANK.XLSX for the appropriate country.
getWorldBankData	Retrieve GDP and Population data from downloaded Excel file from World Bank (use GDP per capita if data exist).
adjustCheckCountry	Check whether user specified countries match the available data.
adjustCheckCommodity	Check whether user specified commodities match the available data.
getExportUnitValues	Function, which returns the export unit value for a given commodity.
exportUnitValue	Function which when given the export volume and value for each commodity, calculates the commodity export unit value as the commodity world price.



	A	B	C	D	E	F	G	H
1	countries	country codes	item	item codes	year	Production (CUM)	Import Quantity (CUM)	Export Quantity (C
2	Afghanistan	2	Industrial Roundwood +	1865	2007	1760000	887	
3	Albania	3	Industrial Roundwood +	1865	2007	75200	590	
4	Algeria	4	Industrial Roundwood +	1865	2007	102600	23937	
5	American Samoa	5	Industrial Roundwood +	1865	2007		15	
6	Andorra	6	Industrial Roundwood +	1865	2007		256	
7	Angola	7	Industrial Roundwood +	1865	2007	1095900	2456	
8	Antigua and Barbuc	8	Industrial Roundwood +	1865	2007		377	
9	Argentina	9	Industrial Roundwood +	1865	2007	9499000	1748	
10	Armenia	1	Industrial Roundwood +	1865	2007	5000	1220	
11	Aruba	22	Industrial Roundwood +	1865	2007		963	
12	Australia	10	Industrial Roundwood +	1865	2007	27083000	1500	10
13	Austria	11	Industrial Roundwood +	1865	2007	16520964	8722000	8
14	Azerbaijan	52	Industrial Roundwood +	1865	2007	3300	5440	
15	Bahamas	12	Industrial Roundwood +	1865	2007	17000	107795	
16	Bahrain	13	Industrial Roundwood +	1865	2007		740	
17	Bangladesh	16	Industrial Roundwood +	1865	2007	282000	10010	
18	Barbados	14	Industrial Roundwood +	1865	2007	6000	6900	
19	Belarus	57	Industrial Roundwood +	1865	2007	7411100	76000	14
20	Belgium	255	Industrial Roundwood +	1865	2007	4275000	3577000	11
21	Belize	23	Industrial Roundwood +	1865	2007	41000	3776	
22	Benin	53	Industrial Roundwood +	1865	2007	427000	164	
23	Bhutan	18	Industrial Roundwood +	1865	2007	132900	0	

Figure 12: IndRound.csv file containing FAOStat production, import and export data for industrial roundwood.

2.3 Calibrating Data for One Year

The following static calibration process is applied to calibrate data for one year (base year):

- Smooth data with moving average or exponential methods;

- Perform static calibration of the base year, with wide but technically possible prior I-O coefficients bounds set by users; the initial I-O coefficient is set as the mean of bounds for individual countries.

The INPUTDATA.XLSX workbook contains all the data needed to calibrate the GFPM when production, trade, and/or price data are updated. In the INPUTDATA.XLSX workbook data are arranged by commodity on separate worksheets. For each commodity the data in INPUTDATA.XLSX (Table 2 and Figure 1) are copied from FAO or World Bank data, input by the user, or calculated (by the *Calibrate* module) for each of the 180 countries in the GFPM.

The programs *Calibration* and *Calibrate* to calibrate the production and trade data from FAOStat are in the CALIBRATION.XLSM workbook. The program modules and files, and their relationship to each other are shown in Figure 13. A description of each module and the procedures (and functions) in each module are presented in Table 27.

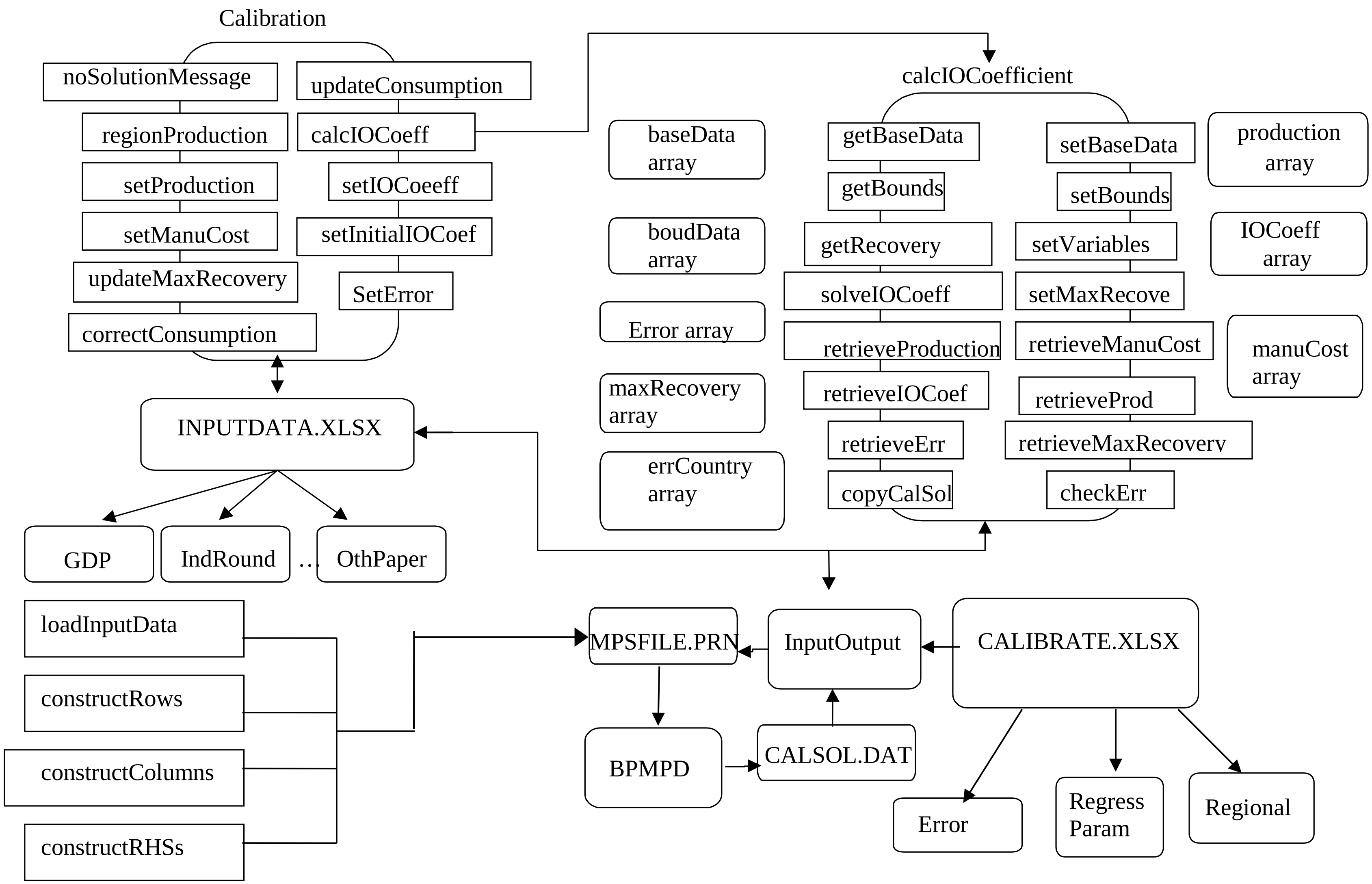


Figure 13: Calibrate Module Design

Table 7: Files and Visual Basic modules used to calibrate FAO and World Bank data, and set this data in INPUTDATA.XLSX.

Module	Purpose
Calibrate	Visual Basic module with procedures and functions to construct MPS file from model setup in Excel worksheet, then call BPMPDto solve the model, and retrieve the results from BPMPDoutput file to Excel worksheet.
Calibration	Visual Basic module with procedures and functions to prepare base data to meet material balance constraints.
CountryList	Array giving the FAO code, WDI code, GFPM name and code for each country in the GFPM database. Used to identify country data to be calibrated and updated.
regionList	List of GFPM regions, 2 columns (region name, ending country name)
CommodityList	Array giving the commodity abbreviation, code, and flags to indicate whether the commodity is final product, or raw materials, or manufactured product, or recycled product, for each commodity in the GFPM database. Used to identify commodity data to be calibrated and updated.
baseData	Array containing country production, import, export, GP weights and prices by commodity
boundData	A multi-dimension array of bounds for a country. Input dimension: input commodities + total input I/O bound; bound dimension: (upper/lower/initial); output dimension: output commodities.
production	Array containing GP estimated commodity production by country
manuCost	Array containing GP estimated commodity manufacturing costs by country
IOCoeff	Array containing GP estimated commodity IO Coefficients by country. Output dimension (commodityList columns), input dimension (commodityList columns)
maxRecovery	Vector containing GP estimated maximum waste paper recovery rate by country
errorArray	Array containing GP estimated percentage error in production estimates by country and commodity.
prevIOData	List of commodities of a country, commodityList columns (for input commodities)
meanIO	List of commodities of a country, commodityList columns (median of IO coefficients of all countries for input commodities)
SmoothedData.XLSX	Excel workbook containing smoothed data based on user specified smoothing parameters. The smoothed data are applied in InputData.xlsx for further processing.
INPUTDATA.XLSX	Excel workbook containing input data for calibration as well as calibrated data for updating WORLD.XLSX. Data is stored in the format shown in Figure 6.

CALIBRATE.XLSX	Excel workbook, which contains "InputOutput" worksheet, used to calculate IO coefficients, manufacturing costs, and maximum recovery rates. Also contains worksheets for constructed model in MPS format and for storing individual country/ commodity and regional production errors from calibration process.
BPMPD	Linear programming software package used to solve for IO coefficients from GP problem specified in MPSFILE.PRN. Solution to GP problem is passed to CALSOL.DAT. Commands for solving the GP problem are in AUTOLD.DAT.
ShellAndWait	Visual Basic procedure for running BPMPD(Refer to BPMPDdocumentation).
MPSFILE.PRN	Text file specifying GP model in MPS format (refer to BPMPDdocumentation for description of the MPS format. A description of the constraints and variables in the GP model are given below)
CALSOL.DAT	Text file produced by BPMPDcontaining the solution to the GP problem.

Module: Calibrate

Procedure/ Function	Purpose
generateMPSFile	Clears the MPSFile sheet in Calibrate.xlsx, then call procedures loadInputData, constructRows, constructColumns, and constructRHSs to generate mps file for a given country.
loadInputData	Loads input data, including all input data specified to a country (the bolded data in InputOutput sheet). The input data are loaded in global variables so they could be accessed when generating mps file.
getInputOutputSheet Properties	Loops through the InputOutput sheet to get the column and row index of some known properties.
constructRows	Procedure to construct the rows of the mps file.
constructColumn	Procedure to construct the columns of the mps file.
constructRHSs	Procedure to construct the right-hand sides of the mps file.
solveIOCoefficients 3	Copies MPS file data from CALIBRATE.XLSX to a separate workbook as a saved and formatted text file MPSFILE.PRN, then call BPMPDto solve the model in MPSFile.prn. Solution is then saved to CALSOL.DAT which resides in same directory as MPSFILE.PRN.
copyCalSolution3	Copies the decision variables from the BPMPDsolution file CALSOL.DAT to the InputOutput worksheet in CALIBRATE.XLSX.

Module: Calibration

Procedure/ Function	Purpose
Main	Main method for calibrating base data.
createCommodityLis t	Creates an array storing the selected commodities in CommodityList sheet of Calibration.xlsm. The list only needs to be created once during any run-time environment.
createCountryList	Creates an array storing the selected countries in CountryList sheet of

	Calibration.xlsm. The list only needs to be created once during any run-time environment.
columnIndex	In an output commodity sheet of InputData.xlsx, identify the index of a specified column.
updateConsumption	Identifies countries for which consumption estimates are negative or zero. Using population, GDP, consumption, and regression parameter estimates (in CALIBRATE.XLSX) predicts mean consumption and 95% upper and lower bounds. Uses these estimated consumption values to set production in INPUTDATA.XLSX and marks the consumption in red.
regionProduction	Calculates and copies the reported and estimated regional production of each commodity to the “RegionProductionError: worksheet in CALIBRATE.XLSX using data from INPUTDATA.XLSX prior to and after calibration.
calcIOCoefficient	Calculates commodity production, IO coefficients and manufacturing cost (for manufactured commodities) and maximum waste paper recovery rate by goal programming for each country in turn.
setProduction	For each country and commodity copy production data from the production array to the corresponding worksheets in INPUTDATA.XLSX. Marks in blue those estimates of consumption that have changed.
setManuCost	For each country and manufactured commodity copy manufacturing costs from the manuCost array to worksheets in INPUTDATA.XLSX.
setIOCoeff	For each country and nonpaper manufactured commodity copy IO coefficients from the IOCoeff array to the corresponding worksheets in INPUTDATA.XLSX.
setError	For each country and commodity copy errors from the errorArray array to the CALIBRATE.XLSX “Error” worksheet.
updateMaxRecovery	For each country copy the estimated maximum recovery rate for each country from the maxRecovery array to the “WastePaper” worksheet in INPUTDATA.XLSX.
correctConsumption	For each country and commodity in INPUTDATA.XLSX identifies countries with negative consumption. For these countries, an import activity is added to make consumption zero. Modified import activities are marked in red.
SetInitialIO	Calls procedures to calculate initial IO for each country then set the initial IO in InputData.xlsx.
calcInitialIOCoefficient	Calculates the initial IO. For static calibration, set initial IO as mean of bounds, for dynamic calibration, set initial IO as smoothed IO if available, otherwise set to previous year's IO, otherwise, set as median IO of all countries.
getPreviousInitialIO	Procedure to get the previous calibration’s IO coefficients.
getSmoothedInitialIO	Procedure to get smoothed IO based on user specification.
setIOMeanStdDev	Procedure to calculate mean and standard deviation of IO coefficients.
createCalibrateFile	Create calibrate.xlsx based on calibrate_blank.xlsx and user selection

	of commodities in CommodityList sheet of Calibration.xlsm.

Module: copyFAOData

Procedure/ Function	Purpose
countryLocation	Function which when given a country name from the CountryList array searches for that country in the appropriate text file and returns the index for the line in which this country's data is stored.
getIndex	Function, which for specified country, identifies array index corresponding to that country to be used to retrieve country's consumption, production, etc data from the corresponding array.
getCommodityIndex	Identify the array index corresponding to a particular commodity passed to the function.

Module: calcIOCoefficient

Procedure/ Function	Purpose
getBaseData	For a specified country and commodity copies import, export, production and price data from INPUTDATA.XLSX to the baseData array.
getBounds	Gets upper bounds, lower bounds, and initial IOs for commodities manufactured from other commodities from INPUT.XLSM commodity sheets. First, boundData() is initialized as (maxCommodity+1) x 3 x maxCommodity matrix with zero entries, then, the input/output relationship is checked in InputData.xls to fill the bounds in boundData() matrix.
getMaxMinRecovery	Gets max and min recovery rates from INPUT.XLSM commodity sheets. First, recoveryData() is initialized as maxCommodity x 2 array with -1 entries, then, the InputData.xls is checked to fill the recovery rates in recoveryData() array.
setBaseData	For specified country sets the production, trade, goal programming weight and price data from the baseData array to the "InputOutput" worksheet in CALIBRATE.XLSX.
setBounds	Sets the upper, lower bounds and initial IO from the boundData array to the "InputOutput" worksheet in CALIBRATE.XLSX.
setBoundsDynamic	Adjust the bounds incrementally to avoid infeasible solution.
setMaxMinRecovery	For specified country copies the maximum and minimum waste paper recovery rate from the "WastePaper" sheet in INPUTDATA.XLSX and sets the values in the "InputOutput" worksheet in CALIBRATE.XLSX.
solveIOCoefficients WithDynamicBounds	Calls solveIOCoefficients procedure in Calibrate module to solve the optimization problem built with mps file. When no optimal solution is obtained, dynamically increases the bounds to get feasible solution.
retrieveProduction	Copies the estimated commodity production from the "InputOutput" worksheet in CALIBRATE.XLSX to the production array.
retrieveManuCost	Copies the estimated commodity manufacturing cost from the

	“InputOutput” worksheet in CALIBRATE.XLSX to the manuCost array.
retrieveIOCoeff	Copies the estimated commodity IO coefficient from the “InputOutput” worksheet in CALIBRATE.XLSX to the IOCoeff array.
retrieveError	Copies the estimated error in production (GP calculated production vs FAO provided production) from the “InputOutput” worksheet to the errorArray array
retrieveMaxRecovery	Copies the estimated maximum waste paper recovery from the “InputOutput” worksheet to the maxRecovery array.

The “InputOutput” worksheet (Figure 14) is the center of the calibration process. The *calibrate and calibration* modules link non-calibrated data from INPUTDATA.XLSX to the “InputOutput” worksheet in CALIBRATE.XLSX and returns the calibrated results (the solution to the goal programming problem for each country) to INPUTDATA.XLSX.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	**Uzbekistan**	**Actual data**				Input to industries																		
2		Prod	Imp	Exp	Cons	Fuelwood	IndRound	Sawnwood	Plywood	ParticleB	FiberB	MechPlp	ChemPlp	OthFbrPlp	WastePape	Newsprint	PWPaper	OthPaper	Com	Productior	Q+	Q-	Total	
3	Fuelwood	**22**	**0**	**0**	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	22.0	0.0	0.0	0.0	=
4	IndRound	**9**	**318**	**3**	324	0.0	0.0	0.0	0.0	269.3	0.0	2.8	42.9	0.0	0.0	0.0	0.0	0.0	**0**	0.0	0.0	9.0	0.0	=
5	Sawnwood	**0**	**1**	**1**	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	0.0	0.0	0.0	0.0	=
6	Plywood	**0**	**18**	**2**	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	0.0	0.0	0.0	0.0	=
7	ParticleB	**0**	**129**	**1**	128	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	120.3	120.3	0.0	0.0	=
8	FiberB	**0**	**88**	**0**	88	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	0.0	0.0	0.0	0.0	=
9	MechPlp	**0**	**2**	**0**	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.4	0.0	**0**	0.8	0.8	0.0	0.0	=
10	ChemPlp	**0**	**1**	**0**	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	8.1	0.0	**0**	9.6	9.6	0.0	0.0	=
11	OthFbrPlp	**0**	**0**	**3**	-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**	3.0	3.0	0.0	0.0	=
12	WastePaper	**0**	**5**	**0**	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.3	0.0	**0**	0.0	0.0	0.0	0.0	=
13	Newsprint	**0**	**15**	**0**	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	8.2	8.2	0.0	0.0	=
14	PWPaper	**11**	**26**	**0**	37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	11.0	0.0	0.0	0.0	=
15	OthPaper	**0**	**15**	**5**	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1**	0.0	0.0	0.0	0.0	=
16	Total Input															8.5	9.9	0.0						
17	Production					22	0	0.0	0.0	120.3	0.0	0.8	9.6	3.0	0.0	8.2	11.0	0.0			Min			
18																								
19	Weight					0.47	0.84	2.45	4.66	2.47	3.74	4.05	5.31	9.79	1.32	5.96	8.86	8.72		**Waste paper recovery**				
20	Price					47.00	112.20	245.00	543.20	280.13	443.46	471.96	630.30	979.00	170.64	663.40	1061.07	997.92		Upper bou	<=			
21	Total output value					1012.0	0.0	0.0	0.0	33566.9	0.0	378.7	6010.6	2934.0	0.0	5461.2	11660.8	0.0		Lower bou	>=			
22	Total Input Cost					0.0	0.0	0.0	0.0	30213.9	0.0	311.3	4817.8	0.0	0.0	2988.3	5838.7	0.0		Computed	0			
23	Total manufacturing cost					1012.0	0.0	0.0	0.0	3353.0	0.0	67.4	1192.8	2934.0	0.0	2472.9	5822.0	0.0						
24	Unit manufacturing cost					47.0	-9999.0	-9999.0	-9999.0	28.9	-9999.0	84.9	125.9	979.0	-9999.0	300.9	530.3	-9999.0						
25	Non-negative manufacturing cost					>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=						
26																								
27	**Upper bound of I/O coefficient**					Fuelwood	IndRound	Sawnwood	Plywood	ParticleB	FiberB	MechPlp	ChemPlp	OthFbrPlp	WastePape	Newsprint	PWPaper	OthPaper						
28	Fuelwood					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
29	IndRound					**0**	**0**	**2.26**	**3.32**	**2.24**	**2.51**	**3.45**	**4.50**	**0**	**0**	**0**	**0**	**0**						
30	Sawnwood					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
31	Plywood					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
32	ParticleB					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
33	FiberB					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
34	MechPlp					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0.195**	**0.24286**						
35	ChemPlp					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.83**	**1.11**	**0.92**						
36	OthFbrPlp					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0.17**	**0.01**						
37	WastePaper					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.57**	**0.03**	**0.37**						
38	Newsprint					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
39	PWPaper					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
40	OthPaper					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**						
41	Total input					**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**1.03**	**0.95**	**1.00**						
42																								
43	**Lower bound of I/O coefficient**					Fuelwood	IndRound	Sawnwood	Plywood	ParticleB	FiberB	MechPlp	ChemPlp	OthFbrPlp	WastePape	Newsprint	PWPaper	OthPaper						

Figure 14: “InputOutput” sheet in CALIBRATE.XLSX

The GP problem set in the *InputOutput* worksheet is specified in MPS format in the *MPSFile* worksheet in CALIBRATE.XLSX. The *MPSFile* worksheet is saved as a text file MPSFILE.PRN which is used by BPMPDto setup the GP problem and solve it, passing the solution to CALSOL.DAT. The method applied to generate the MPS file is described below in detail.

The MPS file is generated in the *MPSFile* worksheet based on the content of the *InputOutput* sheet in CALIBRATE.XLSX. To facilitate the construction of the MPS file, the constraints listed in Table 8 and the GFPM commodities are represented with numeric codes. The possible constraint codes range from 10 to 99 (maximum number of supported constraints is 90), and the possible commodity codes range from 10 to 99 (maximum number of supported commodities is 90). Currently, we have 11 constraints (Table 8) and 14 commodities.

Constraint codes:

Deviation of estimated from reported production (20)
Deviation of estimated from expected input (30)
Material balances (41, 42)
Feasible range of input i for output j (51, 52)
Feasible range of total inputs for output j (61, 62)
Feasible post-consumer recovery (71, 72)
Non-negative manufacturing cost (80)

Commodity codes:

Fuelwood (80), IndRound (81), OtherIndRound (82), Sawnwood (83), Plywood (84), ParticleB (85), FiberB (86), MechPulp (87), ChemPulp (88), OthFbrPlp (89), WastePaper (90), Newsprint (91), PWPaper (92), OthPaper (93)

In Table 8, each constraint is applied over a list of commodities (usually all commodities) in one dimension, and some constraints are further applied over another list of commodities in another dimension. So there are two types of constraints: one-dimensional and two-dimensional. Currently, the one-dimensional constraint codes include 20, 41, 42, 61, 62, 71, 72, 80; and the two-dimensional constraint codes include 30, 51, and 52. For variable details, see Table 9.

A one-dimensional constraint, which is applied over a list of commodities in one dimension, is represented by a six-digit code including constraint code, commodity code, followed by 00, and ranges from 101000 to 999900 (maximum range). For example, the constraint 20 for commodity 80 is 208000. See Table 10 for details.

A two-dimensional constraint, which is applied to a list of commodities in two dimensions, is represented by a six-digit code including constraint code, commodity code in one dimension, and another commodity code in another dimension, and range from 101010 to 999999 (max range). For example, the constraint 51 for commodity 81 in one dimension and commodity 87 in another dimension is 518187.

All variables in MPS file start with "Y". Production variables are represented with commodity codes, like Y80 (for fuelwood production). Production estimation errors (production minus/plus) look like Y80+ or Y80- (estimated above or below reported). Input for output variables look like Y8187 (IndRound input for MechPulp output). Input for output estimation errors (input minus/plus) look like Y8187+ or Y8187-.

Table 8. Goal-programming model to estimate input-output in a country and year.

Objective function:

$$\min Z = \beta \sum_i (Y_i^+ + Y_i^-) w_i + (1-\beta) \sum_i \sum_j (Y_{ij}^+ + Y_{ij}^-)(w_i w_j)^{1/2} \qquad [1]$$

Deviation of estimated from reported production:

$$Y_i - q_i + Y_i^- - Y_i^+ = 0 \qquad \forall i \qquad [2]$$

Deviation of estimated from expected input:

$$Y_{ij} - a_{ij} Y_j + Y_{ij}^- - Y_{ij}^+ = 0 \qquad \forall i, j \qquad [3]$$

Material balance:

$$Y_i - \sum_j Y_{ij} + m_i - x_i = 0 \qquad \forall i \in R \qquad [4.1]$$

$$Y_i - \sum_j Y_{ij} + m_i - x_i \geq 0 \qquad \forall i \in F \qquad [4.2]$$

Feasible range of input *i* for output *j*:

$$Y_j a_{ij}^L \leq Y_{ij} \leq Y_j a_{ij}^U \qquad \forall i, j \qquad [5.1,5.2]$$

Feasible range of total inputs for output *j* (current inputs are 4 fibers):

$$Y_j a_j^L \leq \sum_i Y_{ij} \leq Y_j a_j^U \qquad \forall j \qquad [6.1,6.2]$$

Feasible post-consumer recovery:

$$\sum_j (Y_j - \sum_j Y_{ij} + m_j - x_j) r_{ij}^L \leq Y_i \leq \sum_j (Y_j - \sum_j Y_{ij} + m_j - x_j) r_{ij}^U \qquad \forall i \qquad [7.1,7.2]$$

Non-negative manufacturing cost:

$$\sum_j Y_{ji} w_j - w_i Y_i \leq 0 \qquad \forall i \qquad [8]$$

Input-output coefficient after solving [1] to [8]:

$$A_{ij} = \frac{Y_{ij}}{Y_j} \qquad \forall i, j \qquad [9]$$

Table 9. Variables and parameters used in the goal-programming model, for a given year and country.

Sets and input data:

i,j : Products

` F : Set of final products

R : Set of raw materials or intermediate products

β : weight of official data vs. prior input-output data.

w_i : price of product *i*.

q_i, m_i, x_i: reported data on production, imports, and exports.

a_{ij}^L, a_{ij}^U : lower, upper bound on input *i* per unit of output *j*.

$a_{ij} = (a_{ij}^L + a_{ij}^U)/2$: expected input *i* per unit of output j.

a_j^L, a_j^U : lower, upper bound on total input per unit of output *j*.

r_{ij}^L, r_{ij}^U : lower, upper bound on recycling of product *j* into product *i*.

Choice variables, all non-negative:

Y_i : estimated production of product *i*.

Y_i^+, Y_i^- : estimated production above, or below, reported production of product *i*.

Y_{ij} : estimated input *i* in output *j*.

Y_{ij}^+, Y_{ij}^- : estimated input above, or below, input implied by prior input-output coefficients.

Other variables:

A_{ij} : computed I-O coefficient.

Table 10. Mappings between goal programming model (GP), Excel *InputOutput* worksheet (IO), and MPS file (MPS).

GP Function Index	GP Function Name	IO Formula Exemplar Cell	MPS Row Code	MPS Column Code
[1]	Objective Function	W18	OBJ	Yxx-, Yxx+,

				Yxxyy-, Yxxyy+
[2]	Deviation of estimated from reported production	X3	20xx00	Yxx, Yxx-, Yxx+
[3]	Deviation of estimated from expected input	F147	30xxyy	Yxxyy, Yyy, Yxxyy-, Yxxyy+
[4.1]	Material balance	AA4	41xx00	Yxx, Yxxyy
[4.2]	Material balance	AA3	42xx00	Yxx, Yxxyy
[5.1]	Feasible range of input i for output j	F180	51xxyy	Yyy, Yxxyy
[5.2]	Feasible range of input i for output j	F163	52xxyy	Yyy, Yxxyy
[6.1]	Feasible range of total inputs for output j	Q194	61xx00	Yyy, Yxxyy
[6.2]	Feasible range of total inputs for output j	Q177	62xx00	Yyy, Yxxyy
[7.1]	Feasible post-consumer recovery	V22	71xx00	Yxx, Yyy, Yxxyy
[7.2]	Feasible post-consumer recovery	V21	72xx00	Yxx, Yyy, Yxxyy
[8]	Non-negative manufacturing cost	F26	80xx00	Yxx, Yxxyy

Note: xx in the MPS column represents commodity code, currently ranging from 80 to 93; xxyy represents input xx for output yy, and both currently range from 80 to 93.

2.4 Calibrating the Base Model with Multiple Years' Data

Dynamic calibration calibrates the base year model with multiple years' data. The process wraps a single year's calibration in a loop by defining the First Year and Base Year. If no smoothing is chosen, the base year could be the latest year available within FAO raw data, otherwise, the base year should be at least one year earlier than the latest year in FAO data. If smoothing is used a three-year moving average is applied to the raw FAO data, for example, the raw data for the years 2005, 2006 and 2007 are averaged to give the smoothed data for the year 2006.

The dynamic calibration always uses three years of data (smoothed or unsmoothed), including the base year as the last one. For example, to get a 2006 base year model with dynamic calibration, the 2004, 2005, and 2006 static base year models are calibrated first, at the same time, the calibrated input data are stored in INPUTDATATREND.XLSX, and the calibrated I-O coefficients are stored in TECHTREND.XLSX. When an I-O coefficient cannot be computed, it is set as the previous year's I-O coefficient if it exists, or the median of the I-O coefficients that can be computed for other countries.

After the static calibration from the first year to the base year, the resulting I-O coefficients and the calibrated production are averaged over the three years, and the import, export, and price data used as input in the calibration are also averaged.

Based on the averaged I-O coefficients, the manufacturing cost is calculated.

Based on the averaged production, imports, and exports of final products and averaged I-O coefficients, the production of intermediate and raw materials is calculated.

These I-O coefficients, manufacturing cost, productions, imports, exports, and prices are used as input for the base year model.

During the calibration process, the year-by-year smoothed data, calibrated manufacturing cost and I-O coefficients, and calibrated input data are stored in SMOOTHEDDATA.XLSX, TECHTREND.XLSX, and INPUTDATATREND.XLSX.

A module *DynamicLearning* is added to perform such dynamic calibration. Some functions are also added in the *Calibrate* module to handle bounds and initial I-O settings.

Table 11: Files and modules used to calibrate with dynamic bounds and learning.

Module	Purpose
dynamicLearning	Contains procedures to calibrate each year's data from First Year to Base Year. For each year, three processes are performed: smoothing, setting bounds and initial I/O coefficients, and calibrate model.
RAWDATA.XLSX	Excel workbook containing smoothed and raw production, import, export, and export unit values for countries in the GFPM.
INPUTDATA.XLSX	Excel workbook containing production, import and export, export unit values, population and GDP data for countries in the GFPM. Data for each commodity is stored in a separate worksheet.
INPUTDATA_PREV.XLSX	Excel workbook containing previous year's input data.
SMOOTHEDDATA.XLSX	Excel workbook containing year-by-year smoothed data.
TECHTREND.XLSX	Excel workbook containing year-by-year manufacturing cost and I/O coefficients.
INPUTDATATREND.XLSX	Excel workbook containing year-by-year calibrated input data for world.xlsx.

Module: dynamicLearning

Procedure/ Function	Purpose
Main	Main method for calibrating each year's data from First Year to Base Year.
switchInputDataFiles	Save INPUTDATA.XLSX as INPUTDATA_PREV.XLSX for next calibration, and remove RAWDATA.XLSX and INPUTDATA.XLSX.
calibrateTargetYear	For each year, perform smoothing, setting bounds and initial I/O, and calibrating model.

copyDataByTargetYear	For each year, store smoothed data in SMOOTHEDDATA.XLSX.
copyTechDataByTargetYear	For each year, store calibrated manufacturing cost and I/O coefficients in TECHTREND.XLSX.
copyInputDataByTargetYear	For each year, store calibrated input data in INPUTDATATREND.XLSX.
SmoothInputData	Smooth the calibrated input data, including production, import, export, and prices.
CalculateManuCost	Calculate manufacturing cost based on smoothed I-O coefficients.
AdjustInputData	Calculate the production of intermediate and raw materials based on smoothed I-O coefficients and production of final products; calculate the waste paper recovery rates.

2.5 Updating WORLD.XLSX

The calibrated production, consumption, price, waste paper recovery, and manufacturing coefficient and cost data from the calibration process are stored in INPUTDATA.XLSX. The final step in the calibration process is to update the data in WORLD.XLSX. WORLD.XLSX is the source file for the data used to run the GFPM base year. A detailed description of the data in the WORLD.XLSX is provided in the GFPM User Manual (Zhu et al. 2008).

An important part of the process of updating the data in WORLD.XLSX is setting up the *ExogChange* worksheet to allow the user to specify exogenous changes. To set up the *ExogChange* worksheet, country/ commodity manufacturing activities and trade flows need to be identified and WORLD.XLSX *ExogChange*are updated. Users can then specify exogenous changes relating to manufacturing and recycling activities, and trade flows, e.g., change in IO coefficients or tariffs, in these worksheets. The program *Update* to update WORLD.XLSX data from INPUTDATA.XLSX is in the CALIBRATION.XLSM workbook. The program modules and files, and their relationship to each other are shown in Figure 15. A description of each module and the subroutines in each module are presented in Table 12.

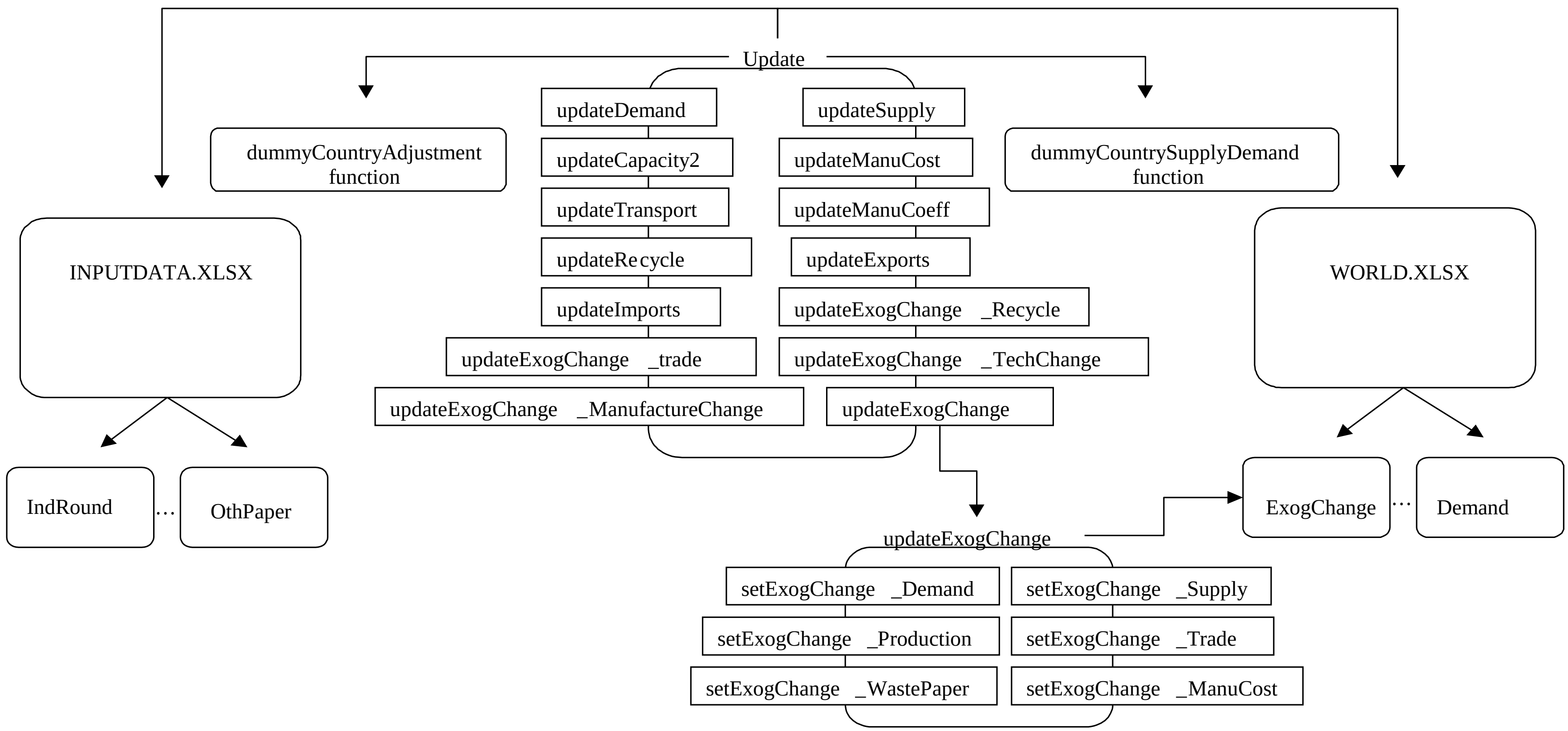


Figure 15: Update Module Design

Table 12: Files and Visual Basic modules used to update calibrated data in WORLD.XLSX.

Module	Purpose
Update	Contains procedures to update the “Demand”, ‘Supply”, “Capacity2”, “Manufacture”, “Transportation” and “ExogChange” worksheets. Also calls functions to calculate dummy region supply, demand and trade.
UpdateExogChange in CALIBRATION.XLSM	Sets the base data in the WORLD.XLSX “ExogChange” worksheet
INPUTDATA.XLSX	Excel workbook containing calibrated production, consumption, price, IO coefficient and manufacturing cost data. This workbook also contains price, tariff and freight factor data.
WORLD.XLSX	Excel workbook containing data for running GFPM base year and scenarios.

Module: Update

Procedure/ Function	Purpose
Main	Main method for copying data from INPUTDATA.XLSX to WORLD.XLSX
updateDemand	Updates demand volume, price and elasticity data in the WORLD.XLSX “Demand” sheet from INPUTDATA.XLSX data. This procedure also calls the *dummyCountryAdjustment* function.
updateSupply	Updates supply volume, price and elasticity data in the WORLD.XLSX “Supply” sheet from INPUTDATA.XLSX data. This procedure also calls the *dummyCountryAdjustment* function.
updateForest	Gets forest stock and area data from the "Forest" sheet in INPUTDATA.XLSX, copy those data to the "Forest" sheet of WORLD.XLSX.
updateCapacity2	Updates production capacity for manufactured commodities in WORLD.XLSX “Capacity2” sheet using data from INPUTDATA.XLSX.
updateManuCost	Updates manufacturing costs for manufactured commodities in WORLD.XLSX “Manufacture” sheet using data from INPUTDATA.XLSX.
updateManuCoeff	Updates manufacturing coefficients for manufactured commodities in WORLD.XLSX “Manufacture” sheet using data from INPUTDATA.XLSX.
updateRecycle	Gets calibrated maximum waste paper recovery rate data from the "WastePaper" sheet in INPUT.XLSX, and copies this data to the "RecycleS" sheet of WORLD.XLSX.
updateImports	Updates import volumes, tariffs, freight costs and import demand elasticities in the WORLD.XLSX “Transportation” sheet using data from INPUTDATA.XLSX. Also calls the *dummyCountryAdjustment* function.
updateExports	Updates export volumes in the WORLD.XLSX “Transportation”

	sheet using data from INPUTDATA.XLSX. Also calls the *dummyCountryAdjustment* function.
updateExogChange	Calls procedures to setup the exogenous change data for shifting demand, supply, waste recovery, production and tariffs between periods in the "ExogChange" sheet in WORLD.XLSX.
dummyCountryAdjustment	Sums world export and import volumes, and returns the difference between these as the dummy country import, export, demand and supply volume for each commodity. This ensures the global material balance is met.

Module: updateExogChange in CALIBRATION.XLSM

Procedure/ Function	Purpose
setExogChange_Demand	This procedure sets the countries and commodities for which demand activities exist in the "ExogChange" worksheet. This procedure does NOT set the actual demand shifter data in the "ExogChange" worksheet.
setExogChange_Demand	This procedure sets the countries and commodities for which supply activities exist in the "ExogChange" worksheet. This procedure does NOT set the actual supply shifter data in the "ExogChange" worksheet.
SetExogChange_ManuCost	This procedure sets the countries and commodities for which manufacturing activities exist in the "ExogChange" worksheet. This procedure does NOT set the actual growth rate in manufacturing costs in the "ExogChange" worksheet.
setExogChange_Production	This procedure sets the countries and commodities for which paper product manufacture activities exist in the "ExogChange" worksheet. This procedure does NOT set the actual changes in IO coefficients in the "ExogChange" worksheet.
setExogChange_Trade	This procedure sets the countries and commodities for which trade flows exist in the "ExogChange" worksheet. This procedure does NOT set the actual changes in tariffs in the "ExogChange" worksheet.
setExogChange_WastePaper	This procedure sets the countries and commodities for which waste paper recovery exists in the "ExogChange" worksheet. This procedure does NOT set the actual changes in maximum recovery rates in the "ExogChange" worksheet.

2.6 Adding Bilateral Trade Data

If users wish to add bilateral trade flow data, such as trade between Canada and the United States, the procedures in the *AddBilateralTrade* module can be used to add this data to WORLD.XLSX.

The program *AddBilateralTrade* copies bilateral trade flow data from BILATERALTRADE.XLSX to the *Transportation, ExogChange* and *Trade* worksheets in WORLD.XLSX. The program modules and files, and their relationship to each other are shown in Figure 16. A description of each module and the subroutines in each module are presented in Table 13

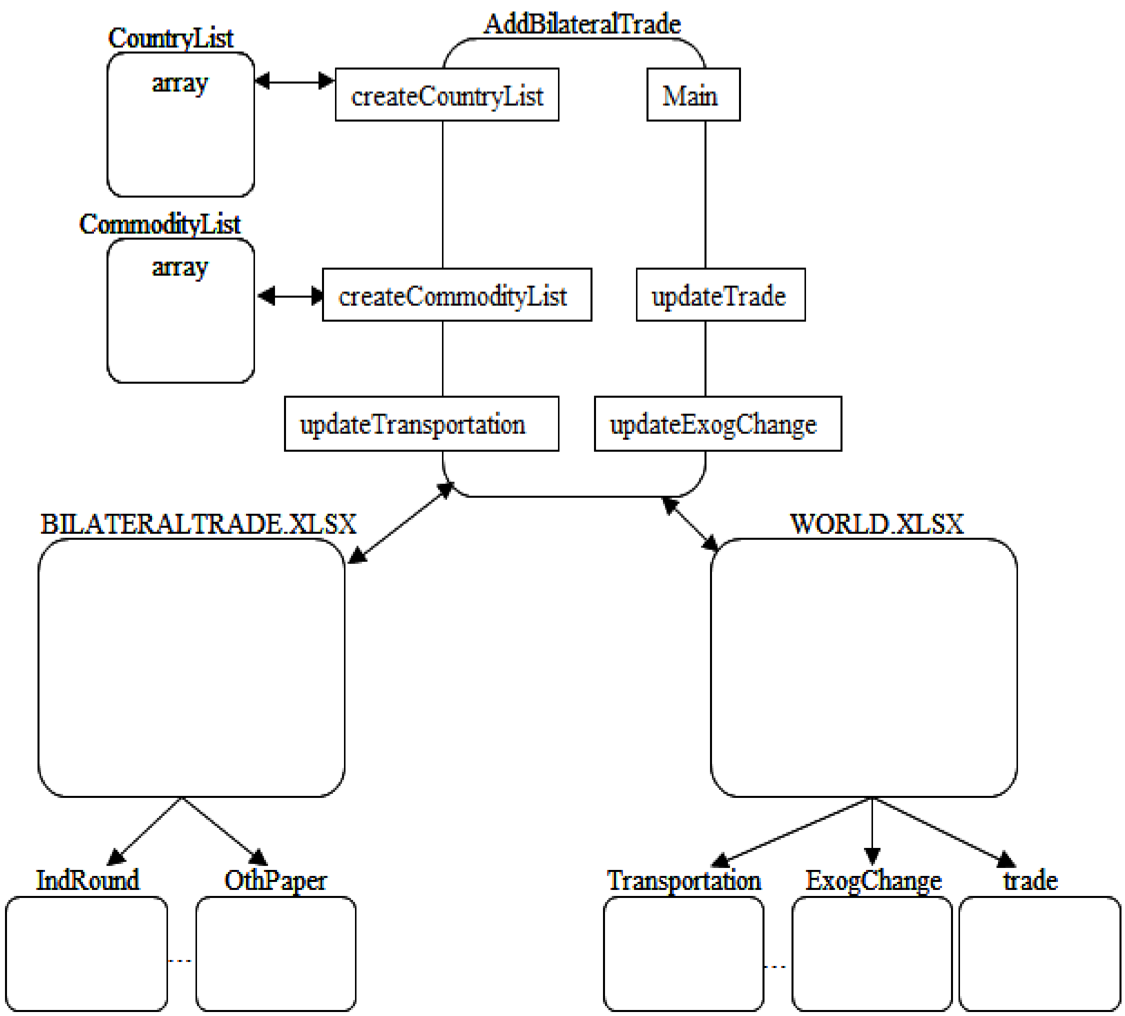


Figure 16: AddBilateralTrade Module Design

Table 13: Files and Visual Basic modules used to add bilateral trade flow data to WORLD.XLSX.

Module	Purpose
AddBilateralTrade	Contains procedures to copy bilateral trade flow data from BILATERALTRADE.XLSX to the “Transportation”, ‘ExogChange”, and “trade” worksheets in WORLD.XLSX.
BILATERALTRADE.XLSX	Excel workbook containing bilateral trade flow data, which includes trade volumes, tariffs, and trade inertia parameters for each trade flow.
WORLD.XLSX	Excel workbook containing data for running GFPM scenarios.

Module: AddBilateralTrade

Procedure/ Function	Purpose
Main	Main method for copying bilateral trade flow data from BILATERALTRADE.XLSX to WORLD.XLSX
createCommodityList	Creates the CommodityList array from the commodity listing in the “CommodityList” worksheet of CALIBRATION.XLSM
createCountryList	Creates the CountryList array from the country listing in the “CountryList” worksheet of CALIBRATION.XLSM.
updateTransportation	Adds bilateral trade volume, freight cost, tariff and trade inertia parameter data to the “Transportation” worksheet in WORLD.XLSX. Part of this process includes adjusting the trade volumes for trade to and from the world region to account for the added bilateral trade.
updateExogChange	Adds bilateral trade flows to the “T” type data in the “ExogChange” worksheet in WORLD.XLSX.

2.7 Updating Historical Data

To update the historical data, from 1992 to the base year, in SUMMARYCHANGE.XLSM, OUTPUT.XLSM and SUMMARY.XLSM, the procedures in the *updateBaseyear* procedure in the *Update* module are used. They invoke the main, updateOutput, and updateSummary procedures in the Historical module.

The SummaryChange.xlsm is the central place to store historical data, which are further processed after being obtained from C:\GFPM\input\inputFiles\ProcessedRawData.xlsx. Historical data in Output.xlsm and Summary.xlsm are copied or aggregated from SummaryChange.xlsm.

The *updateBaseyear* procedure updates OUTPUT.XLSM and SUMMARY.XLSM with the user-supplied base year in INPUTDATA.XLSX. For OUTPUT.XLSM, on the *Output* worksheet the “Baseyear” column header is updated with the year that FAO data is used by the program, for example 2010 is shown if the base year is 2010.

For SUMMARY.XLSM, the historical regional data are updated with the newly aggregated data for the current base year (the previous years have to be updated manually if needed). The aggregation is done with a template corresponding to the summary table in SUMMARY.XLSM. The macro *aggregateDataBasedOnTemplate* in OUTPUT.XLSM retrieves data by matching country names, and aggregates them by applying the formula specified in the template sheet. After obtaining the aggregated data, another macro *updateSummaryTable* copies the data to the summary table in SUMMARY.XLSM.

To simplify the calculation, two kinds of cells are defined in "HistoricalData" sheet in SummaryChange.xls: independent cells and dependent cells, and all dependent cells are calculated from independent cells via Excel formula on the sheet. The independent cells are filled with data obtained from ProcessedRawData.xls via programs, including: Production, Import, Export, Price, Area, Stock; the dependent cells are filled with formula and are updated automatically when the independent cells are updated, including: Consumption, Nettrade, Value_cons, Value_prod, Value_imp, Value_exp, Value_netTrade, Value_added (they are still processed via program when data availability changes for example when 2010 data are downloaded).

When obtaining data from ProcessedRawData.xls to fill the independent cells, most of them are directly copied such as production, import, export, area, and stock, but prices are calculated as unit value of imports (for net importers) and of exports (for net exporters), deflated with the GDP deflator. The GDP per capita imported during calibration is also deflated with the US GDP deflator.

After finishing updating the HistoricalData sheet in SummaryChange.xls; the "Actual" columns on Output sheet of Output.xls are also updated with historical data for the first year and base year (for example 1992 and 2009; GFPM data start from 1992).

For Summary.xls, all historical quantities starting from the first year to the base year are updated (for example from 1992 to 2009); all world prices are updated by deflating them to the base year $, and the chart axis titles are also updated with the specified base year $.

A description of each module and the subroutines in each module are presented in Table 14.

Table 14: Files and modules used to update base year data in OUTPUT.XLSM and SUMMARY.XLSM.

Module	Purpose
Historical	Contains procedures to process historical data in SummaryChange.xlsm, and update data in Output.xlsm and Summary.xlsm.
PROCESSEDRAWDATA.XLSX	Excel workbook containing formatted raw FAO and World Bank data for individual countries.
SUMMARYCHANGE.XLSM	Excel workbook containing full historical data for individual countries
OUTPUT.XLSM	Excel workbook containing centralized output data for all countries and commodities.
SUMMARY.XLSM	Excel workbook containing summarized and aggregated output data and charts.

Module: Historical

Procedure/ Function	Purpose
Main	Main method for copying basic raw data from ProcessedRawData.xlsx to SummaryChange.xlsm, and further processing historical data for aggregated products.
updateOutput	Update the historical data columns in OUTPUT.XLSM
updateSummary	Copies aggregated data to each commodity worksheet of SUMMRY.XLSM.

2.8 Calibrating for Different Numbers of Countries or Commodities

See Calibrating and Updating the Global Forest Products Model (GFPM calibration manual) for details on how to apply calibration programs to change countries and commodities to be calibrated.

Generally, it is easier to change countries when calibrating GFPM. If the desired countries are a subset of the 180 countries included in the GFPM model, they could be selected on CountryList sheet of CALIBRATION.XLSM. If the desired countries are not included in the 180 default countries, if their corresponding data exist in downloaded FAO and World Bank data files under C:\GFPM\Input\InputFiles folder, users could simply add these countries in the above mentioned CountryList, and the calibration program will check and retrieve the data from the downloaded data files. If their corresponding data are not included in the downloaded data files, they have to be added in those files in some way.

Changing commodities in GFPM is more complicated and involves some manual steps. Besides some similar modification as changing countries, the main manual steps are adding sheets in InputData_Blank.xls and completing rows and columns in the "InputOutput" sheet of C:\GFPM\INPUT\CALIBRATE_BLANK.XLSX as for existing commodities. These tasks require thorough understanding of GFPM model structure, and to some extent, understanding the calibration program structure and implementation, since some changes may require modification of the existing programs.