CAPRI Network & Humboldt-Universität zu Berlin, Lebenswissenschaftliche Fakultät, Fachgebiet Internationaler Agrarhandel und Entwicklung

CAPRI Tutorial for the course "Applied Data Analysis: Introduction to and Application of the Partial Equilibrium Model CAPRI in Market and Policy Analysis"

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Abbreviations and acronyms

CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regional Impact model
EC	European Commission
EU	European Union
GAMS	General Algebraic Modelling System
GDX	GAMS Data Exchange
GHG	Greenhouse Gas
GUI	Graphical User Interface
ILO	Intended Learning Outcome
IPCC	Intergovernmental Panel on Climate Change
NUTS	Nomenclature of Territorial Units for Statistics
SVN	Subversion (version control system)

About the tutorial

1.1 Purpose of the Tutorial for the course

The purpose of this tutorial is to ease learning first handling of the CAPRI model and its Graphical User Interface (GUI). After following this tutorial, you will possess the knowledge and skills required to set up the CAPRI software system, run a simple scenario, exploit and manage/navigate results as well as getting an understanding of the basic theory underlying the CAPRI model. Estimated time for completing this tutorial is 3-5 days. You should typically follow the tutorial by the order of the content in this text. This tutorial is also the preparation phase (Block I) for those attending the CAPRI Training Session 2023. It is recommended that all trainees follow the tutorial and complete the exercises. The outline of the course and its organisation is available in muddle.

1.2 Intended Learning Outcomes (ILOs)

After following this tutorial, you will be able to

1) Describe the main components of CAPRI and how they interact

2) Navigate in the Graphical User Interface (GUI)

   a) set up the system on your machine, including auxiliary software (Java and GAMS)

   b) start the GUI

3) Run a simulation with a provided policy file, which includes to

   a) navigate and execute the proper task

   b) verify that the simulation was completed successfully

4) Identify and compare simulation results in the GUI. In particular

   a) Load several result sets into the viewer

   b) Find selected tables in the result viewer

   c) Customize result tables by transposing rows and columns

   d) Compare values in relative and absolute terms

   e) Select subsets of the results

   f) Sort results

5) Reflect on strengths and weaknesses in using CAPRI and possible applications for specific studies.

For each section the ILOs are specified.

1.3 How to use the tutorial

This tutorial is written to be followed sequentially and begins with an overview of CAPRI and examples of applications. You are then guided through setting up the system. Once CAPRI is installed on your computer, you will learn how to run a simulation and explore results from a simulation. Throughout the tutorial, you will find exercises in the corresponding sections. They are there to help you learn. You should fill in your answers in the accompanying answers sheet in a separate document. Please send the separate document to

davide.pignotti@thuenen.de before the 20th of September 2023. Practice each step until you feel confident to master that task.

1.4 Prerequisites

This tutorial is intended to help those who are exposed to CAPRI for the very first time. It gives step-by-step guidance in setting up the system on a PC and in using the basic functions of the system. It is a suitable starting point for those wanting to start exploring the system and required preparation before participating in a CAPRI course (Block II and Block III), which will cover an introduction into GAMS for CAPRI in Block II, lectures and computer exercises in Block III and a student project in Block IV. It does not, however, aspire to explain in detail how the model works in terms of the theoretical models and the coding, but should give a sufficient overview.

To follow this tutorial, you need to know the basics of working with a PC, and it is assumed that you know approximately what CAPRI[1] is all about. For this first introduction to CAPRI, it is not necessary to have advanced skills in mathematics or economic theory. You need the following equipment:

- A PC with 64-bit operating system (no support for iOS/Linux based computers)

Only for users who will attend the CAPRI Training Session 2023: If you encounter problems that you cannot solve yourself, send an email to davide.pignotti@thuenen.de or alexander.gocht@thuenen.de and we will respond as soon as possible.

1.5 Literature

This literature can be helpful if you want more background information:

- CAPRI documentation 2022 (still in a draft version)

https://www.capri-model.org/lib/exe/fetch.php?media=docs:caprijan2022.pdf

https://www.capri-model.org/dokuwiki_help/doku.php

- Britz, Wolfgang (2014) The Graphical User Interface for CAPRI. Version 2014.

https://www.capri-model.org/lib/exe/fetch.php?media=docs:gui2014.pdf

- Overview on CAPRI. http://www.capri-model.org/dokuwiki/doku.php?id=capri:ts:TrainingMaterial

- Frequently Asked Questions. http://www.capri-model.org/dokuwiki/doku.php?id=capri:faq_e

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[1] More information can be found at https://www.capri-model.org/dokuwiki_help/doku.php

Introduction to CAPRI

1.6   What is CAPRI

ILO 1: *Describe the main components of CAPRI and how they interact*

Please watch the general introduction to CAPRI as preparation and overview of this sections.

- https://www.youtube.com/watch?v=gPjahe3DyxE

The Common Agricultural Policy Regional Impact (CAPRI) model is a global **partial equilibrium** model for the **agricultural sector**, with a focus on the European Union (Britz and Witzke 2014). It has been designed for **ex-ante impact assessment** of agricultural, environmental and trade policies. It has a supply module covering the EU and some auxiliary European countries[2] (regional programming models for about 280 European regions, detailed coverage of agricultural policies), embedded in a market module also covering regions in the rest of the world (global market model representing bilateral trade between 44 trade regions[3]). Thus, it has **global coverage** but ignores potential interactions with non-agricultural sectors.
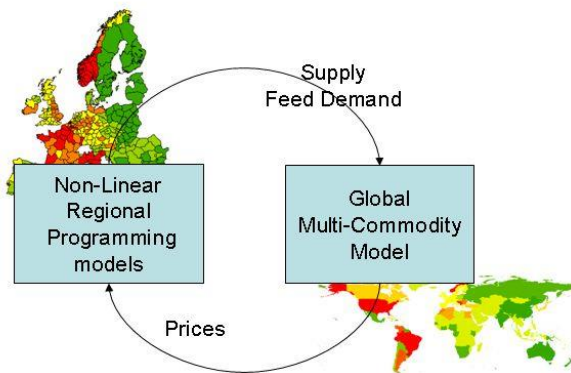
Figure 1: General structure of the CAPRI model

The CAPRI database integrates information from different official data sources (e.g. EUROSTAT, FAOSTAT) in a consistent way across time and spatial scales. Simulation results cover crop areas, herd sizes, production, consumption, trade, income indicators and environmental indicators.

CAPRI is designed for **scenario analysis**. It is a **comparative static** model, which means that it computes changes in market equilibrium at a given point in time because of changes in parameters such as policies or technology. The comparative-static approach is in contrast with dynamic or recursive dynamic models, which compute changes over time. The initial equilibrium is called a **baseline**, and it is computed in the model, based on projections from the Agricultural Outlook published annually by the European Commission's Directorate-General for Agriculture and Rural Development (DG-AGRI) (European Commission 2017). The parameters describing the reactions in the sector are calibrated to the baseline scenario, making the model behave in accordance with the data and projections. The current baseline mirrors the projected agricultural situation up to 2050 under status

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[2]   EU-27 plus Turkey, Norway and the Balkan countries.

[3]   Countries or country aggregates.

quo policy assumptions (CAP 2014-2020). In a simulated scenario, all conditions in the baseline are kept – except for the change to be analysed.

CAPRI contains two modules, market, and supply, which interact (see Figure 1). The **supply module** has one representative farm model for each NUTS2 region[4] of the EU, or similar administrative units in auxiliary countries, amounting to about 280 regions in the model. These models are non-linear programming models which have the same mathematical structure but based on data for the region. Around 55 agricultural inputs produced in about 60 activities are covered in the supply module. The activities include inputs to crop and livestock production from other sectors and intermediate inputs produced by the farms such as feed and young animals. Policy instruments for each region are modelled in detail, especially those in Pillar I. Intensification or extensification in simulations in response to changing conditions are modelled by two technological alternatives (for most activities), representing "high yield, high input" and "low yield, low input", that together represent the average technology.

The supply models optimize regional agricultural income, given the prices for inputs and outputs, subsidy levels and other policy measures. Agricultural supply is constrained by availability of land and reactions to changing land rents, policy, the supply of inputs such as young animals, manure, and fodder as well as feed and plant nutrient requirements for each region. Furthermore, empirically estimated quadratic cost terms affect regional supply decisions in the tradition of the Positive Mathematical Programming (PMP) approach (Jansson and Heckelei 2011). CAPRI has a land supply and transformation functions, allowing for the endogenous supply of arable land and grassland in response to changed marginal land rents. The behavioural functions for land supply were parameterised based on the external information VAN MEIJL et al. (2006), but they were adapted to the regional resolution of CAPRI based on GIS analyses and simulation experiments using the Dyna-CLUE model (VERBURG et al., 2010). CAPRI is built to compute results for NUTS2 regions in Europe, but results can also be downscaled to a finer spatial resolution *homogeneous spatial mapping unit (HSMU)*. The extension is called CAPDIS in CAPRI. The disaggregation of results from NUTS2 region are based on statistical distributions. CAPRI can also be run in *farm type* mode. Here a set of farm types for each NUTS2 region is defined, with its own supply model. Heterogeneity in farming practices can, in this way, be better captured.

The interaction between animal and crop production is established via the feed module, as part of the supply module. It defines how many kg of certain feed categories or single feed stuffs are used per animal, depending on its prices. It thus accounts for the nutrient requirements of animals. Total feed use might be produced regionally (grass, fodder root crops, silage maize, other fodder from arable land) or bought from the market at fixed prices. These prices, however, change with each iteration of the market module.

Market equilibria are calculated by iterations between the supply module and market module. The **market module** simulates supply, demand, and price changes in global markets considering international trade. Agricultural supply is modelled in a simpler way than in the supply module, with behavioural functions. Consumers and traders are represented by economic agents that follow neo-classical micro-economic theory regarding behaviour, which makes it possible to compute welfare effects. About 80 world regions are modelled but aggregated to about 40 trade regions that trade bilaterally with each other, with the possibility of simultaneous import and export. Trade policies such as Preferential Tariff Rates and Tariff Rate Quotas (TRQs) are modelled.

The market module delivers the output prices used in the supply module, allows for market analyses at the global, EU, and national scales, and includes a welfare analysis for the agricultural sector. The supply curve of the market model representing the EU is adjusted to the aggregated supply of the NUTS2 regional programming models during each iteration. This is repeated until an equilibrium is found. The model also includes a market representation for biofuels and biofuel feedstocks (EU, 2013), where ethanol and biodiesel are endogenously

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[4]   See Eurostat web page on for a definition.

determined. Biofuel supply and feedstock demand react to biofuel and feedstock prices and at the same time, biofuel demand and bilateral trade flows react flexibly to biofuel and fossil fuel prices.

Environmental indicators, primarily for nutrient surpluses and greenhouse gas (GHG) emissions, are calculated in CAPRI. Regarding nutrient surpluses, the supply module contains nutrient balance equations for nitrogen, phosphorous and potassium. It considers nutrient uptake by crops following a crop growth function, and supply of nutrients from mineral fertilizer, manure, crop residues, and, for nitrogen, atmospheric deposition, and fixation. The balances also contain factors for over-fertilization, loss rates, and nutrient availability per source. From those balances nutrient surpluses can be calculated per region of the supply model. Technical information from the supply module is used to compute greenhouse gas emissions, based on IPCC methodology[5]. Globally, GHG emissions are computed based on estimated emission intensities per ton of product and production levels for globally traded commodities.

More information about the CAPRI model, including technical documentation, lists of peer-reviewed and other publications, and open access to the modelling system, is available at the model webpage: www.capri-model.org. Also check the literature list in section 1.5.

Exercise 1: General Introduction to CAPRI

   a) What are main CAPRI modules and their functions? Briefly describe how they are connected

   b) In which module are prices computed?

   c) What is the regional scale of CAPRI in the supply module and the market module?

   d) How do the two modules interact?

   e) Which sectors in the economy are covered?

1.7   CAPRI uses the GAMS software

To solve the large-scale, non-linear optimization problems in the model, CAPRI uses a software called GAMS (General Algebraic Modelling System). GAMS is a programming language designed for solving optimization problems, widely used in economic modelling. Models in GAMS are defined by one or several text files (gms files) that contain definitions and solution methods for solving constrained optimization problems (such as the supply models of CAPRI) or systems of equations (such as the market model of CAPRI), as well as commands for data handling and reporting.

Data used or produced by GAMS is generally stored in a file format called GDX (GAMS Data Exchange). CAPRI database and results are stored in gdx files, which can be loaded into the CAPRI Result Viewer in the Graphical User Interface where you can analyse and export the results. Without GAMS, you can view and analyse scenario results from previous scenario runs, but not run new simulations with CAPRI.

GAMS solves models using third-party *solvers* that are linked to GAMS. GAMS comes with a large library of such solvers, most of them specializing types of problems or solution algorithms. CAPRI relies on a particular solver called CONOPT. While CAPRI itself is distributed free of charge for anyone to download and use, GAMS and the solvers such as CONOPT requires a license to work beyond demonstration mode. The tutorial does not however focus on GAMS programming, and it is possible to follow it without any previous experience using GAMS, the course however provides in Block II an introduction to GAMS in CAPRI.

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[5]   Tier 1 or Tier 2 depending on the context.

For those taking this tutorial as part of the CAPRI Training Session 2023, a license is distributed free of charge with star 2.8 and located in the embedded gams version under GUI/gams_exe/34.3/gamslice.txt. This is a student license and only allowed to be used for the course.

1.8   The network

The CAPRI model is developed and used in an open network. No formal consortium exists, but institutions belonging to the network have agreed on a distribution of tasks to maintain and update the system. Researchers from various universities and institutes have over the years contributed to CAPRI, which can be seen from the contributions to many publications.

1.9   Examples of studies with CAPRI

CAPRI has been applied to analyse impacts of a wide range of potential policy changes.

One key application is the ex-ante assessment of the CAP. The impact assessment of the proposals on the post-2020 CAP applies a multi-model approach that includes CAPRI to determine effects on production, prices, trade, GHG emissions and nitrogen balance (European Commission 2018). Furthermore, different policy strategies have been analysed such as direct payment harmonisation (Gocht et al. 2013), CAP greening (Gocht et al. 2017), and an EU-wide policy to extend grassland areas to increase carbon sink capacity (Gocht et al. 2016). The model has also contributed to the assessment of potential impact of agricultural and trade policy reform on land-use across the EU, with a particular focus on land abandonment (Renwick et al. 2012). CAPRI not only support the assessment of Pillar I measures but also Pillar II instruments (Schroeder et al. 2015).

CAPRI enables the assessment of the potential impact of climate change in EU agriculture. In doing so, climate-induced changes in crop yields from biophysical models are introduced in CAPRI as exogenous shifts. This enables to analyse regional changes in production within the EU while considering market feedback, as well as the role of trade to counterbalance uneven effects of climate change across the world (Blanco et al. 2017, Pérez Dominguez and Fellmann, 2018).

About mitigation, recent applications cover the analysis of challenges of including agriculture in climate change mitigation strategies (Fellmann et al. 2018) and the assessment of trade liberalisation impacts on GHG emissions abatement in the agricultural sector (Himics et al. 2018).

CAPRI computes several relevant environmental indicators (e.g., nitrogen balance, ammonia emissions, greenhouse gas emissions, etc.) that makes the model highly suitable for environmental impact assessment of the agricultural sector. The detailed nutrient flow in CAPRI has been exploited to measure nitrogen footprint of food products in the EU (Leip et al. 2014) and to assess the impacts of European livestock production (Leip et al. 2015). In a recent study, Stepanyan et al. (2023) quantitatively analyzed the environmental and economic effects of the possible inclusion of the agricultural sector into a carbon pricing scheme for Germany and for the EU.

CAPRI has also been used in combination with other modelling systems to analyse the effect of dietary changes in the EU (Rieger et al. 2023). Other applications include other topics related to the agricultural sector, such as water-food linkages (Blanco et al. 2018) or bioenergy policies (Blanco et al. 2010, Britz and Delzeit 2013).

A list of publications and contributions based on the CAPRI modelling system can be found here: https://www.capri-model.org/doku.php?id=capri:capri_pub

Setting up the system

ILO 2a: *Set up the system on your machine*

1.10   Install CAPRI Star 2.8

1.10.1   Create a CAPRI folder

To install CAPRI, you first need to decide where to put the files. All files belonging to CAPRI are stored in subdirectories to a main installation directory. We recommend that you put that main directory on a local hard drive, in a path that contains no spaces or special characters and that is not too long. Examples of paths with directory names:

c:\capri

or

d:\models\star_2.8

It is generally not advisable to put the model on e.g., the desktop or in my documents. If the path contains spaces, certain commands inside the model may not function, and furthermore, the path could become so long that when it is used inside the model code, the maximum line length in certain external calls can be exceeded and truncated, with difficult errors as a result. The path shall not exceed 20 characters, excluding the letter of the drive, as example C:\.

In the following, we assume that you will install CAPRI in the folder:

c:\capri\star_2.8 (e.g., 14 characters)

1.10.2   Download the CAPRI release Star 2.8.2

There are various ways to obtain the files needed for the installation. The easiest way to get your version is to download a zipped archive of a Stable Release of CAPRI (simply called a STAR), accessed from the CAPRI wiki page (https://www.capri-model.org/ts/dokuwiki/doku.php?id=start, navigate to "Download Star 2.8.2"). The zip file contains model code and input data.

For this tutorial, and for the Training Session 2023, we will use the CAPRI version STAR 2.8.2 (see Figure 2).

Figure 2: Download CAPRI Star 2.8

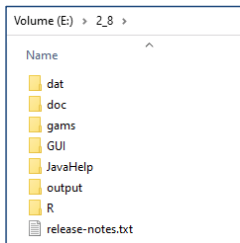Once you have unzipped the Star_2_8.zip file into your CAPRI folder, the folder structure will be as in Figure 6.

Figure 3: Folder structure of CAPRI Star 2.8.1

Some users may have access to the CAPRI SVN[6] repository. In that case, you do not have to download the model but can instead use *check out* the file through https://svn1.agp.uni-bonn.de/svn/capri/tags/star/2.8.1

1.10.3   Get the CAPRI database

The release version of CAPRI comes with all the raw data needed, but without any of the databases that CAPRI needs in simulations. Those databases are built from the raw data using GAMS programs of the model. Building the database can require some troubleshooting and is quite time consuming. To save time and trouble, we provide a zipped archive of compiled CAPRI-databases and selected simulation results, which should be used in this tutorial. The compressed archive containing the results can be downloaded from the CAPRI wiki page (https://www.capri-model.org/ts/dokuwiki/doku.php?id=start, navigate to "Download result data base", see Figure 4). Download the zipped folder results_2.8.zip with results, by choosing *Results from STAR 2.8* and unzip the files into the folder where your results folder is located (e.g. E:\ 2_8\output\results) (replacing the content of the results folder if any).

Figure 4: Downloading results and databases for Star 2.8

Once you have saved the result files into your CAPRI folder, the structure of the output subfolder will be as in Figure 5 (the results folder is organized in 13 subfolders, which contain GDX files).

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[6]   SVN means "Sub Version Numbering" and is a system used for software developers to share common code.
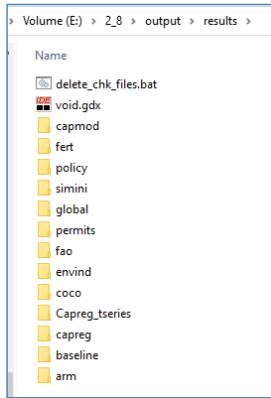
Figure 5: Structure of the output folder for Star 2.8

Structure of CAPRI

This section intends to introduce the general structure of the CAPRI modelling system.

1.11   Physical organization

This section gives a description of the structure of the files used to run the CAPRI model. Obtaining an overview of the folder contents can be a convenient way to understand the CAPRI model. Here, briefly, only the most important files will be described.
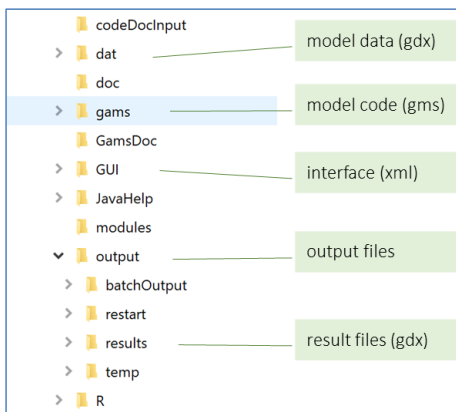

Figure 6: CAPRI file structure

1.11.1   The gams folder
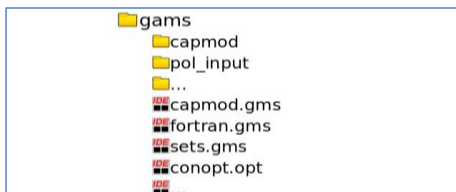
Figure 7: Subfolder structure of CAPRI for gams

The "gams" folder includes the model logic. Among others it contains the capmod subfolder and the pol_input subfolder, which include our scenario file. Other GAMS files are stored in this folder, like main simulation file capmod.gms, the steering file fortran.gms or sets.gms. Sets.gms is central as it contains all the set (i.e. regions and products). Option files are also included, like conopt.opt for particular optimization parameter pass to gams during model solve.

The CAPRI model is built up by numerous files with the file suffix gms containing model code (in GAMS language). These files are usually grouped in different folders according to their functions. You also find other file types that serve supporting purposes for running the GUI or contain data. Some are generated during the model run. The main file types are:

- GMS files (GAMS) containing model code

- GDX files containing data
- XLSX files (MS Excel) with data
- LST files with GAMS program output
- XML files (steering files) defining how the GUI should look and function
- PDF files with model documentation

In your CAPRI directory, you will usually find ten folders (this might change with time due to model development). For the purposes of this tutorial only the gams and GUI folders will be explained in more detail.

The CAPRI system contains many more GAMS programs than the simulation engine (capmod.gms) solving the supply and market modules as introduced in the overview. We call a program of the CAPRI system a *task*, in order not to confuse it with the market or supply *module*. There are several tasks associated with compiling the database from raw data, tasks for estimating parameters such as GHG emission factors, tasks for calibrating the model equations, and tasks for special reporting and testing. The gams folder contains the top-level file with the main program code for each task (file to be executed), whereas code slices that carry out a particular part of the task, sometimes used by several tasks, are stored in sub-directories.

1.11.2   The GUI folder

This folder contains files steering the Graphical User Interface, typically in xml and jar files. In this folder the file start_capri.bat is located, with which you can start the CAPRI graphical user interface. The text files needed to run CAPRI in batch mode (from cmd without the GUI) are also located in this folder. Since Star 2.8 the java runtime version for Windows is stored in the subfolder java and the gams executable in the folder gams_exe\34.3.

The user interface communicates with the GAMS code via gms steering files, generated by the GUI, which are placed in the gams folder every time you execute a task in the GUI.

1.11.3   The Data Folder

All the input data used in CAPRI is stored in a subfolder called *dat*. This data are raw data and does not change in any simulation or preparation task (i.e., FAOSTAT, EUROSTAT data). The GUI folder contains files that define the look of the Graphical User Interface, such as the capri_gui_definition_xml (more below).

1.11.4   The Output and Result Folder

Another folder is the output folder, whereby default all results are stored, together with results of the previous data generation step, like harmonized calibrated database and temporary files. The is also a restart folder, which mainly stores solution of models for later use to initialize the model at already optimal points. This can reduce the solution time for the optimization problems.

Exercise 2: file structure in CAPRI

a) sets.gms contains the definitions of many set elements in CAPRI. It is a good place to look if you wonder what some abbreviation means.

b) Open "sets.gms" and find out what the set element "GVAP" means. _____

c) Find at least three sets where this element is a member. _____ _____ _____

1.12   How Does the Graphical User Interface interact with GAMS?

After starting the batch file start_capri.bat, the Graphical User Interface (GUI) is displayed. This GUI is not CAPRI itself but a generic graphical user interface. This GUI reads steering files, which define the view of the interface and its functions. As example, these files include which buttons and drop-down menus are available in the GUI, which programs will be executed when hitting a button, where the reports will be stored and how the results are organized in pre-defined views. All the settings how the GUI should look like are defined and stored in the file

- capri_gui_definition.xml

The file is read by the JAVA program GGIG.JAR for setup the GUI. Once you have started the GUI, you can choose many options. If you want to run a scenario, first you would select all the options of interest: base year, simulation year, country, policy file, etc. When you hit the run button "Start GAMS", the GUI (the java program) writes a GAMS text file containing all the options that you have selected in the GUI. When the run is executing, you can see all the steps (execution log) in the GAMS output windows in the lower part of the GUI and you will be able to follow all the steps that are being processed during the simulation.
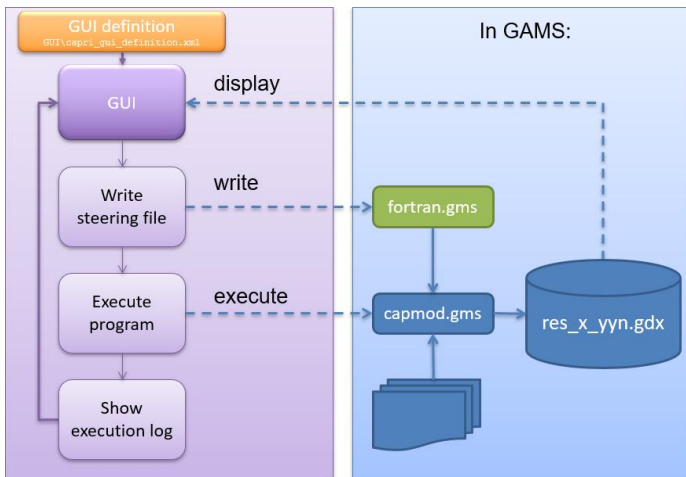

Figure 8: How the GUI interacts with GAMS and the CAPRI gams files (capmod.gms)

When GAMS is done, the results are stored in GDX files. Now the GUI comes back to its original display and through the exploit results option you are able to visualize the scenario results you have just produced.
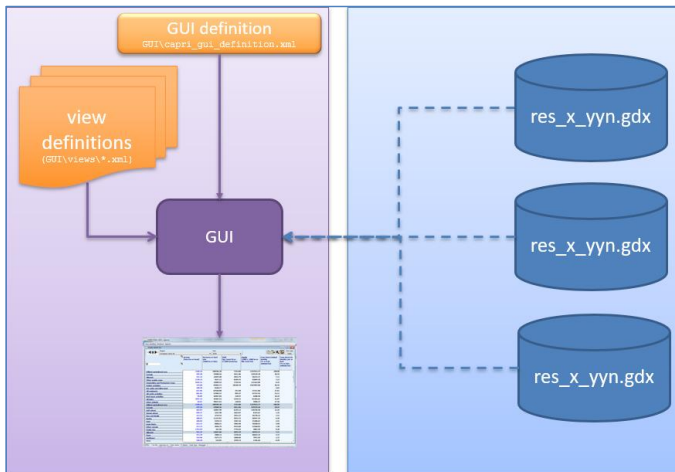
Figure 9: Viewing results from GAMS in the GUI

Exercise 3: Check what GUI does when running a scenario:

- Open capri_gui_definition.xml
- Search for "<name>Run scenario without market"
- Also check the value of "<gamsFile>" _____
- Also check the value of "<incfile>" _____
- Also check the value of "<resdir>" _____
- Look a few lines below at "<gdxSymbol>" _____

1.13   Logical organization

Capmod.gms is a central simulations file. It is important therefore to understand its program flow. Figure 10 shows all the steps, which are described below.
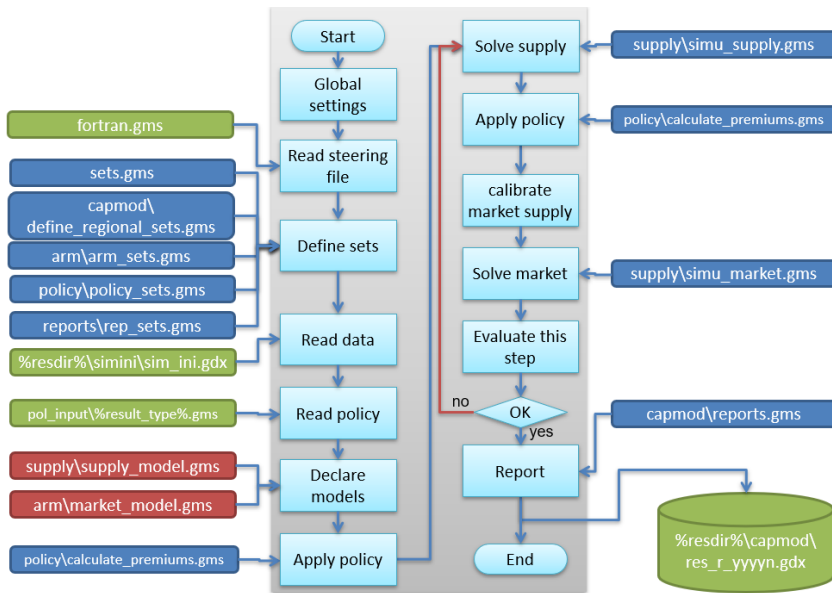
Figure 10: Program flow of capmod.gms

- Capmod reads the file with global settings – Instruction for the GAMS compiler that do not depend on any particular simulation.

- The setting of the current simulation enters by the inclusion of "fortran.gms" written by the GUI based on what the user selected in the interface (Simulation year, Country, …).

- Many files that define the sets are read (regions, products, …). The "sets.gms" is also included here and is the most important file, if you want to understand the set structure, used by GAMS.

- The data required for the simulation are loaded (normally from the "sim_ini.gdx" file).

- The scenario definition is loaded – normally from the pol_input folder.

- After loading the scenario, the economic models are defined: "supply_model.gms" and "market_model.gms" contain all the equations of both modules.

- Before the model can be solved, there is a step to process the policy to use.

- Then a loop starts, iteratively solving supply and market models.

- The supply model is solved in the "simu_supply.gms file". Remember, in the first iteration the supply is solved with fixed prices, which are than updated in the further iterations by the prices produced in the market module.

- After solving the supply module, a re-computation of the policy is required according to the outcomes of the supply module (calculate_premiums.gms).

- The simplified supply functions inside the market module for the EU regions are calibrated to the latest outcome of the supply module.

- The simplified supply function is solved together with the trade and demand functions. This is done in the file "simu_market.gms".

- The whole supply-demand system is evaluated to check if the equilibrium was found. Indicated as "Evaluate this step"
- If the equilibrium has not been reached, the model loops back and solves the supply module again with prices updated by the market model.
- If the equilibrium has been reached, the model writes out report based on the solution. The results are stored in a file called "res_r_yyyyn.gdx". (r = regional resolution= 2 for NUTS2; yyyy = base year + simulation year; n = name of the scenario)

Exercise 4: Understanding the Logic of the capmod.gms file (main simulation gams file)

a) Find the places where the iteration loop starts and ends in capmod.gms: Start line nr: _____, End line nr: _____

b) In which line is simu_supply called? Answer: _____

c) In which line is simu_market called? Answer: _____

Supported Link: https://www.youtube.com/watch?v=0xqhgJkIR28
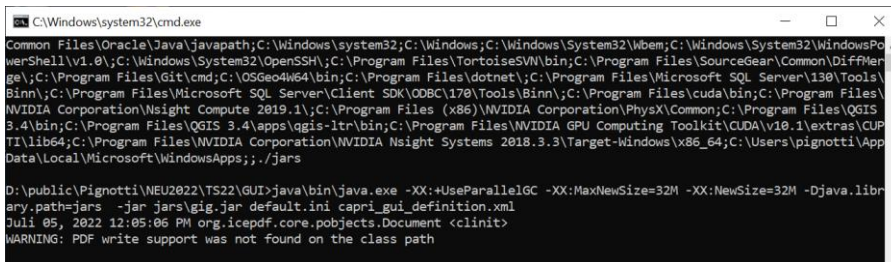
Using CAPRI with the GUI

ILO 2b: *Start the Graphical User Interface (GUI)*

This section gives a basic overview of the Graphical User Interface (GUI). To get more in depth into the use of the GUI, we recommend reading Britz (2014), available on the CAPRI webpage (see section 1.5 Literature) and on the doc folder of the model.

1.14   Start the GUI

Once you have installed CAPRI on your computer (Section 3 "Setting up the system"), the next step is to open CAPRI using the Graphical User Interface (GUI). The GUI is used to run the CAPRI model and define the settings of the model run, with its different tasks. In the GUI, you can also view the results from simulations and databases. In this tutorial, the focus is on running scenarios and exploit results.

You open the GUI by double-clicking the start_capri.bat file, which is in your GUI subfolder (e.g., C:\CAPRI\star_2.8\GUI). You can also make a shortcut to start_capri.bat file and for example place it on your desktop.

Figure 11: The JAVA script for the GUI is starting

A popup window will be displayed as in Figure 11: The JAVA script for the GUI is starting, which indicates the background processes running in CAPRI. When the process is done, the GUI will open (Figure 12: CAPRI Graphical User Interface (GUI)).
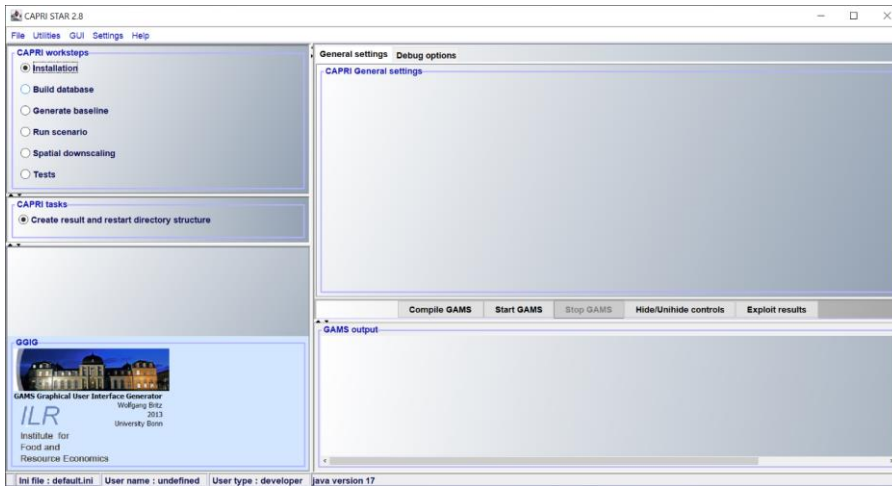
Figure 12: CAPRI Graphical User Interface (GUI)

From the GUI menu you can execute different tasks in CAPRI (build database, generate baseline or run scenario), and view your results. In the tutorial, the focus is on running scenarios and exploiting results. We begin by defining settings and finalizing the installation of CAPRI.

1.15   Change settings

Begin by defining your settings. This is done in the *Settings >>Edit Settings* part in the upper left corner of the GUI menu (Figure 13). **Remember to save your settings when you have finished!**

Figure 13: Open the edit settings window

There are three important steps in defining the settings: *User settings*, *CAPRI System Settings* and *GAMS and R*. Two additional steps allow to select more options.
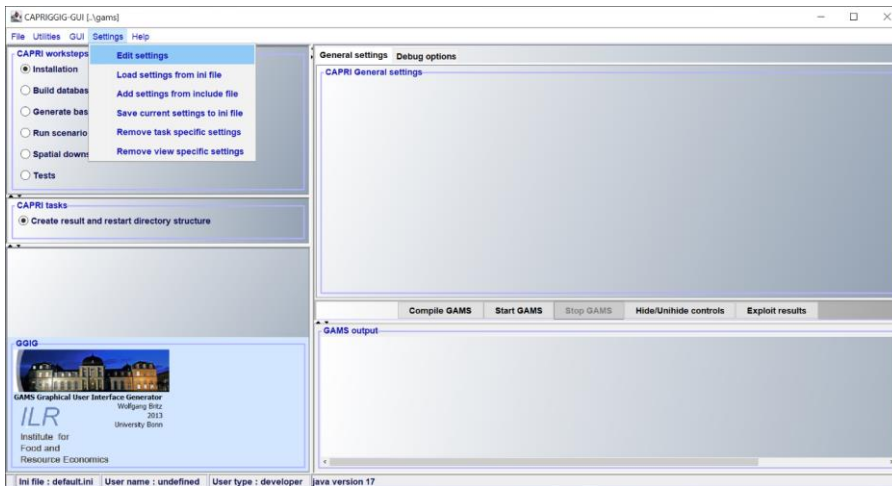
1.15.1   Step 1, User settings

In the tab *User Settings* (Figure 14), fill in your name and select the user type:

User name: Your name

User type: "Developer"

The name you enter will be stored with the result files generated by the model. The type of user determines which choices you can make in the CAPRI work steps and tasks, and for the training session, "Developer" is used.

Figure 14: Change User Settings

1.15.2   Step 2, CAPRI system settings

In the tab *CAPRI System Settings* (Figure 15), you choose where to store results and data, as well as where the GAMS program files are located. There are default settings for where your results are stored, in a subdirectory to your CAPRI directory. Therefore, **you do not have to change these settings**. If you would rather store your result files in another directory, you can write the path here. The paths are interpreted in relation to the GUI folder, so that e.g. "..\gams" means "up one level, then the folder gams". Therefore, you usually do not need to modify all the paths, as they will work with the default settings.

Model files directory: "..\gams". This defines where your GAMS modelling files are located.

Results directory: "..\output\results". Here you may choose the directory where you want the results to be stored. The default path works well, but you may create another folder and choose the corresponding path if needed. The same applies for

Restart directory: "..\output\restart". You can also use another directory, as with results. We will not go into the use of this folder in this tutorial.

Data files directory: "..\dat". This corresponds to the directory with data files in you CAPRI folder, set by default.
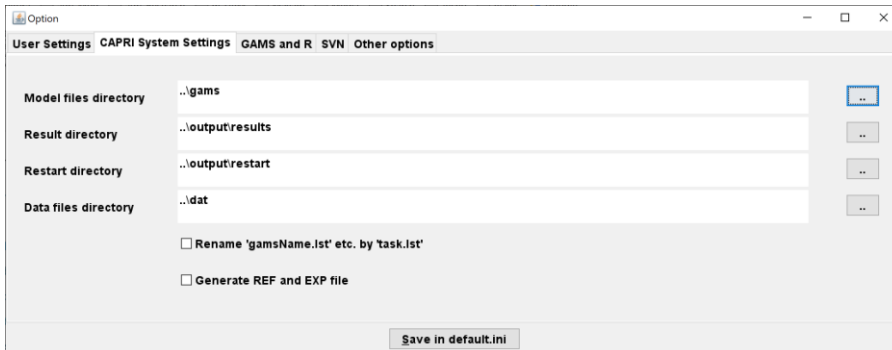
Figure 15: CAPRI System Settings

1.15.3 Step 3, GAMS and R

In the tab *GAMS and R* (Figure 16), you define the path for the GAMS program. There are occasions when you may want to use R, however, in this tutorial it is not necessary.
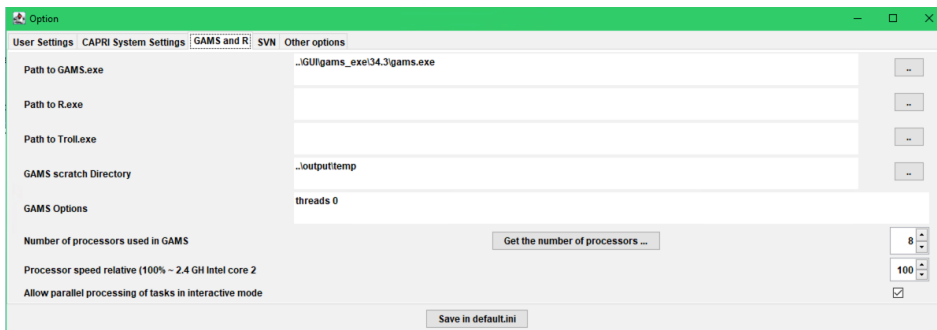

Figure 16: Change the GAMS path in Settings

Path to GAMS.exe: you should insert the path to where you have installed your GAMS program. For example: ..\GUI\gams_exe\34.3\gams.exe

GAMS Scratch directory: "..\output\temp". This determines where GAMS stores temporary files. Keep this default setting.

Numbers of processors used in GAMS: you can click *Get the number of processors* and the number of processors (logical cores) in your machine will be automatically determined. You cannot use more processors than this but might want to decrease the number if you are working with other programs or documents on your computer. Using all available processors will typically slow down your computer.

1.15.4 Step 4 and 5, SVN and Other Options

SVN settings are only needed if you are connected to the SVN repository for CAPRI. See Britz and Witzke (2014) for a more detailed description of the CAPRI use of SVN.

In the tab *Other options* (Figure 17):

Title for Interface: "TS 20XX". This denote the project you are working with. This is useful if you are working with different versions of CAPRI for different projects and want to remember which project you have opened. The title will be shown in the top list of the GUI.
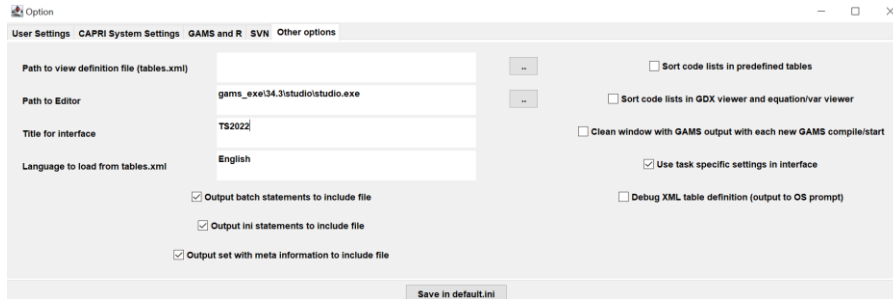

Figure 17: Change Title for Interface

REMEMBER TO SAVE YOUR SETTINGS!

By clicking *Save in caprinew.ini* (or *Save in capri.ini* depending on your computer) save the settings in the GUI directory with the default name.

Exercise 5: GUI Settings

Take a screenshot of the *Edit settings* window, showing that you have saved your user name and user type.

1.16   Tasks in the GUI

In the GUI, there are five different *Work steps* (*Installation*, *Build database*, *Generate baseline*, *Run Scenario* and *Tests*), each with specific *Tasks*. In this tutorial, we will only focus on the *Run Scenarios* step, while the other are described briefly below. Note that the work steps you will see in the GUI depends on your chosen user type. Also, if you have not run *Installation*, and you start using CAPRI from scratch, you will only see this work step.

1.16.1   Installation

The first work step to go through in order to use CAPRI the first time is *Installation.* You can only choose the task *Create result and restart directory structure* (see Figure 18). The task generates the folder structure for your results. Restart is generated for system testing purposes and is not of interest for this tutorial.

The *Installation* task is not needed if you already have result files in your CAPRI folder. Since for this tutorial we use the results from Star 2.8 (see section 3.3), **you do not have to run Installation**.
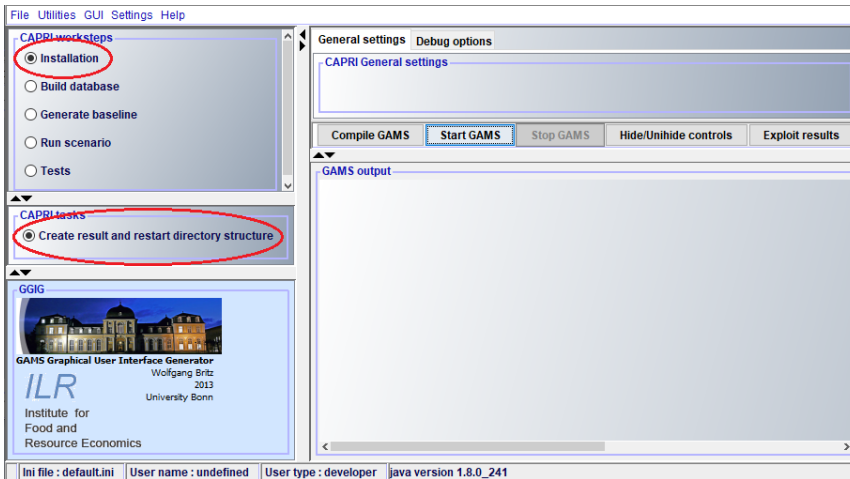
Figure 18: Task Installation

Anyway, we detail here the steps to follow when you want to run CAPRI from scratch. First select the task *Create result and restart directory structure* and click *Compile GAMS*. The normal case is that you get the message "Normal Completion" in the output window, and you can then click *Start GAMS*, and wait for a "Normal Completion" again (see Figure 19). Now the installation is finished. If you cannot see the other work steps, close the GUI and restart it.

If you get an error message, check again that you have the correct JAVA and GAMS version. If still not working, try to download CAPRI again and redo the installation process, and if this fails send the tutorial team an e-mail.
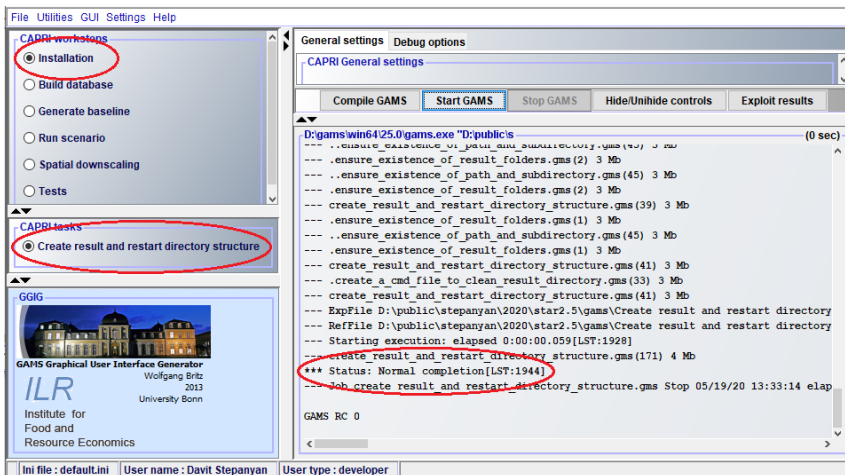

Figure 19: Normal completion of task InstallationBuild database

This work step generates the CAPRI database. This contains data on e.g., agricultural land use, production quantities and prices. The data have different origins such as FAOSTAT and EUROSTAT, but the *build database*

work step harmonizes the data to be a complete and consistent dataset. **You do not need to perform this work step**; you will instead use the database files provided on the homepage, which you have downloaded in section 3.3.3.

1.16.2   Generate baseline

In the *generate baseline* work step, a baseline projection for the chosen simulation year is generated based on a mix of trends, expert knowledge and automated checks that assures logical consistency. The baseline is updated continuously and serves as the point of reference in our ex-ante analysis. In this work step the parameters that determine the behaviour of the model are calibrated. You will not need to perform this work step; the baseline files are included in the CAPRI database for Star 2.8 already downloaded in section 3.3.3.

1.16.3   Run Scenario

In this work step the scenarios are simulated. This step, which is the focus of this tutorial, will be described in section 0.

1.16.4   Tests

In this work step the results of the CAPRI model can be tested with regards to for example stability when using different computers. This is used by developers in a process of improving and identifying development needs of the model.

Exercise 6: Define a reference scenario, running the supply model

1. Make a copy of "gams\pol_input\cap_after_2014\ref " and call it "my_supply_simulation.gms".

2. Start the GUI. Go to the workstep "Run scenario", task "Run scenario without market model". Verify that you find your new scenario in the dropdown.

3. Select only one country (any), base year 2012, simulation year 2030, run!

4. Verify that a new fortran.gms was written in the gams folder.

    1. Find your scenario name in that file!

    2. Find "$setglobal countries" and check that your country appears there

5. Look at the output\results\capmod folder to find the gdx file.

Running your first simulation

In case you are not familiar CAP and subsidies please read to following papers:

- Jansson, T., Nordin, I., Wilhelmsson, F., Witzke, P., Manevska-Tasevska, G., Weiss, F., Gocht, A., 2021. Coupled Agricultural Subsidies in the EU Undermine Climate Efforts. Applied Economic Perspectives and Policy 43, 1503–1519. https://doi.org/10.1002/aepp.13092

- https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/additional-optional-schemes/voluntary-coupled-support_en#vcsexplained

1.17   Define the simulation scenarios

To do a simulation in CAPRI, select the work step *Run scenario*, and select the fitting CAPRI task. The first task under *Run scenario* is *Define scenario*. In this task we define the simulation scenario to run, by specifying their specific data/conditions in a gms file. Scenario files are located in folder *gams\pol_input*. Instead of defining new scenarios, in this tutorial we will use existing ones. More concretely we will use policy scenarios related to the current Common Agricultural Policy (CAP 2014-2020), which are in folder *gams\pol_input\cap_after_2014*. Two scenarios will be selected:

Reference scenario: scenario where the CAP framework prevailing in 2014 is implemented (file ref.gms). This is the reference scenario, or CAPRI baseline.

NoVCS scenario: scenario where the CAP 2014-2020 is implemented, but a change is introduced (file without_voluntary_coupled_support.gms). In this scenario, the voluntary coupled support to specific production activities that is implemented under the current CAP is removed. Instead, the budget spent on this is added to the basic payment scheme that is spread over all eligible hectares of agricultural land.

Remember that to evaluate a simulation scenario you need a reference, or benchmark scenario, to which changes are computed. Typically, the reference scenario will simulate continuation of the current (baseline) policy framework. In this exercise, we will compare a policy change (no voluntary coupled support) against the current CAP implementation (reference scenario).

To avoid overwriting scenario results, we will work in a new folder where we will locate all scenarios used in this tutorial. For this, you need to create a new folder, called *ts*, in *gams\pol_input* (Figure 20).
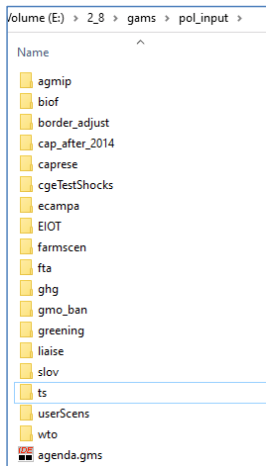
Figure 20: Create new folder in gams\pol_input to store the scenario files

Then, you copy the two scenario files from *gams\pol_input\cap_after_2014* into *gams\pol_input\ts* (Figure 21).

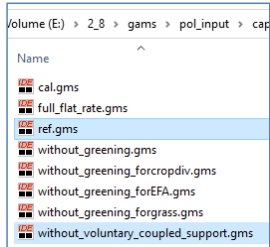**Figure 21: Copy selected scenario file into folder gams\pol_input\ts**

Finally, you rename scenario without_voluntary_coupled_support.gms into pol_novcs.gms (same scenario with a shorter name). Now you will have a new folder *gams\pol_input\ts* where the two selected scenarios are located (Figure 22).
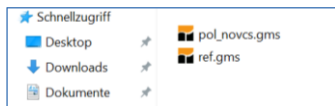

Figure 22: Rename the policy scenario file to pol_novcs

Once the scenarios have been defined, you have several options to run them:

- Run scenario **with** market model: both the supply and market modules are run, in an iterative way. The model accounts for market effects and provides results at the regional level for the EU.

- Run scenario **without** market model: only the supply module is run. The model provides detailed results at the regional level, but market effects are not considered.

- Run scenario **with only** market model: only the market module is run. The model accounts for market effects but does not provide regional results.

For the tutorial, you will run scenarios with the task *Run scenario **with** market model*. Please note that **for running a CAPRI scenario you need a valid GAMS licence**.

We will run both scenarios, but first we need to define the program settings to use.

1.18   Choose scenario settings

There are numerous settings to be done for your simulation, of which the default options often work well. To run a simulation scenario, you can keep most of the default settings, but you need to make some choices in *General settings*, as shown in Figure 23.

Select task *Run scenario>> Run scenario **with** market model*

First you need to select the desired scenario. For this, in tab *Scenario description* (in the upper right of the panel *General settings*), you choose the scenario from the drop-down list. Let us select the Reference scenario:

Dir: ts. *Dir* refers to all folders that might include scenario files, in the directory gams\pol_input.

Files: ref. (Alternatively "ts\ref" is shown if you did *not* choose a file in *Dir*). In the drop-down list you can choose a file in the chosen directory.

Then you need to choose other general settings:

Base year: 2012. This refers to the year for which the three-year average data to compute databases and trends are taken.

Simulation years: 2030. This defines which year to simulate.

EU regional composition: BREXIT. This is the option to use with this tutorial.

Countries: All. All countries are chosen by default.

Regional breakdown: NUTS2. This will generate results for NUTS2 regions and larger aggregates. Other options are the countries and farm type level.

For *Generate GAMS child processes on different threads, Generate CMD per Thread, GHG abatement technology* and *Non-default reference scenario for carbon accounting,* keep the default settings.
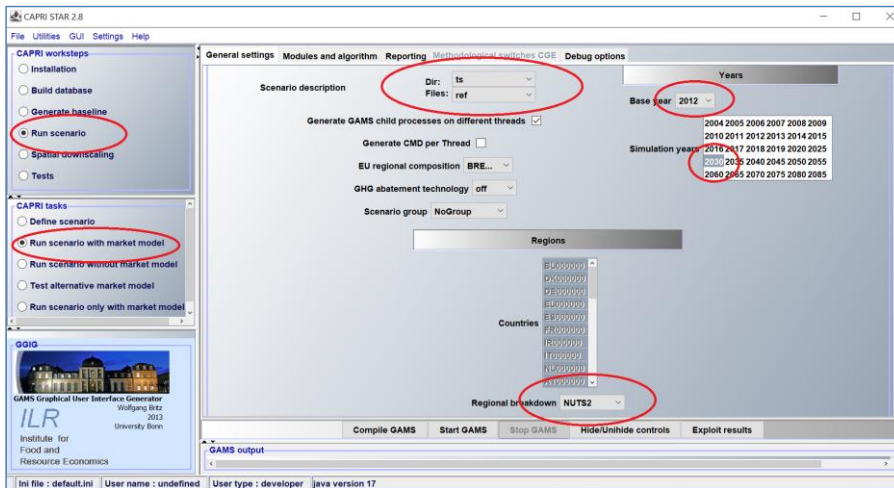
Figure 23: Select general settings to run the Reference scenario

In the reporting panel, uncheck *Life-cycle assessment for energy* and *multi-functionality indicators* (Figure 24).
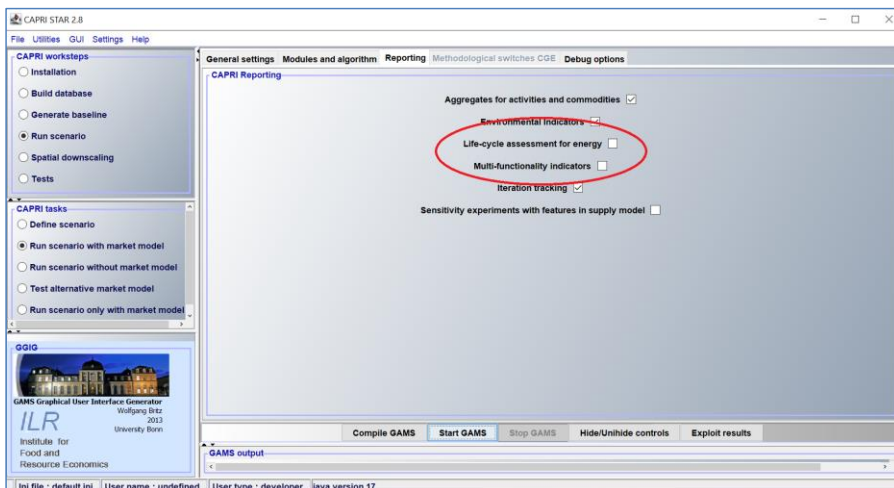

Figure 24: Select reporting settings to run the Reference scenario

As you can see, there are some more panels (*Modules and algorithm, Methodological switches CGE* and *Debug options*). These have default settings and you do not need to change these.

Apart from the scenario file, **keep the same settings for running both the Reference scenario and the Policy scenario!**

1.19   Run a policy scenario

ILO 3a: *Run a simulation with a provided policy file*

ILO 3b: *Verify that the simulation was completed successfully*

1.19.1   Reference scenario

Before you run the first simulation in GAMS, you should close other programs using GAMS[7].

Select task *Run scenario>> Run scenario **with** market model*

To run your scenario, first check that it works in *compilation mode* by clicking *Compile GAMS* (see Figure 25). This tests that there are no invalid statements in the code. Normally, and for this tutorial, **everything should work fine**, which is indicated by the message "Status: Normal Completion" and "GAMS RC 0" shown in the *output window* (see Figure 25).
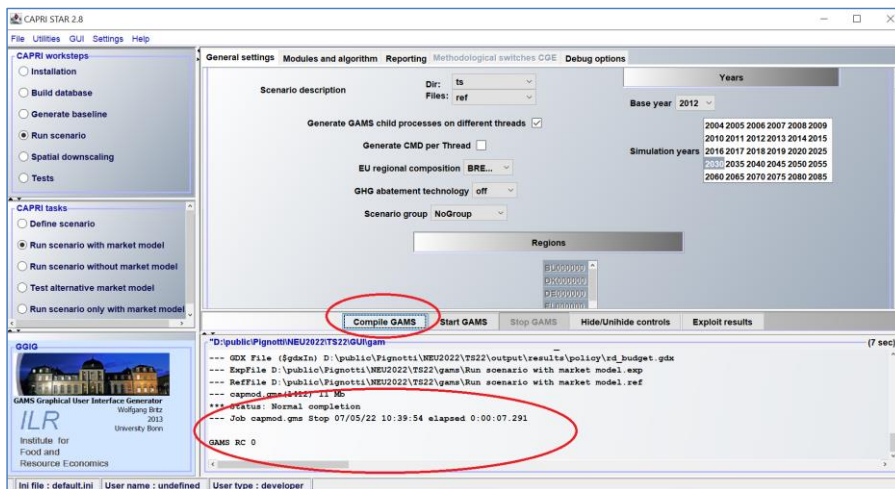

Figure 25: Compiling GAMS program, Status: Normal Completion

If something went wrong, the message will instead be "Status: Compilation Error" (see Figure 26). In the output window, the type of error will be specified, but can be difficult to understand if you are not familiar with GAMS. However, errors should not occur if you have not changed anything in the scenario file. Otherwise in case of an error, check that you filled in all the settings in section Start the GUI and section Choose scenario settings and, if you still encounter problems, contact the organizing team.

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[7]   It is certainly possible to run several instances of GAMS simultaneously, but then you must make sure that they use different directories to store temporary files. Such settings are beyond the scope of this tutorial.
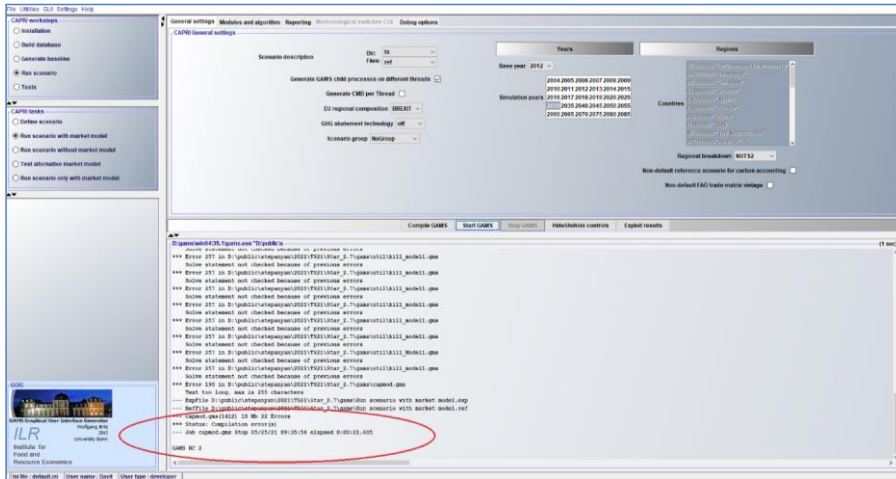
Figure 26: Compiling GAMS program, Status: Compilation Error

When everything works, click *Start GAMS.* This starts the execution of the program, while in the compilation the program code was only tested. Note that the simulation can take some time, up to 30 minutes, depending on your computer configuration and performance. This gives you time to get a coffee and get ready for the next steps ☺. If the simulation completes successfully, you will get the message "Status: Normal Completion" (Figure 27). Otherwise, there will be error message, i.e., "Status: Execution error". This can be due to missing data, if for example there was a problem when you downloaded the results. If you cannot fix this, contact the organizing team.
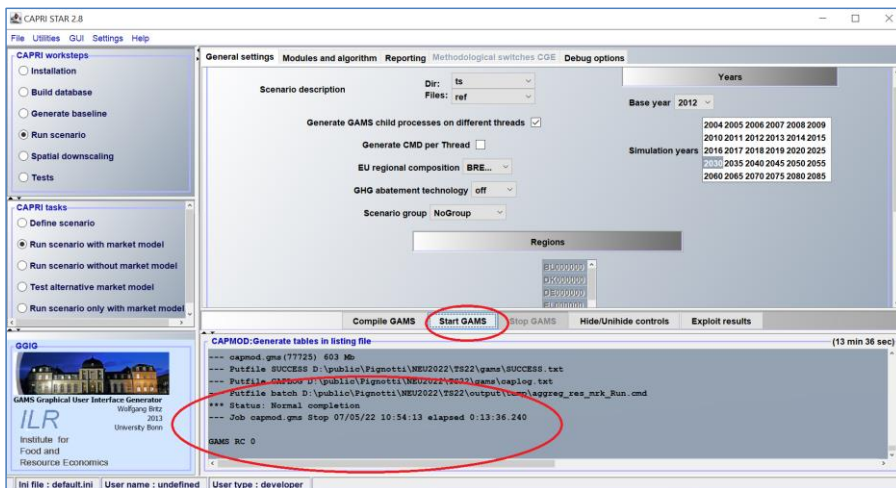
Figure 27: Running GAMS program, Status: Normal Completion

1.19.2   Policy reform scenario

Once you have run the Reference scenario successfully, run the Policy reform scenario. This is done in the same way; you only must change the scenario file.

Run Scenario>>Run Scenario **with** *market model:*

Dir: "ts"

Files: "pol_novcs"

Once you have selected the scenario pol_novcs, click *Start GAMS.* After completion of this task, you should get the message "Status: Normal Completion" (Figure 28).
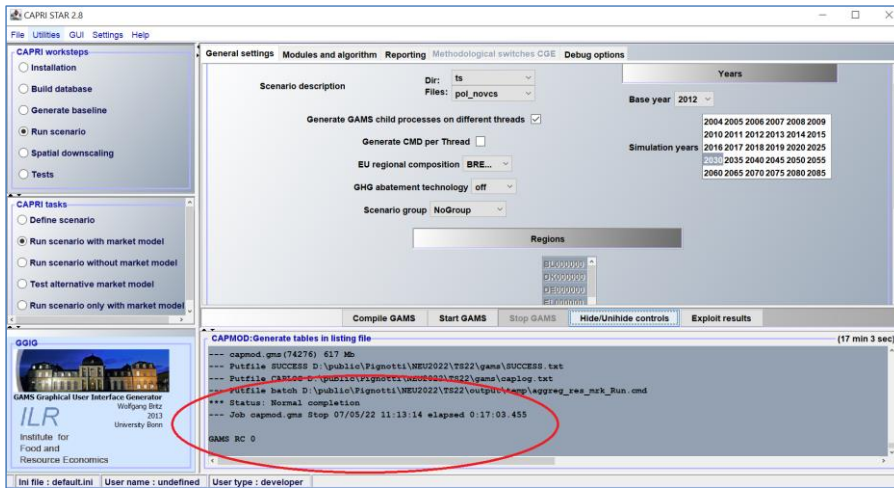

Figure 28: Running the Policy scenario

Exercise 7: Verify that the simulation runs

Verify that the simulation runs terminated successfully by attaching a screenshot of "Normal completion" status.

1.19.3   Run scenarios without the market model

You will run a scenario with the task *Run scenario* **without** *market model*. Here *only* the supply module will be used, which makes the simulation faster. Also, we can run simulations for a particular country. However, in this case, market effects are not considered (exogenous prices). In this exercise, we will run simulations only for Sweden.

Select *Run Scenario>>Run Scenario* **without** *market model:*

Some scenario settings need to be changed. In tab *General Settings*, choose Sweden from the list of Countries (Figure 29):

Dir: "ts"

Files: "ref"

Countries: Sweden
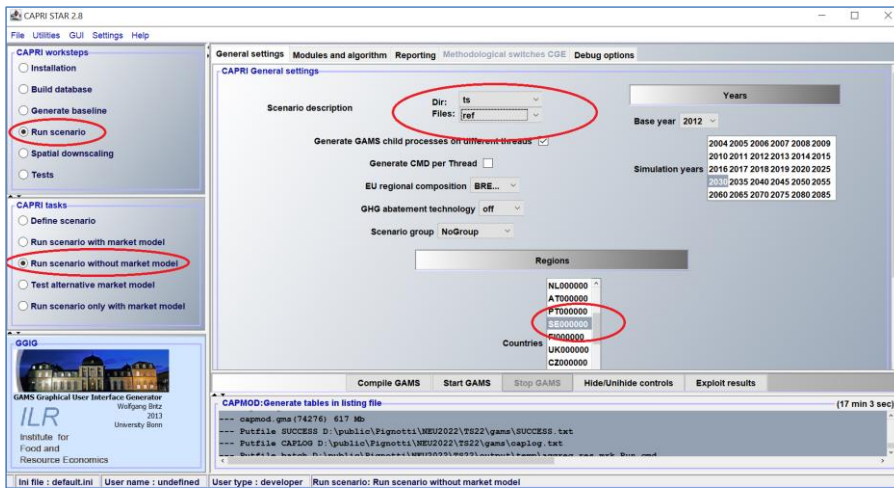
Regional breakdown: NUTS2

Figure 29: General settings for running the scenario for a single country

In tab *Debug options,* you need to put an additional result type identifier. Type: "_SE" (see Figure 30). A result file will be generated in your results directory (e.g., C:\CAPRI\star_2.8\output\results\capmod) with the name of the scenario followed by "_SE" (indicating your choice of Sweden). Adding this result identifier means you can save the results from this run without overwriting the existing result files in the folder (scenario run with market model). **This is important not to overwrite the original result file, which we will analyse in section 6.**

Once you have edited the settings, click *Start GAMS.* After completion of this task, you should get the message "Status: Normal Completion".

Follow the same steps to run the Policy reform scenario, pol_novcs. Apart from the scenario file, **keep the same settings for running both the Reference scenario and the Policy scenario!**
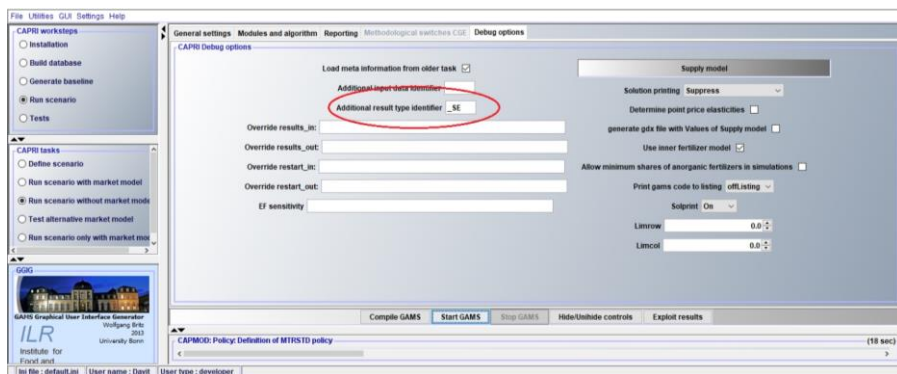
Figure 30: Debug options for running the scenario for a single country

Exercise 8: Verify that the simulation runs without the market model

Verify that the simulation runs without the market model terminated successfully by attaching a screenshot of "Normal completion" status.

Analyzing CAPRI results

To analyse model results, we will use the first scenarios you have run, meaning the simulations that include all countries. That is, we will look at the scenarios "ref" and "pol_novcs", obtained with task *Run scenario with market model* and, therefore, including all countries and market feedbacks from the CAPRI market module.

1.20   Load results

ILO 4a: *Load results into the viewer*

All the results from the different tasks in CAPRI can be viewed in the GUI. This is done by clicking the Exploit Results button in the General settings panel for each task.

For analysing results, go to:

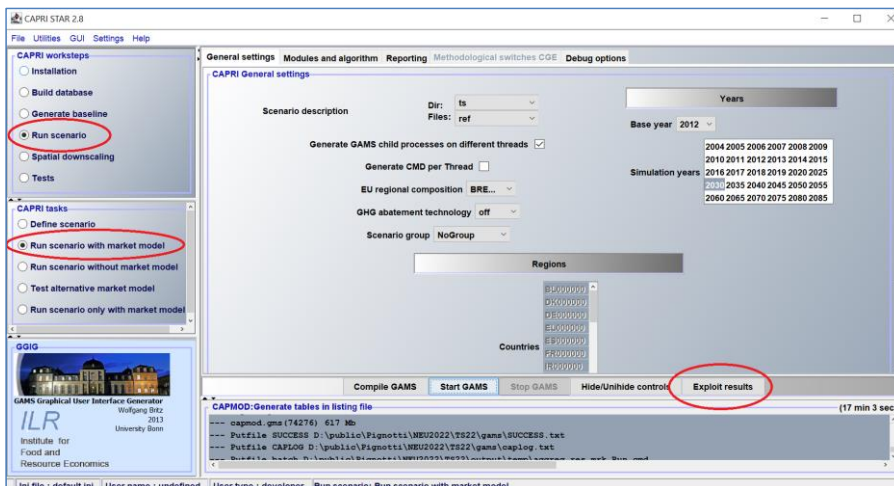*Run scenario>> Run scenario **with** market model>>Exploit results*

Figure 31: Exploit model results

By clicking *"Exploit results"* (Figure 31), another window will open where you can choose the results files you want to analyse (Figure 32). Choose:

Country selection: "All" (default).

Regional level: "2".

Base year: "2012".

Simulation year: "2030".

In the lists for Scenario 1 and Scenario 2, you can choose the corresponding simulation results files from the drop-down lists. These represent result files in the directory output\results\capmod. You can choose as many as you wish, but the Viewer may slow or stop if you choose too many. In the field to the right, you can now name your scenario, which is usually a good idea.

For *Scenario 1*: "ts\ref". Name this: "Reference"

For *Scenario 2*: "ts\pol_nvcs". Name this: "Policy"

Now the scenarios to analyse are chosen. To compare the results, click "*Show Results*" at the bottom of the page (Figure 32). It may take some time to load your results before the result viewer is opened. Sometimes the files are not loaded. It might be enough to press "*Show results*" again. It might also be necessary to restart the GUI. In this case, you do not need to re-run your simulation, only try to reload your results.
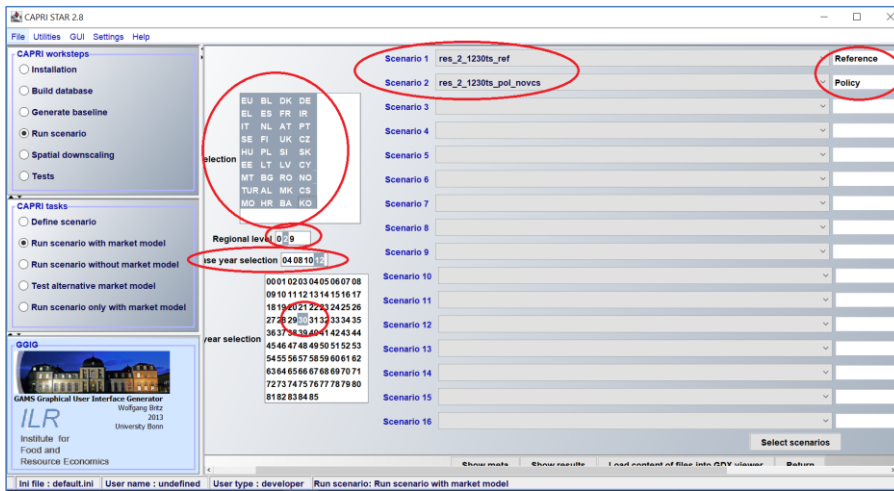

Figure 32: Chose result files to view

1.21   Navigate the Result viewer – choose data to view

ILO 4b: *Find selected tables in the result viewer*

Now you are in the Result viewer, as shown in Figure 33. In the result viewer one or several data view windows can be seen. If no data view windows are visible, click *View handling>> New data view*. You can have several windows open to look at different data. By clicking Windows in the list, you can choose which data view window to view among your open ones.

Figure 33: Options in the Result viewer

In the result viewer you can choose which kind of data to view and which of the loaded scenarios to compare. Figure 34 indicates the symbols for the functions available for the data manipulation, such as the "Eye symbol" to open data views, copy, export, customize as well as pivot and view type. Explanations are given in Figure 34.

	Eye symbol	Open menu of available views.
	Copy	Copy the values shown.
	Export	Export results to a file.
	Customize	Choose which data to view, how to view it, etc.
	Pivot	Choose which dimension to place where.
	Selection dialog	Choose a subset of elements to show.
View type / Table	View type	Choose if the data should be shown as a table, a graph, or something else.

Figure 34: Symbols in the Result viewer

In the results from a simulation there will be data to view for numerous indicators. We will go through the most used. To choose which data to view, click the eye symbol. Here you can choose which data theme to view, and subthemes to these. The data dimensions and elements for each dimension will differ depending on the theme you view.

To go back to the work steps, choose:

1.21.1   Supply details

To start looking at results, open the menu of available views clicking at the eye symbol. Then choose *Farm>> Supply details.* This shows a table with the results for crop areas and production volumes, among other things, i.e., a table like Figure 35.

Figure 35: Chose table to view

Depending on what table you view, the elements in the rows and columns in the window might differ. In CAPRI we can show data with many dimensions. In this case, we have one data point for each *Scenario*, *Data item* (e.g. "Hectares or head"), *Region*, *Year*, and *Agricultural activity*. Some of them will be shown in the rows and columns of the table, and some in drop-down lists at the top of the window. The data dimensions shown differ depending on the theme, and e.g., *Regions* might not always cover the same set of regions in different tables; when relevant the NUTS2 regions are shown (typically for results from the supply module), while some views show all world regions, but not NUTS2 (typically for results from the market module).

An example is shown in Figure 36. Try also to find this yourself. The dimensions in the columns and rows might differ from our picture. Choose these alternatives in the drop-down lists:

Regions: "Germany"

Year: "2030"

You can see that the area of soft wheat in Germany is projected to be 3 368 800 hectares in 2030 in the Reference scenario.

Figure 36: Example of table view

Exercise 9: Analyze results

Find:

a) Number of hectares of cereals in Sweden in 2030 for the Reference scenario.

b) Farm income (Euro/head) from all cattle activities in Ireland in 2030 for the Reference scenario.

c) Number of hectares of wine production in France in 2030 for the Reference scenario.

d) To find other themes, click the eye symbol and go through the menu.

Exercise 10: Find the table Product balances, detailed

Write the path (in the context menu) to where you find the table *Product balances, detailed.*

1.21.2 Markets

The theme *Markets* shows data on production, consumption and trade among other things. Go to *Markets>>Product Balances, market model*. Here you can see that other data items are shown, such as Net production and Human consumption plus losses. If you compare the regions, you can find world regions such as "Brazil" in this table, but not NUTS2 regions such as "Sydsverige" as in the previous table. Further, agricultural activities cannot be found, but instead products, so for example "Beef" but not "Other Cows".

Exercise 11: Find quantity of human consumption

Find the quantity of *human consumption plus losses* of rice in China in 2030 for the Reference scenario.

1.21.3 Prices

Go to *Prices>> Prices market model.* This shows prices in the market-model regions for agricultural products. The dimensions are similar to those in the *Product balances market model.*

Exercise 12: Find values in the GUI

    a) The *producer price* of rapeseed in USA in 2030 for the Reference scenario.

    b) The *producer price* of rapeseed in the aggregate for all regions in North America in 2030 for the Reference scenario.

    c) The *producer price* of the aggregate for all oilseeds in USA in 2030 for the Reference scenario.

Go to *Prices>> Prices.* Again, prices are shown, but differ from the previous theme in some aspects. Here prices for regions in the supply module are shown. This means prices for the regions outside are not shown, only prices for the NUTS2 regions are shown. Both prices for products and shadow prices for inputs such as fodder are shown.

Exercise 13: Producer price of fodder maize

Find the Producer price of fodder maize in Mellersta Norrland (a Swedish NUTS2 region) and Sweden in 2030 for the Reference scenario.

1.21.4   Environment

The *Environment* theme includes results for various environmental indicators

Go to *Environment>>Environmental indicators*. Here, total emissions of ammonium and greenhouse gases for each region in the supply module are shown. You can also view the emissions per hectare of agricultural land. "Global warming potential from agriculture" sums the emissions of the greenhouse gases methane and nitrous oxide using Global Warming Potential coefficients.

Exercise 14: Total emissions of greenhouse gases

Find the total emissions of greenhouse gases in Global Warming Potential (in 1000t CO2 eq) for Sweden in 2030 for the Reference scenario.

1.22   Customize table views - transpose table dimensions

ILO 4c: *Customize result tables by transposing rows and columns*

Changing the dimensions of the table can be helpful to get an overview of the results. Go back to the table *Farm >> Supply details.* By clicking the *Pivot* up in the right corner, rows and columns will change places. By **right** clicking on *Pivot* you will open a window called *Transposing and Merging* as in Figure 37. Here, you can choose freely how to organize your data table by moving around the dimensions *Region*, *Scen*, *Year*, *Item* and *Activity*, and similarly for other themes.

Table control area defines how the table and the data are organized. *Animation* can be used if you want to play up items in one dimension, showing data for one item at a time. *Box (1, 2 and 3)* corresponds to the drop-down lists in the top row of your data view window. *Table columns* and *Table rows* corresponds to columns and rows. The *Table rows*, and *Table columns groups* make it possible to show data with e.g., regions (*Table rows group*), and for each region all products (*Table rows*), in the rows. In *Table area*, you can adjust the data dimension by dragging the dimensions to the different places, depending on what information you want to study. If you put two dimensions in the same place, it will be like putting one of them in the groups, but more difficult to rearrange.
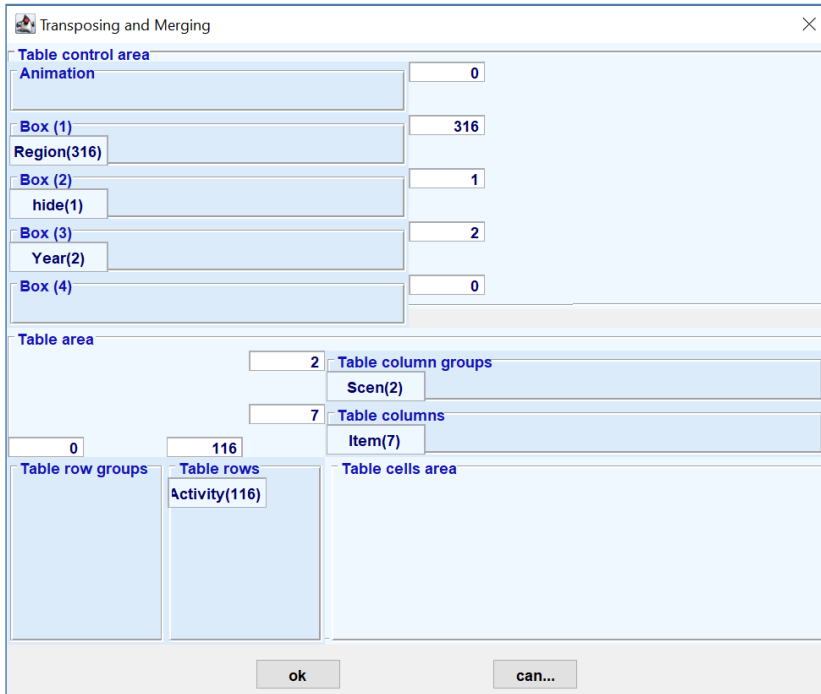
Figure 37: Changing dimensions of a table

Exercise 15: Change the table view

Go back to the table *Farm >> Supply details.* Change the table view so that you have Activities in columns, Items in rows and Scen, Years and Regions in the drop-down lists. Chose the Scen>>Policy scenario, Years>>2030 and Regions>> Finland in the drop-down list. Attach a print screen of the table.

1.23   Compare relative and absolute values

ILO 4d: *Compare relative and absolute values*

Clicking on "Customize" (the spanner) in the right upper corner, you can make several choices about what data to show and how (Figure 38: View comparisons of scenarios). One is to choose how you want your values shown. Click on the Comparison output drop-down list to choose between absolute values, percentages, only values, or differences to the chosen scenario. Choose

Comparison output: "Values and percentage difference".

Data dimension used for comparisons: "Scen".

Element for comparison Scen: "Reference".

Your results should now be shown for the *Policy* scenario in absolute values and percentage differences to the *Reference* scenario.
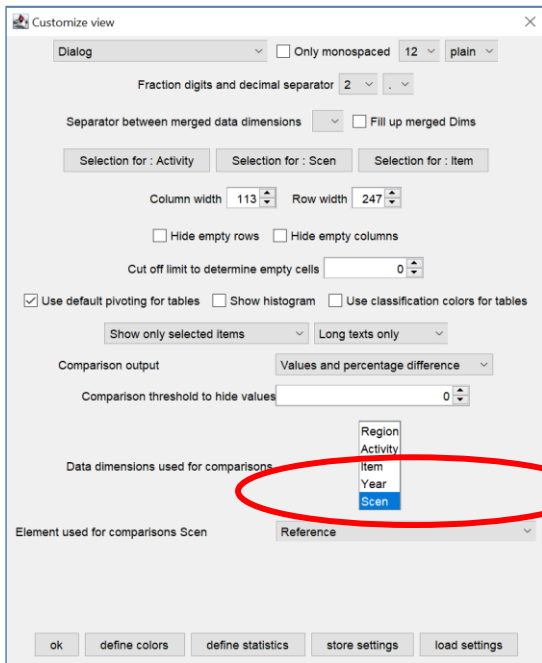
Figure 38: View comparisons of scenarios

Exercise 16: Compare relative and absolute values

a) Compare scenario results. What is the percentage difference for farm income for Cereals in Spanish agriculture in the Policy scenario compared to the Reference?

b) Now compare results in different regions. What is the absolute difference for prices of oats in USA compared to Sweden, in the Reference scenario?

1.24 Select sub-sets of the results

ILO 4e: *Select sub-sets of the results*

In a large data set, finding the results you need can be tedious and difficult. Choosing a sub-set of results can therefore be helpful.

Double clicking on the funnel (red circle in Figure 39) above the column heading, you can choose which activities you want to view. The same applies for the rows (green and blue).

Figure 39: Select sub-sets of the results

A dialog like that in Figure 40below should be shown. Here, you choose what items you would like to view. Hold down the ctrl key to choose several items at a time. The right box in the dialog shows the CAPRI codes for the activities/items/scenarios etc.
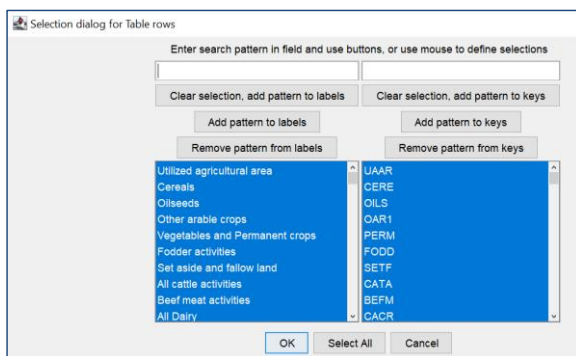
Figure 40: Select items to view

Exercise 17: Select sub-sets of the results

a) Create a subset showing only values Yield and Supply for cereals (soft wheat, durum wheat, rye and meslin, barley, oats, grain maize, other cereals, and paddy rice) for Germany in the Reference scenario. Attach a print screen with your results.

b) Create a subset showing only Income [Euro/ha or head] in Spain, Italy, and Germany, for oilseeds (rapeseed, sunflower, soya, and other oils) for both the Reference and the Policy scenarios. (Hint: You

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may need to use Pivot again to move countries from the drop-down menu). Attach a print screen with your results.

1.25   Sort results

ILO 4f: *Sort results*

The rows are sorted according to a predefined order (e.g. first some larger crop groups, e.g. utilized agricultural area, cereals, oilseed, etc., then the positions of each large group, e.g. soft wheat, barley, and so on for cereals). To get an overview of the data, you might want to sort them by largest or smallest value, or the difference to the *Reference scenario*. By clicking on a specific column header, the values in the columns are sorted by either smallest or largest numbers (Figure 41).

View Handling Windows Options						
Supply details [0]						
Region	European Union 27 after Brexit		Year 2030		Percentage diff. to Scen Reference	
	Reference					
	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]	Yield [kg, Const EU or 1/1000 head/ha]	Supply [1000 t, 1000 ha or Mio Const EU]	Crop share/Animal density [% or 0.01 animals/ha]	Crop share/Animal density, per arable land [% or 0.01 animals/ha]
Pig fattening	-26.52	264815.09	88.48	23430.44	164.14	230.06
All agricultural activities	516.53	257940.09	1408.99	363435.88	159.88	224.08
Utilized agricultural area	825.83	161334.33	1340.39	216250.98	100.00	140.16
Utilized agricultural area	825.83	161334.33	1340.39	216250.98	100.00	140.16
Arable land	805.95	115108.92	1774.19	204224.86	71.35	100.00
Fodder activities	156.23	67392.15	455.12	30671.58	41.77	58.55
Fodder activities	156.23	67392.15	455.12	30671.58	41.77	58.55
Milk Ewes and Goat	3.85	59221.52	76.38	4523.08	36.71	51.45
Milk Ewes and Goat	3.85	59221.52	76.38	4523.08	36.71	51.45

Figure 41: Sort values by clicking the column header.

Clicking again reverses the order. If you have several columns, the data for all columns will be sorted according to the column of interest. If only absolute values are shown, the sorting will be based on this. However, if you have chosen to e.g., compare by percentage difference, the sorting will be based on these differences.

Go back to *Farm >> Supply details.* Place Activities in the rows and data items in the columns. Choose *EU27 after Brexit* in the drop-down menu. Click on the *Hectares* column. The results should now be sorted in the order starting from the lowest (or highest) value. Try clicking on the other columns as well and see how the order of the data changes.

Exercise 18: Sort results

a) Sort the data so that the largest *values* for head/hectares for *European Union West* in the Policy scenario are at the top. Which aggregated land use activity (Cereals, Oilseeds, Other arable crops, Vegetables and permanent crops, Fodder activities, or Set aside and fallow land) uses the largest area? How large is it? Which individual land use activity (Barley, Maize,) uses the largest area?

b) Sort the data so that the smallest *percentage change* in area used for agricultural activities in Sweden is shown, i.e., between the Policy and the Reference scenario. Which aggregate land use activity (Cereals, Oilseeds, Other arable crops, Vegetables and permanent crops, Fodder activities, or Set aside and fallow land) has the smallest percentage change? How small?

1.26 Use results outside the GUI

There are different ways to export your results so that you can use them outside the GUI. The first option is to copy the values in the table by using the copy symbol, or right clicking on the table and choosing *Copy to Clipboard*. By using *Copy selected cells to clipboard* you can copy a selection. When you paste the data into a spreadsheet, labels and settings will also be shown (Figure 42). The other option is to use *Export*, by clicking the symbol or right-clicking. With this you can chose to export the table into an existing file, and you are given the possibility to choose which data to include.

Figure 42: Pasting results into Excel

Exercise 19: Copying results from the GUI

Provide a screenshot with freely chosen results copied from the GUI into a datasheet.

1.27 In-depth exercises

Exercise 20: Compare the Policy to the Reference scenario in Sweden in 2030

Compare the Policy to the Reference scenario in Sweden in 2030.

a) What is the relative change in number (heads) for the aggregate Beef meat activities?

b) For which "component" of Beef meat activities (Other cows, Heifers fattening low weight, Heifers fattening high weight, Male adult cattle low weight or Male adult cattle high weight) is the absolute change (in numbers of heads) largest? How large?

c) In which of the Swedish regions (Stockholm, Oestra mellansverige, Sydsverige, Norra mellansverige, Mellersta Norrland, Oevre Norrland, Smaland med Oearna or Vaestsverige) is the relative change smallest for Beef meat activities (in number of heads)? How large? For the absolute change?

d) What are the prices of Beef in Sweden in the Reference and in the Policy scenario? Attach a screenshot of a spreadsheet or a table showing these *and only* these prices.

Exercise 21: how results differ between using the market module and the supply module

In this exercise you will look at how results differ between using the market module and the supply module.

Step 1: First, go through the exercises looking at the result files that you already loaded (with market model). Look at the Policy scenario for France.

a) Find the activity with the largest absolute and the activity that has the largest percentage change in income (Except all *agricultural activities* and *utilized agricultural area*).

b) For both of these activities, in which of the French regions are the changes largest?

c) Which of the products show the highest price change (in producer prices)? In absolute values? And in percentage? How much?

d) How large are the changes in greenhouse gas emissions (in Global Warming Potentials) in all of France? In which of the French regions is the changes largest?

Step 2: Now you will run a new scenario. Exit the result viewer: *View handling>>Exit*. Go back to *Run scenario>>Run scenario without market model.*

Run the Reference scenario and the Policy scenario for France, with ending _FR in *Additional result type identifier*. Remember to select *Regional breakdown*=NUTS2.

Load the result files. These will be in the same result directory, but the files will end by _FR (*ref_FR* and *pol_novcs_FR*).

Do the same exercises a-d as in Step 1

a) Find the activity with the largest absolute and the activity that has the largest percentage change (Except all agricultural activities and utilized agricultural area).

b) For both of these activities, in which of the French regions are the changes largest?

c) Which of the products show the highest price change (in producer prices)? In absolute values? And in percentage?

d) How large are the changes in greenhouse gas emissions (in Global Warming Potentials) in France? In which of the French regions is the changes largest?

What differences can you see between the results? Why results differ? What do you think?

Problems you might encounter

When you work with this tutorial, or CAPRI in general, you can encounter problems with the interface, as with any software. Here are some hints on how to deal with them. Try these first before contacting the organizing team.

Sometimes your sorting can disappear for no reason, you cannot see the tools etc. You might not have done anything wrong, or you might have, so first just try again! Either try to change the rows and columns, expand the window to full screen, or open a new data view window. Sometimes it will be impossible to close a window. First try to close other windows, then close the GUI and restart. Be careful when clicking on the area above the drop-down menus before exporting results, to make sure that you have the data you wanted, and not, e.g., income instead of hectares.

Read an article

ILO 5: *Reflect on strengths and weaknesses of using CAPRI and possible applications for specific studies*

CAPRI has been used for many analyses. To get a better idea of how it can be used read some of the following articles.

a. Blanco M., Ramos F., Van Doorslaer B., Martínez P., Fumagalli D., Ceglar A., Fernández F.J. (2017b). Climate change impacts on EU agriculture: A regionalized perspective taking into account market-driven adjustments. Agricultural Systems 156: 52–66, doi: https://doi.org/10.1016/j.agsy.2017.05.013

b. Gocht, A., Ciaian, P., Bielza, M., Terres, J. M., Röder, N., Himics, M., & Salputra, G. (2017). EU-wide economic and environmental impacts of CAP greening with high spatial and farm-type detail. Journal of Agricultural Economics, 68(3), 651-681, doi: https://doi.org/10.1111/1477-9552.12217

c. Himics, M., Fellmann, T., Barreiro-Hurlé, J., Witzke, H. P., Domínguez, I. P., Jansson, T., & Weiss, F. (2018). Does the current trade liberalization agenda contribute to greenhouse gas emission mitigation in agriculture? Food policy, 76, 120-129, doi: https://doi.org/10.1016/j.foodpol.2018.01.011

d. Leip, A., Weiss, F., Lesschen, J.P., Westhoek, H. (2014): The nitrogen footprint of food products in the European Union, The Journal of Agricultural Science 152: 20–33.

e. Renwick A., Jansson T., Verburg P. H., Revoredo-Giha C., Britz W., Gocht A., McCracken D. (2013). Policy reform and agricultural land abandonment in the EU. Land use policy 30(1): 446-457.

Exercise 22

Write a short summary of the one of the papers (about ½ page), including answers to the following questions.

a) Why was CAPRI used?

b) What were the advantages of using CAPRI for this study?

c) Give examples of limitations to the study as a result of using CAPRI

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