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METRO V3 INTERFACE
USER GUIDE

This document accompanies the METRO Version 3 Model documentation, TAD/TC/WP/RD(2020)1/FINAL.

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This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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The METRO Model is derived from GLOBE, a Social Accounting Matrix (SAM) based on the CGE model developed by Scott McDonald and Karen Thierfelder.

The interface is based on the existing package "GAMS Graphical user Interface generator" package developed by Wolfgang Britz (GGIG, Britz, 2010a/b and Britz 2014a). The authors would like to thank Marcel Adenäuer for adapting the interface to the METRO trade model.

The authors are also grateful to members of the METRO Model Steering Committee for their valuable insights, guidance, and feedback in the development of the model interface and user guide.

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1. Introduction

The METRO v3 interface user guide provides users with the necessary information to conduct standard experiments. It accompanies the *METRO v3 Model Documentation* (OECD, 2020) which contains the formal description of the base model, its database, and the modules.

METRO is a global computable general equilibrium (CGE) model derived from the Social Accounting Matrix (SAM) based CGE model GLOBE developed by Scott McDonald and Karen Thierfelder (2013). The model is a direct descendant of an early US Department of Agriculture model (Robinson et al., 1990) and NAFTA (Robinson et al., 1993), and follows trade principles from the 1-2-3 model (de Melo and Robinson, 1989; Devarajan et al., 1990). These models divide an economy into tradable and non-tradable goods, and link domestic and world prices through the tradable sectors. The METRO model is calibrated using an augmented Social Accounting Matrix (SAM) version of the GTAP database (for v9, see Aguiar et al., 2016; for v10, see Aguiar et al., 2019).

Technical and licence requirements

Software

- GAMS: Install the latest version of gams.
- The interface requires the installation of Java 8 run time environment (JRE[1], freeware)

Licenses required to run METRO

- GAMS: The model is an MCP model and uses the PATH solver for most applications. It is also possible to use the CONOPT solver. Information and prices on licenses are available at GamsLicence.
- With the exception of the training aggregation, the user will need a license to use the GTAP database of the appropriate version (available at: gtapdatabase). The current model database requires a license for GTAP version 10.

1. https://www.java.com/en/download/manual.jsp#win.

The METRO model uses the GAMS software and consists of various GAMS files, (master, GMS, and include files, INC), and data files (GDX and XLSM). Due to its complex structure, the model is not easily accessible to users. As a result, graphical user interfaces (GUIs) were developed[1] to help navigate the necessary tasks and decisions required to set up, run, and analyse a model simulation. The model interface makes it is possible to run a simulation in METRO using only the interface and excel, and without needing to code in GAMS. The interface combines all possible model and database manipulations in a single place and stores these as metadata. This facilitates replicability. In addition, a comprehensive viewer displaying simulation results is available in the GUI interface.

[1] The interfaces are based on the existing "GAMS Graphical user Interface generator" package developed by Wolfgang Britz (GGIG, Britz, 2010a/b and Britz 2014a), and used in various GAMS based models such as PEM (OECD, 2001), CAPRI (Britz, 2013), GTAP (Britz, 2014b).

There are two GUI interfaces: the first (*"MetroAgg_GUI"*) prepares a version of the database to be used in simulations; the second (*"Metro_GUI"*) is where users will run the model simulations and post-calculations.

Specifically,

- The aggregation programme *"MetroAgg_GUI"* creates a study-specific database from the 65 sector, 8 factor, 65 region METRO database (Section 3);
- The new aggregated database is then used in the model interface "METRO_GUI" to run an experiment via two substeps: calibration and simulation (Sections 4 and 5). It is also possible to derive an Inter-Country Input-Output (ICIO) table and Trade in Value Added (TiVA) indicators as a post-simulation analysis (Section 7).

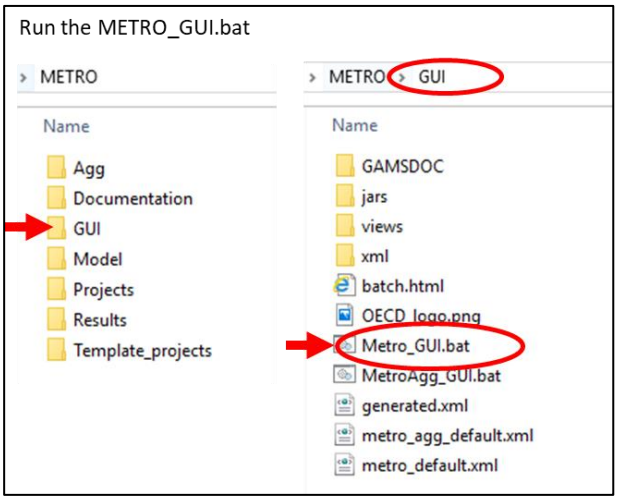
2. Working with the GUI

2.1. Setting up the GUI

The GUI[2] requires a Java 8 run time environment (JRE,[3] freeware). Please ensure that the 64-bit version of the JRE on 64 bit operating systems is installed. After having unzipped the file containing the METRO model, navigate to the GUI folder. This folder contains two GUI programmes:

- the METRO model GUI "Metro_GUI.bat", and
- the database aggregation programme "MetroAgg_GUI.bat".

The distribution version of the METRO model contains a small database with five regions, five sectors, and eight factors. As such, the aggregation programme can be ignored for the moment.



To open the METRO model interface, double-click on the file "Metro_GUI.bat" located in the GUI folder; This should open the interface indicated below:[4]

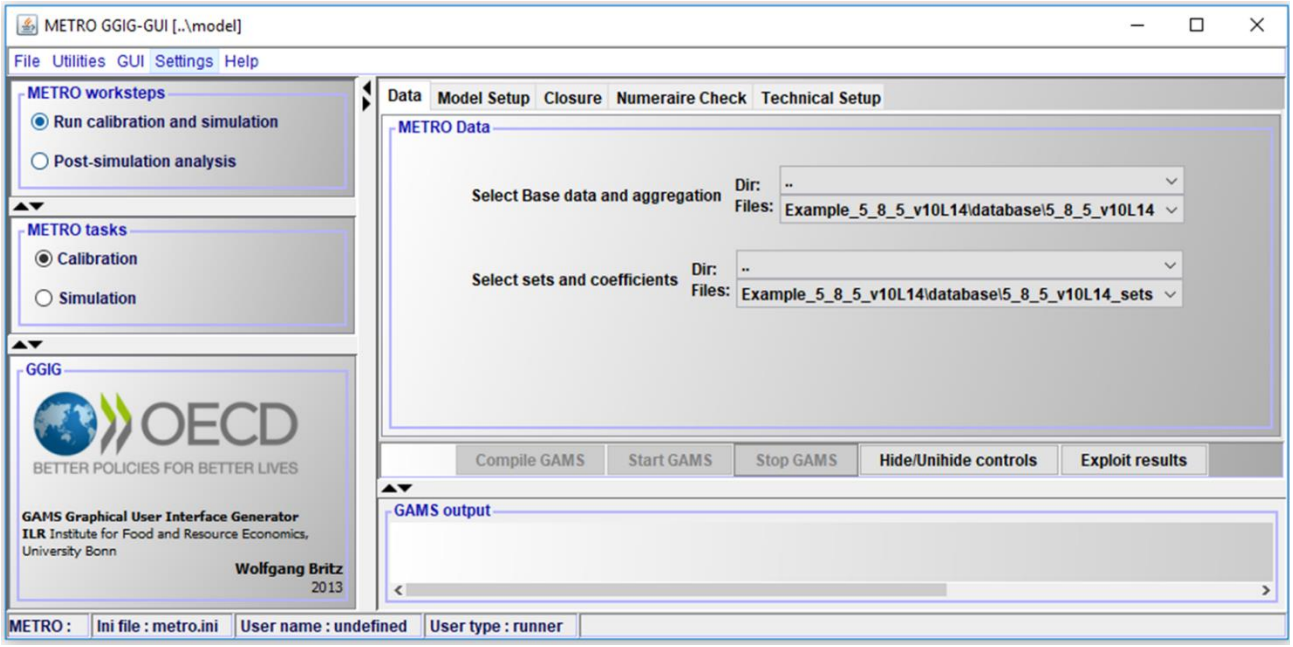
You might first see a message that asks you to enter the location of the GAMS executable (GAMS.exe). This warning can be ignored for now. After pressing "OK", you should see a programme open as below:

[2] This section is based on, and in large parts identical with, the related section in "GTAPinGAMS with a GUI" (Britz, 2014b).

[3] Available at https://www.java.com/en/download/manual.jsp#win.

[4] If this does not work, open a command prompt and navigate to the GUI folder. Start from the "METRO_GUI.bat" batch file and analyse the error. Most probably, JAVA was not found. In this case, either put Java in the proper location or edit the batch file in a text editor, and update the location of the "JavaRT" folder such that it calls Java from the directory where it is installed. For example, SET PATH=<*directory where folder is found*>\JavaRT\bin

Figure 1. Metro Interface at first start



Note: The layout shown in screen shots might not be identical to the distribution version.

The left hand side allows the user to select work steps (top box) and the tasks comprised in them (middle box). The controls to steer these tasks are located on the right hand of the interface. The bar in the middle is comprised of buttons to start the GAMS code or to exploit the resulting output.

Typical reasons why the ***GUI does not open*** and possible remedies:

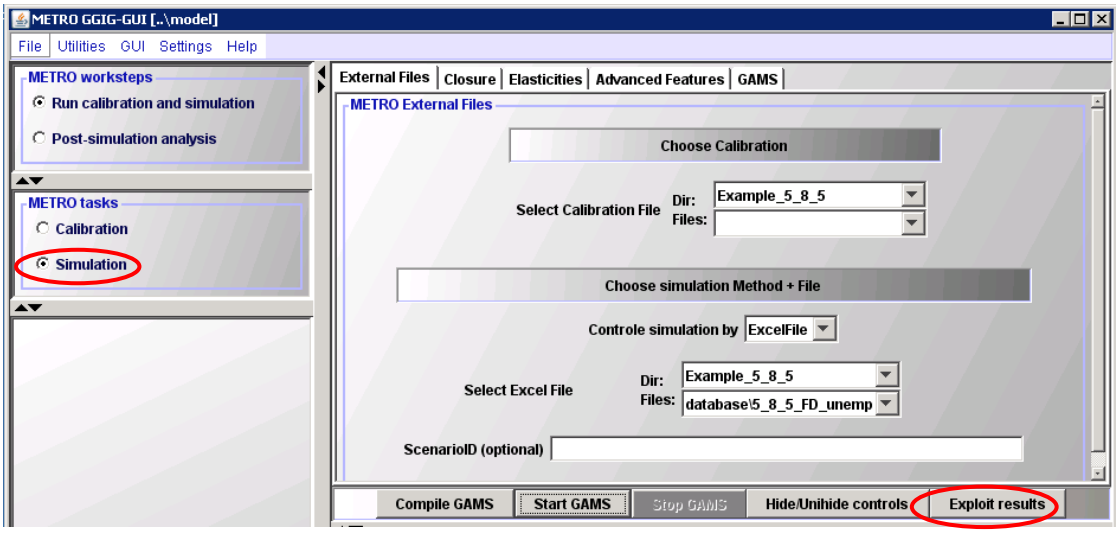
- *Java is not installed* or not registered on the PATH. To test if Java is installed, open a DOS prompt and type Java. If you receive a message that the command is not found, (re-)install Java and ensure that Java updates the PATH during the installation.
- A *wrong Java Runtime Environment* is installed. Please first check if Java version 8 is installed (this check is useful for the GUI of METRO as well as for general security reasons if one uses Java plugins from web pages). On 64 bit Windows operation systems, a 64 bit version of Java should be used. You can test this again in a DOS prompt by typing "java version". The response should look similar as shown below (note the string "64-Bit"). Unfortunately, many 64 bit Windows machines use a 32 bit browser, and if you install Java from such as browser, the 32 bit version is downloaded. As the link JRE points both to a 32 and 64 bit version, make sure the 64 bit version is selected for a computer with a 64 bit OS. Installing a 64 bit version on a computer where the 32 bit version is already installed does no harm and makes the 64 bit version the default.
- If you recently updated your path to Java, a restart of your computer may be required.
- If this still does not help, open a DOS prompt, navigate to the GUI folder and type "Metro_GUI.bat"; possible errors will be shown in the window.

General information on how to work with the GUI can be found in the GGIG user guide at http://www.ilr.uni-bonn.de/em/rsrch/ggig/GGIG_user_Guide.pdf. The PDF document can

also be found in the folder "GUI\jars" in your installation. Please note that the hints given below on using the interface should be considered as a first introduction. Refer to the GGIG user guide for further details.

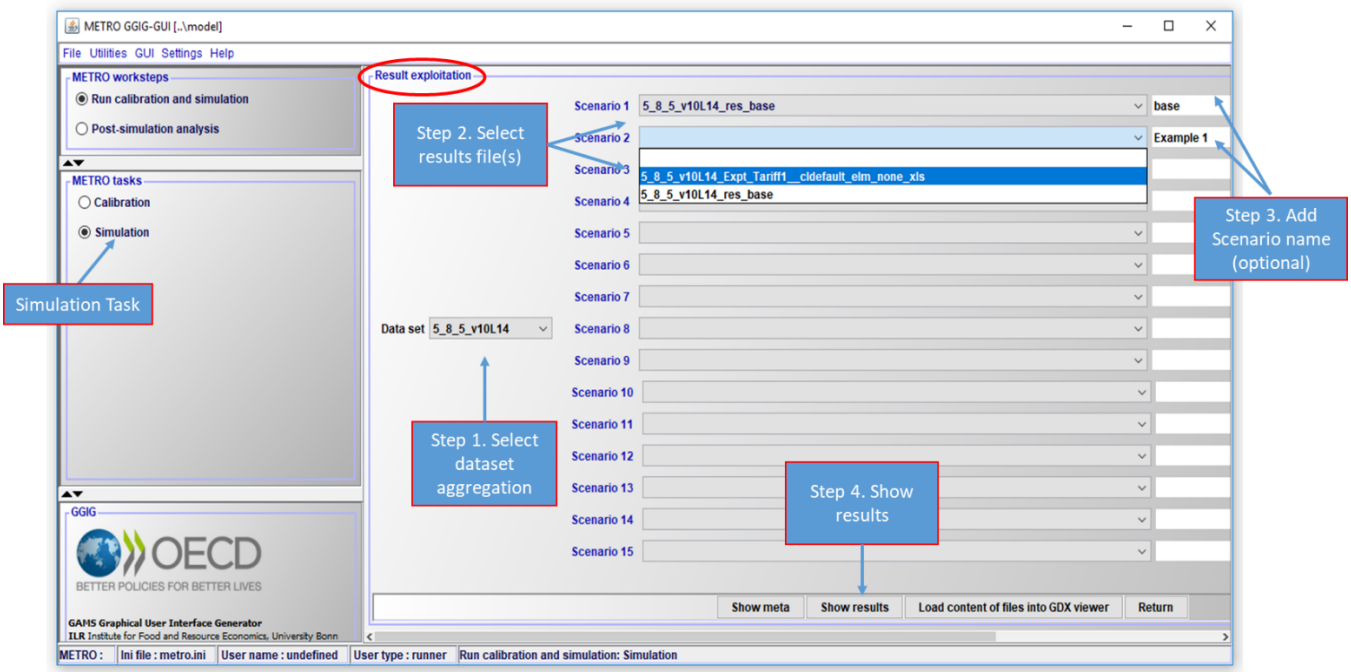
2.2. First steps

The installation includes a set of simulation results to test the interface without the need to run the GAMS code. You can immediately explore these results in the data viewer by selecting on the left hand side the task "Simulation" and then pressing the "Exploit results" button.



Once you select "Exploit results", the layout of the right hand side of the interface will change as seen below. It will now contain the "Result exploitation" section. To select results to view, first select in the drop-down menu labelled "datasets" on the left hand side of the "Exploit results" section, the aggregation dataset used for the calibration and simulation runs (in the example below: "5_8_5_v10L14"). Only scenarios resulting from a simulation or calibration which used the same data set as an input are available for comparison.

Once you select the data set (aggregation) in the boxes labelled "Scenario #", select the data sets of the scenarios you want to view. For scenario 1, select from the drop-down menu the file containing the base data "5_8_5_v10L14_res_base". This file is created during the calibration run. It is possible to give the scenario a name (e.g. "Base") in the text field to the right of the scenario. For scenario 2, select from the drop-down menu the data set that contains the simulation results (in the example below, the file name is "5_8_5_v10L14_res_Expt_Tariff1_clbase_elaMult_none_xls"). In the example, this scenario is named "Example 1". The names of the scenarios given in the text boxes on the right (in our example: "Base" and "Example 1") will be used to refer to the associated data sets in the results viewer.

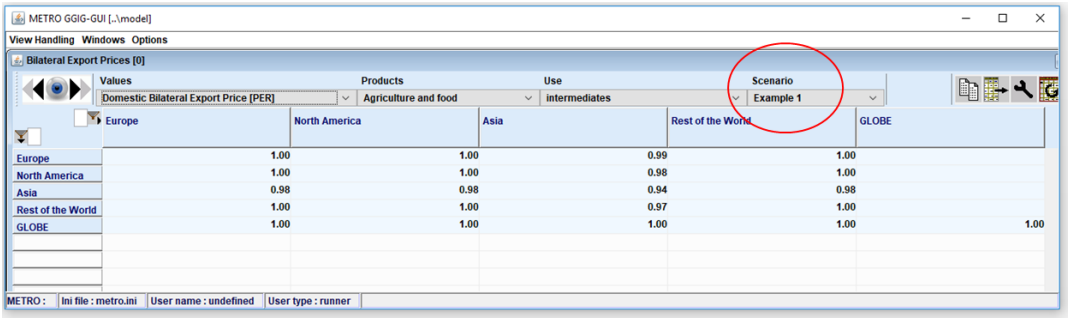


Note that once you have produced your own simulation results, you will find the base data and scenarios generated in the drop-down boxes (on the "Result exploitation" screen). You also may include multiple scenarios in the data viewer for comparison.

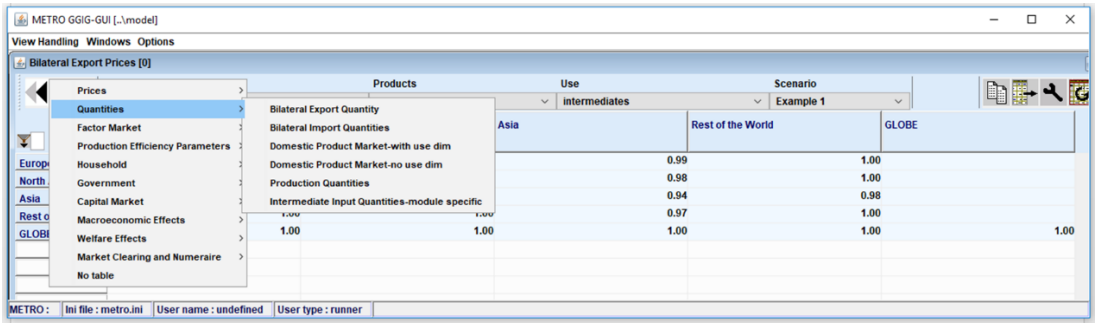
Press "show results". You are now in the data viewer. If this is the first time you are opening the viewer, you might see a blank view like the image below. Click on "View Handling" on the menu bar in the top left corner, and then select "New Data View".



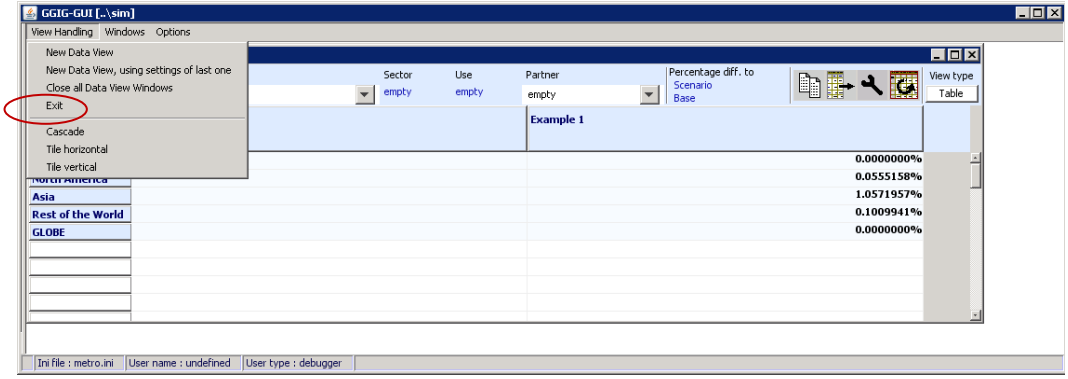
A table similar to the one below should appear. You can rearrange the dimensions of the view via the drop-down menus. In the example below, you can chose to view the Domestic Export Price in the simulation results by selecting "Example 1" in the Scenario drop-down menu. Recall that "Example 1" was the reference name we gave to the Scenario 2 file in the previous screen of the interface, but that the real file name for "Example 1" is "5_8_5_v10L14_res_Expt_Tariff1_clbase_elaMult_none_xls".



The "" view button in the upper left corner allows you to select different tables to view. In the example below, we see that several result tables related to quantities are available, including Bilateral Export, Import Quantities, and Production Quantities.



To exit the results view and return to the "Result exploitation" screen, click on "Exit" under "View Handling". If you click on the "x" button located in the top right hand corner, you will completely exit the interface.

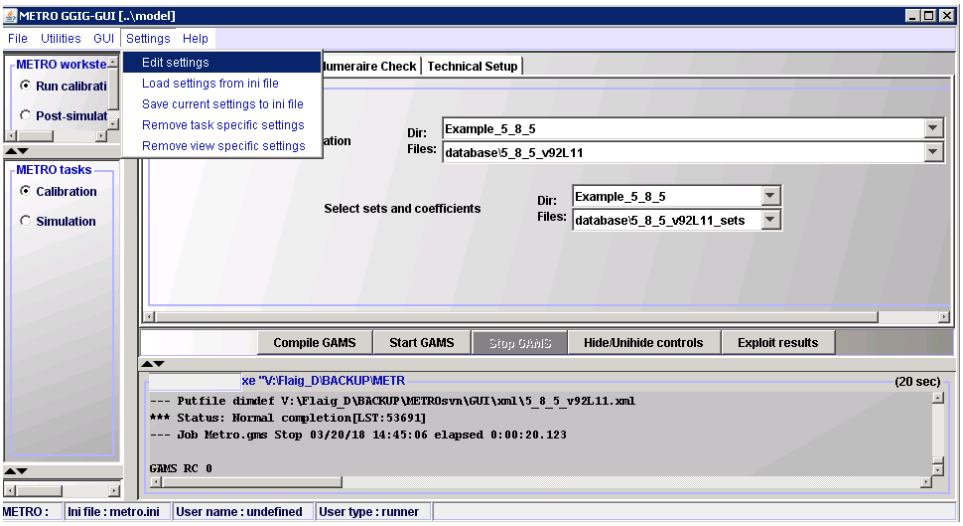


Instructions on how to produce simulation results are found in Sections 3-5. Detailed information on the different views and the use of the viewer is given in Section 6.

2.3. Making the interface work with GAMS

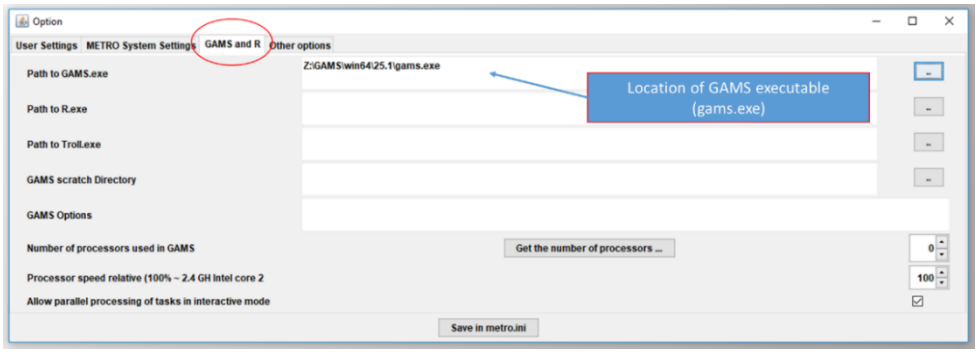
In order to use the GUI to generate data sets or to run simulation, you must first register a GAMS executable. This is done on the main interface screen. If you have not done so already, exit the results viewer by clicking on "View Handling" in the menu bar then select "Exit". If the menu bar is not available when exiting the viewer, you can either maximise or minimise, or switch back and forth between the METRO tasks.

In the interface, open the "Settings" dialogue from the menu bar, click on "Edit Settings":



Next, click on the tab "GAMS and R" and type in the text field next to "Path to GAMS.exe" the directory location including the file name of the gams executable file (gams.exe). Alternatively, you can use the button to the right of the field to navigate to the directory where "gams.exe" is found. Click the "Save in metro.ini" button. Exit the window by clicking on the "x" on the top right corner.

TIP: *Be sure to enter the full path and file name as shown below. Also be sure to choose GAMS.EXE and not GAMSIDE.EXE (the user interface of GAMS).*

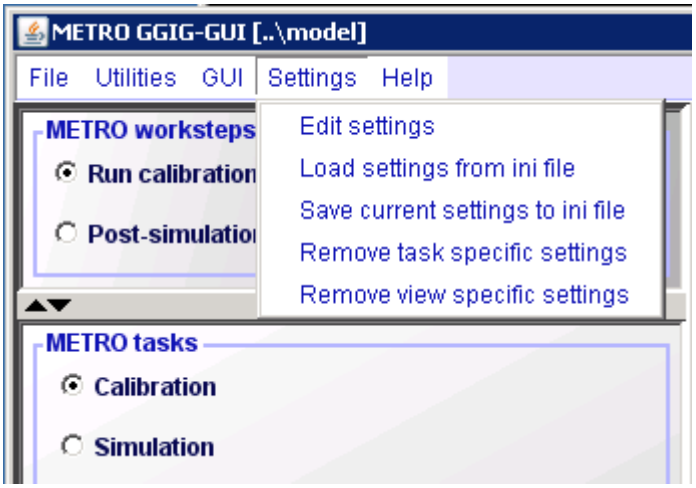


In order to check if the registration has worked, select the "Calibration" task, and then press the "Compile GAMS" button. You should see the compile output from GAMS in the window below the button.

***TIP**: The interface assumes your GAMS license file, which includes the PATH solver for MCP models, is located in the same folder as the GAMS application. If this is not the case, enter the following in the box "GAMS options": License=* location\gamslice_name.*txt where* location *is directory location of the license file and* gamslice_name *is the file name of your license for GAMS with the full version of the PATH solver.*

2.4. Reset to default setup and storing settings

When you want to return to the default settings, select the "Calibration" task, then click on "Settings" in the menu bar and select "remove task specific settings".



***TIP:** This feature is especially useful when you face execution errors or if you feel the interface is no longer working properly.*

You can also save current settings in an ini file ("Save current settings to ini file") and load these later ("Load settings from ini file"). "Remove view specific settings" brings the viewer back to the default settings.

3. METROagg GUI: Data base aggregation

In Brief: Preparing an aggregation database

1. In the 'Projects' directory, prepare a project folder with the following subfolders: 'build_data', 'database', and 'scenarios'
2. Prepare the aggregation input excel file (this is done outside the interface).

   Use the example file '5_8_5_v*DVB*.xlsm' as a template by adjusting the file to match your aggregation (details below) and save it under a new name in the "build_data" folder of the appropriate project directory. "*DVB*" in the file name refers to the version of model database you would like to use+
3. Open MetroAgg_GUI.bat: select aggregation input file and database; press 'Start GAMS'.
4. The aggregation output is directly sent to the project-specific directory containing the input files for the model (\Projects*folder name*\database), where *folder name* is specified by the user.

+The folder "Projects\Example_5_8_5v10L14\build_data" contains the template for use with METRO database version 10L14. The template for METRO database version 92L11 is found in the folder "Template_projects\Example_5_8_5_v92L11\build_data".

3.1. The database

The most recent version of the METRO model database is v10L14.[5] This version contains information on 65 sectors, 8 factors, and 65 regions.[6] Table 1 lists country, sector and factor coverage. The reference year is 2014.

The database is stored in a Social Accounting Matrix (SAM) format as a GDX file. The database is based on GTAP (v10, Aguiar et al., 2019), augmented with data on trade by use (sourced from OECD and UN Comtrade). It also includes several elasticities based on GTAP data and other side accounts, such as remittances data from the GMig database (Walmsley et al., 2005). Please refer to the METRO model documentation for a more detailed description of the METRO database.

[5] Both versions v92L11 and v10L14 databases are available for use with the model and interface. For a description of v92L11, see the *Model Interface v2B User Guide*.

[6] The 65 regions includes Rest of World and Globe. Rather than being a true region, the Globe region is a technical item serving to distribute international trade and transport services.

Table 1. List of countries and sectors in METRO database v10L14

Viet NamRegions				Sectors			
arg	Argentina	ltu	Lithuania	pdr	Paddy rice	bph	Basic pharma products
aus	Australia	lux	Luxembourg	wht	Wheat	rpp	Rubber and plastic products
aut	Austria	mys	Malaysia	gro	Cereal grains nec	nmm	Mineral products nec
bel	Belgium	mlt	Malta	v_f	Vegetables, fruit, nuts	i_s	Ferrous metals
bra	Brazil	mex	Mexico	osd	Oil seeds	nfm	Metals nec
brn	Brunei	mar	Morocco	c_b	Sugar cane, sugar beet	fmp	Metal products
bgr	Bulgaria	nld	Netherlands	pfb	Plant-based fibers	ele	Computer, elect & optical
khm	Cambodia	nzl	New Zealand	ocr	Crops nec	eeq	Electrical equipment
can	Canada	nor	Norway	ctl	Bovine cattle, sheep & goats, horses	ome	Machinery & equipment nec
chl	Chile	per	Peru	oap	Animal products nec	mvh	Motor vehicles and parts
chn	China	phl	Philippines	rmk	Raw milk	otn	Transport equipment nec
col	Colombia	pol	Poland	wol	Wool, silk-worm cocoons	omf	Manufactures nec
cri	Costa Rica	prt	Portugal	frs	Forestry	ely	Electricity
hrv	Croatia	rou	Romania	fsh	Fishing	gdt	Gas manufacture, distrib
cyp	Cyprus	rus	Russian Federation	coa	Coal	wtr	Water
cze	Czech Republic	sau	Saudi Arabia	oil	Oil	cns	Construction
dnk	Denmark	sgp	Singapore	gas	Gas	trd	Trade
est	Estonia	svk	Slovakia	oxt	Other Extraction	afs	Accomm, Food & service
fin	Finland	svn	Slovenia	cmt	Bovine meat products	otp	Transport nec
fra	France	zaf	South Africa	omt	Meat products nec	wtp	Water transport
deu	Germany	esp	Spain	vol	Vegetable oils and fats	atp	Air transport
grc	Greece	swe	Sweden	mil	Dairy products	whs	Warehousing & support act.
hkg	Hong Kong, China	che	Switzerland	pcr	Processed rice	cmn	Communication
hun	Hungary	twn	Chinese Taipei	sgr	Sugar	ofi	Financial services nec
ind	India	tha	Thailand	ofd	Food products nec	ins	Insurance
idn	Indonesia	tun	Tunisia	b_t	Beverages & tobacco products	rsa	Real estate activities
irl	Ireland	tur	Turkey	tex	Textiles	obs	Business services nec
isr	Israel	gbr	United Kingdom	wap	Wearing apparel	ros	Recreational & other services
ita	Italy	usa	United States	lea	Leather products	osg	Public Admin & defense
jpn	Japan	vnm	Vie Nam	lum	Wood products	edu	Education
kaz	Kazakhstan	row	Rest of the World	ppp	Paper products, publishing	hht	Human health & social work
kor	Korea			p_c	Petroleum, coal products	dwe	Dwellings
lva	Latvia			chm	Chemical products		

a) 1. Note by Turkey:
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
2. Note by all the European Union Member States of the OECD and the European Union:
The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Table 2. List of factors in METRO database

Land	Land	tech_aspros	Technical and Assistant Professionals
Capital	Capital	clerks	Clerks
NatRes	Natural Resources	service_shop	Service and shop assistants
		off_mgr_pros	Office managers and Professionals
		ag_othlowsk	Agricultural and other low skilled workers

3.2. Prepare your own aggregation

For an analysis, the user typically defines a project specific aggregation of the 65 sector, 65 regions, 8 factor database. There are two main reasons for this (McDonald and Thierfelder, 2014): 1) if the database is not aggregated, the resulting model would be too large with respect to computer capacity and would yield results that would be not be practical for analysis and interpretation; and 2) models should be focused on specific issues rather than a general overview. Part of this process lies in the identification of the appropriate aggregation for the specific purpose at hand. Once this is determined, the user specifies the aggregation and the related mappings in an excel file. The full database is then aggregated with the MetroAgg GUI interface, which uses this excel file and the full disaggregated database as inputs.

As noted above, two data versions are available. Version 92L11 includes 57 sectors, 61 regions, and 8 factors with the reference year 2011. Version 10L14 includes 65 sectors, 65 regions, and 8 factors with the reference year 2014. Since sector and region coverage of the two versions differ, it is necessary to use the appropriate template.

Model databases, the interface, and the user guide

There are two available model database versions:

- METROsam_57_8_62_v92L11.gdx, which is based on GTAP version 9.2 with reference year 2011.
- METROsam_65_8_65_v10L14.gdx, which is based on GTAP version 10 with reference year 2014.

In addition to the reference year, the available sectors and regions also differ between these two versions.

The METRO interface functions seamlessly regardless of the model database used as an input. The exception is when users create an aggregated database for an analysis. Because of the differences in the available sectors and regions, users must take care that the excel template used in the aggregation step is for the appropriate model database version (see Section 3.2). The instructions to create the aggregation using the interface is the same for both database versions. Similarly, the process to run the experiment is also the same.

3.2.1. *Available example project folders*

A set of example project files are provided with the standard model to help you set up your own experiment. The selection of the example to use as your template will depend on the following: 1) the version of the model database used; and 2) whether the land allocation module is activated. The table below offers an example folder for each situation.

	Input database version+	
Land allocation module Activated	v92L11	v10L14
No	Example_5_8_5_v92L11*	Example_5_8_5_v10L14*
Yes	Ag_supply_DBv92_19_8_6	Ag_supply_DBv10_19_8_6
		Example_Ag_supply_DBv10*

* Includes an analysis database
\+ the basic template (5 regions, 5 sectors, 8 factors without the Land Allocation Module) for database version v10L14 is found in the "Projects" folder. The others are found in the "Template_projects" folder.

METRO model V3 introduces the land allocation module. It allows users to implement a nesting structure for land supplied among agriculture and forest sectors. For more detail on how to implement and set this up, see the Technical Documentation (TAD/TC/CA/WP/RD(2019)4/FINAL) and User Guide (TAD/TC/CA/WP/RD(2019)5/FINAL). Both documents are found in the "Documentation" folder.

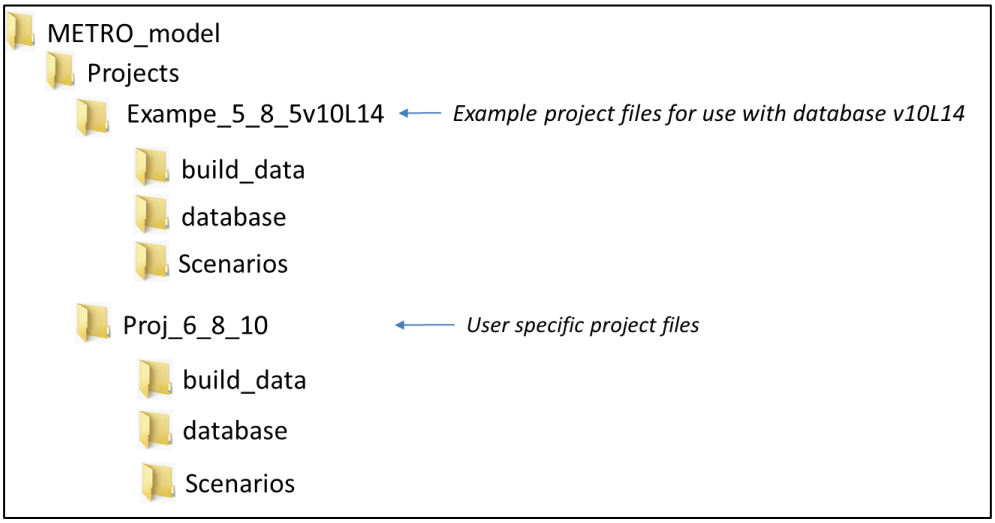
Several templates are available for use with the Land Allocation Module. One set of files provides a template where all the available land-using sectors in the database remain disaggregated. The template creates analyses files with 19 sectors, eight factors, and five regions. Because the use of this template requires a GTAP license, the template project "Example_Ag_supply_DBv10" is based on a smaller set of sectors but maintains the same nesting structure. This example project also includes an analysis database with 10 sectors, eight factors, and 5 regions. See Annex Table 2, Annex Table 3, and Annex Table 4 for the list of sectors, regions, and factors.

3.2.2. *Creating a new project specific folder*

Before creating a new database aggregation, the user must set up the project space folders where the various inputs files will be stored (see Section 8). In the "Projects" directory, create a folder which will house all the folders and input files for the specific analysis. Note that each new project folder should have the same structure, identical to that of the example project folders ("Example_5_8_5v10L14"). In fact, you can use the template project folders as a template.

TIP: *Ensure the template matches the database version. The template aggregating 65 sectors and 65 regions is for model database v10L14, while the template aggregating 57 sectors and 61 regions is for model database v92L11.*

The first step is to create a folder for the project in the "Projects" directory. For example, if you were to run model simulations on a database with 6 sectors, 8 factors, and 10 regions, you could create a folder named "Proj_6_8_10" under the Projects directory. The name of the new folder is at the discretion of the user, but should not contain empty spaces. The new folder must include subfolders named 'build_data', 'database' and 'scenarios'.



The aggregation input excel file should be saved in the "build_data" folder. After running the aggregation program, the resulting aggregation database will be saved in the "database" folder.

3.2.3. *Aggregation input file*

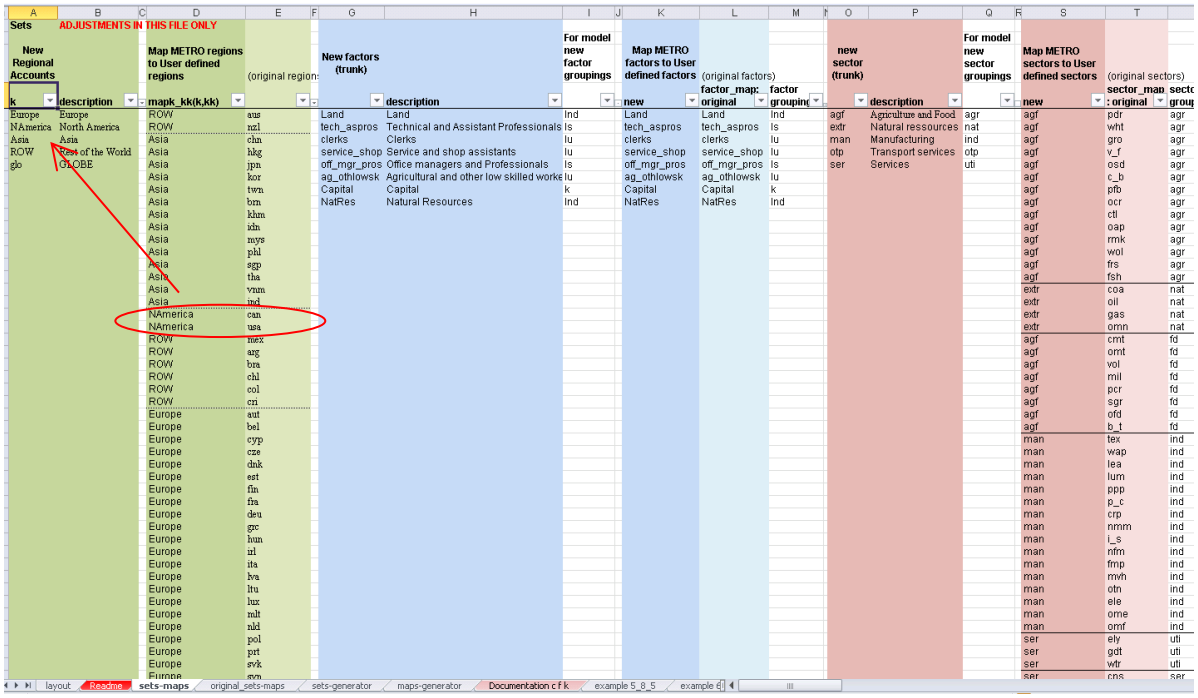
We recommend that users use the template files from the "Example_5_8_5" folders when starting a new project. Copy the excel template from the directory "Projects\Example_5_8_5_v10L14\build_data" into the "build_data" directory of your new project folder. Rename the file using the METRO model naming convention s_f_r_vDByy.xlsm where *s* is the number of sectors, *f* the number of factors, *r* the number of regions, and *DByy* refering to the version of the METRO model database (including reference year). For the project "Proj_6_8_10" which requires a new model database with 6 sectors, 8 factors, 10 regions using database version v10L and reference year 14, the excel file defining the new aggregation is named "6_8_10_v10L14.xlsm" and is located in the directory "\Projects\Proj_6_8_10\build_data".

TIP: *Be sure to save the file as an Excel Macro-Enabled Workbook (*.xlsm).*

Open the excel file and, navigate to the "sets-maps" worksheet. Enter your new regions and labels in columns A and B, respectively. Define your regional aggregation by entering the new regions in Column D for each region in column E. Entries in column D indicates where the region in Column E will be aggregated into. In the example below, "can" and "usa" are aggregated into the new region "NAmerica".

TIP: *The region "glo" should not be combined with any other regions and must remain in the new aggregation. Moreover, all regions in Column D should be listed in Column A.*

In the same manner, declare and label the factors (Columns G and H) and sectors (Columns O and P) that you would like in your new aggregation. Use Columns K and L to map the original factors (Column L) to new ones (Column K). Enter in Column S the new sectors into which the original ones (Column T) belong.



Navigate to the "Readme" sheet. Click on the button "Run STEPS 3 and 4" on row 60 to initiate the macro which will update the sets and maps on worksheet "sets-maps".

***TIPS**: These instructions assume you are able to use macros. The "Readme" sheet has another macro in row 26. Click on the button "Check set and map elements" to verify you have mapped all the original regions, factors, and sectors into your new definitions.*

Project-specific files and naming conventions

The model uses various project-specific excel and GAMS input and output files. These files follow a naming convention that help to navigate through the files. For example, the database used in the modelling exercise and produced with the MetroAgg GUI is identified in the filename by:

- the number of sectors (s), factors (f) and regions (r)
- the METRO database version from which it is derived
- the reference year.

Thus, the database used in this study is identified as: s_f_r_vDByy.

For example, the identifier 5_8_5_v10L14 refers to an aggregation with 5 sectors, 8 factors and 5 regions based on the METRO database v10L (where the "10" stands for the GTAP version from which it is derived and "L" stands for 5 labour categories). "14" is the reference year of the database (2014).

The user may add a study specific identifier (ID) at the end: s_f_r_vDByy_ID (e.g. 5_8_5_v10L14_DF).

When the "*METROAgg_GUI*" interface is used to create a new aggregation, the name of the new database is based in the name of the excel input file. For example, the input file "5_8_5_v10L14.xlsm" creates a database named "5_8_5_v10L14.gdx".

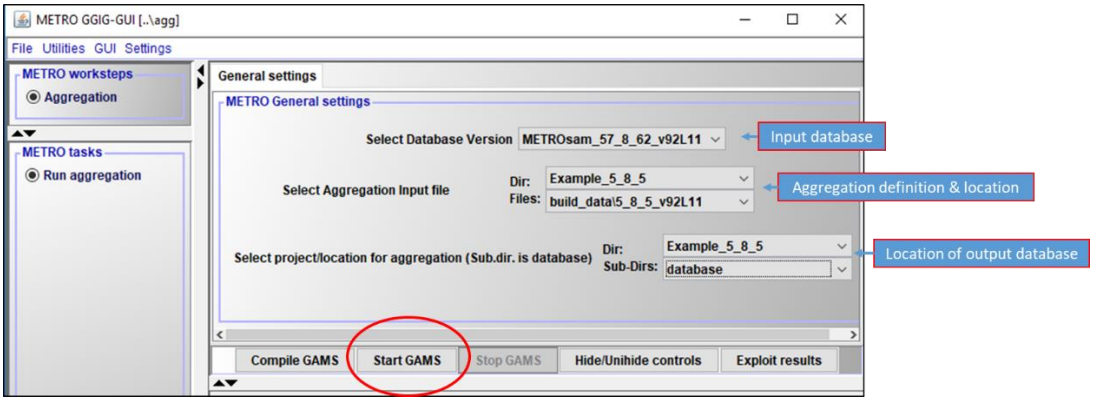
The table below includes a list of files that are study specific (for the Example_5_8_5_v10L14 project). Some files are created automatically, others might need user specification as indicated in the column named 'File and Status'.

METRO Task	File and status	Folder	Example
MetroAgg_GUI			
Aggregation	Adjustment needed: specify aggregation	Projects\Example_5_8_5_v10L14 \build_data	5_8_5_v10L14.xlsm
Aggregation	Automatically created: aggregate database	Projects\5_8_5\database	5_8_5_v10L14.gdx
Metro_GUI			
METRO Work steps: Run calibration and simulation			
Calibration	Adjustment needed: define model sets and mappings	Projects\Example_5_8_5_v10L14 \database	5_8_5_v10L14_sets.xlsm
Calibration	Adjustment needed: define unemployment rates	Projects\Example_5_8_5_v10L14 \database	5_8_5_FD_unemp.xlsx
Calibration	Adjustment needed if using Land Allocation module: define land nesting	Projects\Example_5_8_5_v10L14 \database	5_8_5_LandCET.xlsx
Calibration	Automatically created: calibration restart file Where • "***fm_Mobile***" indicates that factors are assumed to be fully mobile across sectors; Other options include "fm_Immobile" where factors are assumed to be immobile; and "fm_CET" indicates that the land allocation module has been selected (See section 4.3 for more information). • "**unemp_*ON/OFF***" indicates if full employment (OFF) or unemployment (ON) is assumed. • "**Calib**" indicates that the restart file (g00) was created from the calibration run.	Projects\Example_5_8_5_v10L14 \database	5_8_5_v92L11_fm_Mobile_unemp _OFF_Calib.g00
Calibration	Automatically created: template experiment file based on database aggregation	Projects\Example_5_8_5_v10L14 \Scenarios	Expt_base.xlsx
Calibration	Automatically created: result file *s_f_r_*vDByy_res_base.gdx Identifies the set of results in the base file.	Results\Simulation	5_8_5_v10L14_res_base.gdx
Simulation	Adjustment needed: definition of experiment files, excel or INC file *Expt_ID*.xlsx *Expt_ID*.inc Where "*Expt_ID*" is the experiment specific identifier chosen by the user	Projects\Example_5_8_5_v10L14 \Scenarios	Expt_*Tariff1*.xlsx; METRO_expt_*2TM_585*.inc
Simulation	Automatically created: result files *s_f_r_*v*DByy_Expt_ID_ScenarioID_*cl*closureID_*el am_*elastID_xls/gms*.gdx Where: • "**Expt_ID**" identifies the specific experiment (automatic and based on the experiment file name) • **"ScenarioID"** identifies the specific model run (optional and user specified in the interface) • *"***closureID***"* identifies the closure (optional and user specified in the interface) • "**elastID***"* identifies if and which elasticity is changed (automatic) *"**xls or gms**"* identifies if the simulation employed the excel file or the gams INC file (automatic)	Results\ Simulation	5_8_5_v10L14_Expt_Tariff1_exam ple1_clbase_elam_none_xls.gdx From the name above we know that: • The experiment was executed using the excel file: Expt_Tariff1.xlsx • No elasticity multiplier was used (elam_none) • The scenarioID is "example1" The closureID is "base"

Simulation	Automatically created: post simulation restart file *Calibration_restart_file_PostSim RestartID*.g00 • *"**Calibration_restart_file**"* is the calibration restart file selected by the user. • "**PostSim**" indicates that the restart file (g00) was created from the simulation run. • "**RestartID**" (optional) to distinguish between different simulations.	Projects\Example_5_8_5_v10L14\database	5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib_*PostSim*.g00 Note: "5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib_" is the name of the calibration restart file used for simulation
METRO Work steps: Post-simulation analysis			
ICO-TiVA module	Automatically created: Result files *s_f_r_vDByy_Expt_ID_ScenarioID_clclosureID_elam_elastID_xls/gms_ICIO*.gdx Note that the highlighted part of the file name is the results file from which the TiVA indicators are calculated. The ICIO suffix indicates that the file contains the TiVA indicators.	Results\ ICIO-TiVA	5_8_5_v10L14_Expt_Tariff1_example1_clbase_elm_none_xls_ICIO.gdx

3.2.4. *METROagg_GUI*

The aggregation database is created using the "MetroAgg_GUI" interface which is found in the GUI folder. Similar to the METRO_GUI, when opening the MetroAgg_GUI for the first time you might see a message asking you to enter the location of the GAMS executable. After pressing "OK", the interface will open as seen below. If you need to register a GAMS executable, do so in the "Settings"→"Edit settings" dialogue from the menu bar (see Section 2.3).



In the aggregation interface's main window "METRO General Settings", you must make three selections: 1) the input database to aggregate; 2) the input file that defines the new aggregation and its location; and 3) and the location of the new file (directory and subdirectory).

1. Select the input database to aggregate

   In the drop-down menu next to "Select Database Version", select the database you wish to aggregate. In the example above, the input METRO database is the version based on GTAP 9.2 (92) with 5 labour categories (L) and reference year 2011 (11). The instructions are the same when using other database versions.

2. Select the input file that defines your aggregation

   Select from a drop-down menu the main folder (Dir) where your project input files are located. In the example above, the project folder is "Example_5_8_5". Then select the excel file name that maps the original sectors, regions, and factors to your new aggregation level. In the above example, the file name is "5_8_5_v92L11". This file should be stored in subfolder "build_data".

3. Select location of new aggregated file

   First, select the main projects folder where your new database will be written to (Dir). Then select "database" as the subdirectory (Sub-Dirs). The new file must always be stored in the "database" subdirectory of your project folder. Accordingly, the aggregation programme will always create the new database in the "database" directory of your project – no matter which subdirectory you chose.

After selecting the input file and database, press the "Start GAMS" button. The process can take some time.

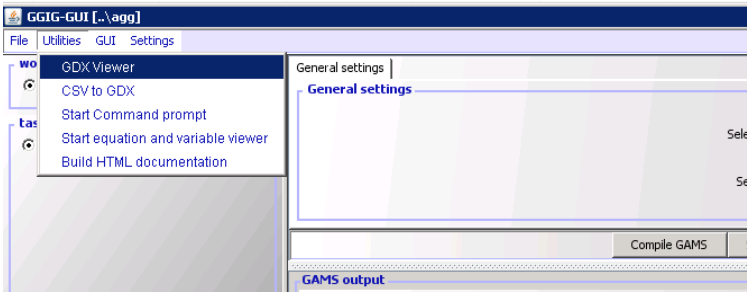
Once the aggregation process is complete, the output file will be directly stored in the "database" directory of the main project folder (for example, "\Projects\Example_5_8_5\database"). This location is where the model simulation interface will look for the input file. If the file does not show up as "choice" in the simulation interface, there is likely an error in the aggregation input file and, as such, the aggregation programme did not finish.

TIP: *If you have an error, this is most likely caused by a mapping error or a typo in the input excel file, as this is where changes have been made in producing the specific aggregation. First, check the input excel file. The gams LST file can also help you determine the source of the error. Open the LST file in folder "Agg" and look for the first error statement, typically at the top of the file. Also, be sure that the input excel file matches the database version that you are aggregating. The regions and sectors in the excel file must match the input database.*

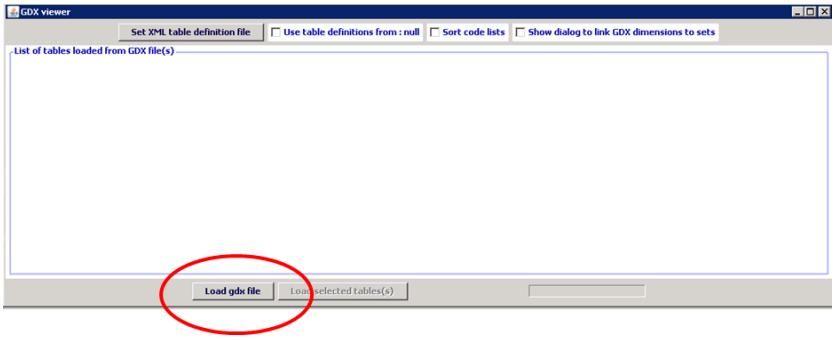
If this does not help you can search the error with the help of the GAMS aggregation programme. Open GAMSIDE. Close all files in the IDE. Create a new project in the "Agg" folder. Open GAMS file METROsam8107_agg.gms. Run the programme by pressing F9 on the keyboard. The programme will abort and a window will pop up. Scroll up to the FIRST error message in red and double click on it. This will show the element causing the error; verify and correct it in the aggregation input file. Repeat until there are no longer any errors.

3.3. GDX viewer

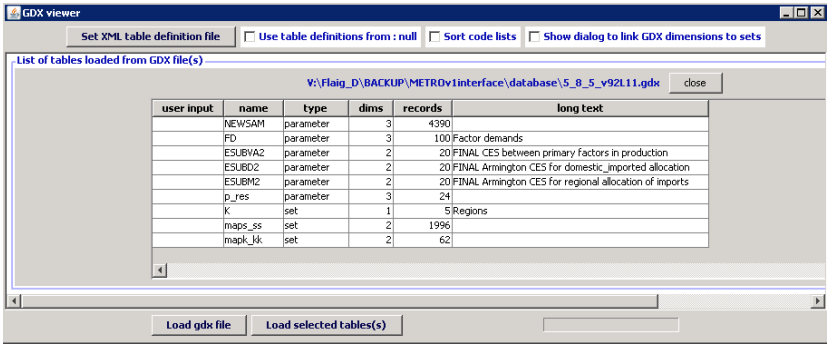
To view the output of the aggregation program, which is stored as GDX file, you can use the **GDX viewer** that is part of the interface. To open the GDX viewer, select "Utilities" and then "GDX Viewer" from the menu bar at the top.



The following view should open:



Click on "Load gdx file" at the bottom and navigate to the "database" directory where the aggregation output is stored. Open the GDX file with the name of your aggregation; the following view should show up:



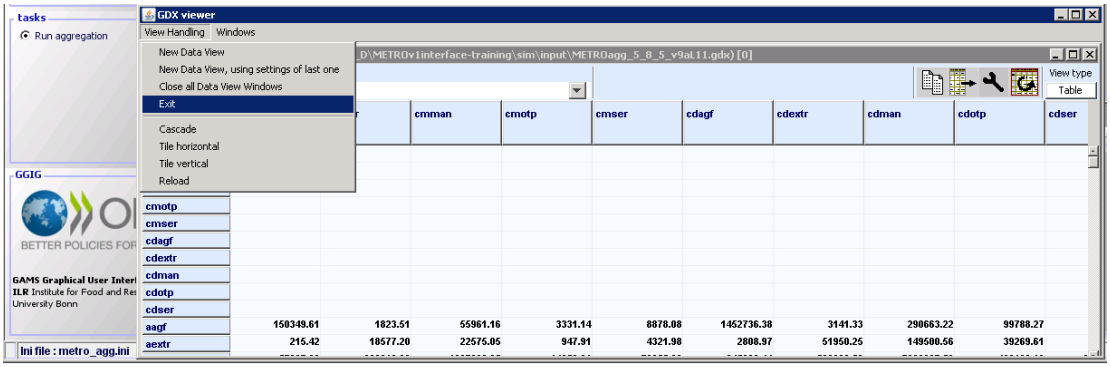
The file contains the following parameters and sets:

- Parameter
  - NEWSAMG: This is the aggregate database stored in SAM format, valued in million USD.
  - FD: Factor demand in number of workers by sector (in million).
  - ESUBVA2, ESUBD2, ESUBM2: GTAP Elasticities as indicated (weighted average).
  - ECET_PEM: Transformation elasticities from the OECD Policy Evaluation Model (PEM). The elasticities are used in the LAND Allocation Module.
  - p_res: This parameter contains two control parameters to check if the aggregated database is balanced and to indicate if the mapping is complete. SAMCHECK shows the difference between row and column sums, and SAMCHECK2 the difference between the total value of the original database and the total value of the aggregate database.

TIP: *In general, the values should be small; SAMCHECK2 should be around -0.001 and SAMCHECK should be smaller. If there are larger values there is an error in the aggregation input file*.

- Four sets:
  - Set k lists the regions in the aggregation.
  - Set kk lists the original 65 regions (before aggregation)
  - maps_ss maps the original elements of the SAM to the elements in the user aggregation and thus identifies, e.g. how sectors and factors are aggregated
  - mapk_kk shows how the 65 original regions are aggregated

You can view several elements by double clicking in the respective rows. The viewer works in a similar fashion as the viewer used for the results. To return to the overview and select a different element, click on “View Handling” and “Exit”.



4. METRO GUI: Calibration

In Brief: Calibration run

1. Outside the interface, within your project's "database" folder, prepare the following excel files: sets and coefficients file; the unemployment file; and if applicable the excel file describing the land allocation nesting.
2. In the "Data" tab of the interface, select the database (aggregation produced with MetroAgg_GUI.bat) and sets and coefficients file in their respective directory locations.
3. In the "Model Setup" tab, select modules; set elasticities and small shares (optional).
4. In the "Closure" tab, select unemployment box ON or OFF in the drop-down menu and select the factor market closure (other closure setups do not need adjustments at this stage).

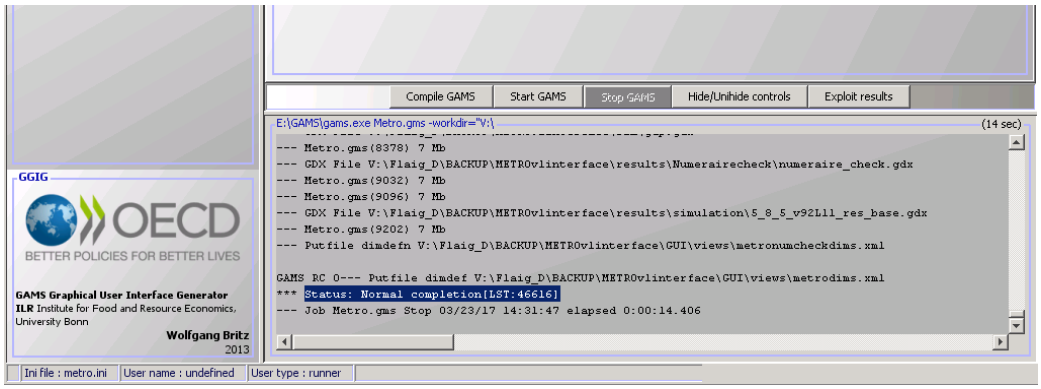
   Note: Selecting "CET" as the factor market closure activates the Land Allocation module. In this case, you will also need to select the excel file for the module.
5. Press "Start GAMS".

The user can run a numéraire check in tab "numéraire check" and view results via the button "exploit results"

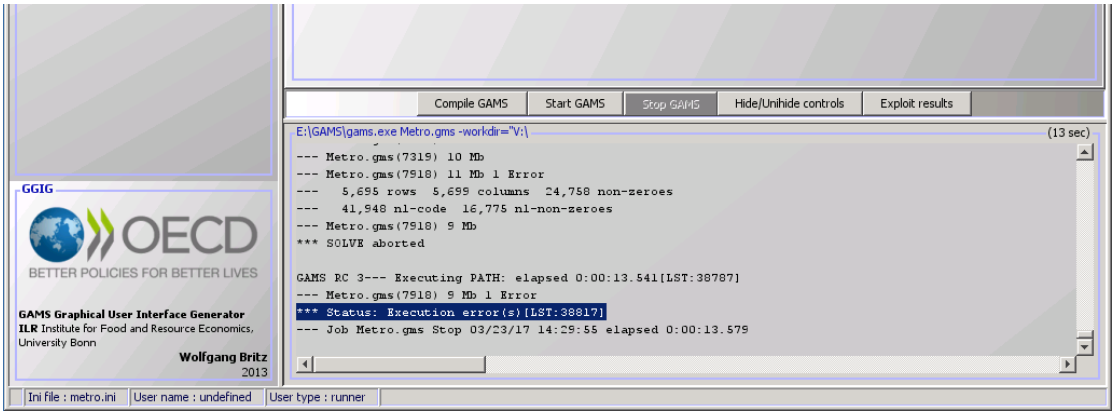
The tab "Technical Setup" normally does not need adjustment.

Two tasks – calibration and simulation – build the model. Both are available when the user selects the "Run calibration and simulation" radio button as the METRO work step on the left panel. The first task is calibration in which the model is defined and the parameters are calibrated to replicate the database. This task also produces the base data (gdx) used as a reference for comparison against simulation outcomes when analysing the results. It also produces a parameters file (g00) which will be used as an input into the simulation task.

The calibration task contains five tabs which are described in detail in the subsections below. For now, you can run the calibration of the example project by pressing "start GAMS". It will create the calibration parameters file and base outcome data set. With the default setting, the model calibration should run without errors, exit with a solution found and end with a "normal completion".



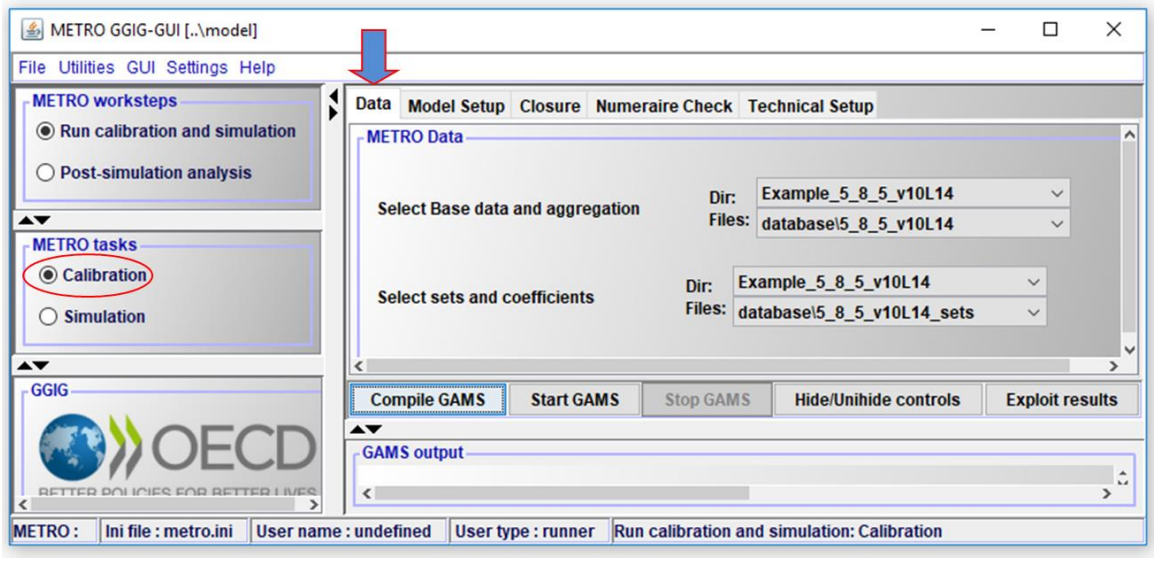
If the calibration is not successful, you will receive a statement similar to the one below:



TIP**: If you have an error, check the model setup. For example, check if the closures are correctly specified and that you are using the correct database and data excel file. There could also be an issue with the data input files. For example, you will have an error if the element names in the excel file do not match what is used in the database. To test this, reset to default settings and rerun the programme; if there is still an error, it is in the database and/or the excel file you are using. Alternatively you can open the "METRO.lst" file in "Model" directory and search for "$$$$" and "*". This will show you why the programme aborted.*

4.1. Calibration tab: Data

On the "Data" tab, users select a previously produced input database at the desired level of aggregation including the file and its directory location. The user also chooses the file containing the definitions of sets and coefficients in the project specific directory. The sets and coefficients file must be at the same level of aggregation, and refer to the same names and definitions of sets and elements as the selected database. For example, if the new database aggregates all European countries into the region "Europe", the sets and coefficients excel file must refer to the region "Europe" and not the individual member countries.



Both the aggregated database and the sets and coefficients files, which are the main inputs to the calibration task, must be produced before running the calibration. See *Section 3 METROAGG GUI: DATA BASE AGGREGATION* for instructions to create an aggregated database. Note that each time a database is created with a new level of aggregation, the user must also prepare the corresponding "sets and coefficients" excel file.

4.1.1. *Sets and coefficients file*

The "sets and coefficients" excel file has many purposes. It contains the sets and maps used by the model. It is where you enter your own elasticities if you wish. It is where you would modify the value added nesting structure. Lastly, it is where you define the model numeraire.

For each new project, you must create a "sets and coefficients" excel file in the database folder of the project. To create this file for a new project, it is recommended that you use the template provided in the standard model. To begin, copy the template excel file "5_8_5_v10L14_sets.xlsm" from the "Example_5_8_5_v10L14\database" folder into the "database" folder of your project. Rename this file using the METRO model naming convention s_f_r_vDByy_sets.xlsm, where s refers to the number of sectors, f the number of factors, r the number of regions, vDB refers to the version of the input database, and yy is the reference year of the database. The "_sets" suffix in the file name tells the interface that it contains the sets and coefficients definitions.

TIP 1*: If you receive a security warning that the "macros have been disabled", click on the "Enable Content" button. Otherwise, you will not be able to use the macro features to update the file.*

Sets and mappings

The sets and mappings in this file must correspond to the region, sector, and factor aggregation and definitions of the associated database. Therefore, any changes to the aggregation level of the database must also be made to the sets and coefficients file before any simulation run.

The first step is to update the information on the "Readme" worksheet so that the region (Column A), sectors (Column D), and factors (Column H) reflect your model aggregation. The nomenclature in this file must match the one in the corresponding model database. The next step is to add the appropriate descriptions in Columns B, E, and I. These descriptions are used when viewing results in the interface. Users may want to copy elements and descriptions from the "sets-maps" worksheet in the excel file used in the database aggregation (build_data\s_f_r_vDByy.xlsm) to ensure that the nomenclatures match.

Important! *Some sets have required elements.*

- *Regions "glo" and "row" should be the last two elements of the region accounts set.*
- *There must be at least one transport sector.*

Entries in Column F (sector subsets) allow the users to group sectors together when viewing certain results. It may be used when applying shocks and is used in the ICIO-TiVA module. There is a limited set of allowable values for this field (see table below). It is not necessary that all categories be used, although all sectors in Column D must be classified into a subset in Column F. Once you have defined your sector subsets, add the values you used in Column V along with its label description in Column W.

Table 3. Sector groupings

Subsets for new sector (Cols F and V)		Default labels (Col W)
agr	Agricultural Commodities or Activities	Agriculture
nat	Natural Resource Commodities or Activities	Natural Resources
fd	Food Commodities or Activities	Food
ind	Industrial Commodities or Activities	Industrial
otp	Transport Commodities or Activities	Transport
uti	Utility Commodities or Activities	Utilities
ser	Service Commodities or Activities	Services

***TIP**: There must be at least one sector (column D) grouped into the otp sector group (column F).*

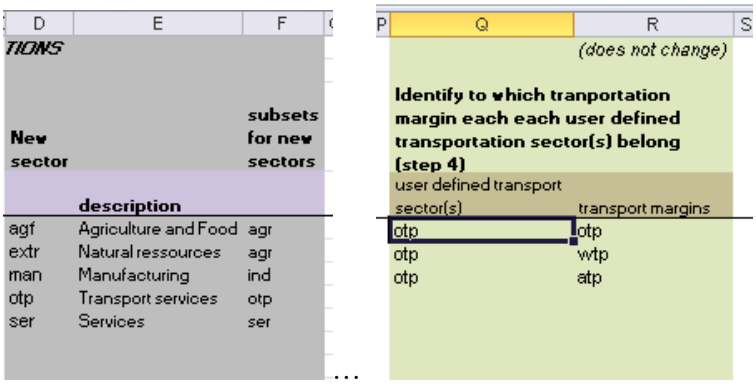
Similarly, create factor groupings. In column J. Use the values in the table below to create user defined groups.

Table 4. Factor groupings

Factor groupings (COL J)	
ls	Skilled labour
lu	Unskilled labour
k	Capital Factors
lnd	Land and natural resources

With the exception of the transport services sector group (*otp*), the sector and factor groupings are not used in the model, but could be used to group results or to create shock groups of sectors/activities.

Next, map transport margins to the transport services sector(s) in your new database. The model distinguishes three transport margins: water transport (*wtp*), air transport (*atp*), and other transport (*otp*), which are listed in column R. Map these three transport margins to the transport services sector(s) in your new aggregation by entering in column Q your defined transportation sectors (i.e., those found in column D). In the example below, there is only one transport sector in the new database (*otp* in Column D). In Column Q, the three transport margins in Column R are mapped to the only aggregate transport services sector (*otp*) listed in Column D.



Value added nesting

The value added nesting structure is defined in columns L-O. Column L defines the factors and aggregated factors in Level 1 of the value added nest. In our example below, we have defined the first level of the value added nesting as land (*fLand*), natural resources (*fNatRes*), and two aggregate factors: skilled labour (*fsc*) and unskilled labour (*funskl*). Note that in the columns defining your value added nest, the entries include the prefix "f" to indicate they are factors.

***TIP**: Elements in this set will either be primary factors listed in Column H, or elements which represent aggregated factors. In the example below, fsc and funskl are composite factors.*

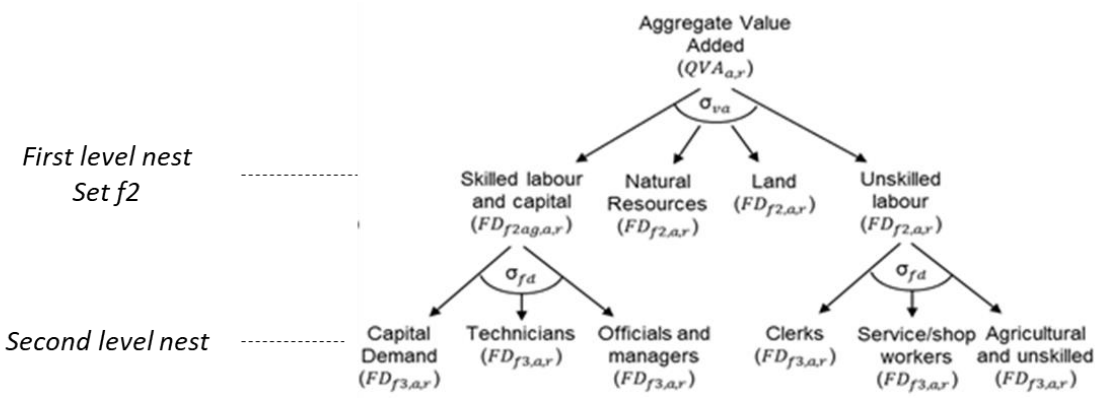
Once you have entered the elements in the first level of the nest, define the second level in columns N and O. In column O, enter all the factors in your model that are not part of the first level of the nest. In column N, enter the aggregated factors of Level 1 that will demand each natural factor in column O. In the example below, demand for unskilled labour (*funskl*) in Level 1 is supplied by either clerks (*fclerks*), service and shop assistants (*fservice_shop)*, or agricultural and other low skilled workers (*fag_othlowsk*).

***TIP**: All entries in column L, N, and O must start with the prefix "f". All natural factors in column H must be listed in either column L or Column O, but not both.*

H	I	J	K	L	M	N	O	P
				prefix f		prefix f	prefix f	
New factors (aka natural factors)	**description**	**subsets for new factors**		**Define elements of first level nest (Step 3a)** **f2**	**description**	**Map natural factors from column H (to aggregated factors used in the first level nest (Step 3b)** aggregated factors	natural factors from col H	
Land	Land	Ind		fLand	Land	fsc	ftech_aspros	
tech_aspros	Technical and Assistant Professionals	ls		fNatRes	Natural Resources	funskl	fclerks	
clerks	Clerks	lu		fsc	Skilled	funskl	fservice_shop	
service_shop	Service and shop assistants	lu		funskl	Unskilled	fsc	foff_mgr_pros	
off_mgr_pros	Office managers and Professionals	ls				funskl	fag_othlowsk	
ag_othlowsk	Agricultural and other low skilled workers	lu				fsc	fcapital	
Capital	Capital	k						
NatRes	Natural Resources	Ind						

Below is a visual representation of the value added nesting defined in the example above.

Figure 2. Aggregated value added nesting example



Global numéraire

The final step is to identify the global numéraire. In Column T of the *Readme* worksheet, identify the reference region or regions. All entries must correspond to a defined region in the model database, i.e. listed in Column A.

Once all the necessary information on the *Readme* worksheet has been updated, you are ready to update the worksheets related to the sets and mappings in the model. Click the button in cell AD71 on the *Readme* spreadsheet with the label "Create sets and maps". The macro will use the information entered on the "Readme" worksheet to update all relevant information in the "sets and coefficients" file.

***TIP**: There is a macro in cell AD62 of the Readme worksheet that verifies the information entered. If you cannot run the macros, follow the instructions on the worksheet files "Instructions-sets", "Instructions-maps", "Instructions-Maps_SAMG" to update the information manually.*

Elasticities

In addition to the transaction data, the model requires a series of elasticities. So-called user defined elasticities are stored in the sets and coefficients excel file (see table below for the list). The elasticities are defined at the regional, sectoral, and in some cases the factor levels. Accordingly, the region, sector and factor definitions used in the elasticities worksheets must match the database definition.

To update the elasticities worksheet, run the macro that updates all the elasticities worksheets by clicking on the button "Update elasticity worksheets" in cell AD84. The macro will change the structure of the sheets to reflect the aggregation defined on the *Readme* worksheet. Once this is updated, you may update the default entries with your own information.

The standard model employs nine sets of elasticities which are supplied to the model from the sets and coefficients excel file. Some elasticities (trade and production) can also be sourced from GTAP. The GTAP-based elasticities are supplied in the model database, while the user-defined elasticities are supplied to the model from the sets and coefficients excel file. The user selects the source of the elasticities via the user interface (See Section 4.2.1 for more information).

***TIP**: The structure of these worksheets must be updated, regardless of whether you use the GTAP or your own elasticities.*

You are advised to execute the macro that updates the worksheets before entering your own elasticities. The macro updates these worksheets and pre-fills the information with a default value which over-writes anything previously entered.

User defined elasticities for the Land Allocation Module are set in a separate spreadsheet. See section 4.3.2 for more information.

Table 5. Worksheets to update for a new database aggregation

Worksheet	Description	Fig.* notation		Notes
1. sets	Sets used in the model	na		No user intervention required if using macro.
2. maps	Maps used to links sets	na		No user intervention required if using macro.
3. maps_SAMG	Maps used to links sets	na		No user intervention required if using macro.
4. mod_sets	aleon, rleon	na	Sets to control production structure Level 1	Must manually update if appropriate.
Elasticities worksheets				
Import Substitution Elasticities[1]				
5. comelastm	Elastm (commodity, region)	$\sigma^{I}{}_{c,u,r}$	Elast. for Armington CES functions- the elasticities of substitution between aggregate imports and domestic commodities. *GTAP equivalent: ESUBD2=2*ESUBM2*	Update table structure by clicking the button "Update elasticity worksheets" in cell AD84 on the *Readme* worksheet. Update with user defined elasticities only after running macro.
6. comelastrm	Elastrm (commodity, region)	$\sigma^{II}{}_{c,u,r}$	Elast. for Armington CES over regions- the elasticities of substitution between aggregate imports from different regions. *GTAP equivalent: ESUBM2*	
Export Transformation Elasticities[2]				
7. comelaste	Elaste (commodity, region)	$\Omega^{I}{}_{c,u,r}$	Elasticities for CET functions- the elasticities of transformation between aggregate exports and domestic commodities	
8. comelastre	Elastre (commodity, region)	$\Omega^{II}{}_{c,u,r}$	Elast. for CET over regions - the elasticities of transformation between aggregate exports to different regions	
Production Function Elasticities[3]				
9. actelastx	Elastx (activities, region)	σ_x	Elasticities for CES production function Level 1- the elasticities of substitution between aggregate intermediate inputs and aggregate value added	
10. actelastva	Elastva (activities, region)	σ_{VA}	Elasticities for CES production function Level 2- the elasticities of substitution between primary inputs. *GTAP equivalent: ESUBVA2*	
11. actelastfd	Elastfd (factors & aggregate factors, activities, region)	σ_{fd}	Elasticities for CES production function Level 3	
Linear Expenditure System Elasticities[4]				
12. frischelast	Elastf (region, household[5])	na	Frisch parameters for LES demand system	
13. incelast	Elasty (commodity, region)	na	Income elast. of dmd for LES demand system	

Notes: the remaining worksheets are either instructions, the layout worksheet to read the file into GAMS, or used only when not using the METRO Model User Interface.
* See "Tree" structures at the end of this User Guide.
1. In the GTAP model substitution elasticities are common across regions and differentiated only by commodity. Aggregation is by weighted average.
2. There is no equivalent to the CET elasticities in the GTAP model because of differences in behavioural assumptions. When CET elasticities for the model are derived from the GTAP database, they are in fact based on the GTAP Armington elasticities.
3. In the GTAP model, the top level of the production nest is fixed as Leontief, i.e. zero substitution elasticities. When CES elasticities are derived from the GTAP database, they are in fact based on the value added substitution elasticities used by GTAP.
4. Supplied only from Excel, and require you to provide both income elasticities of demand and Frisch elastcities. The default values for ELASTY and ELASTF are all (minus) one. This is a special case whereby the LES utility functions reduce to Cobb-Douglas utility functions for all regions.
5. This table may be slightly confusing because of the additional column of labels – "hous" – but since there is only a single household in each region for the GTAP model, this is only included for model convenience and (future) flexibility.

Elasticities

The determination of appropriate elasticities is the responsibility of the user; the numbers in the model template are placeholders only.

- Import substitution elasticities are needed for both levels of the Armington functions. These are recorded in two worksheets, 'comelastm' and 'comelastrm', where the former contains the elasticities of substitution between aggregate imports and domestic commodities (model parameter ELASTM), and the latter the elasticities of substitution between aggregate imports from different regions (model parameter ELASTRM). Both are two dimensional matrices that allow for differences in the substitution elasticities by commodity and region.
- Export transformation elasticities are needed for both levels of the CET functions. These are recorded in two worksheets, 'comelaste' and 'comelastre', where the former contains the elasticities of transformation between aggregate exports and domestic commodities (model parameter ELASTE) while the latter worksheet contains the elasticities of transformation between aggregate exports to different regions (model parameter ELASTRE). Both are two dimensional matrices that allow for differences in the transformation elasticities by commodity and region.
- Production Function Elasticities: Substitution elasticities are required for both levels of the nested CES production functions. These are recorded in two worksheets, 'actelastx' and 'actelastva', where the former contains the elasticities of substitution between aggregate intermediate inputs and aggregate value added (model parameter ELASTX) and the latter the elasticities of substitution between primary inputs (model parameter ELASTVA). Both are two dimensional matrices that allow for differences in the substitution elasticities by activity and region.
- Linear Expenditure System Elasticities: The elasticities of substitution used for the linear expenditure systems (LES) are only supplied from Excel, and require the user to provide both income elasticities of demand and Frisch elasticities. The *income elasticities* of demand are recorded in the worksheet 'incelast' and supply data for the model parameter ELASTY. This table may be slightly confusing because of the additional column of labels – "hous" – but since there is only a single household in each region for the GTAP model, this is only included for model convenience and (future) flexibility. The *Frisch elasticities* are recorded in the worksheet 'frischelast' and supply data for the model parameter ELASTF; note how these elasticities are defined by region and household. The default values for ELASTY are one and ELASTF are minus one. This is a special case whereby the LES utility functions reduce to Cobb-Douglas utility functions for all regions.

Sets to control production nesting structure

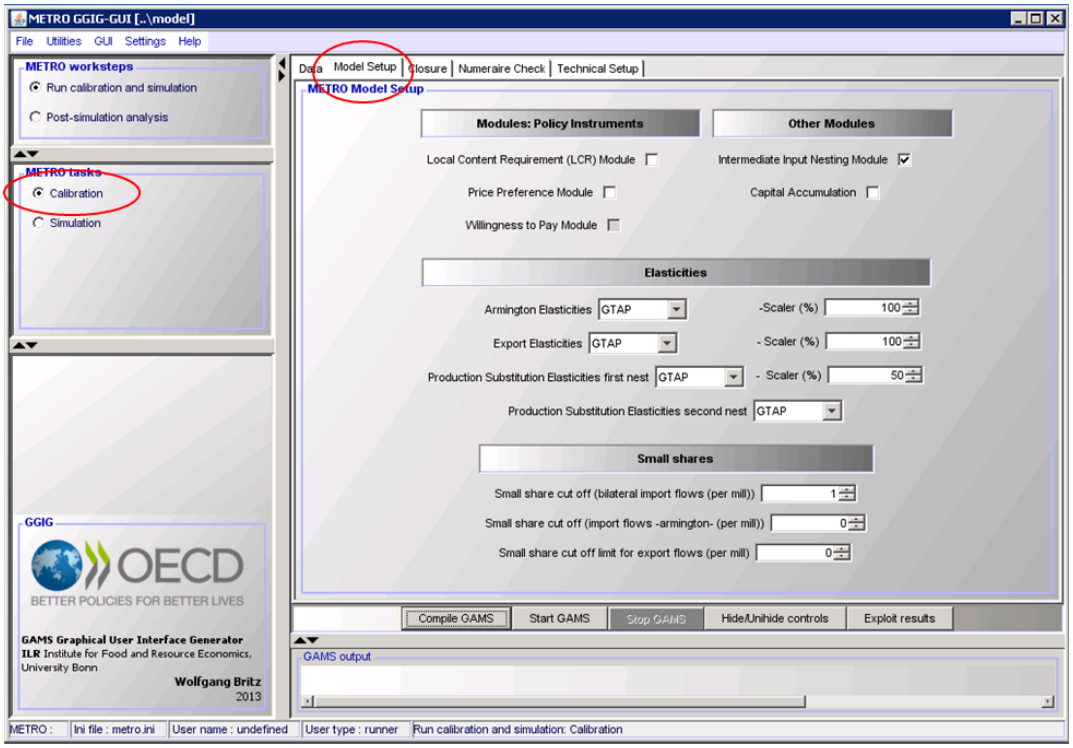
Domestic production is depicted through a three-level nested production process. In the first nest, intermediate demand and value added form output with the possibility of assuming either Leontief or CES technology, with CES being set as the default technology. You have the flexibility to change the default settings.

In the worksheet "mod_sets", Column A under the set name "aleon" and Column B under the set name "rleon" list the sector-region pairs which use Leontief technology in the top (first) production nest. Note that the sectors listed here must correspond to elements listed in Column D the Readme "worksheet", but with the added prefix "a" indicating "activity". The

regions listed as part of the set "rleon" must be defined in your database aggregation level (those listed in Column A of the *Readme* sheet).

4.2. Calibration tab: Model setup

The tab "Model Setup" defines the model structure. This tab is where users will set the elasticities to be used, activate the different modules, and set the small share thresholds.



4.2.1. *Elasticities*

For each set of elasticities, the user can select the ones sourced from GTAP (select "GTAP" in the drop-down menu), or alternatively users may provide their own elasticities (select "UserDefined" in drop-down menu). The elasticities can be scaled, if appropriate.

METRO sources two levels of Armington (import) and production elasticities from *GTAP*; by design, the second level (bilateral imports) is double the value of the first (aggregate imports). The export elasticities equal the import elasticities, assuming the same substitutability in the import and export markets. The production elasticities sourced from GTAP are for the second nest (aggregate Value Added) and, following the general rule for nested CES, the elasticities are by default halved in the first production nest (scaler is 50%). The elasticities can be scaled if wished.

When you want to apply your own estimates of elasticities, select *"UserDefined"* for a specific set of elasticities or all. The user defined elasticities are specified in the excel file (sets and coefficients) and by default populated with simple placeholders (please find a detailed description in Section 4.1.1). These can easily be changed in the excel file by any value and thus can deviate from the 'doubling rule' for the relation between levels.

The model employs three additional sets of elasticities in addition to the elasticities depicted in the interface. These three additional sets of elasticities are defined in the data excel file: elasticities for the third level of the production nest governing the substitution of factor demand; frisch elasticities, indicating the subsistence level of consumption, which are set minus 1 by default; and income elasticities which are set 1 by default (please find a detailed description in the Section 4.1.1). All elasticities which are specified in excel are set at a placeholder value and the user should consider changing them.

4.2.2. *Additional modules*

You may choose to add different modules and combinations of modules[7] to the model structure; these modules are described in detail in the METRO documentation (OECD, 2020) and METRO development working papers (OECD, 2017; OECD, 2018, OECD, 2019). Three modules extend the model structure by additional policy instruments:

- Local Content Requirement Module
- Price Preference Module
- Willingness to Pay Module

Other modules that extend the model structure

- Intermediate Input Nesting (default)
- Capital Accumulation
- Land Allocation Module

The modules, with the exception of one, are activated by ticking ON the respective box in the "Model Setup" tab. The Land Allocation Module is activated on the "Closure" tab by selecting "CET" as the factor market closure. See Section 4.3. Most modules can be combined, and the interface will block combinations that are not possible.

***TIP**: It is worth noting that the modules can add serious complexity to the model and the analysis due to the additional variables, parameters, and equations. As a result, this could influence model performance.*

4.2.3. *Small shares*

METRO has the possibility to change from substitution relationships (in CES nests) to fixed proportions (Leontief technology). This feature avoids large percentage effects of very small amounts in the outer area of the CES function. The user can chose the per mille threshold which qualifies as a small share.

- For example, when the small share cut off for bilateral imports is 1 (default), then all trade flows which account for less than 1 per mill of the import value of this good (and use) are imported in fixed shares.
- Similarly, the Armington function is changed to a Leontief function when the import share is below the threshold.
- The third box establishes a threshold for the relation between goods exported and those supplied domestically.

[7] A module is a specific model feature that includes sets of equations, variables, and parameters that are included or excluded in the standard model structure at the calibration phase.

***TIP**: While this feature typically improves model performance (i.e. the solution of relatively disaggregated models), there is a danger that the model will become too rigid and thereby lose adjustment possibilities. This can occur when the threshold is too high or when different thresholds are combined.*

4.3. Calibration tab: Closure

METRO allows for various closure setups, which serve two purposes: 1) technically they make sure that the amount of variables and equations are equal; and 2) they resemble macroeconomic assumptions of economic theory.

The calibration stage reproduces the database, and closures do not affect the output of this task with two exceptions: unemployment and the land supply structure of the agriculture sectors.

Unemployment/full employment is set at the calibration step. To allow for unemployment, select "ON" in the drop-down menu to the right of "Read Unemployment" and select the corresponding unemployment excel file. This excel file defines the factor and region pairs that are unemployed, and sets the unemployment level. If the "Read Unemployment" is set to "OFF" there is full employment.

***TIP:** The selection of unemployment "ON" and "Off" is indicated in the name of the parameters file from the calibration step (s_f_r_vDB_fm_Mobile_unemp_**OFF/ON** _Calib.g00). See Box 1 on naming conventions.*

Assumption about **factor market mobility** is also set at the calibration stage. Under the section "Other closures", users have three choices for the Factor Market Closure: factors can be perfectly mobile (Mobile); perfectly immobile (Immobile); or imperfectly mobile (CET). Selecting "**Mobile"** assumes that all factors are perfectly mobile across sectors in the model with the exception of the natural resource factor, which is always immobile regardless of the closure the user selects. Selecting "**Immobile**" assumes that factors are not transferable across sectors. Selecting "**CET**" assumes that land is imperfectly mobile and the land allocation module is activated.

If the user selects "CET" as the Factor Market Closure, then the user must also identify the file and location of the excel file that defines the CET nesting structure (see Section 4.3.2 on how to set up this file). In addition, the user must select the source of the module elasticities.

***TIP**: Like the employment closure assumption, the selection of the factor market closure is also indicated in the name of the parameters file from the calibration step (s_f_r_vDB_fm_**Mobile/Immobile/CET**_unemp_OFF_Calib.g00).*

The majority of the other closures can be ignored in the calibration stage, it is only important to keep the number of equations and variables balanced. To maintain the number of equations and variables, two of the government account closure boxes must show the word "fixed" and one "flexible", the combination does (technically) not matter. The closures are described in further detail under the section describing the simulation task, where closures selection is crucial.

4.3.1. *Unemployment file*

Users may allow for unemployment in the model. To select this closure assumption, the user must provide unemployment rates for the countries and labour factors in the model. The information is stored as proportions in the excel file s_f_r_FD_unemp.xlsx where s is the

number of sectors, f the number of factors, and r the number of regions. The suffix "_unemp" tells the interface that the excel file contains the unemployment rates for each labour factor. It is possible to add a specific ID before _unemp, in the 5_8_5 example "FD". The unemployment excel file is located in the "Projects*\database\" directory where "*" is the name of the project folder.

To use the unemployment file in the model, update the worksheet "uef_factors" to include only the labour factors with unemployment (Column A) in each region (Column B). The employment rate is entered in worksheet "unemp_rate" where Column B are the model regions and Row 5 lists the labour factors. The factor-region pairs should be the same in both worksheets. Note that factor-region pairs not in the file are assumed to have full employment.

***TIP**: Regions and factors should reflect the database aggregation definition. Factors referred to in this worksheet are those defined as natural factors with prefix "f".*

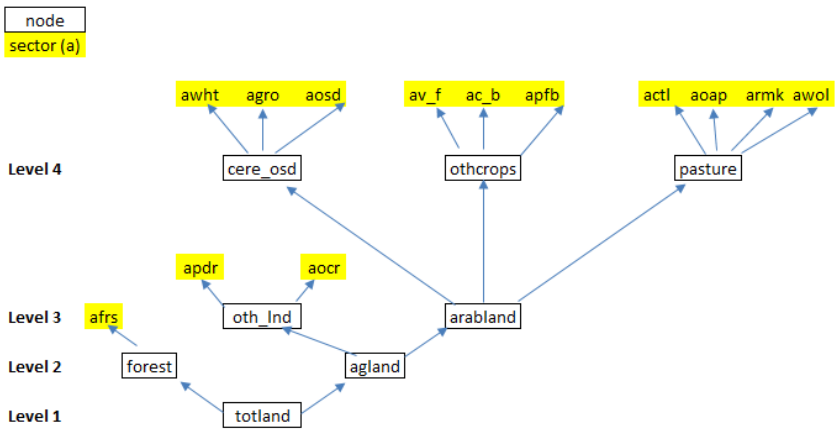
4.3.2. *Definition of the land allocation nesting (optional)*

This step is required only if the land allocation module is to be activated. A technical documentation [TAD/TC/CA/WP/RD(2019)4/FINAL] *and detailed user guide* [TAD/TC/CA/WP/RD(2019)5/FINAL] *for this module is available.*

An excel file (s_f_r_METRO_LandCET.xlsx) is used to define the nesting structure of land supply in the agriculture sector. The figure below is an example of the nesting structure defined in the excel file 19_8_6_LandCET.xlsx among the thirteen different agriculture sectors. This nesting structure includes all land-using sectors available in the METRO database. Users may wish to examine the associated spreadsheet in the "Example_Ag_supply_DBv10\database" folder describes the nesting of land supply with a smaller number of sectors. This folder is found in the "Template_projects" directory and includes a small model database file.

***Tip**: The land allocation nesting requires a minimum of 2 levels and 3 nodes. Therefore, the 5_8_5_LandCET.xlsx is only a place holder. Users cannot run the 5_8_5 example database with the land allocation module because there is only one agriculture sector.*

Figure 3. Nesting structure defined in 19_8_6_LandCET.xlsx



There are three main spreadsheets used to define the nesting:

- *sets_agriland* where users define the nodes
- *agriland_ag* defines nesting of land use in agriculture sectors of the users database
- *agriland_elast* where users may define their own elasticties (optional)

Spreadsheet sets_agriland

The worksheet "sets_agriland" contains the set of nesting aggregates or nodes, and the point at which land is allocated between nodes at a higher level or between agricultural sectors. All nodes of the CET nesting should be defined in this spreadsheet.

The spreadsheet contains three columns: factor, name, and label.

- The "Factor" column should give the domain factor to which the node CET structure belongs. For land, the domain factor will be "fLand".
- "Name" should contain the node name. The nodes correspond to the groupings of the domain factor; for the land allocation module, the groupings refer to the type of land (e.g. pasture, arable)
- "Label" describes the node

Spreadsheet agriland_ag

The spreadsheet "agriland_ag" describes the CET nesting structure. The first column is devoted to the factor domain ("fLand") and the following columns (*lnd_ag1*, *lnd_ag2*, *lnd_ag3*, *lnd_ag4*) indicate how the domain factor is allocated at each of the four different levels of the CET. Each cell is a node where the supply of the factor can be allocated at the next level. In the figure above, for example, *totland* is a node at level 1, and *totland* can supply land to either *agland* or *forest* in level 2. The last column in the "agriland_ag" worksheet contains the list of all sectors for which the factor is available. All sectors that use land must be allocated to a node at Level 4.

***TIP**: Only one structure can be defined for all the regions, but elasticity values entered in the given structure can be region specific.*

Below is the entry for the worksheet "agriland_ag" that corresponds to the nesting structure in the previous diagram.

	A	B	C	D	E	F
1	**Factor market CET nesting structure**					
2		**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Sectors**
3						
4	**f**	**lnd_ag1**	**lnd_ag2**	**lnd_ag3**	**lnd_ag4**	**a**
5	fLand	totland	agland	oth_lnd	oth_lnd	apdr
6	fLand	totland	agland	arabland	cere_osd	awht
7	fLand	totland	agland	arabland	cere_osd	agro
8	fLand	totland	agland	arabland	othcrops	av_f
9	fLand	totland	agland	arabland	cere_osd	aosd
10	fLand	totland	agland	arabland	othcrops	ac_b
11	fLand	totland	agland	arabland	othcrops	apfb
12	fLand	totland	agland	oth_lnd	oth_lnd	aocr
13	fLand	totland	agland	arabland	pasture	actl
14	fLand	totland	agland	arabland	pasture	aoap
15	fLand	totland	agland	arabland	pasture	armk
16	fLand	totland	agland	arabland	pasture	awol
17	fLand	totland	forest	forest	forest	afrs
18						

Spreadsheet agriland_elast

The spreadsheet "agriland_elast" contains the user defined elasticities (optional). These parameters are used only if the elasticity source in the GUI is set to "UserDefined" in the calibration. Otherwise, the default PEM elasticities will be used.

In the Excel spreadsheet, each node represents a single CET function; therefore, one elasticity per node is necessary. Elasticities are to be entered for each region and can vary from one region to the next.

***TIP**: All regions in the model database must be included in the "agriland_elast" spreadsheet. Note that sectors correspond to activities, so entries in this column must start with the prefix "a"; and include all sectors in the analysis database that uses land.*

The figure below is an example of the elasticities spreadsheet for a database with 6 regions and 19 sectors.

	A	B	C	D	E	F	G	H
1	**Land CET elasticities (User defined)**							
2								
3	**Domain**	**Nest level**	**Regions**					
4			Europe	USA	Canada	Asia	ROW	
5	fLand	totland	0.05	0.1	0.05	0.05	0.05	
6	fLand	forest	0.05	0.1	0.05	0.05	0.05	
7	fLand	oth_lnd	0.05	0.1	0.05	0.05	0.05	
8	fLand	agland	0.05	0.1	0.05	0.05	0.05	
9	fLand	arabland	0.21	0.15	0.14	0.11	0.21	
10	fLand	pasture	0.22	0.29	0.28	0.15	0.22	
11	fLand	othcrops	0.23	0.55	0.58	0.2	0.23	
12	fLand	cere_osd	0.23	0.55	0.58	0.2	0.23	
13								

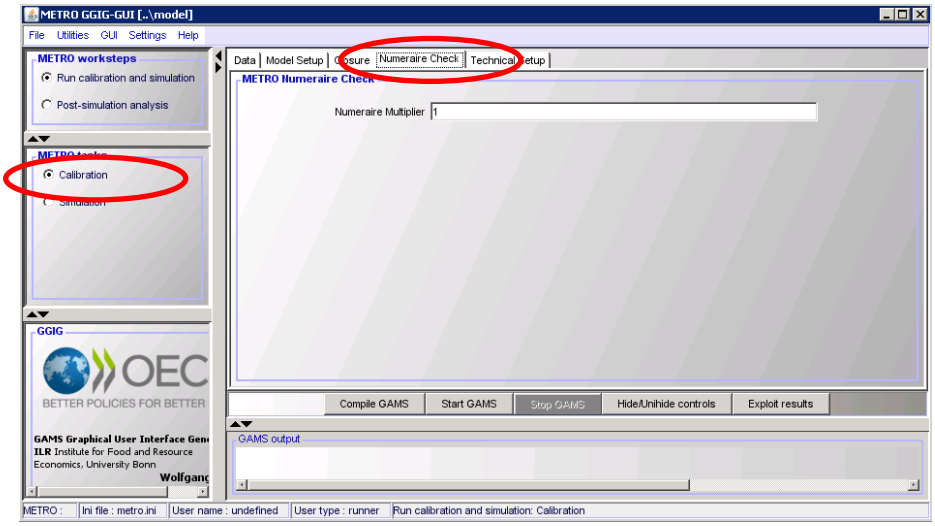
Note that in the figure above, the "Nest level" column corresponds to the node "Name" in the "sets_agriland" worksheet.

***TIP**: For more detailed information on how to set up the Land Allocation Module spreadsheet, see the User Guide [TAD/TC/CA/WP/RD(2019)5/FINAL].*

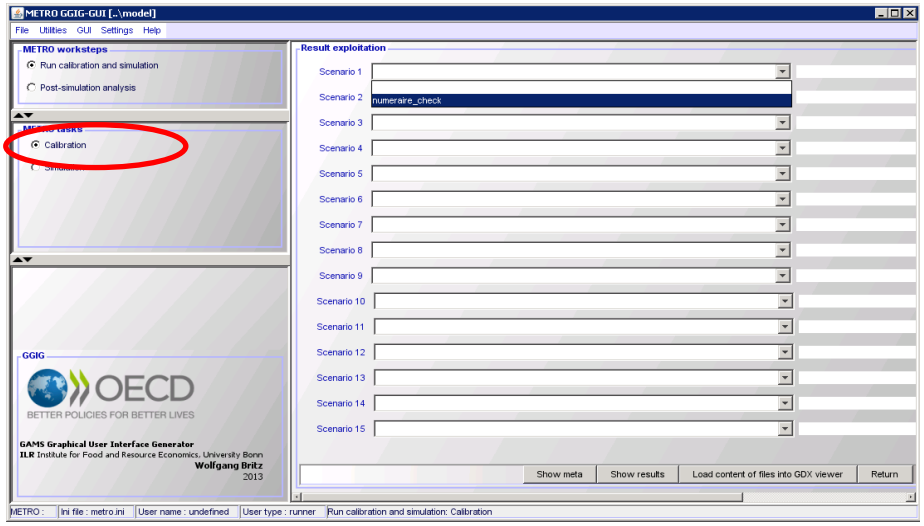
4.4. Calibration tab: Numéraire check

A numéraire check tests if the model is correctly specified and calibrated. If the numéraire is changed to a value different from 1, this should change all prices by the same amount. To test this, change the numéraire from 1 to, for example, 2 and press the "start GAMS" button.

***TIP**: A base results gdx file will not be produced from the numéraire check. However, a calibration file (*_Calib.g00) will be produced and available for selection as an input to the simulation task. Users should take care that the calibration file used as an input into the experiment simulation is the one where the numéraire multiplier has been set to 1 by running the calibration after the numéraire check.*



After a successful completion, you can check if the model is correctly calibrated by pressing "Exploit Results". Then select the numéraire check in the drop-down menu and click on "Show results". The file contains a select set of prices to show if the test has been successful.



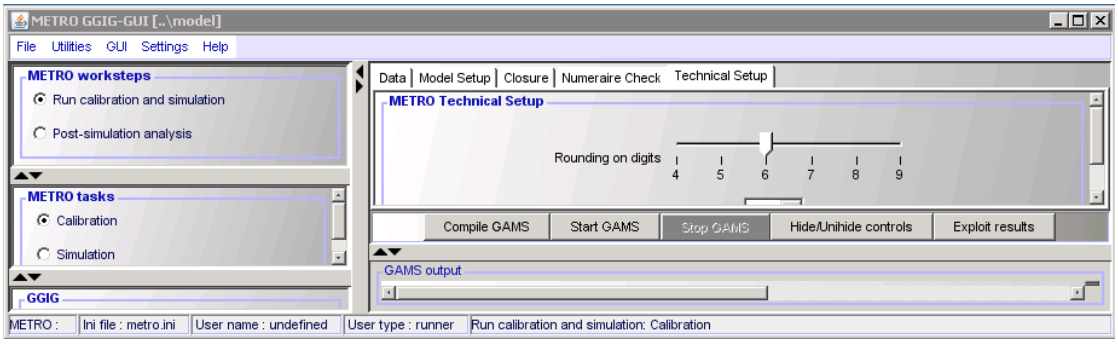
***TIP**: The numéraire check is also useful to test the model performance, i.e. if it converges, if you have enough computing power, and if you need to be careful with the size and nature of shocks. In the case where your simulation does not converge, a test should show if the reason is due to the shock or to the model setup or its size. This only applies to large models which typically do not solve with a numéraire value of 2.*

4.5. Calibration tab: Technical setup

The technical setups typically do not need adjustment. The default settings are displayed in the picture below. The tab contains several control elements for data manipulation which support the solver, i.e. rounding and scaling.

- "Rounding to digits" (e.g. the GTAP database is rounded to 6 digits) in order to delete very small entries which are basically zero. This has two reasons: 1) those entries typically complicate the analysis and 2) they can be an issue in the equation system, as most equations perform best in the middle part of the functions.

- "Scaling target" (default is 10). The solver works best with numbers around 1 and the database is scaled to support the solver.



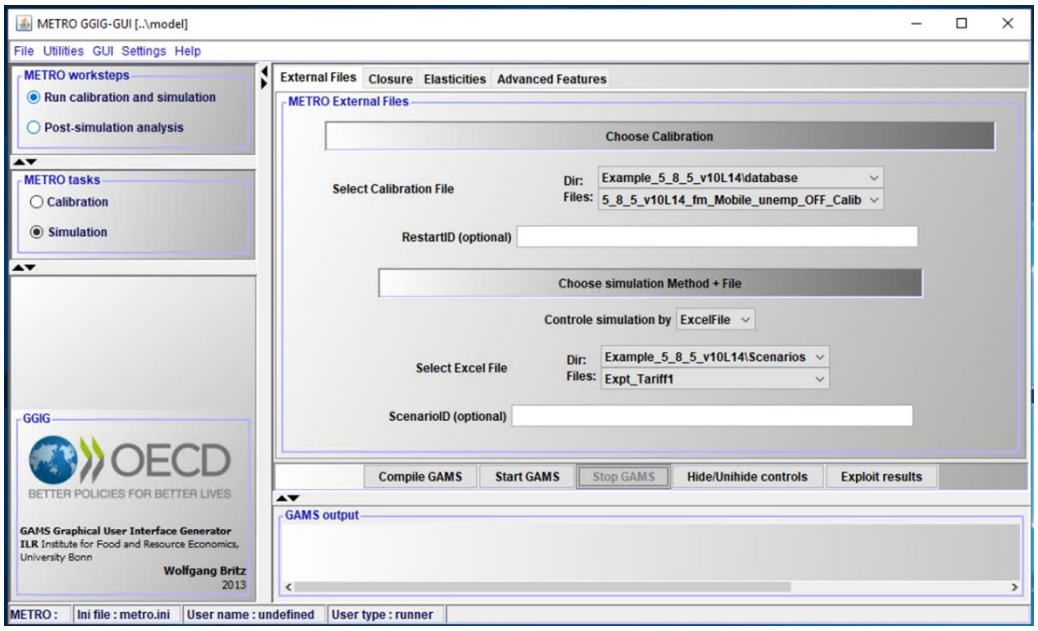
5. METRO GUI: Simulation

In Brief: Running a simulation

1. Prepare the simulation files (Outside the interface, within your project's "scenarios" folder) in Excel and/or GAMS (INC) and save under a specific name
2. Select the calibration file
3. (optional) Specify a restart ID to include in the filename of the parameter (g00) file of the simulation
4. Select simulation method (excel or GAMS) and simulation file
5. (optional) Specify an additional scenario ID in the "External files" tab (e.g. to indicate if unemployment is ON or OFF) in the results filename
6. (optional) Specify a closure ID in the "Closure" tab which will be used in the results filename
7. Possibility to specify elasticities and other advanced features
8. "Start GAMS"
9. View results with button "exploit results"

Once the calibration step is successfully completed, the created calibration file is used as an input for the simulations. It is also possible to use the parameters file saved after a previous simulation as the calibration file for a subsequent simulation.

5.1. Simulation tab: External files



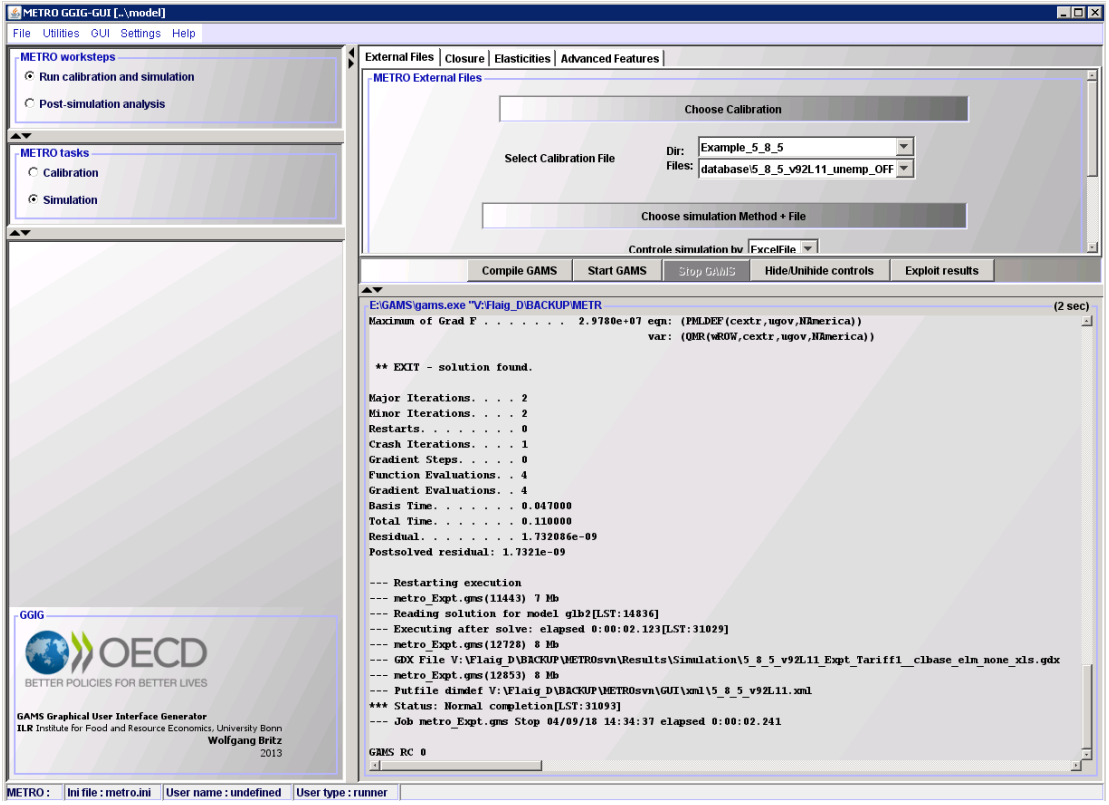
The simulation can be executed with an excel file or a GAMS include file. To run a simulation, first select the calibration file. For example:

- "5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib" for the training aggregation with full employment, or
- "5_8_5_v10L14_fm_Mobile_unemp_ON_Calib" in case you created a version with unemployment.

The naming convention for the calibration file is the following: the calibration always starts with the aggregation identifier (e.g. 5_8_5_v92L11), followed by the factor market closures (fm_Mobile/Immobile/CET) and the employment specification (unemp_ON/unemp_OFF). The files ending with "Calib" contain the parameters used by the model which were calculated at the calibration stage.

Second, select from the drop-down menu the method to control the simulation (Excel or GAMS), and then select the simulation file you want to use. The excel experiment file allows for multiplicative shocks of the standard policy instruments and no GAMS knowledge is required. The GAMS experiment file allows for more complex simulations and requires knowledge of GAMS.

When you open the model interface for the first time, there will be no calibration; this needs to be created (Section 4). There are two examples of simulation files, one for each method. Select the method and file and press the "start GAMS" button to create your first results. As in the calibration step, the process of the computation is shown in the lower part of the interface. The model run is successful when the report shows "normal completion" and "EXIT – solution found".



5.1.1. *Excel simulation file*

The calibration run creates an excel file in the "Scenarios" directory of your project folder. This file serves as the template for your experiment file. It is named "Expt_base.xlsx".

To prepare your own experiment file, open the template that accords to your aggregation (in your project directory "Projects/*/Scenarios") and rename it by changing "base" to your experiment ID (e.g. rename "Expt_base.xlsx" to "Expt_Tariff1.xlsx") and save it in the "Projects/*/Scenarios" directory. You implement your shock in the excel file by updating the appropriate adjuster. For example, in the training experiment file Expt_Tariff1.xlsx, we implemented a 100% unilateral increase of tariffs in Asia by setting the "Tariff" worksheet adjusters for the Asia region to 2 (see image below).

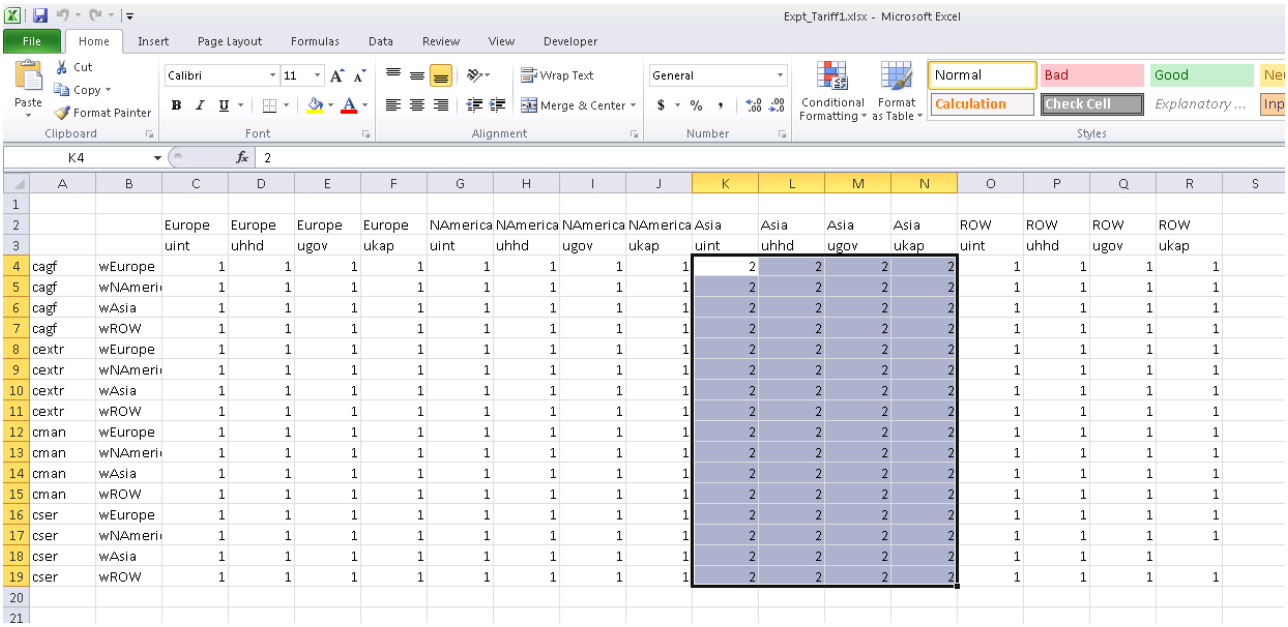
The experiment excel file contains multiplicative adjusters for each of the available policy instruments:

- Export tax (dimensions are: column: product and partner; row: region and use category)
- Tariff (dimensions are: column: product and partner; row: region and use category)
- Specific tariff (dimensions are: column: product and partner; row: region and use category)
- Factor tax (dimensions are: column: factor and sector; row: region)
- Income tax (dimensions are: column: Household; row: region)
- Factor income tax (placeholder, not in database)
- Production tax (dimensions are: column: sector; row: region)
- Sales tax (dimensions are: column: product and use category; row: region)
- Value added tax (dimensions are: column: product; row: region)
- Efficiency level1 (dimensions are: column: sector; row: region)
- Efficiency level2 (dimensions are: column: sector; row: region)
- Factor efficiency (dimensions are: column: Factor and sector; row: region)
- Factor supply (dimensions are: column: Factor; row: region)
- Iceberg costs (dimensions are: column: product and partner; row: region and use category) – for iceberg costs an increase signifies a reduction in barriers, e.g. a value of 1.01 would simulate a reduction of barriers equivalent to 1% of the import price.

In the base experiment file, the value of all adjusters is 1. An empty cell means that the base value of the policy variable is already 0. Note that the set element names are as specified in the set and coefficient file ("5_8_5_v92L11_sets.xlsm").

***TIP**: The model employs several set identifiers (prefixes) which are useful to know: c stands for commodity, a for producing activity (commodity c is produced by activity a) and f for factors; w identifies the partner region in bilateral dimensions: this means for import variables that "EU" imports from "wAsia"; and for exports variables that "Asia" exports to "wEU".*

For example, in the file below, "Expt_Tariff1.xlsx", Asian tariffs of all goods (Column A) versus all trade partners (Column B) and in all use categories (row 3) are multiplied by 2, simulating a unilateral 100% tariff increase by Asia on imports from all partners of all uses categories.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2			Europe	Europe	Europe	Europe	NAmerica	NAmerica	NAmerica	NAmerica	Asia	Asia	Asia	Asia	ROW	ROW	ROW	ROW	
3			uint	uhhd	ugov	ukap	uint	uhhd	ugov	ukap	uint	uhhd	ugov	ukap	uint	uhhd	ugov	ukap	
4	cagf	wEurope	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
5	cagf	wNAmeri	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
6	cagf	wAsia	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
7	cagf	wROW	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
8	cextr	wEurope	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
9	cextr	wNAmeri	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
10	cextr	wAsia	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
11	cextr	wROW	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
12	cman	wEurope	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
13	cman	wNAmeri	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
14	cman	wAsia	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
15	cman	wROW	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
16	cser	wEurope	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
17	cser	wNAmeri	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
18	cser	wAsia	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1		
19	cser	wROW	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	
20																			
21																			

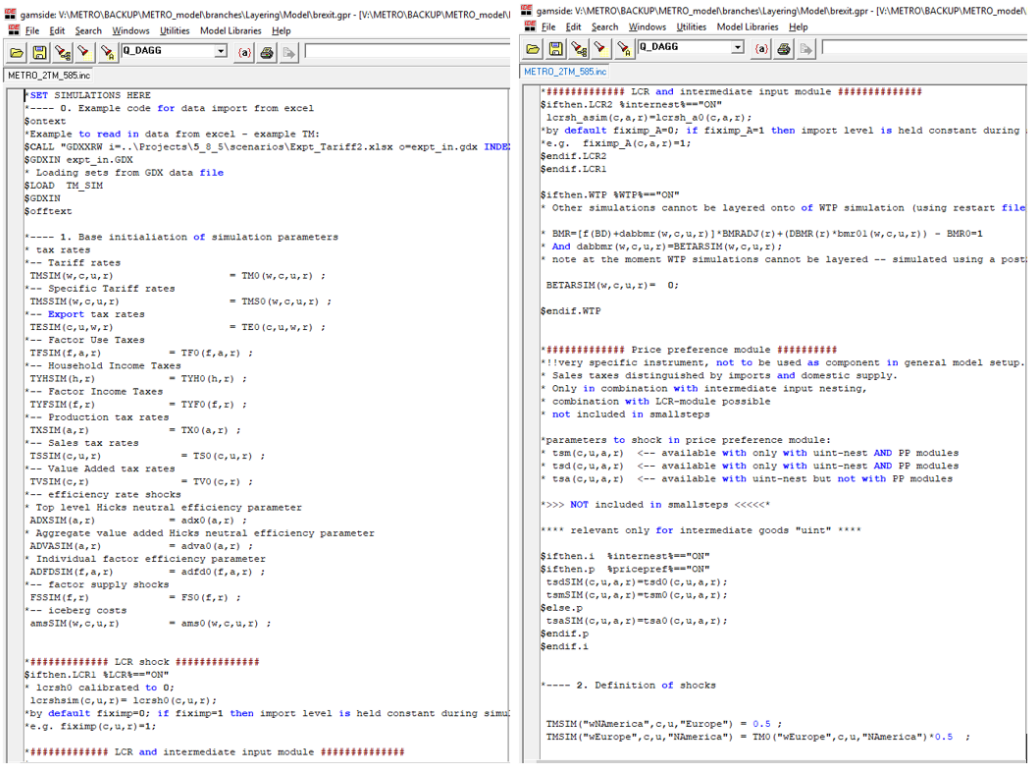
5.1.2. *GAMS simulation file*

The GAMS simulation template file ("METRO_2TM_585.inc") is included as part of the template files in the "Projects/ Example_5_8_5_v10L14 /Scenarios" folder and has the following structure: in the first section, simulation parameters are initialised to the base value. In the second section, the shock is defined. The user makes changes in the second section after the line "*---- 2. Definition of shocks".

To set up your own simulation, copy the template file "METRO_2TM_585.inc" the "Scenario" folder of your project. Rename the file by replacing "2TM_585" with your experiment ID. Replace the sample code found below the line "*---- 2. Definition of shocks" with your shocks. The example below shows the file "METRO_2TM_585.inc" which models a bilateral tariff reduction of 50% between Europe and North America.

***TIP**: You can shock either a whole set or a single element. The element names of each set are specified in the set and coefficient file. Elements must be in quotation marks.*

At the beginning of the file, there is an example code in case the user wants to read in values from xlsx.



Policy instruments that can be added with modules

When the **local content requirement (LCR) module** is activated (in the calibration phase), you can simulate an LCR using the GAMS experiment file. Similar to the standard simulation parameters, copy the line "lcrshsim(c,u,r)= lcrsh0(c,u,r)" into section 2 of your experiment file. You can either set the simulation level of the local content share. For example, to 50% with the code lcrshsim(c,u,r)= 0.50. Or by some factor of the base level. For example, doubling the base level with the code lcrshsim(c,u,r)= lcrsh0(c,u,r)*2. The base level (lcrsh0(c,u,r)) is equal to 0 after the calibration step. If you choose to restart your simulation based on a previous simulation, then lcrsh0(c,u,r) is equal to the level at the end of the previous simulation.

For the local content share, values between 0 (no LCR) and 1 (100% LCR, no imports) are possible. Alternatively, there is the possibility to hold the import level (quantity) constant, if "fiximp" is set equal to 1. When the intermediate input nesting is ON, the LCR for the intermediate use category is activity specific. The parameter names are therefore lcrsh_asim/fiximp_a. When the intermediate input nesting is OFF, the name remains lcrshsim /fiximp.

The **price preference module** gives the possibility to distinguish commodity taxes on imports from domestic origin. It MUST be combined with the intermediate input nesting module. If both modules are active, the activity specific sales tax (tsa) is zero and the commodity tax for imports (tsm) and domestic goods (tsd) are used instead (note that these policy measure cannot be used with the "small steps" and "presolve" option).

The **willingness-to-pay (WTP) method** (documented in OECD, 2017) is an alternative approach to modelling NTMs. It assumes that quicker delivery of a good increases the utility of this good for consumers who are therefore willing to pay more for it. In economic terms,

this shifts the utility function downwards, as less quantity is needed to obtain the same level of utility. WTP is introduced into the model through the variable BMR, the WTP for imports from region w (QMR). BMR is the shock variable in order to raise a consumer's WTP for imports, when for instance reduced delivery times triggered by trade facilitation improvements raise the consumer's WTP for imports by region. The main shock parameters are $dabbmr_{w,c,u,r}$ and $BMRADJ_r$.

The model has a **module for tariff rate quotas (TRQs)** (documented in OECD, 2017), the option is not (yet) implemented in the interface but can be activated in the file Model/controls.inc (by changing the line "$setglobal TRQ OFF" to "$setglobal TRQ ON" and saving it). The implementation of TRQs is data intensive, i.e. data is needed on the size of the quota, and the in-quota and out-of quota tariffs. This information must be mapped to the actual import quantity to define whether the quota is binding or not; if it is binding, then the size of the rent and its distribution must be defined. There may also be out-of-quota imports.

In a default situation, the METRO database does not include TRQs in such detail; it does, however, include *ad valorem* equivalents for TRQs under the heading 'specific tariffs'. In order to implement TRQs, selected measures can be introduced in a pre-simulation (removing at the same time the respective 'specific tariff'). This pre-simulation recalibrates the database and the resulting database can then be used for analysis and simulations on TRQs. The respective parameter and variable names can be found in 'Model/METRO_IMEXquota.inc'.

5.2. Simulation tab: Closure

METRO allows for a range of general and specific closure rules. Choose amongst the available possibilities from the drop-down menus.

5.2.1. *Government account closure*

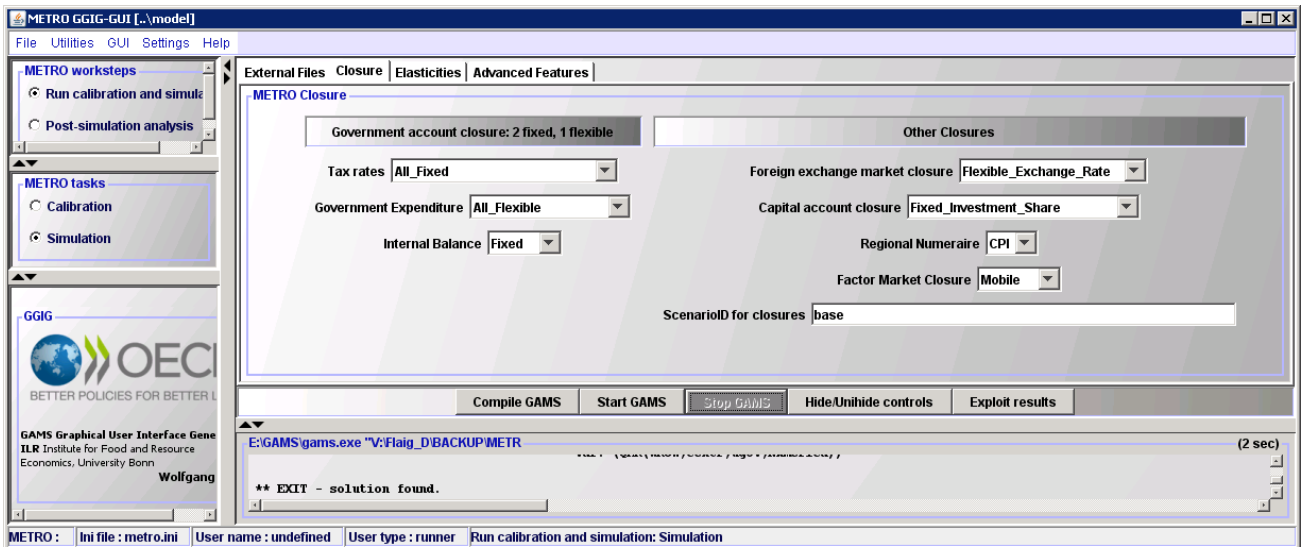
The government account closure allows for selection among three elements that reflect assumptions about income (tax rates), expenditure, and government savings (internal balance). Two of these elements must state "fixed", and one is flexible; the combination can be freely chosen. For example, in the default specification for the government account, all tax rates are fixed; assuming government income to be 'fixed', the internal balance is fixed and government expenditure is variable.

- Government income (Tax rates) is either predefined, with all taxes fixed (*"All_Fixed"*) or flexible to balance the government account. Each tax rate can be selected to adjust with multiplicative or additive tax rate scaling factors. It is advisable to choose a tax which is not distortive and one with a large enough rate to be able to balance the government account, e.g. the income tax rate (*"Flexible_Income_Tax_Mult"*).
- Government expenditure is either flexible (*"All_Flexible"*) or controlled by fixing the quantity of commodities demanded (*"Fixed_Volume_Real"*), the value of government consumption expenditure (*"Fixed_Value_Nominal"*), or the share of government expenditure in the total value of domestic final demand (*"Fixed_Share"*).
- The internal balance (government savings) is either fixed or free to adjust.

The number of possible permutations for closing the government account for each region is substantial. Practical experience indicates that great care is needed when adjusting the government closure rules to avoid both unbalancing the model and imposing closure rules that are contradictory.

Users should be careful of the different possible effects when setting the constraints on government demand. If the volume of government demand is fixed (*"Fixed_Volume_Real"*), then the value of government expenditure might change due to changes in the prices of commodities. If the value of government expenditure is fixed (*"Fixed_Value_Nominal"*), then both government savings must be free to adjust as must the actual volume of expenditure when all tax rates are fixed. The same applies if the shares of government expenditures in final demand are fixed (*"Fixed_Share"*).

Figure 4. Closure tab showing the default closure setting



5.2.2. *Other closures*

Foreign exchange market closure: The current account can be defined with fixed exchange rates and a flexible current account balance (*"Flexible_External_Balance"*), assuming an inflexible currency system. Alternatively, the current account balance is fixed and the exchange rate floating (*"Flexible_Exchange_Rate"*), whereby the exchange rates for regions which are a member of the set "ref" (as defined in the sets and coefficients file) are fixed, forming an exchange rate index which serves as global numéraire.

Capital account closure: For the capital account closure, savings can either be investment driven or investment is savings driven. When investment is savings driven, savings are to be fixed (neo-classical approach). Under this closure setting, saving rates adjusters are fixed and investment free to adjust. The user has the choice between fixing the regional savings rate (*"Fixed_Regional_Savings_Rate"*) or private savings (*"Fixed_Savings_Rate_Mult"*). Investment driven savings (Keynesian approach) can be achieved in several ways. On the investment side, either the real volume of investment (*"Fixed_Investment_Volume_Real"*), the nominal value of investment (*"Fixed_Investment_Value_Nominal"*), or the share of investment in total final demand can be fixed (*"Fixed_Investment_Share"*).

There are potentially important interaction effects as there are additional sources of potential savings: the government and the trade balances. The magnitudes of these other savings sources can be controlled through the closure rules. Consequently, there is an important interdependence between the choice of closure rules for different accounts; the most obvious one to be aware of is the interaction between household savings rates and household income tax rates when tax rates are made flexible and the level of government savings/deficit is fixed.

Regional numéraire: The model allows for a choice between two price normalisation equations: the consumer price index (*"CPI"*) and a producer price index (*"PPI"*). A numéraire is needed for each region to serve as a base since the model is homogenous of degree zero in prices for each region, and hence only defines relative prices.

Factor market closure: There are several possibilities to specify factor markets for each region. Factors can be fully employed or unemployed – this first dimension is defined in the calibration step. For the second dimension, factors can be *"mobile", "immobile", imperfectly mobile (CET)* across activities. In the case where factors are defined as immobile across activities, factor demand is fixed, and there are therefore no employment effects. If CET is selected, then the land factor allocated across agriculture sectors specified with a Constant Elasticity of Transformation function. See Technical Documentation [TAD/TC/CA/WP/RD(2019)4/FINAL] for more information.

The factor market specifications are determined by the interplay of factor supply, factor prices, sectoral proportions of factor prices, and factor demand. Typically, for long-term projections, factors are assumed to be mobile and fully employed:. In this case factor price is flexible and factor supply fixed. For short-term projections, factors could become immobile across activities, i.e. capital; accordingly, factor demand is fixed. For this specification, the sectoral factor price proportions adjust to clear the factor market.

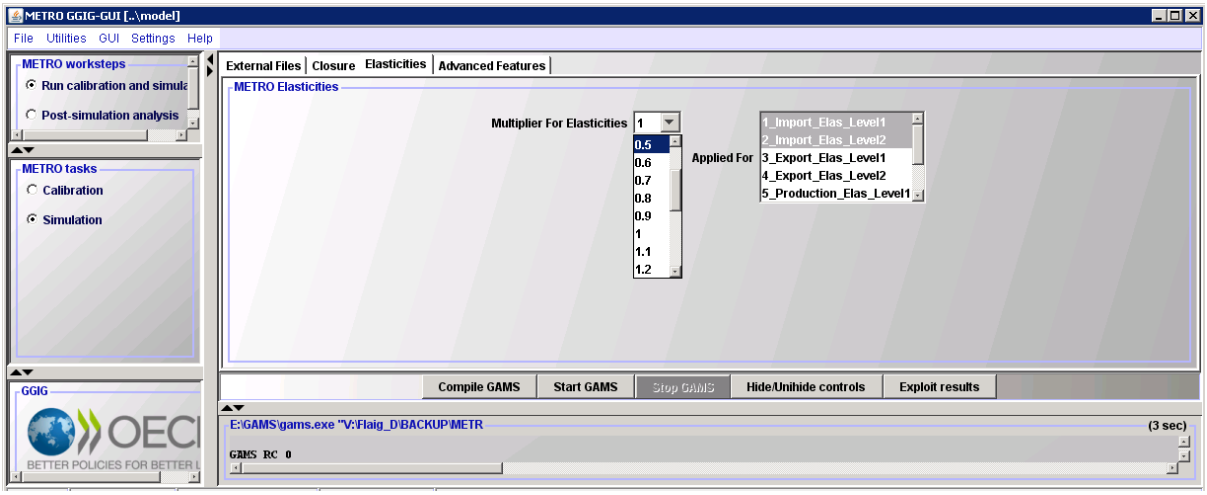
***TIP**: The same factor market closure must be selected for the calibration and simulation.*

5.3. Simulation tab: Elasticities

The elasticities tab offers the possibility to make a simple sensitivity analysis and to manipulate the elasticities from the base calibration. Select the elasticities you want to adjust, as well the the multiplier. If it is set to 0.5, all selected sets of elasticities are halved. If it is 1.1, the elasticities are increased by 10%. Note that if the value of the elasticity is 1, the base value is maintained. In the picture below both levels of import elasticities are halved.

***TIP**: To select multiple sets of elasticities, hold the ctrl key while making the selections.*

Each elasticity has a number identifier which will appear in the name of the results file together with the multiplier. In the case shown below the results file will be named "res_METRO_2TM_585_clbase_elaMult_0.5_for_12_gms": This means the file contains results from simulation *2TM_585*, with closure ID *clbase*, and that elasticities 1 and 2 are multiplied by 0.5. The simulation file is a GAMS file.



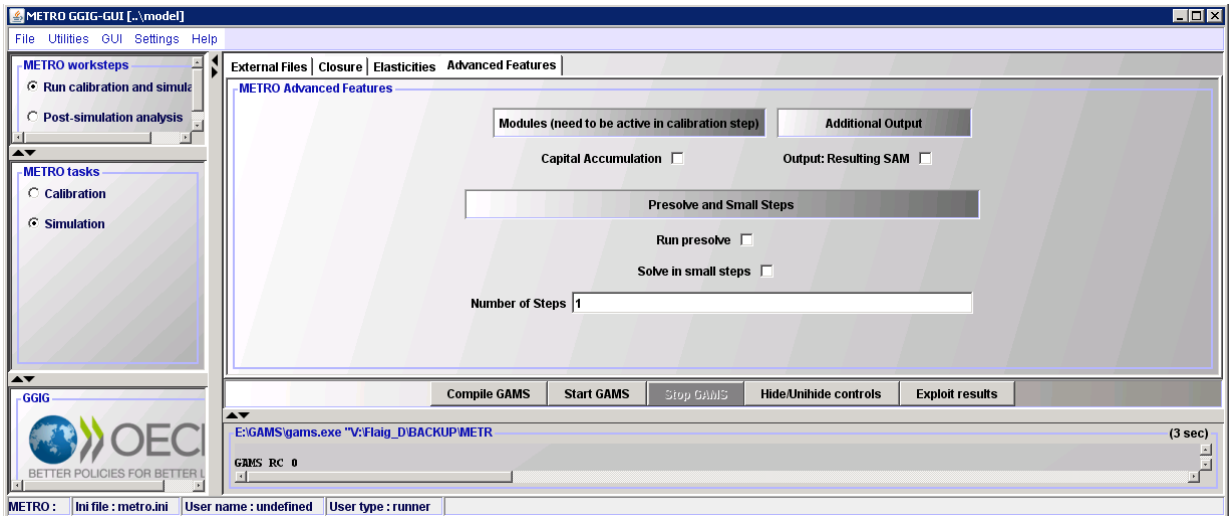
5.4. Simulation tab: Advanced features

Additional output: The user has the option to produce an *output SAM* by ticking the box "Output: Resulting SAM". The Output SAM is stored in the project directory "Projects/*/database" and can be used as a database for subsequent simulations.

Presolve and small steps: Two features could help in case the model has problems converging to a single solution. The first is the option to apply a *presolve* method which will runs the simulation in a kind of single country mode, breaking the model down by region, and thus considerably decreasing the quantity of equations the solver has to satisfy. Tick the box to activate this feature.

Secondly, and most important, the simulation can be solved in *small steps*, which breaks the shock into several smaller steps. Starting with a smaller shock, each step increases the shock until at the final step the full shock is applied. To activate this feature, tick the relevant box and indicate the number of steps in the text field below the box.

Modules: In the simulation step, the user has the choice to run the simulation with or without capital accumulation. The precondition is that the capital accumulation has been activated at the calibration step.



5.5. Simulation parameters file (g00)

After each simulation run, a new parameters file is saved. This file contains all parameters from the simulation, but notably the base levels of the "shockable" policy are set to their values at the end of the simulation run. This means that users may choose this post simulation parameter file as the "calibration file" for the next simulation. The only limitation is that all subsequent simulations must use the same presolve and small steps setting on the "Advanced Features" tab.

The new parameter file is saved in the "database" folder of the project. The filename is the name of the calibration file used in the simulation with the ending "PostSim".

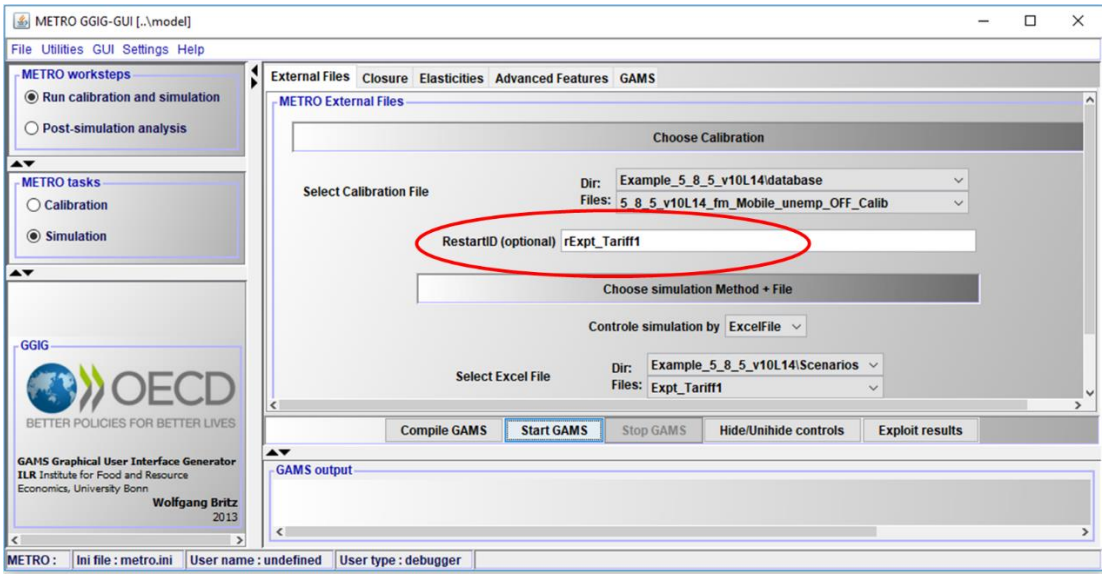
Using the Example_5_8_5_v10L14 project,

5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib.g00 is the parameters file saved after the calibration run.

5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib_**PostSim.**g00 is the parameters file saved after a simulation run.

If the user included a restartID (for example "rExpt_Tariff1") in the box labelled "RestartID (optional)" on the "External Files" tab of the interface, then this ID would be included at the end of the post simulation parameters file:

5_8_5_v10L14_fm_Mobile_unemp_OFF_Calib**_PostSimrExpt_Tariff1**.g00

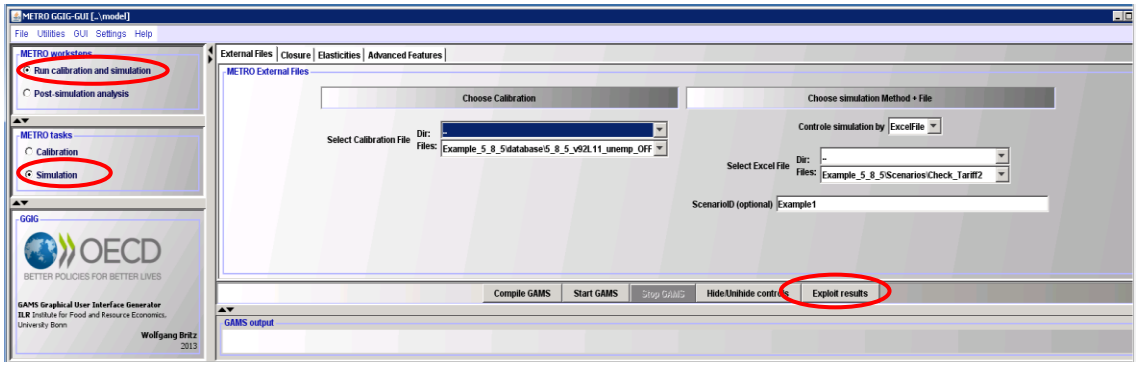


6. METRO GUI: Viewing results

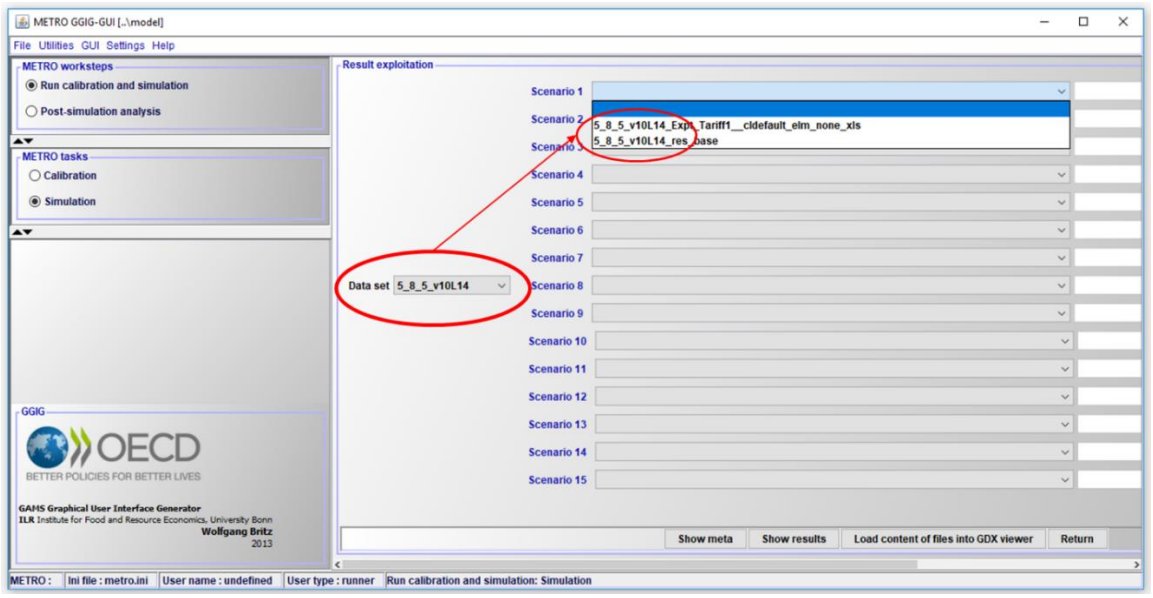
6.1. Calibration and simulation: Simulation results

6.1.1. *Open the viewer: Select simulations, open view and navigation*

In order to view the simulation results, press "Exploit results" in the "Simulation" task of the "Run calibration and simulation" work step.



The view below will appear where you be able to select the various results files to view together.

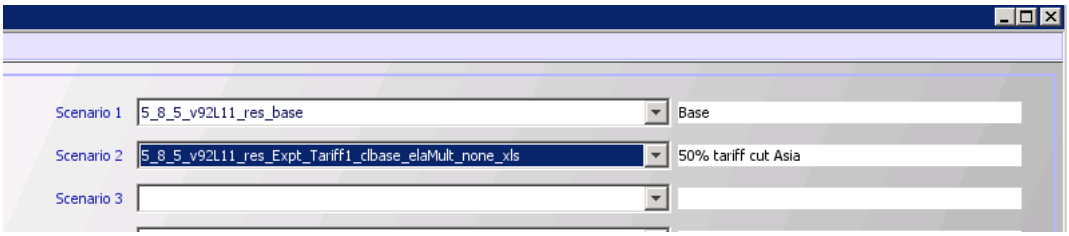


First, select the data set used as an input to the calibrations and simulations. Once the data set is identified, all calibration and simulation result files that used this database will be available in the drop-down menus to select as a scenario to view.

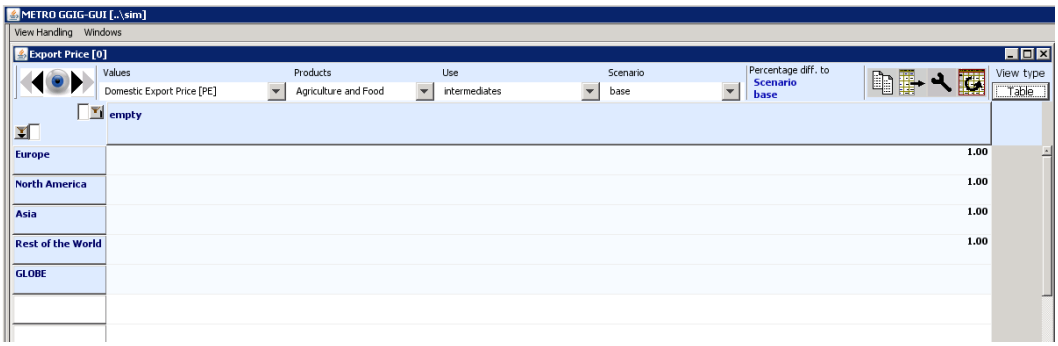
***TIP**: The viewer uses data set dimensions stored in an xml file that is created during the calibration run. These xml files are saved in the folder "GUI/xml". You cannot view results without this file. Moreover, if you run several calibrations with different setups, the available sets and variables in the view are based on the last calibration run. For example, if you run*

multiple experiments using database 5_8_5v10L14 with the LCR module turned on, the 5_8_5_v10L14.xml file will contain the parameters for the LCR module. If you then run another set of simulations but with the LCR turned off, the xml file no longer includes LCR variables. Moreover, you will not see the LCR parameters in the viewer, even if you are looking at the results from the first simulation. This is because the 5_8_5_v10L14.xml was overwritten with a different set of dimensions that does not include the LCR variables.

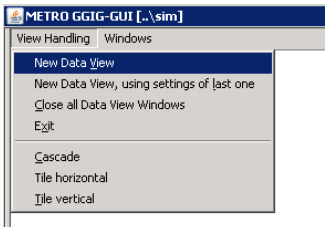
In the scenario selection box, choose the base and simulations files from the drop-down menu. In the box to the right, give each scenario a name. This name will be used to refer to the scenario and the underlying data in the data viewer. Then press "show results" on the bottom panel. If you would like to compare the results of a simulation to the base values, always include the base scenario when selecting files to view[8]. An example is given below:



Click on the bottom "Show results" found on the bottom of the screen. The following view will pop up, showing a table of results (the actual result which is shown might differ).



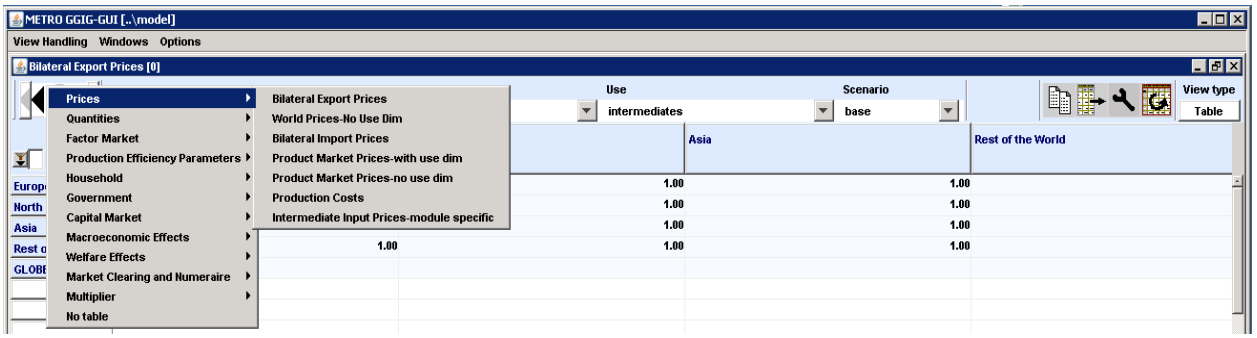
In case the view is empty, a new view can be opened by clicking on "View Handling" and then on "New Data View" in the upper left corner.



Select "Exit" to close viewer and return to the model interface.

[8] Users should note that the viewer displays the information from the gdx results files using single 7 digit precision.

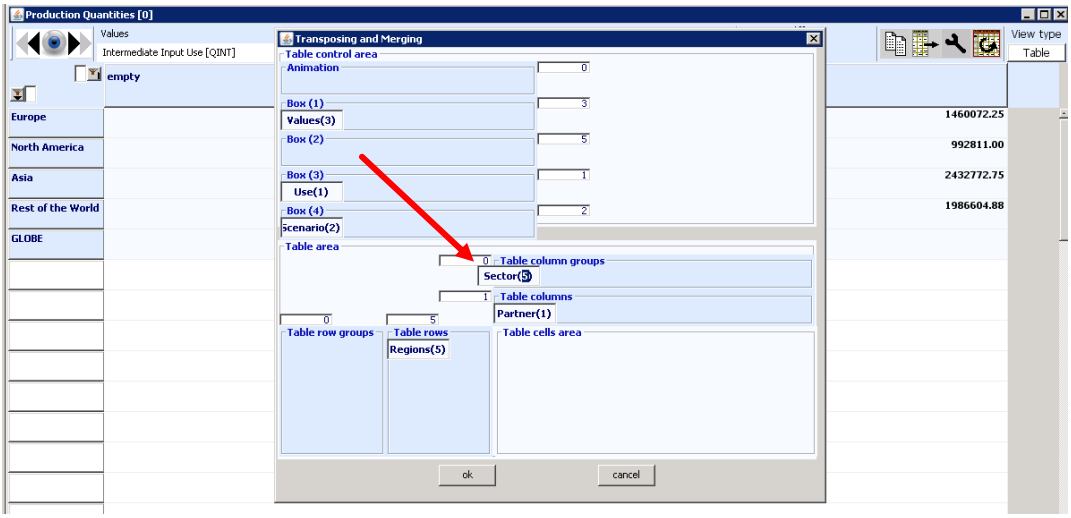
The viewer contains various tables (details in Section 6.1.3). To navigate through the results, click on the "" view button in the upper left corner and select the results you wish to view.



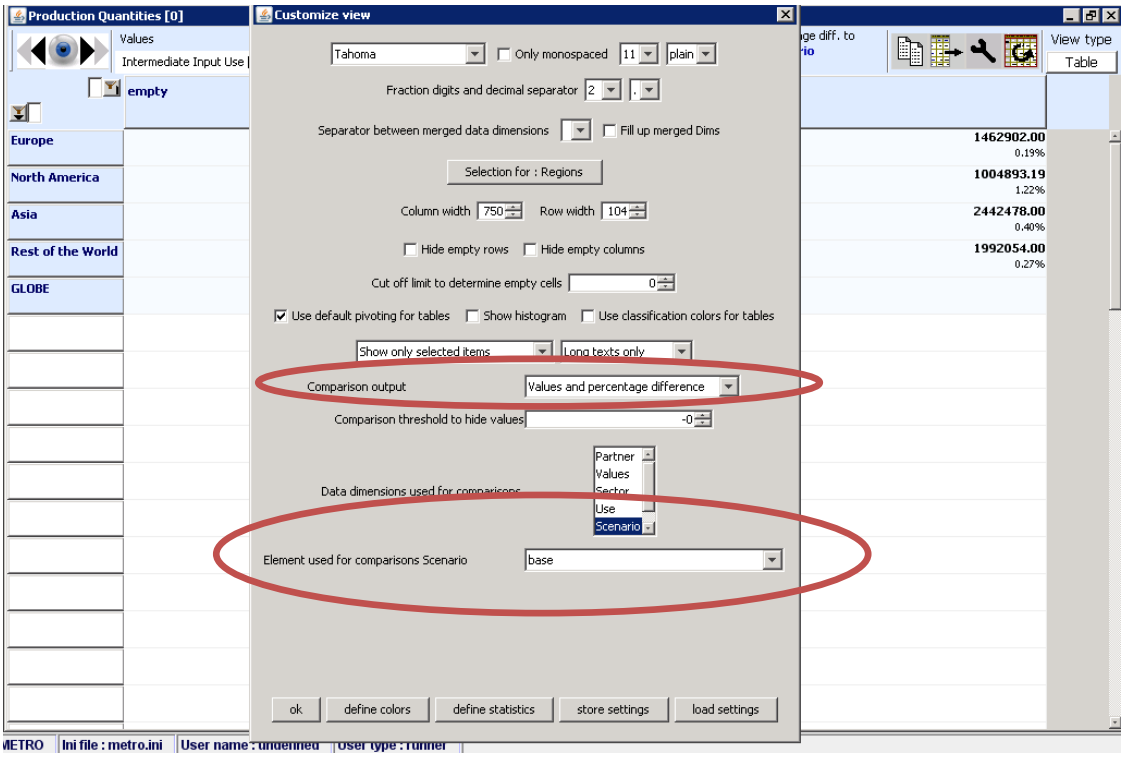
6.1.2. *Adjusting the view: Customise view and other options*

- *Drop-down menu*: You change the element shown in the table by selecting the elements in the drop-down menus. For example, you can switch from looking at results from the scenario "base" to the scenario "50% tariff cut Asia" by clicking the drop-down menu under Scenario and making your selection.
- *Pivot*: To rearrange the table layout, right click with the mouse on the  symbol in the upper right corner. In the new window, you can change the table dimensions by using drag and drop elements into the Table area or Table control box.

In the example below, the dimension "Sectors" is moved from "Box (2)" to the "Table column groups". The combination of dimensions is fully flexible; it is also possible to have multi-dimensions on the table axes. The only requirement is that the "Table row" and "Table columns" must contain at least one dimension.



- *Customise*: The results can be displayed in various ways. If you click on the symbol  on the upper right menu, this opens the following view:



In the box "Comparison Output", you can select to view results in values or percentage changes, either both at the same time or other comparison variants. In general, you would choose the data dimension "scenario" for comparison and compare it against the element "base". This will give you results in percentage change from the base (as displayed above). If you wish to compare two simulation results, you select the scenario to use as the basis for the comparison in the "Element used for comparisons Scenario" of the drop-down menu.

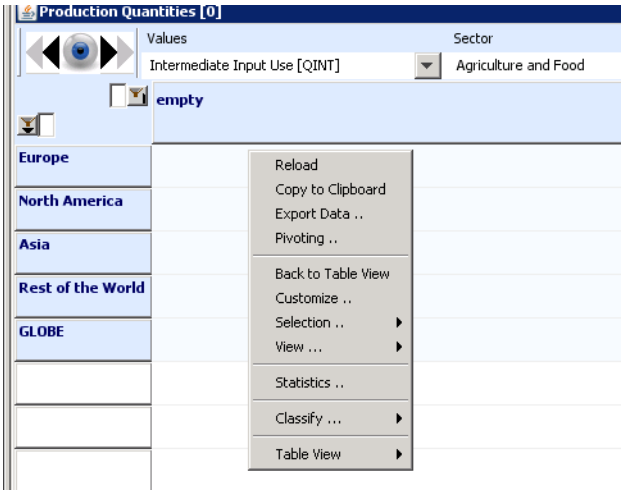
Other options to compare the output are normalisation and the so-called "GTAP difference" and various combinations thereof. "Normalisation" means that the value is divided by the comparison points, allowing, for example, to calculate shares. The "GTAP" difference is a compromise between a percentage and an absolute difference: it multiplies the difference in logs (percentage) with the difference (absolute).

You can also customize other elements of the viewer such as the font, font size, and the number of digits displayed.

Other features include:

- *Export to excel-with copy to clipboard*: The table you view is easily exported to excel by clicking on the  symbol and paste in the destination excel file.
- *View type*: The "Table" button on the upper right corner gives the possibility to change the view type from table to various types of graphs, e.g. bar or pie charts.

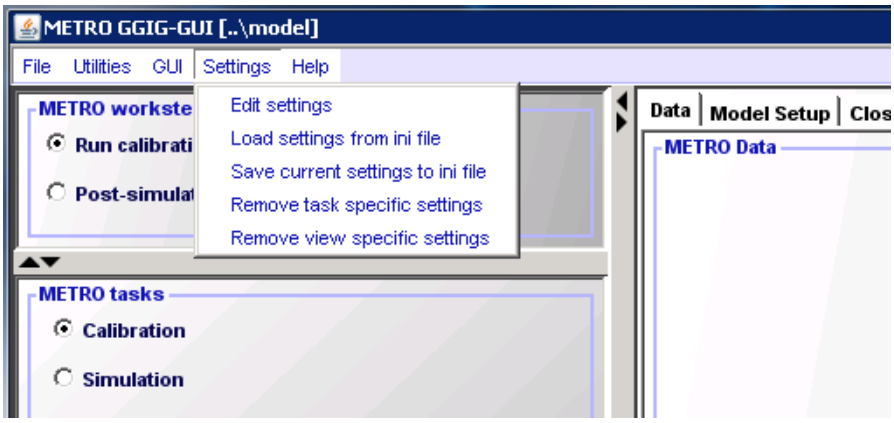
All of these options (Pivoting, Customize, Copy to clipboard, View) can either be accessed via the respective symbols on the tool bar or with a right click in the data area, which opens a menu showing these and additional options.



Two other options are good to know:

- *Selection of elements:* You can limit the number of rows and columns to show only a subset of dimension elements. Right click in the data area. In the "Selection" option, select the dimension to filter (row or column). In the box that appears, select the elements you want to show in your table. To remove the filters, select "Reset" in the "Selection" option.
- *Statistics*: There is the possibility to view various simple data statistics for the specific table, e.g. sum, mean, median etc. Right click in the data area, and select "Statistics".

***TIP**: To delete all the changed settings of the data viewer and go back to default, exit the viewer and click on "Settings" on the top menu bar and select "Remove view specific settings". Similarly, you reset the model back to default settings by selecting "Remove task specific settings", but be sure to select the calibration task first. If the menu bar is not available when exiting the viewer, you can either maximise or minimise, or switch back and forth between the METRO tasks.*



6.2. Tables available in viewer[9] [10]

6.2.1. *Tables available in default model setup*

Prices		
•Bilateral Export Prices	(PER,PWE)	
•World Prices-No Use Dimension	(PWEAGG, PWEAGG2, PWMAGG, PWMAGG2)	!empty region
•Bilateral Import Prices	(PMR, PWM, PWMFOB)	
•Product Market Prices-with use dimension	(PE, PS, PD, PQD, PQS, PT, PM, PML, PMS, PWEAGGU)	
•Product Market Prices-no use dimension	(PXC, PINTD, PCD, PGD, PINVD)	
•Production Costs	(PINT, PVA, PX)	
•Intermediate Input Prices- module specific	(PDA, PMA, PINTA, PINTS, PDA2, PMA2) *available with interm input nesting module*	
Quantities		
•Bilateral Export Quantity	(QER)	
•Bilateral Import Quantities	(QMR, QT)	
•Domestic Product Market-with use dimension	(QE, QS, QD, QQ, QM, QML, QMS)	
•Domestic Product Market-no use dimension	(QXC, QINTD, QCD, QGD, QINVD)	
•Production Quantities	(QINT, QVA, QX)	
•Intermediate Input Quantities-module specific	(QDA, QMA, QINTA) available with intermediate input nesting module	
Factor Market		
•Factor Market	(FS,WF,UNEMP,YF, YFDIST)	
•Factor Market - Activity Specific	(FD, WFD, WFDIST)	
Production Efficiency Parameters		
•Level 1 of Production	(ADX, ADXADJ)	!empty sector
•Level 2 of Production	(ADVA, ADVAADJ)	!empty sector
•Level 3 of Production	(ADFD, ADFDaADJ, ADFAfADJ, ADFDrADJ)	!empty sector, factor and region
Household		
•Income and Expenditure	(YH, YHD, YHF, HEXP, HHLDSAV, SHH, SADJ, DSHH)	!empty household
•Remittances	(REMIN, REMINW, REMOUT, REMOUTW, REMRYHF, REMADJ, DREM)	!empty household and partner
Government		
•Government Income and expenditure	(YG, EG, VGDSH, QGDADJ, KAPGOV)	
•Tax Revenue	(ETAX, MTAX, MSTAX, FTAX, HTAX, ITAX, STAX, VTAX)	
•Tax Rates - Export and Tariff	(TE, TM, TMS)	
•Tax Rates - Sales and Value Added	(TS, TV)	!empty use
•Tax Rates - Income Tax	(TYH)	
•Tax Rates - Factor Related and Indirect	(TF, TX,TYF)	!empty factor and activity
•Tax Rates Scaling Factors	(TEADJ, TFADJ,TMADJ,TMSADJ,TSADJ,TVADJ,TXADJ,TYFADJ,TYHADJ)	
•Other Policy Parameters	(AMS, DABBMR)	
Capital Market		
•International	(KAPREG, KAPWOR, ER)	!empty partner
•Regional	(IADJ, INVEST, INVESTSH, TOTSAV, SREGH)	
Macroeconomic Effects		
•Nominal	(GDP, VFDOMD, nQCDTOT, nQGDTOT, nQINVTOT, nIMPORT, nEXPORT, nSUPPLY, nUSE, nYHTOT, nYHDTOT, nREMIN, nREMOUT, nYGTOT, nYFTOT, nYFDISTTOT, nYFLABTOT, nTOTSAV, nHOSAV, nFSAV, nDEPREC)	
•Real	(rGDPEXP, rQABSORP, rQCDTOT, rQGDTOT, rQINVTOT, rIMPORT, rEXPORT, rSUPPLY, rUSE)	
•Trade by Use	(rUEXPORT, rUIMPORT, nUEXPORT, nUIMPORT)	
•Terms of Trade Effects	(TOT, TOTcagg)	!empty sector
•Other Price Effects	(GPI,IPI)	
Welfare Effects		
•Household Welfare Effects	(EV, IC, EV_alt, EV_R_slutsky, EV_H_slutsky)	!empty household

[9] '!empty' in the table refers to the case where the dimension does not exist.

[10] See Annex Table 1 for description of items available in each table view.

Market Clearing and Numeraire		
•Numéraire	(PPI, CPI, ERPI)	!empty region
•Market Clearing	(GLOBESLACK, WALRAS, KAPWORSYS)	!empty region

6.2.2. *Tables available only with certain modules*

Willingness to Pay

Theme and associated tables will only appear when Willingness to Pay Module is selected

Willingness to Pay*		
•Welfare and regional income	EVGTAP, WEV, Y, Y_ALT, YEV, Y_CHK, POPN, QHLD, QGOVT, DOMSAV, NETINV, QINV, QSAVE, QHSAV, QGSAV, PINV, PDOMSAV	*!empty sector and use*
•Welfare Decomposition-Expenditure Side	d1_hsub, d1_hcons, d1_gcons, d1_hsav, d1_gsav, d1_WTPHC, d1_WTPHS, d1_WTPGC, d1_WTPGS, d1_pop, d1_total, d1_diff	*!empty sector and use*
•Welfare Decomposition-Income Side	d2_Alloceff, d2_Endow, d2_Remitt, d2_TOT, d2_SITOT, d2_WTP, d2_techchg, d2_pop, d2_total, d2_diff	*!empty sector and use*
•Decomposition of Technological Change	dt_production, dt_demand, dt_supply, dt_imports, dt_exports, dt_total, dt_diff	
•Utility	UC, UG, UHS, UGS, UGS	*!empty sector and use*
•Iceberg Effect	QMACT, QMICE	*!empty sector and use*
•WTP Parameters and Ratios-Commodity Related	BMR, BM, BD, BQ, BMRRATM, BMRATQ, BDRATQ	
•WTP Parameters and Ratios-Activity Related	BX	*!empty use*
•WTP Parameters and Ratios-Agent Related	BSAV, BU, BHC, BHHD, BQRATH	

Local content requirement

Tables available in each theme only when the Local Content Requirement module is selected.

Government	
•Other policy parameters	lcrshVAR
•Other Policy Parameters - module specific	lcrsh_AVAR
Quantities	
•Domestic Product Market-with use dim	QDLCR, QDNL, QLCR, QQARM
•Intermediate Input Quantities-module specific	QDLCR_A, QDNL_A, QLCR_A, QQARM_A
Market Clearing and Numeraire	
•Market Clearing-LCR Module	SLACK, SLACK_A

Land Allocation Module

Tables below appear when the Land Allocation Module is activated

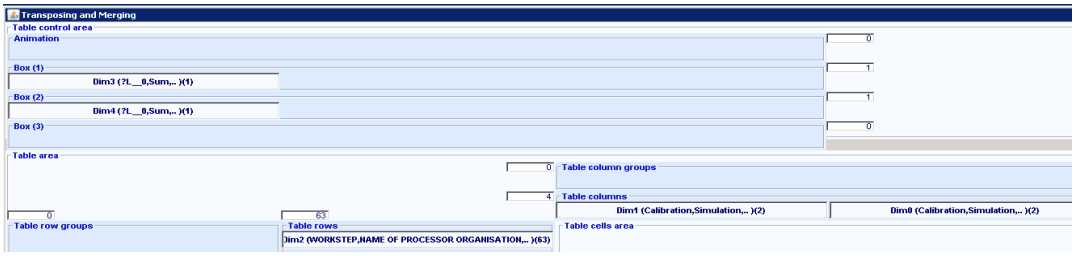
Factor Market	
• Factor Market – Land Allocation (Supply)	FS_CET1, FS_CET2, FS_CET3, FS_CET4
• Factor Market – Land Allocation (Price)	WF_CET1,WF_CET2,WF_CET3, WF_CET4

6.3. Metadata

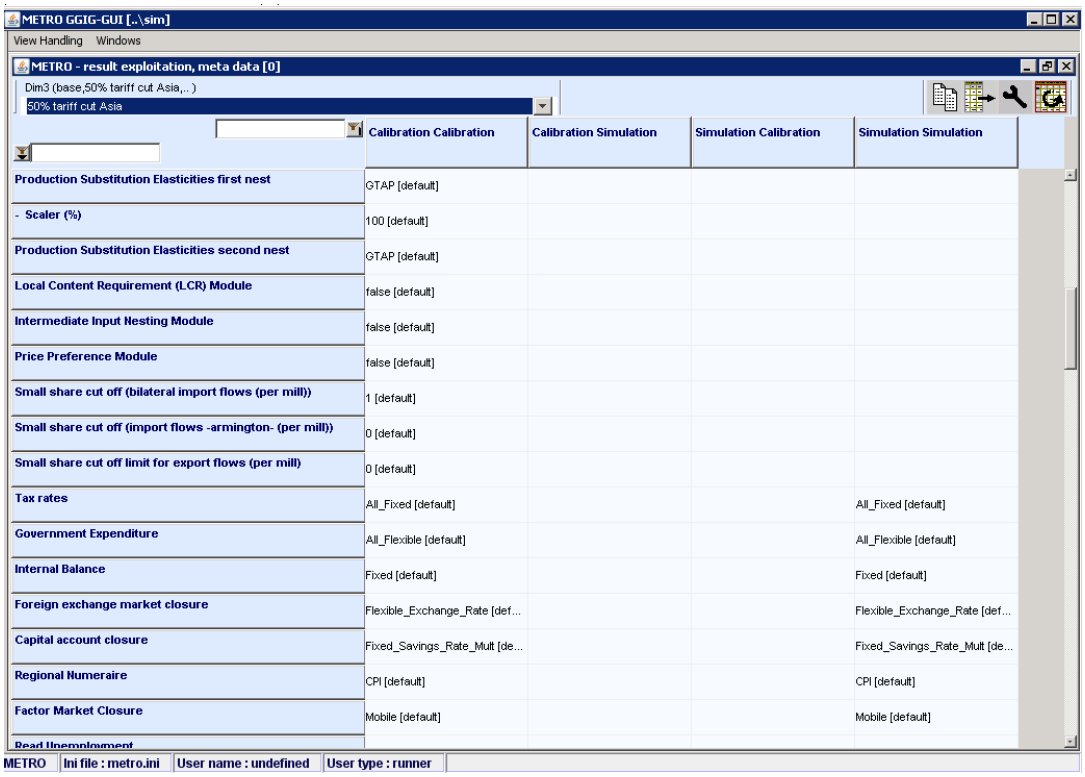
Each result file contains metadata documenting the interface setup and input files used to produce the respective results at both calibration and simulation steps. This metadata ensures the replicability of the results and acts as a verification tool to ensure the correct setup of the simulation. The metadata is stored in the same file as the results (gdx file in folder 'Results').

To access the metadata, press the "Exploit results" button in the simulation step and then select one scenario that you are interested in (we recommend looking at one file at a time). Next, press the "Show meta" button on the left bottom.

Similar to when viewing results, you can select the scenario and rearrange the view using the pivot feature. One suggested table setup (accessed by right clicking on the  button) is to have Dim 2 as the table row, and Dim1 and Dim 0 as table columns.



This set up will give you the table below.



The column “Calibration Calibration” indicates the setup of the calibration file used and the column “Simulation Simulation” shows the setup in the simulation step; the other two columns are empty.

The base scenario is produced at the calibration stage and does not have any entry for the simulation step.

7. METRO GUI: Post-simulation analysis

The step "Post simulation analysis" contain modules that calculate the parameters and indices of the base and resulting simulation databases. The interface includes one module which computes ICIO-TiVA indicators for analysing global value chains. Several types of indicators and types of Value Added (VA) decomposition are available.

7.1. ICIO-TiVA module: How to run the module

In Brief: ICIO-TiVA Module

Programme: METRO-ICIO.gms

Input: Result files from simulation (and base data from calibration); Directory Results/simulation
!with intermediate input nesting module activated!

Output: Directory Results/ICIO-TiVA

1. Inter-Country-Input-Output table (ICIO).
2. Value added exports
   a. Value added exports matrix
   b. VA composition of exports: domestic VA; foreign VA (backward linkage); gross exports
   c. VA used in exports: sector VA in total exports, in own sector's exports, in partner region's exports (forward linkage)
3. TiVA indicators
   a. Backward indicator
   b. Forward indicator
   c. Position
   d. Participation
4. Direct and indirect VA in final demand by product group
   a. Gross consumption
   b. Total VA in final demand
   c. Direct VA in final demand
5. Indirect VA in final demand

Analyse: Create indicators for base and simulation.

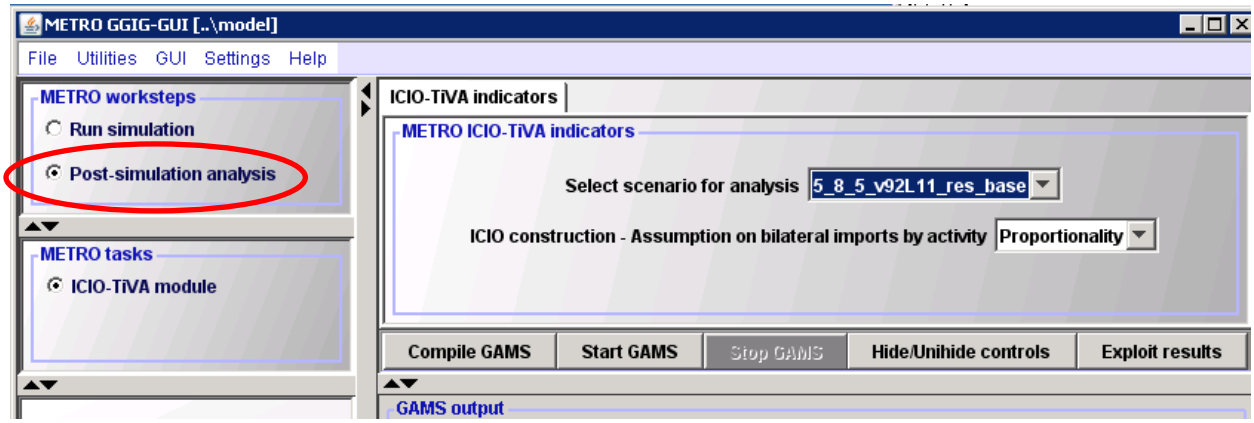
1. Workstep: Post-simulation analysis
2. METRO tasks: ICIO-TiVA module
3. Select scenario for analyses. *TIP: An ICIO indicator must be created for all scenarios you want to compare, including the base!*
4. Select assumption to construct ICIO. *TIP: Only one choice at present.*
5. Start GAMS and exploit results as usual.

The model contains a module for the analysis of global value chains (GVCs). The Inter-Country-Input-Output table (ICIO) and Trade in Value Added (TiVA) indicators are computed as a post-simulation analysis.

To view and analyse the indicators, the user must first generate them. To create the indicators, select the work step "Post-simulation analysis" and the task "ICIO-TiVA module". Select the scenario to analyse and the assumption to create the ICIO table (currently there is only one), then click the "Start GAMS" button.

The output of the ICIO-TiVA module is based on files generated from the calibration and simulation runs. ICIO-TiVA indicators for the base data will originate from the base scenario that is produced during calibration, while the file generated from the simulation run is used to calculate the ICIO-TiVA indicators resulting from the policy shock.

***TIP**: In order to be used in the ICIO-TiVA module, the respective simulation file must be created with the intermediate input nesting module activated in the model setup (Calibration step). If this is not activated, the programme will abort.*

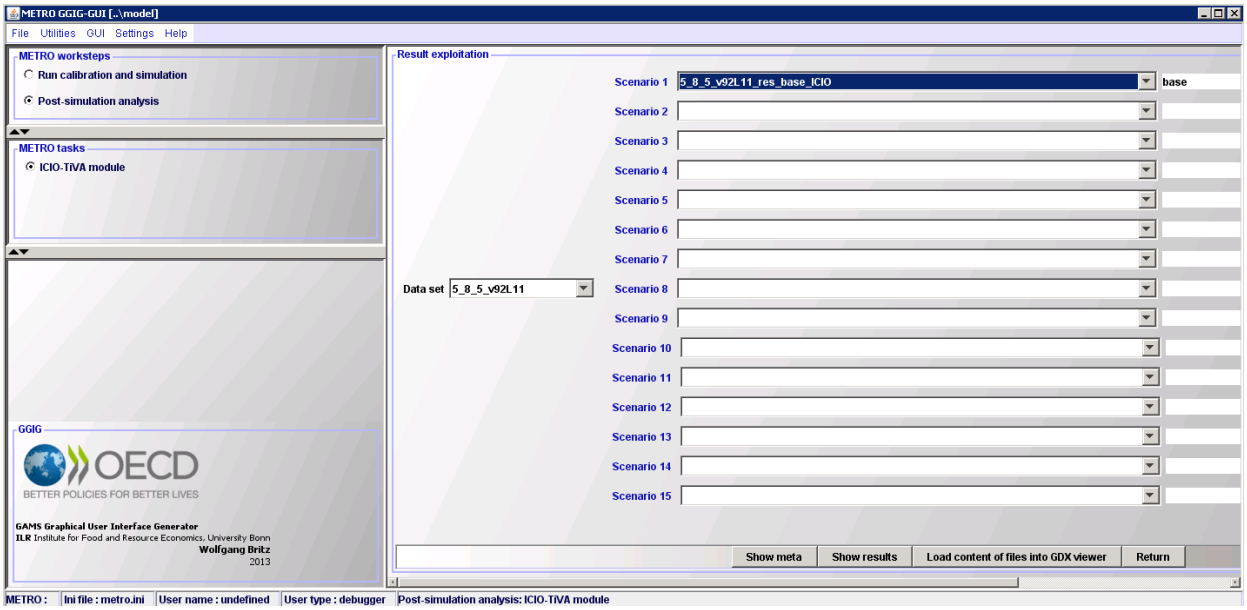


METRO results from the simulation and calibration runs contain information on import use by sector, e.g. the quantity of imported manufacturing goods used by the domestic agricultural sector. METRO results also have information on bilateral imports used as intermediates, e.g. the quantity of manufactured goods imported from Asia. However, the construction of an ICIO requires information on the import use of intermediates from each source by sector (e.g. the quantity of imported manufacturing goods used in the domestic agriculture sector comes from Asia). In order to add this dimension, an assumption is needed. The module currently assumes proportionality to distribute bilateral imports across sectors. Thus, while the sectors differ by the values of the imports used (of each intermediate commodity), the bilateral composition of these imports is equal among sectors.

***TIP**: The GVC analysis of the database is straightforward. Be careful, however, when analysing and interpreting changes in indicators or value flows, as these can only reflect the structure and assumptions employed in the model. In addition, note that trade within aggregate regions are classified as domestic flows (this is due to the structure of the ICIO). You should consider this when defining your aggregation.*

7.2. ICIO-TiVA module: Output

The results can be viewed and compared in the viewer. Click on "Exploit results" and select the data set and file(s) you want to view.



The module consists of GAMS programme (METRO_ICIO.gms) that creates ICIO and TiVA indicators based on scenarios that are previously run. Each simulation results file can serve as possible input to create an ICIO[11].

To compute the TiVA indicators, the module first computes an Inter-Country-Input-Output table. A value added export matrix is then derived from the ICIO table. The TiVA indicators are derived from the VAE matrix.

***TIP**: The ICIO-TiVA concept is complicated. Annex B details an example which should help to interpret the module output.*

7.2.1. *The Inter-Country-Input-Output Table (ICIO)*

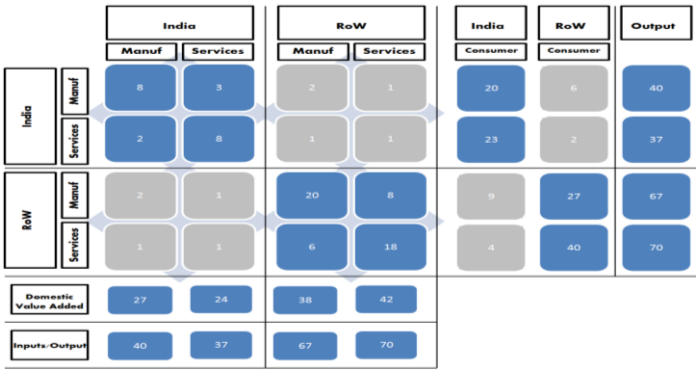
The ***Inter-Country-Input-Output Table (ICIO)*** serves as the basis for the TiVA analysis. All indicators and value added decompositions are derived from it. The structure of the ICIO table is described in the next section. It has 4 dimensions, 2 rows, and 2 columns, which are indicated in the viewer, respectively, by 'source region', 'inputs' and 'destination region', 'demand'.[12] The ICIO shows economic flows from source region to destination region, where dimension 'inputs' include intermediate inputs, value added and taxes. 'Demand' includes production activities and final demand.

***TIP**: See below for the structure of the ICIO table. Note that value added and taxes do not have a source region.*

[11] Under the condition that it is created with the intermediate input module switched on.

[12] It is worth noting that when working with aggregate regions, trade within countries of these regions is classified as domestic flows.

Figure 5. ICIO Table

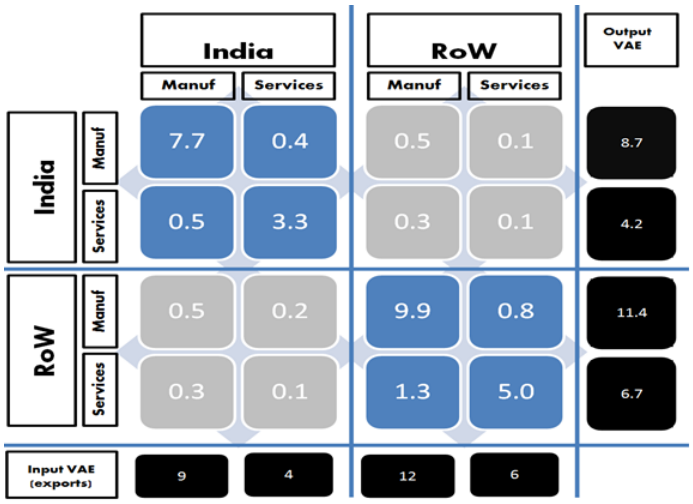


Rows indicate source country and inputs. Columns indicate destination region and demanding sector.

7.2.2. *The value added exports matrix (VAE)*

The ***value added exports matrix (VAE)*** depicts the origin (source region) of value added in the exports of a region. This information goes into further at the sectoral level. Value added exports are derived from the ICIO by matrix inversion and multiplication, and serve as the basis for the calculation of TiVA indicators.[13] The VAE matrix has 4 dimensions, 2 rows and 2 columns, which are indicated in the viewer by 'VA source region', 'VA source sector' and 'Exporting region', 'Exported commodity'.

Figure 6. Value Added Export Matrix



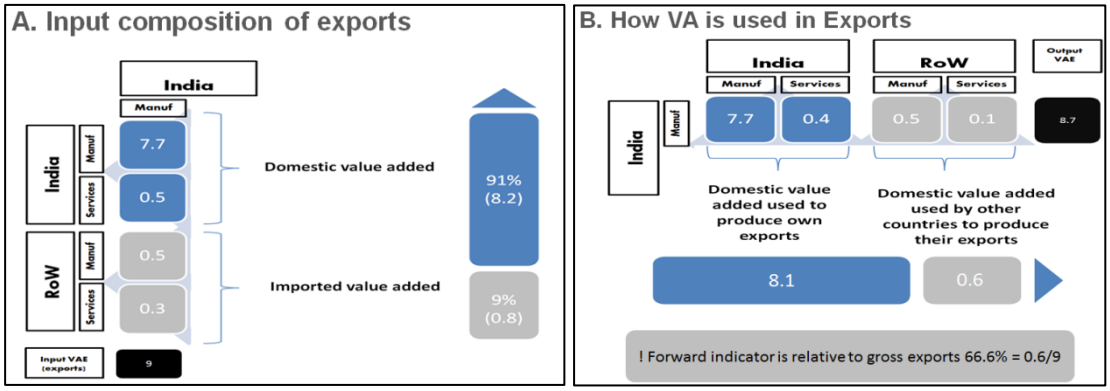
Rows indicate exporting country and exported commodity. Columns indicate the source of the value added by country and sector.

Using the VAE matrix, we can decompose value added in exports in two ways to provide useful insights on a country's involvement in the global value chain. One way of decomposing a region's exports is to identify the value added generated within the country (Figure 7A), i.e. ***domestic value added***, and the value added which is imported, i.e. ***foreign***

[13] For a detailed technical description, see Flaig, Kawasaki and Greenville (2018)

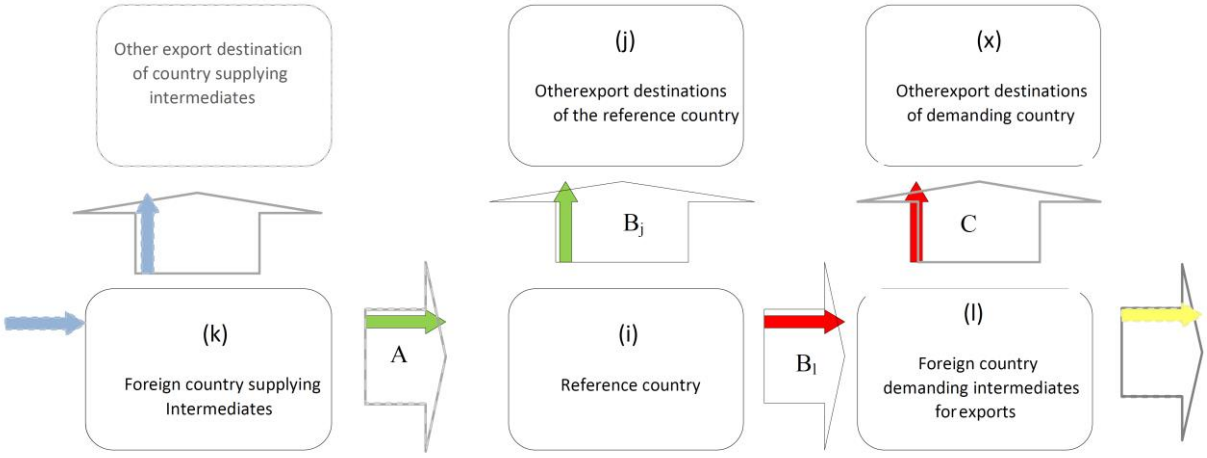
value added (backward linkage). The sum of domestic and foreign value added is gross exports. This information is available by region and by sector.

Figure 7. Decomposing value added exports



Another VAE decomposition details how the value added of a sector is used in exports: the ***value added content of a sector in total exports*** from a region (Figure 7B). This includes the ***value added content in the sector's own exports*** and exports of other sectors for which it serves as input in production. The forward linkage shows the use of a sector's ***value added in exports of partner regions***. Thus, the forward linkage indicates if the own product is part of a longer value chain (further processed and again exported) in comparison to goods that are designed for final demand.

Figure 8. Backward and forward participation: Supply and demand of intermediates



Note: The green arrows denote the foreign value added embodied in imported intermediates used for exports of reference Country (i) the backward linkage. The red arrows denote the value added of the reference Country (i) embodied in its exports of intermediates which are used for exports of Country (l) the forward linkage.
Source: OECD (2015, p.15).

7.2.3. *Trade in Value Added (TiVA) indicators*

The value added exports values can be expressed using the so-called TiVA indicators: ***Backward participation*** represents the foreign value added share in total exports from a reference country (green arrows in Figure 8). ***Forward participation*** represents the share of a reference country's value added exports in the total value of their trading partners' exports, expressed as a share of the industry's "gross" exports (red arrows in Figure 8). The indexes measure very different forms of engagement. For example, a country that predominantly assembles products into final goods that are subsequently exported will have a strong backward participation index but a small forward participation measure. Conversely, a country that predominantly supplies intermediates to an assembler will have a strong forward participation indicator but a small backward participation measure. These participation measures therefore give us a metric of engagement in the form of buying from (backward participation) and selling (forward participation) GVCs.

The total ***participation indicator*** is defined as the sum of the backward and forward participation (Koopman et al., 2011). To capture a country's position, Koopman et al. (2011) proposed the ***position index***, whereby two countries can have identical values of the total participation index in a given sector while having very different degrees of position in GVCs (that is, whether they are more involved upstream or downstream in the value chain). To capture a country's position, the position index is given by a log ratio of forward and backward indicators: ln(1 + forward indicator) – ln(1 + backward indicator). If the sector lies upstream in a supply chain, the first term (numerator) tends to be large. If it lies downstream, then the second term (denominator) tends to be large. For example, in the home electronics sector, if Japan specialises in providing components to assembly firms in the People's Republic of China (hereafter "China"), the index tends to take on a high value for Japan and a low value for China.

7.2.4. *Direct and indirect Value Added in final demand*

An alternative way to explore GVCs is through the source and final destination of value added. Domestic value added can end up in foreign final demand through a number of pathways. It can flow directly from one country to the next – a direct bilateral flow – or it can flow indirectly through a third (or fourth, and so on) country.

In a first step, final demand (from the ICIO) is added and aggregated by commodity group. Two sets of measures are available:

- ***Consumption demand***, which includes household demand and government consumption
- ***Final demand***, which includes household, government and investment consumption.

The resulting ***gross consumption/gross final demand*** is decomposed into regions and sectors where value added was originally created. The decomposition is available by commodity group and shows VA flows of final demand commodity (group) by source region and final demand region.

VA in consumption/final demand depicts the VA the source region contributes to final demand in each region. It is the sum of direct and indirect VA flows. Total final demand in value added and gross terms are equal, but the composition differs. Thus, the sum of the source region equals the sum over source region of gross consumption.

Direct VA in consumption demand/final demand shows the VA that flows directly from one region to the next. Either the traded good is for final demand or it is traded in the form of an

intermediate good and reprocessed inside the importing region. It also includes domestic VA flows when the VA source and demand regions are the same.

Indirect VA in consumption demand/final demand depicts VA flows that reach final consumption over a third (or fourth…) region.[14] Indirect flows thus capture the part of final consumption that is part of global value chains.

7.3. ICIO-TiVA module: Tables available in viewer

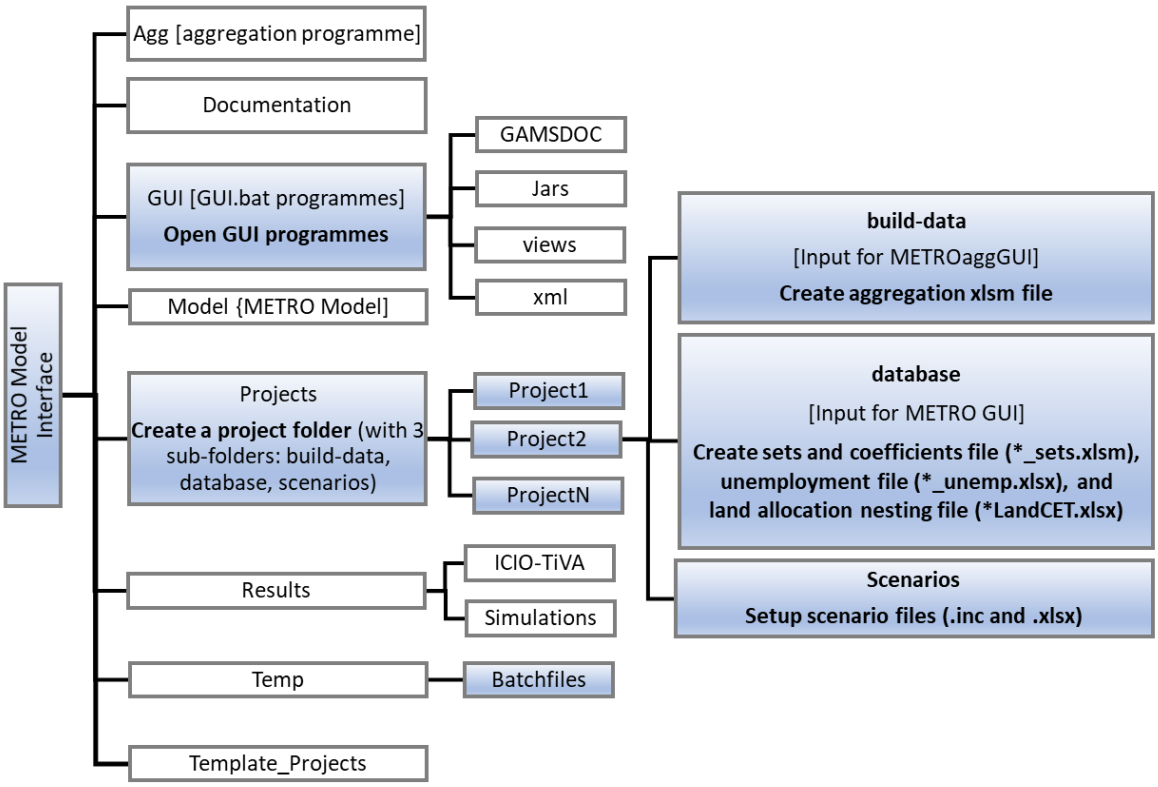
Theme	Table group	Item name (Key)
TiVA indicators		
	TiVA indicators	Backward indicator (backward) Forward indicator (forward) Participation indicator (participation) Position indicator (position)
Value added exports		
	VAE decomposition (column): gross exports	Gross exports of sector (gross_exp) decomp. gross exports: domestic VA (domestic_VA) decomp. gross exports: foreign VA (backward_VA)
	VAE decomposition (row): VA used in Exports	Sector VA in own sector exports (VAE_own) Sector VA in total exports (VAE_total) Sector VA in partner exports (forward_VA)
	VAE-matrix	Value Added Exports Matrix (VAE-Matrix)
direct-indirect value added		
	Value added in final demand (Govt+Hhd+Inv)	Gross final demand (gross_consumption_PGI) VA in final demand (VA_FDtotal_PGI) Direct VA (VA_FDdirect_PGI) Indirect VA (VA_FDindirect_PGI)
	Value added in consumption demand (Govt+Hhd)	Gross consumption (gross_consumption_PG) VA in consumption (VA_FDtotal_PG) Direct VA (VA_FDdirect_PG) Indirect VA (VA_FDindirect_PG)
ICIO		
	ICIO (matrix)	ICIO (ICIO)

[14] It is worth noting that when working with aggregate regions, trade within countries of these regions are classified as domestic flows. For example, when working with an aggregate European Union, exports of Brazilian beef for consumption in Germany would be classified as a direct flow, even when pre-processed in Poland.

8. Technical documentation

8.1. Directory structure: Where do I find what?

The figure below shows the structure of the METRO directory, which contains eight folders and several sub folders.



When using the interface, the user needs to access only three folders to run simulations: "GUI", "Projects", and, if running simulations in batches, "Batchfiles".

- **GUI**: this folder contains the interface (GUI) programmes 'Metro_GUI.bat' and 'MetroAgg_GUI.bat'. Other files and sub-folders in the GUI folder define the interface structure and appearance.
- **Projects**: When starting a new project add a folder to the "Projects" directory and make sure to add 3 subfolders. The name of the project folder can freely be chosen, but should not contain empty spaces. The subfolders must be named 'build_data', 'database' and 'scenarios'. Project folder "Example_5_8_5" containing a toy aggregation serves as example and template:
  - **"build_data"**: This folder contains the xlsm file used to define the aggregation, the file is used as input for aggregation programme 'METROagg_GUI.bat'. The

name of the xlsm file defines the name for the aggregation database and thus will be the identifier for the aggregation. Keep it short but comprehensive. The following naming convention has proven useful: s_f_r_DBversion-year_(optional)projectID (e.g., 5_8_5_v10L14). The aggregation excel file 5_8_5_v10L14.xlsm will create an aggregated database with the name 5_8_5_v10L14.gdx. The aggregation excel file 5_8_5_v10L14_example.xlsm will create an aggregated database with the name 5_8_5_v10L14_example.gdx

- **"database"**: This folder must generally contain two files which is created by the user:
  - **The sets and coefficient xlsm file**: the name of the file is equal to the database but MUST end with '_sets.xlsm' as the GUI is searching for a file with this ending (e.g. 5_8_5_v10L14_sets.xlsm).
  - **The unemployment xlsx file** where unemployment is defined and unemployment rates are set: the name of the file is typically equal to the database but MUST end with "_unemp.xlsx" as the GUI is searching for a file with this ending (e.g. 5_8_5_unemp.xlsx).
  - **The land allocation nesting excel file**: this file is only required to be updated when the land allocation module is turned on; As with the other files in the "database" folder , the file name should include the database name. However, the file name MUST end with "_LandCET.xlsx".
- **"Scenarios"**: Contains all simulation files, excel (xlsx) and gams (inc)

Other folders in the directory are:

- **Agg**: The folder contains the aggregation programme and the METRO databases (available with GTAP license).
- **Documentation**: The folder contains several useful METRO documents
- **Model**: This folder contains the model.
- **Results**: Results from the calibration and simulation steps run and Post simulation analyses are stored in this directory. Results are grouped into output from the simulation run and ICIO-TiVA module output.
- **Temp**: The sub-folder 'Temp\batchfile' contains files for batch file execution (discussed later in this document). When using this advanced option the user can define the batch file in this folder. The "Temp" folder is also where the resulting gdx file from the numeraire check is stored.
- **Template_projects**: Useful project templates are found here, including projects using the METRO database version 9.2 and a project for use with all land using sectors with the Land Allocation Module activated.

***TIP**: **To archive**: After completion of a study all relevant result files and project folder (gdx and xml) should be archived.*

***TIP**: **Cleaning up the files**: The programme produces various temporary files which can be large but which can be deleted after the simulation has been finished. To clean up, run the 'cleanall.bat' in your project folder (available in the template folder Example_5_8_5_v10L14). You run the batch files by double clicking on them.*

In the 'Model' folder, the 225x folders where these exist can be deleted. These folders are created when there have been errors during a run of the model.

8.2. GUI overview

The following figures illustrate the link between the various folders and files at each step.

Figure 9. Link of files: Aggregation (METROagg_GUI)

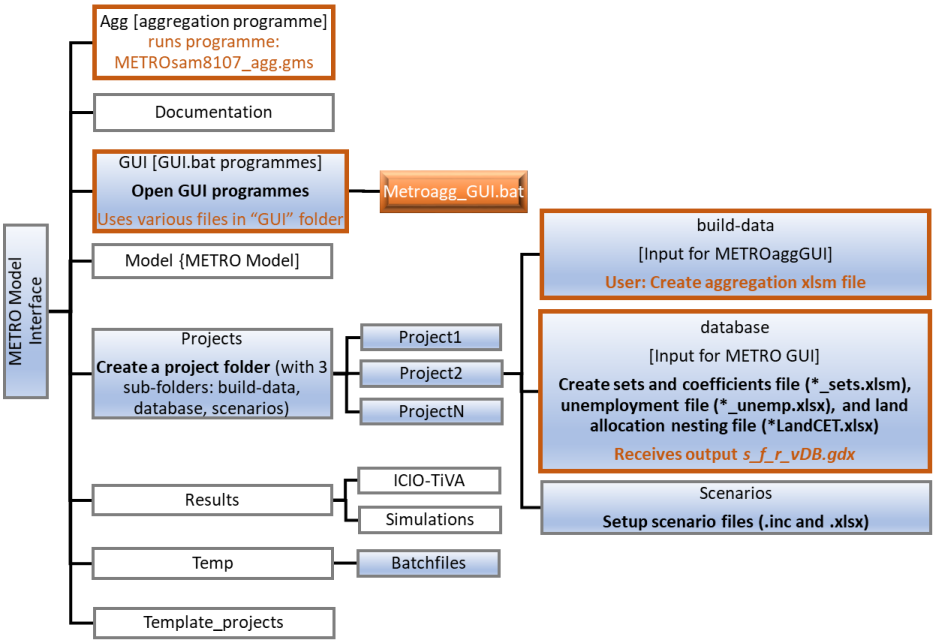


Figure 10. Link of files: METRO_GUI, calibration step

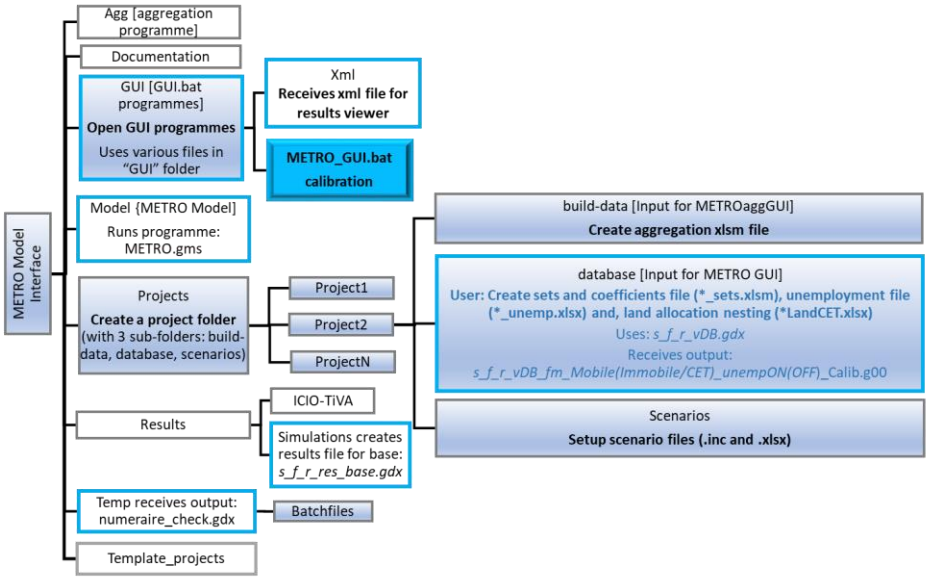


Figure 11. Link of files: METRO_GUI, simulation step

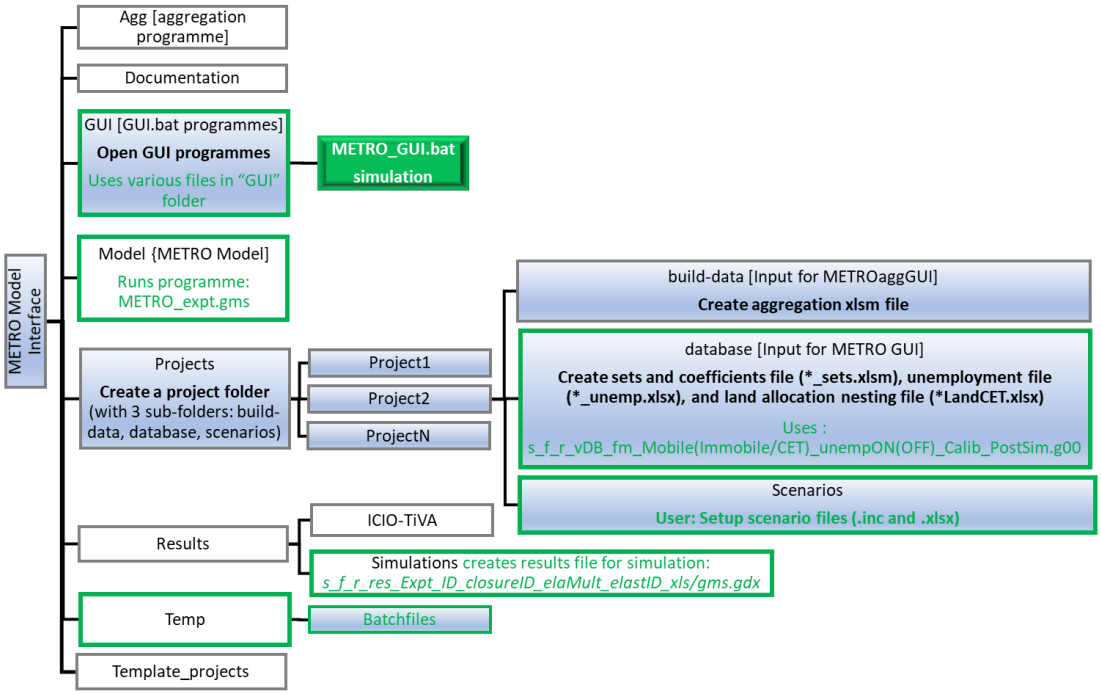
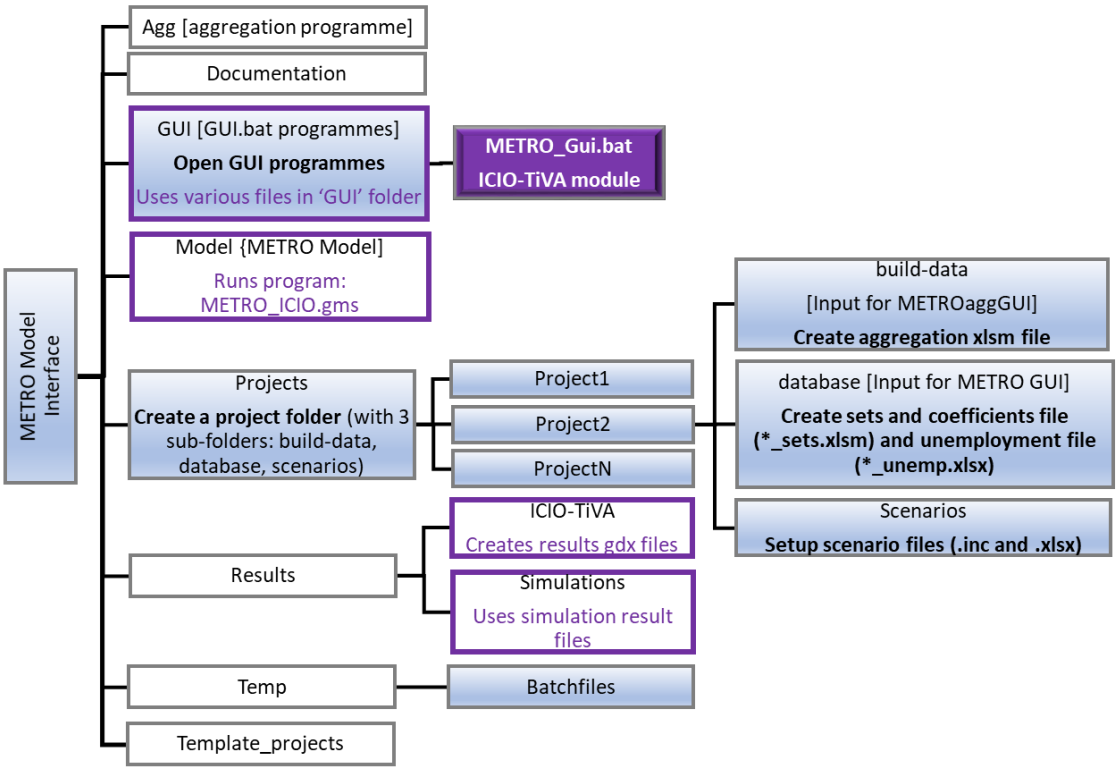


Figure 12. Link of files: METRO_GUI, post simulation analysis – ICIO-TiVA-module



8.3. The model file structure and modelling conventions

The model consists of one master gams file (GMS) and a series of include files (INC), the different types of files are listed in the Table below. Data is read into the model with a GAMS Data Display (GDX) and an excel file. These files contain the basic SAM data (GDX) and definitions of set, variable and parameters names as well as other supporting information. For control and information, the model produces several GDX files during each run, including the initial calibration run. Figure 13 illustrates the file structure and shows the place where each INC file is called into the core programme, together with the titles of each of the sections of the core programme file itself. In addition, the descriptions down the left hand side indicate the role each INC file plays in the programme, the right hand side shows resulting outputs via GDX files.

Table 6. Major GAMS file types

GPR	GAMS project file: stores all project information in a specific directory
GMS	GAMS master file
INC	GAMS include file: auxiliary files linked to the GMS master file
GDX	GAMS data exchange file: platform independent, binary data file. GDX files can be used to pass data between GAMS and other programs
LST	GAMS output file: lists all output information, automatically generated
LOG	GAMS output file that contains information relevant to the solution and error status

Figure 13. Model file structure

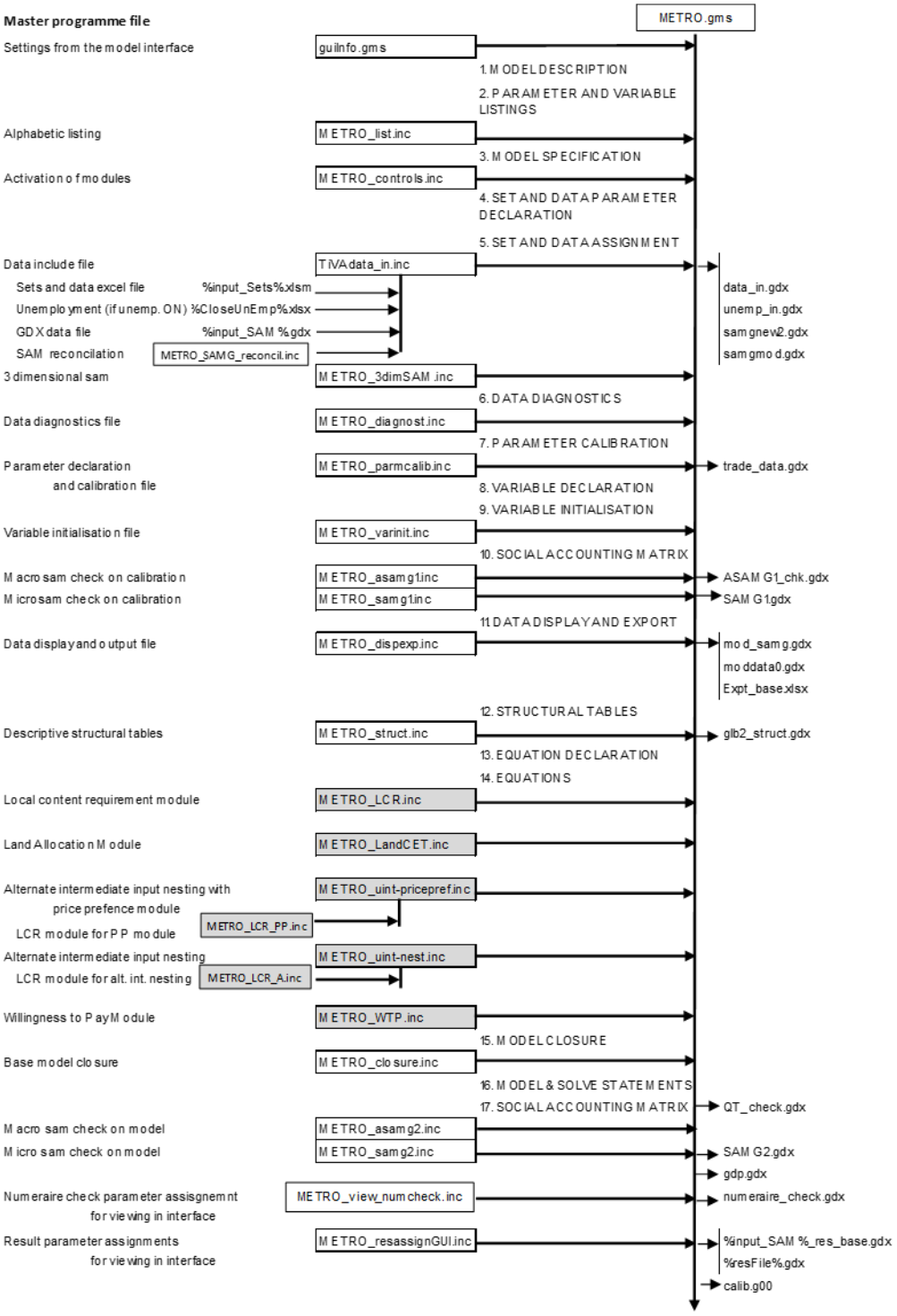
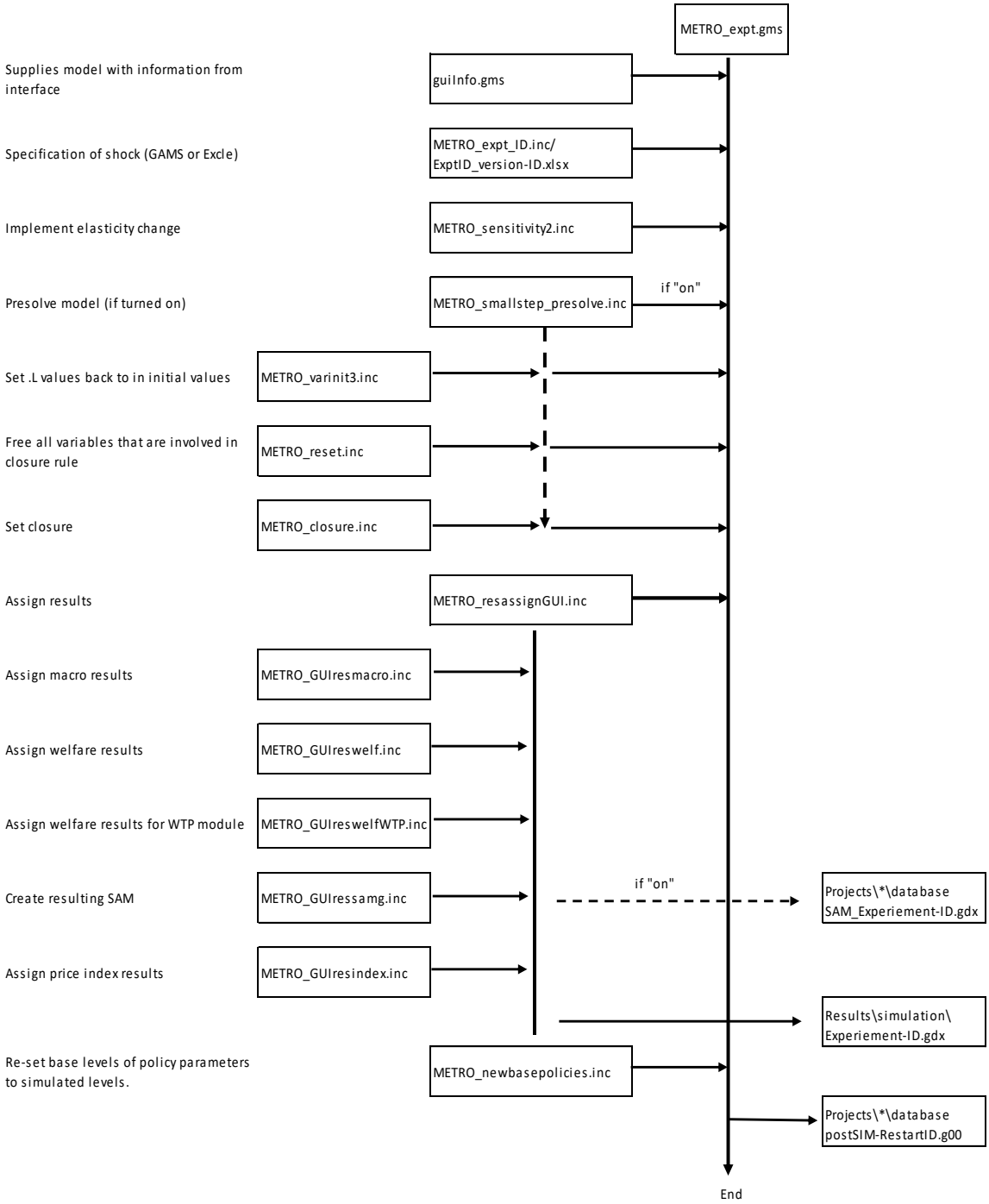


Figure 14. Experiment file structure



The model is made up of a series of equations, parameters and variables. The equations for the model are set out in nine 'blocks', each usually, but not always, containing several sub-blocks. The equations, defined in METRO.gms, are grouped under the following headings.

1. TRADE BLOCK
   a. Exports Block
   b. Imports Block
2. COMMODITY PRICE BLOCK
3. NUMERAIRE PRICE BLOCK
4. PRODUCTION BLOCK
   a. Production
   b. Intermediate Input Demand
   c. Commodity Output
   d. Activity Output
5. FACTOR BLOCK
6. HOUSEHOLD BLOCK
   a. Household Income
   b. Household Expenditure
7. GOVERNMENT BLOCK
   a. Government Tax Rates
   b. Government Tax Revenues
   c. Government Income
   d. Government Expenditure Block
8. CAPITAL BLOCK
   a. Savings Block
   b. Investment Block
9. MARKET CLEARING BLOCK
   a. Factor Accounts
   b. Commodity Accounts
   c. Investment and Savings Accounts
   d. Commodity Trade Accounts
   e. Margin Trade Accounts
   f. Absorption Closure
   g. Slack

This grouping is carried throughout the model code, i.e. it is the basis for the parameter declaration and calibration, variable declaration, and variable initialization sections. This modularization of the code is adopted for ease of reading and altering of the model, rather than being a requirement of the model.

A series of conventions are adopted for the naming of variables and parameters. These conventions are not a requirement of the modelling language, but are designed to ease reading of the model.

- All VARIABLES are in upper case.
- The standard prefixes for variable names are: P for price variables, Q for quantity variables, W for factor prices, F for factor quantities, E for expenditure variables, Y for income variables, and V for value variables
- All variables have a matching parameter that identifies the value of the variable in the base period. These parameters are in upper case and carry a '0' suffix, and are used to initialise variables. For example, *YH* is household income and *YH0* sets household income in the base period.
- There are a series of variables that allow for the equi-proportionate multiplicative adjustment of groups of variables. These variables are named using the convention **ADJ, where ** is the variable series they adjust. For example, *TEADJ* allows all export taxes to be changed by a common amount.
- A series of variables are declared that allow for the additive adjustment of groups of variables. These variables are named using the convention D**, where ** is the variable series they adjust. For example, *DTE* allows for a consistent adjustment to export taxes.
- All parameters are in lower case, except those paired to variables that are used to initialise variables.
- Parameter names have a two or five character suffixes which distinguish their definition, e.g. **sh is a share parameter, **av is an average, and **const is a constant parameter.
- For the Armington (CES) functions all the share parameters are declared with the form delta**, all the shift/efficiency parameters are declared with the form ac**, and all the elasticity parameters are declared with the form rho**, where ** identifies the function in which the parameter operates.
- For the CET functions all the share parameters are declared with the form gamma**, all the shift/efficiency parameters are declared with the form at**, and all the elasticity parameters are declared with the form rho**, where ** identifies the function in which the parameter operates.
- All coefficients in the model are declared with the form io****, where **** consists of two parts that identify the two variables related by the coefficient. For example, *ioqint* is the intermediate input output coefficient.
- The index ordering follows the specification in the SAM: row, column, and then r to indicate the region. For example, the quantity of exports from region r to region w would be $QER_{c,u,w,r}$ because region r's export data in its SAM is found in the commodity row (c) by use category (u) and the trade partner column (w). Likewise,

imports in region r from region w are designated, $QMR_{w,c,u,r}$ because region r's import data in its SAM is found in the trade partner row (w) and the commodity column (c) by use category (u).

- All sets have an alias given by the set name, followed by "p". For example, the set of commodities may be called *c* or *cp*. This is useful when writing equations using the same set of commodities in two different ways (e.g. two different dimensions).

8.4. List of sets, variables and parameters

Rather than writing out each and every equation in detail, it is more useful to define a series of sets over which an equation holds; thereafter, if a behavioural relationship applies to all members of a set, an equation needs to be specified only once.

The model contains a master set (*sac*) for all the transactions by each region plus a series of sets that group commodities, use categories, activities, factors, import duties, export taxes, trade margins, trade and finally some individual accounts relating to domestic institutions. These sets are used both in the model equations and to set dimensions when reading in the data. Data that are read into the model with data set dimensions are transformed into basic set dimensions during the organization process, and then used in the modelling process.

Table 7 through Table 9 contain full lists of sets, variables and parameters in alphabetical order. Table 10 provides additional variables and parameters applied in the specific modules that support the core model.

Table 7. List of sets used in the model

sac(*)	**SAM accounts, master set**		
Basic sets for each region in this model			
c(sac)	Commodity accounts	tff(sac)	Factor tax account
u(sac)	Use category	tss(sac)	Sales tax account
a(sac)	Activity accounts	h(sac)	Household accounts
ff(sac)	Factors and aggregates	g(sac)	Government accounts
tmr(sac)	Ad valorem tariff accounts	i(sac)	Investment accounts
tmrs(sac)	Specific tariff accounts	owatpmarg(sac)	Trade and transportation margin services
ter(sac)	Export subsidy accounts	w(sac)	Rest of world trade partners
Database sets - only used in calibration phase:			
mc(sac)	Import commodities	tsu(sac)	Sales tax by use category
dc(sac)	Domestic commodities	wwu(sac)	RoW trade partners by use category
tmu(sac)	Tariff (ad valorem) accounts by use categories	wwugn(wwu)	wwu without Globe region
tmsu(sac)	Tariff (specific) accounts by use categories		
teu(sac)	Export subsidy by use category		
Subsets specified by user (in excel spreadsheet)			
Subsets of c		Subsets of ff	
cagr(c)	Agricultural commodities	f(ff)	Natural factor accounts
cnat(c)	Natural resource commodities	fag(ff)	Aggregate factors
cfd(c)	Food commodities	f2(ff)	Factor inputs to QVA at level 1
cind(c)	Industrial commodities	f3(ff)	Factor inputs to FAG at level 2
cotp(c)	Transport commodities	l(f)	Labour Factors
cuti(c)	Utility commodities	ls(l)	Skilled Labour Factors
cser(c)	Service commodities	lu(l)	Unskilled Labour Factors
cagg	Aggregate commodity groups	k(f)	Capital Factors
Subsets of a		lnd(f)	Land factors
aagr(a)	Agricultural activities	uef(f,r)	Unemployed factors by region
anat(a)	Natural resource activities	Subsets of w	
afd(a)	Food activities	wgn(w)	Rest of world without Globe
aind(a)	Industrial activities	wagg	Aggregate region groups
aotp(a)	Construction activities		
auti(a)	Utility activities		
aser(a)	Service activities		
aagg	Aggregate activity groups		
Dynamic sets: Various subsets of a, c and r are declared and then assigned on the basis of certain characteristics of the data set used to calibrate the specific implementation of the model			
Subsets of c		Subsets of a	
ct(c,r)	Trade margin commodities	acx(a,r)	Activities purchased domestically
ctn(c,r)	Non trade margin commodities	acxn(a,r)	Activities NOT purchased domestically
ct2(c)	Trade margin commodities	aq(a,r)	Activities and regions with domestic production
ctn2(c)	Non trade margin commodities	aqn(a,r)	Activities and regions without domestic production
ce(c,u,r)	Export commodities	aqx(a,r)	Activities and regions with CES fn at Level 1
cen(c,u,r)	Non-export commodities	aqxn(a,r)	Activities and regions with Leontief fn at Level 1

cer(c,u,w,r)	Export commodities by region	aleon(a)	Activities with Leontief top level prodn function
cern(c,u,w,r)	Non-export commodities by region	set of regions, r, and its subsets	
cm(c,u,r)	Imported commodities	r	SAM regions
cmn(c,u,r)	Non-imported commodities	ragg	Aggregate region groups
cmr(w,c,u,r)	Imported commodities by region	rgn(r)	SAM Regions without Globe
cmrn(w,c,u,r)	Non-imported commodities by region	ref(r)	Reference region
cmrs(w,c,u,r)	Small shares imported commodities by region	rleon(r)	Regions with Leontief top level prodn function
cmrsn(w,c,u,r)	Non-small shares imported commodities by region	ror(w,h,r)	Remittances outflows by partner region
cms(c,u,r)	Commodities with small shares	rorn(w,h,r)	No remittances outflows
cmrl(w,c,u,r)	Large shares imported commodities by region	rir(h,w,r)	Remittances inflows by partner region
cmrln(w,c,u,r)	Non-large shares imported commodities by region	rirn(h,w,r)	No remittances inflows
cml(c,u,r)	Commodities with large shares	A macro SAM that facilitates checking various aspects of model calibration	
cx(c,r)	Comm. produced domestically	ss	ASAM categories
cxn(c,r)	Comm. NOT produced domestically AND imported	Various other sets declared to facilitate aspects of model operations	
cd(c,u,r)	Comm. produced and demanded domestically	sacn(sac)	SAM accounts excluding TOTAL
cdn(c,u,r)	Comm. NOT produced and demanded domestically	ssn(ss)	ASAM categories excluding TOTALS
cintd(c,r)	Comm. with intermediate demand by region	fcons	Set for parameters controlling program flow
cintdn(c,r)	Comm. without intermediate demand by region	mcons	Set for parameters controlling model content
cqq(c,u,r)	Comm. and uses and regions with CES fn at supply nest		
cqqn(c,u,r)	Comm. and uses and regions with Leontief fn at supply nest		
cqs(c,u,r)	Comm. and uses and regions with CES fn at production nest		
Special sets for modules			
Activation of the alternate intermediate input nests		**Sets for land allocation module**	
ui(u)	Intermediate use	af	Factor CET nesting aggregate
uin(u)	Final use categories	af1(af)	Factor CET nesting aggregate - Level 1
ri(r)	Activation of equation for alternate int. use nesting	af2(af)	Factor CET nesting aggregate - Level 2
rin(r)	Activation of without alternate int. use nesting	af3(af)	Factor CET nesting aggregate - Level 3
		af4(af)	Factor CET nesting aggregate - Level 4

Table 8. List of mapping sets used in model

The model also makes use of a series of mapping files that are used to link sets		map_tff_f(tff,f)	**Factor taxes to factors reverse**
map_w_tmr(w,tmr)	Ad valorem tariff mapping	map_aagg_a(aagg,a)	Mapping from activities to aggregate activities
map_tmr_w(tmr,w)	Ad valorem tariff mapping reverse	map_cagg_c(cagg,c)	Mapping from commodities to aggregate commodities
map_w_tmrs(w,tmrs)	Specific tariff mapping	map_wagg_w(wagg,w)	Mapping from regions to aggregate regions
map_tmrs_w(tmrs,w)	Specific tariff mapping reverse	map_ragg_r(ragg,r)	Mapping from regions to aggregate regions
map_w_ter(w,ter)	Export tax mapping	map_fag_f3(fag,f3)	Mapping from natural factors f to aggregates
map_ter_w(ter,w)	Export tax mapping reverse	***Mappings used only for the Land Allocation Module***	
map_c_w_marg_u(c,w,owatpmarg,u)	Trade margin mapping of owatpmarg to ct2 and w	map_fag_f3(fag,f3)	Mapping from natural factors f to aggregates
map_marg_w(owatpmarg,w)	Trade margin mapping of w to owatpmarg	map_af(f,af,af,af,af,a)	CET nesting aggregate - All mapping
map_r_w(r,w)	Region to trade partner mapping	map_af1(f,af,af)	CET nesting aggregate - Level 1
map_w_r(w,r)	Region to trade partner mapping	map_af2(f,af,af)	CET nesting aggregate - Level 2
map_wwu_r(wwu,r)	Region to trade partner mapping by use	map_af3(f,af,af)	CET nesting aggregate - Level 3
map_f_tff(f,tff)	Factor taxes to factors	map_af4(f,af,a)	CET nesting aggregate - Level 4

Table 9. List of variables in the model

ADFD(ff,a,r)	Shift parameter for factor and activity specific efficiency	*HEXP(h,r)*	Household consumption expenditure
ADFDaADJ(a)	Activity Scaling Factor for flow parameter on ADFD	*HHLDSAV(h,r)*	Household savings
ADFDfADJ(f)	Factor Scaling Factor for flow parameter on ADFD	*HTAX(r)*	Household income tax revenue
ADFDrADJ(r)	Region Scaling Factor for flow parameter on ADFD	*IADJ(r)*	Investment scaling factor
ADVA(a,r)	Shift parameter for CES production functions for QVA	*INVEST(r)*	Total investment expenditure
ADVAADJ(r)	Scaling Factor for Shift parameter on CES functions for QVA	*INVESTSH(r)*	Value share of investment in total final dom demand
ADX(a,r)	Shift parameter for CES production functions for QX in r	*ITAX(r)*	Indirect tax revenue
ADXADJ(r)	Scaling Factor for Shift parameter on CES functions for QX	*KAPGOV(r)*	Government Savings
CPI(r)	Consumer price index - Region numeraires	*KAPREG(w,r)*	Bilateral current account balance
DADVA(r)	Partial scaling factor for Shift parameter on CES functions for QVA	*KAPWOR(r)*	Current account balance
DADX(r)	Partial scaling factor for Shift parameter on CES functions for QX	*KAPWORSYS*	Slack variable for global system
DREM(r)	Partial remittance rate scaling factor	*MSTAX(r)*	Specific Import tariff revenue
DSHH(r)	Partial household savings rate scaling factor	*MTAX(r)*	Ad valorem Import tariff revenue
DTE(r)	Uniform adjustment to Export taxes	*PCD(c,r)*	Consumer price of household consumption
DTF(r)	Uniform adjustment to factor use tax by activity	*PD(c,u,r)*	Consumer price for domestic supply of commodity c
DTM(r)	Uniform adjustment to Ad valorem Tariff rates	*PE(c,u,r)*	Domestic price of exports by commodity c
DTMS(r)	Uniform adjustment to Specific Tariff rates	*PER(c,u,w,r)*	Domestic price of exports of comm'y to regions and aggregates
DTS(r)	Uniform adjustment to sales tax	*PGD(c,r)*	Consumer price of government consumption
DTV(r)	Uniform Value added tax rate scaling factor	*PINT(a,r)*	Price of aggregate intermediate input
DTX(r)	Uniform adjustment to indirect tax	*PINTD(c,r)*	Consumer price of intermediate inputs
DTYF(r)	Uniform adjustment to direct tax on factors	*PINVD(c,r)*	Consumer price of investment demand
DTYH(r)	Uniform adjustment to direct tax on households	*PM(c,u,r)*	Domestic price of competitive imports of commodity c
EG(r)	Expenditure by government	*PML(c,u,r)*	Dom price of imports of comm'y c from region with small shares
ER(r)	Exchange rate (domestic per world unit)	*PMR(w,c,u,r)*	Domestic price of imports of comm'y from regions and aggregates
ERPI	Exchange rate index - Global numeraire	*PMS(c,u,r)*	Dom price of imports of comm'y c from region with large shares
ETAX(r)	Export tax revenue	*PPI(r)*	Producer (domestic)
FD(ff,a,r)	Demand for factor f by activity a in r	*PQD(c,u,r)*	Consumer price of composite commodity c
FS(f,r)	Supply of factor f in r	*PQS(c,u,r)*	Supply price of composite commodity c
FTAX(r)	Factor use tax revenue	*PS(c,u,r)*	Producer price of composite domestic output by use
FYTAX(r)	Factor income tax revenue	*PT(c,u,r)*	Price of imported transport services (same price to imports from all regions)
GDP(r)	Gross Domestic Product by Expenditure definition	*PVA(a,r)*	Value added price for activity a in r
GLOBESLACK	Slack variable for Globe	*PWE(c,u,w,r)*	World price of exports of commodity c from region r in dollars

PWM(w,c,u,r)	CIF price of competitive imports of commodity c from region w	*TEADJ(r)*	Export subsidy Scaling Factor
PWMFOB(w,c,u,r)	FOB price of competitive imports of commodity c from region w	*TF(ff,a,r)*	Tax rate on factor use
PX(a,r)	Composite price of output by activity a	*TFADJ(r)*	Factor Use Tax Scaling Factor
PXC(c,r)	Producer price of composite domestic output	*TM(w,c,u,r)*	Ad valorem Tariff rates on imported comm'y c from w by r
QCD(c,h,r)	Household consumption by commodity c	*TMADJ(r)*	Ad valorem Tariff rate Scaling Factor
QD(c,u,r)	Domestic demand for commodity c	*TMS(w,c,u,r)*	Specific Tariff rates on imported comm'y c from w by r
QE(c,u,r)	Domestic output exported by commodity c	*TMSADJ(r)*	Specific Tariff rate Scaling Factor
QER(c,u,w,r)	Exports of comm'y c to regions and aggregates	*TOTSAV(r)*	Total savings
QGD(c,r)	Government consumption demand by commodity c	*TS(c,u,r)*	Sales tax rate
QGDADJ(r)	Government consumption demand scaling factor	*TSADJ(r)*	Sales tax rate scaling factor
QINT(a,r)	Agg quantity of intermediates used by activity a in r	*TV(c,r)*	Value added tax rates
QINTD(c,r)	Demand for intermediate inputs by commodity in r	*TVADJ(r)*	Value added tax rate scaling factor
QINVD(c,r)	Investment demand by commodity c	*TX(a,r)*	Indirect tax rate
QM(c,u,r)	Imports of commodity c	*TXADJ(r)*	Indirect Tax Scaling Factor
QML(c,u,r)	Supply of composite import from large share regions	*TYF(f,r)*	Direct tax rate on factor income
QMR(w,c,u,r)	Imports of comm'y c from regions and aggregates	*TYFADJ(r)*	Factor Income Tax Scaling Factor
QMS(c,u,r)	Supply of composite import from large share regions	*TYH(h,r)*	Direct tax rate on households
QQ(c,u,r)	Supply of composite commodity c	*TYHADJ(r)*	Income Tax Scaling Factor
QS(c,u,r)	Domestic production by commodity c in r by use	*UNEMP(f,r)*	Unemployed factors
QT(w,c,u,r)	Quantity of margin services for total imports from region w	*VFDOMD(r)*	Value of final domestic demand
QVA(a,r)	Quantity of aggregate value added for level 1 production	*VGDSH(r)*	Value share of Govt consump in total final dom demand
QX(a,r)	Domestic production by activity a in r	*VTAX(r)*	Value added tax revenue
QXC(c,r)	Domestic production by commodity c in r	*WALRAS(r)*	Slack variable for Walras's Law
REMADJ(r)	Remittance rate scaling factor	*WF(ff,r)*	Price of factor f in r
REMIN(h,w,r)	Remittances in	*WFD(ff,a,r)*	Price of factor f in activity a in r
REMINW(h,w,r)	Remittances in	*WFDIST(ff,a,r)*	Sectoral proportion for factor prices in r
REMOUT(w,h,r)	Remittances out	*YF(f,r)*	Income to factor f
REMOUTW(w,h,r)	Remittances out	*YFDIST(f,r)*	Factor income for distribution after depreciation
REMRYHF(w,h,r)	Remittances out ratio	*YG(r)*	Government income
SADJ(r)	Savings rate scaling factor	*YH(h,r)*	Income to household h
SHH(h,r)	Household savings	*YHD(h,r)*	Disposable Income to household h
STAX(r)	Sales tax revenue	*YHF(h,r)*	Factor Income to household h
TE(c,u,w,r)	Export taxes on exported comm'y c from r to w		

Table 10. List of model parameters

ac(c,u,r)	Shift parameter for Armington CES function	*dadfd(f,a,r)*	Change in shift parameter for factor and activity specific efficiency
acr(c,u,r)	Shift parameter for Armington CES over imports by aggregate region	*delta(c,u,r)*	Share parameter for Armington CES function
adfag(ff,a,r)	Shift parameter for factor and activity specific efficiency	*deltafd(ff,ff,a,r)*	CES Share parameters for Aggregated FD fag using ff by a
adfdb(f,a,r)	Base Shift parameter for factor and activity specific efficiency	*deltar(w,c,u,r)*	Share parameter for Armington CES over imp by region & aggregate
adva01(a,r)	0-1 par for flexing of shift parameter on functions for QVA	*deltava(ff,a,r)*	Share parameters for CES production functions for QVA
advaadj01(a,r)	0-1 par for flexing the multiplicative scaling for QVA	*deltax(a,r)*	Share parameter for CES production functions for QX in r
advab(a,r)	Base Shift parameter for CES production functions for QVA	*deprec(f,r)*	depreciation rate by factor f on stock of factor f
adx01(a,r)	0-1 par for flexing of shift parameter on functions for QX	*f_closure(f,r)*	Factor market closure (0 = fixed factor 1 = full mobility 2 = CET)
adxadj01(a,r)	0-1 par for flexing the multiplicative scaling for QX	*frisch(h,r)*	Elasticity of the marginal utility of income
adxb(a,r)	Base Shift parameter for CES production functions for QX in r	*gamma(c,u,r)*	Share parameter for CET function
ams(w,c,u,r)	Iceberg cost as in GTAP	*gammar(c,u,w,r)*	Share parameter for CET over exports by region & aggregate
at(c,u,r)	Shift parameter for CET function	*hexps(h,r)*	Subsistence consumption expenditure
atr(c,u,r)	Shift param for CET over exports by aggregate region	*hvash(h,f,r)*	Share of income from factor f to household h
beta(c,h,r)	Marginal budget shares	*ioqdqq(c,u,r)*	Share of QD in QQ
comhav(c,h,r)	Household consumption shares	*ioqdqs(c,u,r)*	Share of QD in QS
dabadva(a,r)	Change in base shift parameter on functions for QVA	*ioqeqs(c,u,r)*	Share of QE in QS
dabadx(a,r)	Change in base shift parameter on functions for QX	*ioqint(c,a,r)*	intermediate input output coefficients
dabrrh(w,h,r)	Change in base Household saving rates	*ioqintqx(a,r)*	Agg intermed quantity per unit QX for Level 1 Leontief agg
dabshh(h,r)	Change in base Household saving rates	*ioqmlqm(c,u,r)*	Share of QML in QM
dabte(c,u,w,r)	Change in base export taxes on comm'y from regn	*ioqmqq(c,u,r)*	Share of QM in QQ
dabtf(ff,a,r)	Change in base factor us tax rate on activities	*ioqmrqms(w,c,u,r)*	Share of QMR in QMS
dabtm(w,c,u,r)	Change in base Ad valorem tariffs on comm'y imptd by regn	*ioqmsqm(c,u,r)*	Share of QMS in QM
dabtms(w,c,u,r)	Change in base Specific tariffs on comm'y imptd by regn	*ioqvaqx(a,r)*	Agg value added quant per unit QX for Level 1 Leontief agg
dabts(c,u,r)	Change in base sales tax rate	*ioqx(c,a,r)*	use matrix coefficients
dabtv(c,r)	Change in base value added tax rate	*ioqxcqx(a,c,r)*	Share of commodity c in output by activity a
dabtx(a,r)	Change in base indirect tax rate	*margcor(w,c,cp,u,r)*	Margin c per unit of r's import of commodity cp from region w
dabtyf(f,r)	Change in base direct tax rate on factors	*Margcorotp (w,owatpmarg,cp,u,r)*	Margin c per unit of r's import of commodity cp from region w
dabtyh(h,r)	Change in base direct tax rate on households		

mod_elastm(c,u,r)	Level 1 CES elasticities used in the model	*tf02(ff,a,r)*	tf for calibration of production functions
mod_elastre(c,u,r)	Level 2 CET elasticities used in the model	*tfb(ff,a,r)*	Factor use tax rate
mod_elastrm(c,u,r)	Level 2 CES elasticities used in the model	*thetava(f,a,r)*	Share of primary factor in QVA
mod_elastva(a,r)	Level 2 CES elasticities used in the model	*thetax(a,r)*	Share of QVA in QX
mod_elastx(a,r)	Level 1 CES elasticities used in the model	*tm01(w,c,u,r)*	0-1 par for flexing of Ad valorem Tariff rates on comm'ies
qcdconst(c,h,r)	Volume of subsistence consumption	*tmb(w,c,u,r)*	Ad valorem Tariff rates on comm'y imported from region w
qgdconst(c,r)	Government demand volume	*tmreal(w,c,u,r)*	Real tariff rates by commodity and region
qgdconst0(c,r)	Initial Government demand volume	*tms01(w,c,u,r)*	0-1 par for flexing of Specific Tariff rates on comm'ies
qinvdconst(c,r)	Investment demand volume	*tmsb(w,c,u,r)*	Specific Tariff rates on comm'y imported from region w
qinvdconst0(c,r)	Initial Investment demand volume	*ts01(c,u,r)*	0-1 par for flexing of sales tax rates
remrYHF0(w,h,r)	Initial Remittance rate	*tsb(c,u,r)*	Base sales tax rate
remrYHFb(w,h,r)	Base Remittance rates	*tv01(c,r)*	0-1 par for flexing of value added tax rates
remrYHF01(w,h,r)	0-1 par for potential flexing of Household saving rates	*tvb(c,r)*	Base Value added tax rates
rhoc(c,u,r)	Elasticity parameter for Armington CES function	*tx01(a,r)*	0-1 par for flexing of indirect tax rates
rhoe(c,u,r)	Elast parameter for CET over exports by aggregate region	*txb(a,r)*	Base indirect tax rate on activity a
rhofd(ff,a,r)	Elasticity parameter for CES prodn fns for Aggregated FD	*tyf01(f,r)*	0-1 par for flexing of direct tax rates on factors
rhom(c,u,r)	Elast parameter for Armington CES over imports by aggregate region	*tyfb(f,r)*	Factor income tax rate
rhot(c,u,r)	Elasticity parameter for Output CET function	*tyh01(h,r)*	0-1 par for flexing of direct tax rates on h'holds
rhova(a,r)	Elasticity parameter for CES production function for QVA	*tyhb(h,r)*	Direct tax rate on household h
rhox(a,r)	Elasticity parameter for CES production function for QX in r	*unemp_rate(f,r)*	Unemployment rates
shh0(h,r)	Initial Household saving rates	*use(c,a,r)*	use matrix transactions
shh01(h,r)	0-1 par for potential flexing of Household saving rates	*vqcdsh(c,r)*	Share of commodity c in total household commodity demand
shhb(h,r)	Base Household saving rates	*vqdsh(c,u,r)*	Share of value of domestic output for the domestic market
sumelast(h,r)	Weighted sum of income elasticities	*vqesh(ref)*	Share of total Exports by reference regions
te01(c,u,w,r)	0-1 par for flexing of export taxes on comm'ies	*yhelast(c,h,r)*	(Normalised) household income elasticities
teb(c,u,w,r)	Export tax rates on exports of comm'y c to region w	*f_closure(f,r)*	Factor market closure (0 = fixed factor 1 = full mobility 2 = CET)

Table 11. List of parameters for model data and calibration checks

Parameters for model data			
ELASTE(c,r)	Elasticities for CET functions	*impmarg(w,c,cp,u,r)*	Margins of type c paid by comm'y cp on r's imports from region w
ELASTF(r,h)	Frisch parameters for LES demand system	*impmargotp(w,owatpmarg,cp,u,r)*	Margins of type c paid by comm'y cp on r's imports from region w
ELASTFD(ff,a,r)	Elasticities for CES Production function level 3	*imprtsh(w,c,u,r)*	import trade shares
ELASTM(c,r)	Elasticities for Armington CES functions	*LABUSE(ff,a,r)*	Labour use by activity
ELASTMG(c,r)	Elasticities for Armington CES functions	*mod_cont(mcons)*	values for parameters controlling model content
ELASTRE(c,r)	Elasticities for CET over regions Level 3	*pop(h,r)*	population data by household
ELASTRM(c,r)	Elasticities for Armington CES over regions Level 3	*popn(r)*	GTAP population data
ELASTRMG(c,r)	Elasticities for Armington CES over regions	*SAMDOM(sac,sacp,u,r)*	Domestic Matrix by use
ELASTVA(a,r)	Elasticities for CES Production function level 2	*SAMG(sac,sacp,r)*	the GTAP SAM database
ELASTVAG(a,r)	Elasticities for CES Production function level 2	*SAMGFACT(sac,sacp,r)*	Factor use by activity
ELASTX(a,r)	Elasticities for CES Production function level 1	*SAMIMP(sac,sacp,u,r)*	Import Matrix by use
ELASTY(c,h,r)	Income elasticities of demand for LES demand system	*samscal*	SAM scaling factor
FACTUSE(ff,a,r)	Factor use by activity	*un_rate(r,f)*	Unemployment rates
flow_cont(fcons)	values for parameters controlling program flow		
Parameters for calibration checks			
ASAMG1(sac,sacp,r)	Aggregate SAM for calibration check	*cqsh(c,u,r)*	share of imports in supply for cqq
ASAMG2(sac,sacp,r)	Aggregate SAM for base run check	*cqssh(c,u,r)*	share of exports in domestic production for cqs
CHKSAMG1(sac,r)	Check on row and column totals	*deltafdchk(ff,a,r)*	Check on share parameters for Aggregated FD
cmrCNT	Count of activity import transactions	*deltarCHK(c,u,r) C*	Check on deltar
cmrlCNT	Count of large shares imported commodities by region	*deltavacheck(a,r)*	Check on deltava
cmrsCNT	Count of small shares imported commodities by region	*deltaxCHK(r)*	Check on share parameter for CES production functions for QX
CNTSAMG1(r)	Count of non-zero entries in DIFFSAMG1	*DIFFSAMG1(sac,sacp,r)*	Differences between SAMG and SAMG1
CNTSAMG2(r)	Count of non-zero entries in DIFFSAMG1	*DIFFSAMG2(sac,sacp,r)*	Differences between SAMG and SAMG1
COMTAXE0(r)	Check on export taxes	*gammarchk(c,u,r)*	Check on gammar
COMTAXM0(r)	Check on import tariffs	*HCON(c,r)*	Household consumption
COMTAXS0(r)	Check on sales taxes	*ioqmCHK(c,u,r) C*	Check on ioqm
COMTAXT0(r)	Check on total commodity taxes	*SAM (*	Check on ioqmrqms

ioqqCHK(c,u,r) C	Check on ioqq	*qqdif(c,u,r) C*	Check on QQ0
numerchk	numeraire check value	*QT_chk(w,c,u,r)*	Check on QTL v QT0
perDIFFSAMG1(sac,sacp,r)	Percentage differences between SAMG and SAMG1	*QT0sum(c,u,r)*	Sum by w of QT0
perDIFFSAMG2(sac,sacp,r)	Percentage differences between SAMG and SAMG1	*QTsum(c,u,r)*	Sum by w of QT
QECALIB(c,u,r)	CALIBRATED VALUE OF QE0	*SAMG1(sac,sacp,r)*	Post calibration Global SAM
QEDIFF(c,u,r)	DIFFERENCE BETWEEN CALIBRATED AND ACTUAL QE0	*SAMG12CHK(sac,sacp,r)*	Check on comparison of SAMG1 with SAMG2
QER_chk(c,u,w,r)	Check on QER	*SAMG12CHK_alt(sac,sacp,r)*	Check on comparison of SAMG1 with SAMG2
QM02(c,u,r)	alternate calculation	*SAMG2(sac,sacp,r)*	Post Solve Global SAM
qm02chk(c,u,r) C	Check on QM0	*SAMG2CHK(sac,r)*	Check on row and column totals
QM03(c,u,r) a	alternate calculation	*TOTCON(r)*	Check on total consumption
qm03chk(c,u,r) C	Checkon QM0	*TOTPROD(r)*	Check on total production
QMCALIB(c,u,r)	CALIBRATED VALUE OF QM0	*vqcdshCHK(r)*	Check on CPI weights
QMDIFF(c,u,r)	DIFFERENCE BETWEEN CALIBRATED AND ACTUAL QM0		

Table 12. Module parameters and variables

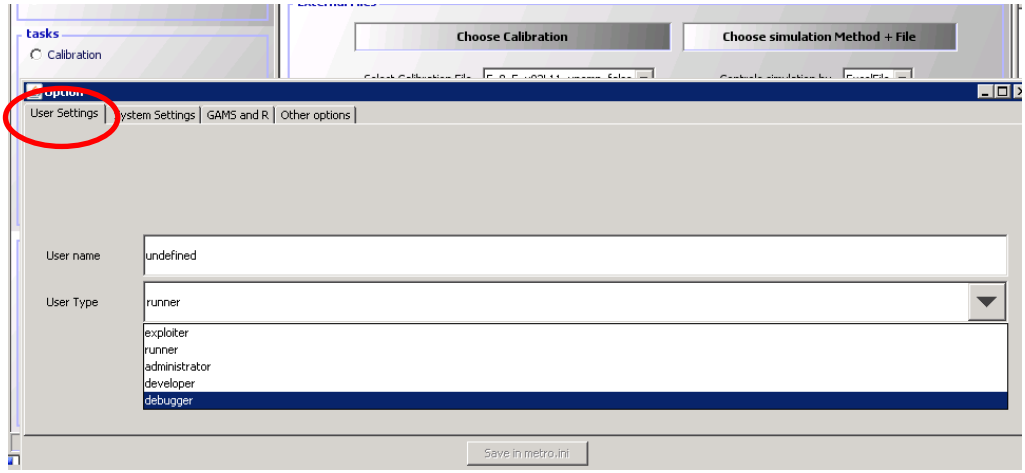
Parameter		Variable	
Local Content Requirement (LCR)			
lcrsh(c,u,r)	local content requirement share	*QDLCR(c,u,r)*	Additional domestic produced quantity provided under LCR
		QDNL(c,u,r)	Domestic produced quantity not affected by LCR
		QLCR(c,u,r)	Local content requirement quantity
		QQARM(c,u,r)	Supply of composite commodity (Armington function)
		SLACK(c,u,r)	Slack variable QDL
Alternate intermediate input nesting			
ac_a(c,u,a,r)	Shift parameter for Armington CES function by activity	*PDA(c,u,a,r)*	Activity specific price for domestic supply of commodity c
delta_a(c,u,a,r)	Share parameter for Armington CES function by activity	*PINTA(c,a,r)*	Activity specific price for aggregate intermediate input
ioqdaqq(c,u,a,r)	Share of domestic supply in composite intermediate supply by activity	*PINTS(c,u,a,r)*	Activity specific supply price for of composite commodity c
ioqmaqq(c,u,a,r)	Share of imports in composite intermediate supply by activity	*PMA(c,u,a,r)*	Activity specific domestic price of competitive imports of comm'y c
tsa(c,u,a,r)	Sales tax parameter for intermediates by activity	*QDA(c,u,a,r)*	Aggregate quantity of intermediates used by activity a in r
		QINTA(c,a,r)	Activity specific price for aggregate intermediate input
		QMA(c,u,a,r)	Activity specific imports of commodity c

Parameter		Variable	
LCR - Alternate intermediate input nesting			
lcrsh_A(c,a,r)	local content requirement share	*QDLCR_A(c,u,a,r)*	Activity specific additional domestic produced quantity provided under LCR
		QDNL_A(c,u,a,r)	Activity specific domestic produced quantity not affected by LCR
		QLCR_A(c,u,a,r)	Activity specific local content requirement quantity
		QQARM_A(c,u,a,r)	Activity specific supply of composite commodity (Armington function)
		SLACK_A(c,u,a,r)	Activity specific slack variable QDL
Price preference instrument			
tsd(c,u,a,r)	Sales tax parameter for domestic intermediates by activity	*PDA2(c,u,a,r)*	Activity specific consumer price for domestic supply
tsm(c,u,a,r)	Sales tax parameter for imported intermediates by activity	*PMA2(c,u,a,r)*	Activity specific domestic consumer price of imports
Land Allocation Module			
WF0_CET1(f,af,r)	Factor price aggregate CET nesting - Level 1	*WF_CET1(f,af,r)*	Factor price aggregate CET nesting - Level 1
WF0_CET2(f,af,r)	Factor price aggregate CET nesting - Level 2	*WF_CET2(f,af,r)*	Factor price aggregate CET nesting - Level 2
WF0_CET3(f,af,r)	Factor price aggregate CET nesting - Level 3	*WF_CET3(f,af,r)*	Factor price aggregate CET nesting - Level 3
WF0_CET4(f,af,r)	Factor price aggregate CET nesting - Level 4	*WF_CET4(f,af,r)*	Factor price aggregate CET nesting - Level 4
FS0_CET1(f,af,r)	Factor aggregate CET nesting - Level 1	*FS_CET1(f,af,r)*	Factor aggregate CET nesting - Level 1
FS0_CET2(f,af,r)	Factor aggregate CET nesting - Level 2	*FS_CET2(f,af,r)*	Factor aggregate CET nesting - Level 2
FS0_CET3(f,af,r)	Factor aggregate CET nesting - Level 3	*FS_CET3(f,af,r)*	Factor aggregate CET nesting - Level 3
FS0_CET4(f,af,r)	Factor aggregate CET nesting - Level 4	*FS_CET4(f,af,r)*	Factor aggregate CET nesting - Level 4
af_sigma(f,af,r)	Elasticity of transformation for node in the factor CET nesting structure		
ECET_PEM(r,)*	PEM elasticities for CET nesting structure		

9. Advanced uses

9.1. User settings: “Runner mode” and “debugger mode”

As a default, the interface is opened in “runner mode”. There are additional technical choices available when using the model interface as a “debugger”; these features are typically not needed for a standard model but could be interesting for an experienced user. These features are described below. You can change the user type to “debugger” by selecting “Settings” from the interface menu (top left corner) then in “Edit settings”. On the new window, select the “User Settings” tab. Click on the drop down window next to “User Type” and select “debugger”. You can save the settings in the METRO.ini or close the window (the settings will be saved to the METRO.ini when closing the GUI).



There are two additional features available in the debugger mode.

9.1.1. *Calibration: Technical setup*

The technical setups in debugger mode contain more choices in addition to rounding and scaling. All options are described below.

- “Rounding to digits” (e.g. the GTAP database is rounded to 6 digits) to get rid of very small entries which are basically zero. There are two reasons for this. First, such entries typically complicate the analysis and, secondly, they can be an issue in the equation system, as most equations perform best in the middle part of the functions.

Three elements are related to scaling (the model performs auto-scaling to a defined target):

- “Scaling target” (default is 10): The solver works best with numbers around 1 and the database is scaled to support the solver.

- "SAM scaling factor and initial value autoscaling": The SAM is divided by this value. However, the programme adjusts this value automatically to meet the required proportion of non-zero elements that must be below the target level, as specified in the next bullet point.
- "Proportion of non-zeroes below target level": By default, 95% of entries must be below the scaling target; this can be adjusted.

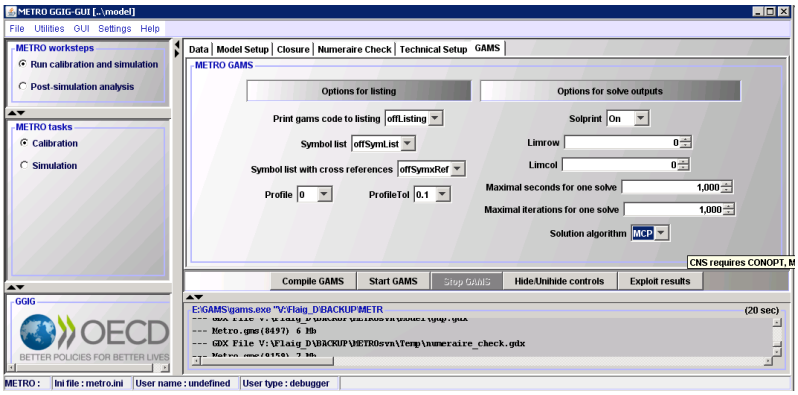
Other technical setups:

- "Minimum share of intermediates in cost for aqx": In the drop-down menu, the user selects a minimum share value. All activity-region pairs with intermediate inputs where intermediates account for more than this value share are members of the set aqx. All members of this set are assigned with a CES function at Level 1 (aggregation of value added and intermediate inputs). All other activity-region pairs are assigned with Leontief at the top level.
- "Tolerance level for differences between data and solution SAM" (default is 0.0001): The programme aborts if the difference is greater than tolerance level.

9.1.2. *GAMS*

The GAMS tab is available at the calibration and simulation step, and only in debugger mode. It gives various possibilities to specify GAMS options; in particular the possibility to choose between the solvers PATH (MCP) and CONOPT (CNS).

***TIP**: Some features will not work when using the model as CNS, i.e. anything that requires MCP specifications. For example, unemployment is either on or off. There is no automatic switch when, for example, full employment is reached. If this is the case, the model could abort with a CNS specification. In addition, the LCR and TRQ modules will not work as CNS. The GAMS setup in calibration and simulation must match.*

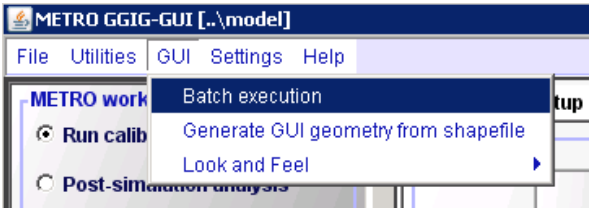


9.2. Running loops: Batch file mode

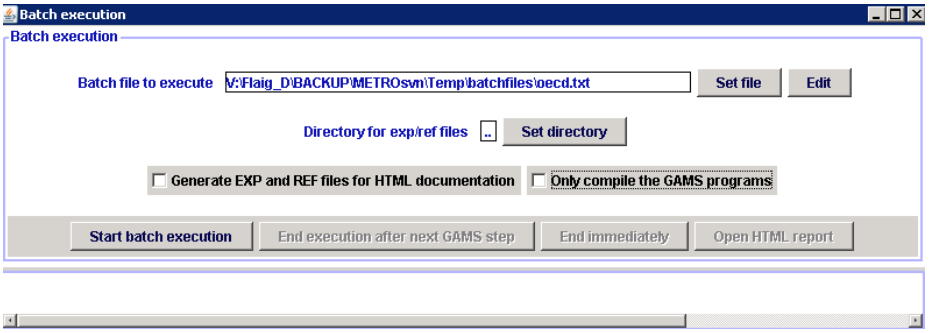
Multiple simulations in a row can be run automatically using the batch execution option.

9.2.1. *Running a batch file in the METRO GUI*

Open the batch execution under 'GUI' in the menu bar:



The following window will pop up:



Select the file in the field "batch file to execute" by clicking on the "set file" button and navigating to the file. It is advised to keep the batch files in the directory 'temp\batchfiles'. In the example above the batch file selected is oecd.txt. Note that the file must be saved as a text file with a "txt" extension.

Before starting the batch execution, UNTICK the two boxes in the middle bar 'generate EXP and REF files…' and 'Only compile the GAMS programmes'. Execute the batch job by clicking the "Start batch execution".

9.2.2. *Create batch file*

Generate code

The code that you use for your batch file is generated automatically when compiling the simulation step.

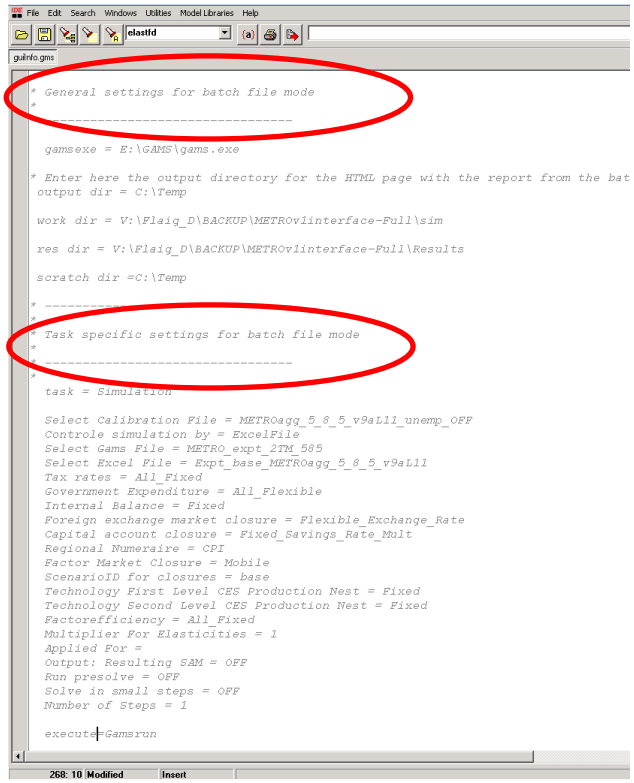
To create and get the code: go back to the main METRO_GUI window; set up your model as if you were to run it from the interface; and press the button "Compile GAMS" in the main window. The code for the batch file is written into 'guiInfo.gms', found in the 'Model' folder, each time you press the compile button.

Add code to your batch file

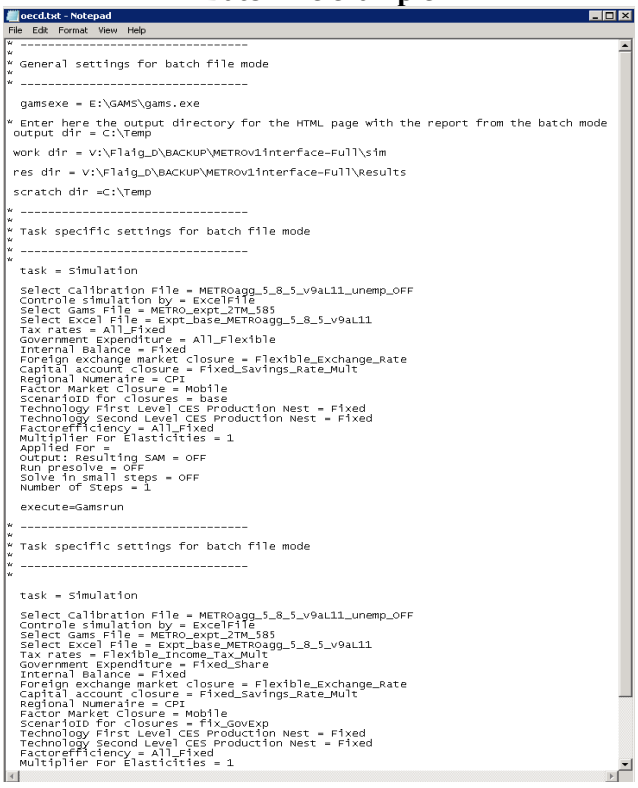
At the end of the 'guiInfo.gms' file there is a section containing 'General settings for batch file mode' and 'Task specific settings for batch file mode' (as indicated below). Copy these two sections into an empty text file that will contain your batch file.

To add a second task or model run into your batch file, adjust the settings in the interface (e.g. change the closure as in the example below) and click again on 'compile GAMS'. Note that the file 'guiInfo.gms' is updated every time you compile or run the programme. Go to 'guiInfo.gms' again and copy over the section with the 'Task specific settings for batch file mode' at the end of your batch file. The 'general settings' need to be set only once, after that the 'task specific settings' can be listed one after the other as shown in 'oecd.txt' below.

GUI_INFO.gms



Batch file example

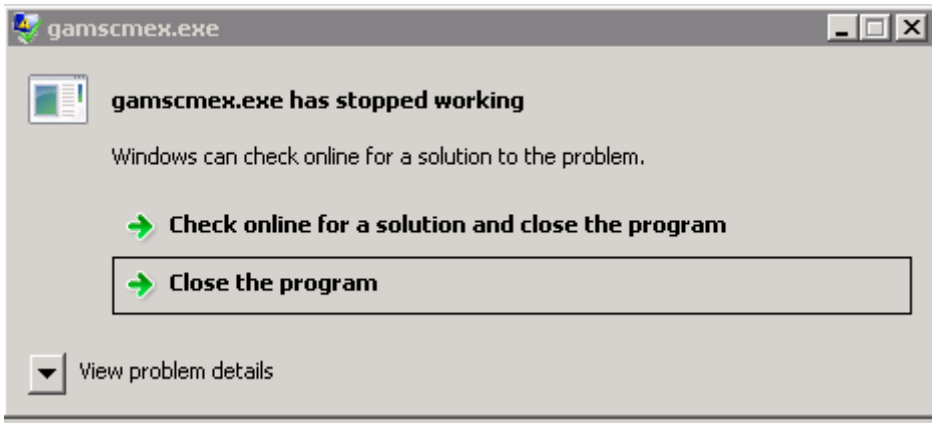


9.3. Debugging

If you have an error (and you did not change the model code) the problem lies most likely in the input files or the setup of the GUI.

First, check if the GUI is set up correctly (see Section 2.1). In particular, verify that you are reading the correct input files from the correct project directories. You might want to reset the GUI to default by: 1) METRO task panel: select calibration; 2) menu bar: select settings > remove task specific settings.

If you receive a message that gamscmex.exe has stopped working, exit the interface and delete the file metro.ini in the GUI folder. Open the interface and remove task specific settings.



Second, check LST files to facilitate your error search in the input files:

- in aggregation step: METROsam8107_agg.lst (folder 'Agg')
- in calibration step: metro.lst (folder 'Model')
- in simulation step: metro_expt.lst (folder 'Model').

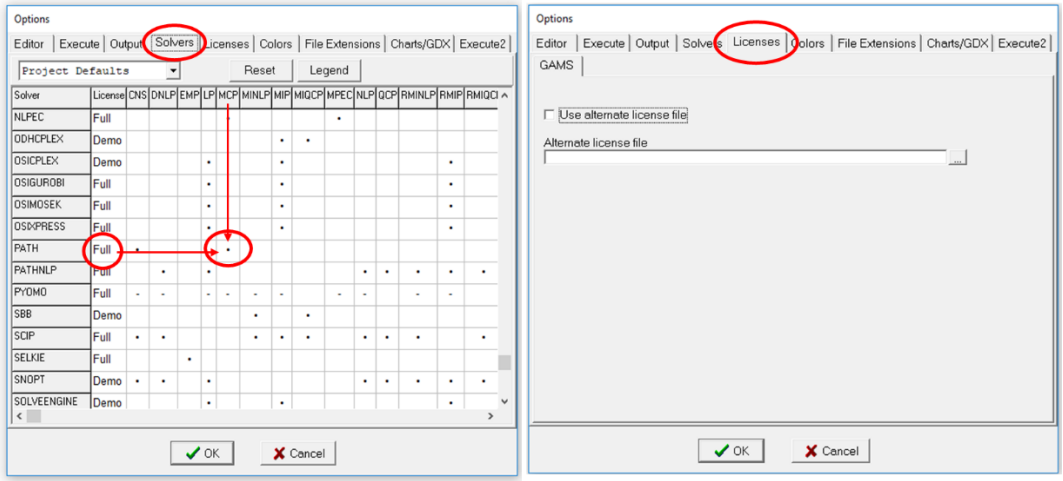
In the LST file the error is typically indicated at the top of the file (you can find the error code in the help facilities of GAMS). Most likely there is a typo, you forgot to change an item, did not run all the excel macros and save your changes, forgot to produce a specific file, or tried to combine two files which relate to different aggregations:

***TIP**: Always take care of the FIRST error and then rerun the model. If it goes uncorrected it will often generate further errors. Make sure you save the changed file before rerunning.*

***TIP**: In case you prefer debugging outside the interface, i.e. using the GAMS programme for debugging, be aware of the complications that arise from inter-linkage with the interface and the use of 'umbrella' gms files.*

If you receive a "normal completion" message but you find that your shocks have not been applied, it is probably a GAMS license problem. Recall that the METRO model is an MCP model that uses the PATH solver. Accordingly, you will need the full GAMS license for this solver. If you did not adapt your user settings (Section 2.3) by adding the location of the correct license file, then the interface looks for license in the GAMS folder. You can check which solvers are licensed by opening the GAMSIDE in the same location as the gams.exe file used in your interface.

On the GAMSIDE menu, click on “Files” the “Options”. On the “Solvers” tab, confirm that you have the “Full” license for the PATH solver in the MCP column. You can also verify if an alternative license is used.



If you do not have the full license for PATH, contact the information technology specialist for the location of the proper license and enter the location in the User settings as instructed in Section 2.3 of this user guide.

9.4. Model checks

The model comes with a set of basic checks of the database and calibration which are run automatically. [15] If they fail, the model run aborts.

Whenever the user makes **any changes to the model or the model data**, these checks should be conducted BEFORE carrying out any simulations; failure to do so may mean that the simulations are conducted using an incorrectly specified model. The initial verification run is the first of the two-step process described in the opening section of this Users’ Guide. However, it is good practice to run these checks the first time an experiment is conducted, even when using a previously used version of the model and database.

- Slack variables: All the slack variables should equal or near as possible to zero. Search for ‘var walras, ‘var kapworsys’, ‘var globeslack’ in the LST file – all should be zero. (Note: if the version of GAMS used has indexing for the list file select SolVar and the slacks are reported at the end of the list of variables.)
- Check the left-hand side: Search for ‘LHS’ in the LST file; after finding the first occurrence of ‘LHS’ search for ‘***’. Any equations incorrectly specified are identified. (Note: if the version of GAMS used has indexing for the list file select SolEQU and then the first named equation; this will move the cursor to the first equation.)
- Check data replication: First check the Macro SAM, several test parameters are reported in the LST file: search for ‘ASAMG2CHK’ – all values should equal 1; then search for DIFFASAMG2 and CNTASAMG2 – these should be zero or close to zero. Second check the Micro SAM: search for and check DIFFSAMG2 and

[15] This section is based on and partly identical to McDonald and Thierfelder (2013).

CNTSAMG2 – these should be zero or close to zero. (Note: if the version of GAMS used has indexing for the list file select DISPLAY.)

- Check the numéraire to test homogeneity: In the sets and data excel workbook, go to the worksheet 'mcontrols' and change the value of 'numerchk' to 2. Save the excel file and rerun the model Next, check the Macro SAM: search for 'ASAMG2CHK' – all values should equal 2; note that DIFFASAMG2 and CNTASAMG2 are no longer meaningful and therefore the micro SAM calculations have not been implemented. (For an alternative, see Section 4.4 for instructions on running the numéraire check in the model interface).

If the model passes all these checks, it will (usually) be correct.

References

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Annex A. List of model parameters and variables

Annex Table 1. List of parameters and variables available in the viewer

Item	Description	Item	Description
ADFD(ff,a,r)	Shift parameter for factor and activity specific efficiency	BSAV(r)	Distribution parameter on savings
ADFDaADJ(a)	Activity Scaling Factor for flow parameter on ADFD	BU(u,r)	Distribution parameter on agent
ADFDfADJ(f)	Factor Scaling Factor for flow parameter on ADFD	d1_WTPGC(r)	WTP government consumption
ADFDrADJ(r)	Region Scaling Factor for flow parameter on ADFD	d1_WTPGS(r)	WTP government savings
ADVA(a,r)	Shift parameter for CES production functions for QVA	d1_WTPHC(r)	WTP household consumption
ADVAADJ(r)	Scaling Factor for Shift parameter on CES functions for QVA	d1_WTPHS(r)	WTP household savings
ADX(a,r)	Shift parameter for CES production functions for QX in r	d2_Alloceff(r)	Allocative Efficiency
ADXADJ(r)	Scaling Factor for Shift parameter on CES functions for QX	d2_diff(r)	Check Total
ams(w,c,u,r)	ams(w,c,u,r)	d2_Endow(r)	Endowment Effect
BD(c,u,r)	Distribution parameter on domestic goods QD	d2_pop(r)	Population
BDRATQ(c,u,r)	Ratio of distribution parameter on domestic goods	d2_Remitt(r)	Remittances Effect
BHC(h,r)	Distribution parameter on household consumption	d2_SITOT(r)	Savings and Investment Terms of Trade
BHHD(h,r)	Distribution parameter on household consumption and savings	d2_techchg(r)	Technological Change
BM(c,u,r)	Distribution parameter on composite imports QM	d2_TOT(r)	Terms of Trade
BMR(w,c,u,r)	Distribution parameter on imports by region QMR	d2_total(r)	Total
BMRATQ(c,u,r)	Ratio of distribution parameters on composite imports	d2_WTP(r)	Willingness to Pay
BMRRATM(w,c,u,r)	Ratio of distribution parameter on goods in agent consumption	dabbmr(w,c,u,r)	Change in base WTP on comm'y imptd by regn
BQ(c,u,r)	Distribution parameter on composite goods QQ	DADVA(r)	Partial scaling factor for Shift parameter on CES functions for QVA
BQRATH(c,h,r)	Ratio of distribution parameter on domestic in composite goods	DADX(r)	Partial scaling factor for Shift parameter on CES functions for QX

Annex Table 1 continued

Item	Description	Item	Description
DOMSAV(r)	Domestic savings	EV_R_slutsky(r)	Slutsky approx EV
DREM(r)	Partial remittance rate scaling factor	EVGTAP(r)	EV GTAP
DSHH(r)	Partial household savings rate scaling factor	nFSAV(r)	Foreign savings (Nominal)
dt_demand(r)	Demand	FS(f,r)	Supply of factor f in r
dt_diff(r)	Check Total	FTAX(r)	Factor use tax revenue
dt_exports(r)	Exports	FYTAX(r)	Factor income tax revenue
dt_imports(r)	Imports	GDP(r)	Gross Domestic Product by Expenditure definition
dt_production(r)	Producton	GLOBESLACK	Slack variable for Globe
dt_supply(r)	Supply	GPI(r)	Government Consumption Price Index
dt_total(r)	Total	HEXP(h,r)	Household consumption expenditure
DTE(r)	Uniform adjustment to Export taxes	HHLDSAV(h,r)	Household savings
DTF(r)	Uniform adjustment to factor use tax by activity	HTAX(r)	Household income tax revenue
DTM(r)	Uniform adjustment to Ad valorem Tariff rates	IADJ(r)	Investment scaling factor
DTMS(r)	Uniform adjustment to Specific Tariff rates	IC(r)	LES Indirect Compensation
DTS(r)	Uniform adjustment to sales tax	IC_cap(h,r)	LES Indirect Compensation per capita
DTV(r)	Uniform Value added tax rate scaling factor	INVEST(r)	Total investment expenditure
DTX(r)	Uniform adjustment to indirect tax	INVESTSH(r)	Value share of investment in total final dom demand
DTYF(r)	Uniform adjustment to direct tax on factors	IPI(r)	Investment Consumption Price Index
DTYH(r)	Uniform adjustment to direct tax on households	ITAX(r)	Indirect tax revenue
EG(r)	Expenditure by government	KAPGOV(r)	Government Savings
ER(r)	Exchange rate (domestic per world unit)	KAPREG(w,r)	Bilateral current account balance
ERPI	Exchange rate index - Global numeraire	KAPWOR(r)	Current account balance
ETAX(r)	Export tax revenue	KAPWORSYS	Slack variable for global system
EV(r)	EV by household on consumption	lcrshVAR(c,u,r)	local content requirement share
EV_alt(r)	LES Alternative EV	lcrsh_AVAR(c,a,r)	local content requirement share when modules are used
EV_alt_cap(h,r)	LES Alternative EV per capita	MSTAX(r)	Specific Import tariff revenue
EV_cap(h,r)	EV per capita by household on consumption	MTAX(r)	Ad valorem Import tariff revenue
EV_H_slutsky(h,r)	Slutsky approx EV by hhd	nDEPREC(r)	Depreciation (Nominal)

Annex Table 1 continued

Item	Description	Item	Description
NETINV(r)	Net investment	PGD(c,r)	Consumer price of government consumption
nEXPORT(r)	Value of export supply (Nominal)	PINTA(c,a,r)	Consumer price of composite intermediate commodity c by activity
FD(ff,a,r)	Demand for factor f by activity a in r	PINTD(c,r)	Consumer price of intermediate inputs
nHOSAV(r)	Household savings (Nominal)	PINTS(c,u,a,r)	Supply price of composite intermediate commodity c by activity
nIMPORT(r)	Value of import demand (Nominal)	PINV(r)	Initial Price of investment goods
nQCDTOT(r)	Value of household consumption (Nominal)	PINVD(c,r)	Consumer price of investment demand
nQGDTOT(r)	Value of government consumption (Nominal)	PM(c,u,r)	Domestic price of competitive imports of commodity c
nQINVTOT(r)	Value of investment consumption (Nominal)	PMA(c,u,a,r)	Domestic price of competitive imports c by activity
nREMIN(r)	Remittance Income (Nominal)	PMA2(c,u,a,r)	Domestic price of competitive imports c by activity
nREMOUT(r)	Remittance Income (Nominal)	PML(c,u,r)	Dom price of imports of comm'y c from region with small shares
nSUPPLY(r)	Total domestic production (Nominal)	PMR(w,c,u,r)	Domestic price of imports of comm'y from regions and aggregates
nTOTSAV(r)	Total savings (Nominal)	PMS(c,u,r)	Dom price of imports of comm'y c from region with large shares
nUEXPORT(u,r)	Value of export supply by use (Nominal)	POPN(r)	Population
nUIMPORT(u,r)	Value of import supply (Nominal)	PPI(r)	Producer (domestic)
nUSE(r)	Total intermediate inputs (Nominal)	PQD(c,u,r)	Consumer price of composite commodity c
nYFDISTTOT(r)	Distributed factor income (Nominal)	PQS(c,u,r)	Supply price of composite commodity c
nYFLABTOT(r)	Labour income (Nominal)	PS(c,u,r)	Producer price of composite domestic output by use
nYFTOT(r)	Factor income (Nominal)	PT(c,u,r)	Price of imported transport services (same price to imports from all regions)
nYGTOT(r)	Government income (Nominal)	PVA(a,r)	Value added price for activity a in r
nYHDTOT(r)	Disposable income (Nominal)	PWE(c,u,w,r)	World price of exports of commodity c from region r in dollars
nYHTOT(r)	household income (Nominal)	PWEAGG(c,r)	World Export Price by Region
PCD(c,r)	Consumer price of household consumtion	PWEAGG2(c)	Aggregate World Price
PD(c,u,r)	Consumer price for domestic supply of commodity c	PWEAGGU(c,u,r)	World Export Price
PDA(c,u,a,r)	Consumer price for domestic supply of commodity c by activity	PWM(w,c,u,r)	CIF price of competitive imports of commodity c from region w
PDA2(c,u,a,r)	Consumer price for domestic supply of commodity c by activity	PWMAGG(c,r)	World Import Price by Region
PDOMSAV(r)	Price savings goods	PWMAGG2(c)	Aggregate World Price
PE(c,u,r)	Domestic price of exports by commodity c	PWMFOB(w,c,u,r)	FOB price of competitive imports of commodity c from region w
PER(c,u,w,r)	Domestic price of exports of comm'y to regions and aggregates	PX(a,r)	Composite price of output by activity a

Annex Table 1 continued

Item	Description	Item	Description
PXC(c,r)	Producer price of composite domestic output	QMR(w,c,u,r)	Imports of comm'y c from regions and aggregates
QCD(c,h,r)	Household consumption by commodity c	QMS(c,u,r)	Supply of composite import from large share regions
QD(c,u,r)	Domestic demand for commodity c	QQ(c,u,r)	Supply of composite commodity c
QDA(c,u,a,r)	Domestic demand for commodity c by activity	QQARM(c,u,r)	Supply of composite commodity (Armington function)
QDLCR(c,u,r)	additional domestic produced quantity provided under LCR	QQARM_A(c,u,a,r)	Supply of composite commodity (Armington function)
QDLCR_A(c,u,a,r)	Additional domestic produced quantity provided under LCR	QS(c,u,r)	Domestic production by commodity c in r by use
QDNL(c,u,r)	Domestic produced quantity not affected by LCR	QSAVE(r)	Savings quantity
QDNL_A(c,u,a,r)	Domestic produced quantity not affected by LCR	QT(w,c,u,r)	Quantity of margin services for total imports from region w
QE(c,u,r)	Domestic output exported by commodity c	QVA(a,r)	Quantity of aggregate value added for level 1 production
QER(c,u,w,r)	Exports of comm'y c to regions and aggregates	QX(a,r)	Domestic production by activity a in r
QGD(c,r)	Government consumption demand by commodity c	QXC(c,r)	Domestic production by commodity c in r
QGDADJ(r)	Government consumption demand scaling factor	REMADJ(r)	Remittance rate scaling factor
QGOVT(r)	Initial govt consumption	REMIN(h,w,r)	Remittances in
QGSAV(r)	Initial Quantity of government savings	REMINW(h,w,r)	Remittances in
QHLD(r)	Initial household Income	REMOUT(w,h,r)	Remittances out
QHSAV(r)	Initial Quantity of household savings	REMOUTW(w,h,r)	Remittances out
QINT(a,r)	Agg quantity of intermediates used by activity a in r	REMRYHF(w,h,r)	Remittances out ratio
QINTA(c,a,r)	Demand for intermediate inputs by commodity by activity in r	rEXPORT(r)	Value of export supply (Real)
QINTD(c,r)	Demand for intermediate inputs by commodity in r	rGDPEXP(r)	GDP from Expenditure side - C + I + G + E - M (Real)
QINV(r)	Investment quantity	rIMPORT(r)	Value of import demand (Real)
QINVD(c,r)	Investment demand by commodity c	rQABSORP(r)	Value of Domestic final demand (Real)
QLCR(c,u,r)	Local content requirement quantity	rQCDTOT(r)	Value of household consumption (Real)
QLCR_A(c,u,a,r)	Local content requirement quantity	rQGDTOT(r)	Value of government consumption (Real)
QM(c,u,r)	Imports of commodity c	rQINVTOT(r)	Value of investment consumption (Real)
QMA(c,u,a,r)	Total imports of comm'y by activity	rSUPPLY(r)	Total domestic production (Real)
QMICE(r)	Imports consumed by agents (differs from QMACT by iceberg affect	QMACT(r)	Actual imports received by region r from all regions
QML(c,u,r)	Supply of composite import from large share regions	rUEXPORT(r)	Value of export supply by use (Real)

Annex Table 1 continued

item	Description	Item	Description
rUIMPORT(u,r)	Value of import supply (Real)	TYF(f,r)	Direct tax rate on factor income
rUSE(r)	Total intermediate inputs (Real)	TYFADJ(r)	Factor Income Tax Scaling Factor
SADJ(r)	Savings rate scaling factor	TYH(h,r)	Direct tax rate on households
SHH(h,r)	Household savings	TYHADJ(r)	Income Tax Scaling Factor
SLACK(c,u,r)	Slag variable QDL	UC(r)	Utility from Household Consumption
SLACK_A(c,u,a,r)	Slag variable QDL	UG(r)	Utility from Government Consumption
SREGH(r)	Regional Savings Rate	UGS(r)	Utility from Government Saving
STAX(r)	Sales tax revenue	UGS(r)	Total Utility
TE(c,u,w,r)	Export taxes on exported comm'y c from r to w	UHS(r)	Utility from Household Saving
TEADJ(r)	Export subsidy Scaling Factor	UNEMP(f,r)	Unemployed factors
TF(ff,a,r)	Tax rate on factor use	VFDOMD(r)	Value of final domestic demand
TFADJ(r)	Factor Use Tax Scaling Factor	VGDSH(r)	Value share of Govt consump in total final dom demand
TM(w,c,u,r)	Ad valorem Tariff rates on imported comm'y c from w by r	VTAX(r)	Value added tax revenue
TMADJ(r)	Ad valorem Tariff rate Scaling Factor	WALRAS(r)	Slack variable for Walras's Law
TMS(w,c,u,r)	Specific Tariff rates on imported comm'y c from w by r	WEV(r)	World EV
TMSADJ(r)	Specific Tarrif rate Scaling Factor	WF(ff,r)	Price of factor f in r
TOT(r)	Terms of Trade	WFDIST(ff,a,r)	Sectoral proportion for factor prices in r
TOTcagg(r)	ToT by Product Group	Y(r)	Initial regional income from expenditure side
TOTSAV(r)	Total savings	Y_ALT(r)	Initial regional income from income side
TS(c,u,r)	Sales tax rate	Y_CHK(r)	Check on initial regional income
tsa(c,u,a,r)	Sales tax parameter for intermediates by activity	YEV(r)	Base for EV
TSADJ(r)	Sales tax rate scaling factor	YF(f,r)	Income to factor f
tsd(c,u,a,r)	Sales tax parameter for domestic intermediates by activity	YFDIST(f,r)	Factor income for distribution after depreciation
tsm(c,u,a,r)	Sales tax parameter for imported intermediates by activity	YG(r)	Government income
TV(c,r)	Value added tax rates	YH(h,r)	Income to household h
TVADJ(r)	Value added tax rate scaling factor	YHD(h,r)	Disposable Income to household h
TX(a,r)	Indirect tax rate	YHF(h,r)	Factor Income to household h
TXADJ(r)	Indirect Tax Scaling Factor		

Annex Table 2. Regions, Sectors, and Factors in 5_8_5 example databases

Regions	Description	Sectors	Description	Factors	Description
Europe	Europe	agf	Agriculture and food	Land	Land
NAmerica*	North America	extr	Natural resources	tech_aspros	Technical and assistant professionals
Asia	Asia	man	Manufacturing	clerks	Clerks
ROW	Rest of the World	otp	Transport services	service_shop	Service and shop assistants
glo	GLOBE	ser	Services	off_mgr_pros	Office managers and professionals
				ag_othlowsk	Agricultural and other low skilled workers
				Capital	Capital
				NatRes	Natural resources

*NAmerica includes Canada and the United States

Annex Table 3. Regions, Sectors, and Factors in 10_8_5 Land Allocation Module example database

Regions	description	Sectors	description	factors	description
Europe	Europe	pdrp	Paddy rice and other crops	Land	Land
NAmerica**	North America	grosd	Grains and oilseeds	tech_aspros	Technical and assistant professionals
Asia	Asia	othcrops	Veg, sugar, and plant based fibers	clerks	Clerks
ROW	Rest of the World	livestock	Livestock	service_shop	Service and shop assistants
glo	GLOBE	frs	Forestry	off_mgr_pros	Office managers and professionals
		oagf	Fish and food	ag_othlowsk	Agricultural and other low skilled workers
		extr	Natural ressources	Capital	Capital
		man	Manufacturing	NatRes	Natural resources
		otp	Transport services		
		ser	Services		

*NAmerica includes Canada, Mexico and the United States

Annex Table 4. Regions, Sectors, and Factors in 19_8_6 Land Allocation Module example database

Regions	Description	Sectors	Description	Factors	Description
Europe	Europe	pdr	Paddy rice	Land	Land
USA	United States	wht	Wheat	tech_aspros	Technical and assistant professionals
CAN	Canada	gro	Other coarse grains	clerks	Clerks
Asia	Asia	v_f	Vegetable and fruits	service_shop	Service and shop assistants
ROW	Rest of the World	osd	Oilseeds	off_mgr_pros	Office managers and professionals
glo	GLOBE	c_b	Sugar crops	ag_othlowsk	Agricultural and other low skilled workers
		pfb	Fibre crops	Capital	Capital
		ocr	Other crops	NatRes	Natural resources
		ctl	Cattle meat		
		oap	Monogastrics		
		rmk	Dairy cattle		
		wol	Wool, other anim		
		frs	Forestry		
		fsh	Fisheries		
		pcf	Processed food		
		extr	Natural ressources		
		man	Manufacturing		
		otp	Transport services		
		ser	Services		

Annex B. ICIO-TiVA module Tables

Annex Table 5. Value Added Exports – MATRIX

	Exporting region	Europe					North America					Asia					Rest of the World					Total
VA source region	Exported good VA source sector	Ag&Food	Nat. res	Manu-facturing	Transport services	Services	Ag&Food	Nat. res	Manu-facturing	Transport services	Services	Ag&Food	Nat. res	Manu-facturing	Transport services	Services	Ag&Food	Nat. res	Manu-facturing	Transport services	Services	
Europe	Ag&Food	69,206	131	14,006	1,036	5,472	310	8	617	36	94	164	4	1,483	48	115	1,148	535	1,191	127	190	*95,922*
Europe	Nat. res	973	21,820	42,618	1,540	3,158	121	23	2,436	104	163	59	15	4,960	114	249	265	1,238	3,389	297	290	*83,831*
Europe	Manufacturing	11 505	2,063	857,261	27,266	31,103	1,603	310	25,355	1,377	2,233	701	127	48,069	1,445	2,596	3,836	17,446	36,819	4,438	3,740	*1,079,294*
Europe	Transport	3,511	649	33,751	71,540	9,228	192	35	1,795	402	406	103	16	4,057	514	364	456	2,115	2,686	796	479	*133,095*
Europe	Services	36,375	5,098	413,539	41,831	477,976	1,483	284	16,711	1,159	2,546	772	140	36,755	1,555	3,201	3,542	17,295	25,517	3,552	3,883	*1,093,214*
North America	Ag&Food	328	5	781	61	134	83,954	92	6,231	302	3,098	858	8	3,277	84	308	1,338	361	952	88	167	*102,427*
North America	Nat. res	163	38	5,742	339	435	1,944	29,107	58,652	1,634	3,360	89	19	6,238	143	313	325	1,445	3,913	349	335	*114,583*
North America	Manufacturing	992	161	28,917	2,197	2,465	14,815	2,076	553,805	13,708	17,482	549	77	29,513	869	1,598	2,293	9,795	21,038	2,477	2,105	*706,934*
North America	Transport	132	23	2,210	590	354	4,125	805	24,595	34,562	4,859	90	9	2,412	249	200	223	808	1,324	263	183	*78,018*
North America	Services	1,099	160	20,491	1,846	3,543	43,428	6,548	233,581	17,645	317,620	800	77	21,023	833	1,820	2,013	7,492	12,343	1,581	1,701	*695,642*
Asia	Ag&Food	829	26	4,330	337	526	979	42	3,344	178	390	79,459	228	78,507	2,351	9,427	1,520	1,497	3,285	371	407	*188,034*
Asia	Nat. res	179	32	5,443	383	462	253	49	4,156	208	349	906	11,046	101,781	1,544	5,401	405	1,890	4,760	460	427	*140,135*
Asia	Manufacturing	1,948	318	57,659	4,267	4,914	2,905	566	46,600	2,395	3,995	8,916	1,863	1,254,263	16,987	39,061	4,255	19,399	41,479	4,886	4,152	*1,520,828*
Asia	Transport	236	40	4,551	927	623	270	48	3,216	378	455	2,696	424	72,578	48,775	8,160	409	1,826	3,045	584	405	*149,648*
Asia	Services	1,370	207	29,744	2,564	4,199	1,666	315	21,061	1,266	2,608	16,282	2,781	490,606	23,595	281,805	2,362	11,111	19,534	2,488	2,451	*918,015*
ROW	Ag&Food	2,482	26	3,733	270	723	1,590	24	2,047	99	329	1,361	18	6,879	175	570	171,611	6,165	22,304	1,506	4,834	*226,746*
ROW	Nat. res	2,187	726	96,358	4,209	6,252	2,277	450	61,521	1,982	2,919	1,680	656	189,053	3,026	8,504	6,793	1,214,868	171,985	7,840	9,887	*1,793,173*
ROW	Manufacturing	1,311	207	36,118	2,670	3,019	1,553	289	24,730	1,247	2,038	620	110	40,069	1,096	2,093	14,487	52,038	520,418	17,097	15,305	*736,514*
ROW	Transport	419	71	6,631	1,630	964	305	47	3,583	443	481	200	34	9,255	655	616	7,792	34,356	31,462	82,674	6,293	*187,912*
ROW	Services	1,711	244	31,987	2,436	3,972	1,422	219	18,774	939	1,763	877	157	45,001	1,205	2,726	43,130	176,209	212,455	28,271	229,607	*803,108*
sum: gross exports		*136,958*	*32,045*	*1,695,870*	*167,940*	*559,521*	*165,195*	*41,338*	*1,112,812*	*80,063*	*367,190*	*117,181*	*17,811*	*2,445,783*	*105,262*	*369,127*	*268,202*	*1,577,892*	*1,139,898*	*160,143*	*286,843*	

Columns indicate exporting regions and the good that is exported. Rows indicate where the value added was created, by (source) region and (source) sector. For example, Ag&food exports in Europe include USD 992 million of VA generated by manufacturing in North America.

Yellow cells are the domestic flows of value added. Grey cells are the international flows of value added. Boxed cells indicate a country-sector's own value added exports.

VAE decomposition

Column: Value added composition of exports of a region (backward)

- Domestic value added in exports from a sector in a region is the sum of all rows representing domestic sources of VA (yellow cells in Annex Table 5): European ag&food exports incorporate domestic VA of USD 121 570 million (69 206 + 973 + 11 505 + 3 511 + 36 375)
- Total foreign value added in exports from a sector in a region is the sum of all rows representing foreign sources of VA, (grey cells in Annex Table 5): USD 15 387 million.
- Gross exports = total domestic value added + total foreign value added. This is the column sum.

Annex Table 6. Example based on from 5_8_5_v92L11 base data.

Exporting region	Exported commodity	Gross exports of sector [value]	Decomp. gross exports: domestic VA [value]	Decomp. gross exports: foreign VA [value]
Europe	Agriculture and food	136,958	121,570	15,387
	Natural resources	32,045	29,762	2,283
	Manufacturing	1,695,870	1,361,175	334,695
	Transport services	167,940	143,214	24,726
	Services	559,521	526,936	32,584

Alternative way to decomposition value added exports of a region (forward)

- Sector VA in own sector exports: Value added content the sector contributes to its own exports = cells where source country is also the exporting country, and source sector is similar to exported good (boxed cells in VAE matrix above). European agriculture and food exports contain VA that originates from domestic agriculture and food production worth USD 69 206 million.
- Sector VA in total exports: Value added sector contributes to total exports in a region. This includes own sector's exports and VA that is exported in form of other goods; for example, direct exports of cotton and cotton that is processed into textiles inside the country and then exported. The sector VA in total exports = sum over exporting sectors for each region where source region equals the exporting region (yellow cells in Annex Table 5). European agriculture and food production contributes USD 89 851 million to all European exports (of which USD 69 206 million are in form of agriculture and food exports).
- Sector value added in exports of partner regions = sum over exporting sectors for partner regions (grey cells). USD 6 070 million of VA created in European agriculture and food production is reprocessed and again exported by partner regions.

Annex Table 7. VAE decomposition

Source region	Source sector	Sector VA in own sector exports [value]	Sector VA in total exports [value]	Sector VA in partner exports - [value]
Europe	Agriculture and Food	69,206	89,851	6,070
Europe	Natural resources	21,820	70,108	13,722
Europe	Manufacturing	857,261	929,198	150,096
Europe	Transport services	71,540	118,679	14,416
Europe	Services	477,976	974,820	118,394

TiVA indicator calculations

- Backward participation = foreign value added in total exports = backward_va/total gross exports. For example, Europe's agriculture and food sector's backward participation rate is 0.11= 15 387/136 958. Which means that 11% of the value of agriculture and food exports originates from domestic VA.
- Forward participation = the share of a region's value added exports in their trading partners' exports (sum of grey cells of industry row), expressed as a share of the industry's gross exports. For example, Europe's agriculture and food sector's forward participation rate is 0.04=6 070 / 136 958. This is 4% of Europe's agriculture and food exports to partner regions.
- Participation index = sum of forward and backward indicator.
- Position index = ln(1 + forward indicator) – ln(1 + backward indicator). If the sector lies upstream in a supply chain, the first term (numerator) tends to be large; if it lies downstream, the second term (denominator) tends to be large. For example, in the home electronics sector, if Japan specialises in providing components to assembly firms in China, the index tends to take on a high value for Japan and a low value for China.

Annex Table 8. TiVA indicators

		Backward indicator - [share]	Forward indicator - [share]	Participation indicator - [index]	Position indicator - [index]
Europe	Agriculture and food	0.11	0.04	0.16	-0.06
Europe	Natural resources	0.07	0.43	0.5	0.29
Europe	Manufacturing	0.20	0.09	0.29	-0.10
Europe	Transport services	0.15	0.09	0.23	-0.05
Europe	Services	0.06	0.21	0.27	0.14

Direct-indirect VA

VAE showed the VA composition of exports, we now look at the VA composition of ***final demand***. Two versions are available: i) 'final demand' including household and government consumption as well as investment demand (see Annex Table 9); and 'final consumption' including household and government demand (the concept is similar to final demand and is thus not iterated in this example).

- The first column in Annex Table 9 shows gross final demand of agricultural and food products in Europe. Europe consumes agricultural and food products worth USD 981 453 million, of which 915 432 are from European production, 9 285 are imported from North America, and so forth.
- VA in final demand shows where the VA originates. Total final demand in VA terms equals gross consumption. The table below shows that in VA terms, however, the intra-European contribution is smaller, indicating that European food processing is using imported intermediates. These intermediates originate partly from North America, which contributes VA worth USD 27 750 million compared to gross imports of final demand goods of USD 9 285 million.
- USD 26 475 million of this trade flow from North America to Europe is direct: goods are either exported by North America as final demand goods for consumption in Europe or are exported in the form of intermediate goods and further processed in Europe directly from North America to Europe without intermediary countries.
- Agriculture (and food) goods indirectly traded amount to USD 1 275 million. This means that at least one additional country was involved to produce the good, between value added creation in North America and final demand in Europe.
- The direct VA flow from Europe to Europe (812 581) shows the value that is not traded. Indirect VA where Europe is both the source and consuming region (1 918) indicates the amount of reimports, e.g. a good is sent for processing to another region and then reimported for consumption.

Annex Table 9. VA composition of final demand

Consuming region: Europe					
Commodity group	**Source region**	**Gross final demand [value]**	**VA in final demand [value]**	**Direct VA [value]**	**Indirect VA [value]**
Agriculture	Europe	915432	814,499	812,581	1,918
Agriculture	North America	9,285	27,750	26,475	1,275
Agriculture	Asia	12,889	44,211	42,406	1,805
Agriculture	Rest of the World	43,848	94,994	94,071	923
Agriculture	Europe	915,432	814,499	812,581	1,918
	Sum	***981,453***	***981,453***	***975,533***	***5,920***

Figure 15. Commodity market: Quantity system

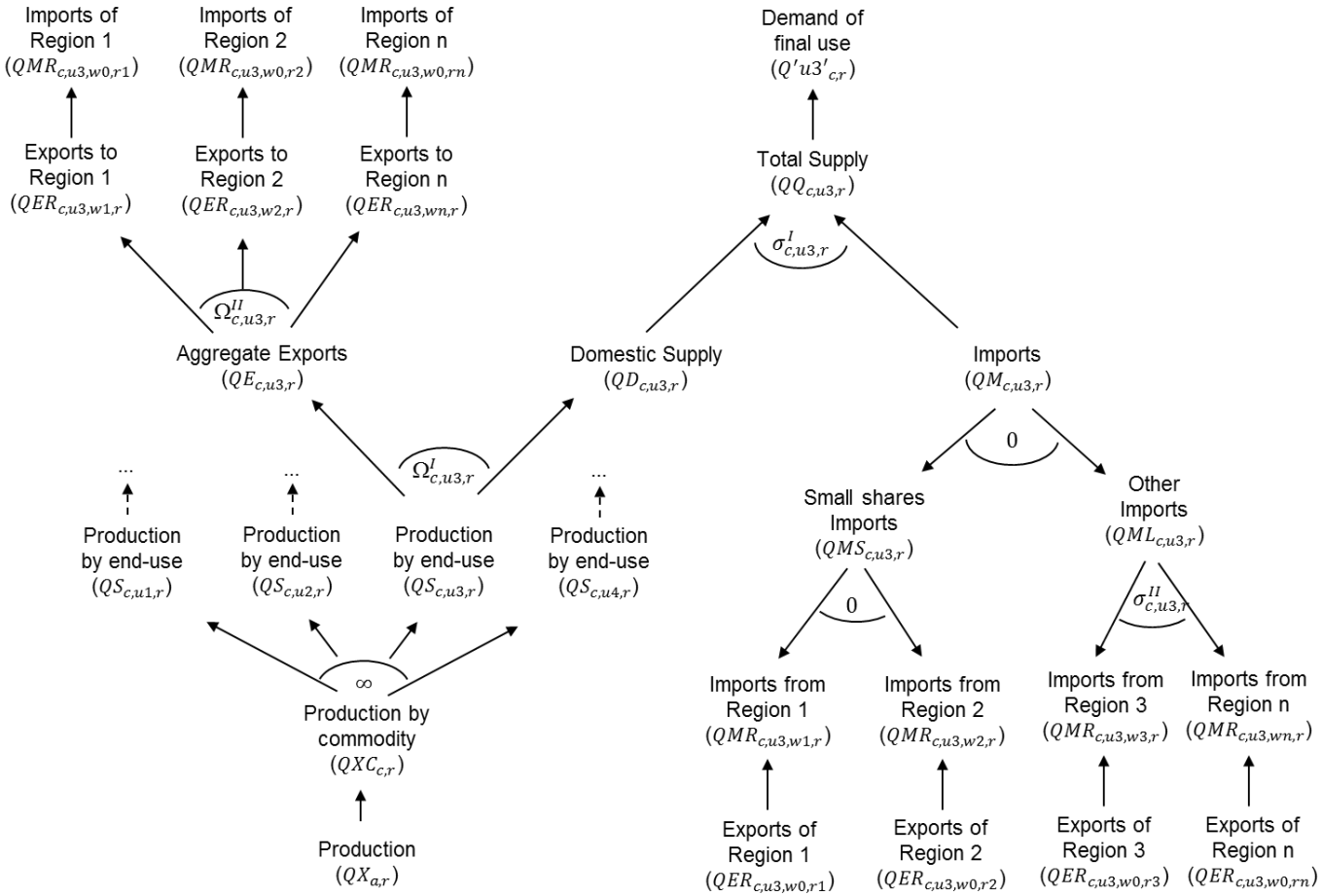


Figure 16. Commodity market: Price system

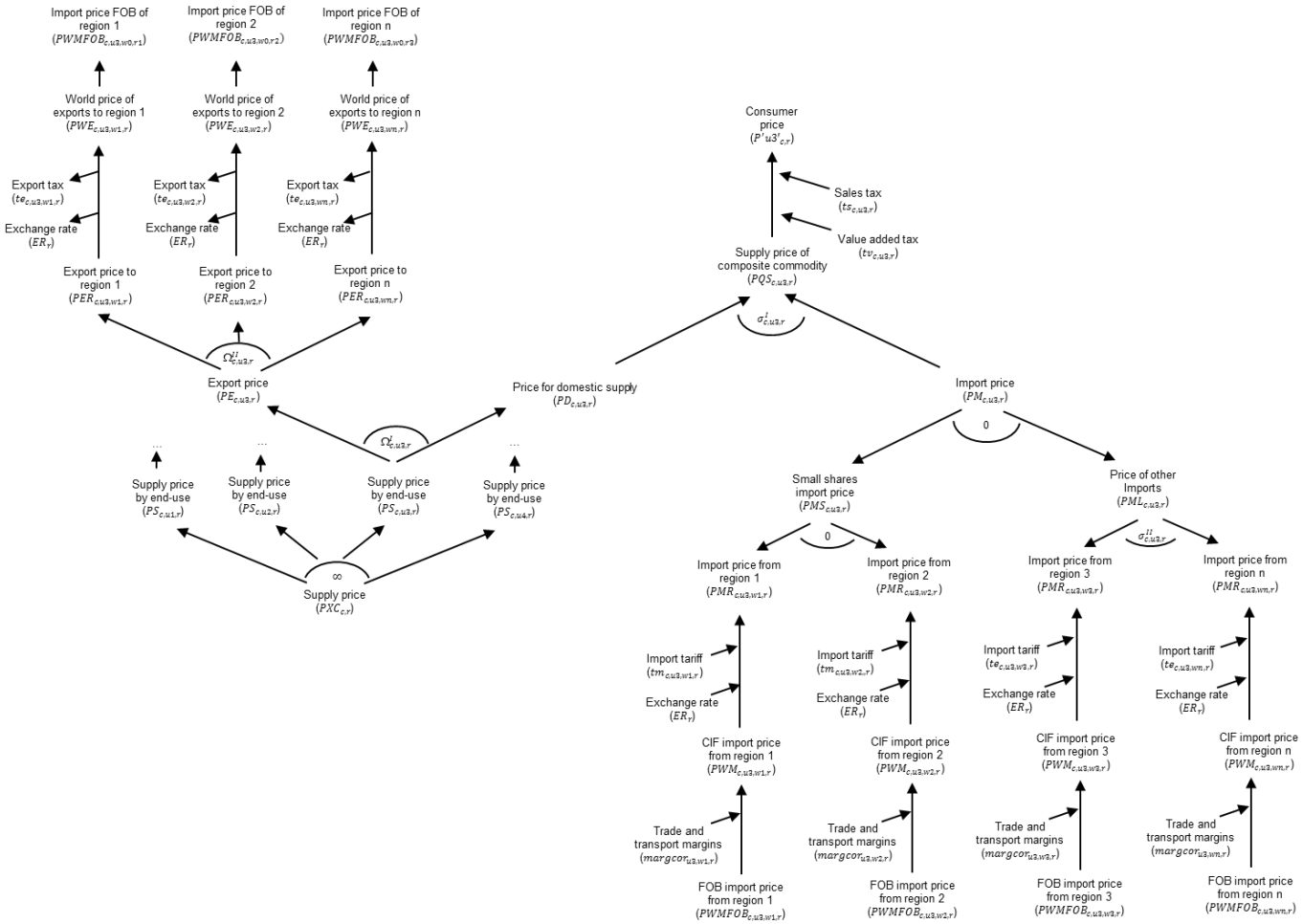


Figure 17. Production system: Quantities

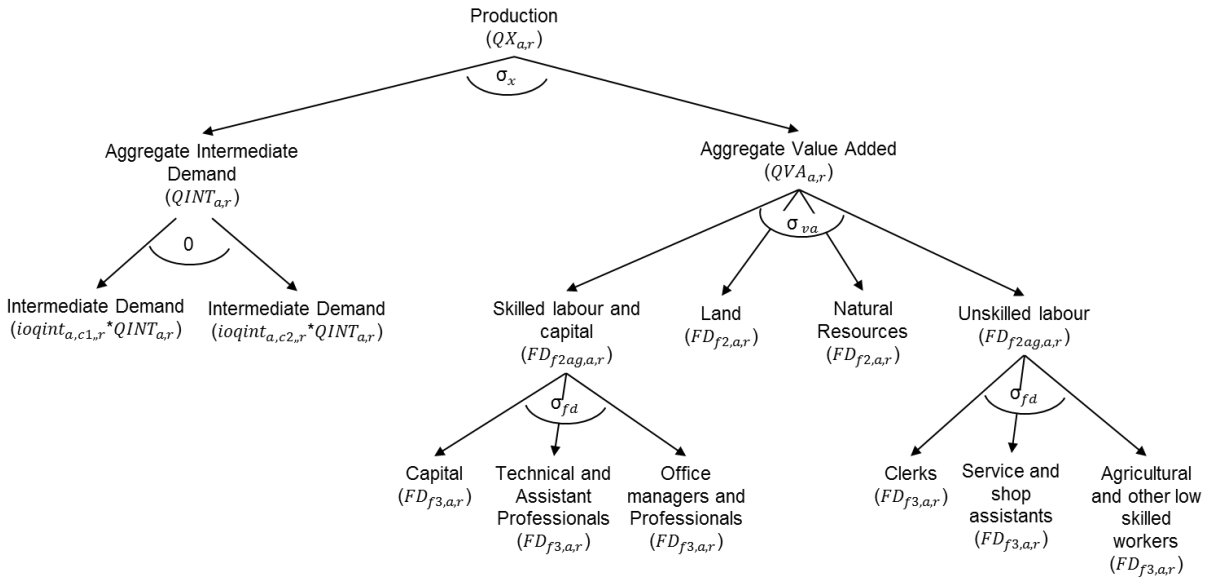


Figure 18. Production system: Prices

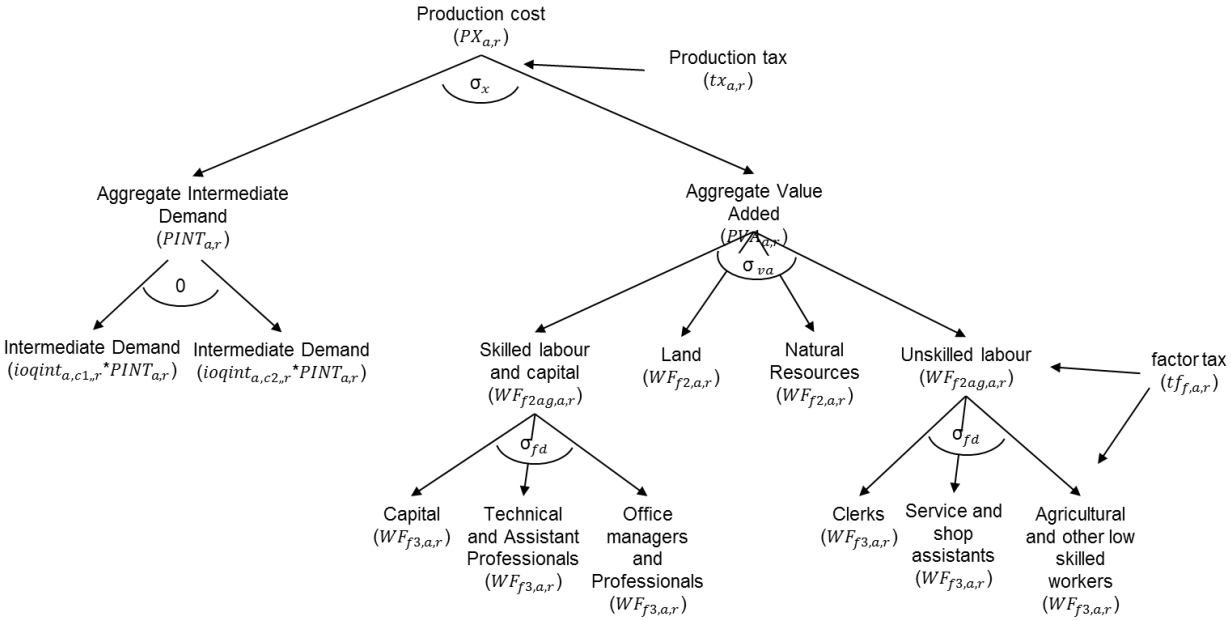
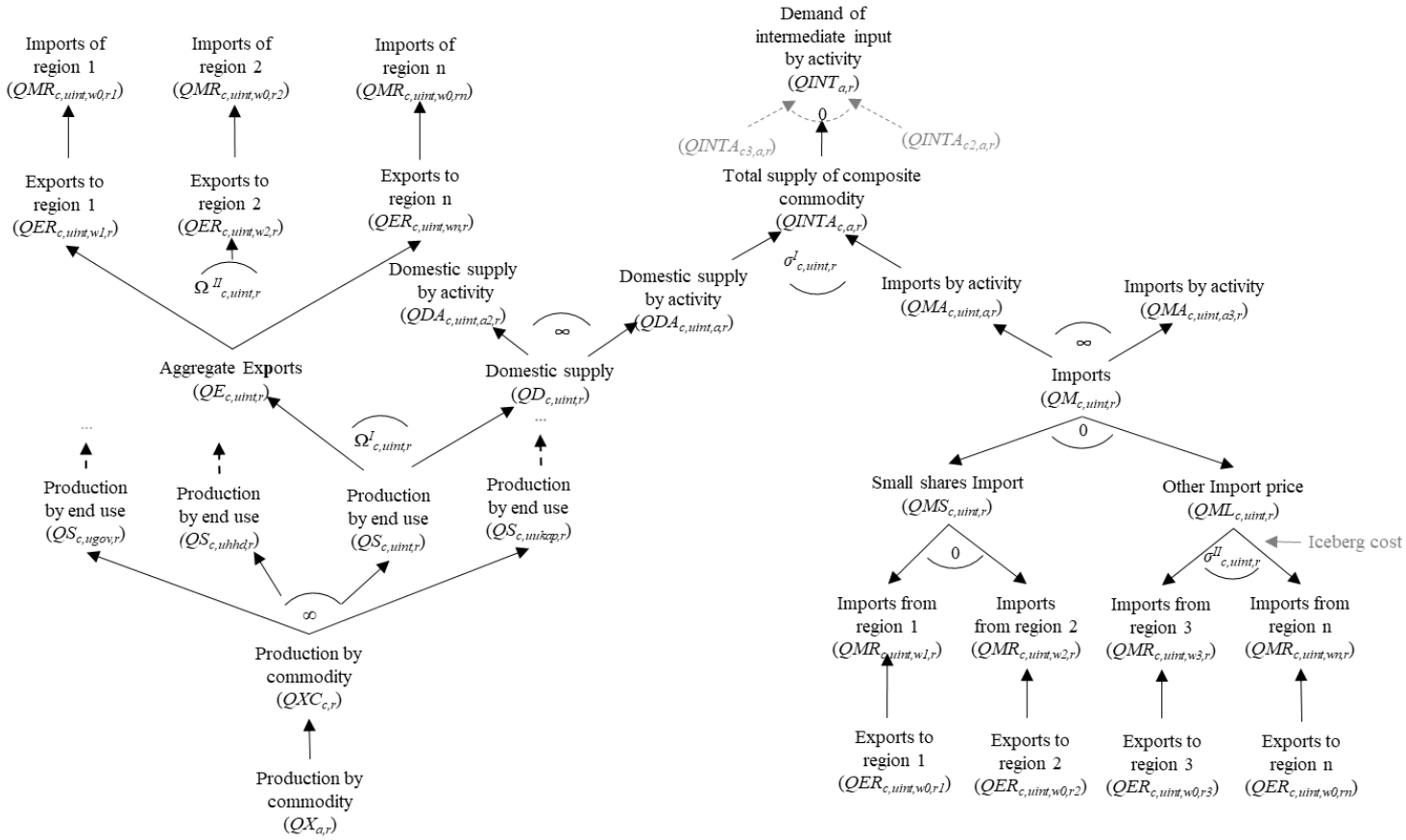
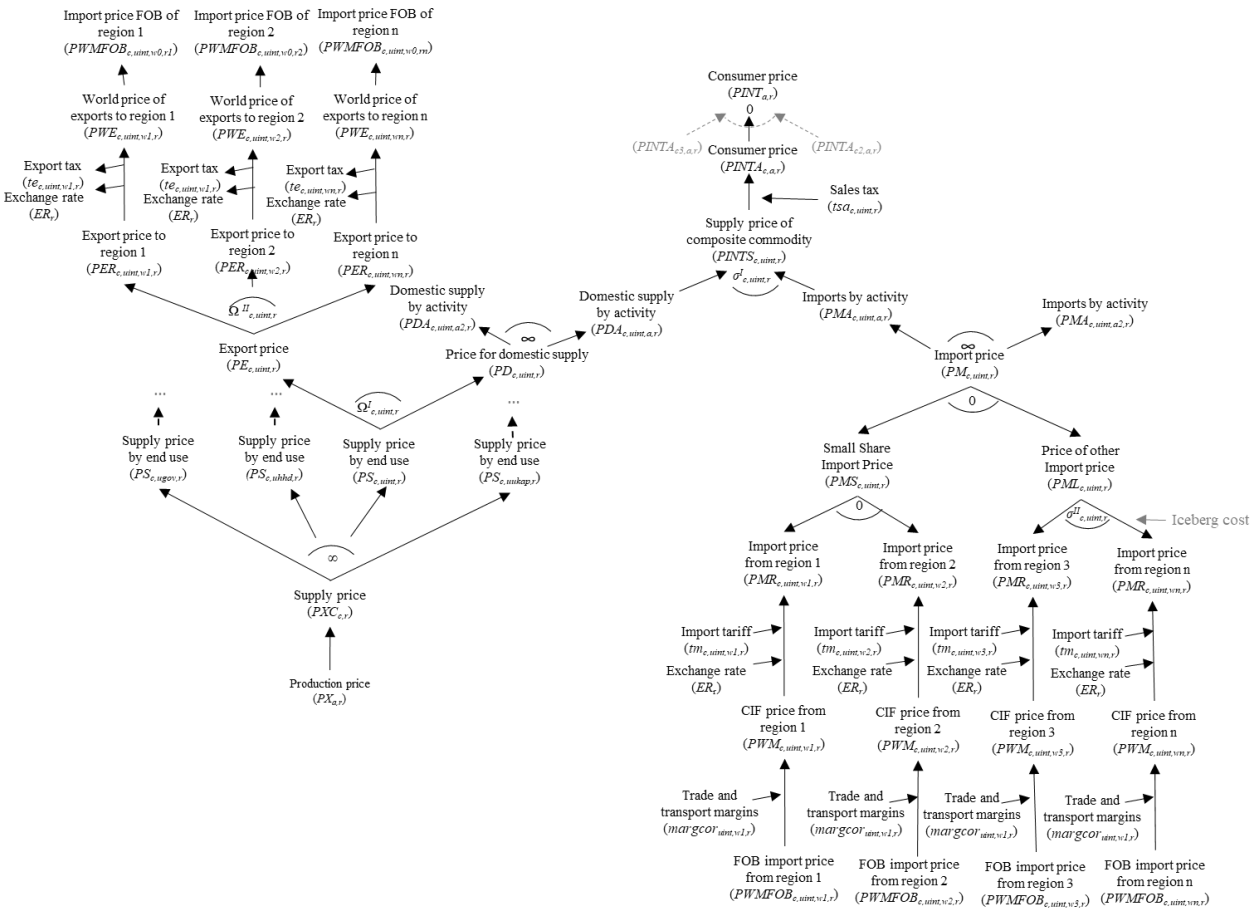


Figure 19. Commodity market: Quantity system with intermediate input nesting



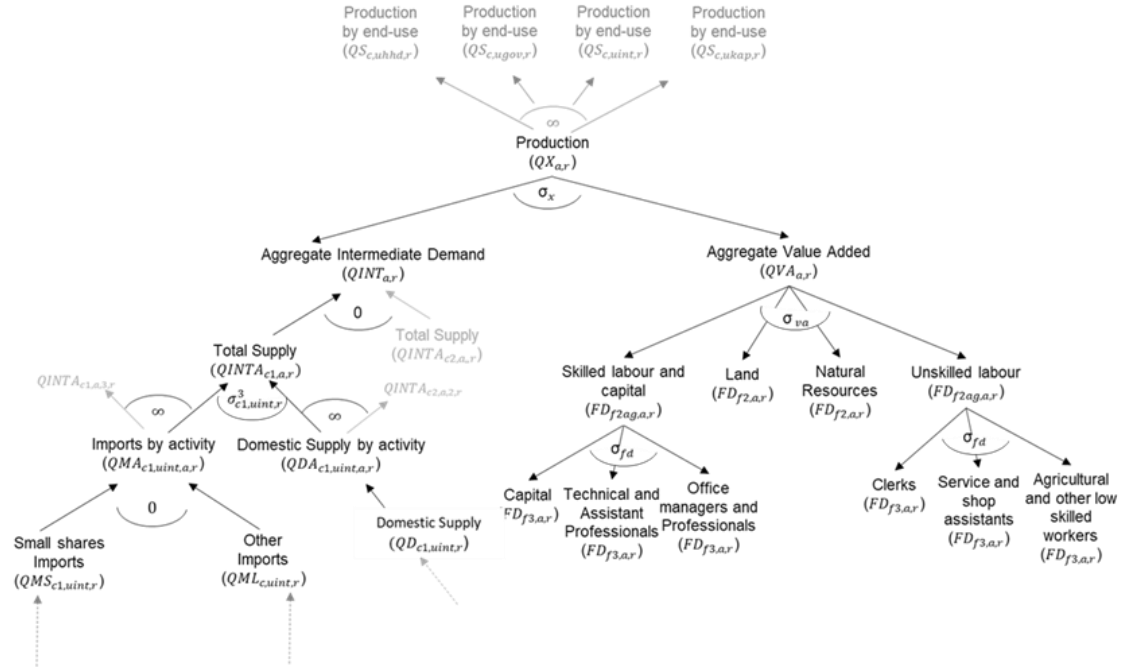
Note: When the intermediate nesting module is ON, the structure is relevant for intermediate goods only, while the structure described in Figure 15 remain relevant for final goods (uhhd, ugov, ukap).

Figure 20. Commodity market: Price system with intermediate input nesting



Note: When the intermediate nesting module is ON, the structure is relevant for intermediate goods only, while the structure described in remain relevant for final goods (uhhd, ugov, ukap).

Figure 21. Production system: Quantities with intermediate input nesting



Note: When the intermediate nesting module is ON, the structure for quantities and prices described in Figure 21 and Figure 22 are relevant for intermediate goods only, while he structure described in Figure 17 and Figure 18 remain relevant for final goods (uhhd, ugov, ukap).

Figure 22. Production system: Quantities with intermediate input nesting

