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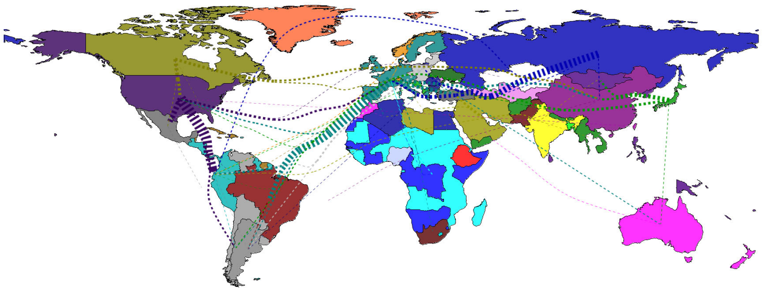

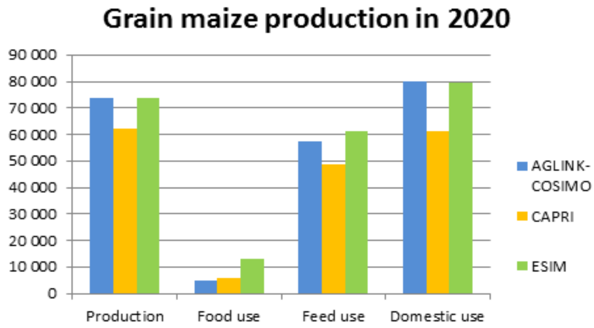

JRC TECHNICAL REPORTS

Calibrating the CAPRI and ESIM models to the mid-term commodity market outlook of the European Commission

Mihaly Himics

Marco Artavia

Sophie Hélaine

With the contribution from Ole Boysen

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Joint Research Centre

European Commission

Joint Research Centre

Institute for Prospective Technological Studies

Contact information

Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)

E-mail: jrc-ipts-secretariat@ec.europa.eu

Tel.: +34 954488318

Fax: +34 954488300

http://ipts.jrc.ec.europa.eu

http://www.jrc.ec.europa.eu

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AUTHORS' AFFILIATIONS

Mihaly Himics[1]

- European Commission, Joint Research Centre, Institute for Prospective Technological Studies
- Universität Bonn, Institut für Lebensmittel- und Ressourcenökonomik

Marco Artavia

- European Commission, Joint Research Centre, Institute for Prospective Technological Studies

Sophie Hélaine[2]

- European Commission, Joint Research Centre, Institute for Prospective Technological Studies
- European Commission, Directorate-General for Agriculture and Rural Development

Ole Boysen

- Universität Hohenheim, Fachgebiet Agrar- und Ernährungspolitik (420a)

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[1] *Present affiliation is Universität Bonn*

[2] *Present affiliation is the European Commission, Directorate-General for Agriculture and Rural Development*

ACRONYMS

CAP	Common Agricultural Policy
CGE	Computable General Equilibrium
PE	Partial Equilibrium
EC	European Commission
DG AGRI	Directorate General for Agriculture and Rural Development
DG ECFIN	Directorate General for Economic and Financial Affairs
JRC-IPTS	Joint Research Centre-Institute for Prospective Technological Studies
EU	European Union
MS	Member State
NUTS	Nomenclature of Territorial Units for Statistics
FAO	Food and Agricultural Organization
OECD	Organization for Economic Co-operation and Development
IIASA	International Institute for Applied Systems Analysis
IFPRI	International Food Policy Research Institute
iMAP	Integrated Modelling Platform for Agro-economic commodity and Policy analysis
CAPRI	Common Agricultural Policy Regionalised Impact Modelling System
CAPTRD	Trend projection module of the CAPRI modelling system (EU, Norway and Western Balkans)
CAPMOD	Simulation engine of the CAPRI modelling system
COCO	Complete and Consistent database of CAPRI (EU Member States)
CAPREG	Regional database of CAPRI (NUTS2 and farm type coverage)
GLOBIOM	A global model to assess competition for land use between agriculture, bioenergy, and forestry; maintained by IIASA
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade, CGE model maintained by IFPRI
PRIMES	Partial equilibrium model for the European Union energy markets
AMECO	Annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs
AMAD	Agricultural Market Access Database
FADN	Farm Accountancy Data Network
FSS	Farm Structure Survey
GAMS	General Algebraic Modeling System (programming language)
GDX	GAMS data exchange format

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1. INTRODUCTION[1]

Economic models are one of the cornerstones of impact assessment studies supporting the policy decision making process of the European Commission (EC). The complexity of targeting social, economic and environmental aspects of policy options requires combined application of different modelling tools. JRC-IPTS maintains a modelling platform, called the Integrated Modelling Platform for Agro-economic Commodity and Policy Analysis (M'Barek et al. 2012), in order to contribute to the impact assessment of agricultural and trade policies. iMAP is mainly used to evaluate ex-ante the economic and environmental impacts of policy options in the political debate. Operating a modelling platform, however, requires the calibration of the included models to the same point of departure. The current report describes how two of the partial equilibrium models of the iMAP platform, CAPRI and ESIM, are calibrated to a common baseline.

As a regular exercise, the EC constructs medium-term projections for the agricultural commodity markets. The EC's baseline is published every year by the EC's Directorate General for Agriculture and Rural Development (DG AGRI) in the 'Prospects for Agricultural Markets and Income in the EU'. The outlook presents a consistent set of market and sector income prospects elaborated on the basis of specific policy and macroeconomic assumptions (Nii-Naate, 2011).

The EC's baseline serves as a reference for the CAPRI and ESIM models so that the simulated outcomes of the models are based on the same point of departure. To achieve and maintain this level of consistency within the iMAP models, CAPRI and ESIM are calibrated to the EC's baseline every year. The final outcome of the calibration exercise is the respective baseline scenarios for both models. The baseline scenario serves as the benchmark for any counterfactual policy analysis done with the models.

The aim of this report is to describe the calibration of CAPRI and ESIM to the EC's baseline. Both models have a different calibration approach reflecting on the differences in model structures and other characteristics, as described in section 2. A general discussion on calibrating partial equilibrium models follows in section 3. The calibration approaches of the single models are presented in more details in separated sections, including an evaluation of the 2012 and 2013 calibration exercises[2]. A summary concludes in section 6, highlighting those areas of the calibration exercise where further improvements are desired. The annexes provide further background information on model specific aspects of the calibration.

2. BRIEF OVERVIEW OF THE MODELS

In this section those model characteristics are highlighted that are crucial for understanding the differences in the calibration approaches. More detailed model descriptions are available in the respective model documentations (OECD, 2006), (Britz and Witzke, 2013) and (Banse and Grethe, 2008).

2.1 AGLINK-COSIMO

AGLINK-COSIMO is a multi-region, recursive-dynamic, partial equilibrium, supply-demand model covering the main agricultural products and the first stage processing industry. AGLINK-COSIMO features explicit import and export equations with market-clearing conditions imposed on the global commodity markets

[1] *Disclaimer: The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.*

[2] *The evaluation focuses on the 2012 exercise. Nevertheless, the conclusions drawn are valid for the current model versions if not stated otherwise.*

(yielding associated equilibrium world prices). The EU is depicted by two sub regions: the EU-15 and the EU-N12 (the EU-N13 since 2013). No results are derived for the single Member States (MS).

AGLINK has been developed by the OECD Secretariat[3] in close co-operation with OECD countries. AGLINK not only covers most OECD members individually but also several non-OECD countries (Brazil, Argentina, China, and Russia). The COSIMO model of FAO was merged with AGLINK in order to improve the regional coverage of the modelling system. COSIMO covers important agricultural producers that are not OECD members especially in the African and Asian continents (OECD, 2006). The EU module of the AGLINK-COSIMO model has been developed and maintained in collaboration between DG AGRI and JRC-IPTS.

The main purpose for developing the AGLINK-COSIMO model was to provide a consistent framework for the several (mainly sector specific) outlook activities. The model provides a theoretical framework for integrating projections from market experts, national agencies, international institutions etc. In technical terms, the AGLINK-COSIMO model is calibrated so to produce projections those are in-line with expert opinions on market developments. The baseline exercise does not only provide a valuable projection of EU agricultural commodity markets (the publication itself), but also delivers a calibrated AGLINK-COSIMO model that can be used as a basis for further counterfactual policy analysis.

The projection period used in AGLINK-COSIMO is typically 10 years on an annual basis. Being recursive dynamic the model calculates successive equilibrium states of the economy for each year. The final outcome of the OECD-FAO outlook exercise is published annually towards June or July[4]. It is the starting point for the EC's baseline construction work. To that purpose the EU module of the AGLINK-COSIMO model is updated as explained in Chapter 3.1.

2.2 CAPRI

CAPRI is a comparative static partial equilibrium model, focusing primarily on the EU countries but covering the global agricultural commodity markets as well (Britz and Witzke 2013). The model is built of a number of mathematical programming models (covering EU agricultural supply) and a global equilibrium model for the agricultural commodity markets. The programming models of supply can work at regional or farm type level (where geographical regions closely follow the NUTS2 administrative regions[5] and the classification of farm types follows the classification concept established in the Commission Decision 85/377/EEC of 7 June 1985 on a Community typology for agricultural holdings.

The supply models and the global market model are interlinked and solved in an iterative process. The mathematical programming models simulate the supply response of agricultural producers to changes in commodity prices calculated in the market model (see Figure 1). The market model, in turn, gives a price feedback to the supply models linking the EU agricultural production to the global commodity markets.

The market model currently covers ca. 77 countries (grouped in ca. 40 country blocks) and 47 commodities (see Annex 1). CAPRI covers the trade of many commodities that are not available in AGLINK-COSIMO, e.g. fruits and vegetables. The market model depicts bilateral trade using the

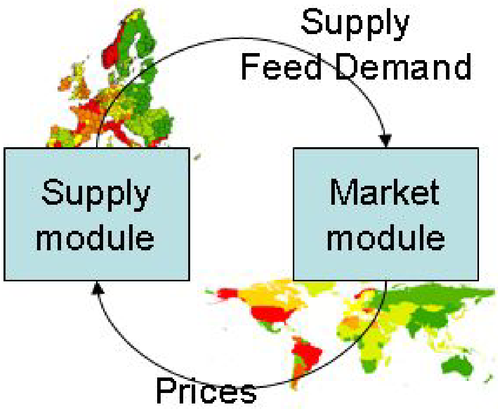
[3] Disclaimer: The results of any analysis based on the use of the AGLINK-COSIMO model by parties outside the OECD are outside the responsibility of the OECD Secretariat. Conclusions derived by third-party users of AGLINK-COSIMO should not be attributed to the OECD or its member governments.

[4] The latest Outlook can be found at: http://www.oecd.org/site/oecd-faoagriculturaloutlook/

[5] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the European Union. The classification is established by regulation EC 1059/2003

Armington approach[6]. Incorporating the single bilateral trade flows requires significantly more input data compared to AGLINK-COSIMO, where traded commodities are not differentiated by source of origin.

Figure 1: The supply models of the EU regions/farm types and the market module are linked iteratively



Source: CAPRI website

CAPRI incorporates a detailed nutrient flow model per activity and per region. Nutrient requirements and availability are balanced using an accounting scheme for feed and fertilizers. The market for young animals is also integrated in the iterative process explained above. Inter-regional trade of calves, young bulls, piglets and lambs are covered between the EU Member States which determines the costs of animal purchases during the simulation.

The challenge in calibrating the CAPRI modelling system is to calibrate both the supply modules and the market module to the same point of departure. In other words, the aggregated supply of the regional and farm type models should be equal to the EU supply in the market module under the equilibrium conditions.

CAPRI includes an extensive set of data preparation modules. A big effort is made to prepare a consistent and complete database for the EU regions (and farm types) and for the global agricultural markets. The data exchange between the modules and the simulation engine is via .gdx files (the native data exchange format of the GAMS programming language).

The CoCo (short for Complete and Consistent) module creates a complete and consistent database for the countries covered by the supply modules, mainly building on EUROSTAT information. CAPREG breaks it down to the level of NUTS2 regions and farm types. For the farm type break-down additional information from the Farm Accountancy Data Network (FADN) and the Farm Structure Survey (FSS) is used. CAPTRD derives projections based on historical trends and external information sources, including the EC's baseline. The *global* module provides a database for the global agricultural commodity markets, covering mainly market balances, bilateral trade and trade policies. CAPMOD is the acronym of the simulation engine. If operated in baseline mode CAPMOD calibrates the parameters of the modelling system. In simulation mode CAPMOD performs simulations driven by a pre-defined scenario file.

Information from the EC's updated version of AGLINK-COSIMO enters the data preparation process at two points (see Figure 2): (1) CAPTRD uses the EU-level results for projecting Member States/regional/farm-type balances and prices; (2) the global module uses the global commodity balances, macroeconomic data and biofuel related information to compile the global database for the simulation engine.

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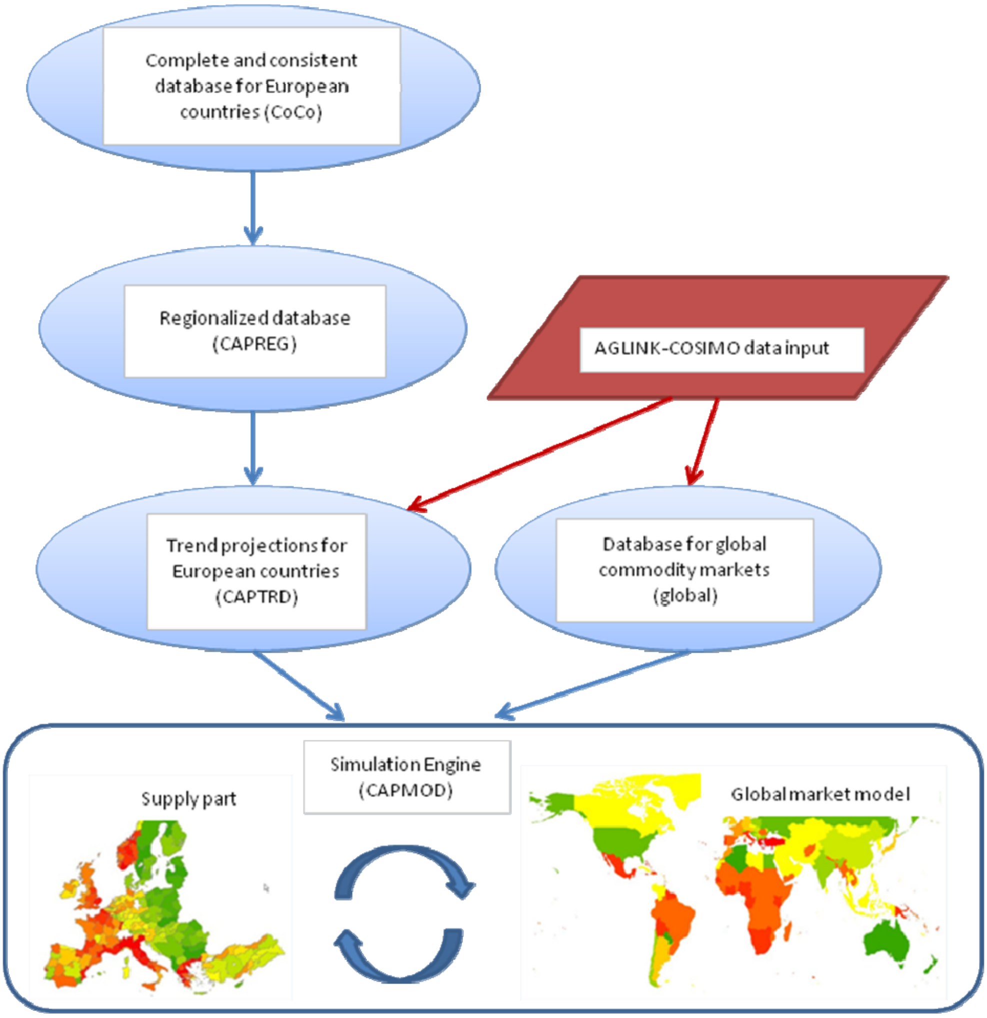
[6] *Commodities are differentiated by place of origin in the consumption bundle.*

CAPRI is calibrated against an internally produced projection which is based on several data sources and external projections, including the EC's baseline. There is a regular CAPRI baseline update scheduled after the EC baseline is published in order to include the latest mid-term market projections.

Figure 2: Main modules of CAPRI indicating the entry points of EC' baseline data input



2.3 ESIM

ESIM is a multi-region, comparative static, partial equilibrium, net trade, supply-demand model covering the main agricultural products. The ESIM projections are built by running the comparative static model structure for each consecutive year. The model, however, cannot be classified as recursive dynamic since the successive results are independent.

The commodity coverage presents some differences when compared to AGLINK-COSIMO (see Annex 1). The EU is represented with a geographical resolution of the Member States. By design ESIM focuses on the EU agricultural markets and accession candidate countries (Croatia[7], Turkey and Western Balkans). The rest of the countries are split into the US and an aggregate 'rest of the world' (ROW). Supply and demand functions are of the Cobb-Douglas type. Agricultural policies are only modelled for the EU, either at EU level (price policies[8]) or at MS level (direct payments, and sugar and milk quotas).

The EU price mechanism in ESIM allows for different price levels depending on the net export situation. A logistic functional form provides a smooth transition between the upper and lower price levels. Briefly summarized, the upper price levels correspond to net import situations with tariffs or threshold prices. Lower price levels, on the other hand, define the maximum between world market prices or intervention prices. The system accounts for export subsidies, export subsidy limits, and Tariff Rate Quotas as well, by using a combination of two logistic functions per commodity.

Due to the high data requirements of constructing balance sheets at MS-level, the consistent database for the base year is not updated regularly. By contrast, the historical time-series in AGLINK-COSIMO are updated annually. In the 2013 version, the base year for the market elements (supply, demand, prices, etc.) is an average of 2006 and 2007. As a result, ESIM projects over a longer time period (e.g. 2008-2023) than AGLINK-COSIMO (e.g. 2014-2023). As the rest of the world geographical aggregate is quite heterogeneous, world price developments in the projection period must be set model exogenous instead of using the ESIM's own projections. Currently, this price information is coming from the EC's AGLINK-COSIMO baseline results.[9] For an explanation of the behavioural functions as well as further details on the price mechanism please see Grethe (2012).

3. General issues on calibration

In general, the process of calibration can be defined as finding the values for a subset of the model parameters so that the model reproduces a historic or projected state of the economy (often called benchmark or reference year). The baseline assumptions cover expectations regarding the development of all exogenous factors that lead to the ex-post or projected state of the economy. Normally the baseline assumptions include no change in policies and a 'normal' path for economic development (represented by e.g. the GDP growth). Assumptions need to be made on the structure of specific commodity markets as well (e.g. changing consumer preferences over time). Many assumptions are only indirectly made (e.g. investment decisions underlying the expected supply potentials in the future), which can make the baseline harmonization across models cumbersome. Ensuring these baseline assumptions are as similar as possible in the three models is indeed the first step of the calibration exercise.

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[7] *In the 2013 baseline exercise Croatia was still treated as a candidate country in ESIM.*

[8] *As ESIM assumes one price for all MS (except for milk,), price policies are model at the EU level.*

[9] *In earlier ESIM versions the FAPRI price forecasts were used.*

The set of the calibrated parameters varies to a great extent among different models and depends on the calibration technique at hand. The supply models of CAPRI, for example, are calibrated by adding non-linear (PMP) terms to the objective function. The Armington system for global trade, on the other hand, is calibrated by the so called share and shift parameters. The Cobb-Douglas supply functions of ESIM are calibrated by adjusting the technical progress parameter.

The calibration of such complex modelling systems as CAPRI or ESIM is a resource intensive endeavour. Even if the calibration is highly automated, many issues still require manual adjustments:

- Integrating different sources of information can lead to inconsistencies that cannot be solved with the built-in calibration algorithms,

- Some policy changes over the projected period might require adjustments in the behavioural models or their parameterization. One example is the expiry of the sugar quota system in the EU which leads to a substantial change in the sugar market structure.

Applied equilibrium models can only be calibrated to a price-quantity framework that is consistent with the model structure and the underlying behavioural assumptions, i.e. the input data set could have been produced with the model. That is why constructing a consistent dataset is an integral part of the calibration of both ESIM and CAPRI. The consistent datasets deliver those target values (market balances, prices, etc.) that the models are calibrated to.

An inevitable side effect of creating consistent target values is that the reproduction of the reference data set cannot be exact. Therefore validating the calibration results must be an integral part of the baseline process and the deviations from the reference data must be carefully evaluated. Both ESIM and CAPRI provide pre-defined reports that help the analysts validating the calibration results.

3.1 The EC's baseline process as a calibration exercise

The EC's baseline construction is indeed a calibration exercise. AGLINK-COSIMO provides a framework to integrate the market intelligence of experts in an economically consistent model. Expert knowledge is first introduced in the model via initial values for the projection period. Then, production and demand curves are adjusted to satisfy equilibrium conditions, while incorporating market intelligence at the same time, using adjustment factors (R-factors). Thus the consistency of projections is achieved across agricultural sectors, geographical regions and successive years. The EC's updated model version integrates DG AGRI short term forecasts and their own experts' expectations. The EU projections are discussed and evaluated each year not only in-house, but also in a designated workshop involving leading market experts from various organisations. The big emphasis put on the validation is one of the main strengths of the EC's baseline publication. A detailed description of the baseline process is available in (Nii-Naate 2011).

By calibrating to the EC's baseline, ESIM and CAPRI modelling teams take advantage of the above review and validation process. It makes them possible to produce a high quality baseline with their own models with significantly lower investment in human resources.

3.2 Target values and the precision of the calibration

Calibration to a common baseline is an important prerequisite for doing scenario analysis with various models simultaneously. A consensus on the underlying baseline keeps the focus of the discussion on the differences in scenario results rather than on the differences in the baselines themselves. When using a model platform for policy impact analysis (in the ideal case) the differences in model results should come from the differences in model structures and not from the deviations in the baselines. Assuming a common baseline, different model results reveal different aspects of the same policy question[10].

In practice, it is important to calibrate as precise as possible to those variables that characterize the commodity markets. Those variables include net trade position, relative prices (domestic market prices vs. world market price, market price vs. institutional prices), fill rates of tariff rate quotas, active/non-active policy instruments (e.g. export subsidies), relative size of market balance items (e.g. domestic use vs. production, especially for those products where production quotas or mandates are in place).

Achieving an exact calibration of ESIM and CAPRI to the full result set of AGLINK-COSIMO is not feasible for a number of reasons. Integrating other information sources in the baselines and the resulting inconsistencies are the number one reasons. Product definitions can also be different to such an extent that calibrating these commodity specific results is not a suitable approach. Common issue, for example, is that dairy products are divided into different categories, and therefore an exact calibration is impossible. Different modelling approaches (e.g. in the case of the feed system or the biofuels) might also lead to unavoidable deviations from the target values.

In the above cases, not all of the EC's baseline figures can be reproduced simultaneously. Some calibrated values will be either very different or even not comparable with the original EC's baseline figures. In the case of biofuels, for example, one can choose to calibrate to the share of renewable energy in transport fuels (and so hit that target value on renewables with precision), but let the model achieve it with more imports or domestic production compared to the AGLINK-COSIMO figures (deviation from these target values).

The approaches for modelling international trade are very different between AGLINK-COSIMO and CAPRI. The latter includes bilateral trade flows while AGLINK-COSIMO features single export and import equations per commodity. Thus the CAPRI market model requires significantly more information for calibrating its trade balances. The consistency of the additional information with the AGLINK-COSIMO projections must first be established by the market balancing routines. Only then can the actual calibration of the functions in the market model be started (see page 14). To achieve consistency, the data balancing algorithm might need to adjust the original AGLINK-COSIMO target values, making an exact calibration in the subsequent steps impossible.

Harmonisation of product definitions across the suite of economic models would naturally improve the precision of the calibration exercise. Similarly, using common input data sources for the historic data would help reducing the differences in the starting points and so would ease the calibration. That is why there are ongoing efforts in the iMAP modelling framework aiming at data harmonization across the iMAP models (see e.g. Helaine et al. 2013).

3.3 Harmonization of policy and macroeconomic assumptions

All three models taking part in the calibration exercise are partial equilibrium models: the impact of the agricultural sector on the other sectors of the economy is assumed to be negligible. In technical terms, the variables describing the macroeconomic environment are model exogenous. Such variables include GDP and population growth rates, GDP deflator, inflation rate, exchange rates and oil price. The assumptions concerning the development of the exogenous macroeconomic variables are relatively easy to harmonize. In fact, both ESIM and CAPRI take over many of the macroeconomic variables directly from the AGLINK-COSIMO result set.

[10] *That is one of the main arguments supporting the use of several models to investigate the same policy question, i.e. the motivation behind the use of modelling platforms such as iMAP.*

It is more difficult to harmonize indirect assumptions that are only implicitly defined by functional forms or model parameters. These assumptions include e.g. changes in consumption patterns or production technologies over time.

Agricultural and trade policies need also to be harmonized. The rule of thumb in this respect is to include only those policies that are in force or will surely enter into force during the projection period. As AGLINK-COSIMO only covers the EU with two geographical aggregates, the member state or regional level implementation of agricultural policies is missing. Both ESIM and CAPRI build their policy data on other data sources and ensures only that the aggregate figures are in line with those used in AGLINK-COSIMO. Unfortunately, there is a lack of a consistent database of EU agricultural policies with a detailed geographical coverage.

Certain policy instruments require to be harmonized with other model variables as well. For example, market intervention measures depend on pre-defined trigger prices, making the calibration of relative prices (producer prices vs. administrative prices) important. This cross-dependency of harmonized model variables cannot be neglected during the baseline exercise.

3.4 Validation of the baseline projections

The EC's baseline is scrutinized by market experts both in DG AGRI and in partner institutions. A similar validation approach is not feasible either for ESIM or CAPRI. The amount of results produced by these two models is significantly larger due to the finer geographical resolution. The teams producing the baseline, on the other hand, are much smaller and lacking market experts. Therefore, the validation approach for ESIM and CAPRI must build on automated consistency checks and comparison with other (already validated) projections.

The trend projection module of CAPRI, for example, contains an extensive set of consistency checks in order to avoid unrealistic regional disaggregation of country-level results. The problem of the full validation of national, regional and farm type-level results, however, remains unresolved. Unfortunately, no external EU wide projections for agricultural markets at MS or regional level are available for comparison purposes. The necessary financial and human resources for involving numerous market experts in the baseline processes do not seem within reach either.

The situation is similar in the case of ESIM. Calibrated results are not validated at the MS level. Thus, the country-level baseline figures and the scenario results building on that should be used with precaution.

In general, any increase in geographical coverage is constrained with the increased resources for validating model results. Even if regional statistical databases and increased computational resources facilitate building more geographically disaggregated models, validation remains a bottleneck for further regional disaggregation.

4. CAPRI CALIBRATION

4.1 CAPRI calibration approach

The supply and market modules of CAPRI are subject to a sequential calibration (see Britz 2008). The modules are calibrated to the same price-quantity framework but following different principles. The supply modules are calibrated with advanced PMP techniques (Heckelei and Britz 2005) or Heckelei, Britz, and Zhang 2012)). The behavioural blocks (e.g. human demand, feed, processing) of the market module, which is formulated as a system of equations, are calibrated one after the other by solving the corresponding calibration models. Annex 4 gives an overview of the behavioural sub-systems and their main characteristics, including also the calibrated parameters.

Creating consistent market balances is an integral part of the market model calibration (we refer to this in the following as 'market balancing'). This procedure ensures the consistency of market balances, bilateral trade flows and prices at the global scale. Important to note that EU market balances and prices are fixed at the projected levels during the market balancing. This ensures that the resulting balances are as close as possible to those in the EC's baseline. The main data inputs for the calibration are the trend projections (for countries covered by the supply module) and the global database for international trade and market balances.

The so called trend projection module (CAPTRD) projects commodity balances and prices for the EU countries[11], Norway, Turkey and Western Balkans (countries covered by the supply modules). Trend projections are derived in a multi-step procedure, integrating a multitude of external information sources (including the EC's baseline) and historical trends:

- Step 1 draws independent trends for the model variables based on historical data

- Step 2 introduces consistency constraints and expert information concerning specific countries or commodities (e.g. sugar-beet and biofuels)

- Step 3 introduces additional expert information at more aggregated level. The results can optionally be broken down to regional or even farm-type level

In the above steps an estimator is constructed that minimizes the deviation from pre-defined support points while satisfying a set of consistency constraints at the same time. The a-priori information sources for defining the support points are typically forecasts and projections from national and international organizations (e.g. EC prospects for commodity markets, OECD market outlook,). There exists also a built-in possibility in CAPRI to rank the information sources by their 'reliability'. This involves assigning appropriate weights to the bits of a-priori information in the above estimator. This issue is highly relevant in applied research (e.g. in policy impact analysis) because the uncertainty in projecting different model parameters varies to a great extent. For example, cropping areas at country level can usually be predicted with precision, unlike e.g. net trade position which typically shows big variation over time and therefore difficult to predict.

Consistency constraints link the different information sources by forcing some technical and logical relationships to be satisfied. A simple example is the area balance that links utilized agricultural area and cropping areas: total land use of agricultural activities should be equal to total utilized agricultural area. The consistency constraints are fully described in (Britz and Witzke 2013). The estimator is formulated as an optimization problem and so minimizes weighted deviation from the support points subject to the above consistency constraints. The optimal values can therefore be interpreted as the closest consistent projections to a set of external forecasts and historical trends.

The communication between CAPTRD and the simulation engine of CAPRI is via a set of .gdx containers including:

- Growth factors for the unit values (prices) in the CAPRI supply modules, derived from AGLINK-COSIMO results *(AGLINK_for_capmod.gdx)*

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[11] *From 2013 onward, Croatia is included in the list of EU countries.*

- Full result set of the trend estimation procedure, including intermediate steps for debugging purposes *(results_0420.gdx*[12]*)*. Note that the Graphical User Interface (GUI) of CAPRI provides extended options for interactive debugging.

- Trend estimates for the commodity balances and prices in the simulation year *(trends_04_20.gdx)*. This is a subset of the full result set, containing only the part directly used later by the calibration process

CAPTRD focuses on the EU, Norway, Turkey and the Western Balkans. But the market module requires more information at global scale. In order to project global commodity balances and market prices, a multitude of information sources are included:

- EC's baseline projections

- Supply and Utilization Account, trade matrixes and @2030 projections from FAO

- Longer term projections derived with the GLOBIOM and IMPACT models

- Biofuel related (trade) data from the COMEXT database of EUROSTAT, from USDA and from FO-Licht

CAPRI has a separate data preparation module *(so called global module)* that collects information from the above sources, does consistency checks and converts it into an appropriate format. The final outcome of *global* is a consistent database for the global agricultural commodity markets. The database is stored in a set of .gdx containers:

- (1) FAO trade matrixes (trade flows) and commodity balances, (2) biofuel-related balances, trade and technical parameters and (3) technical parameters and elasticities from the World Food Model *(file fao_agg_04.gdx).*

- Transportation cost estimates, derived by the global module's own estimation procedure (based on the difference between c.i.f. and f.o.b. prices, file *tc_04.gdx*).

- Trade policy related information, especially applied and bound rates for specific and ad-valorem tariffs, compiled mainly from the AMAD database (*tariffs.gdx).*

- Long term projections with the IMPACT model *(f2050_impact.gdx*) and compiled from other sources as well, including GLOBIOM, PRIMES, IFPRI and FAO *(longrun_info_fac*.gdx*)*. Not relevant for the EC's baseline calibration due to the wider time horizon.

4.2 Data preparation steps for the EC's baseline

As the first step in preparing the calibration to the EC's baseline the user needs to convert the original AGLINK-COSIMO result set (which is usually provided in one table in text file format) into a GAMS readable format (gdx file). A set of GAMS routines automate this process to the possible extent. The files

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[12] The numbers in the file name refer to the base and simulation years, 2004 and 2020 respectively. It is a general policy in CAPRI to include this crucial information in the file names. The CAPRI system is flexible enough to choose different base and simulation years. When switching to different base or simulation years, the file names change accordingly.

'convert_to_gdx.gms' and *'codes_not_mapped.gms'* (1) convert the result set in the right format and (2) perform certain tests on the code mappings between CAPRI and AGLINK-COSIMO.

The model nomenclatures are automatically cross-checked highlighting new or outdated codes in AGLINK-COSIMO (see Figure 3). The AGLINK-COSIMO nomenclature changes frequently over time due to the new model releases. The file *'codes_not_mapped.gms'* further checks if there are any AGLINK-COSIMO definitions that are in use in CAPRI but not anymore maintained (or changed) in AGLINK-COSIMO. The above GAMS routines create Excel files for reporting.

The Java-based Graphical User Interface (GUI) of CAPRI is capable of showing the EC's baseline projections in its original nomenclature. This makes possible to get an overview of the general trends in the EC's baseline and alternatively compare it to previous ones. This insight is proved to be very helpful in the subsequent steps of the calibration process, where understanding inconsistencies between the EC's baseline and other information sources is essential.

Figure 3: Structure of the 'convert_to_gdx' module (GAMS code)

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$ontext

   CAPRI project

   GAMS file : CONVERT_TO_GDX.GMS

   @purpose  : to convert the original aglink  excel sheet into the appropriate
                gdx format
   @author   : mihalyh
   @date     : 02.11.10
   @refDoc   :
   @seeAlso  :
   @calledBy :

   updated   : 07.11.2011.

$offtext
********************************************************************************

$setlocal excelfile  "oecd_full.xlsx"
$setlocal gdxresultfile aglink2012OECDMarcel_oriData


*--- READ IN DATA FROM AGLINK RESULT FILE (Excel) ------------------------------
------------------------------------------------------------------------------------------ 21 line(s) not displayed -----------
*--- INCLUDES CODE LISTS, must be cross-checked with codes in the Excel file----
------------------------------------------------------------------------------------------ 4 line(s) not displayed ------------
* sending the  code definiton list (as defined in codelists.gms) to an Excel sheet for further investigation...
------------------------------------------------------------------------------------------ 12 line(s) not displayed -----------
* sending the full code list as found in the dataset (Excel file)  to an Excel sheet for further investigation...
------------------------------------------------------------------------------------------ 12 line(s) not displayed -----------
*--- AGLINK DIMENSIONS ALREADY EXPLAINED ----------------------------------------
------------------------------------------------------------------------------------------ 20 line(s) not displayed -----------
*--- CHECKING MISSING OR EXTRA CODES IN codelists.gms --------------------------
------------------------------------------------------------------------------------------ 2 line(s) not displayed ------------
* codes not covered in the definition set (needs to be checked afterwards...)
------------------------------------------------------------------------------------------ 20 line(s) not displayed -----------
execute 'gdxxrw.exe temp_codes.gdx O=newCodesFound.xlsx @missing_codes.txt';
------------------------------------------------------------------------------------------ 21 line(s) not displayed -----------
execute 'if exist ExtraCodesFound.xlsx rm ExtraCodesFound.xlsx'
------------------------------------------------------------------------------------------ 5 line(s) not displayed ------------
*--- CREATES DATA FILE USED BY CAPRI --------------------------------------------
------------------------------------------------------------------------------------------ 12 line(s) not displayed -----------
execute_unload "..\results\%gdxresultfile%.gdx" p_aglinkOri, aglinkRegions, aglinkCols, aglinkRows, aglinkYears, aglinkTuple;
------------------------------------------------------------------------------------------ 7 line(s) not displayed ------------
* * * End of File * * *
```

In the following sections we concentrate on how the EC's baseline is included in the data preparation algorithms of CAPTRD and *global*.

4.3 EC's baseline information in the trend projection tool

AGLINK-COSIMO results are loaded by the *load_aglink* module in CAPTRD. The user can define the AGLINK-COSIMO model version of choice and the respective scenario directly in the GUI (in case several baselines were produced with the same AGLINK-COSIMO model version, see Figure 4).

The *load_aglink* module has the following functions:

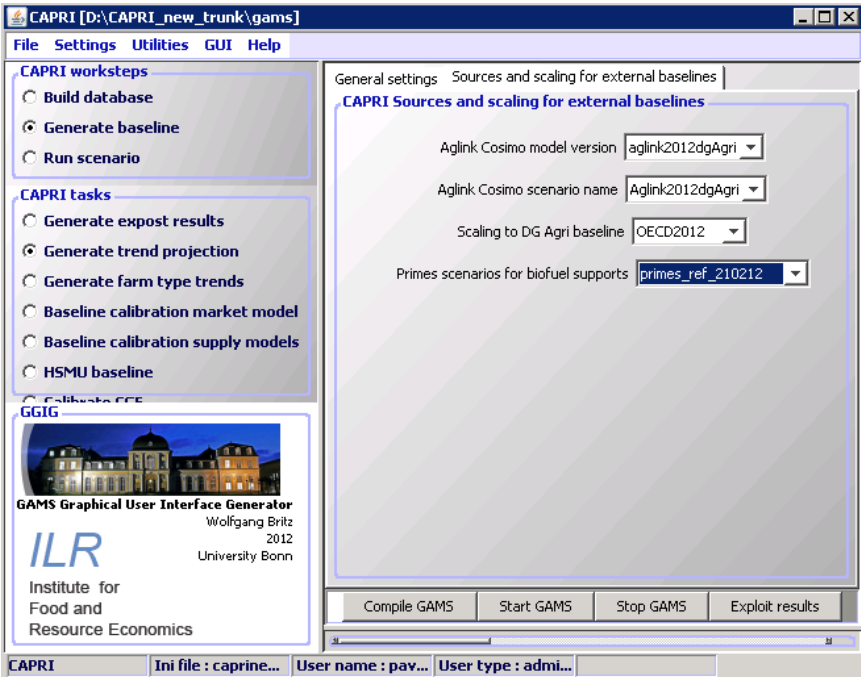
1. Initialize set definitions and mappings between the two models nomenclatures; Load in the raw data under the parameter *p_aglinkOri.*

2. Restrict the complete AGLINK-COSIMO result set to the EU and calculate balance items that can be later on mapped one-to-one to the CAPRI balances. This includes breaking down EU-27 results to EU-15/EU-N12 when necessary; calculating missing balance items etc. This is done in the parameter *p_aglink*.

3. The content of the *p_aglink* parameter is mapped to the CAPRI nomenclature and stored under *p_aglinkTrd*. Some additional items are also calculated here, e.g. crop yields, balances for different intensity variants of CAPRI activities (e.g. high yield dairying), demand for biofuel feedstock and cow milk demand.

4. The results of the above calculations are saved under *p_result* and *p_aglinkUVAG*. The first parameter is the general container for results; information stemming from AGLINK-COSIMO is marked with flag 'dgAgri'.

Figure 4: GUI settings for the load_aglink module in CAPTRD



The AGLINK-COSIMO information needs also to be scaled in order to match the base year values coming from the CoCo and Capreg databases. This is done in the sub-module *scale_DG_Agri_baseline.gms*. The results of the scaling algorithm are stored under the flag 'dgAgri1' in the *p_result* parameter.

As already noted above, CAPTRD can optionally derive projections at regional or farm-type level. That means that AGLINK-COSIMO results, which are given at EU-15/EU-N12/EU-27 level, must be broken-down to more detailed geographical levels. The trend models of CAPTRD do this job by integrating further information sources (Coco and Capreg databases, expert information) under consistency constraints. The trend models are defined in *equations.gms*, the consistency constraints guarantee a consistent set of projections at all geographical levels (see Figure 5).

The Graphical User Interface of CAPRI provides a convenient solution to check and validate trend projections. For example, the GUI is capable of providing the user with a quick comparison of the final projections versus the original EC's baseline (see Figure 6).

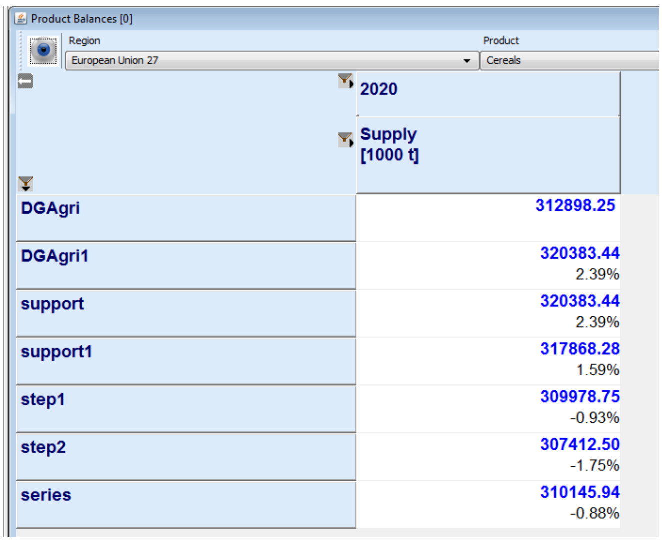
Figure 5: Equations of the CAPTRD trend models

```
EQUATIONS

   AREAB_(rall,*)                         "Area balance"
   LANDUSEB_(rall,*)                      "Land use balance"
   OSET_(rall,*)                          "Obligatory set-aside definition"
   GROF_(rall,ROWS,years)                 "Production equal activity levels multiplied with yields"
   LABO_(rall,years)                      "consistency of labour trends: total = family + paid"
   MSGROF_(rall,ROWS,years)               "Adding up restriction for production at MS level"
   MSLEVL_(rall,COLS,years)               "Adding up restriction for activity level MS level"
   MSLANDUSE_(rall,COLS,years)            "Adding up restriction for some land use classes (FORE, ARTIF, OLND) to MS level"
   MSFEEDI_(rall,MPACT,FEED,years)        "Adding up restriction for bulk FEED use by animals MS level"
   NT2GROF_(rall,ROWS,years)              "Adding up restriciton for production at NUTS II level"
   NT2LEVL_(rall,COLS,years)              "Adding up restriciton for activity level NUTS II level"
   NT2FEEDI_(rall,MPACT,FEED,years)       "Adding up restriction for bulk FEED use by animals NUTS II level"
   MAPR_(rall,ROWS,years)                 "Production equal processing times processing yield"
   MaprByFeed_(rall,RESIMP,years)         "Production equal processing times processing yield"
   BIOF_(rall,SECO_BIOF,years)            "Production of biofuels from processing"
   DDGS_(rall,years)                      "Production of DDGS from bio-ethanol production"
   SugaQuot_(rall,years)                  "Production quotas for sugar are upper bound"
   MLKCNT_(rall,MLKCNT,years)             "Fat and protein balances for milk products"
   REVE_(rall,PACT,years)                 "Revenue of produciton activities"
   EAAG_(rall,ROWS,years)                 "Production value equal price times quantity"
   UVAD_(rall,ROWS,years)                 "Unit value as function of producer price"
   EXPE_(rall,ROWS,years)                 "Consumer expenditures as price times consumption"
   EXPETOT_(rall,years)                   "Total consumer expenditure"
   REQS_(rall,PACT,ReqsT,years)           "Energy and protein use of animals must be covered"
   LU_(rall,years)                        "Definition of stocking density in LU per ha of UAA"
   OYANI_(rall,OYANI,years)               "Production equal use plus net trade of young animals"
   SOYANI_(rall,OYANI,years)              "Definition of stock changes for young animals"
   HERD_(rall,MPACT,years)                "Relationship of LEVL to HERD and process length in DAYS"
   FinalWgt_(rall,COLS,years)             "Relating final weights to days and daily increase"
   Dailyup_(rall,BULF,years)              "Upper bound for daily growth of BULF as in reqfcn"
   SplitFix_(rall,COLS,years)             "Preserving the expost 50:50 distribution of splitacts"
   FEED_(rall,Feed,years)                 "Definition of feed use"
   EFED_(rall,*,years)                    "ensure that endogenous feed in a region is used"
   STRA_(rall,*,years)                    "keep straw to main yield relation constant"
   MBAL_(rall,ROWS,years)                 "Production plus imports equals exports plus sinks"
   PosLo_(rall,COLS,ROWS,years)           "Keep seed use and losses in certain relation to ressources"
   PosUp_(rall,COLS,ROWS,years)           "Keep seed use and losses in certain relation to ressources"
   SEED_(rall,ROWS,years)                 "Production must exceed losses and seed use"
   MBALGRP_(rall,COLS,ROWS,years)         "Market balance positions for group of products"
   DOMM_(rall,ROWS,years)                 "Total demand for products"
   NTRD_(rall,ROWS,years)                 "Net trade"
   HCOM_(rall,ROWS,years)                 "Human consumption as per capita consumption multiplied with population"
   GRPLVL_(rall,COLS,years)               "Adding up to activity levels for groups"

   SSQS_                                  "Objective function - constrained trends"
;
```

Figure 6: Trend projection steps in the GUI (here percentage deviation to original AGLINK-COSIMO)



4.4 EC's baseline information in the global module

The global module of CAPRI takes over commodity balances and price developments from the EC's baseline. This information enters at two points in the global module: in the sub-modules *'global\convert_aglink.gms'* and in *'global\bio_fuel_markets.gms'*.

'global\convert_aglink.gms' loads in the original EC's baseline results, convert them into the CAPRI nomenclature and does corrections on commodity balances. The converted AGLINK-COSIMO projections are stored in the parameter *p_dataMarket* for further processing.

'global\bio_fuel_markets.gms' aims to compile a consistent data set for the biofuel markets based on AGLINK-COSIMO and F.O. Licht[13] information. The module calculates balances for the down-stream sector of biofuel production as well. Processing coefficients and extraction rates are harmonized with the ones used in AGLINK-COSIMO. The results are stored in the parameter *p_bioDat*.

4.5 Market balancing problem and calibration

When running CAPMOD in baseline mode, the building blocks of the CAPRI modelling system are calibrated one by one. First the market balancing problem is solved providing a consistent database for the calibration of the behavioural equations in the market model.

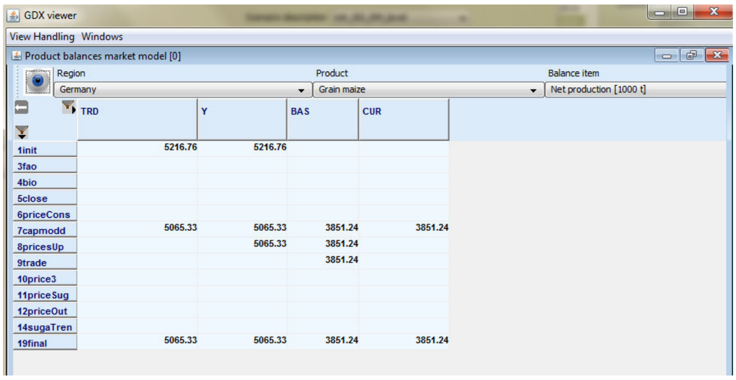
The calibration process starts with the *'arm\data_prep.gms'* module collecting base year information and growth factors from the various gdx containers. The compiled data set is stored under the parameters *DATA* and *p_growthRateMarketModelPos*. The data integration process can be checked in every relevant step with a designated GUI (see Figure 7).

A prerequisite for the calibration is a consistent quantity/price framework in the simulation year. To construct that, a market balancing problem is set up and solved during calibration in the *'arm\data_cal.gms'* module. Projections on commodity balances, trade flows and prices for all market regions enter as inputs in the balancing problem. The balancing problem is defined as a mathematical optimization problem in 'arm\cal_models.gms' and includes the following equations:

- Balance identities for supply, for the two-stage Armington demand system and for trade
- Trade policy mechanisms for public intervention, specific and ad-valorem tariffs, tariff rate quotas, export subsidies and the entry price system of fruits and vegetables
- Accounting equations along the supply chain, i.e. feeding, processing and biofuel production
- Price linkages, i.e. prices derived from the equilibrium market prices (producer, consumer, cif, import and Armington prices); processing margins

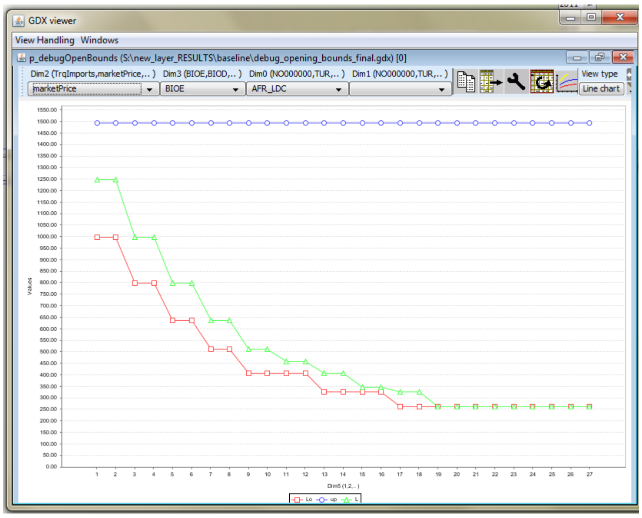
[13] *F.O. Licht's World Ethanol and Biofuels Report provides statistical information and projections on global biofuel production and use.*

Figure 7: Users can track back the data preparation steps with the GUI



The balancing problem is first solved for the base year. After deriving the consistent base year data, prices and quantities are shifted to the simulation year and the balancing problem is solved again. The market model is then calibrated to the consistent price and quantity framework of the simulation year. The algorithm for the balancing problem keeps certain variables fixed while gradually relaxes others in order to find a feasible solution. The relaxation of bounds can be checked with a designated GUI (see Figure 8).

Figure 8: Gradually relaxed lower bounds in the market balancing; here the calibrated value (green) follows the stepwise decrease in the lower bound (red)



4.6 Calibrating the supply models

The last step to complete the calibration of the CAPRI modelling system is to calibrate the regional programming models. Those are calibrated to the projected balances (as derived with CAPTRD) at the given equilibrium prices (result of the market module calibration). Therefore, information from the EC's baseline enter only indirectly (through the CAPTRD results) in the supply model calibration. Users wishing to calibrate CAPRI to the EC's baseline do not need to manually adjust the supply model calibration.

The CAPRI supply models are mathematical programming models; the gross value added of the agricultural sector is maximized subject to a set of constraints. The decision variables include crop acreages (agricultural land use), herd sizes, feed input coefficients (optimal feed mix), fertilizer application to crops (both organic and mineral) and further netput quantities (e.g. young animals, tradable feed). The set of constraints includes the following items:

- Quantity balances
- Land market
- Feed requirements for animal activities
- Crop nutrient balances (N, P, K-balances)
- Policy constraints including Single Farm Payment entitlements, CAP greening measures[14] and production quotas
- GHG emission constraints (optional)

At the calibration point marginal revenues of agricultural activities should be equal to the marginal costs. In order to satisfy this condition non-linear (PMP) terms are added to the cost function. Theoretically, the PMP-terms cover all non-observed or not included marginal revenues and costs. After correcting the objective function with the PMP-terms the calibration point can be interpreted as the profit maximizing choice of the representative agricultural producer.

Following this principle, gross margins at the calibration point must equal to marginal opportunity costs (see Table 1). The shadow values of two critical constraints (land balance and milk quotas) are set exogenously to econometrically estimated levels in CAPRI.

[14] *Direct payments include a mandatory greening component supporting agricultural practices that are beneficial for climate and environment. Greening measures include crop diversification, maintaining permanent grassland and creating ecological focus areas.*

Table 1: Marginal revenue equals to marginal costs (including opportunity costs) in the calibration point

Revenues	Value of outputs	+
	Premiums	+
Linear cost term	Variable inputs (linear part of cost function)	-
Opportunity cost / shadow prices	Value of feed (shadow value of feed balance)	+
	Value of young animals (shadow value of young animal balances)	+
	Value of fertilizers (shadow value of fertilizer balances)	+
	Land rents (shadow value of land balance)	+
	Opportunity cost of set aside (shadow value of set aside restrictions)	+
	Quota rents (shadow value of quota limits)	+
Non-linear cost term	PMP-term of activities	-
	PMP-term of feed	-
	PMP-term of Land conversion and expansion (optional)	-

Prior to calibrating the supply models with the PMP-terms, the feed and fertilizer sub-systems need to be balanced. In order to calibrate the feeding block a Highest Posterior Density (HPD) estimator is constructed. The estimator provides feed input coefficients taking into account the following restrictions:

- Feed use of crop products
- Nutrient requirement of animals based on requirement functions
- Minimum and maximum dry matter intake
- Feed cost equation based on pre-estimated feed prices

The calibration of the fertilizer sub-system also builds on an HPD estimator. The restrictions cover the nutrient balances of cropping activities including the nutrient supply of manure.

4.7 Harmonizing further baseline assumptions

The high-level regional disaggregation in CAPRI enables a very detailed implementation of the CAP[15]. Different coupled and decoupled subsidies of the first Pillar as well as the major items from the second Pillar (LFA support, agri-environmental measures, NATURA2000) are implemented in CAPRI. The differences in national implementations and regional differences are taken into account. Being more detailed, the CAPRI policy module does not need to be updated with the EC's baseline information on CAP policies. Still, a manual cross-check of the main figures is advisable.

The global module includes a detailed calculation of specific and ad valorem tariffs. This is based on an aggregation process calculating average tariff rates for the CAPRI commodities from the raw data at

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[15] In contrast to AGLINK-COSIMO where the EU-15/EU-N13 aggregation leads to a simplified representation of national/regional policies

HS-6 level. Given the different product definitions, tariffs are not cross-checked with the AGLINK-COSIMO result set. There is however a need to cross-check trade policy assumptions regarding the EU (WTO notifications, institutional prices, tariff rate quotas, etc.). Those are defined in CAPRI following the latest legislation and might need to be manually updated during the calibration exercise.

GDP growth rates and exchange rates are mostly taken over directly from AGLINK-COSIMO. This is integrated in the *load_aglink.gms* and *convert_aglink.gms* modules (see above).

CAPRI integrates several projections regarding the biofuel sector. Unfortunately, most of them rely on different assumptions and therefore provide inconsistent projections. It is indeed challenging, for example, to achieve consistency between the EC's baseline projections for biofuels and the more detailed projections of other energy models (e.g. PRIMES, POLES). Currently the CAPTRD module uses PRIMES results of feedstock production for bioenergy production. Those are given at a more detailed (national) level than what can be obtained from the EC's baseline. During the trend calculations the biofuel market balance projections can be optionally scaled to the EC's baseline figures providing a full consistency at EU-15 and EU-N12 aggregated levels. Therefore CAPRI is calibrated to the same biofuel demand at EU aggregated level and so is able to match the EC's baseline assumptions on mandates and their rate of fulfilment.

4.8 Practical steps to calibrate CAPRI to the EC baseline

This section summarizes the working steps the user need to go through in order to calibrate the CAPRI modelling system to a new set of AGLINK-COSIMO results.

1. Convert the original result sheet in the appropriate format; check possible changes in nomenclatures and mappings; get a first impression on the original projections by using the GUI; (see section 4.2);

2. Update code lists and mappings in *'\baseline\aglink_sets.gms'* and *'baseline\aglink_mappings.gms'*;

3. Run CAPTRD with the new AGLINK-COSIMO results; examine results with the GUI; update or adjust the *'load_aglink.gms'* module if necessary; modify variable bounds or equations of the trend models if necessary (see section 4.3);

4. Run the global module in order to prepare the global database including the new baseline projections; examine results and modify the modules *'global\convert_aglink.gms'* and *'global\bio_fuel_markets.gms'* if necessary[16];

5. Cross-check those implicit assumptions that are set manually in the market balancing procedure but should be harmonized with the ones used in the EC baseline. This mainly includes the policy assumptions (tariffs, WTO notifications, institutional prices etc.). The relevant code snippets are in the *'arm\data_cal.gms'* module;

6. Run CAPMOD in 'baseline mode' so the market module and the supply modules are calibrated to the results of CAPTRD and global.gms;

7. Run CAPMOD again in 'simulation mode' with the baseline scenario to get the full set of calibration results;

[16] *Note that the global module uses the same mappings as CAPTRD, so no additional work need to be done in this respect*

8. Run test scenarios with CAPMOD in order to check the simulation behaviour of the calibrated modelling system. For this, test scenarios are available from the CAPRI developers.

For further details on the practical aspects of calibration and on best practices please refer to (Himics et al. 2013).

4.9 Evaluation of the CAPRI calibration exercise

After the technical steps of the calibration, the CAPRI results need to be cross-checked and validated in order to ensure reliability and plausibility of the baseline. As CAPRI is calibrated to the AGLINK-COSIMO baseline, first objective of the validation exercise is to check the deviation of the derived results from the original projections. The desired outcome is that CAPRI results are relatively close to AGLINK-COSIMO results. However, they are not expected to replicate them exactly due to a multitude of factors including (1) a significantly higher level of disaggregation in terms of regional coverage and agricultural production activities, EU supply representation, (2) differences in behavioural models for agricultural supply and demand and (3) more detailed CAP policy modelling. Given its higher complexity, the CAPRI model needs to take into consideration significantly more interactions between model agents and more micro- and macroeconomic constraints (e.g. cost allocation, nutrient balances, policies) during the calibration.

Taking into account the above differences in model structures, the CAPRI baseline results are first evaluated at the most aggregated level. The EU aggregate results (EU-27, EU-15, and EU-N12) are directly comparable with those of AGLINK-COSIMO for example by using the data management tool DataM (Helaine et al. 2013). Some examples are presented for baseline comparison on Figure 9 to Figure 13, all of them are related to the 2012 calibration exercise. As exemplified above, CAPRI does not exactly replicate the AGLINK-COSIMO baseline in either case.

The next step of the evaluation consists of examining results at MS level and blocks of other non-EU countries. The focus in this case is on prices, production level (areas, number of animals), supply/demand (production, domestic use), trade (export, import, net export) and applied policy instruments. An important distinction has to be made between activities that are available in AGLINK-COSIMO and those that are not. The results for non-AGLINK-COSIMO activities are evaluated based on expert opinion or other sources (e.g. the Outlook workshop organised by the DG AGRI and JRC-IPTS, Agricultural Markets Briefs[17]).

The main challenge in validating the CAPRI baseline is the high geographical resolution of EU results. CAPRI produces a huge quantity of regional and farm-type data which are difficult to cross-check with other information sources. The AGLINK-COSIMO baseline does not provide results beyond EU aggregate level and no other baseline projections are available with a comparable regional coverage. Time and resources limitations typically do not allow checking all the disaggregated results and derived indicators. Thus, a detailed expert validation must concentrate on selected indicators at representative countries, sectors, activities and policy areas, typically chosen according to a specific particular study or scenario analysis for which the baseline is constructed.

[17] European Commission (2012): Prospects for the olive oil sector in Spain, Italy and Greece – 2012-2020', Agricultural Markets Briefs. Available at http://ec.europa.eu/agriculture/analysis/markets/market-briefs/02_en.pdf

Figure 9: Comparison of CAPRI and AGLINK-COSIMO baselines for wheat balances in the EU-27 (1000 t)

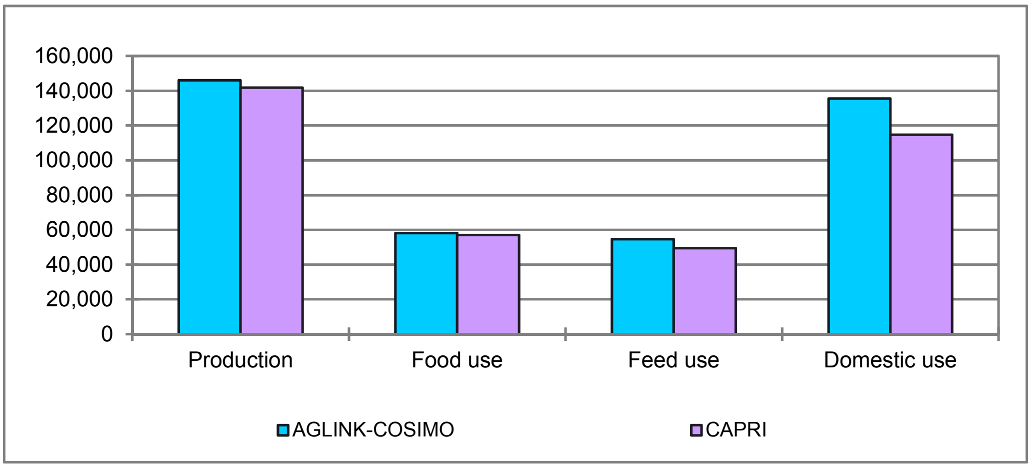


Figure 10: Comparison of CAPRI and AGLINK-COSIMO baselines for grain maize balances in the EU-27 (1000 t)

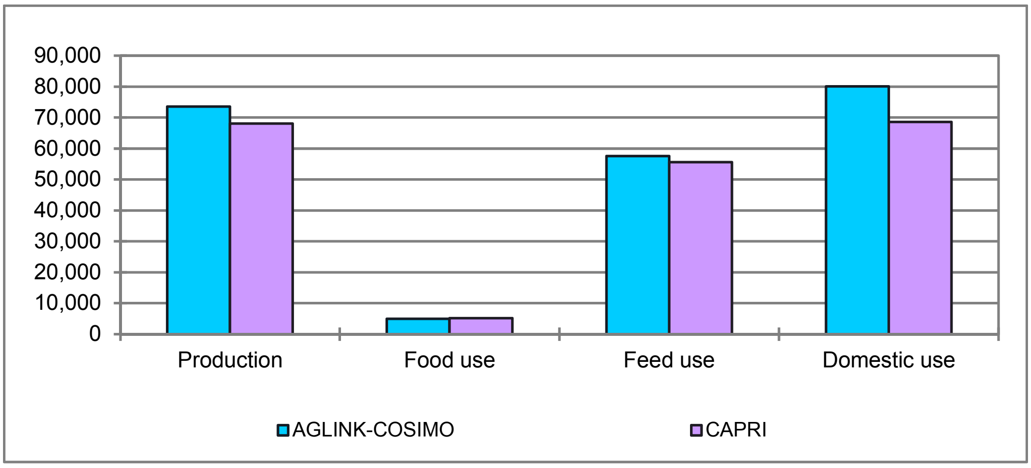


Figure 11: Comparison of CAPRI and AGLINK-COSIMO baselines for rapeseed balances in the EU-27 (1000 t)

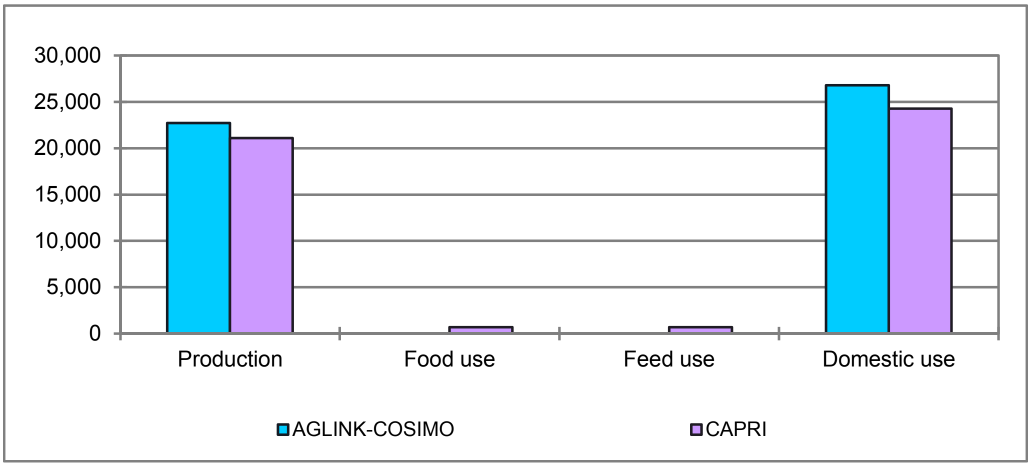


Figure 12: Comparison of CAPRI and AGLINK-COSIMO baselines for beef and veal meat balances in the EU-27 (1000 t)

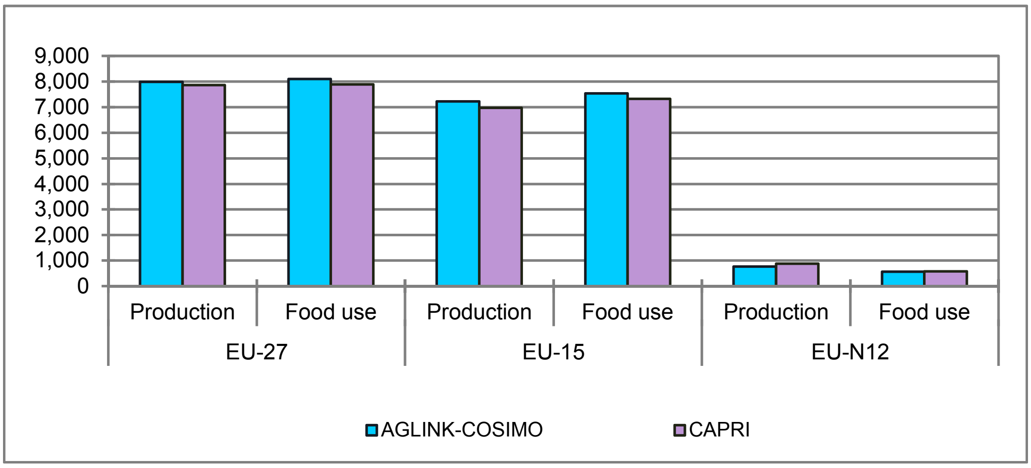
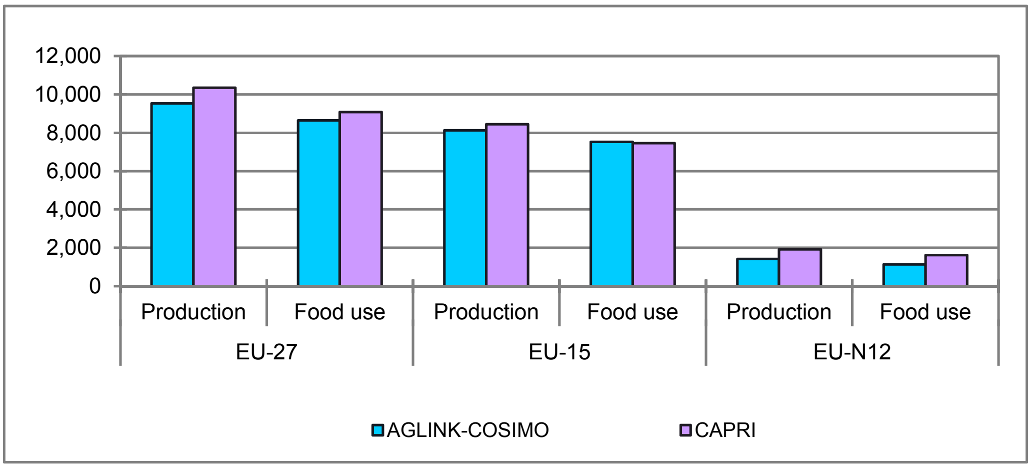


Figure 13: Comparison of CAPRI and AGLINK-COSIMO baselines for cheese balances in EU-27 (1000 t)



5. ESIM CALIBRATION

5.1 Background

Before 2012, ESIM was calibrated manually according to the price development[18] on the global commodity markets as projected by the EC baseline. This method did not ensure a complete alignment of the model with the market balances of the EC baseline. The approach relied on a trial and error process of finding appropriate parameter values. A thorough evaluation revealed the following disadvantages of the approach:

- Time consuming
- Requires deep knowledge of the model behaviour and modelling skills
- Not monitored or checked automatically for plausibility (i.e. unrealistic high values allowed)

[18] *ESIM was calibrated to relative changes in market prices rather than to absolute values.*

- The multidimensional nature of the problem makes it difficult to find solutions for more than one target values
- More than one solution vector exist with the same initial conditions (path dependency of manual corrections)
- The solution vector depends on individual decisions of the modeller, making the baseline process difficult to reproduce

In order to tackle these problems a project was launched aiming at the generation of an automated calibration procedure. The outcome of the project addressed all of the problems identified above and significantly improved the overall quality of the calibration procedure.

5.2 Automated calibration procedure

The automated calibration procedure is the approach underlying the recent (2012 and 2013) baseline exercises. The procedure is divided in several steps with different input requirements. Its main purpose is to homogenize as far as possible the data used of exogenous market drivers and to produce similar EU-15 and EU-N12[19] market balances as AGLINK-COSIMO which gives the EC baseline. The basic idea is to compliment the AGLINK-COSIMO market projections at the EU-15 and EU-N12 levels with further details at the MS level. Furthermore, the calibration procedure ensures that the market projections of both models are in line with each other.

The input data of the procedure are collected in the following files:

- 'IPTS_DATA_REQU.xls': this file contains information on the developments of macroeconomic variables, yield growth rates, trends in human demand, price policies, direct payments, milk and sugar quotas and the exogenous land used for second generation biofuels. The information is harmonized as far as possible with the assumptions of the EC baseline.
- 'calibration_aglink_input.xls': for the period from 2008 until the last projection year this file contains the following annual data of the EC baseline:
    - EU-15 and EU-N12 percentage development of production (SUPPLY in ESIM) and total consumption (TUSE in ESIM), relative to the average of 2006 and 2007[20] as the reference situation;
    - percentage development of world market prices;
    - absolute values of net exports (NETEXP);
    - margins of acceptance of deviation of the market balances of ESIM from EC baseline values (SUPPLY and TUSE in percentages and NETEXP in absolute values);
    - percentage developments of EU prices (only for comparison purposes and not for calibration).

---

[19] As mentioned in Section 2.3, in the 2013 baseline exercise Croatia was still treated as a candidate country in ESIM, thus it was calibrated to EU-N12 market balances.

[20] Note that in ESIM the current base year is an average of the years 2006 and 2007 for supply and demand and for prices of animal products. For crop prices, only the year 2006 is taken into account in order to avoid the extreme prices from 2007. Furthermore, the model uses Eurostat balance sheet data while AGLINK-COSIMO uses Eurostat production data. There is a major difference in these two databases. The marketing year corresponds to the harvesting year in the production survey while it corresponds to the harvesting year + 1 in the balance sheet data. For example, the marketing year 2005/2006 corresponds to 2006 in AGLINK-COSIMO and in the Eurostat production survey, while it corresponds to 2007 in ESIM and in Eurostat balance sheets. For this reason to calibrate both models the reference in AGLINK-COSIMO is the average of 2005 and 2006 for crops.

- 'cal_control.xls': this file enables to select which market balances will be calibrated to the target values from the EC baseline.

For the automated procedure of calibration the behavioural equations in ESIM, which are at the MS level, are extended with calibration parameters. In the MS of the EU-15 and the EU-N12 those calibration parameters shift the market items of supply and demand by the same factor. The shift ensures that the MS target values (generated based on the development of the market balances from AGLINK-COSIMO) are matched. In this way, the differences between the EU-15 and EU-N12 in the ESIM database are not altered. However, note that the procedure does allow for the application of different calibration factors between the Member States of the EU-15 and EU-N12 regional aggregates. The target values at MS level are obtained by applying the percentage changes derived from the AGLINK-COSIMO dataset[21] to the MS base year values in ESIM. As a result, the aggregated SUPPLY, TUSE and NETEXP may differ from the original AGLINK-COSIMO target values at EU-15 and EU-N12 levels. . For this reason, margins of acceptance need to be defined for the deviation in SUPPLY, TUSE and NETEXP. In this way the absolute targets are transformed to target intervals, and the derived market balances (at the MS level) are consistent with the developments in AGLINK-COSIMO (at the EU-15 and EU-N12 levels).

The automated calibration procedure can be summarized in two main steps:

- The first step of the calibration is to generate, for the projection period (starting in 2008), ESIM consistent target market balances (at the MS level) which are in accordance with percentage developments of SUPPLY and TUSE and with the absolute NETEXP targets obtained in the EC's baseline (EU-15 and EU-N12 levels). With margins of acceptance of deviation, freedom is given to the system since definitions, base year data, and modelling systems often present differences between the models. The input required for this step is contained in the file 'calibration_aglink_input.xls'.
- The second step is shifting the behavioural curves at MS level (yields, human demand, feed demand and processing demand) so that the model reproduces the target market balances from step 1. In this step the values of the calibration parameters are defined. The procedure is flexible enough to operate for only some of the market elements (partial calibration) or for a majority or all of them (full calibration).

Since the calibration exercise allows for selecting specific markets, only world market prices and the EU biofuels/plant oils/oilseeds system were calibrated in past partial calibration exercises. The reason to select only those markets is that ESIM has not been designed with the purpose of simulating developments in the world markets and that the biofuels/plant oils/oilseeds system is still in an immature stadium subjected to high policy influences and structural changes. Thus, a calibration of those markets based on external information sources is inevitable.

The partial calibration has the advantage that, for non-calibrated markets, it shows the ESIM simulated reaction to policy changes and to macroeconomic and world market price developments. Thus, the partial calibration allows for a comparison of the market behaviours in ESIM and in AGLINK-COSIMO. This highlights differences between the models which may lead to the identification of (1) markets responding to exogenous factors (introduced into AGLINK-COSIMO to meet the expectations of market experts) rather than price movements, or (2) of differences in the utilized data, behavioural coefficients or other assumptions. Thus, the exercise contributes to the better understanding of market structures in the two models which can also result in corrections and improvements of the models.

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[21] *The percentage change is calculated as projected Aglink-Cosimo values relative to the calculated Aglink-Cosimo base year*

The full documentation of the automated calibration procedure can be found in Annex 5. Both the approach and the procedure itself are described, specifying the required input data and explaining the generated outcomes.

5.2.1 Alignment of policy and macroeconomic information

After calibrating the model to the base year data, the next step is updating the relevant policy information and macroeconomic variables. The required information is collected in an Excel file (IPTS_DATA_REQU.xls). This file is a direct input to the automated procedure.

(1) Trade policies

In 2011, the trade policy representation in the ESIM model was harmonised with the EU module of AGLINK-COSIMO. The same representative tariff lines have been chosen for the modelled commodities (this defines tariff rates and tariff rate quota instruments in ESIM). For example, the out of quota and the in-quota tariff rates for beef refers to the tariff line 0201 30 00 (Meat of bovine animals, fresh/chilled, boneless) in both models. Quota limits under tariff rate quota regimes (TRQ) are harmonized too.

Each year, any new information on concluded trade agreements introduced in the AGLINK-COSIMO EU module is to be updated in the ESIM model. For example, an additional TRQ has been granted to the US and Canada for beef, entering into force in 2013. Therefore the total beef TRQ limits had to be modified in both models for the 2012 baseline exercise.

Assumptions on the applied export refund policies are harmonized across the two models. For example, in the 2012 baseline exercise, export refunds for dairy products were assumed not to be activated by the Management Committee over the EC's baseline projection period. Consequently, export subsidies for the dairy sector were set to zero in ESIM.

(2) The CAP

The baseline assumption is a continuation of the CAP as it has been already decided at the time of the baseline exercise. The finer geographical resolution allows depicting EU agricultural policies in more detail compared to AGLINK-COSIMO. Nevertheless, the following assumptions need to be cross-checked with AGLINK-COSIMO for the calibration exercise:

- Quotas are abolished or phased out the same years: for example, milk quotas are abolished by 2015 and for sugar by 2017 further to the 2013 CAP reform;
- Intervention prices and ceilings are in line and export refunds are treated the same way.

(3) The biofuel sector

The assumptions on the development of the biofuels markets need to be harmonized with those underlying the EC's baseline in terms of share of renewable energy in total fuel consumption and the contribution of second-generation biofuels to that target. The necessary information relates to:

- The total fuel consumption in tonne of oil equivalent
- The energy share of first-generation biofuel in the total fuel consumption

(4) The macroeconomic assumptions

The same macroeconomic assumptions as for the EC's baseline construction cannot be used because the information needs to be disaggregated at MS level and also because in ESIM prices are expressed in real terms whereas they are nominal in AGLINK-COSIMO. However the same data sources are used.

The relevant macroeconomic variables for the ESIM model are: the population growth, the deflator, the oil price and the GDP growth.

For the EU MS, Turkey and Croatia the AMECO[22] historic data and short term projections (Year N+2) are used. For the remaining years the growth rate projected by IHS Global Insight is utilised. For the population projections the source is Eurostat, but only the changes are applied to avoid any break in time series. For the US and the World the AGLINK-COSIMO numbers, calculated based on IHS Global Insight forecasts, are used. The Western Balkans aggregate is calculated using the IHS Global Insight numbers from Kosovo, Serbia, Bosnia, Montenegro and Macedonia.

The oil price and the USD deflator of the AGLINK-COSIMO model are used to calculate the oil price development in real terms.

The assumptions on exchange rate developments in AGLINK-COSIMO are not used in the ESIM model because those are nominal exchange rates. An attempt to introduce corrected exchange rates to remove the inflation effect in the ESIM model has been carried out for the baseline 2010 but it was discarded as the results were not reliable. For this reason, ESIM assumes no exchange rate development and a fixed real exchange rate of 1.31 USD/EUR.

5.2.2 Transfer of the AGLINK-COSIMO information

The required data to start the automated calibration procedure are the change relative to ESIM base year in supply (QP in AGLINK-COSIMO), total use (QC), real world prices (XP) and the real EU prices (PP). The absolute values of net exports (QP-QC) are needed. All the data is to be provided for the EU-15 and EU-N12. As mentioned above, the data is to be collected in a template named 'calibration_aglink_input.xls' following a specific format.

Whereas for CAPRI the mapping between AGLINK-COSIMO and CAPRI is done in GAMS as part of the calibration program, for ESIM the AGLINK-COSIMO data is formatted in the required format using the data management tool DataM (see Hélaine 2013). A pre-defined DataM report derives the absolute values which are then exported to Excel as 'AGLINK data for ESIM calibration_DataM.xls'. This file, in turn, is linked to 'AGLINK data for ESIM calibration.xls'. Thanks to these links the data process can be rapidly updated each time the preliminary EC's baseline is modified.

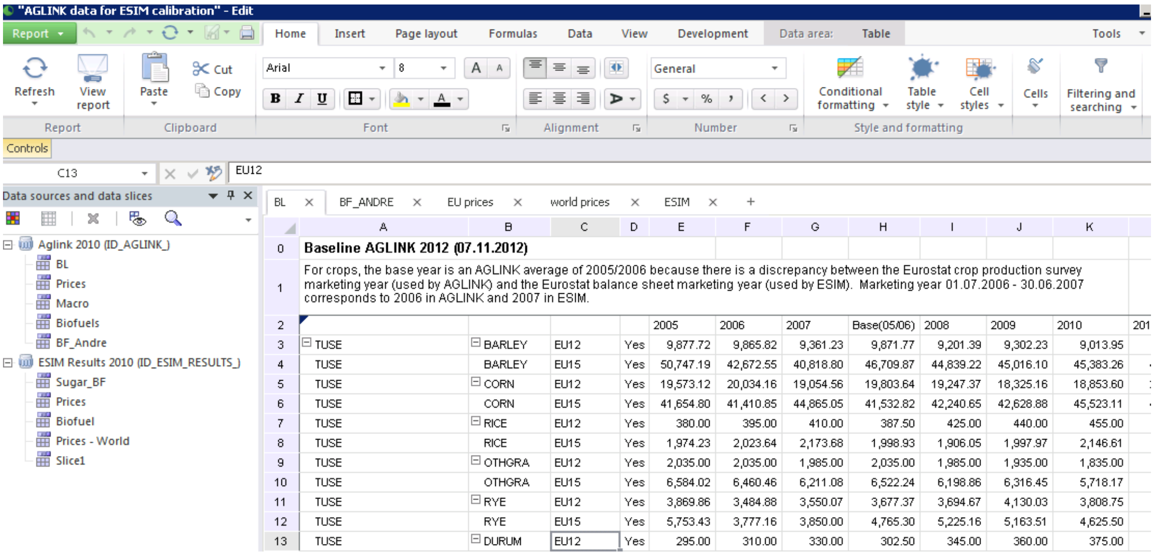
In DataM the data of one model (in this case AGLINK-COSIMO) can be displayed using the codes of another model (ESIM here) (see Figure 14). In addition the base year average is automatically calculated: for crop balance items a 2005/2006 average is calculated, for crop prices base is 2006 and for animal products base correspond to the 2006/2007 average in AGLINK-COSIMO. For biofuels, the details for the

[22] *From the AMECO database, the following data series are used:*
Total population (National accounts) (NPTD)
Gross domestic product at 2005 market prices (OVGD)
Price deflator gross domestic product at market prices (PVGD)

From the IHS Global Insight database, the following forecasts are used:
Population: Total
Real Gross Domestic Product
Deflator: GDP Year-on-Year Percent Change

EU-15 and EU-N12 are not available in AGLINK-COSIMO therefore the EU-27 numbers are repeated twice.

Figure 14: DataM application screen; AGLINK-COSIMO data in ESIM nomenclature



Sugar requires the major data transformation because of the difference in definitions (see Annex 1). Total use in ESIM (TUSE) is calculated as sugar food use in AGLINK-COSIMO plus the sugar beet quantity used for biofuel production times the transformation coefficient between sugar beet and sugar ('YLD..SBE'). Sugar supply in ESIM is associated with sugar beet production times the transformation coefficient ('YLD..SBE'). The milk supply is calculated as milk deliveries (DEL) plus feed use (FE).

Concerning commodities for the balance items many can be mapped one to one (see Annex 1) except for:

- Other grains in ESIM are mapped to Oats which is the main component of the ESIM aggregate.
- Drinking milk in ESIM is mapped to Fresh dairy products despite the AGLINK-COSIMO aggregate is much wider but as only percentage changes are needed it's a good proxy.

AGLINK-COSIMO does not provide world prices for all ESIM products. Therefore, the world prices of some ESIM products are linked to different commodities in AGLINK-COSIMO (see Table 2).

Table 2: AGLINK-COSIMO world prices used for ESIM products

ESIM	AGLINK-COSIMO
Barley, corn	Maize (MA)
Common wheat	Wheat (WT)
Rice	Rice (RI)
Sunflower seed, Rapeseed, Soybean	Oilseeds (OS)
Soy meal, Sunflower meal, Rape meal	Protein meals (PM)
Sunflower oil, Soya oil, Rape oil, Palm oil	Vegetable oil (VL)
Sugar	Sugar Raw (SUR)
Beef	Average of the Beef (BV) Atlantic and Pacific prices
Pork	Average of the Pork (PK) Atlantic and Pacific prices
Poultry	Poultry (PT)
Sheep	Sheep (SH)
Butter	Butter (BT)
Cheese	Cheese (CH)
SMP	SMP (SMP)
WMP	WMP (WMP)

Net exports for the EU-15 and EU-N12 are calculated as the difference between production and consumption (in the file 'AGLINK data for ESIM calibration.xls'). The reason for not taking over net export figures directly from AGLINK-COSIMO is a difference in the treatment of stocks.

For more details on biofuels see the specific Annex 3.

5.3 Possible pitfalls of the calibration procedure

ESIM being a complex system of interrelated equations, the calibration procedure may not solve automatically. Some modules are more exposed to difficulties. For example, the modules of the processing industry are especially sensitive.

5.3.1 Oilseeds/plant oils/biofuels

In the EU, biodiesel supply determines to a great extent the demand for rape oil. Furthermore, the supply of rapeseed oil (being the primary derived product) fully determines the demand for rapeseed. As a consequence, when calibrating the supply of biodiesel and rapeseed oil, the demand for rapeseed is already indirectly calibrated. In this case, in the file 'cal_control.xlsx', only the calibration of the supply side needs to be indicated (set value to 1). A direct calibration of the demand side is unnecessary (set value to 0). Forcing a direct calibration of TUSE of rapeseed or rape oil most likely drives the system into an infeasible problem setup.

The processing systems 'sunflower seed/sunflower oil/biodiesel' and 'soybean/soy oil/biodiesel' are less rigid. In the EU, demand for sunflower oil and soy oil is more diversified; the share of human demand is bigger than for rapeseed oil.

Rapeseed meal, sunflower seed meal and soy meal are by-products of the plant oil production and are thus excluded from the calibration.

5.3.2 Milk and dairy products

In ESIM the commodity MILK is the milk delivered for processing plus the milk used for feed. In AGLINK-COSIMO the quantity produced of milk is disaggregated to deliveries, feed use and other use. Thus, MILK in ESIM is associated with the addition of milk deliveries and milk used for feed from AGLINK-COSIMO. MILK is a non-tradable product subject to a domestic equilibrium. For that reason calibration is only done with respect to SUPPLY or TUSE. Additionally, the transformation of raw milk to dairy products is different in the two models (see Annex 1).

Only the main dairy products are calibrated, the less important ones are left to freely adjust. SUPPLY and TUSE of butter, cheese, skim milk powder (SMP) and whole milk powder (WMP) are calibrated. The rest of the dairy products are not. It is generally possible to increase the number of calibrated dairy products. In the 2012 exercise, for example, drinking milk (CMILK) was mapped to fresh dairy products from AGLINK-COSIMO but at the end it was not calibrated. In case of calibrating them, as these are different products, it is important to align only to the percentage changes with respect to the base year and not to the absolute values because of the significant differences in product definitions. Since CMILK is non-tradable only SUPPLY or TUSE should be calibrated.

5.3.3 Other grains

'Other grains' is an aggregate commodity with different components in the two models. In ESIM 'other grains' consists of oats, sorghum, triticale, mixed grains other than maslin, and other cereals derived from the EUROSTAT database (buckwheat, millet, and canary seed). 'Other grains' in AGLINK-COSIMO, on the other hand, does not contain oats (which is modelled separately) but contains maslin.

For the 2012 calibration, given the importance of oats relative to the other grains in this group, the other cereals in ESIM were mapped to oats in AGLINK-COSIMO. However, at the end in the "cal_control.xls" file it was decided not to calibrate this aggregate. In the case of a direct calibration of the other grains market, it is advisable to exclude the net exports for the generation of consistent market balances (step 1) and to calibrate only to the percentage development of SUPPLY or TUSE.

5.3.4 Consequences of the sensitivity of some modules in the settings for the calibration procedure

Step 1 of the calibration generates target balances for ESIM. Step 2 only searches for the values of the calibration parameters but does not change the target balances of step 1. An important aspect is the selection of the balance items that will be calibrated. The user must be aware of the main differences in definitions, base year data and modelling systems (processing modules and static vs. dynamic) before generating the target balances and selecting the balance items for calibration. These two aspects are controlled in the files 'calibration_aglink_input.xls' and 'cal_control.xls'. Users have control over the calibration procedure by setting three options in these two files.

The first possibility is to define the margins of acceptance of deviations for SUPPLY, TUSE and NETEXP in the file 'calibration_aglink_input.xls'. Remember, SUPPLY and TUSE are calibrated to percentage developments while NETEXP to absolute values. The system will generate the target balances even if the generated balances are lying outside the desired intervals. In these cases the system will report these markets as infeasible (see parameter 'infeschk' in the outcome from GAMS after running the file 'cal_market_balancing.gms'). The user can still decide to use the generated targets, although the margins of acceptance are not respected.

The second possibility the user has is to delete the NETEXP of some of the markets in the file 'calibration_aglink_input.xls'. This can be used in the cases where the user desires to calibrate to the development of only one of the market items, for example supply. Deleting NETEXP in the above file results in fewer constraints in step 1 of the calibration. Thus, the generated target values can reproduce exactly the percentage development in the EC baseline. Of course, as these percentage developments are applied to the base year data of ESIM, the generated balances will not reproduce the net exports from the EC baseline. In the 2012 exercise the NETEXP of the oilseeds and the plant oils were omitted. Due to the characteristics of the 'oilseeds/plant oils/biofuels' system mentioned above, it is desired to calibrate only to the supply of oilseeds and plant oils. Thus, the removal of NETEXP from the file 'calibration_aglink_input.xls' results in a more accurate calibration of supply[23]. Note that due to differences in definitions, the target developments used in step 1 of the calibration were defined based on the mapping presented in Annex 1.

The file 'cal_control.xls' gives the user the third possibility to control the calibration procedure. The user can define in this file to which targets (World prices (PW), SUPPLY and TUSE) the commodity balances should be calibrated to. It is not required to indicate the calibration to NETEXP since this is the result of SUPPLY-TUSE. Careful attention must be paid when completing this file and the characteristics of the processing systems mentioned above should be considered. The final setting of the 2012 calibration exercise is presented in Table 3. In 2013 only a partial calibration was conducted.

Note that in Table 3 'other grains' (OTHGRA) is omitted from calibration as product definitions differ to a large extent. Sugar (SUGAR) is not calibrated either, since this product is subject to production quotas[24], which makes it impossible to harmonize the development of SUPPLY between the aggregated EU and the single MS level (see Annex 5 for further information). Also, the automated procedure applies the target percentage change equally to all MS. In the case of sugar, this would not be the most appropriate approach due to the big difference in shadow prices between MS. Other commodities were not calibrated due to specificities in the processing systems or because they are not captured in AGLINK-COSIMO.

[23] The generation of target market balances is formulated as a minimization problem. It searches for SUPPLY and TUSE values which minimize the sum of the squared percentage deviations to the given targets (see Annex 5). In the case that NETEXP are not considered SUPPLY and TUSE targets can be matched without deviations.

[24] The expiry of the EU sugar quota system by the end of the 2016/2017 marketing year might change the treatment of sugar in future model versions.

Table 3: Final setting of the 'cal_control.xls' file of the 2012 full calibration exercise

	SUPPLY		TUSE		PW – World price
	EU-15	EU-N12	EU-15	EU-N12	
CWHEAT	X	X	X	X	X
DURUM	X	X	X	X	X
BARLEY	X	X	X	X	X
CORN	X	X	X	X	X
RYE	X	X	X	X	
OTHGRA			X	X	X
RICE	X	X	X	X	X
SUGAR					X
POTATO					
SOYBEAN	X	X			X
RAPSEED	X	X			X
SUNSEED	X	X			X
SOYMEAL					
RAPMEAL					
SUNMEAL					
SMAIZE					
FODDER					
GRAS					
GLUTFD					
SMP	X	X	X	X	X
WMP	X	X	X	X	X
CREAM					
CONC_MLK					
ACID_MLK					
WHEY					
MILK	X	X			
CMILK					
BUTTER	X	X	X	X	X
CHEESE	X	X	X	X	X
OTHDAIRY					
BEEF	X	X	X	X	X
SHEEP	X	X	X	X	X
PORK	X	X	X	X	X
POULTRY	X	X	X	X	X
EGGS	X	X	X	X	
SOYOIL	X	X			X
RAPOIL	X	X			X
SUNOIL	X	X			X
PALMOIL					X
BIODIESEL	X	X	X	X	X
ETHANOL	X	X	X	X	X

5.4 Evaluation

The automated procedure addressed all disadvantages of the manual calibration that was carried out in 2011 and before. The main disadvantages presented in Section 5.1 have been removed. However, the automated procedure still requires deep knowledge of both models. Furthermore, even though the procedure is equipped with several monitoring tools (infeasibilities in the generation of consistent market balances or shifter alerts when calibration parameters go above or below pre-defined values given by the user), a final validation of the obtained results at MS level still needs to be carried out.

A visualization of the baseline results obtained with the partial calibration and full calibration compared to the AGLINK-COSIMO gives a hint of markets which required strong calibration parameters. An excel template, using the data management tool DataM (see DataM 2013), has been generated at IPTS for this purpose. It generates tables of those three baselines at the EU-27 level that can be graphically analysed in Excel. As mentioned in Section 5.3.4, in 2013 only a partial calibration was conducted. In 2013, ESIM was required to do an analysis of the consequences of the milk quota abolition at Member State level for which the partial calibration was sufficient. For that reason the examples presented below are based on the 2012 calibration exercise.

Figure 15: AGLINK-COSIMO baseline, partial and full calibration of ESIM: common wheat in the EU-27

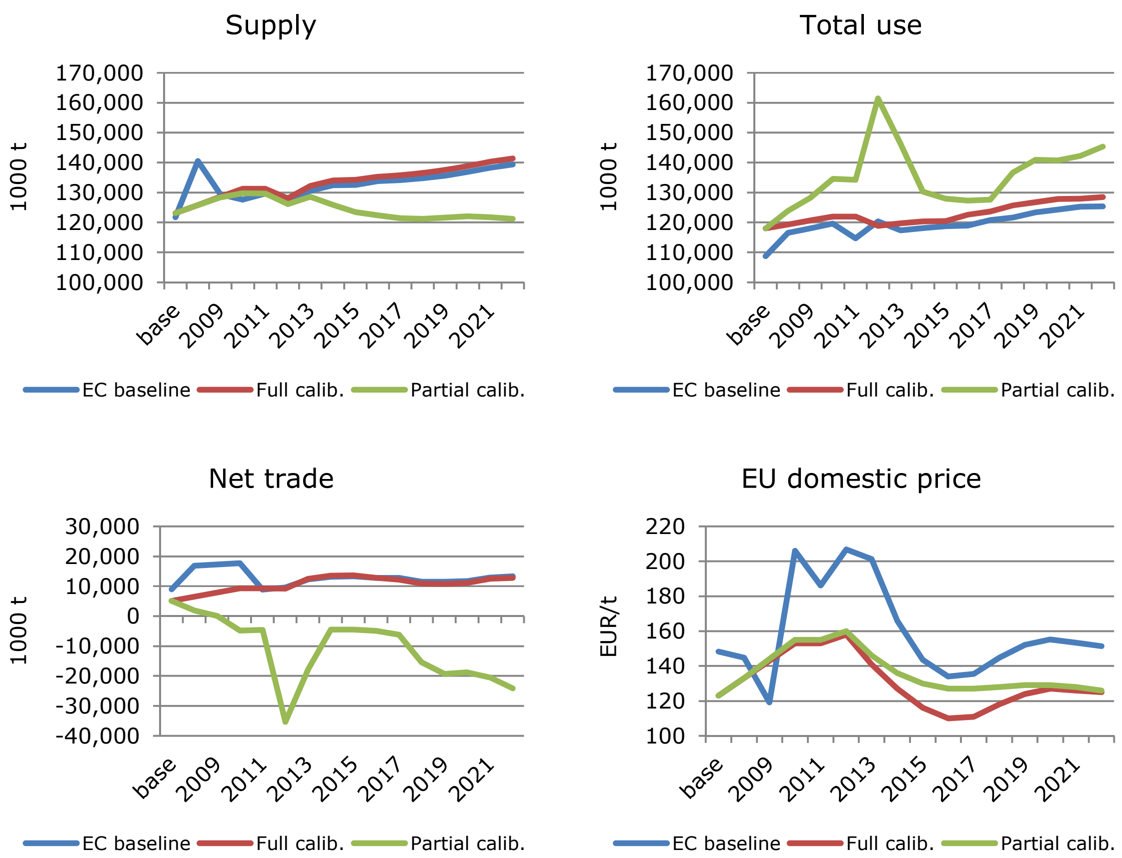


Figure 16: AGLINK-COSIMO baseline, partial and full calibration of ESIM: sheep meat in the EU-27

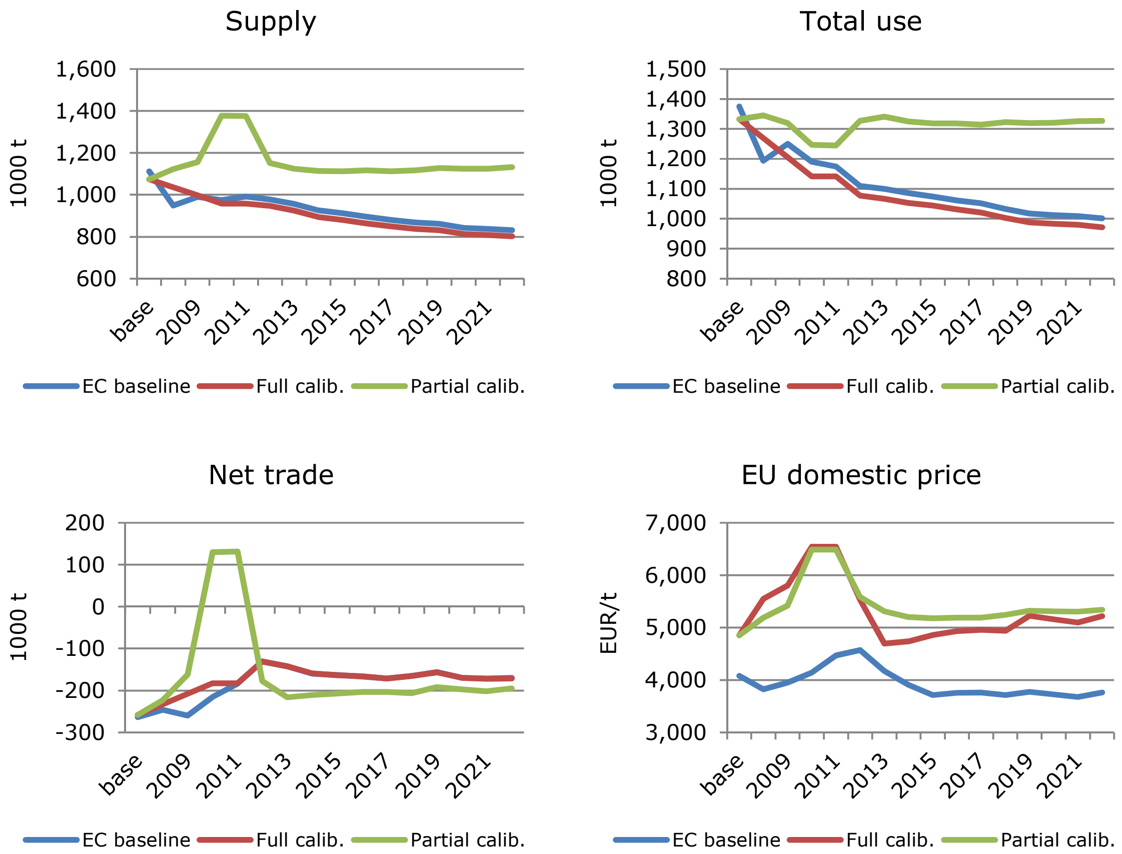
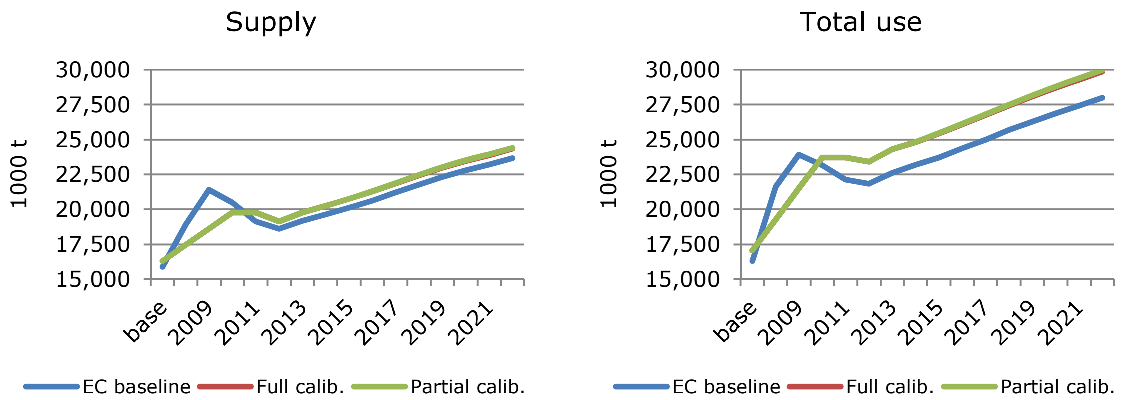


Figure 17: AGLINK-COSIMO baseline, partial and full calibration of ESIM: rapeseed in the EU-27



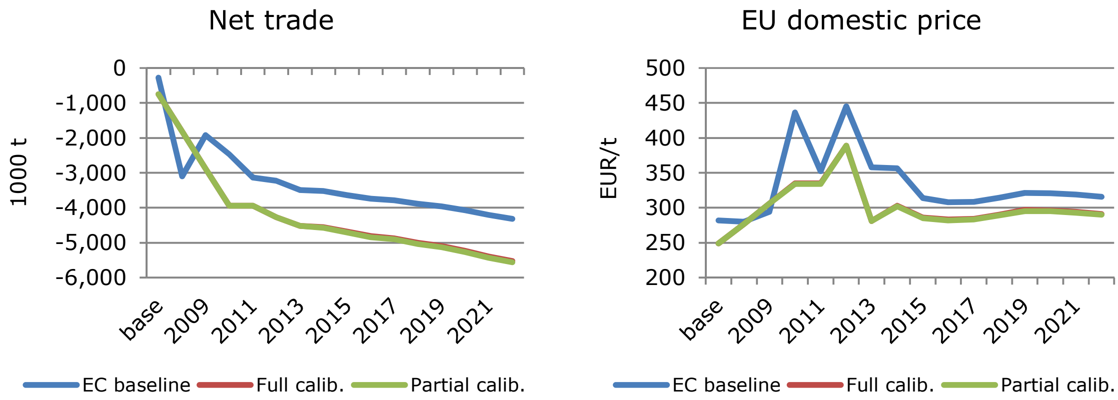


Figure 18: Prices (real) of cereals in the EU in ESIM

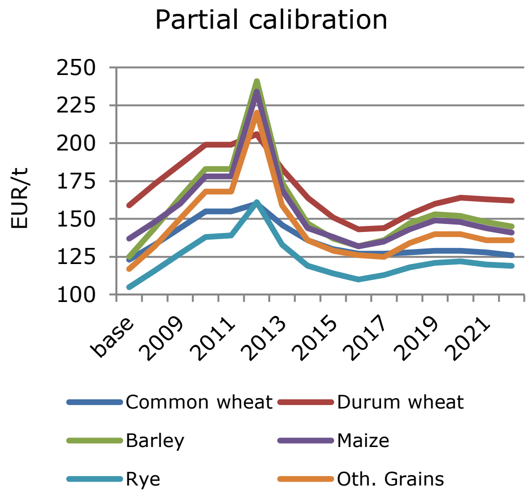
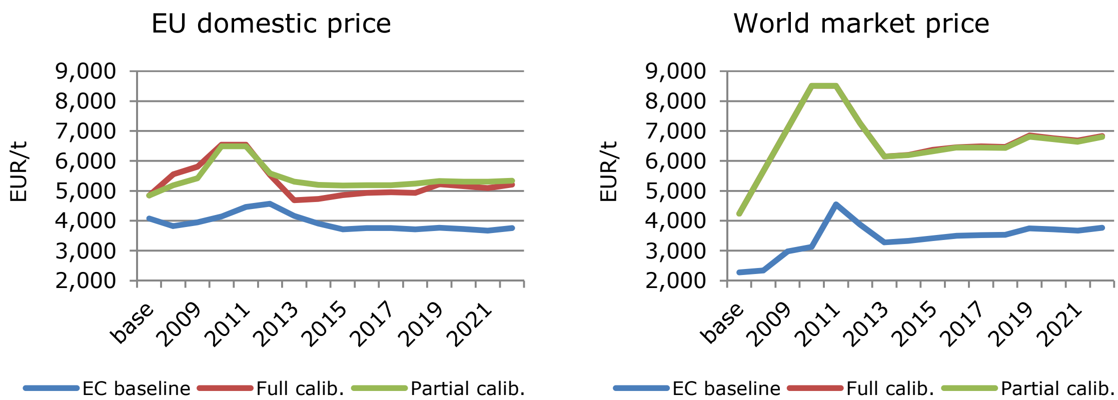


Figure 19: EU domestic and word market prices (real) of sheep meat



By analysing the differences in the above baselines, important (and potentially hidden) aspects can be revealed. The comparison also gives relevant information about the performance of the calibration procedure.

For example, in Figure 15 it can be seen that the partial calibration of SUPPLY and TUSE of common wheat in the EU does not follow the baseline from AGLINK-COSIMO. Supply in ESIM is driven by own-price (relatively stable in this case) and cross-price effects of close substitutes as for example barley and maize whose price development is more favourable than common wheat (see Figure 18). TUSE of common wheat in the partial increases due to an increase in EU prices of other cereals (barley, maize, rye and other grains, see Figure 18). The cross-price effect is strong in ESIM and higher than in AGLINK-COSIMO. One reason for this behaviour is that ESIM has a static structure (subsequent equilibrium states are always determined with respect to the base year), while AGLINK-COSIMO has a dynamic one (it considers prices of past years). This structural difference results in higher price reactions simulated with ESIM (partially calibrated) than with AGLINK-COSIMO; these reactions are often captured by the price elasticities.

Figure 16 is a good example of an autonomous development considered in AGLINK-COSIMO but not in ESIM. EU real domestic prices of sheep meat are slightly decreasing in AGLINK-COSIMO and slightly increasing in ESIM (see Figure 19). Also the projected domestic prices of substitutes (beef, pork and poultry) are stable in AGLINK-COSIMO. Thus, the downwards trend in production in AGLINK-COSIMO (decrease of 25.3% between base and 2022) is not price driven (price fall of only 7.7% between base year and 2022), but corresponds to an autonomous negative trend in sheep production (despite the increasing trend in world market prices over the past years). This negative trend is difficult to capture in an economic model where producers are assumed to be profit maximizers and which does not explicitly contains the negative trend.

The last example is the market for rapeseed (see Figure 17). It can be seen that the calibration of ESIM with AGLINK-COSIMO has been achieved; however, with some consequences at MS level. In the case of supply, in the historic period (from the base year to 2012) important developments in the area cultivated have occurred which are not explained only by price developments since rapeseed prices have not significantly increased in comparison to the other grains. ESIM does not capture this area increase since its base period is the average of 2006 and 2007. The automated procedure inserts strong calibration parameters (shifters) in order to align the market balances between the models. But in the supply side shifters are only attached to the yield equations resulting in implausible high yields. This occurs specially in the EU-N12 pushing the yield of those MS up.

Non-price driven developments in the historic period may have occurred in the supply as well as in the demand of other commodities. These developments can originate from structural changes in the partial elements of supply (area and yield) and demand (human demand, feed use and processing demand). In the demand side, the calibration parameters take the same value for all the partial elements. As a result, a comparison of the partial elements between the models, for the EU-15 and EU-N12, is recommended before using ESIM for simulation analyses. In the case that ESIM has missed some historical developments it is advisable either to correct the problem manually (by incorporating a correction parameter directly into the partial element were the historical development occurred) or run simulation analyses without calibration and to concentrate on the relative changes and not on the absolute values of the variables. The generation of an excel template for the comparison of the partial elements would facilitate the evaluation of the calibration procedure as well as the detection of historical developments.

In case the market is subject to trade policies (export subsidies, TRQ, tariffs, threshold prices) it has to be checked that the net export situation is similar to that of AGLINK-COSIMO so that the response of prices can be comparable.

In summary the following factors are important for the evaluation and improvement of the calibration procedure:

- Remember the structural difference between the models (static vs. dynamic): static results induce stronger reactions to the highly variable prices observed between ESIM base and the last year with historic information in AGLINK-COSIMO thus calibrate only for the projection period of AGLINK-COSIMO (from 2013 for the 2012 baseline exercise).

- If the reaction in the ESIM results is still bigger than of AGLINK-COSIMO, check the prices of substitutes as well as cost indices (feed cost index, intermediate inputs, labour and capital costs). This may have an important effect due to the static condition of the model. Again, the reaction in AGLINK-COSIMO may have been smoothened due to its dynamic condition (reaction based on the previous three years).

- Check for developments which are not price driven in the elements of supply and demand in order to avoid simulated results which seem implausible.

- Note that only the developments of the world markets prices are calibrated and not the transmission to the EU domestic prices. This may be different between the models leading to different results. For instance in AGLINK-COSIMO there is no direct transmission function but instead a second market clearing on the domestic market. In addition, for the purpose of the EC's baseline construction, EU price developments can be partially disconnected from the world price developments. This typically happens because the available information at the time of the EC exercise is different from the one at disposal of the OECD-FAO at the time they build their World Outlook (usually a few months in advance). World prices are not always updated but EU prices are mostly adapted to the latest information in the DG AGRI version of AGLINK-COSIMO. This happened, for example, with butter price developments in the 2011 EC's baseline exercise.

Note also that the procedure calibrates to the percentage developments of the markets with respect to the average year (2006/2007) in AGLINK-COSIMO. The procedure has been constructed in this way in order to give the possibility to calibrate commodities with different definitions. However, for products with the same definition between the models one could try to calibrate to the absolute values (this is already done for the biofuel system).

6. Conclusions and Outlook

In this report the calibration of ESIM and CAPRI to the EC’s baseline is reviewed, highlighting similarities and differences in the calibration approaches.

Creating a consistent database is essential for both models. The ways how the consistent databases are derived, however, differ to a great extent. Having an iterative linkage between supply and market models in CAPRI complicates deriving the projections to which the model is calibrated in the simulation year. There is a separate module that calculates projections for those countries covered by the supply part. The module combines historical trends, baseline projections, expert knowledge and consistency constraints in an optimization framework. For the global market module, a consistent dataset is only created for the simulation year, building heavily on changes (in prices, balances etc.) taken over from the EC’s baseline.

ESIM builds its consistent dataset by minimizing the difference between the generated dataset (at the MS level) and the EC baseline (at the EU-15 and EU-N12 levels). The initial differences in the minimization algorithm are calculated by applying relative rather than absolute changes in the EC baseline on the ESIM base year values. The only exception is NETEXP, which is a key determinant of the market situation, and where the absolute changes are taken into account. This procedure has been selected in order to (1) avoid strong calibration parameters produced as a result of differences in the base year values between ESIM and AGLINK-COSIMO and (2) to allow a calibration of commodities with slightly different product definitions (i.e. other grains in ESIM includes oats while oats is treated separately in AGLINK-COSIMO). It would be advisable to handle those commodities with an equal definition separately. Markets with the same product definitions could be calibrated to absolute values, yielding a simplified calibration algorithm for net exports.

Both the ESIM and the CAPRI calibration procedures are highly automated. The recent development of an automated procedure for the ESIM calibration improved the quality of the calibration exercise to a great extent and addressed most of the previous shortcomings. Also, it allows for the selection of those commodity markets submitted to the calibration process. This flexibility makes possible calibrating all (full calibration) or only a subset (partial calibration) of the commodity markets. The partial calibration is unique in ESIM and it can be used to evaluate the economic reasoning behind the projected trends in the EC's market prospects. Contrasting the EC's baseline with the results of the partial and full calibration helps the analysts getting a better understanding of the expected changes in the agricultural commodity markets.

Current technical developments in the CAPRI baseline process have improved the transparency in the data consolidation steps. The graphical user interface has been extended with debugging tools allowing modellers track back changes in the data preparation and consolidation steps. The CAPRI databases (CoCo and Capreg) have been also updated recently and, based on these updates, a new base year (2008) was introduced by early 2014.

Several limitations of the calibration exercise have been identified in the report. The exact calibration to the EC's baseline figures is not possible for a multitude of reasons. Having finer geographical resolution and broader commodity coverage, differences in model structures and definitions are the main reasons for the inevitable deviations. The data requirements of ESIM and CAPRI cannot be fulfilled only with the EC's baseline figures thus the models require introducing additional information sources. A negative side effect of combining information sources is that they might be inconsistent. Even if the market balancing procedures successfully solve these inconsistencies, they might induce significant deviations from the original EC's baseline figures. This impact is bigger in the CAPRI baseline with its finer regional resolution, longer product list and detailed interrelationships between sectors (e.g. nutrient requirements of animals versus deliveries from the feeding industry).

It is important to bear in mind that although the balance sheets are calibrated at the aggregate EU levels, the further disaggregation to country, regional or farm type levels is not based on the EC's baseline (the necessary information being unavailable). Both ESIM and CAPRI apply their specific rules to derive a consistent regional disaggregation of the baseline figures and both apply consistency and logical checks to avoid unrealistic results. However, validation remains an unresolved issue since there is no basis for comparison, i.e. baseline projections published for the complete EU at the necessary geographical resolution. An expert based validation approach similar to the one used in the EC's baseline process is not a viable alternative, given the obvious constraints in human and financial resources.

A limitation of the ESIM calibration process is that the further disaggregation to the MS level may result in implausible values of some market items. The process attaches the same calibration parameters to all MS of the EU sub-aggregates (EU-15 and EU-N12) when further disaggregation assumption are missing. Attaching calibration parameters of the same size can lead to implausible projections if important market developments occurred between ESIM's base period and the last year of historical data. This happened indeed in the 2012 calibration exercise. Between ESIM's base period (average 2006-2007) and the current period (2011) there was a significant non-price-driven expansion of rapeseed area in the EU-N12 and with a respective increase in production. ESIM's automated procedure only attaches calibration parameters to yields (and not to harvested area) to reproduce the supply targets which resulted in implausible high yields in the MS of the EU-N12. In order to avoid these situations it is suggested to include an area correction parameter in ESIM which is outside the automated calibration procedure and which will shift the area curve according with historical developments.

It is recommended to include further correction parameters in the ESIM calibration procedure in order to reproduce MS market situations in the historical period (areas planted, yields, human demand, processing demand, feed demand) more closely. These parameters must be generated and included externally into the modelling framework by the model user and should be based on further MS specific information. The correction parameters would define explicitly how market developments of more aggregated levels are broken down to the MS level.

Further harmonization of model assumptions and input data still has a big potential to improve the final outcome of the calibration exercise. Sharing databases and harmonizing model nomenclatures can obviously ease finding a common point of departure for the models. Indirect assumptions are more difficult to harmonize, especially if they are implicitly defined by functional forms or model structures. The different geographical dimensions induce a further difficulty in applying assumptions that are made at the EU scale in AGLINK-COSIMO to the country and regional level in the other two models. Assumptions on meeting the Renewable Energy Targets at the EU level, for example, need to be channelled down to the single MS or even to the regional level.

The iMAP modelling platform provides a strong institutional background for the calibration exercise. A further integration of the ESIM and CAPRI calibration in the EC's calibration exercise might further improve the final baselines. The participation of ESIM and CAPRI modellers in the annual baseline week (melt down) in DG AGRI could be a step towards further integration. By involving the modellers in the melt down week, important background information on the EC's baseline construction is transmitted, including relevant macroeconomic assumptions and market intelligence behind the market prospects.

The iMAP modelling platform already contributes to the improvement of the EC's baseline. The partial calibration results of ESIM, for example, give a timely feedback on AGLINK-COSIMO projections, and can identify unexpected market developments in preliminary results. ESIM and CAPRI already provide detailed analyses addressing the uncertainties in the EC's baseline assumptions. Those results are an integral part of the EC's Prospects for Agricultural Markets and Income, and also presented during the annual Outlook Workshop.

A very important outcome of the calibration exercise is a common baseline that can be used for further counterfactual policy analysis with a combination of models. The calibration allows taking advantage of the expert knowledge shaping the EC's baseline projections a second time. A long list of recent studies proves that the annual calibration exercise contributes to a great extent to the quality and reliability of economic analysis of agricultural, environmental, trade and energy policies.

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ANNEXE 1: MAPPING BETWEEN THE COMMODITIES[25]

EC's baseline & AGLINK-COSIMO		ESIM	CAPRI
Label	Code		
Soft wheat	WTS	CWHEAT	SWHE
Durum wheat	WTD	DURUM	DWHE
Barley	BA	BARLEY	BARL
Maize	MA	CORN	MAIZ
Rye	RY	RYE	RYEM
Oats	OT		OATS
Other cereals	OC	OTHGRA	OCER
Rice	RI	RICE	RICE
Soybeans	SB	SOYBEAN	SOYA
Rapeseed	RP	RAPSEED	RAPE
Sunflower	SF	SUNSEED	SUNF
Soybean oil	SL	SOYOIL	SOYO
Rapeseed oil	RL	RAPOIL	RAPO
Sunflower oil	SFL	SUNOIL	SUNO
Palm oil	PL	PALMOIL	PLMO
Soybean meal	SM	SOYMEAL	SOYC
Rapeseed meal	RM	RAPMEAL	RAPC
Sunflower meal	SFM	SUNMEAL	SUNC
Sugar[1]	SU	SUGAR	SUGA
Potatoe		POTATO	POTA
Manioc		MANIOC	-
Fodder maize		SMAIZE	MAIF
Fodder		FODDER	FEED[4]
Grass land		GRAS	GRAS[4]
Beef and veal meat	BV	BEEF	BEEF
Sheep and goat meat	SH	SHEEP	SGMT
Pork	PK	PORK	PORK
Poultry	PT	POULTRY	POUM
Eggs	EG	EGGS	EGGS
Milk	MK	MILK	MILK
Cheese	CH	CHEESE	CHES
Butter	BT	BUTTER	BUTT
SMP	SMP	SMP	SMIP

[25] *This mapping does not apply to world prices*

WMP	WMP	WMP	WMIP
Whey powder	WYP	WHEY	WHEP
Fresh dairy products[2]	FDP	CMILK	FRMI
Cream		CREAM	CREM
Concentrated milk		CONC_MLK	COCM
		ACID_MLK[3]	

Notes – differences in definitions:

1: Sugar in AGLINK-COSIMO is the sum of the sugar coming from sugar cane and sugar beet (beet for ethanol production is excluded) in raw sugar equivalent. Balance items, therefore, are not directly comparable to the ones in ESIM and CAPRI. In ESIM and CAPRI the sugar used for biofuel production is included in the sugar balance. A further difference is that sugar in CAPRI is expressed in white sugar equivalent. Note also that ESIM does not cover sugar beet only sugar, which is considered as a crop with area and yield.

2: Fresh Dairy Products in AGLINK-COSIMO include the drinking milk, yogurts, cream and other fresh products; In ESIM only the drinking milk is included, the other products are separated. In CAPRI, the fresh milk products include the drinking milk and yogurts.

3: Mainly yogurts

4: CAPRI distinguishes between tradable and non-tradable feed. Non-tradables include grass (GRAS), fodder maize (FMAI), other fodder produced on arable land (FOFA), fodder root crops (FROO), cow milk for feeding (FCOM) and sheep and goat milk for feeding (FSGM). Tradable feedstock is grouped into 'bulk' feed categories: feed cereals (FCER), feed rich protein (FPRO), feed rich energy (FENE), feed from milk products (FMIL) and other (FOTH). The single agricultural activities are linked to the feed categories. The animal sector uses feed as intermediate input. Nutritional balances ensure that deliveries from feed meet the requirement of the animal sectors (also including further restrictions e.g. min/max dry matter content).

ANNEXE 2: MAPPING FOR THE ATTRIBUTES[26]

AGLINK-COSIMO		ESIM		CAPRI	
Label	Code	Label	Code	Label	Code
Balance items					
Usable production / Gross production	QP	Total supply[1]	SUPPLY	Marketable Production / Gross production	MAPR[27]/GROF
Consumption	QC	Total use	TUSE	Domestic use	DOMM
Production - Consumption	QP - QC	Net exports[2]	NETEXP	Trade balance	NTRD
Food use	FO	Human demand	HDEM	Human consumption	HCOM
Feed use	FE	Feed demand	FDEM	Feed use	FEDM
Biofuel use[3]	BF	Processing demand	PDEM	Biofuel processing	BIOF
Crushing[3]	CR	Processing demand	PDEM	-	-
Other use	OU	-	-	Losses and other use	LOSM
Prices					
World price[4]	XP	World market price	PW	-[28]	-
Producer price[4]	PP	Wholesale price[5]	PD	Market price	PMRK

Notes – differences in definitions:

1: Contrary to AGLINK-COSIMO and CAPRI, the ESIM total milk supply does not include the farm use, it corresponds to the deliveries and feed use.

2: In ESIM and CAPRI there are no stocks, that is why the net exports are not equivalent to the AGLINK-COSIMO net trade but to the difference between the Production and Consumption. Exceptions are the intervention stocks; the CAPRI market module explicitly models intervention stocks.

3: In AGLINK-COSIMO the processing is divided between the biofuel processing and the crushing of oilseeds. The other processing like barley into malt is included under other use. In ESIM the use of barley for beer production is under human demand. In CAPRI and in ESIM the crushing is under processing demand.

4: In AGLINK-COSIMO prices are nominal and they are real in ESIM, therefore to make them comparable the deflator of AGLINK-COSIMO is used. CAPRI uses directly the nominal prices of AGLINK-COSIMO.

5: ESIM has further depiction of prices. The most important are farm gate prices (PP) and wholesale prices (PD) which accounts for observed margins between the two.

[26] Here 'attributes' refer to balance items and prices of the models that are usually defined for all geographic regions and products (or derived directly from the model variables). The attributes of AGLINK-COSIMO can be found back in the balance sheets of the EC market prospects publication. Price projections are usually not made publicly available by the EC. Establishing a mapping between model attribute is essential for the comparison of model results.

[27] Balance items are scaled to meet base year values in CoCo/Capreg and broken down to sub-categories

[28] CAPRI has no theoretical 'world price' defined; as the model follows the Armington assumptions all markets has its own market price. The development of world market price in AGLINK-COSIMO still can be used in CAPRI to define certain market prices in the baseline.

ANNEXE 3: MAPPING FOR BIOFUELS

In AGLINK-COSIMO the biofuel balance sheet is not detailed for EU-15 and EU-N12. Only the EU-27 balance is available.

Units

In AGLINK-COSIMO the whole biofuel balance sheet is expressed in million liters. Therefore it is necessary to use coefficients to have comparable data with ESIM and CAPRI.

Table 4: Biofuel conversion coefficients

	t.o.e./t	t.o.e./m^3	t/m^3
Ethanol	0.645	0.5016	0.778
Biodiesel	0.884	0.7882	0.892
Gasoline	1.027	0.764	
Diesel	1.027	0.860	

Source: based on the Annex of the directive 2009/28/EC of the European Parliament and of the Council

1st and 2nd generation biofuels

In AGLINK-COSIMO the ethanol and biodiesel production includes 2nd generation biofuels whereas it is not the case in ESIM which is modelling only the 1st generation biofuels, 2nd generation biofuels are not included explicitly in the model but can be calculated in an Excel sheet template. CAPRI distinguishes between 1st and 2nd generation biofuels but the supply and demand of 2nd generation biofuels are kept fixed during the simulations. In order to set the baseline level of 2nd generation biofuels CAPRI uses the AGLINK-COSIMO variables 'QP..RES' (production of biofuels based on residuals, mainly biodiesel based on waste oils) and 'QP..SEC' (production of other 2nd generation biofuels).

Non fuel use of ethanol

In AGLINK-COSIMO the non-fuel use of ethanol is included exogenously. CAPRI and ESIM only calculates endogenous balances for ethanol produced for fuel use.

Feedstock used for biofuel production

CAPRI uses the AGLINK-COSIMO information on feedstock used for biofuel production (see Table 5). In ESIM this information is not taken into account. The distribution between different feedstocks is mainly driven by the ESIM model behaviour.

Table 5: Mapping of biofuel related variables (AGLINK-COSIMO vs. CAPRI)

CAPRI	AGLINK-COSIMO	Description
bioECgra	QP..CG	Production from Coarse grain
NAGR	QP.NAGR	Production from non-agricultural sources
bioeSuga	QP..SBE	Production from Sugar beet
bioeWhea	QP..WT	Production from Wheat
SECG	QP..SEC	Production of other 2nd generation biofuels than waste oils
SECG	QP..RES	Production of biodiesel from waste oils
bioDOilP	QP..VL	Production from Vegetable oils
MAPR	QP	Marketable production
DOMM	QC	Domestic use
BIOF	BF	Biofuel use
INDM	OU	Non fuel use
NTRD	NT	Net Trade
IMPT	IM	Imports
EXPT	EX	Exports
TARV	TAVI	Ad valorem tariffs
TARV_bind	TAVI	Ad valorem bound tariffs
TARS	TSP	Specific tariffs
CTAX	TAX	Taxes
PROCMARG	MAR	Processing margin
CPRI	CP	Consumer price
QUTS	QCS..OBL	Blending Quotas (relative to total fuel demand without any double counting)

Table 6: Mapping of biofuel related variables (AGLINK-COSIMO vs. ESIM)

ESIM	AGLINK-COSIMO
EU-27 Ethanol supply =	{Total ethanol production (E27_ET_QP) – 2nd generation Ethanol (E27_ET_QP..SEC) – Other use of ethanol (E27_ET_OU)} * 0.778
EU-27 Ethanol total use =	{Ethanol consumption (E27_ET_QC) – 2nd generation Ethanol (E27_ET_QP..SEC) – Other use of ethanol (E27_ET_OU)} * 0.778
EU-27 Biodiesel supply =	{Total biodiesel production (E27_BD_QP) – 2nd generation Biodiesel (E27_BD_QP..RES + E27_BD_QP..SEC)} * 0.892
EU-27 Biodiesel total use =	{Biodiesel production (E27_BD_QC) – 2nd generation Biodiesel (E27_BD_QP..SEC + E27_BD_QP..RES)} * 0.892

ANNEXE 4: BEHAVIOURAL SUB-SYSTEMS, CAPRI MARKET MODULE

		Behavioural block	Comments	Calibrated parameters
1.		Human consumptions	Generalized Leontief Expenditure system	p_pdGL, p_pbGL
2.		Supply of agricultural commodities	Derived from a Normalized Quadratic profit maximization framework	p_cnstNQSupp (constant term), p_hessNQSupp (Hessian)
3.		Feed block		
	3.a	Feeding block for countries not covered by the supply models	Normalized Quadratic feed cost function, feed balance based on calorie content	p_cnstNQFeed (constant term), p_hessNQFeed (Hessian), pv_feedConv (feed conversion param.)
	3.b	Feeding block for countries covered by the supply models	CES share equation for feed demand, feed in aggregated grops e.g. 'cereals for feed'	p_dpCESFeed (CES share parameters), pv_feedConv (feed conversion param.), p_feedBlkConst (constant term of feed demand eq.)
4.		Trade policies		
	4.a	Export subsidies	Sigmoid function	pv_sigmParSubsExports, pv_bevFuncSubsExpCorrFact
	4.b	Tariffs under Tariff Rate Qoutas	Sigmoid function	p_trqSigmoidSlope,
	4.c	Entry price system for fruits and vegetables	Sigmoid function	p_entryPriceFac
	4.d	Flexible levy system	Smooth approximation of min/max	no calibration
	4.e	Public intervention	Market prices are assumed normally distributed, mean and s.d. estimated	pv_bevFuncIntAddFac, pv_bevFuncIntMultFac (additive and multiplicative calibration parameters)
5.		Processing industry	General processing function from Normalized Quadratic profit function	p_cnstNQProc, p_hessNQProc
	5.a	Oils and cakes	demand under fixed I/O coefficients, derived from Normalized Quadratic profit function	
	5.b	Dairy	Fat and protein balance	p_cnstNQDairy, p_hessNQDairy

	5.c	Biofuel processing	Supply according to a double log formulation over processing margins	p_bioSupPar (contains both constant and elasticity terms)
6.	Land supply and demand		Land is a direct input of production activities with supply/demand functions of the NQ form	p_cnstLandSupply, p_landSupplyElas, p_cnstNQSupp, p_hessNQSupp
7.	Biofuel demand equations		CES demand equations for feedstock, market clearing price for out-of-quota 'C' sugar, sigmoid for biofuel share in total transportation fuels	p_dpCESBiof, p_cSugarCalPar, p_bioDemPar
8.	Two-tier Armington system for trade		CES share equations, exogenous substitution elasticities	p_dpCESTrade,

ANNEXE 5: ESIM AUTOMATED PROCEDURE OF CALIBRATION

by Ole Boysen[29]

This documentation is one of the deliverables of the EC-JRC specific contract No. 152039.X6. It has been slightly adapted by Marco Artavia.

1. OBJECTIVES

The objective of the calibration procedure is the alignment of the ESIM baseline with the baseline produced by the AGLINK-COSIMO model by modifying the ESIM parameter set. This is accomplished by meeting a set of corner target values from the AGLINK-COSIMO baseline. More specifically, these corner targets are total use (TUSE), supply (SUPPLY), and net exports (NETEXP)[30] for the aggregate values of the EU-N12 and EU-15 regions, respectively, as well as the world prices (PW) for selected ESIM commodities. It is important to note, that ESIM only calibrates against this corner targets, but not to underlying partial market balances. E.g., in order to meet the percentage change in total supply given by AGLINK-COSIMO, yield in ESIM is shifted. As a result, total supply will match, but not necessarily changes in yield and changes in area. Therefore, it is advised to scan the results of the automatic calibration procedure carefully in order to understand the potential, but also the limitations in interpreting its results as well as its implications for potential scenario analysis.

The calibration procedure is designed to generate a set of reproducible, calibrated parameter values in an automated way.

2. APPROACH

AGLINK-COSIMO target values are provided by the user in a specified format. As ESIM base data may differ from AGLINK-COSIMO historic values due to different sources, commodity definitions and data processing, the target values for total use, supply, and world market prices are provided in percentage change terms compared to the base year. However, net exports targets are specified as quantities. Consequently, commodity market balances, i.e., the identity that net exports equal the difference between supply and demand, are generally violated when the percentage changes are applied to the ESIM base year data. Thus, the first step required is a market balancing procedure which modifies the user input data to yield quantity data which fulfils the market balance for each commodity. Afterwards, the main calibration procedure adapts certain ESIM parameters so that ESIM meets those modified AGLINK-COSIMO targets. Both procedures are formulated in GAMS and are run independently in succession. The outcome of the entire procedure is a set of parameters which, when used in an ESIM simulation run, reproduces the modified AGLINK-COSIMO targets.

From a user's point of view, the complete calibration procedure consists of manually initiating three steps:

> Step 1: Read AGLINK-COSIMO user input data and modify the input data to construct consistent market balances (run GAMS file 'cal_market_balancing.gms').

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[29] University of Hohenheim, Stuttgart, Germany.

[30] The net exports are defined as (Supply – Total use) in ESIM. In AGLINK-COSIMO there is stock variation, therefore (Exports – Imports) are not equal to (Supply-Total use).

Step 2: Generate a set of production and demand parameters for ESIM which reproduces the above consistent market balances (run GAMS file 'esim.gms').

Step 3: Store the original AGLINK-COSIMO targets and the calibrated ESIM results together with some measure of deviation in a file to facilitate reporting on the calibration outcome (run GAMS file 'cal_comparison.gms').

3. USER INPUT DATA

The procedure calibrates ESIM so that the following target values are met: for selected ESIM commodities, total use, supply, and net exports for the aggregate values of the EU-N12 and EU-15 regions, respectively, as well as the world market prices for selected commodities. The target values are provided by the user in terms of percentage changes from the base year in all cases with the exception of net exports which are provided in terms of the traded quantity. In addition, the column 'base' takes the base year values which are solely used to facilitate the comparison of AGLINK-COSIMO targets and ESIM calibration results after the calibration procedure finished. The entire input data needs to be provided in form of an especially formatted MS Excel workbook file named "calibration_aglink_input.xlsx". The first sheet of the workbook "Instructions_Hohenheim" contains instructions on the required format. The sheet "Instructions_IPTS" contains some notes on general aspects and on the mapping. The sheet "Input data" contains the AGLINK-COSIMO percentage developments (with respect to the calculated AGLINK-COSIMO base year) as well as the absolute net trade values. The column 'base' displays the calculated AGLINK-COSIMO base year values which are solely used to facilitate the comparison between the baselines after the calibration procedure finished.

A second Excel workbook named "cal_control.xlsx" provides some options to control the calibration procedure (see Section5).

4. GENERATION OF ESIM CONSISTENT MARKET BALANCES (TARGETED MARKET BALANCES)

Initially, the user-provided percentage change and quantity targets are modified so that the market balance identity holds for each market. To this end, the percentage change targets are translated to absolute quantities by applying the target percentage change to the corresponding base year quantity from the ESIM database. The net export quantities are taken unmodified. Besides the target values, the user input data specifies "margins of acceptance" which relax the target quantities to target intervals. This data is fed into a GAMS-based mathematical model to produce consistent market balances while minimizing the sum of the squared percentage deviations from the targets (see file "cal_market_balancing.gms"). The margins of acceptance are implemented as bounds on the supply, total use and net export variables. If the PARAMETER ENFORCE_TRADEDIR(COMM) is set to 1, a further bound is added to guarantee that the direction of trade as implicit in the AGLINK-COSIMO net export target is preserved (the direction of trade remains free if the parameter is set to zero). Setting the PARAMETER NETEXP_CHG to 'no', the NETEXP target is set to the AGLINK-COSIMO target level as given. If set to 'yes', the NETEXP target is based on the ESIM NETEXP level plus the absolute quantity *change* in the NETEXP level calculated from the AGLINK-COSIMO targets.

In cases of widely differing base year data or commodity definitions, the user specified target intervals might not facilitate the construction of a consistent market balance. If such cases occur, these are listed in the parameter "infeschk" after the run of the market balancing procedure ends. The procedure automatically deals with such cases by relaxing the bounds on the variables and optimizing for the "closest" possible solution, as defined by the squared percentage deviations mentioned above, while only the direction of trade is enforced (if ENFORCE_TRADEDIR is switched on). Furthermore, the parameter "bound" can give additional insight about the cause of the infeasibility of the user-provided targets.

"bound" shows the upper and lower bounds implicit in the AGLINK-COSIMO target data for each of supply (S), total use (D) and net exports (X) in level terms. For instance, bound('2008','EU','S.LO','CWHEAT') and bound('EU','S.UP','CWHEAT') are the lower and upper bounds on the supply of CWHEAT which are calculated by applying the AGLINK-COSIMO target supply percentage change minus and plus, respectively, the 'margin of acceptance' to the ESIM base supply quantity of CWHEAT.

To improve the outcome and resolve these infeasibilities, the user should adapt the margins of acceptance and rerun the procedure. This way, the procedure can be guided to generate more satisfactory outcomes. For very broadly defined commodities or those with strongly differing definitions between ESIM and AGLINK-COSIMO, it should be considered to drop the targets on net exports. The procedure then automatically calculates the net export target as the difference between supply and total use in terms of ESIM quantities.

When the procedure finishes, the percentage deviations from the targets are presented in the parameter "pcdev". The absolute percentage deviation minus the margin of acceptance, i.e., the excess over the bounds is listed in the parameter "pcdevoutma". Finally, the parameter "target" contains the consistent market balances along with the other user input data and is stored in the file "aglink_input_balanced.gdx".

Summary of files:

- File to run: 'cal_market_balancing.gms'
- Data input file: 'calibration_aglink_input.xlsx'
- Data output file: 'aglink_input_balanced.gdx'

5. Alignment to the generated and targeted market balances

The calibration procedure requires a modified ESIM model where new variables are introduced to adapt as calibration coefficients while corresponding target variables are held constant. To this end, variables, equations, and complementarity conditions are combined into a new model (BASELINECALIB, see file "cal_model.gms"). The ESIM model mechanisms differ between product groups and thus calibration coefficients are introduced in different equations corresponding to the specifics of the target variable and commodity group. The details are described below, for each target variable (PW, SUPPLY, TUSE, NETEXP) separately.

The general approach is to scale demand and supply curves by changing the efficiency parameter in front of ESIM's Cobb-Douglas type supply and demand functions. This can be interpreted as technical progress in the case of supply and as market scaling or preference shifting in the case of demand functions. The model formulation differs between product groups as there are a number of special product relationships and characteristics requiring special treatment as detailed in the following subsections.

The AGLINK-COSIMO targets are specified only for the aggregated regions EU-15 and EU-N12. The targets need to be broken down to the level of individual Member States. In absence of country-specific information, the calibration procedure assumes that the respective functions for all countries within an aggregate region are scaled by the same coefficient. This coefficient is introduced to the function in addition to the already existing efficiency parameter so that initial country-specific differences are retained as well as those changes of that parameter which are introduced as assumptions about economic developments over time as specified in the ESIM macro data.

Technically, the model is formulated as a Mixed Complementarity Problem (MCP) which implies that the specification of equations and variables forms a fully determined equation system. Thus, assuming well-behaved functions, the calibration model delivers a unique set of calibrated parameters. The calibrated parameters have to be interpreted in the light of the targets and are the unique and only solution to reach those targets. "Very high" or "very low" parameter values indicate a large discrepancy of ESIM's base data and behavioural assumptions from those implicit in the AGLINK-COSIMO targets.

It is important to note that the calibration model has to be maintained together with the main ESIM model, i.e., each time an ESIM model equation is changed the change has to be propagated also to the calibration model ("cal_model.gms"). Failure to follow this will invalidate the calibration procedure and the resulting parameters will not reproduce the original baseline targets when used in ESIM simulation runs.

Inputs to the calibration procedure are the file with the consistent market balance data "aglink_input_balanced.gdx" and the calibration control file "cal_control.xlsx".

The main output of the calibration procedure, the set of calibrated parameters, is saved in the file "calpar.gdx". The detailed results on the target variables in absolute and percentage terms, on country and aggregate region level are stored in the file "simres.gdx".

Possible deviations from the targets are listed in the parameter "devtgt". If deviations have occurred, the procedure aborts with an error message (*after* saving the results). However, the resulting set of calibrated parameters is valid as long as the parameter "solvestat" shows the model has been solved optimally (see Section 5). Thus, the user might decide that the deviations are acceptable and to proceed with this calibrated parameter set.

Note that percentage changes for the EU-N12 and EU-15 regions are used as targets. Since associated quantities in the ESIM database are different from those in AGLINK-COSIMO, meeting the percentage changes for EU-N12 and EU-15 does not necessarily imply that percentage changes for the EU-27 are also met. Nevertheless, as net exports are targeted in terms of quantities, the EU-27 trade figures will be the sum of EU-N12 and EU-15 figures in any case.

World market prices do not exist for non-traded commodities. In these cases only one of supply OR demand is calibrated (as supply = demand).

5.1 Calibration shifters

The variables which are calibrated to AGLINK-COSIMO target values are world market prices (PW) and supply and total use (SUPPLY and TUSE) in the EU-15 and EU-N12, respectively. Net exports (NETEXP) are calibrated implicitly if SUPPLY and TUSE in the EU15 or EU12 are both fixed to AGLINK-COSIMO targets (as NETEXP = SUPPLY – TUSE). All other variables are not subject to calibration.

5.1.1 Calibration shifters to align world market prices

Note that PW only exists for traded commodities. Moreover, PW calibration is not enabled for by-products (GLUTFD, SUNMEAL, RAPMEAL, and SOYMEAL) which depend on the primary product according to a fixed input-output ratio, e.g., SOYMEAL occurs as a by-product of SOYOIL production. Calibration against a target PW is reached by scaling the supply or demand curves of the non-EU regions so that market clearing occurs at the targeted PW. Technically, this corresponds to a change of the efficiency parameter of the Cobb-Douglas type supply and demand function. The specific modelling formulation used depends on whether it is a processed commodity (i.e., the processing is explicitly modelled in ESIM) or not and how the processing itself has been modelled. All non-EU countries experience an identical relative change of their efficiency parameter.

Unprocessed commodities[31]

This includes all primary crops and livestock products which include SUGAR and PALMOIL in ESIM. These markets are calibrated against PW by scaling the supply curve. Technically, an additional technical progress parameter (TP_GR_NONEU) is introduced to the supply functions of the non-EU countries and adapts to meet the target PW.

Final dairy products[32]

In ESIM, the raw milk commodity is first split into their fat and protein components (according to fixed content coefficients) which are then recombined to produce a final dairy product like cream or cheese. An efficiency parameter (PDEM_TR) is introduced to the ESIM equation (PROCM_EQ) which determines total processing demand for FAT and PROTEIN from dairy processing. This parameter changes the production of a particular dairy product by changing its processing demand for FAT and PROTEIN. The parameter could be interpreted as changing the production preferences between dairy products. The corresponding parameter in the calibration model is called PDEM_TR_CAL.

Plant oils[33]

Each plant oil (SOYOIL, RAPOIL, or SUNOIL) is processed from a specific input crop where input relates to output according to a constant extraction coefficient. This constellation does not allow direct introduction of a supply-side calibration parameter. Instead, calibration is facilitated by increasing the processing demand for the associated oil seed inputs. Accordingly, a calibration coefficient (PDEM_TR_NONEU_OIL) is introduced to the processing demand function for oilseeds. The increase in oilseed inputs then leads to an increase in oil output and scales the supply curve. The production of plant oils yields oilseed cakes / meals (SOYMEAL, RAPMEAL, SUNMEAL) as by-products according to a fixed input-output coefficient.[34] The output of these by-products is thus implicitly determined when calibrating for the corresponding oils.

Biofuels

Equivalently to the plant oils, biofuels depend on a downstream input commodity according to a fixed input-output ratio. In ESIM, ETHANOL (first generation) is produced from CORN, CWHEAT and SUGAR while BIODIESEL (first generation) is produced from SOYOIL, RAPOIL, SUNOIL and PALMOIL. The supply curve of biofuels is rotated directly by introducing a new processing demand trend coefficient (PDEM_TR_NONEU_BF) to the supply function of the two fuels which determines the quantity of oil mix (as aggregated by a CES function) to be processed.

5.1.2 Calibration shifters to align total use (TUSE)

Total use (demand) is calibrated to target quantity values for the aggregate country regions EU--15 and EU-N12. As no further information about changes of the individual EU member states' quantity levels is available from AGLINK-COSIMO and moreover, it is desired to retain the inherent economic structure of ESIM, the efficiency parameter of the Cobb-Douglas type demand functions is used for calibration and scaled using the same multiplier across all countries within the respective country group.

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[31] *These include: CWHEAT, DURUM, BARLEY, CORN, RYE, OTHGRA, RICE, SUGAR, SOYBEAN, RAPSEED, SUNSEED, MANIOC, BEEF, SHEEP, PORK, POULTRY, EGGS, PALMOIL.*

[32] *These include: SMP, WMP, CREAM, CONC_MLK, ACID_MLK, WHEY, BUTTER, CHEESE. CMILK is a non-tradable in the current database.*

[33] *In ESIM, PALMOIL is an unprocessed commodity.*

[34] *As an artificial example, let 100 tons of oilseeds be the input to the oil production process and let the fixed input-output coefficient for oil be 0.3 and the one for oil meals be 0.2 . Then, the production yields 30 tons of oil and 20 tons of oil meals.*

Unprocessed commodities and final processed commodities

For unprocessed commodities as well as final processed commodities, TUSE is calibrated by adapting the efficiency parameter of the human demand function (HDEM_TR_EU) and the one of the feed demand function (FDEM_TR_EU). These parameters are calibrated to an identical value within each group of European countries so that the target value for the sum of TUSE over all these countries is met. More specifically, HDEM_TR_EU for a product is equal for all countries within an EU country group and HDEM_TR_EU is equal to FDEM_TR_EU, i.e., the demand trend developments are assumed to be identical for human and feed demand. It was decided to use both demand functions for calibration as in some cases the share of one of the two demands in total use is so small that very large trend parameters would be necessary to meet the target TUSE quantity and could lead to the infeasibility of the model.

Feedstuff

Feedstuff (biofuel processing by-products and MANIOC, SMAIZE, FODDER, GRAS) are not intended to be calibrated as this would disturb the feed use behaviour as implicit in the ESIM parameters.

Oilseeds

In order to calibrate oilseed quantities (SOYBEAN, SUNSEED) to levels independent of the respective processed oil, both feed and human demand are adapted as either is only a small fraction of the total use. The main use is for processing which is linked to oilseed input by an input-output coefficient and thus cannot be used for calibration. Thus, deviations of oilseed use not implicitly originating from oil processing will likely result in large shifters on the human and feed demand functions. Moreover, trying to calibrate SOYBEAN and SUNSEED to such developments which are very different from the corresponding oils developments might cause the calibration procedure to fail solving. Human and feed demand are shifted by the same multiplier (HDEM_TR_EUGRP = FDEM_TR_EUGRP). RAPSEED cannot be calibrated as RAPSEED in its entirety is processed to RAPOIL and RAPMEAL and there is no human or feed demand for it.

5.1.3 Calibration shifters to align supply (SUPPLY)

Crops

The supply of crops from the EU15 and EU12 country groups is calibrated to target quantities by adapting the technical progress parameter of yields (TP_GR_EU). Products without own EU production, such as MANIOC, cannot be calibrated. The differences in yield development between countries (the technical progress) are nevertheless taken into account in the distribution of the supply among countries within each EU group.

Sugar

Due to the fact that sugar is subject to a production quota, there is a model-inherent problem that prevents any meaningful calibration of sugar supply in the EU regions. For illustration, assume sugar quotas are extended and the AGLINK-COSIMO sugar supply target for the EU also implies an expansion of sugar production. Then, some countries can achieve filling their quotas with a moderate increase of their technical progress parameter. However, the common EU region's efficiency parameter is increased further to also move the other EU countries closer to their quota. As the production of countries already producing at their quota limits cannot be expanded further, any additional increases in their technical progress need to be matched by decreases in their sugar crop area. In consequence, yields for these countries rise to unrealistic levels and the entire market for the input factor land gets distorted. As a bottom line, EU sugar supply cannot be calibrated.

Livestock

The supply of livestock from the EU15 and EU12 country groups is calibrated to target quantities by adapting their respective technical progress parameters (TP_GR_EU).

Final dairy products

In ESIM, the raw milk commodity (MILK) is first split into their fat and protein components (according to fixed content coefficients) which are then recombined to produce a final dairy product like cream or cheese. The content of fat and protein included in the different dairy products can change somewhat according to the contents' prices and elasticities. A balance equation guarantees that all fat and protein from MILK produced is used up in the processing of final dairy products. Thus, there is no demand for MILK itself apart from the dairy processing activities. A scaling parameter (PDEM_TR) is introduced to the ESIM equation which determines total processing demand for FAT and PROTEIN from dairy processing. This parameter changes the production of a particular dairy product by changing its processing demand for FAT and PROTEIN. The parameter could be interpreted as changing the production preferences between dairy products. The corresponding parameter in the calibration model is called PDEM_TR_CAL.

Plant oils

Plant oil supply is calibrated by adapting the processing demand trend parameter for the respective oil seeds (PDEM_TR_CAL), for example, RAPSEED demand for processing into RAPOIL is adapted to match the target figure for RAPOIL supply. Products without own EU production, such as PALMOIL, cannot be calibrated.

Biofuels

Equivalently to the vegetable oils, biofuels depend on an earlier stage commodity according to fixed input-output ratio. The supply curve for biofuels is calibrated by adapting the PDEM_TR_CAL processing demand parameter equivalently to the calibration of biofuels for PW targets above.

5.2 Aligning net exports (NETEXP)

Net exports are calibrated implicitly when supply and total use are calibrated in the EU of which the difference defines NETEXP. When supply and total use in the EU are fixed, and the world price is fixed and the supply in the ROW adapted accordingly, the demand in the ROW represents the function which will need to adapt to accommodate the given NETEXP as the NETEXP of the EU are also the negative NETEXP of the ROW. This uses up the last degree of freedom for the calibration of the model system.[35]

6. RUNNING THE CALIBRATION PROCEDURE

After generating consistent market balance input data as described in Sections 5 to 5.2, its output ('aglink_input_balanced.gdx') gives the starting point for the main calibration procedure. The calibration procedure is embedded directly in the ESIM simulation code. Thus, it is started by running the GAMS file 'esim.gms' after modification of some switches:

- calibrateToAglink: 'yes' switches on the calibration procedure while 'no' runs a normal ESIM simulation.

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[35] *Remark from the authors: the alignment of net exports can be interpreted as using a market clearing condition for international trade in a two-country model of trade equilibrium. As the net trade of EU has been already (implicitly) calibrated, the demand functions of ROW should be calibrated so that the market clearing condition for net exports holds in the calibration point.*

- useCalibratedShifters: 'yes' injects the calibrated parameters from the previous calibration run into the model for a run of a normal ESIM simulation while 'no' runs ESIM without the calibrated parameters.

As a standard setting in the GAMS file 'simulation.gms', the calibration interpolates the years 2008 to 2011 as these "historic" AGLINK-COSIMO targets are particularly difficult to match. Note that in consequence, the simulations results for 2008 to 2011 should not be interpreted.[36]

To calibrate ESIM, the normal switch parameter setting should be:

calibrateToAglink yes

To run a normal ESIM simulation based on the calibrated parameter values, the normal switch parameter setting should be:

calibrateToAglink no

useCalibratedShifters yes

6.1 Controlling the calibration procedure

The Excel workbook 'cal_control.xlsx' features a number of options to control the calibration procedure.

6.1.1 Controlling to which targets ESIM is calibrated to

First, there are three sheets (TUSE_CS, SUPPLY_CS, PW_CS) which control the calibration sets for TUSE, SUPPLY and PW, i.e. entering the number '1' into a particular cell for a country group and commodity switches on the calibration towards the target as specified in the consistent market balances file. For example, in sheet 'TUSE_CS', setting the cell (CWHEAT, EU15) to one causes the procedure to calibrate towards the AGLINK-COSIMO target for CWHEAT in the EU-15. Setting it to zero or leaving it empty switches the calibration off for this target. Cells marked red should not be switched on.

6.1.2 Controlling interpolation

To speed up the calibration and simulation of ESIM, the introduction of parameter changes is split into several steps within a simulation period. Often, this is necessary to generate a feasible solution in the first place. In the sheet 'Simulation control', the user can enter the number of interpolations for each simulation period. For example, entering a 5 for year 2012 will cause the simulation to run 5 times for the period from 2011 to 2012. It is important to note that the number of interpolations can only be changed for the calibration but then is kept for running ESIM simulations based on the calibrated parameters.

6.1.3 Shifter alerting

Using the sheet 'Shifter alerting', the user can define thresholds for the four different shifter categories, i.e., define when the parameters are considered 'too large' or 'too small'. Those will then be reported after the simulation run in the parameter "Shifter alert".

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[36] Setting INTERPOL2020: /yes/ applies a linear interpolation to the calibration target values from the base period up to the period set by the global variable INTERPOL_UPTO. This serves the purpose of enabling a feasible solution and increasing the speed of the calibration procedure but this normally should need to modification.

6.2 Diagnostic output

After a calibration run, several parameters are reported in the 'esim.lst' file to give some diagnostic information on the solution obtained. The output is also saved in the file "cal_diagnostic_output.gdx".

- 'solvestat': Shows the model- and solver-status which occurred after each period. The values should be all equal to one, otherwise some solver problem has occurred and the corresponding solution is invalid. See the GAMS PATH solver user manual for details on the PATH solver status codes.

- 'devtgt': Shows percentage point deviations from target values, i.e., devtgt=result% - target%. Should be zero for all if the calibration succeeded.

- 'shifterAlert': Displays shifter values only where they exceed the user-defined thresholds (defined in 'cal_control.xlsx').

- 'atLowerBound': Shows certain variables which have hit a lower bound and thus can be the cause of problems with solving this calibration model.

- 'atQuota ': Lists all variables which are at their quota limit. This is usually intentional but also might hint to input data problems.

- 'rest_quota' and 'rest_quota_agg': Difference between quota and supply level for single countries and country groups, respectively.

To see whether the calibration finished successfully or not, it first is necessary to look at the 'solvestat' parameter. If this deviates from the normal values as stated above, there can be various causes including severely deviating target values in the input data (An increase of the number of interpolations for the corresponding years in the calibration control file might help.) and problems with the quotas or other bounds.

If 'solvestat' indicates a normal completion of the calibration, then 'devtgt' shows the deviations from the targets defined in the 'aglink_input_balanced.gdx'. If this parameter is empty, the calibration was technically successful and all targets have been met. If small deviations are shown, it must be decided on a case-by-case basis whether this is acceptable.

Next, the 'shifterAlert' parameter should be scrutinized. There is no general rule on what magnitude of shifters should be considered too small or large. It is an outcome of how much the model needs to be distorted to meet the given AGLINK-COSIMO target values. The "shifters" are scaling factors. Taking a simple supply function by itself, for example, a shifter of 2 would mean a doubling of the output which seems huge. However, in the context of the system of model equations, a scaling factor of 2 might not mean much of a supply change because of all the interactions in the model which might counteract the effect of the shifter.

Looking at the processing modules in ESIM, the processing demand trend parameters (pdem_tr_cal) are particularly difficult to interpret. Taking the dairy processing module as an example, this is a system where all the available fat and protein needs to be processed in its entirety. Assuming the available raw milk is fixed and pdem_tr_cal for SMP is 2, this means that, *ceteris paribus*, twice as much fat and protein is demanded for SMP. However, as fat and protein supply is fixed, prices of these components increase so that demand decreases and the market gets back into balance. How big these reactions are depends mainly on the input price elasticities of the dairy products and their shares in the demand for fat and protein. A product with a large share of use in these processing components has of course a large impact on prices and thus on the production levels of the other dairy products. Moreover, a small shift in one of the dairy products with a large share in total dairy production will have huge impacts on the products with small shares as the required fat and protein which has to be removed from their production represents a comparatively large quantity. If several products are calibrated at once, it is again more difficult to see what the necessary shifters' magnitudes need to be to meet all those targets simultaneously. As a bottom line, no general rule exists for "acceptable" magnitudes of the shifters and decisions have to be made on a case-by-case basis, likely involving some or all of the following and even more: examination of the input data, comparison of the AGLINK-COSIMO and ESIM base year data, model formulations of processing modules and product dependencies, and behavioral parameter values to start the list.

6.3 Output files

- 'calpar.gdx': Includes the calibrated parameters. This is the main result of the calibration procedure.

- 'calparinterpol.gdx': Includes the calibrated parameters but also those of the interpolation steps within a period. This is intended only for internal use by the ESIM simulation procedure.

- 'simres.gdx': Includes results for the simulation variables in level and percentage change terms on country as well as on country group level. This is the output of an ESIM simulation run but is also created by the calibration procedure.

7. Generating the comparison output file

Running the GAMS file 'cal_comparison.gms' generates the file 'cmpres.gdx' which compares the original AGLINK-COSIMO targets as given in the targets Excel input file 'calibration_aglink_input.xlsx' and the ESIM results. The parameter 'cmpres' includes level and percentage change data from ESIM results and AGLINK-COSIMO targets as well as the differences between those in percentage and level terms. The output file 'cmpres.gdx' can then be used for further data processing.

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Title: Calibrating the CAPRI and ESIM models to the mid-term commodity market outlook of the European Commission

Authors: Mihaly Himics, Marco Artavia, Sophie Hélaine

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Abstract

JRC-IPTS maintains a suite of large scale economic models, the Integrated Modelling Platform for Agroeconomic Commodity and Policy Analysis (iMAP), in order to contribute to the impact assessment of agricultural and trade policies of the European Commission. Operating a modelling platform requires the calibration of the included models to the same point of departure. The current report describes how two of the partial equilibrium models of the iMAP platform, CAPRI and ESIM, are calibrated to a common baseline. The models are aligned to the mid-term prospects for agricultural markets and income, published annually by the Directorate General for Agriculture and Rural Development.

The report provides both an overview of the baseline calibration exercise (and of the endeavour to calibrate large-scale economic models in general) and goes into practical details regarding the specificities of the single models. A critical evaluation of the 2012 and 2013 baseline exercises, with several illustrative examples, is also included. The report concludes with highlighting strengths and weaknesses of the calibration process and gives suggestions for further improvements. Numerous technical annexes complete the report helping practitioners to understand the observable differences in the models' baselines.

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