



**System for Environmental and Agricultural Modelling;  
Linking European Science and Society**

**Documentation of model components EXPAMOD  
and CAPRI**

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## General Information

Task(s) and Activity code(s):	3.6
Input from (Task and Activity codes):	3.3
Output to (Task and Activity codes):	3.5
Related milestones:	Final tested version on SEAMLESS-IF

## Executive summary

This deliverable documents the models developed or adjusted within Task 3.6, EXPAMOD and CAPRI and their formal linkages to each other. It aims at improving the understanding of these models and supporting the future use and further development of SEAMLESS-IF.

A major objective in SEAMLESS is the consistent integration of farm level supply and aggregated market models. This is achieved by transmitting endogenous farm level supply changes from a selection of farm simulation (FSSIM) models (Louhichi et al., 2006) to the CAPRI market model (Britz et al., 2007), and applying endogenous prices from the market model to FSSIM in turn. The EXPAMOD model, developed from scratch in the SEAMLESS project to ensure the consistent linking, is described in the core of this document. This deliverable also contains important updates to the modelling component CAPRI that have initially been documented in PD3.5.11. Mainly the adjustments and amendments of the CAPRI component developed during the project are reported here.

This report consists of one main chapter documenting the extrapolation procedure and the first empirical results of this exercise. The first section of this chapter (1.1) introduces aggregation, up-scaling and extrapolation issues in modelling agricultural systems. Section 1.2 presents the main conceptual idea behind the EXPAMOD model. Section 1.3 covers data related issues involved in the implementation of this model within the SEAMLESS model chain. These issues include the appropriate choice of regions for extrapolation, rules for mapping meta-data between the two models linked and choice of explanatory variables and aggregation weights. Section 1.4 discusses functional forms and estimation methods suited to specify the desired response functions. Sections 1.5 and 1.6 deal with performance evaluation. In section 1.7 the linkage between EXPAMOD and CAPRI is described and the final section concludes and contains a critical reflection on the re-usability of this estimation approach in different contexts than SEAMLESS. We have to clearly state that Sections 1.1 to 1.5 are copied from Pérez Domínguez et al (2009) and all rights on it are located at the journal *Environmental Science and Policy*.

In section 2 a more technical documentation of EXAPMOD is provided including information on the integrated software approach, as well as the representation of EXPAMOD in GAMS. Section 3 describes the CAPRI version used in SEAMLESS-IF in terms of the differences that were introduced compared to the main CAPRI version.





## Model Documentation

### 1 EXPAMOD

#### 1.1 Motivation for and approaches to linking farm and market level models

In integrated modelling systems bio-economic farm models are particularly important as they provide a link between biophysical and economic models. Farmers seek to achieve their objectives by choosing from a set of available agricultural practices determined by feasible technologies, and the specific biophysical environment. In turn, the chosen practices also impact on the biophysical environment.

Farms are the basic decision units in agriculture and their choices influence market outcomes, land use, and the environment. Since each farm's production is small compared to the total production in society, each farmer perceives prices as fixed. Farm level optimization models take the same perspective. As long as the policies investigated are such that market prices stay reasonably constant, the error made from this simplification is negligible. However, horizontal policies that affect multiple farmers may have profound market impacts and, hence, influence agricultural commodity prices. The resulting supply changes may involve different commodities, since farmers may alter the composition of the farm enterprise to produce more of the commodities that are less sensitive to the regulation in question.

Market level models, like CAPRI (Heckelei and Britz, 2000) or GTAP (Global Trade Analysis Project, Hertel, 1997), consider prices as endogenous variables and are able to capture price effects from simulated policies. However, market level models provide less detail in modelling agricultural production and production externalities than farm level models, and are therefore less suitable for integration with biophysical models. The primary reason for this is that most aggregate models derive the supply behaviour on the basis of representative cost or profit functions. This has benefits in terms of reducing model complexity and empirical specification of model parameters, but it comes at a loss of detail on the production technology and biophysical information, which are implicitly embedded in parameters of the cost or profit function.

The lack of available integrated modelling tools encompassing different scales such as farm and market level models is acknowledged in many disciplines. Literature dealing with up-scaling in environmental sciences refers to both moving from smaller (point) to larger systems (vertical up-scaling), and replication of the same systems (horizontal up-scaling or scaling out, i.e. increased adoption), see for example Ngigi et al. (2007).

Different methods have been employed in natural sciences to estimate system responses across scales or levels. The simplest approach is the extrapolation of results obtained from a detailed level to a higher level (Ewert et al., 2006). Other approaches have tried to couple models from different levels of organization ranging, for example, from leaf to ecosystem (Anderson et al., 2003). The input data and model parameter requirements are high when such process models are to be coupled. Insufficiently detailed data, at the various levels, often restricts the applicability of such a modelling approach. To overcome the problems of ineffective modelling detail, data requirements and/or simulation runs, important relationships may be calculated from model simulations at lower-levels. The derived

parameters can be used as inputs for higher-level models. For instance, yield response functions have been developed for climate change impact assessment studies (Rosenzweig et al., 1999; Iglesias et al., 2000; Parry et al., 2004). Such pre-derived relationships have the advantage of reducing the computation time. However, they do not enable consideration of complex interactions and feedback mechanisms (Ewert et al., 2006).

In social sciences, micro and market level models have been linked for quite some time in consumer demand estimations (see Deaton and Müllbauer, 1980, for an early review). With rather strong assumptions on the individual behavioural axioms being valid at the market level, market demand analyses have frequently been carried out. Blundell and Stoker (2005) have made a recent survey of theoretical and empirical work in the area of demand analysis. They state that "aggregation problems are among the most difficult problems faced in either the theoretical or empirical study of economics" (Blundell and Stoker, 2005:384). One of the major challenges in aggregation is capturing the heterogeneity across individuals. Blundell and Stoker (2005) therefore suggest incorporating distributional information into aggregate relationships.

Aggregation or model linking on the supply side is often perceived to be more trivial. A recent paper by Böhringer and Rutherford (2008) shows that this is not necessarily the case. In their paper they utilize the equilibrium conditions in a general equilibrium framework, with a set of nested CES functions capturing technological change at the micro level. Their approach is applicable whenever the functional forms are the same at the micro and market level. This is not the case in our setting where positive mathematical programming models are used at the micro level.

Hourcade et al. (2006) present an overview of the relative strengths and weaknesses of firm and market level models. They outline three main types of linking these modelling approaches:

1. Soft linking in independently developed bottom-up and top-down models. A major challenge with this approach is to achieve overall coherence due to differences in behavioural assumptions at the firm and market level.
2. Using one of the two model forms and applying only a reduced form representation of the other to capture what is omitted due to the initial focus in the modelling exercise.
3. Completely integrated models based on solution algorithms for mixed complementarity problems. Böhringer and Rutherford (2008) is a recent representative of this modelling approach.

Our approach mainly falls in the first category, but has elements of the second approach in order to capture regional differences, and variations in soil and climate. Below, we briefly address some of the specifics of agriculture that further warrant our selected approach.

Heterogeneity in time and space is one of the important issues to account for up-scaling agricultural production from a disaggregated level (i.e. field/farm level) to the meso-level. Other issues are existence of ecological and economic feedback loops and the non-linearity of many functional relationships. Wossink et al. (2001) illustrate the integrated agronomic-economic modelling of pesticide use in crop farming using the statistical aggregation method of Antle and McGucking (1993). This method assumes that the characteristics of individual farms in the population induce a joint distribution of the aggregate outcomes (input use and environmental impacts in this study). In order to simplify the interpretation of the model outcomes, the results simulated for each individual farm were aggregated to the sectoral level using farm-specific weights. This becomes considerably more difficult if price changes are high, for example, from a policy change. The primary reason for this is that the distribution of

producers may change as a result of entry and exit in the market. Hansen and Romstad (2007) have noted this problem in terms of environmental regulations.

Kruseman (2000) undertakes aggregation from primal production models to a local market level for the case of smallholders in Mali. In his case, the functional form of primal production models is invertible allowing for a rather straight forward derivation of the cost functions and, hence, the local market supply functions and the corresponding elasticities of substitution. Kruseman did not experience any major entry-exit problems as agents' responses to policies were minor.

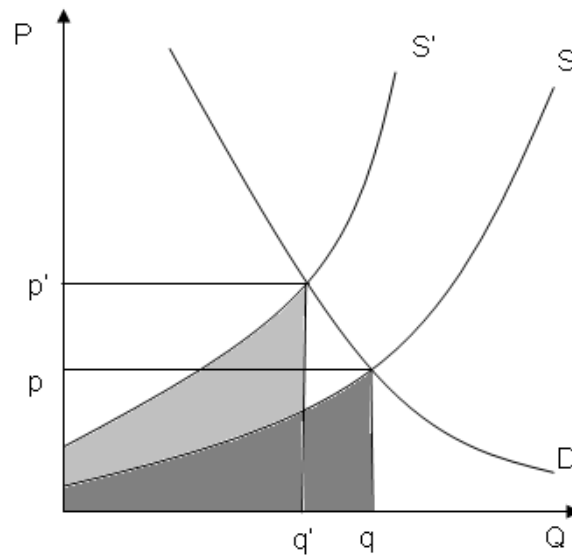
Roebeling et al. (2000), using an iterative approach, developed a method in which a regional equilibrium model incorporates farm type characteristics as well as the equilibrium equations for product markets. Aggregation takes place on the product side for all considered crops, to determine market-clearing prices. Regional product supply, in combination with the respective product demand curves faced by producers in the region, determines market clearing equilibrium prices for products. In turn, these newly determined prices form the input of subsequent partial model runs for each farm type. This procedure is repeated until product prices deviate less than 1% from corresponding prices determined in the previous iteration. The application made for the crop sector in the Atlantic Zone of Costa Rica suggests that the effectiveness of policy measures is overestimated when product prices are assumed exogenous, since endogenously determined product prices limit specialization in the most profitable crops.

The approaches of Kruseman (2000) and Roebeling et al. (2000) bear similarities with our approach of combining detailed farm level and bio-economic analysis while incorporating market price feedbacks when relevant. However, the approach considered covers a considerably larger and more heterogeneous farm population of the European Union, and relies on a statistical extrapolation procedure as the framework for linking economic models at different scales.

In integrated modeling systems like SEAMLESS, bio-economic farm models are particularly important as they provide a link between biophysical and economic models. Farmers try to achieve their objectives by choosing from a set of agricultural practices. The available set of practices is largely determined by economically feasible technology, and the specific biophysical environment. In turn, the chosen practices also impact on the biophysical environment.

Farms are the basic decision units in agriculture, and therefore influence market outcomes, land use, and the environment. Since each farm's production is small compared to the total production in society, each farmer perceives prices as given. Farm level optimization models take the same perspective. As long as the policies investigated are such that market prices stay reasonably constant, the error made from this simplification is negligible. However, policies affect multiple farmers and the aggregated response from these farmers and their interaction may have profound market impacts, and hence in turn influence agricultural commodity prices. Figure 1 reflects an upward shift of the firm's supply curve (decrease of supply for a given price) due to a technology change or a change in the structure of the farm.

Figure 1: Price impact from a supply shift when the demand curve is unchanged



This shift in supply (from S to S') implies a new setting of prices and quantities and also leads to a new vector of price-supply elasticities. Supply and prices are variables available in both farm management models and aggregate market models, and should be shared in order to integrate their responsiveness to shocks in other specific variables.

Market level models, like CAPRI or GTAP (Global Trade Analysis Project), consider prices as endogenous variables and are able to capture price effects from simulated policies. Their relative weaknesses compared to farm level models, which consider prices as exogenous, are their lack of detail in modeling agricultural production and hence insufficient integration with biophysical models. The primary reason for this is that most aggregate models derive the supply behavior on the basis of representative cost or profit functions. This has several benefits in terms of reducing model complexity and enabling an easier empirical specification of model parameters. The downside is that much of the technological detail that goes into primal models (with explicit formulation of technology) becomes less visible as they are embedded in parameters of the cost or profit function.

## 1.2 EXPAMOD - a tool for linking farm level and market level models

### 1.2.1 Structure of the farm level model

In order to understand the nature of the supply response to be extrapolated and up-scaled, and to derive an appropriate statistical model, we have a short and relatively abstract look at the structure of the mathematical programming part of the bio-economic farm level models in SEAMLESS (Farming Systems Simulator, FSSIM; for more information see Louhichi et al. in review). Consider the set of regions  $\mathbf{R}$  and the set of farm types  $\mathbf{Z}$ . Each FSSIM farm type model  $M_i$ ,  $i = 1, \dots, N$ , is then characterized by belonging to a specific region  $r_i \in \mathbf{R}$  and a specific farm type  $z_m \in \mathbf{Z}$ , i.e. the index  $i$  of each farm type model corresponds to a unique pair  $\{l, m\}$ . Now define  $\mathbf{x}_i$  as a  $(V_i \times 1)$  vector of non-negative decision variables (activity levels),  $\mathbf{gm}_i$  as a  $(V_i \times 1)$  vector of gross margins, and  $\boldsymbol{\theta}_i$  as  $(U_i \times 1)$  parameter vector (e.g. risk aversion coefficient and variances of gross margins). According to the concept for FSSIM models in SEAMLESS, the model  $M_i$  can then be written in general form as maximizing expected utility  $f(\mathbf{x}_i, \mathbf{gm}_i, \boldsymbol{\theta}_i)$  subject to  $W_i$  linear resource constraints, i.e. as

$$(1) \quad M_i = \begin{cases} \text{Max}_{\mathbf{x}_i} Z_i = f(\mathbf{x}_i, \mathbf{gm}_i, \boldsymbol{\theta}_i) \\ \text{subject to} \\ \mathbf{A}_i \mathbf{x}_i \leq \mathbf{b}_i \\ \mathbf{x}_i \geq \mathbf{0} \end{cases}$$

where  $\mathbf{A}_i$  is a  $(V_i \times W_i)$  coefficient matrix and  $\mathbf{b}_i$  is a  $(W_i \times 1)$  vector of resource endowments (in a general sense). The explicit optimization in (1) implicitly defines a functional mapping where the optimal values of the decision variables  $\mathbf{x}_i^*$  depend on gross margins, parameters, technical coefficients and resource endowments, i.e.,

$$(2) \quad \mathbf{x}_i^* = \mathbf{g}^0(\mathbf{gm}_i, \boldsymbol{\theta}_i, \mathbf{A}_i, \mathbf{b}_i)$$

Because of the inequality constraints, this functional mapping is not continuously differentiable with respect to all its arguments. For example, changes in resource endowments will lead to a discontinuous reaction of decision variables, depending on changes in the nature of resource and non-negativity constraints as binding or not. Consequently, any multivariate statistical approach based on continuous functions that tries to capture the functional mapping is, by design, only an approximation. In addition, the interaction between the arguments and the function value is likely to be highly non-linear.

Output quantities are the prime focus in this paper and their optimal values are represented by the  $(J \times 1)$  vector  $\mathbf{q}_i^*$ . Given a  $(J \times V_i)$  matrix  $\mathbf{D}_i$  containing yields per activity level and the linear technology formulation, one can directly calculate corresponding output quantities from optimal activity levels as  $\mathbf{q}_i^* = \mathbf{D}_i \mathbf{x}_i^*$ . Consequently, a functional mapping from exogenous model components to optimal output quantities is written as

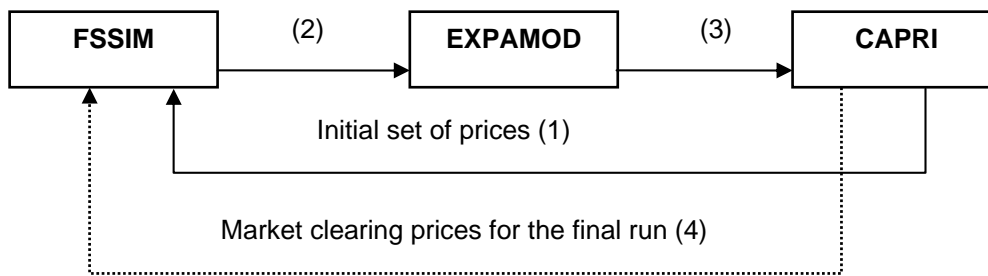
$$(3) \quad \mathbf{q}_i^* = \mathbf{D}_i \mathbf{g}^o(\mathbf{g}\mathbf{m}_i, \phi_i, \mathbf{A}_i, \mathbf{b}_i) = \mathbf{g}(\mathbf{g}\mathbf{m}_i, \phi_i, \mathbf{A}_i, \mathbf{b}_i, \mathbf{D}_i)$$

Equation (3) establishes a general description of how the existing FSSIM models determine output quantities and changes in output quantities.

### 1.2.2 Conceptual overview

The basic model linking principle of EXPAMOD is to parameterize one model (CAPRI; Britz et al., 2007) using the simulated response behaviour of the other (FSSIM; Louichi et al., in review). Our approach is an alternative for a full or “hard link” where a certain model completely substitutes the endogenous simulation of variables in a more aggregate or less detailed model. The need to model bio-economic interactions at the farm level, with sufficient detail to allow for interaction with biological models, renders the cost of data collection for a full representation of all farm-types in each of the EU-27 NUTS 2 regions (Nomenclature des Unités Territoriales Statistiques, EUROSTAT) very high. Our “soft link” approach comes at the cost of approximation, but significantly reduces set-up and maintenance costs of the system and may also save on computation time of the application.

Figure 2: Flow of prices (1, 2 and 4) and price-supply elasticities (3) between models



In order to map the supply behaviour of farm simulation models to the market model, the methodology comprises the following sequence of steps (see figure 1):

(Step 1) Baseline prices for the agricultural commodities in CAPRI are mapped to the more detailed product differentiation of FSSIM;

(Step 2) The obtained price vector and systematic variations around it are used to run price response experiments with the existing farm type models. The resulting price-supply combinations, for all relevant products, are given to the EXPAMOD model;

(Step 3) EXPAMOD estimates a meta-supply response function, by means of an econometric approach, depending on price variations, farm characteristics, and corresponding soil and climate conditions. The marginal effects of prices are extrapolated to those farm types and regions not covered by FSSIM models. Finally, price supply elasticities (relative marginal effects) are calculated and aggregated to match the product categories distinguished in CAPRI;

(Step 4) The regional supply modules in CAPRI are calibrated to the aggregated supply elasticities coming from EXPAMOD. Finally, FSSIM is run with market clearing prices from CAPRI, resulting in the final consistent specification at the farm level.

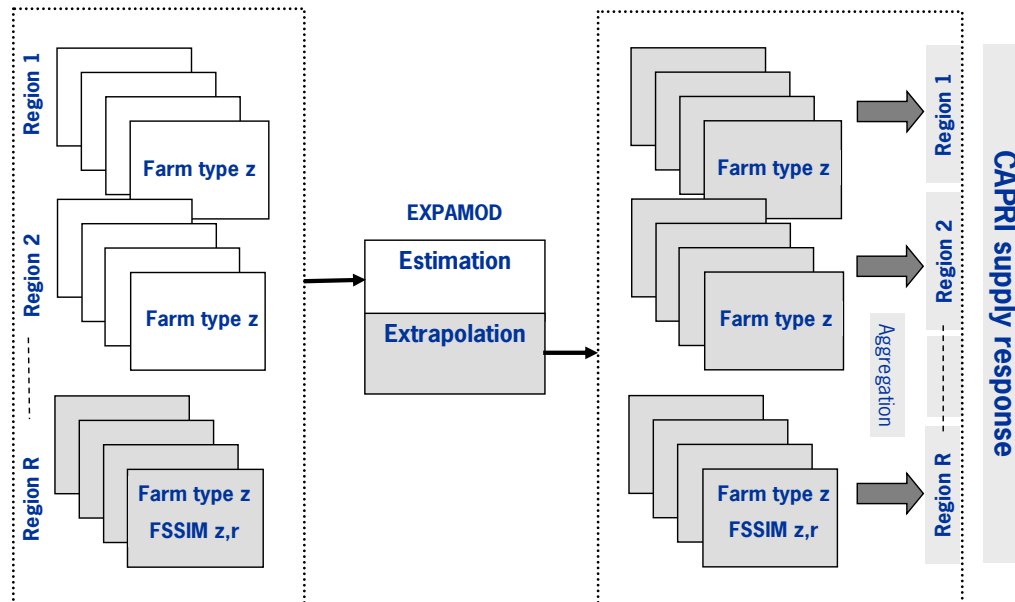
EXPAMOD is, therefore, a statistical meta-model that describes the price-quantity responses of farms given specific farm resources and biophysical characteristics that are available EU-wide. A meta-model, in this context, is an approximation of the input-output behaviour of the underlying simulation model, i.e. it describes the main relationships between key FSSIM

variables and the supply of products. Thus, the meta-model is estimated using simulated price-quantity data for farm types in regions for which FSSIM models exist and then applied to project supply responses of other farm types and regions.

It should be noted that the loop presented in figure 1 is repeated for different scenarios: baseline and policy (impact) scenarios. Nevertheless, the sequence of this CAPRI-FSSIM link is generally independent of policies entering at the market or at the farm level. On the one side, changes at the farm level imply changes in regional supply behaviour for a specific scenario and, therefore, require the calibration of the CAPRI supply responses. For example, the adaptation of pig farms to the Nitrate Directive could be achieved by introducing new manure management techniques which imply additional costs. These would not only affect the relative supply response to changing pork meat prices but also imply a shift in production at the same prices, which needs to be considered as well in the calibration process. On the other side, if policy changes enter at the market level, the calibration process needs to be done only once, because then there is no technology or bottom-up induced supply changes. This is the case, for example, of a modification of agricultural trade barriers or abolition of agricultural export subsidies.

Before moving into the database construction and the empirical implementation, we theoretically motivate the general structure of the econometric procedure aimed at accomplishing the task of extrapolation and model linking. The paradigm followed, in the overall approach, is the idea that FSSIM determines appropriately the price-supply response surface at the farm level and its variation depending on technological or policy shocks relevant for the farmer's decision problem. Consequently, it is the main objective of the extrapolation procedure to project farm responses to changing prices, closely approximating the behaviour of those farm models that could have been built for other regions if data, time and finances were not limiting resources. This implies that the statistical extrapolation method is required to exploit the supply structure of the farm models in the best possible way. It also follows that an appropriate validation of the extrapolation procedure is an out-of-sample projection of FSSIM results when more farm models become available at a later stage. Figure 2 illustrates the EXPAMOD procedure, i.e. how the results obtained from FSSIM for a sample of regions and farm types ('grey boxes') will be "expanded" to the other regions and farms that are out of the sample ('white boxes'). The "expanded" results will then be aggregated to the regional level using farm type representativity weights, based on farm size, and farm transition probabilities if structural change is considered (see Zimmermann et al., 2008).

Figure 3: Links between FSSIM, EXPAMOD and CAPRI



### 1.3 Data issues

#### 1.3.1 Use of SEAMLESS farm typologies

In order to arrive at a sensible number of FSSIM models, a specific farm typology has been derived within the SEAMLESS project (Andersen et al., 2006). According to this farm typology, 3 to 10 most-representative farm types per region are selected, so that they adequately represent farm, soil and climate differences among regions. The choice of agro-environmental variables is linked closely to the determinants of farm typology such as size, intensity, specialization and land use as well as agro-environmental typology used in a statistically based farm spatial allocation procedure (see Elbersen et al., 2006).

As a result, 189 farm types were derived in SEAMLESS. These farm types have been spatially allocated (nested) within a bio-physical typology in SEAMLESS consisting of two layers (Hazeu et al., 2006):

- 12 climate zones which is the result of a Principal Component Analysis (PCA) of the 20 most relevant and available environmental variables (grouped under climate, geomorphology, closeness to oceans and latitude).
- 6 topsoil organic carbon classes.

As a result of spatial farm allocation, each farm type has one of these twelve environmental zone attributes and six soil classes, which combined provide the corresponding agri-environmental zone (maximum of 13608 farm types with differentiated agri-environmental attributes, i.e. 189 potential farm types in 72 agri-environmental zones). This allows differentiating farm types according to their responses to the environment, thereby



improving the extrapolation procedure from a sample of regions and farms to all European regions. The main climate determinants used in the environmental stratification in SEAMLESS (as updated from Metzger et al., 2005) are minimum and maximum temperature, precipitation and solar radiation for January, April, July and October. The analysis showed that 95% of the variation in soil classes is explained by topsoil (see also Hazeu et.al., 2006). These climate-soil variables are crucial in explaining the variation in bio-physical environment under which farm decisions are taken.

An important implication of the spatial farm allocation that overlays two typologies (farm and bio-physical) is that, in many cases, one farm type within each administrative region can be found in several agri-environmental zones. Thus, one farm type may have multiple soil types. Table 1 presents the distribution of land across various agri-environmental zones and farm types. Farms in Brandenburg are rather large and on average the area per farm type takes about 706 ha.

**Table 1** Area of land per two selected farm types allocated in agri-environmental zones (Brandenburg, Germany)

Farm type <sup>1</sup>	Environmental zone <sup>2</sup>	Soil type (Carbon content, %)	Area			% in the region ( $\omega_{zr}$ ) <sup>4</sup>
			Average per farm type, ha	Total, ha	% ( $\omega_{zrc}$ ) <sup>3</sup>	
Large size, low intensity, specialized in arable/cereals	Continental	0.1-1.23	413	68	0	9.1
		1.23-2.46		35 138	23.8	
		2.46-3.94		25 925	17.5	
		3.94-5.66		10 441	7.1	
		5.66-8.86		13 640	9.2	
		8.86-63.0		61 154	41.4	
Large size, low intensity, specialized in arable/fallow	Continental	1.23-2.46	574	28 287	30.1	5.8
		2.46-3.94		30 681	32.6	
		3.94-5.66		24 865	26.4	
		5.66-8.86		4 209	4.5	
		8.86-63.0		5 157	5.5	
other farm types	...	...				...
Total				958 453	-	

<sup>1</sup> In this region there are five farm types identified based on farm size, intensity and specialisation/land use.  
<sup>2</sup> In this region there is only one environmental zone. The number of environmental zone across all seven regions varies from 1 (Brandenburg, Germany) to 6 (Castilla-Leon, Spain).  
<sup>3</sup>  $\omega_{zrc}$  is a share of land of biophysical type  $c$  on farm type  $z$  within NUTS2 region  $r$ . In this case biophysical type  $c$  refers to climate-soil combination.  
<sup>4</sup>  $\omega_{zr}$  is an aggregation weight of farm type  $z$  within NUTS2 region  $r$ .  
<sup>4</sup> Total does not sum up to 100 because of the area coverage problem caused by the disclosure rule of FADN, see also section 4.2 and table 3.

This multiple relationship of farm data with soil types is accounted for in FSSIM models through differentiation of activities, operated by different technologies depending on soil type (matrix D as mentioned in equation 3). When linking farm and market level supply, the differentiation of quantities by management techniques is ignored since the market model does not distinguish products at this level of detail. Therefore, the information on soil types is used in a way that accounts for variation in soil (and implicitly in climate) characteristics between farm types. This is done by using area-weighted soil type shares, climate and soil variables within a region (see  $\omega_{zrc}$  in table 1). Climate and soil variables that were endogenously used to derive the bio-physical farm typology (such as minimum and maximum temperature, solar radiation, average rainfall, topsoil carbon content, available water capacity) are tested later in the empirical part.

### 1.3.2 Selection of a sample region

A sample of regions has been identified for collecting detailed data on farm management practices not available in pan-European statistical data sources. These detailed data are necessary to feed the FSSIM supply models. Following Andersen et al. (2007), the selection of sample regions was made at the NUTS 2 level, as this is the minimum disaggregation level for the market models in SEAMLESS. Nevertheless, the major source of farm type data is only available for the regional classification of the Farm Accountancy Data Network (FADN). Therefore, a mapping between these two classifications is necessary (Janssen et al., 2008). Due to laborious requirements on the data collection, 16 sample regions were selected, as this was judged to be feasible for data collection and modelling purposes. This sample of regions is expected to represent a large variation in biophysical conditions for farming across the EU-27. This implied, for example, considering environmental zones where complex agricultural patterns are observed (e.g. the case for zones highly influenced by altitude rather than latitude/longitude). Moreover, regions including the most important farm types in terms of area farmed within an environmental zone were selected. This resulted in a selection of regions that differed in terms of, for example, arable versus livestock specialised farms or small versus large farms. The variation in soil types should also be well represented, at least in terms of the carbon content as this is the soil characteristic explaining most of the variation in other soil characteristics in the European soil map, as was shown in the principle component analysis applied to create the agri-environmental zones (see Hazeu et al., 2006).

In FSSIM, regional supply at NUTS 2 level can be recovered by aggregating farm type supply using farm representative weights from the FADN. Next to the weights suggested in table 1, as area shares, the number of farms represented in the total population of farms in a region could also be used (see Wieck and Heckeley, 2007). Turpin et al. (2007) elaborate on the use of weights for deriving indicators such as aggregated values from FSSIM models. How well the farm types selected are representative of the farm composition within a NUTS 2 region (denoted by  $\omega_{zr}$  in table 1) is, therefore, an important issue for EXPAMOD. Nevertheless, weights derived from the observed data are only suitable for the calibration of the model in the base year, since they refer to FSSIM results. For ex-ante scenario analysis, farm type weights should be adjusted to consider structural changes in agriculture (see Zimmermann et al., 2008). Moreover, since SEAMLESS targets the ex-ante impact assessment of agricultural policies, the projection of agricultural markets to a baseline period in the future, requires additional assumptions on technological development, changes in consumer demand, inflation, GDP growth, etc. These effects are explicitly handled by the market model and fed back into the farm models.

### 1.3.3 Generation of Pseudo-observations

As mentioned above, the main data provider to EXPAMOD is the selected sample of farm models, i.e. FSSIM models. The price impacts from supply changes in the farm optimization models generate information interpreted as 'pseudo-observations' for the econometric estimation of EXPAMOD. The current simulation design implements varying 'one-price-at-a-time'. The price vector, for each scenario, is kept at the 100% level of the initial price vector obtained from CAPRI and additional price-quantity vectors for 4 different price shocks in FSSIM are considered (-40%; -20%, +20% and +40% from the initial price). These scenarios generate information on own and cross price-quantity effects which are introduced in the extrapolation routine of EXPAMOD. In most cases, price changes are likely to be far smaller. However, sufficient variation of prices is needed to stabilize the estimates of the price-related coefficients. Table 2 shows how this information enters the model as input data, where each price set requires a separate run of FSSIM.

**Table 2** Price-quantity vectors from a selected farm type\* (Brandenburg, Germany)

	Price Variation	Soft Wheat		Rapeseed	
		Price, €/t	Quantity, 1000 t	Price, €/t	Quantity, 1000 t
Baseline	0%	92	498	205	586
Change in Price of Winter Soft Wheat	-40%	55	0	205	607
	-20%	74	140	205	605
	20%	110	976	205	544
	40%	129	976	205	544
Change in Price of Rapeseed	-40%	92	440	123	280
	-20%	92	553	164	432
	20%	92	458	246	652
	40%	92	457	287	704

Price changes for one product at a time, other prices kept constant at the baseline level.

\*An arable farm type of large size and low intensity specialised in cereal crops.

## 1.4 Empirical model

The basic idea, as presented above, is to estimate functions using simulated “observations” from existing FSSIM models that, *in principle*, depict the relationship described in equation (3). The general approach to be followed in the selection of variables is to promote their highest explanatory relevance and availability for all EU-farm types and regions. Following equation (3), each FSSIM model is developed for a particular farm type ( $z$ ) in NUTS 2 region ( $r$ ) at simulated price level  $l$ . The notation for NUTS 2 region is denoted by the superscript ‘FSSIM’ to emphasize the difference between estimation (equation 4) and extrapolation (equation 5). Following the notation used above and in Louhichi et al., (2006), and explicitly using the two indices  $z$  and  $r^+$  replacing the index  $i$  above in equation (3), a meta-model of the FSSIM models is defined in the following way:

$$(4) \quad Q_{klzr^+} = f(\mathbf{p}_{k'l'r^+}, \mathbf{b}_{wzr^+}, \mathbf{c}_{czr^+})$$

where

$Q_{zklr^+}$  is the estimated quantity of product  $k$  supplied to the market as simulated by an FSSIM model  $q_{zlr^+}$  (model of specific farm type  $z$  in region  $r^+$ ) at price level  $l$ ,

$\mathbf{p}_{k'l'r^+}$  are prices of product  $k'$  ( $k, k' \in V, V$  vector of products) at price level  $l$  ( $l \in L, L$  vector of price shocks) in NUTS 2 region  $r^+$ ,

$\mathbf{b}_{wzr^+}$  is a vector ( $W_{zr^+} \times 1$ ) of farm resource endowments from model  $q_{zlr^+}$  (on farm type  $z$  in NUTS 2 region  $r^+$ ) and

$\mathbf{c}_{czr^+}$  is a vector ( $C_{zr^+} \times 1$ ) of biophysical characteristics of farm type  $z$  in NUTS 2 region  $r^+$ .

The logarithmic specification of a polynomial functional form in equation (4) is defined in the following way:

$$(5) \quad \ln Q_{kzr^+} = \alpha_{kzr^+} + \sum_{k'} \beta_{kk'} \cdot \ln p_{k'lr^+} + \sum_w \gamma_{kw} \cdot b_{wzr^+} + \sum_c \lambda_{kc} \cdot c_{czr^+} + \sum_w \varphi_{kw} \ln(p_{k'lr^+}) \cdot b_{wzr^+} + \sum_c \delta_{kc} \ln(p_{k'lr^+}) \cdot c_{czr^+} + e_{kzr^+}$$

where

$e_{kzr^+}$  is the error term and

$\alpha, \beta, \gamma, \lambda, \varphi, \delta$  are the parameters to be estimated.

The cross terms between the own price variable ( $p_{k'lr^+}$ ) and farm resources ( $b_{wzr^+}$ ) and between own price and biophysical characteristics ( $c_{czr^+}$ ) are introduced to allow for more flexibility of price responses across a wide variation of conditions and ultimately allow regional differentiation of price elasticities to be recovered in the estimation and extrapolation step.

The primary motivation for this model specification is that price responses for the different products in relative terms genuinely depend on the biophysical characteristics and farm resources (e.g. co-influence of good soils and high prices for cereals). This formulation allows the recovery of this additional explanatory power at the cost of certain degrees of freedom in the estimation, an important factor to take into account if the number of observations or the variance of the sample is low. However, when all FSSIM models in sample regions are running, this should be of minor importance for most products.

The above specification is applicable only to regions for which FSSIM models exist, thus, the subscript  $r^+$  (“r-plus”) in equation (5) refers to the FSSIM sample regions. The farm resources considered ( $\mathbf{b}_{wzr^+}$ ) are economic size units, area, machinery, labour and buildings. The agri-environmental variables ( $\mathbf{c}_{czr^+}$ ) are soil-related (five soil type shares, carbon content and available water capacity) and climate-related (average over last 30 years minimum, and maximum temperature, average rainfall, and average radiation). For extrapolation,  $\omega_{zr^+}$  is used as the vector of aggregation weights of farm type  $z$  within NUTS 2 region  $r^+$ .

Both farm and regional models have product lists of the main agricultural outputs, with a different level of detail. Matching these product lists is essential to guarantee the consistency between the two models (CAPRI and FSSIM). During estimation, EXPAMOD works with FSSIM classifications which are used for deriving price-supply elasticities. During extrapolation, the aggregated elasticities for the CAPRI product classification (e.g. soft wheat) are derived from the estimated parameters for FSSIM products (e.g. winter soft wheat, spring soft wheat).

Disaggregation is required when the endogenous prices obtained from CAPRI have to be used by the farm model FSSIM (step 4 in figure 2). The assumption here is that within one crop family the FSSIM optimal solution will only select crops which are close substitutes. Based on this assumption, the price of barley, for example, can be averaged from prices of summer and winter barley. When combining the FSSIM product list with the CAPRI list, price effects obtained from CAPRI are translated to FSSIM. In order to obtain the new FSSIM prices, the original prices are multiplied by the percentage price change obtained by CAPRI (i.e. the original price ratios of product varieties in FSSIM within the composite product in CAPRI are kept constant).

Once the parameters from equation (4) are estimated, the extrapolation takes place according to (5) using the parameter estimates (denoted by “hats”) and the data on prices, resource endowments and biophysical characteristics from non-FSSIM regions (denoted  $r^-$ , “r-minus”). The extrapolation of elasticities is based on the first derivative of the logged supply function with respect to the logarithm of prices and is therefore obtained from the parameter estimates as

$$(6) \quad \varepsilon_{kk'r} = \frac{\partial \ln \hat{Q}_{kz^-}}{\partial \ln \hat{p}_{k'r^-}} = \hat{\beta}_{kk}, \text{ where } k \neq k' \text{ for cross-prices, and}$$

$$(7) \quad \varepsilon_{kkr} = \frac{\partial \ln \hat{Q}_{kr^-}}{\partial \ln \hat{p}_{kr^-}} = \hat{\beta}_{kk} + \hat{\phi}_{kw} \cdot b_{wzr^-} + \hat{\delta}_{kc} \cdot c_{c zr^-} \text{ for own prices}$$

Within the specification (6) the cross-price elasticities are the same for all regions, as it would happen with a Cobb-Douglas functional form (no cross-terms contain cross-prices in our formulation). Region and farm-type-specific own price elasticities appear in equation (7).

As required by CAPRI, price elasticities are aggregated to NUTS 2 regions (currently the lower level of disaggregation in CAPRI) for sample regions (estimation) or non-sample regions (extrapolation). Within this aggregation structural change can be reflected by adjusting the Farmtype weights according to the results of the structural change analysis as described in Zimmermann et al (2008). Their estimates for stationary transition probabilities are made available in the SEAMLESS database and connected to the SEAMLESS typology so that they could directly be used inside EXPAMOD as aggregation weights for farm types. However this is technically not yet integrated due to technical problems and the fact that the inclusion would not improve EXPAMOD at its current stage.

## 1.5 Main findings and performance

The results presented in this section refer to econometric work done at the point when the data from 7 NUTS2 regions were available, having respectively 26 crop products. A summary of the data used in the econometric analysis is presented at the end of this section in table A1. Section 1.6 reflects on further updates as they become available at the moment of this report writing (data from 13 NUTS2 regions and 26 crop products)

The model specification for EXPAMOD, as presented above, is tested for the production activities observed in a farm type model. Table A3 presents the estimation results for six selected crops. These crops have sufficient number of observations and are rather important for the selected seven sample regions, as presented in table A2. For other crops which appear in optimal solutions of the farm models (out of 26 in total) the number of observations is between 82-624 which is low to run sound regressions (for example for olives, onion, rice, soya, grain maize, fodder maize, sugar beet, triticale, durum wheat, oats, peas, cotton, grapes for wine). Since not all crops that can potentially be grown in a region are actually selected in the optimal solution, sample means are imputed for missing prices to include all the price variables in the estimations. Nevertheless, some own as well as cross-price variables are dropped from the regressions due to collinearity problems, which might be caused by a rather low number of regions available implying insufficient variation. Moreover, a more complex design of the price experiments could mitigate this problem and will be explored in future modifications. However, collinearity between different variables containing the same price is really not a fundamental problem, because it is the total marginal effect of the price and the

fit of the model which is important for the extrapolation. In overall, the estimations hint at a fairly stable behaviour of the farm models considered for the analysis and, producing a good fit of the response functions as indicated by the high  $R^2$ .

**Table 3** *Price-quantity elasticities calculated at regional sample mean (7 sample NUTS2 regions)*

NUTS2-region name/FADN-region (Country)	Soft wheat		Barley		Rapeseed		Sunflower		Rye		Potatoes	
	mean	N	mean	N	mean	N	mean	N	mean	N	mean	N
Schwaben/Bayern (Germany)	1.5	212	1.8	197	1.2	212	1.4	159	1.1	212	5.0	208
Brandenburg (Germany)	1.6	194	7.6	192	1.1	195	4.6	126	2.1	189	7.4	172
Denmark (Denmark)	5.5	274	2.4	228	2.4	285			4.4	265	4.8	105
Castilla-Leon (Spain)	2.8	206					3.5	173				
Andalucia (Spain)	1.6	264					0.7	315			4.8	217
Midi-Pyrenees (France)			11.7	30	2.5	80	2.0	121				
Flevoland/Netherlands (Netherlands)	-0.0	72									2.3	74
Sample total	2.6	222	4.2	647	1.8	772	2.1	894	2.7	666	5.2	776

Source. EXPAMOD

Table 3 presents the price-supply elasticities at regional means as well as the sample. This table also indicates the number of observations of the six crops in each region. Strictly positive elasticities for the own prices, except for one negative elasticity of soft winter wheat in one of the regions (see table 3), also point to correct predictions. Although the behaviour of the farm models seems to be correctly picked up by the estimation approach, the elasticities seem rather low when compared to the literature, e.g. with those presented in Jansson (2007).

The negative (although very low) own-price elasticity for soft winter wheat may be a result of not imposing restrictions on parameters of the crop supply functions to ensure for the regularity conditions. However, it is important to bear in mind the underlying farm optimisation models do not fulfil the regularity conditions required in conventional duality theory, because the technology is not twice continuously differentiable with respect to outputs. Consequently, symmetry and curvature are unlikely to hold exactly at the margin. Homogeneity, i.e. insensitivity of supply quantities to a general inflation of prices, should hold. One could still argue that all standard conditions could be approximated with the continuous function, but symmetry and curvature cannot be globally imposed with the current functional form. Local or “regional” imposition with Bayesian techniques is not feasible within an automated up-scaling procedure. Different from typical estimation set-ups in economic analysis, here we are able to theoretically increase the number of observations (without requiring increasing generality of the model) until a sufficiently flexible functional form will adhere to theoretical restrictions.

Given the difficulties of imposing these theoretical restrictions at the estimation stage, regional elasticities are calibrated to microeconomic restrictions before their use in the market model (i.e. they are part of the calibration process of the regional supply functions in CAPRI). This implies some overall efficiency loss related to not using the information during estimation, but this cannot be avoided due to the combination of requirements put on the extrapolation approach.

**Table 4** *Availability of data in 7 sample NUTS2 regions*

NUTS2-region name / FADN-region (Country)	Number of farm types modelled with FSSIM	Maximum number of products in optimal solutions	Number of observations	% area represented to total
Flevoland (Netherlands)	4	7	100	78
Denmark (Denmark)	6	10	342	90
Castilla-Leon (Spain)	10	6	210	83
Andalucia (Spain)	10	9	450	50
Midi-Pyrenees (France)	3	11	123	51
Brandenburg (Germany)	3	15	195	59
Schwaben/Bayern (Germany)	4	14	212	83
<b>Total</b>	40	26	1 632	-

Source. EXPAMOD

**Table 5** *Area representativity for different production activities in seven sample regions (%)*

Crops <sup>1</sup>	Andalucia	Brandenburg	Castilla y Leon	Danmark	Flevoland	Midi-Pyrenees	Schwaben
Soft wheat (Spring+Winter)	3.9	19.8	19.4	31.0	15.0	8.7	25.2
Barley (Spring+Winter)	26.7	0.3	0.4			14.1	0.1
Rapeseed	2.5	7.5	41.6	28.4	5.1	2.0	17.9
Sunflower	11.2	13.3	3.2	4.7		18.1	9.0
Rye	11.2	1.9	3.2			13.8	0.2
Potatoes	8.5	7.7	15.2	7.5	2.1	7.5	5.1
Durum Wheat (Spring + Winter)		9.4	0.8	2.0	0.1		1.9
Oil seeds		8.5		4.7		1.1	6.8
Sugar beet	3.8	0.1	0.5	2.6	29.6		3.8
Maize	1.3	1.3	1.7	3.0	13.5		9.0
Fresh vegetables	1.0	1.5	2.7		0.4	14.9	4.6
Fallow land	0.2	0.1		0.2	14.8	0.6	1.7
Other crops	29.6	28.4	11.2	15.7	19.3	19.3	14.6
<b>Total</b>	100	100	100	100	100	100	100

Source. own presentation based on FADN data (2003).

<sup>1</sup> The estimation results for the first 6 crop production activities are presented in the paper (see table A3).

**Table 6** Estimation results for six selected crop products in 7 NUTS sample regions

		Soft winter wheat		Barley		Rapeseed		Sunflower		Rye		Potatoes	
		Coef.	P> t	Coef.	P> t	Coef.	P> t	Coef.	P> t	Coef.	P> t	Coef.	P> t
Logged prices <sup>1</sup>	Potatoes	-0.14	0.52	-0.22	0.20	-0.08	0.07	-1.52	0.00	-0.16	0.37	-0.86	0.00
	Rapeseed	-0.48	0.07	-0.47	0.00			-0.63	0.04	-0.83	0.00	0.03	0.86
	Rye	-0.36	0.16	-0.24	0.12	-0.04	0.27	-0.46	0.20			-0.02	0.91
	Sunflower	-0.07	0.75	-0.52	0.01	-0.28	0.00	1594.40	0.20	0.18	0.45	-1.02	0.00
	Barley	-1.53	0.00			-0.24	0.00	-1.51	0.01	-0.24	0.39	-0.43	0.00
	Soft winter wheat	-8203.92	0.00	-1.26	0.00	-0.29	0.00	-1.56	0.00	-0.86	0.00		
Farm resources and biophysical characteristics	Machinery	-386.82	0.00	-3.95	0.62	7.17	0.00	93.92	0.15			106.24	0.00
	Labour	-356.03	0.00	0.57	0.59	5.83	0.00	86.11	0.15	39.00	0.00	97.40	0.00
	Buildings	-319.36	0.00	0.29	0.80	7.10	0.00	75.96	0.16	45.32	0.00	86.49	0.00
	Economic size unit	-278.71	0.00	-0.11	0.91	7.04	0.00	65.62	0.17	42.45	0.00	73.17	0.00
	Area	-203.77	0.00			6.65	0.00	48.96	0.19	61.09	0.00	68.66	0.00
	Share soil type 1	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.09	-0.01	0.00	0.00	0.08
	Share soil type 2	0.00	0.02	0.00	0.92	-0.03	0.00	0.04	0.00	-0.17	0.00	0.00	0.26
	Share soil type 3	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00
	Share soil type 4	0.19	0.00	0.48	0.84	2.07	0.00	-1.34	0.00	13.20	0.00	-0.03	0.70
	Share soil type 5	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.18	0.01	0.00	0.00	0.28
	Minimum temperature	-96.55	0.00					31.75	0.25			28.70	0.23
	Maximum temperature	129.13	0.00			-25.31	0.00	-41.64	0.31				
	Radiation	-0.12	0.00	0.02	0.78	0.04	0.00	0.02	0.42	0.35	0.00	-0.03	0.00
	Precipitation	90.75	0.00					-7.16	0.77			124.08	0.07
	Soil available water capacity	5.12	0.00	1.32	0.29	-2.44	0.00	1.45	0.31	-7.72	0.00	4.70	0.01
	Topsoil carbon content	-2711.68	0.00					681.28	0.12			740.70	0.00
	Cross Terms (own logged price * non-price variables)	Price * share soil type 1	79.03	0.00	1.01	0.55	-0.42	0.03	-15.14	0.21			3.45
Price * share soil type 2		72.76	0.00	0.39	0.66	-0.28	0.02	-13.89	0.21	-6.96	0.00	3.10	0.00
Price * share soil type 3		65.25	0.00	0.54	0.59	-0.50	0.01	-12.24	0.22	-8.69	0.00	2.97	0.00
Price * share soil type 4		56.95	0.00	0.57	0.59	-0.55	0.01	-10.59	0.23	-8.62	0.00	3.47	0.00
Price * share soil type 5		41.60	0.00	0.77	0.58	-0.51	0.02	-7.88	0.25	-5.60	0.00	-2.25	0.00
Price * machinery		0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.48
Price * labour		0.00	0.02	0.00	0.21	0.00	0.00	-0.01	0.00	0.04	0.00	0.00	0.55
Price * buildings		0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.67
Price * economic size unit		-0.04	0.00	0.08	0.58	-0.29	0.00	0.24	0.00	-3.11	0.00	-0.02	0.16
Price * area		0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.04
Price * min.temperature		19.94	0.00					-4.82	0.34			21.48	0.00
Price * max.temperature		-26.56	0.00			3.88	0.00	6.06	0.42	54.70	0.00	-38.26	0.00
Price * radiation		0.03	0.00	0.00	0.92	-0.01	0.00	0.00	0.53	-0.05	0.00	0.04	0.00
Price * precipitation		-18.28	0.00					0.44	0.92			-49.42	0.00
Price * soil available water		-1.05	0.00	-0.38	0.29	0.32	0.00	-0.23	0.38	3.46	0.00	-2.29	0.00
Price * carbont content	554.42	0.00			3.45	0.01	-110.19	0.18			24.47	0.00	
Constant	40151.71	0.00	-447.09	0.67	-409.86	0.00	-9807.21	0.15	-8186.57	0.00	-11735.83	0.00	
R2	0.92		0.93		0.99		0.94		0.97		0.99		
number of parameters	47		36		40		46		35		45		
Nr. of observations	1222		647		772		894		666		776		
Prob. F-test	0.00		0.00		0.00		0.00		0.00		0.00		

Source. EXPAMOD

<sup>1</sup> In order to reduce the size of this table only the logged prices of the 6 selected products is included (out of 26 products). The results in this Table are based on the data from 7NUTS2 regions.

## 1.6 Evaluation of final delivered version

The final delivered version of EXPAMOD is able to use farm types for 12 sample regions.<sup>1</sup> In this section we assess again the explanatory power of EXPAMOD but highlight also the main problems connected to the final model stage.

We hereby start with a look at the input data coming from FSSIM. Primarily, we check which crops are represented in FSSIM models when using the 12 sample regions. The results are shown in Table 7, from which the following information can be extracted:

- A seemingly sufficient number of FSSIM farm types exists producing sugar beets, winter soft wheat, rape and sunflowers spread around at least 6 regions.

<sup>1</sup> Although FSSIM uses 13 sample regions, one of them (The Great Britain region North West) only contains 1 Farmtype with only 3 crops and it was therefore not used in EXPAMOD.



- For the group formed by potatoes, peas, fodder maize, rye, oats summer and winter barley, table olives as well as corn, the number of farm types producing these products is in between 9 and 14 spread around at least 3 regions (exemption table olives with only 1 region). For this group significant problems of representativeness are likely to occur because biophysical and farm endowment variables in three regions will likely have a much smaller variance than the one used for extrapolation.
- For all products reported below 'maize' in the table, the number of farm types is below 6 and they are located in a maximum of two regions. Apart from the representativeness problem, that is even bigger than in the previous group, we additionally face the problem of possible bad performance of the estimator due to low variance in explanatory variables.

**Table 7** *FSSIM observations*

	Number of farm types	Regions per crop
Total	281	13
WSWH	41	10
SUGB	39	9
SUNF	26	6
RAPE	25	8
POTA	14	5
PEAS	14	5
MAIF	13	3
RYES	12	3
OATS	12	3
SBAR	11	4
WBAR	10	6
TABO	9	1
MAZE	9	4
WDWH	6	1
TWIN	5	1
COTT	5	1
ONIO	4	1
SSWH	4	2
ALFA	4	1
CERO	4	2
TRIT	3	2
OLIV	3	1
RICE	3	1
SOYA	3	1
GRST	1	1
GRSS	1	1

Source. EXPAMOD <sup>2</sup>

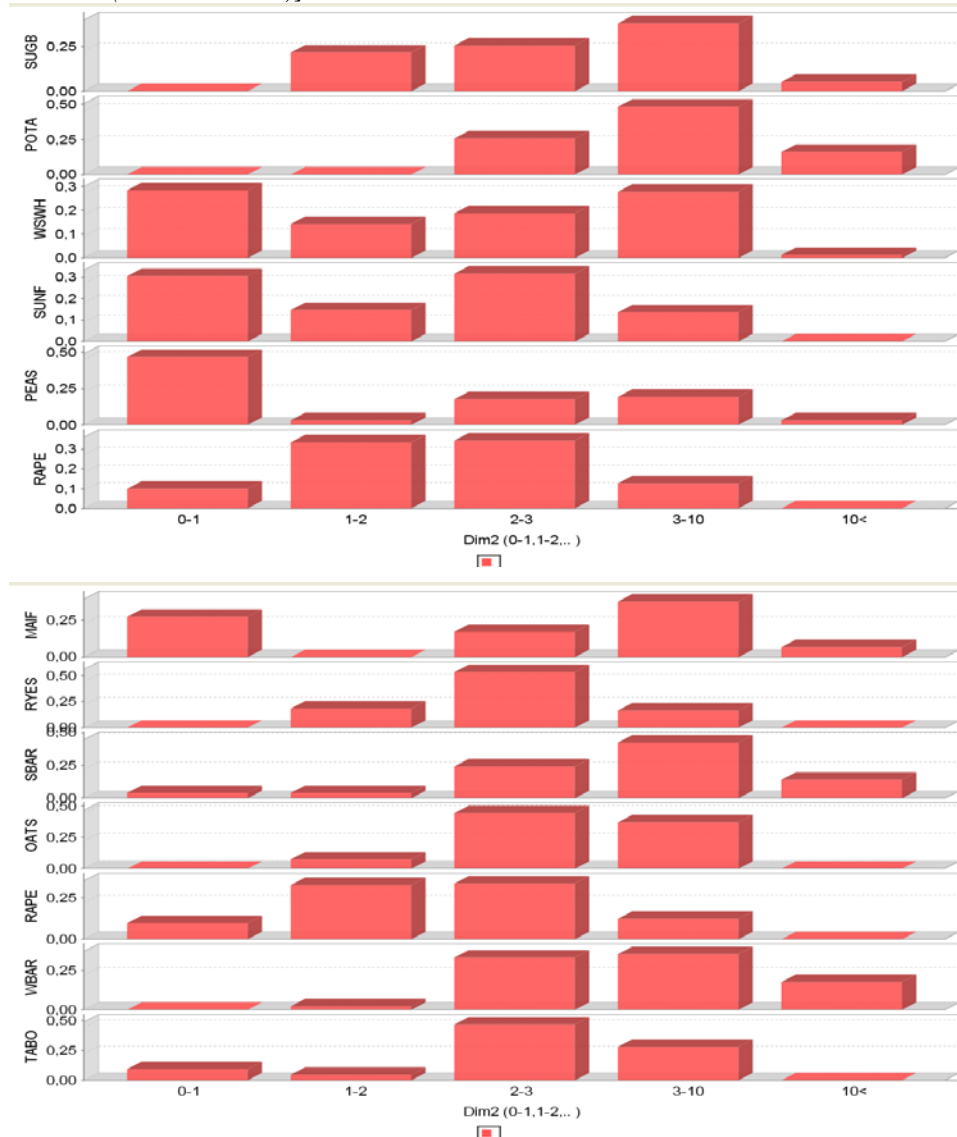
Currently EXPAMOD uses the first two groups. We will have a closer look at the representativeness of the explanatory variables later on.

Let us now assess the elasticities coming from FSSIM. As described before, EXPAMOD reads data from FSSIM price experiments in terms of price-quantity combinations. It is therefore possible to calculate the point elasticities from those experiments. For the following overview we calculated elasticities between each price experiment and the baseline optimal solution in FSSIM. That means each of the resulting point elasticities is calculated with respect to baseline prices and baseline quantities. The point elasticities are then stacked into a

<sup>2</sup> SUGB= Sugarbeet, POTA = Potatoes, MAIF= Fodder maize, WSWH = Winter softwheat, SUNF= Sunflowers, RYES = Rye SBAR = Summer barley, OATS = Oats, RAPE= Rape seed, WBAR= Winter barley

histogram. We chose the categories between 0 and 1, between 1 and 2, between 2 and 3, between 3 and 10, and greater than 10. Here only those distinguished for the first 2 groups identified in Table 7 are presented .

Figure 4: Elasticity histograms of own price point elasticity calculated from FSSIM optimal solution (baseline 2013)]



Source. EXPAMOD<sup>2</sup>

It becomes apparent that for most of these products, the main part of the elasticity distribution is between 0 and 3, which is a range where elasticities are commonly found. For potatoes, suber beet, summer barley and winter barley, elasticities are found in higher ranges, e.g. the distribution is skewed to the right.

Generally, we can not tell how realistic these results are without knowing about the area shares for each crop, as higher elasticities are more likely for small area shares. However, there seems to be a tendency of overestimation of supply response in FSSIM. Especially if we look at the resulting aggregated regional own price elasticities:

**Table 8** *FSSIM own price elasticities in 12 NUTS2 regions*

	SUGB	POTA	MAIF	WSWH	SUNF	RYES	SBAR	OATS	RAPE	WBAR	MAZE
DK000000	5.79		4.69						2.79		
DE400000	3.13	7.02		3.74	2.81	3.73	5.20	5.17	4.13		4.43
DE270000	3.53			0.19							
ES410000	0.78			0.10	0.06						
ES610000	5.24	2.93		1.44	0.27						
FR210000	4.42						3.01		1.26		
FR530000					3.17				2.85	7.49	2.05
FR620000			3.72	4.69	1.92				1.95	2.74	2.10
FR720000					2.06				2.31	3.38	2.74
NL230000	3.00	4.45	0.40	1.98							
PL340000	1.70	6.38		4.06		2.27	5.17	3.40			
PL420000	1.51	5.85		4.00		2.24	3.57	4.18	1.72		

Source: EXPAMOD <sup>2, 3</sup>

For example, the winter soft wheat column (WSWH), we see quite high elasticities in 5 regions (all around 4). The region Brandenburg (DE400000) produces a considerable amount of soft wheat and a supply elasticity of 4 seems to be very high, if we compare it for example to the result for soft wheat in Brandenburg estimated by Jansson (2007), where the author reports a supply elasticity of 2. Potato elasticities are high in general in the FSSIM results. Therefore we may conclude that the general supply response simulated by FSSIM is somewhat more elastic expected.

The next question to investigate is how good EXPAMOD fits the FSSIM results. In **Error! Reference source not found.** we report the  $R^2$  statistics of the performed translog regression in the column “Estimation”. It turns out that  $R^2$  values are quite high indicating that a large share of the logged supply quantities can be explained by the model. However, the logarithm of the supply quantities is not the most interesting variable in our case, because we need to assess the fit of the real supply quantities. This can be done by calculating the squared correlation coefficient between the original and the fitted supply quantities (which is equivalent to  $R^2$  in linear regression). It becomes obvious that the fit is low for almost all crops and bad for some of them. Generally one can say that larger absolute supply quantities increase the probability of a weaker fit. For example, if the error term of the estimation equation was 0.1, it would translate into an error term for the supply quantities of 1 if the initial quantity was 10 and of 42 if the initial value was 400. Since there are no weights in least squares regression the deviation from both cases is evaluated with the same penalty in the objective function. Therefore switching to a weighted least squares estimation may help improving the estimation fit of the original values.

<sup>3</sup> DK000000 = Danmark, DE400000 = Brandenburg, DE270000 = Schwaben, ES410000 = Castilla-Leon, ES610000 = Andalusia, FR210000 = Champagne-Ardenne; FR530000 = Poitou-Charentes, FR620000 = Midi-Pyrenees, FR720000 = Auvergne; NL230000 = Flevoland, PL340000 = Podlaskie, PL420000 = Zachodniopomorskie

**Table 9** *Estimation fit of supply quantities and elasticities*

	<b>Estimation</b>	<b>Without log</b>	<b>Elasticities</b>
SUGB	0.657	0.124	0.003
POTA	0.823	0.114	0.021
MAIF	0.889	0.570	0.819
WSWH	0.759	0.672	0.393
SUNF	0.932	0.777	0.698
RYES	0.982	0.883	0.332
SBAR	0.929	0.366	0.003
OATS	0.978	0.929	0.855
RAPE	0.678	0.792	0.281
WBAR	0.902	0.768	0.760
MAZE	0.980	0.960	0.518

Note: The table reports squared correlation coefficients between observed and fitted values

Source: EXPAMOD<sup>2</sup>

In the column "Elasticities" of **Error! Reference source not found.** we report the squared correlation coefficient between the average elasticities per farmtype and crop and those resulting from EXPAMOD calculated using equation 7. For some products the squared correlation coefficients are above 0.5 (fodder maize, sunflowers, oats, winter barley) but again, important products show poorly fitting supply responses between the two models. This is to some extent due to outliers. For example, to calculate the correlation coefficient between FSSIM and EXPAMOD elasticities for potatoes, we only have 10 observations available. For 9 of them, the two values appear to be quite close, but the 10<sup>th</sup> is out of range and dominates the calculation of sample mean and variance. This also occurs for other crops like summer barley.

The only crops that have above 20 observations are sugar beet, winter soft wheat, sunflowers and rape seed. Within the group of these 4 crops, only sunflowers show relatively closely fitting elasticities. This can again be explained by the bad fit of the absolute supply quantities for the other 3 crops, shown in the "Without log" column of **Error! Reference source not found.**

As already indicated above it can be said that if the supply quantities across farm types for one crop show a high variance, the farm types with higher supply quantities tend to be poorly estimated. For example, supply quantities of sugar beet farm types vary between 0 and 40000 t. In Denmark we find 2 farm types supplying around 2000 t of sugar beets, which is a quite large number. This may explain the considerable differences between regional averages of FSSIM and EXPAMOD elasticities reported in Table 10Table 10. The phenomenon of high supply quantities does also explain the bad fit found for Poland.

In general, the fit of regional aggregated elasticities appears to be acceptable as shown in the following table. Apart from some outliers like sugar beet in the polish regions, Andalucía (ES610000) and in Brandenburg (DE400000), rapeseed, sugar beets or fodder maize in Denmark, the relative differences between both elasticity types are found in between the range of plus minus 40%. The results still leave some room for improvements.

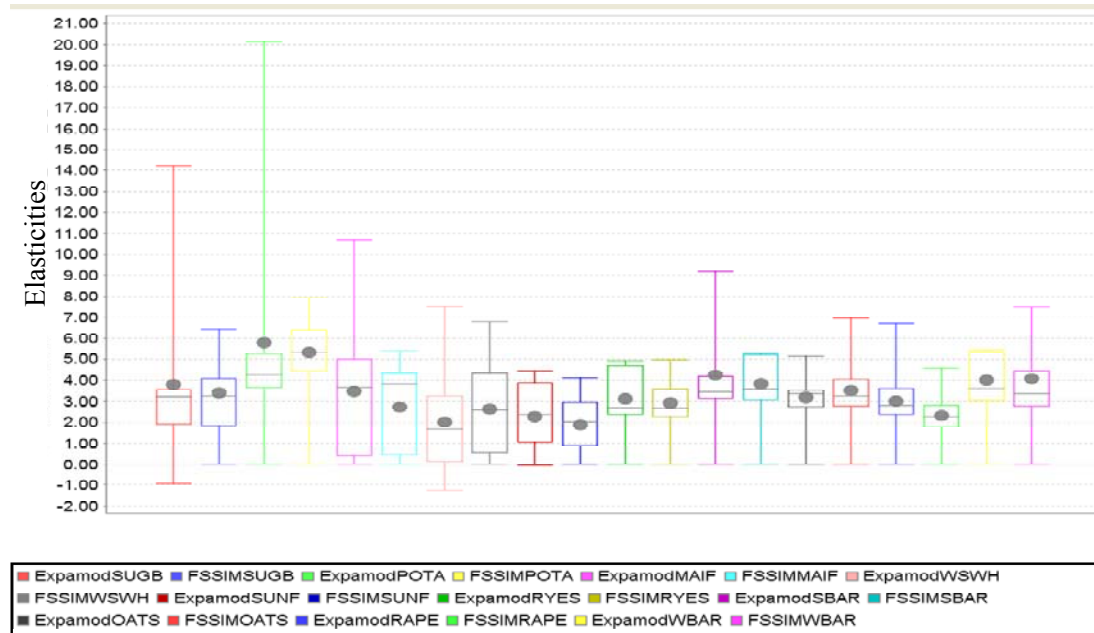
**Table 10** Comparing FSSIM and EXPAMOD own price elasticities for 12 NUTS2 sample regions

		SUGB	POTA	MAIF	WSWH	SUNF	RYES	SBAR	OATS	RAPE	WBAR	MAZE
DK000000	EXPAMOD	-3.92		7.29						4.91		
	FSSIM	5.79		4.69						2.79		
	% diff	-248%		-36%						-43%		
DE400000	EXPAMOD	-0.08	4.78		6.02	4.34	4.87	4.22	4.27	3.95		3.36
	FSSIM	3.13	7.02		3.74	2.81	3.73	5.20	5.17	4.13		4.43
	% diff	-3787%	47%		-38%	-35%	-23%	23%	21%	4%		32%
DE270000	EXPAMOD	3.67			0.02							
	FSSIM	3.53			0.19							
	% diff	-4%			933%							
ES410000	EXPAMOD	0.68			-0.01	0.06						
	FSSIM	0.78			0.10	0.06						
	% diff	14%			-1544%	-8%						
ES610000	EXPAMOD	16.56	3.79		2.02	0.08						
	FSSIM	5.24	2.93		1.44	0.27						
	% diff	-68%	-23%		-29%	247%						
FR210000	EXPAMOD	3.36						5.23		1.23		
	FSSIM	4.42						3.01		1.26		
	% diff	31%						-42%		2%		
FR530000	EXPAMOD					4.25				2.43	5.68	0.75
	FSSIM					3.17				2.85	7.49	2.05
	% diff					-26%				17%	32%	174%
FR620000	EXPAMOD			3.67	3.12	2.66				2.65	3.19	2.76
	FSSIM			3.72	4.69	1.92				1.95	2.74	2.10
	% diff			1%	50%	-28%				-26%	-14%	-24%
FR720000	EXPAMOD					3.02				2.54	3.79	2.80
	FSSIM					2.06				2.31	3.38	2.74
	% diff					-32%				-9%	-11%	-2%
NL230000	EXPAMOD	2.77	5.29	0.37	4.31							
	FSSIM	3.00	4.45	0.40	1.98							
	% diff	9%	-16%	8%	-54%							
PL340000	EXPAMOD	0.99	4.87		5.55		3.04	4.28	3.24			
	FSSIM	1.70	6.38		4.06		2.27	5.17	3.40			
	% diff	72%	31%		-27%		-25%	21%	5%			
PL420000	EXPAMOD	0.92	4.13		3.54		2.51	3.52	3.29	3.53		
	FSSIM	1.51	5.85		4.00		2.24	3.57	4.18	1.72		
	% diff	65%	42%		13%		-11%	1%	27%	-51%		

Source. EXPAMOD <sup>2,3</sup>

The following figure highlights, that EXPAMOD creates more variance in elasticities than originally comes from FSSIM. The so called Box and Whisker chart shows important variables of a sample in a condensed way. The grey filled circles give the sample means, while the short horizontal line gives the median. The boxes show the range of the 2 middle quartiles, whereas the vertical line that is bound by the two horizontal ones gives the range of all values.

Figure 5: Comparison of FSSIM and EXPAMOD own price elasticities

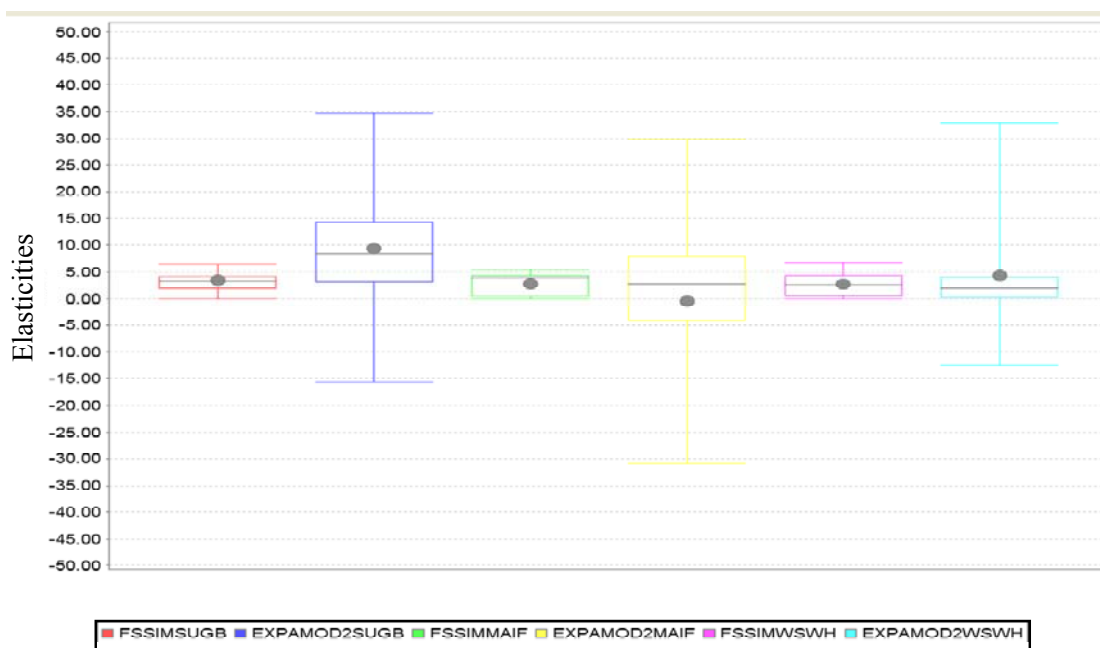


Source: EXPAMOD <sup>2</sup>

Although sample means of EXPAMOD and FSSIM elasticities are similar (Table 10Table 10), the range of regular values is larger for most of the EXPAMOD estimates. This might indicate that the chosen functional form is not flexible enough to provide a sufficient fit. Furthermore, it does not prevent own price elasticities to become negative. We can conclude that the regression fit of EXPAMOD is rather high, but estimates of absolute supply quantities and elasticities turn out to be rather weak.

In addition to the estimation part, EXPAMOD contains an extrapolation routine to the EU NUTS2 regions that are not in the FSSIM sample. In the following figure, we compare the range of FSSIM elasticities for 3 selected products to that of EXPAMOD elasticities including the extrapolation. It becomes obvious that the spread of own price elasticities is much higher and large parts of the sample show negative or unreasonably high values. When we further keep in mind that for the other products not presented in Figure 6 the gap between FSSIM and EXPAMOD is even larger we must conclude that the extrapolation does not work properly with the current FSSIM and EXPAMOD versions, although the tests with synthetic data have proven the principal functionality.

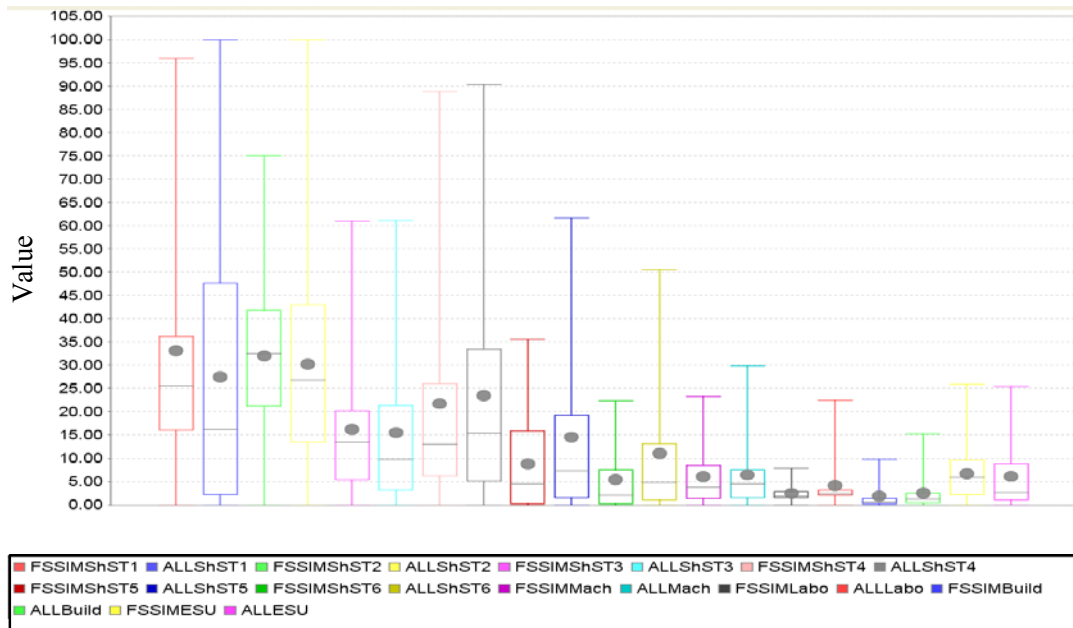
Figure 6: Comparison of FSSIM own price elasticities and EXPAMOD extrapolated own-price elasticities



Source: EXPAMOD<sup>2</sup>

But what are the differences between the Monte Carlo experimental data and the “real” FSSIM data? One important difference is the variance in explanatory variables. The experimental data was chosen such that the range of explanatory variables in the total sample is covered by that of the reduced sample regions, or expressed differently, the domain of explanatory variables in estimation is close to the one used for extrapolation. We now show that this necessary condition is not satisfied by the current FSSIM sample. At first, Figure 7 gives the impression that the variance between the total and the FSSIM sample for most explanatory variables is quite similar. It only seems that soil type 5 and 6 (ShST5, ShST6) as well as the labour endowment (Labo) show deficiencies in this respect. In this figure all explanatory variables have been scaled between 0 and 100 in order to fit them in one diagram. The FSSIM sample therefore, in general, represents the population fairly well in this respect.

Figure 7: Variance of explanatory variables. Total sample compared to FSSIM sample



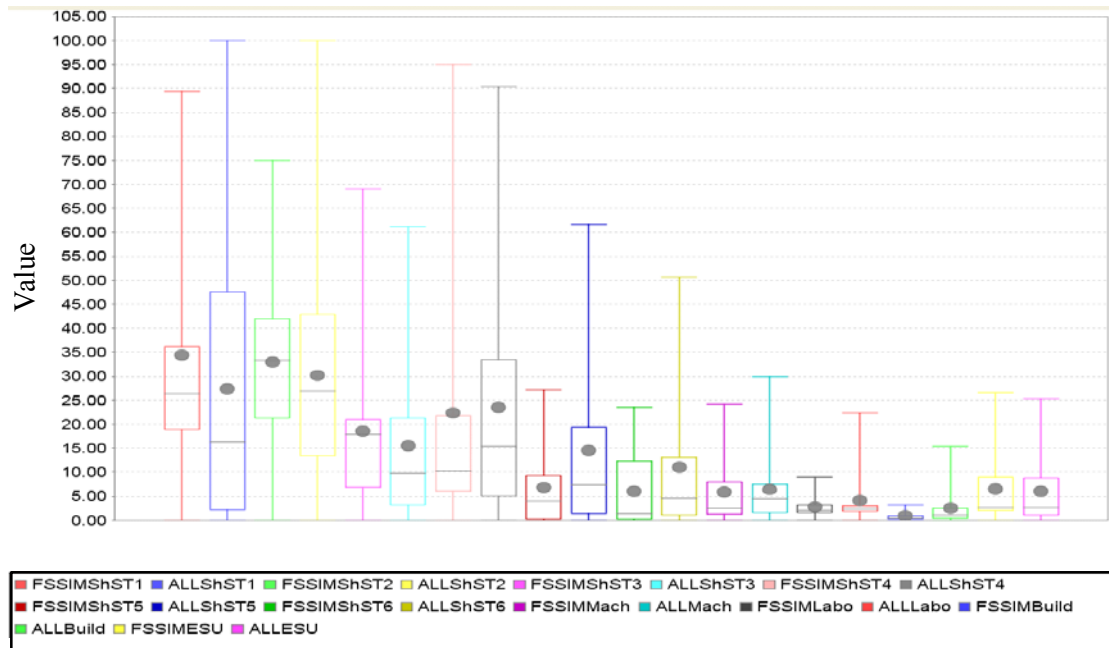
Source: EXPAMOD <sup>2,4</sup>

Unfortunately, the estimation for single products is not done over the full sample of FSSIM experiments. For example, wheat supply functions are only estimated over farms that supply wheat and consequently only the variance in explanatory data over wheat producing farms enters the estimation. If we remember Table 7, the number of observations per product are quite different and for some products rather low. We therefore would have to redraw Figure 7 for each product. We do this exemplary for winter soft wheat (Figure 8) as one of the better represented products and rye (Figure 9) as one of the poorer ones. It becomes obvious that Figure 8 looks very similar to Figure 7, meaning that wheat producing farms cover most of the variance in explanatory variables of the total sample. The main differences are that wheat producing farms cover less of the variance in soil type 5 and less of the variance of buildings. The rye producing farms cover much less of the variance of most explanatory biophysical and farm management data as visible in Figure 9. We can conclude that this is one of the reasons why extrapolated elasticities are worse for rye than for soft wheat.

<sup>4</sup> ShST1 = Share Soil Type 1, ShST2 = Share Soil Type 2, ShST3 = Share Soil Type 3, ShST4 = Share Soil Type 4, ShST5 = Share Soil Type 5, ShST6 = Share Soil Type 6, Mach = Machinery, Labo = Labour, Build = Buildings, ESU = Economic Size

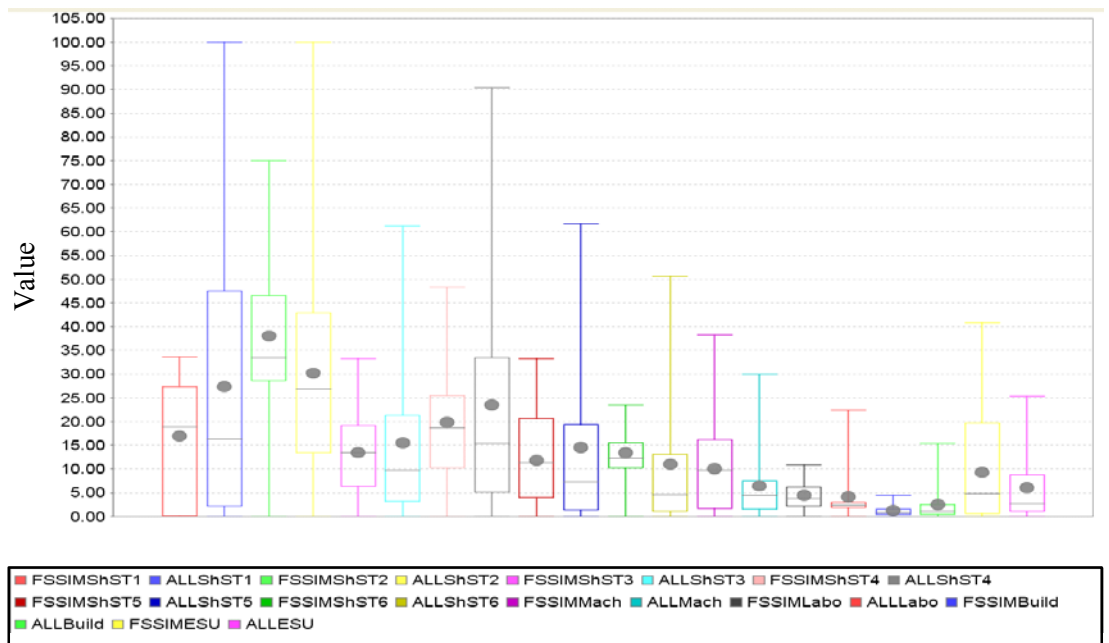


Figure 8: Variance of explanatory variables. Total sample compared to FSSIM sample of wheat producers



Source: EXPAMOD <sup>2,4</sup>

Figure 9: Variance of explanatory variables. Total sample compared to FSSIM sample of rye producers



Source: EXPAMOD <sup>2,4</sup>

Note that if we can sensibly extrapolate to farm types only if all explanatory variables are within the range of the FSSIM farm types in the estimation, the extrapolation is limited to certain regions, as visible in Table 11. While soft wheat and sugar beets elasticities could be extrapolated to nearly half of the EU NUTS 2 regions (ca 250), it is much less for other products. Note that this calculation does not take into account that some products do not need to be extrapolated to some regions, where they usually are not produced.

**Table 11** *Number of regions for extrapolation differentiated by products*

SUGB	POTA	MAIF	WSWH	SUNF	PEAS	RYES	SBAR	OATS	RAPE	WBAR
123	85	2	139	28	34	2	17	2	65	1

Source: EXPAMOD<sup>2</sup>

We can clearly identify that the range of the explanatory variables in the FSSIM sample is currently not sufficient to apply EXPAMOD for an EU wide extrapolation. We cannot finally evaluate how severe this problem is for a final version of FSSIM applied to the sample regions, as currently only farms specialised for cropping are included in the FSSIM sample. An extension to livestock and mixed farms would to some extent improve the variance. However, it will likely not add much to the estimation of important cropping activities.

Lack of variance and representativeness are not the only problems in the EXPAMOD extrapolation part. In the current version, the extrapolation equation (7) is applied on regional level only. Average regional data on biophysical and farm management data is used to achieve regional elasticities. A better procedure would be to first extrapolate elasticities to farm types and then aggregate those to regional elasticities, although this is only relevant if aggregation weights do not add up to 1 or equation (7) was non linear.

A natural improvement of the empirical work to a limited extent can be achieved through increasing the number of FSSIM model calculations. To enable this, first the area coverage issue that has to deal with the rules of FADN data has to be addressed. The matter here, as it is mentioned in Andresen et al (2007), that at the moment the agricultural area represented at the regional level in the SEAMLESS farm typology is too low because the regulation on use of FADN data only allows use of aggregates that are based on at least 15 sample farms.

**Table 12** *The share of the agricultural area covered when applying the SEAMLESS farm typology at the regional level respecting the disclosure rules of FADN (sample regions in BOLD)*

Area coverage	FADN region
<b>0-24%</b>	Baleares, <b>Alentejo-Algarve</b> , Madrid, Kozep-Magyarország, Cantabria, Lisboa e Vale do Tejo (Ribatejo e Oeste), Pohjanmaa (Vali-Suomi), Corse
<b>25-49%</b>	Sodra och Mellersta Sveriges skogs- och mellanbygdsland, Saarland, Cyprus, Eszak-Magyarország, Provence-Alpes-Cote-d'Azur, Murcia, Sisa-Suomi (Ita-Suomi), Molise, Extremadura, Lazio, Liguria, Kozep-Dunantul, Rhone-Alpes, Pohjois-Suomi, Acores-Madeira, Estonia, Abruzzo, Languedoc-Roussillon, Toscana, Eszak-Alfold, Basilicata, Alsace, Navarra, Campania, Lan i Norra Sverige
<b>50-74%</b>	Haute-Normandie, <b>Andalucia</b> (incluido Ceuta & Melilla), <b>Midi-Pyrenees</b> , Pais Vasco, Northern Ireland, Marche, Del-Alfold, Umbria, Slovenia, Friuli-Venezia Giulia, Aquitaine, Etela-Suomi, Veneto, Limousin, Basse-Normandie, Rheinland-Pfalz/Del-Dunantul, Lombardia, Calabria, Sodra och Mellersta Sveriges slattbygdsland, <b>Brandenburg</b> , Valle d'Aosta, Mecklenburg-Vorpommern, Sicilia, Sardegna, Comunidad Valenciana, Asturias, <b>Poitou-Charentes</b> , Aragon, Piemonte, Nyugat-Dunantul, <b>Auvergne</b> , Pays-de-la-Loire, Bourgogne, England-West, Franche-Comte, Galicia, Sachsen, Slovakia, Sterea Ellas-Nissi Egeou-Kriti, La Rioja, Thessalia, Hessen, Picardie, Trentino-Alto Adige, Lorraine, Lithuania, Baden-Wurttemberg, Norte-Centro (PT)

<b>75-100%</b>	Nord-Pas-de-Calais, Puglia, Latvia, Centre (FR), Bretagne, Thuringen, <b>Netherlands</b> , Nordrhein-Westfalen, Luxembourg, England-East, Schleswig-Holstein, Sachsen-Anhalt, Castilla-La Mancha, England-North, <b>Castilla y Leon</b> , <b>Bayern</b> , Belgium, Malopolska-Pogorze, Makedonia-Thraki, Ipiros-Peloponnisos-Nissi Ioniou, Austria, Ile-de-France, Hamburg, Bremen, Berlin, Niedersachsen, <b>Emilia-Romagna</b> , Czech republic, Scotland, Pomorze-Mazury, <b>Denmark</b> , Canarias, Champagne-Ardenne, Wales, Ireland, <b>Mazowsze-Podlasie</b> , Wielkopska-Slask
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Initially it was estimated that 80% of the agricultural area should be represented at the regional level when applying the typology, but this is not the case in the present dataset where all dimensions of the farm types (Size, intensity and specialisation/land use) is included and taken into account the threshold level of 15 sample farms. Only in 37 of the 117 FADN regions we have more than 75% of the area represented (see table 12 and also Table 4 ). In 33 of the regions less than 50% of the area is represented.

There are 4 types of solutions to the area coverage problem, as identified in Andersen et al (2007):

- Option 1 is to merge all farm types with less than 15 sample farms into one or more aggregated farm types. This will keep the information on farm types that are already represented, but it will also create some new aggregated farm types that will be very heterogeneous..
- Option 2 is to skip one or more dimensions of the farm types in the critical regions. This will mean that we will loose the details on some of the farm types already represented, but that we will increase the area represented.
- Option 3 is to keep the farm types that already have more than 15 sample farms and add the farm types that have less than 15 sample farms by letting these be represented by farms of the same type in neighbouring regions.
- Option 4 would be to try to elaborate a method to add and describe the farm types based on the method for spatial allocation of farm types. This has already been used on the agricultural area, so that the data in the database will include all farm types present at the regional level and information on the area they manage.

The solution to be pursued is a variant of option 3. The farm type information will be aggregated for ‘agro-management zones’ i.e. for each of the 13 environmental zones used in the biophysical typology. This approach is also used in relation to alternative activities, where rotation constraints are gathered for these regions. It will thus fit in the overall spatial framework. This should get an area coverage very close to 100% in all regions – if not we will handle the specific problems individually to reach 100% coverage.

## 1.7 Linking EXPAMOD to CAPRI

The calibration of programming models to exogenous supply elasticities by setting parameters of a quadratic cost function is an established idea in the context of “Positive Mathematical Programming” (Howitt 1995). Existing approaches (see e.g. Helming 2001) refer only to own price elasticities, and systematically overestimate the supply responsiveness of the calibrated model by neglecting the effect of changes in dual values. The procedure builds on attempts to estimate variable cost functions of programming models (see e.g. Britz & Heckelei 2000, Heckelei & Wolff 2003, Jansson 2007), and proposes an estimator based on an analytical derivation of the supply response (Heckelei, 2002), including cross-price terms. The calibration defines a symmetric quadratic matrix of cost function parameters to recover given own- and cross price elasticities. It can be seen as a special case of an estimation characterized by zero degrees of freedom and a specific data generating process. The approach is motivated by the integration of the large-scale agricultural sector model CAPRI (Common Agricultural Policy Regionalised Impact) into the SEAMLESS model chain (van Ittersum et.al. 2008) where supply elasticities derived from FSSIM and EXPAMOD (see previous sections) are used in the calibration process for CAPRI’s regional programming models.

### 1.7.1 Methodology

The basic structure of each CAPRI regional model may be described as

$$\max_x Z = \mathbf{gm}'\mathbf{x} - \mathbf{d}'\mathbf{x} - \frac{1}{2}\mathbf{x}'\mathbf{Q}\mathbf{x}$$

where  $\mathbf{gm}$  is a vector of per activity gross margins, and  $\mathbf{d}$  and  $\mathbf{Q}$  are parameters of a variable cost function, all region specific, subject to

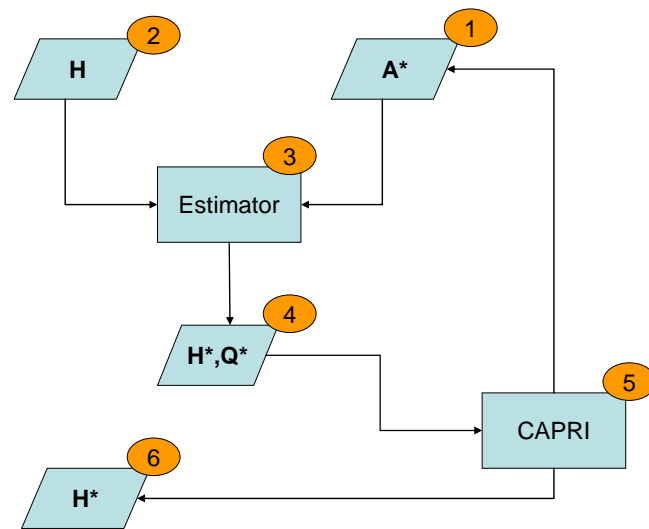
$$\mathbf{A}\mathbf{x} \geq \mathbf{b}[\lambda], 0 \leq \mathbf{x}$$

The vector  $\mathbf{x}$  comprises levels for about 50 crop and animal production activities in each of the about 250 regional models in CAPRI,  $\mathbf{b}$  is a vector of resource constraints and  $\mathbf{A}$  the related coefficient matrix, again region specific. The calibration estimates the matrix  $\mathbf{Q}^*$  which generates the Jacobian matrix of the activity level equations

$$\mathbf{H}^* = \frac{\partial \mathbf{x}}{\partial \mathbf{gm}} = \mathbf{Q}^{-1} - \mathbf{Q}^{-1}\mathbf{A}^* (\mathbf{A}^* \mathbf{Q}^{-1} \mathbf{A}^*)^{-1} \mathbf{A}^* \mathbf{Q}^{-1}$$

which comes close to a matrix  $\mathbf{H}$  derived from exogenous elasticities at a given simplified coefficient matrix  $\mathbf{A}^*$ . The following graph gives an overview of the whole process. In (1), a simplified coefficient matrix  $\mathbf{A}^*$  is derived which comprises the major constraints such as land and fodder balances, set-aside or sales quotas from the CAPRI regional programming models and sets feed input coefficients to constant levels. At the same time, low and high yield variants for the crop activities in CAPRI are aggregated.

Figure 10: Estimation work flow



The gross margins for activity k are defined as

$$gm_k = \sum_j o_{kj} p_j + prem_k - costs_k$$

where  $o$  are output coefficients,  $p$  are prices,  $prem$  are subsidies and costs variable costs per activity. From there, supply effects describing reaction to output price changes can be derived as

$$\frac{\partial x_k}{\partial p_j} = \frac{\partial x_k}{\partial gm_l} \frac{\partial gm_l}{\partial p_j} = \frac{\partial x_k}{\partial gm_l} \frac{\partial \left( \sum_j o_{lj} p_j + prem_l - costs_l \right)}{\partial p_j} = \frac{\partial x_k}{\partial gm_l} o_{lj} = H_{kl} o_{lj}$$

and elasticities defined as

$$\varepsilon_{ij} = \frac{\partial S_i}{\partial p_j} \frac{p_j}{S_i} = \frac{\partial \sum_k x_k o_{ki}}{\partial p_j} \frac{p_j}{S_i} = \sum_{kl} H_{kl} o_{ki} o_{lj} \frac{p_j}{S_i}$$

The estimator then derives in point (3) of Figure 10 a matrix  $Q^*$  along with a matrix  $H^*$  which deviates from the matrix  $H$  as defined from the elasticities due to differences in structure and parameterization between CAPRI and FFSIM. In order to ensure regularity,  $Q^*$  must be positive definite, guaranteed by a Cholesky decomposition.  $Q^*$  and an appropriately set vector  $\mathbf{d}'$  calibrate the regional programming models in point (4) in Figure 10. The resulting models are then used in the (5) to perform sensitivity analysis while changing the revenues  $gm$ , and the resulting supply effects are in the final step compared with  $\mathbf{H}$ .

### 1.7.2 Problems and experiences with the approach

For a large-scale calibration exercise involving the 250 regional programming models of CAPRI and about 50 activities, numerical stability and good fit are crucial. The latter ensures mutual consistency between prices simulated in CAPRI based on the supply response of the regional programming models and the simulation behaviour of FSSIM used to analyze

environmental or farm type specific impacts at simulated prices. Compared to existing approaches, we allow for the integration of cross-price effects while considerably reducing the estimation error. Tests with randomly drawn matrices of supply elasticities were performed. The errors between the estimated supply effects and the ones derived in the sensitivity analysis are in an acceptable range. The major drawback compared to simplistic calibration approaches is the numerical complexity resulting from the need to integrate both matrix inversions and a Cholesky decomposition for large matrices in the estimation process. It leads to considerable computing time. Therefore, parallel estimation of several regions combined with algorithms to generate suitable starting values are used to speed up processing.

The general functionality of this CAPRI calibration procedure has been proven with experimental data. When it came to include “real” data from EXPAMOD two main problems were identified: (1) Computation time was rather high even for a small number of regions and (2) the fit of calibrated CAPRI elasticities to those given by EXPAMOD was quite bad. The main reason is the limited product set of elasticities provided due to the problems with FSSIM representativeness analysed in section 1.6. Since the CAPRI regional supply models require a full product set, elasticities from EXPAMOD were combined with fixed cost function parameters based on original CAPRI elasticities (Jansson, 2007). This produces a prior elasticity matrix for the calibration step which strongly conflicts with the base year prices and quantities and often also violates theoretical restrictions (e.g. the right curvature). This created numerical challenges for the calibration step and lead to strong deviations of calibrated CAPRI from EXPAMOD elasticities. Given the lack of time for testing and the pressure to deliver a stable and relatively fast link between EXPAMOD and CAPRI, it was decided not to apply the envisaged methodology in the final version of SEAMLESS-IF but instead to choose a more pragmatic solution (see next section). The full calibration approach will be reconsidered when FSSIM product coverage is improved.

### 1.7.3 A pragmatic solution to link EXPAMOD and CAPRI

Within this pragmatic solution we made use of the linkage which was already established in previous prototypes. We used own price elasticities only to change the own price effects of the non linear cost function in CAPRI. The procedure falls into the following steps:

- 1) Calculation of CAPRI standard elasticities at the baseline point for all regions and all products. This was done by shifting all product prices *ceteris paribus* by 10% and subsequent calculation of point elasticities.
- 2) Calculation of the ratio between CAPRI and EXPAMOD elasticities.
- 3) Shifting the own price effects of the marginal cost function in CAPRI with this ratio

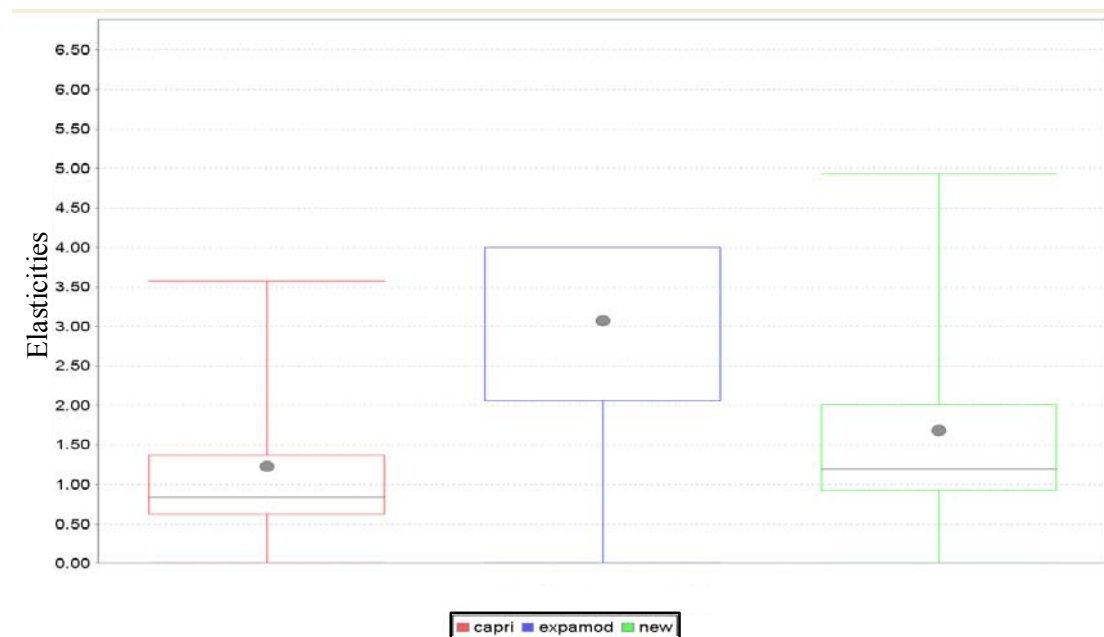
using the formula 
$$\delta_{r,x,x}^{\text{new}} = \delta_{r,x,x}^{\text{ori}} \cdot \frac{\epsilon_{r,x,x}^{\text{CAPRI}}}{\epsilon_{r,x,x}^{\text{EXPAMOD}}}$$
 where  $\delta$  are the slope parameters

of the marginal cost function and  $\epsilon$  the elasticities,  $r$  denotes the regional index and  $x$  is the set of CAPRI products.

- 4) Check if supply models still calibrate. If not, the curvature of the new cost function is not right. In that case we reset the region to standard CAPRI values. If calibration is maintained, we proceed with the next step:
- 5) Calculation of new CAPRI elasticities according to step 1
- 6) Comparison of CAPRI and EXPAMOD own price elasticities.

With this procedure, it turned out that many NUTS2 regions could not be calibrated to elasticities from EXPAMOD due to curvature problems in the initial matrix. That does not mean that CAPRI is not able to be calibrated to elasticities that are generally on a higher level, but that the combination of elasticities coming from EXPAMOD and those that are left unchanged did not fit together. Furthermore the usage of only own price effects limits the possible calibration fit. But for those where calibration could be achieved, the new elasticities of CAPRI went closer to those from EXPAMOD as visible in Figure 11, where we again make use of the Box and Whisker diagram. The EXPAMOD elasticities were censored at 4 in order to avoid extremely high elasticities. We further see that most of the standard CAPRI elasticities are found around 1, whereas EXPAMOD elasticities are mainly around 3. This again highlights the hypothesis made in the previous chapter that FSSIM and EXPAMOD tend to overestimate elasticities, keeping in mind that the standard CAPRI elasticities are calibrated based on an outcome of an econometric estimation by Jansson (2007) and do reflect the observed price reactions over an ex-post period. After our calibration approach, the new elasticities, shown to the right of the figure, move towards those from EXPAMOD, but do not reach their magnitude.

Figure 11: Distribution of CAPRI and EXPAMOD own price elasticities



Source: CAPRI

Due to the problems described above, we cannot fully judge if the fit between EXPAMOD and CAPRI elasticities is good enough or not. The calibration procedure can only be finally evaluated, if the elasticity input matrix is convenient in theoretical terms (magnitude of elasticities, curvature, homogeneity and completeness) and we allow for cross terms to be adjusted as well.

Open issues to be implemented could be:

- Some pre-tests on the EXPAMOD matrix for checking curvature and homogeneity and to generate from there a consistent matrix that is as close as possible to the original one. This could then be used in the calibration
- Evaluation of the new CAPRI supply response and comparison to that of the Version with standard elasticities.

- To evaluate the calibration method, input data that is reliable is needed. An approach for testing would be to use calculated price elasticities for some sample regions directly from FSSIM and try to calibrate CAPRI to those.

## 1.8 Conclusions

This chapter has presented a feasible approach for up-scaling economic results from the farm level to regional and EU levels. The approach establishes a link between a bio-economic farm model operating at the level of a representative farm (FSSIM) and an aggregate economic model of the entire EU-27 (CAPRI). The tests, performed with a flexible functional form, show plausible results and a high explanatory power. Nevertheless, some poor predictions have been observed for estimations with a low number of observations and high number of parameters. This should be easily solved by generating a higher number of pseudo-observations. Additionally, a higher variance has been observed in the data (especially for products under a quota regime, such as sugar beet) and a closer link of results to the biophysical and farm management variables would be desirable and especially a better representativeness of single crops in the FSSIM sample has to be achieved.

The EXPAMOD model described here is one of the links within the SEAMLESS model chain (van Ittersum et.al., 2008). Since data exchange for both the estimation and extrapolation procedures are programmed to be automated, the number of explanatory variables is opted to be the same whether the model runs for seven or for a larger number of regions. Moreover, the approach developed in this section also allows for further research regarding the validation of the model specification selected. Currently the validation was based on correlation coefficient between predicted and observed values. The overall sample is still relatively small and therefore in the future an out-of-sample projection will be more appropriate. This will be done by running EXPAMOD for a sub-sample of the farm models and comparing the estimated results with the other part of the sample. When a more stable and reliable set of extrapolated elasticities is achieved, the calibration Method inside CAPRI has to be revisited and refined in order to achieve a reasonable fit of CAPRI the farmtype-model behaviour, keeping in mind model performance issues.

In future versions of EXPAMOD, panel data estimation and non-parametric approaches (dealing with a large number of variables in functional forms with higher order polynomials) will be considered. Moreover, future developments will address experimental meta-modelling designs that are appropriate, given the underlying relationships whereas the current simulation design implements varying one-price-at-a-time. The explanatory variables need to cover variability in farm types and scales, soils and climates. It will be further checked whether the sole focus on production quantities already provides sufficient variation in production conditions and farm types. This is because regions specializing in different products do not coincide much in terms of biophysical characteristics and farm types. The approach chosen might be also applicable to scale up non-economic results, such as environmental impacts. However, further research is needed to refine the method employed for up-scaling such impacts, in particular where the spatial distribution of impacts matter. The approach could also be considered in contexts different from SEAMLESS providing an alternative for sequential calibration approaches when linking computable general equilibrium models, with more detailed partial equilibrium models (agriculture, energy, forestry).

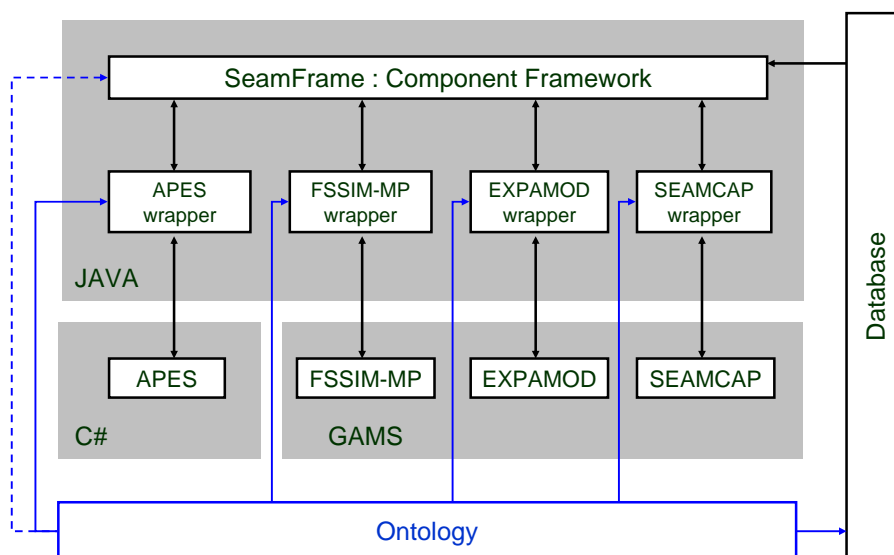


## 2 Technical documentation for EXPAMOD model component

### 2.1 EXPAMOD as model component

SEAMLESS-IF uses the Open Modelling Interface and Environment (OpenMI) (Gijsbers *et al.*, 2003) to support the (technical) linking of models. The conceptually correct linking among components of models, data and indicators is ensured through the use of an ontology in which the variables and concepts to be exchanged are defined (Wien *et al.*, in review; Janssen *et al.*, this issue). Clearly, the ontology has to ensure that data types from different models (and the database) with the same meaning can be linked.

Figure 12: Schematic representation of the technical model and data base linking in SEAMLESS-IF and the use of ontology

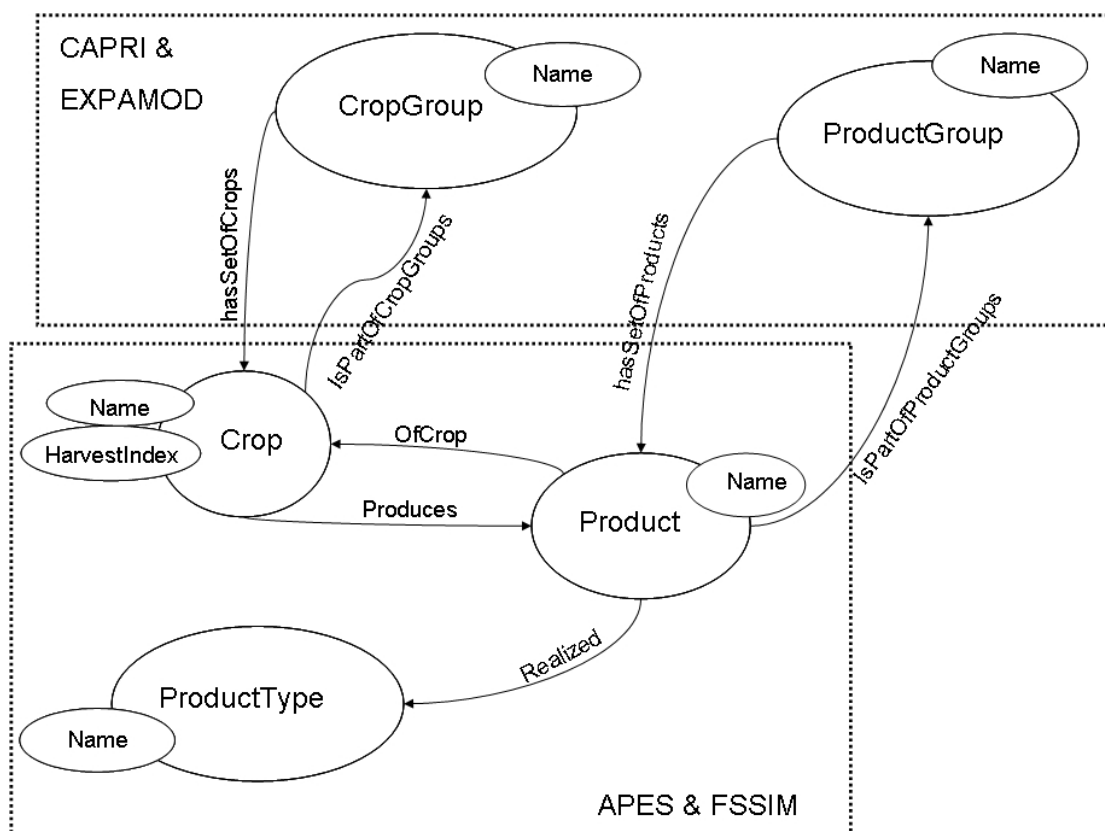


Note that the models are written in different languages and that the linking of models is through the component framework. Wrappers are the interfaces developed to link software components. Dotted line represents a relationship that will be considered in future versions.

Source: Ewert *et al.*, 2009 (under revision in Environmental Science and Policy, special issue).

EXPAMOD as model component consists of the model in GAMS language, EXPAMOD wrapper which communicates with the SeamFrame and the Ontology. The ontology used in EXPAMOD model shares such concepts as CropGroup and ProductGroup with the CAPRI model as depicted in Figure 13. The figure can be read along the lines, while the dashed squares indicate the use of the concepts by the models.

Figure 13: The Crop-Product ontology showing the relationships between the concepts Crop, Product, ProductType, CropGroup and ProductGroup and their properties.

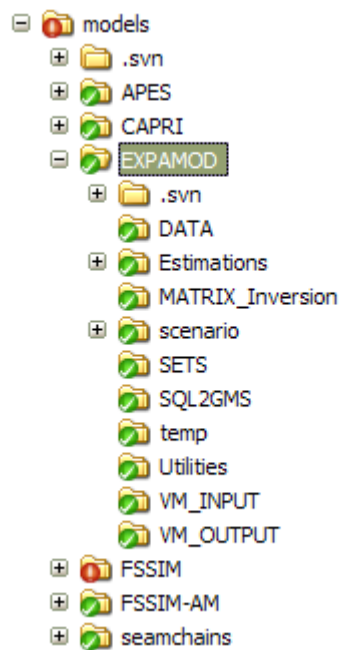


Source: Janssen et al, Linking Models for Assessing Agricultural Land Use Change, in Review.

The EXPAMOD wrapper enables the communication between the EXPAMOD model written in GAMS and the rest of the SEAMLESS-IF. This is done by an exchange of several files described in the next section.

Next, we provide some technical details mainly concerning the EXPAMOD stand-alone model itself within SEAMLESS-IF. EXPAMOD model code is written in GAMS but the estimation data can also be exported in different formats so that the estimation can also be carried out in econometric software packages like STATA. The Folder structure of the EXPAMOD folder is given in Figure 14. Some econometric work was done in STATA to fine tune the code which was finally programmed in the GAMS environment. This work is stored in the sub-folder called Estimations\STATA. Files with extension \*.do have the STATA code to generate variables and run regressions; files with extension \*.dat are the data files used or generated by the code.

Figure 14: EXPAMOD folder Structure



The data folder contains basically the explanatory data on biophysical and farm management variables. These also stem from the SEAMLESS database, but are not connected automatically in SEAMLESS-IF. This refers to three files which are prepared from SQL queries with subsequent manual adjustments to get the data into gams format. This is an intermediate solution. The three files are `expamod_clim_data.inc` (containing climate data), `Expamod_farm_data.inc`, containing farm management data and `expamod_soil_data.inc` including data on soiltypes. These three files are merged into one `gdx` file and appropriate gams parameters for the estimation that is then called with each EXPAMOD standard run (`aggegrweightresults.gdx`).

The “Estimations” folder contains intermediate results on previous estimations only and is not essential for the integrated framework. The same accounts for “Matrix inversion” where gams code to invert a Matrix is provided.

In the “SETS” folder all SET definitions (the driving indices in gams) are given. In the SQL2GMS some tests to achieve data directly from the DB within gams code are stored. This is currently not used in the integrated framework. The temp folder is supposed to hold some intermediate files. In “Utilities” we store some useful gams program pieces that are called many times during the execution of EXPAMOD. “VM\_input” and “VM\_outout are neither used currently.

The scenario folder is very important for the integrated framework, because it contains experiment specific subfolders. Each of these contains 4 subfolders called inputs, outputs, log and scrdir. In the latter intermediate gams variables are and in the log file, the gams listing file is stored. The input folder contains a file called `expamod_inputs.gdx` that contains experiment specific data that is either coming from the database or from the FSSIM models.

This file is used for communication between the data coming from outside EXPAMOD and provided by the EXPAMOD wrapper. It contains the following variables which can be distinguished by their origin. We start with those coming from the database:

Baseline prices from CAPRI per CAPRI product are stored on the parameter `EQUI_PRICE` and linked to the table *equilibriumprice* in the data base.

All farmtypes existent in the SEAMLESS typology are stored in the set FTYPE. They are currently created by the wrapper and not loaded from the database.

All SEAMLESS NUTS2 regions are stored in the set REG and linked to the table *nutsregion* in the database.

Baseline prices from CAPRI per CAPRI product are stored on the parameter EQUI\_PRICE and linked to the table *equilibriumprice* in the data base.

The linkage between FSSIM and CAPRI products as defined from LOUHICHI et al (2007) is stored in the set FSSIM\_TO\_CAPRI and linked to the table *productgroupsetofproducts* in the data base.

The wrapper provides three further inputs from the database which are currently not yet used inside EXPAMOD:

The definition of a SEAMLESS activity group which refers to the CAPRI activities is stored in the set A and connected to the data base table *activitygroup*.

The definition of a SEAMLESS input group which refers to the agricultural inputs used in CAPRI is stored in the set I and connected to the data base table *inputgroup*.

The definition of a SEAMLESS product group which refers to the combination of CAPRI products, inputs and activities is stored in the set PG and connected to the data base table *productgroup*.

The remaining information stored in the *expamod\_inputs.gdx* file are stemming from the FSSIM models that where executed before EXPAMOD:

All farmtypes that where used in the FSSIM models are stored in the set FSFtype.

All NUTS regions for which FSSIM models where executed are stored in the set FSREG

All crops that where found in the optimal farm behaviour across all farmtypes used are stored in the set CPRD

The optimal crop production of each farmtype for the used experiment as well as the corresponding prices is stored on the parameter FSSIM\_PQ\_BASE

The optimal crop production for each of the sensitivity experiments is stored on the parameter FSSIM\_Q

The price shock coefficients for each of the sensitivity experiments is stored on the parameter PShock. It contains the coefficient with which the baseline prices where multiplied in each of them.

The corresponding set for the price experiments is stored on PSIM.

## 2.2 File sequence within the EXPAMOD model

The entire source code of EXPAMOD can be found on the seamless SVN server under trunk\models\EXPAMOD. Here we only present the sequence of files called during the standard EXPAMOD execution.<sup>5</sup> EXPAMOD has to be called with “gams expamod – simcode %mycode%”

EXPAMOD\expamod.gms

*Main program file, containing estimation equations and main calculations and the execution of the estimation and extrapolation.*

..EXPAMOD\sets\sets\_expamod.gms

*Defibition of driving sets.*

..EXPAMOD\sets\load\_static\_sets.gms

*Reading set information created from the SEAMLESS-IF system*

..EXPAMOD\scenario\%simcode%\inputs\expamod\_inputs.gdx

*File containing all information created by the EXPAMOD wrapper.*

..EXPAMOD\scenario\test\inputs\expamod\_inputs\_rest.gdx

*File containing information currently not yet provided by the wrapper.*

...EXPAMOD\sets\CAPRI\_Regions.inc

*Definition of NUTS regions in CAPRI.*

...EXPAMOD\sets\CAPRI\_MS.inc

*Defibition of CAPRI EU Member States.*

...EXPAMOD\sets\MS\_REG\_Map.inc

*Mapping between NUTS regions and Member States.*

..EXPAMOD\sets\FSSIM\_AllSimulations.inc

*Driving set for FSSIM price experiments.*

..EXPAMOD\data\_read.gms

*.. Reading data form FSSIM experiments.*

..EXPAMOD\sets\FSSIM\_ConcSets.gms

*.. Concatenate sets for the use in STATA.*

..EXPAMOD\sets\sel\_CurCPRD.gms

*.. Selection of products in Estimation. Estimation started afterwards.*

..EXPAMOD\statistics.gms

*..calculation of estimation statistics*

..EXPAMOD\extrapolation.gms

*..Some calculations for extrapolation.*

---

<sup>5</sup> EXPAMOD can be executed in different modes. The standard mode is the one used in the integrated framework.

### 2.3 Data base queries to create explanatory data files.

3 Data files are static (as an intermediate solution). There used to be SQL files which are not stored under EXPAMOD folder. The files form the list below are prepared by using the SQL scripts which are documented now.

Expamod\_clim\_data.INC  
Expamod\_soil\_data.INC  
Expamod\_farm\_data.INC

**\*\* FARM DATA \*\***

```
SELECT nutsregion.label_gms, agrienvironmentalzone.environmentalzone AS EnvZ,  
agrienvironmentalzone.soiltype,  
  
representativefarminagrienvregion.area/representativefarm.representedfarms AS area,  
  
representativefarm.size_          AS          size,representativefarm.intensity          AS  
intens,representativefarm.specialization AS spec,  
  
representativefarm.machinery/representativefarm.representedfarms AS Mach,  
representativefarm.labourinputs/representativefarm.representedfarms AS Labo,  
representativefarm.buildings/representativefarm.representedfarms AS Build,  
representativefarm.esu/representativefarm.representedfarms AS ESU  
  
FROM          representativefarm,representativefarminagrienvregion,agrienvironmentalzone,  
nutsregion  
WHERE representativefarm.id=representativefarminagrienvregion.representativefarm  
AND  agrienvironmentalzone.id=representativefarminagrienvregion.agrienvironmentalzone  
AND  nutsregion.id=agrienvironmentalzone.nutsregion
```

```
AND  nutsregion.label_gms <>"
```

**\*\*CLIM DATA \*\***

```
SELECT          nutsregion.label_gms,climatezonedailyclimate.climatezone_id          AS  
climz,agrienvironmentalzone.environmentalzone AS EnvZ,  
          avg(dailyclimate.maximumtemperature) AS AvMaxTemp,  
          avg(dailyclimate.minimumtemperature) AS AvMinTemp,
```

```
stddev(dailyclimate.maximumtemperature) AS StdMaxTemp,  
stddev(dailyclimate.minimumtemperature) AS StdMinTemp,  
variance(dailyclimate.maximumtemperature) AS VarMaxTemp,  
variance(dailyclimate.minimumtemperature) AS VarMinTemp,  
max(dailyclimate.maximumtemperature) AS MaxMaxTemp,  
min(dailyclimate.minimumtemperature) AS MinMinTemp,  
avg(dailyclimate.radiation) AS AvRAD,  
avg(dailyclimate.rainfall) AS AvRain
```

FROM

```
dailyclimate,climatezonedailyclimate,agrienvironmentalzone,nutsregion
```

WHERE

```
dailyclimate.month_ > 2 AND dailyclimate.month_ < 10 AND  
dailyclimate.id=climatezonedailyclimate.dailyclimate_id  
AND agrienvironmentalzone.climatezone=climatezonedailyclimate.climatezone_id  
AND nutsregion.id=agrienvironmentalzone.nutsregion  
AND nutsregion.label_gms<>"
```

GROUP

BY

```
nutsregion.label_gms,climatezonedailyclimate.climatezone_id,agrienvironmentalzone.nutsreg  
ion,agrienvironmentalzone.environmentalzone
```

**\*\* SOIL DATA \*\***

```
SELECT nutsregion.label_gms,agrienvironmentalzone.environmentalzone AS EnvZ  
,agrienvironmentalzone.soiltype AS SoilType,  
agrienvironmentalzone.carboncontenttopsoil AS CarbCont,  
soilcharacteristics.thicknesssurfacesoil AS SoilDepth,  
soilcharacteristics.maximumusablemoisturereserve AS SAWC  
FROM agrienvironmentalzone,nutsregion,soilcharacteristics,soiltype  
WHERE nutsregion.id=agrienvironmentalzone.nutsregion  
AND soilcharacteristics.id=agrienvironmentalzone.soilcharacteristics  
AND soiltype.id=agrienvironmentalzone.soiltype  
  
AND nutsregion.label_gms<>"
```





### 3 The CAPRI version of SEAMLESS-IF

The CAPRI modelling system consists of specific databases, a methodology, its software implementation, and the researchers involved in their development, maintenance and applications.

The databases exploit wherever possible *well-documented, official and harmonised data sources*, especially data from EUROSTAT, FAOSTAT, OECD and extractions from the Farm Accounting Data Network (FADN)<sup>6</sup>. Specific modules ensure that the data used in CAPRI are mutually compatible and complete in time and space. They cover about 50 agricultural primary and processed products for the EU (see Britz et al. (2008) in the Annex), from farm type to global scale including input and output coefficients.

The economic model builds on a *philosophy of model templates* which are structurally identical so that instances for products and regions are generated by populating the template with specific parameter sets. This approach ensures comparability of results across products, activities and regions, allows for low cost system maintenance and enables its integration within a large modelling network such as SEAMLESS. At the same time, the approach opens up the chance for complementary approaches at different levels, which may shed light on different aspects not covered by CAPRI or help to learn about possibility aggregation errors in CAPRI.

The economic model is split into two major modules. The *supply module* consists of independent aggregate non-linear programming models representing activities of all farmers at regional or farm type level captured by the Economic Accounts for Agriculture. The programming models are a kind of hybrid approach, as they combine a Leontief-technology for variable costs covering a low and high yield variant for the different production activities with a non-linear cost function which captures the effects of labour and capital on farmers' decisions. The non-linear cost function allows for perfect calibration of the models and a smooth simulation response rooted in observed behaviour. The models capture in high detail the premiums paid under CAP, include NPK balances and a module with feeding activities covering nutrient requirements of animals. Main constraints outside the feed block are arable and grassland, set-aside obligations and milk quotas. The complex sugar quota regime is captured by a component maximising expected utility from stochastic revenues. Prices are exogenous in the supply module and provided by the market module. Grass, silage and manure are assumed to be non-tradable and receive internal prices based on their substitution value and opportunity costs.

The market module consists of two sub-modules. The sub-module *for marketable agricultural outputs is a spatial, non-stochastic global multi-commodity* model for about 40 primary and processed agricultural products, covering about 40 countries or country blocks in 27 trading blocks. Bi-lateral trade flows and attached prices are modelled based on the Armington assumptions. The behavioural functions for supply, feed, processing and human consumption apply flexible functional forms where calibration algorithms ensure full compliance with micro-economic theory including curvature. The parameters are synthetic, i.e. to a large extent taken from the literature and other modelling systems. Policy instruments cover Product Support Equivalents and Consumer Support Equivalents (PSE/CSE) from the OECD, (bi-lateral) tariffs, the Tariff Rate Quota (TRQ) mechanism and, for the EU,

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<sup>6</sup> FADN data are used in the context of so-called study contracts with DG-AGRI, which define explicitly the scope for which the data can be used, who has access to the data and ensure the data are destroyed after the lifetime of the contract.

intervention stocks and subsidized exports. This sub-module delivers prices used in the supply module and allows for market analysis at global, EU and national scale, including a welfare analysis. A second sub-module deals with prices for young animals.

As the supply models are solved independently at fixed prices, *the link between the supply and market modules* is based on an iterative procedure. After each iteration, during which the supply module works with fixed prices, the constant terms of the behavioural functions for supply and feed demand are calibrated to the results of the regional aggregate programming models aggregated to Member State level. Solving the market modules then delivers new prices. A weighted average of the prices from past iterations then defines the prices used in the next iteration of the supply module. Equally, in between iterations, CAP premiums are re-calculated to ensure compliance with national ceilings.

*Post-model analysis* includes the calculation of different income indicators as variable costs, revenues, gross margins, etc., both for individual production activities as for regions, according to the methodology of the EAA. A welfare analysis at Member State level, or globally, at country or country block level, covers agricultural profits, tariff revenues, outlays for domestic supports and the money metric measure to capture welfare effects on consumers. Outlays under the first pillar of the CAP are modelled in very high detail. Environmental indicators cover NPK balances and output of climate relevant gases according the guidelines of the Intergovernmental Panel on Climate Change (IPCC). Model results are presented as *interactive maps* and as thematic *interactive drill-down tables*.

The *technical solution* of CAPRI is centred on the modelling language GAMS which is applied for most of the data base work and CONOPT applied as solver for the different constrained (optimisation) problems. The different modules are steered by a Graphical User Interface currently realised in C, which interacts with FORTRAN code and libraries which are inter-alias dealing with data base management. Typically, these applications generate run-specific parts of the GAMS code. Exploitation tools apply additionally Java applets for interactive maps and XLM/XSLT to generate interactive HTML tables.

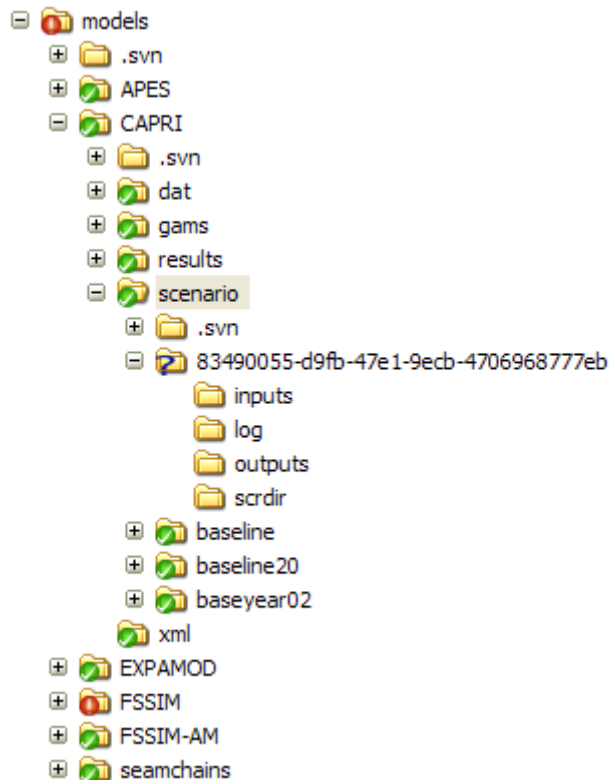
A detailed documentation of the CAPRI modelling system can be found in Britz et al. (2008) at [http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/Final\\_Report\\_Model\\_Description.pdf](http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/Final_Report_Model_Description.pdf).

Within the SEAMLESS project an adjusted version of the simulation engine of CAPRI (capmod) has been developed (called SEAMCAP) in order to integrate it into the SEAMLESS framework that

- allows to use external elasticities provided by EXPAMOD to steer the supply response in the regional supply models (see section 1.7)
- allows to transfer scenario parameters from a Guided User Interface (GUI) for scenario handling
- prepares a subset of model outputs to make them available to the user of SEAMLESS-IF

The adjustments to achieve the two latter points will be described in the following. One generally point is, that when CAPRI is called by SEAMLESS-IF, an experiment specific folder is created. In Figure 15, the general structure is shown. Under the CAPRI directory a new directory called “scenario” was introduced. Inside this folder, the scenario (or experiment to keep SEAMLESS wording) specific data is stored. The baseline and baseyear folders comprise the files from the standard runs of CAPRI and are hardcoded with each delivery of CAPRI for SEAMLESS-IF. The subfolder with the unique name of a terrible label combination is created by the SEAMLESS-IF system for one specific experiment run.

Figure 15: CAPRI folder Structure



Source: SEAMLESS-IF

Each of the subfolders in the scenario folder falls into 4 further subfolders called inputs, log, outputs and smdir. The latter only contains intermediate files produced by GAMS and CAPRI. The log directory currently contains two files, the gams listing file and a log file giving some information on the performance of CAPRI. Both files are created when CAPRI is executed. The content of the remaining two folders is straight forward. One contains the inputs created by the SEAMLESS-IF system within only one file called seamcap\_inputs.gdx. Section 3.1 deals with the context of it. In the output folder we find 3 important files. Two of them are standard CAPRI outputs, the CAPRI results cube (Allresults.gdx) and the iteration log (Iterationlog.gdx) and could be used by the CAPRI results viewer. The third file (seamcap\_outputs.gdx) contains those CAPRI results that are made available to SEAMPRESS (section 3.2). After an experiment run of CAPRI has finished, those 4 folders are compressed and stored on the SEAMLESS server.

### 3.1 Linking CAPRI to the Experiment designer – CAPRI inputs

At a certain stage of the project it was decided not to integrate the whole CAPRI input database into SEAMLESS-IF, but only those parameters that are relevant for policy scenario analysis. A final list was defined leading to the following parameters, distinguished by the categories Outlook and policy parameters.

**Table 13** *CAPRI input parameters*

<b>Outlook parameters</b>	<b>Policy Parameters</b>
Inflation	Coupling degree
Exchange rate	Set aside rates
Energy price	Export subsidies
Demand shift	Global Tariffs
Biofuel demand	Bilateral Tariffs
Yield growth	Trade reform proposal
Modulation	

Source: SEAMLESS-IF

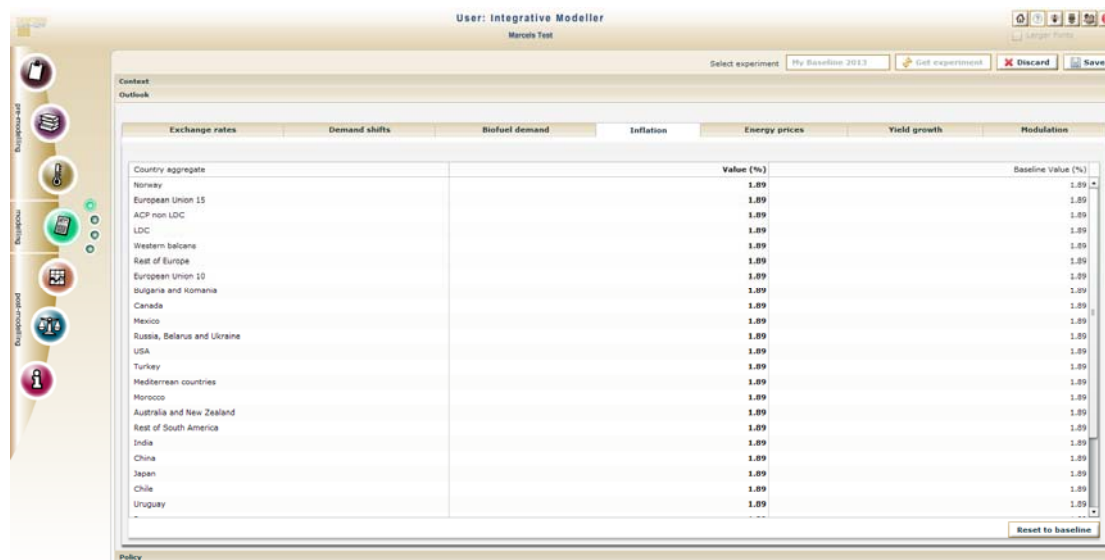
We now explain those parameters and their linkage to the database of SEAMLESS-IF one by one.

#### 3.1.1 Inflation

Inflation gives the yearly inflation rate that is relevant in the trading regions of CAPRI. The standard value is 1.9% per year. Changing this parameter will have an impact on the relative exchange rate between trading country aggregates. Changing the parameter for all country aggregates by the same percentage will, however, not affect anything.

The parameter is stored in the SEAMLESS database in the table *inflationrate*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *inflation\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

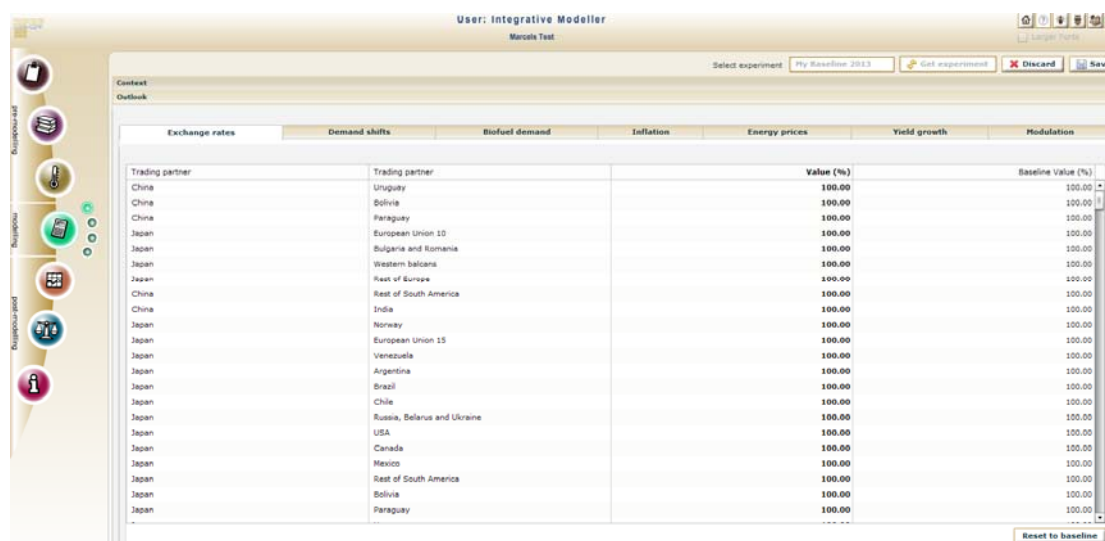


### 3.1.2 Exchange rates

CAPRI features relative exchange rates. All prices are converted into Euros and in the Baseline run all relative exchange rates are equal 1. The “real” exchange rates between the single currencies are not known in the system. The user can only change relative values indicating if the currency of one country changes its value relative to that of the others. The rates exist for all combinations between trading aggregates inside CAPRI, but half of them are redundant, because the relative exchange rate between Dollar and Euro e.g. can be calculated from that between Euro and Dollar. Therefore the SEAMLESS-IF User can only adjust half of the existing combinations and the other half is calculated inside CAPRI automatically.

The parameter is stored in the SEAMLESS database in the table *exchangerates*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *exchr\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

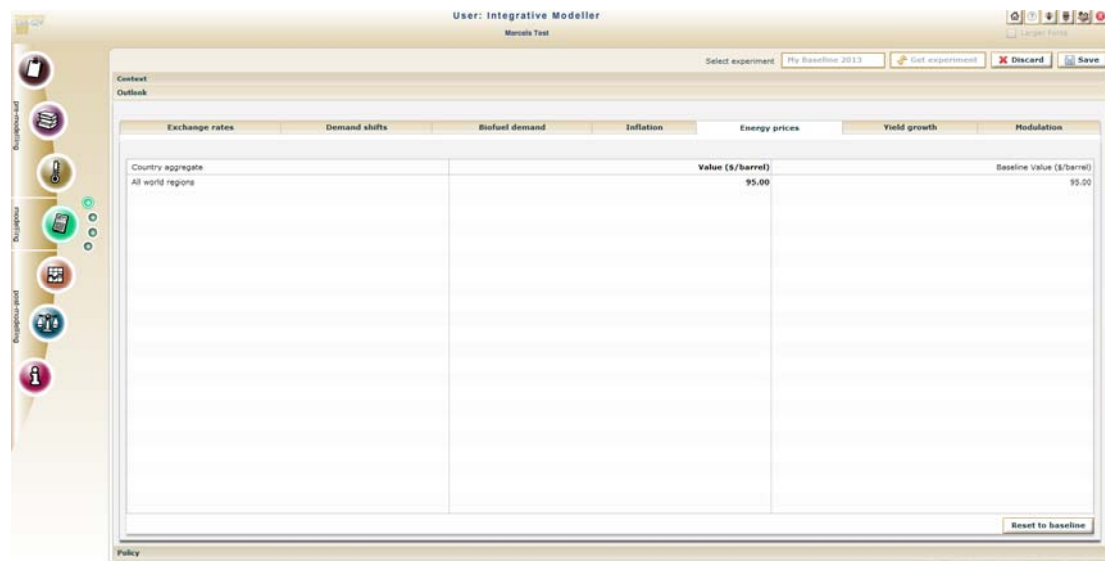


### 3.1.3 Energy prices

To analyse the impact of the Energy price level on Agriculture, the Crude Oil price is included in the system. It is not yet connected to CAPRI so the system will not produce any feedback. The parameter is transferred to CAPRI but not yet used, but will be in future versions.

The parameter is stored in the SEAMLESS database in the table *energyprice*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *penergy\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

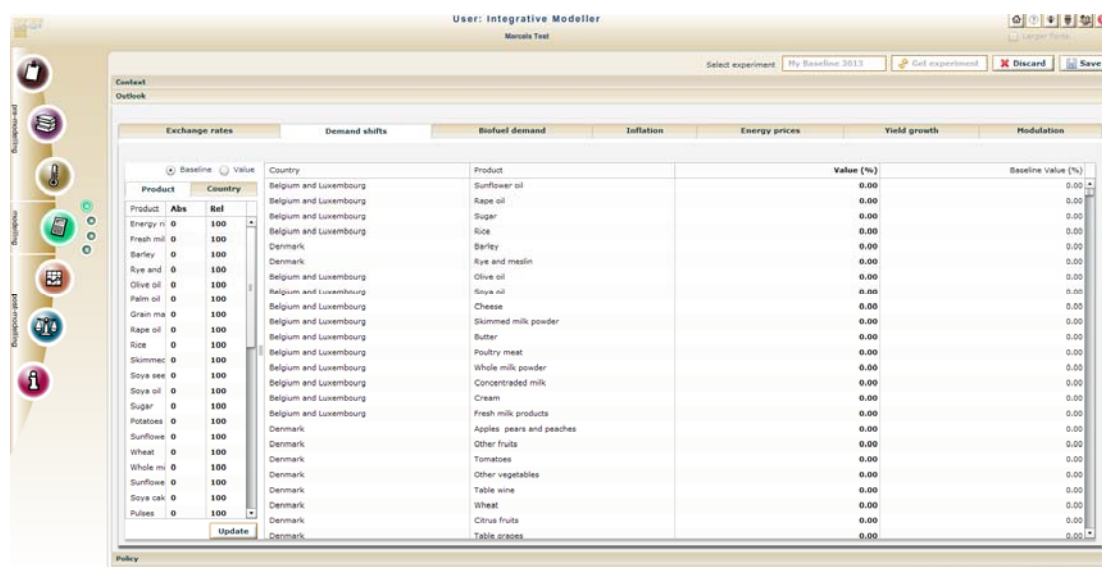


### 3.1.4 Demand shifts

With the demand shift parameter one can move the human consumption of a certain product for a certain country. Hereby one can simulate changes in demand patterns, e.g. an increase for beef demand in china, in order to get the feedback on international prices. In the baseline, no demand shifts exist (set to zero). The user can change these values. It is expressed as percentage of human consumption in the respective baseline. Setting it to 10 means to increase human consumption by 10%.

The parameter is stored in the SEAMLESS database in the table *demandshift*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *demshift\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

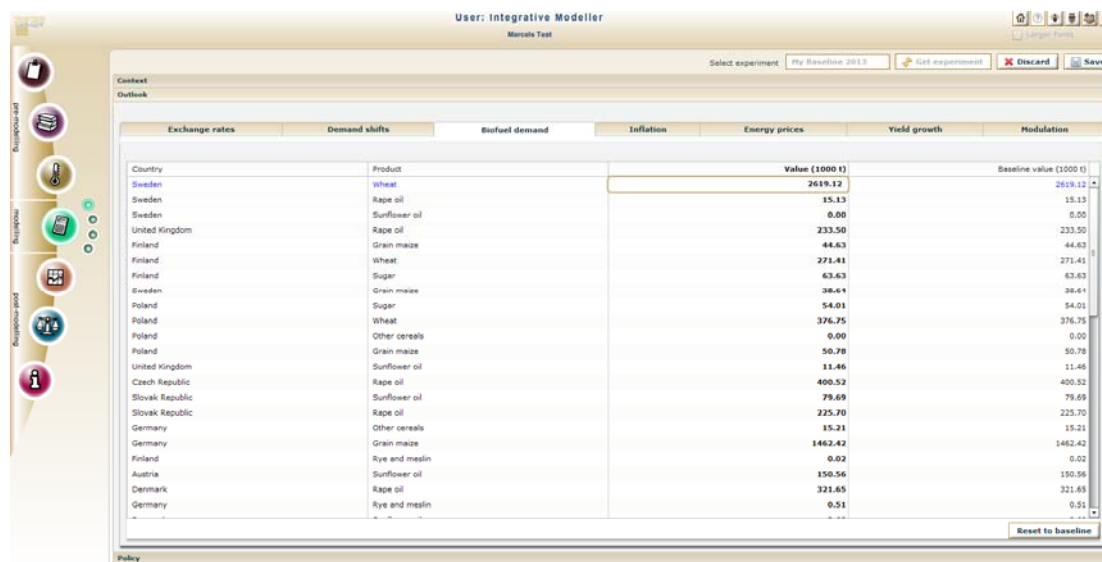


### 3.1.5 Biofuel Demand

In the actual version of SEAMLESS-IF, demand of agricultural commodities for biofuel processing is included as an exogenous parameter for EU countries. The values can be altered in order to simulate the effects of changing demand for biofuels.

The parameter is stored in the SEAMLESS database in the table *biofueldemand*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *biodem\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

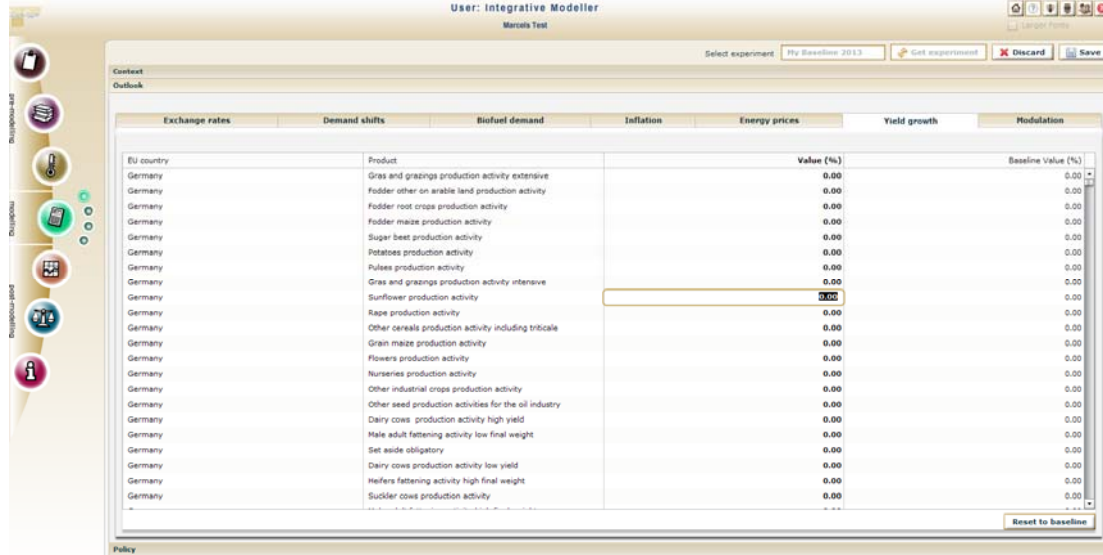


### 3.1.6 Yield growth

Different assumptions on yields for agricultural production activities will alter the optimal solution of a CAPRI run. With the yield growth parameter one can change the yields that are applied in the baseline by a certain percentage. The baseline value of the yield growth parameter is certainly zero and changing it to 10 will increase yields by 10 percent. Note that -10 is also possible.

The parameter is stored in the SEAMLESS database in the table *yieldgrowth*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *yieldg\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

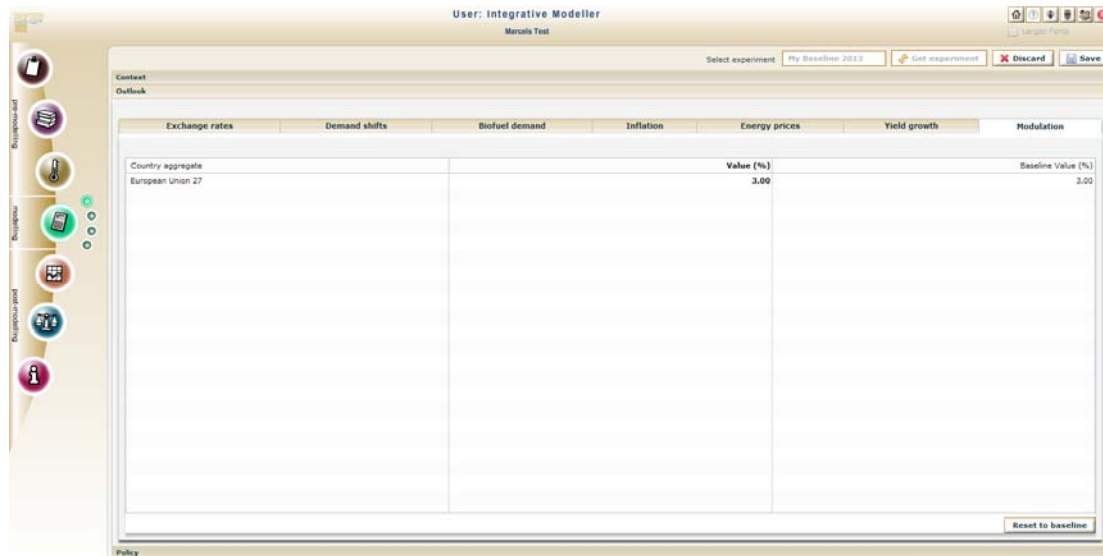


### 3.1.7 Modulation

The modulation rate gives the percentage of premiums that are transferred from the first to the second pillar. Since CAPRI only includes first pillar payments, changing this parameter will only affect the total amounts of subsidies paid in the system. It will have only a budgetary but no reallocation effect.

The parameter is stored in the SEAMLESS database in the table *modulation*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *modu\_store*.

In the SEAMGUI the parameter can be changed through the following screen:



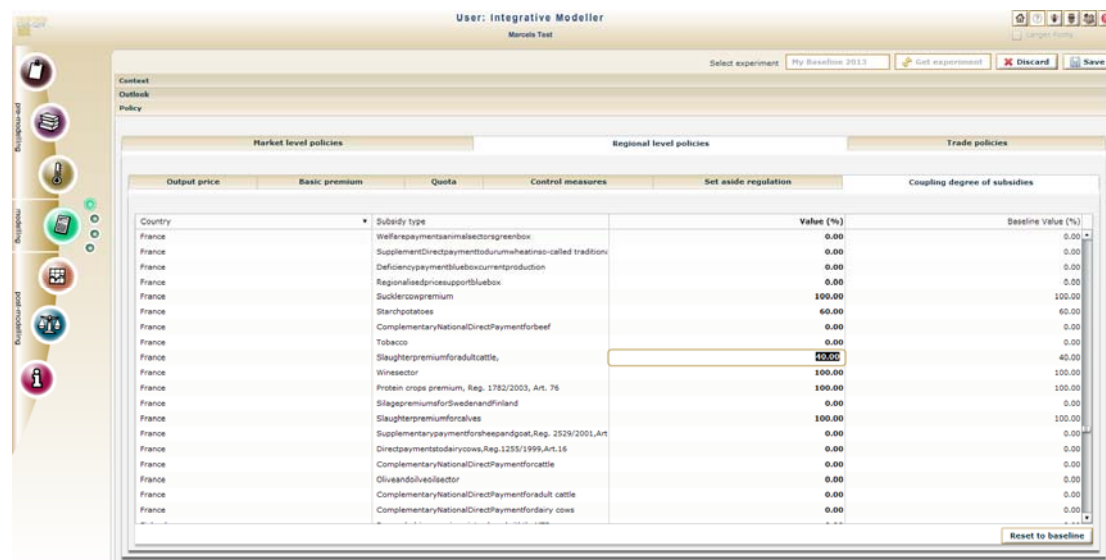


### 3.1.8 Coupling degree

The coupling degree of subsidies is an interesting variable since the mid term review of the CAP. Since then the AGENDA 2000 premiums which have been coupled to activity levels have been at least partially decoupled and translated into single farm payments. The coupling degree table gives the choices of the different EU members after the CAP reform of 2003. Those values could be changed to e.g. simulate AGENDA 2000 policies by setting all values to 100.

The parameter is stored in the SEAMLESS database in the table *couplingdegree*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *copt\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

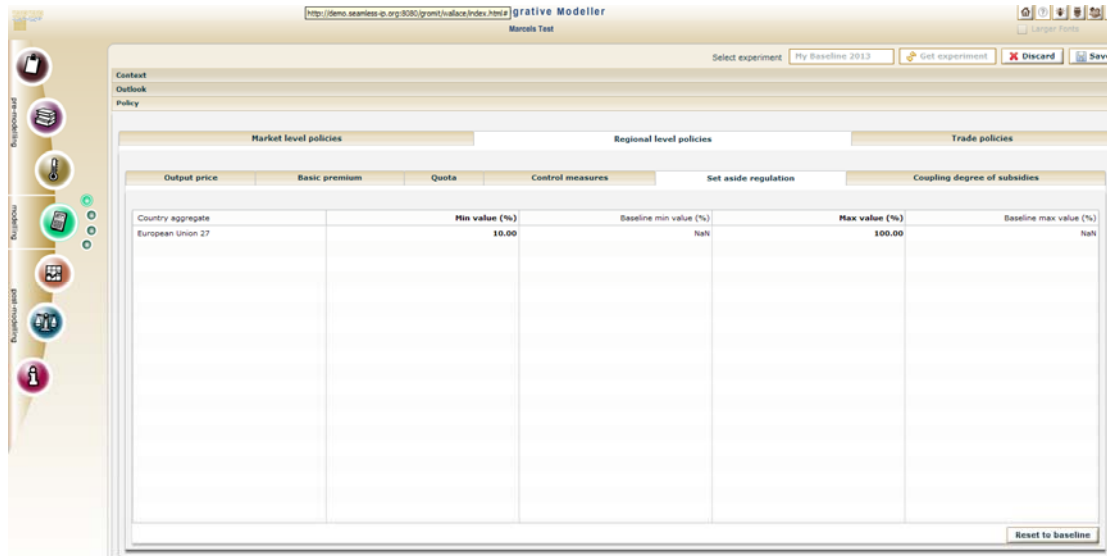


### 3.1.9 Set aside rates

Since the Mc Sharry CAP reform, farmers producing Cereals and Oilseeds had to partly set aside a certain amount of their area. The set aside rates given here are meant relative to the grand culture area. It has a minimum and a maximum value and is expressed in percent.

The parameter is stored in the SEAMLESS database in the table *setasideregulation*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *seta\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

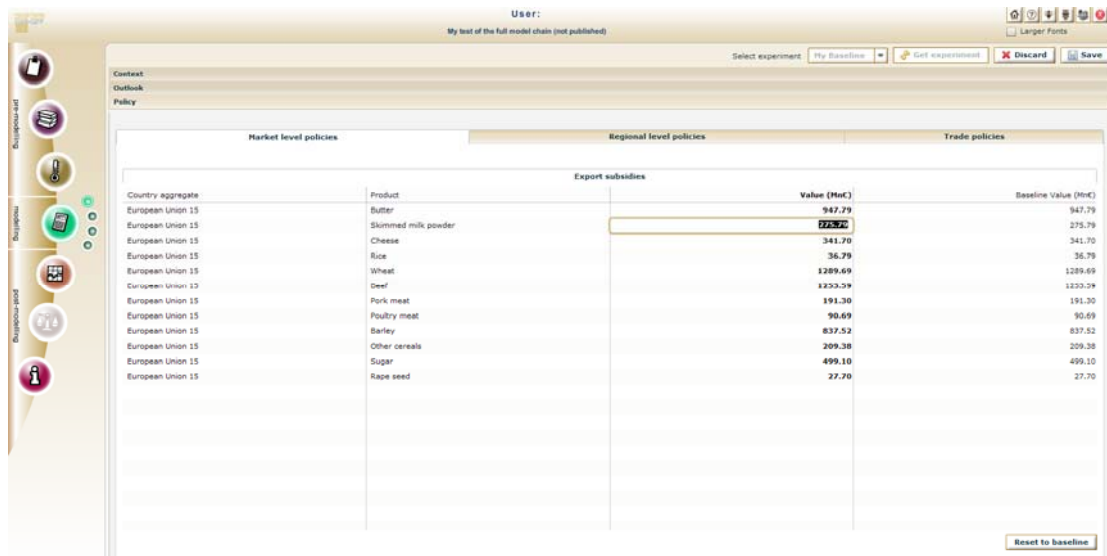


### 3.1.10 Export subsidies

Export subsidies are paid for certain commodities in the EU. Here, one can change the maximal amount of money available for these exports. It can only be adjusted for products that receive already subsidies in the baseline so that new payments cannot be introduced

The parameter is stored in the SEAMLESS database in the table *subsidisedexport*. The wrapper transfers this into GAMS code in the seamcap\_inputs.gdx file on the parameter *exps\_store*.

In the SEAMGUI the parameter can be changed through the following screen:

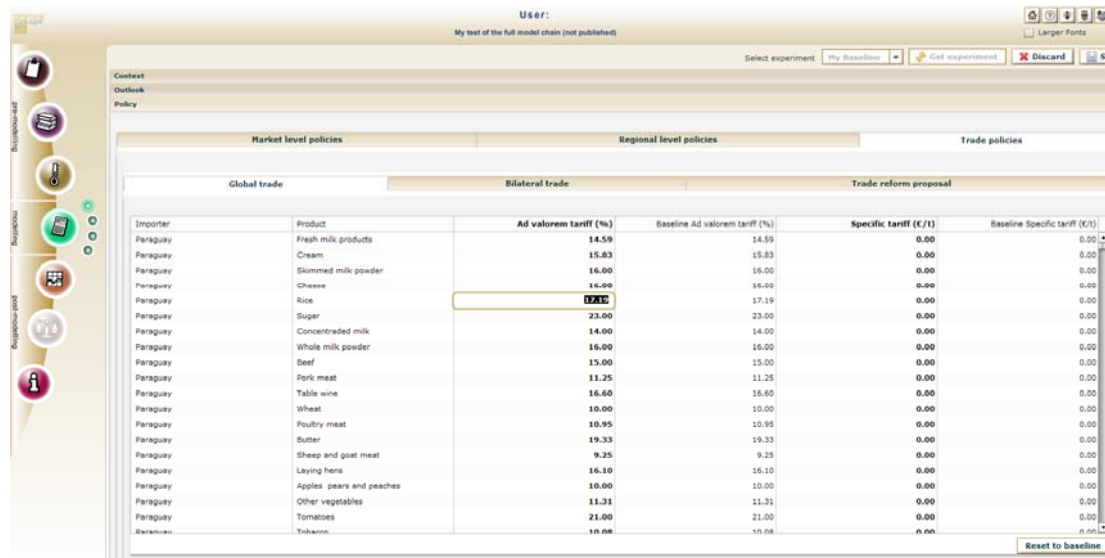


### 3.1.11 Global Tariffs

Each trading country block has a certain degree of border protection. The most common instruments are tariffs. Global tariffs are applied to all imports at the border which do not benefit from preferential agreements (see section 3.1.12). They can either be specific expressed in Euro per ton or ad valorem expressed as percentage of the input price. For some products even both types exist.

The parameter is stored in the SEAMLESS database in the table *globaltariff*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *mfn\_store*.

In the SEAMGUI the parameter can be changed through the following screen:



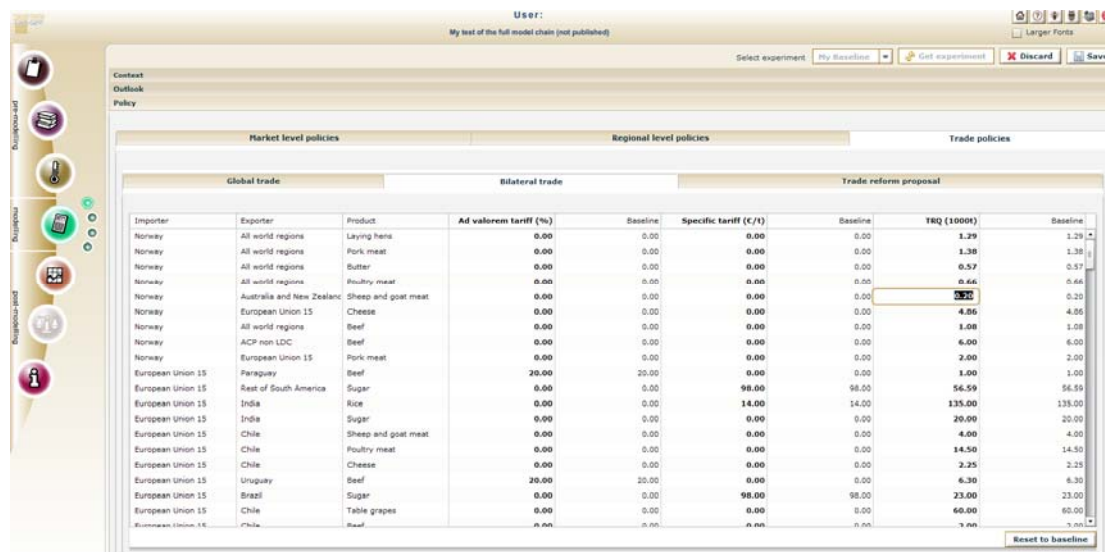
Global trade		Bilateral trade		Trade reform proposal	
Importer	Product	Ad valorem tariff (%)	Baseline Ad valorem tariff (%)	Specific tariff (€/t)	Baseline Specific tariff (€/t)
Paraguay	Fresh milk products	14.59	14.59	0.00	0.00
Paraguay	Cream	15.83	15.83	0.00	0.00
Paraguay	Skimmed milk powder	16.00	16.00	0.00	0.00
Paraguay	Cheese	16.00	16.00	0.00	0.00
Paraguay	Rice	17.19	17.19	0.00	0.00
Paraguay	Sugar	23.00	23.00	0.00	0.00
Paraguay	Concentrated milk	14.00	14.00	0.00	0.00
Paraguay	Whole milk powder	16.00	16.00	0.00	0.00
Paraguay	Beef	15.00	15.00	0.00	0.00
Paraguay	Pork meat	11.25	11.25	0.00	0.00
Paraguay	Table wine	16.60	16.60	0.00	0.00
Paraguay	Wheat	10.00	10.00	0.00	0.00
Paraguay	Poultry meat	10.95	10.95	0.00	0.00
Paraguay	Butter	19.33	19.33	0.00	0.00
Paraguay	Sheep and goat meat	9.25	9.25	0.00	0.00
Paraguay	Laying hens	16.10	16.10	0.00	0.00
Paraguay	Apples, pears and peaches	10.00	10.00	0.00	0.00
Paraguay	Other vegetables	11.31	11.31	0.00	0.00
Paraguay	Tomatoes	21.00	21.00	0.00	0.00
Paraguay	Tobacco	10.00	10.00	0.00	0.00

### 3.1.12 Bilateral Tariffs

Trading partners may have preferential trading agreements. For example market access for the exporting country is lower than the global tariffs, possibly subject to a certain import quota. Therefore, this parameter contains specific and ad valorem preferential tariffs as well as the tariff rate quota.

The parameter is stored in the SEAMLESS database in the table *bilateral tariff*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *bilateral\_store*.

In the SEAMGUI the parameter can be changed through the following screen:



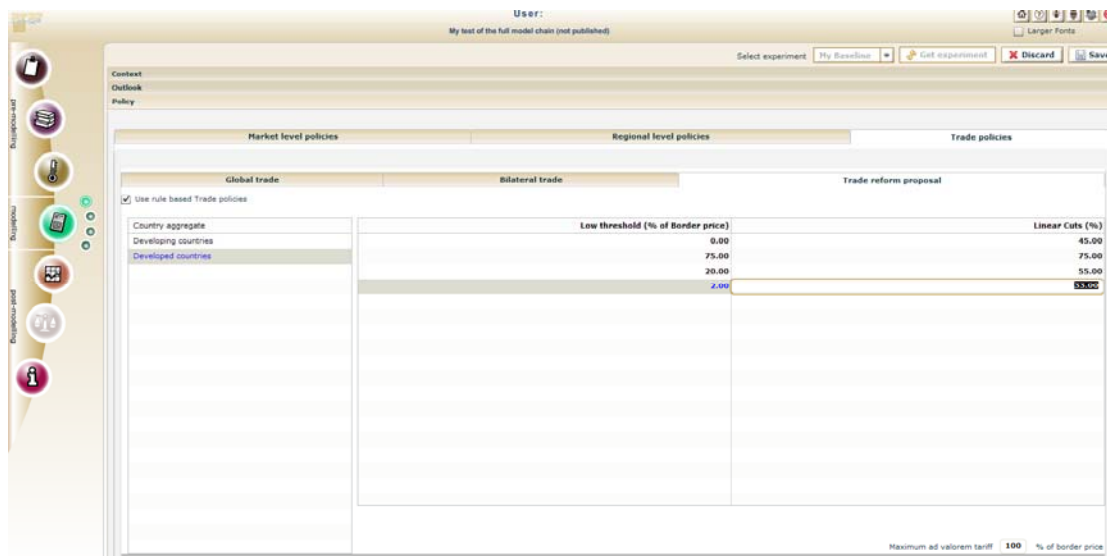
Global trade		Bilateral trade		Trade reform proposal				
Importer	Exporter	Product	Ad valorem tariff (%)	Baseline	Specific tariff (€/t)	Baseline	TRQ (1000t)	Baseline
Norway	All world regions	Laying hens	0.00	0.00	0.00	0.00	1.29	1.29
Norway	All world regions	Pork meat	0.00	0.00	0.00	0.00	1.38	1.38
Norway	All world regions	Butter	0.00	0.00	0.00	0.00	0.57	0.57
Norway	All world regions	Poultry meat	0.00	0.00	0.00	0.00	6.66	6.66
Norway	Australia and New Zealand	Sheep and goat meat	0.00	0.00	0.00	0.00	0.00	0.00
Norway	European Union 15	Cheese	0.00	0.00	0.00	0.00	4.26	4.26
Norway	All world regions	Beef	0.00	0.00	0.00	0.00	1.08	1.08
Norway	ACP non LDC	Beef	0.00	0.00	0.00	0.00	6.00	6.00
Norway	European Union 15	Pork meat	0.00	0.00	0.00	0.00	2.00	2.00
European Union 15	Paraguay	Beef	20.00	20.00	0.00	0.00	1.00	1.00
European Union 15	Rest of South America	Sugar	0.00	0.00	98.00	98.00	56.59	56.59
European Union 15	India	Rice	0.00	0.00	14.00	14.00	135.00	135.00
European Union 15	India	Sugar	0.00	0.00	0.00	0.00	20.00	20.00
European Union 15	Chile	Sheep and goat meat	0.00	0.00	0.00	0.00	4.00	4.00
European Union 15	Chile	Poultry meat	0.00	0.00	0.00	0.00	14.50	14.50
European Union 15	Chile	Cheese	0.00	0.00	0.00	0.00	2.25	2.25
European Union 15	Uruguay	Beef	20.00	20.00	0.00	0.00	6.30	6.30
European Union 15	Brazil	Sugar	0.00	0.00	98.00	98.00	23.00	23.00
European Union 15	Chile	Table grapes	0.00	0.00	0.00	0.00	60.00	60.00
European Union 15	Chile	Beef	0.00	0.00	0.00	0.00	0.00	0.00

### 3.1.13 Trade reform proposal

The “G20 Proposal” made during the DOHA WTO round proposes a world wide cut in tariffs according to a certain key that reduces tariffs according to the initial protection rate and the developing state of a nation. High tariffs receive a stronger cut than lower ones and developing countries are less affected than developed ones. Within SEAMLESS, the user can currently adjust the thresholds as well as the corresponding cut in tariffs and also to high tariff cap.

The parameter is stored in the SEAMLESS database in the tables *tradereformproposal* and *tradereformproposalcut*. The wrapper transfers this into GAMS code in the *seamcap\_inputs.gdx* file on the parameter *G20\_store*.

In the SEAMGUI the parameter can be changed through the following screen:



### 3.1.14 EXPAMOD elasticities

The elasticity matrix produced by the EXPAMOD component is also stored in the *seamcap\_inputs.gdx* file. They are not stored in the SEAMLESS database but taken directly to EXPAMOD and stored on the *gams* parameter *expamod\_elas*

### 3.2 Linking CAPRI to SEAMPRESS

CAPRI results are stored within a file called seamcap\_outputs.gdx. Within this file one can find a subset of all possible CAPRI results. This subset has been chosen according to the indicators definition by WP2 (see Alkan Olsson et al, 2009). Moreover, some variables that were deemed to be interesting but not defined as indicators have been chosen. These outputs, which we may call model variables, have been grouped according to the dimensions they are referring to. Principally there exist 3 types of model variables. The first type (stored on the parameter `indi_region`) are those that have only a regional dimension, the second type (stored on `indi_region_prod`) has additionally a product group dimension and the third one has the dimensions importing country, exporting county and product group.

Within SEAMLESS-IF those 3 types are further broken down, because it was decided that the spatial scale is indicator specific. Therefore the SEAMLESS-DB stores e.g. the agricultural income per NUTS region in a different tale than the agricultural income for an EU country. Within SEAMLESS-IF 3 spatial scales that are important for CAPRI are included. The lowest scale is a *NUTS region*. In the middle e find the *country* scale and on the top level so called *country aggregates* like the EU27 or the Mercosur block. The product group is further broken down into the three types inputs, outputs and activities. This leads to 13 different types of tables (because some combinations do not exist). All model variables made available for SEAMLESS-IF, their units and SEAMCAP codes as well as an information if they belong to the group of endorsed indicators are given in the following tables.

**Table 14** *Model variables with regional dimension only at country aggregate scale.*

Variable name	Unit	
Aggregate scale: N retained by crop in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: N from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Aggregate scale: N at tail applied in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: N from crops residues and atmospheric deposition in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: P2O5 retained by crop in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: P2O5 at tail applied in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: P2O5 from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Aggregate scale: P2O5 from crop residues in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: P2O retained by crop in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: K2O at tail applied in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: K2O from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Aggregate scale: K2O from crop residues in kg per ha and region	kg/ha	Not endorsed
Aggregate scale: Subsidies received per ha and region	Euro/ha	Endorsed
Aggregate scale: Subsidies received per annual work unit and region	Euro/AW U	Endorsed
Aggregate scale: Ammonium losses per ha	kg/ha	Endorsed
Aggregate scale: Ammonium losses from mineral fertiliser application	kg/ha	Not endorsed
Aggregate scale: Ammonium losses from manure application	kg/ha	Not endorsed
Aggregate scale: Share of Animal output in total output value	none	Endorsed
Aggregate scale: Value of Animal production per region and hectare	Euro/ha	Endorsed
Aggregate scale: Value of Cattle production per region and hectare	Euro/ha	Not endorsed
Aggregate scale: Value of Cereal production per region and hectare	Euro/ha	Not endorsed
Aggregate scale: CH4 emissions	kg/ha	Endorsed
Aggregate scale: Value of Crop production per region and hectare	Euro/ha	Endorsed
Aggregate scale: Family labor use	Annual Working Units	Not endorsed
Aggregate scale: Global warming potential of all emissions	kg/ha	Endorsed
Aggregate scale: Total agricultural Input value per region and hectare	Euro/ha	Endorsed
Aggregate scale: Regional income per total labor input	Euro/AW U	Endorsed
Aggregate scale: Land value	Euro	Endorsed
Aggregate scale: Energy use by mineral fertiliser	MOE	Endorsed
Aggregate scale: Measurement to assess consumers welfare	Mn Euro	Endorsed
Aggregate scale: N2O emissions	kg/ha	Endorsed
Aggregate scale: Total surplus in Nitrate application	kg/ha	Endorsed
Aggregate scale: Value of other than cattle animal production per region and hectare	Euro/ha	Not endorsed
Aggregate scale: Value of Oilseed production per region and hectare	Euro/ha	Not endorsed
Aggregate scale: Total agricultural output value per region and hectare	Euro/ha	Endorsed
Aggregate scale: Total agricultural output value per region and hectare net of subsidies	Euro/ha	Not endorsed
Aggregate scale: Total surplus in Phosphate application	kg/ha	Endorsed
Aggregate scale: Total surplus in Potassium application	kg/ha	Not endorsed
Aggregate scale: Income from applying Tariffs on imported goods	Mn Euro	Endorsed
Aggregate scale: Terms of Trade	none	Endorsed
Aggregate scale: Total income in Agriculture (without second pillar income) = Output + premiums - input	Mn Euro	Endorsed
Aggregate scale: Total value of all inputs but labour for producing agricultural primary products	Mn Euro	Endorsed
Aggregate scale: Total value of all primary agricultural products produced <sup>^</sup>	Mn Euro	Endorsed
Aggregate scale: All outlays of the first pillar of the EU budget. This pillar finances CAP premiums Subsidised exports and intervention costs	Mn Euro	Endorsed
Aggregate scale: Expenditures for intervention within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Aggregate scale: Total labor use	Annual Working Units	Not endorsed
Aggregate scale: Subsidies paid direct to farmers within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Aggregate scale: Total profit of processing industry	Mn Euro	Endorsed
Aggregate scale: Expenditures for subsidised exports within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Aggregate scale: Welfare in the EU Agricultural sector = Benefit of all actors in the agricultural sector.	Mn Euro	Endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvaluecountryaggregate

**Table 15** *Model variables per region and agricultural products at country aggregate scale.*

Variable name	Unit	
Aggregate scale: Producer price for agricultural outputs	Euro	Not endorsed
Aggregate scale: Marketable production of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Bio Fuel processing demand of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Human consumption of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Exports of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Imports of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Ratio exports to imports	%	Endorsed
Aggregate scale: Market price of agricultural commodities	Euro	Not endorsed
Aggregate scale: Per capita consumption of agricultural commodities	kg/capita	Not endorsed
Aggregate scale: Processing demand of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Losses and Stock change of agricultural commodities	1000 t	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table  
 indicatorvalueproductgroupcountryaggregate

**Table 16** *Model variables per region and agricultural inputs at country aggregate scale.*

Variable name	Unit	
Aggregate scale: Nutrient export with harvested material and crop residues or animal products	kg/ha	Not endorsed
Aggregate scale: Nutrient imported Atmospheric deposition	kg/ha	Not endorsed
Aggregate scale: Nutrient imported by biological fixation	kg/ha	Not endorsed
Aggregate scale: Nutrient losses in runoff from mineral fertilizer	kg/ha	Not endorsed
Aggregate scale: Nutrient Surplus to soil	kg/ha	Not endorsed
Aggregate scale: Total surplus as nutrient input net of exports in products	kg/ha	Not endorsed
Aggregate scale: Nutrient runoff from manure management	kg/ha	Not endorsed
Aggregate scale: Price for agricultural inputs	Euro	Not endorsed
Aggregate scale: Use of agricultural inputs	1000 t	Not endorsed
Aggregate scale: Nutrient imported by crop residuals from previous harvests	kg/ha	Not endorsed
Aggregate scale: Nutrient losses in gaseous emissions NH <sub>3</sub> & N <sub>2</sub> O & NO <sub>x</sub> from mineral fertilizer	kg/ha	Not endorsed
Aggregate scale: Nutrient imported by Manure	kg/ha	Not endorsed
Aggregate scale: Nutrient imported by mineral fertiliser	kg/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueinputgroupcountryaggregate

**Table 17** Model variables per region and agricultural activity at country aggregate scale.

Variable name	Unit	
Aggregate scale: N retained by crop in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: N from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: N at tail applied in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: N from crops residues and atmospheric deposition in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: P2O5 retained by crop in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: P2O5 at tail applied in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: P2O5 from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: P2O5 from crop residues in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: P2O retained by crop in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: K2O at tail applied in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: K2O from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: K2O from crop residues in kg per ha and activity	kg/ha	Not endorsed
Aggregate scale: Level of agricultural production activities	1000 ha or 1000 heads	Not endorsed
Aggregate scale: Subsidies received through agricultural production activities	Euro/ha	Not endorsed
Aggregate scale: Main yield of agricultural production activities	kg/ha or kg/head	Not endorsed
Aggregate scale: Income per hectare of agricultural production activities	Euro/ha	Endorsed
Aggregate scale: Revenue per hectare of agricultural production activities	Euro/ha	Not endorsed
Aggregate scale: Costs per hectare of agricultural production activities	Euro/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table

indicatorvalueactivitygroupcountryaggregate

**Table 18** Model variables between two regions per product at country aggregate scale.

Variable name	Unit	
Aggregate scale: Import price (to region from region) of agricultural commodities	Euro	Not endorsed
Aggregate scale: Trade flows (to region from region) of agricultural commodities	1000 t	Not endorsed
Aggregate scale: Tariff rate quotas (to region from region) of agricultural commodities	1000 t	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvaluebetweenecountryaggregates



**Table 19** Model variables with regional dimension only at country scale.

Variable name	Unit	
Country scale: N retained by crop in kg per ha and region	kg/ha	Not endorsed
Country scale: N from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Country scale: N at tail applied in kg per ha and region	kg/ha	Not endorsed
Country scale: N from crops residues and atmospheric deposition in kg per ha and region	kg/ha	Not endorsed
Country scale: P2O5 retained by crop in kg per ha and region	kg/ha	Not endorsed
Country scale: P2O5 at tail applied in kg per ha and region	kg/ha	Not endorsed
Country scale: P2O5 from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Country scale: P2O5 from crop residues in kg per ha and region	kg/ha	Not endorsed
Country scale: P2O retained by crop in kg per ha and region	kg/ha	Not endorsed
Country scale: K2O at tail applied in kg per ha and region	kg/ha	Not endorsed
Country scale: K2O from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
Country scale: K2O from crop residues in kg per ha and region	kg/ha	Not endorsed
Country scale: Subsidies received per ha and region	Euro/ha	Endorsed
Country scale: Subsidies received per annual work unit and region	Euro/AW U	Endorsed
Country scale: Ammonium losses per ha	kg/ha	Endorsed
Country scale: Ammonium losses from mineral fertiliser application	kg/ha	Not endorsed
Country scale: Ammonium losses from manure application	kg/ha	Not endorsed
Country scale: Share of Animal output in total output value	none	Endorsed
Country scale: Value of Animal production per region and hectare	Euro/ha	Endorsed
Country scale: Value of Cattle production per region and hectare	Euro/ha	Not endorsed
Country scale: Value of Cereal production per region and hectare	Euro/ha	Not endorsed
Country scale: CH4 emissions	kg/ha	Endorsed
Country scale: Value of Crop production per region and hectare	Euro/ha	Endorsed
Country scale: Family labor use	Annual Working Units	Not endorsed
Country scale: Global warming potential of all emissions	kg/ha	Endorsed
Country scale: Total agricultural Input value per region and hectare	Euro/ha	Endorsed
Country scale: Regional income per total labor input	Euro/AW U	Endorsed
Country scale: Land value	Euro	Endorsed
Country scale: Energy use by mineral fertiliser	MOE	Endorsed
Country scale: Measurement to assess consumers welfare	Mn Euro	Endorsed
Country scale: N2O emissions	kg/ha	Endorsed
Country scale: Total surplus in Nitrate application	kg/ha	Endorsed
Country scale: Value of other than cattle animal production per region and hectare	Euro/ha	Not endorsed
Country scale: Value of Oilseed production per region and hectare	Euro/ha	Not endorsed
Country scale: Total agricultural output value per region and hectare	Euro/ha	Endorsed
Country scale: Total agricultural output value per region and hectare net of subsidies	Euro/ha	Not endorsed
Country scale: Total surplus in Phosphate application	kg/ha	Endorsed
Country scale: Total surplus in Potassium application	kg/ha	Not endorsed
Country scale: Income from applying Tariffs on imported goods	Mn Euro	Endorsed
Country scale: Total income in Agriculture (without second pillar income) = Output + premiums - input	Mn Euro	Endorsed
Country scale: Total value of all inputs but labour for producing agricultural primary products	Mn Euro	Endorsed
Country scale: Total value of all primary agricultural products produced^	Mn Euro	Endorsed
Country scale: All outlays of the first pillar of the EU budget. This pillar finances CAP premiums Subsidised exports and intervention costs	Mn Euro	Endorsed
Country scale: Expenditures for intervention within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Country scale: Total labor use	Annual Working Units	Not endorsed
Country scale: Subsidies paid direct to farmers within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Country scale: Total profit of processing industry	Mn Euro	Endorsed
Country scale: Expenditures for subsidised exports within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed
Country scale: Welfare in the EU Agricultural sector = Benefit of all actors in the agricultural sector.	Mn Euro	Endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvaluecountry

**Table 20** Model variables per region and agricultural products at country scale.

Variable name	Unit	
Country scale: Producer price for agricultural outputs	Euro	Not endorsed
Country scale: Marketable production of agricultural commodities	1000 t	Not endorsed
Country scale: Bio Fuel processing demand of agricultural commodities	1000 t	Not endorsed
Country scale: Human consumption of agricultural commodities	1000 t	Not endorsed
Country scale: Exports of agricultural commodities	1000 t	Not endorsed
Country scale: Imports of agricultural commodities	1000 t	Not endorsed
Country scale: Market price of agricultural commodities	Euro	Not endorsed
Country scale: Per capita consumption of agricultural commodities	kg/capita	Not endorsed
Country scale: Processing demand of agricultural commodities	1000 t	Not endorsed
Country scale: Losses and Stock change of agricultural commodities	1000 t	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueproductgroupcountry

**Table 21** Model variables per region and agricultural inputs at country scale.

Variable name	Unit	
Country scale: Nutrient export with harvested material and crop residues or animal products	kg/ha	Not endorsed
Country scale: Nutrient imported Atmospheric deposition	kg/ha	Not endorsed
Country scale: Nutrient imported by biological fixation	kg/ha	Not endorsed
Country scale: Nutrient losses in runoff from mineral fertilizer	kg/ha	Not endorsed
Country scale: Nutrient Surplus to soil	kg/ha	Not endorsed
Country scale: Total surplus as nutrient input net of exports in products	kg/ha	Not endorsed
Country scale: Nutrient runoff from manure management	kg/ha	Not endorsed
Country scale: Price for agricultural inputs	Euro	Not endorsed
Country scale: Use of agricultural inputs	1000 t	Not endorsed
Country scale: Nutrient imported by crop residuals from previous harvests	kg/ha	Not endorsed
Country scale: Nutrient losses in gaseous emissions NH <sub>3</sub> & N <sub>2</sub> O & NO <sub>x</sub> from mineral fertilizer	kg/ha	Not endorsed
Country scale: Nutrient imported by Manure	kg/ha	Not endorsed
Country scale: Nutrient imported by mineral fertiliser	kg/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueinputgroupcountry

**Table 22** Model variables per region and agricultural activities at country scale.

<b>Variable name</b>	<b>Unit</b>	
Country scale: N retained by crop in kg per ha and activity	kg/ha	Not endorsed
Country scale: N from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Country scale: N at tail applied in kg per ha and activity	kg/ha	Not endorsed
Country scale: N from crops residues and atmospheric deposition in kg per ha and activity	kg/ha	Not endorsed
Country scale: P2O5 retained by crop in kg per ha and activity	kg/ha	Not endorsed
Country scale: P2O5 at tail applied in kg per ha and activity	kg/ha	Not endorsed
Country scale: P2O5 from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Country scale: P2O5 from crop residues in kg per ha and activity	kg/ha	Not endorsed
Country scale: P2O retained by crop in kg per ha and activity	kg/ha	Not endorsed
Country scale: K2O at tail applied in kg per ha and activity	kg/ha	Not endorsed
Country scale: K2O from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
Country scale: K2O from crop residues in kg per ha and activity	kg/ha	Not endorsed
Country scale: Level of agricultural production activities	1000 ha or 1000 heads	Not endorsed
Country scale: Subsidies received through agricultural production activities	Euro/ha	Not endorsed
Country scale: Main yield of agricultural production activities	kg/ha or kg/head	Not endorsed
Country scale: Income per hectare of agricultural production activities	Euro/ha	Endorsed
Country scale: Revenue per hectare of agricultural production activities	Euro/ha	Not endorsed
Country scale: Subsidy cut factor per activity	none	Not endorsed
Country scale: Costs per hectare of agricultural production activities	Euro/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueactivitygroupcountry

**Table 23** Model variables with regional dimension only at NUTS region scale.

Variable name	Unit	
NUTS scale: N retained by crop in kg per ha and region	kg/ha	Not endorsed
NUTS scale: N from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
NUTS scale: N at tail applied in kg per ha and region	kg/ha	Not endorsed
NUTS scale: N from crops residues and atmospheric deposition in kg per ha and region	kg/ha	Not endorsed
NUTS scale: P2O5 retained by crop in kg per ha and region	kg/ha	Not endorsed
NUTS scale: P2O5 at tail applied in kg per ha and region	kg/ha	Not endorsed
NUTS scale: P2O5 from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
NUTS scale: P2O5 from crop residues in kg per ha and region	kg/ha	Not endorsed
NUTS scale: P2O retained by crop in kg per ha and region	kg/ha	Not endorsed
NUTS scale: K2O at tail applied in kg per ha and region	kg/ha	Not endorsed
NUTS scale: K2O from mineral fertilizer in kg per ha and region	kg/ha	Endorsed
NUTS scale: K2O from crop residues in kg per ha and region	kg/ha	Not endorsed
NUTS scale: Subsidies received per ha and region	Euro/ha	Endorsed
NUTS scale: Subsidies received per annual work unit and region	Euro/AWU	Endorsed
NUTS scale: Ammonium losses per ha	kg/ha	Endorsed
NUTS scale: Ammonium losses from mineral fertiliser application	kg/ha	Not endorsed
NUTS scale: Ammonium losses from manure application	kg/ha	Not endorsed
NUTS scale: Share of Animal output in total output value	none	Endorsed
NUTS scale: Value of Animal production per region and hectare	Euro/ha	Endorsed
NUTS scale: Value of Cattle production per region and hectare	Euro/ha	Not endorsed
NUTS scale: Value of Cereal production per region and hectare	Euro/ha	Not endorsed
NUTS scale: CH4 emissions	kg/ha	Endorsed
NUTS scale: Value of Crop production per region and hectare	Euro/ha	Endorsed
NUTS scale: Family labor use	Annual Working Units	Not endorsed
NUTS scale: Global warming potential of all emissions	kg/ha	Endorsed
NUTS scale: Total agricultural input value per region and hectare	Euro/ha	Endorsed
NUTS scale: Regional income per total labor input	Euro/AWU	Endorsed
NUTS scale: Land value	Euro	Endorsed
NUTS scale: Energy use by mineral fertiliser	MOE	Endorsed
NUTS scale: N2O emissions	kg/ha	Endorsed
NUTS scale: Total surplus in Nitrate application	kg/ha	Endorsed
NUTS scale: Value of other than cattle animal production per region and hectare	Euro/ha	Not endorsed
NUTS scale: Value of Oilseed production per region and hectare	Euro/ha	Not endorsed
NUTS scale: Total agricultural output value per region and hectare	Euro/ha	Endorsed
NUTS scale: Total agricultural output value per region and hectare net of subsidies	Euro/ha	Not endorsed
NUTS scale: Total surplus in Phosphate application	kg/ha	Endorsed
NUTS scale: Total surplus in Potassium application	kg/ha	Not endorsed
NUTS scale: Total income in Agriculture (without second pillar income) = Output + premiums - input	Mn Euro	Endorsed
NUTS scale: Total value of all inputs but labour for producing agricultural primary products	Mn Euro	Endorsed
NUTS scale: Total value of all primary agricultural products produced^	Mn Euro	Endorsed
NUTS scale: Total labor use	Annual Working Units	Not endorsed
NUTS scale: Subsidies paid direct to farmers within the CAP regulations. (no second pillar payments)	Mn Euro	Endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvaluenutsregion

**Table 24** Model variables per region and agricultural products at NUTS region scale.

Variable name	Unit	
NUTS scale: Producer price for agricultural outputs	Euro	Not endorsed
NUTS scale: Marketable production of agricultural commodities	1000 t	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueproductgroupnutsregion

**Table 25** Model variables per region and agricultural inputs at NUTS region scale.

Variable name	Unit	
NUTS scale: Nutrient export with harvested material and crop residues or animal products	kg/ha	Not endorsed
NUTS scale: Nutrient imported Atmospheric deposition	kg/ha	Not endorsed
NUTS scale: Nutrient imported by biological fixation	kg/ha	Not endorsed
NUTS scale: Nutrient losses in runoff from mineral fertilizer	kg/ha	Not endorsed
NUTS scale: Nutrient Surplus to soil	kg/ha	Not endorsed
NUTS scale: Total surplus as nutrient input net of exports in products	kg/ha	Not endorsed
NUTS scale: Nutrient runoff from manure management	kg/ha	Not endorsed
NUTS scale: Price for agricultural inputs	Euro	Not endorsed
NUTS scale: Use of agricultural inputs	1000 t	Not endorsed
NUTS scale: Nutrient imported by crop residuals from previous harvests	kg/ha	Not endorsed
NUTS scale: Nutrient losses in gaseous emissions NH <sub>3</sub> & N <sub>2</sub> O & NO <sub>x</sub> from mineral fertilizer	kg/ha	Not endorsed
NUTS scale: Nutrient imported by Manure	kg/ha	Not endorsed
NUTS scale: Nutrient imported by mineral fertiliser	kg/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueinputgroupnutsregion

**Table 26** Model variables per region and agricultural activities at NUTS region scale.

Variable name	Unit	
NUTS scale: N retained by crop in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: N from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: N at tail applied in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: N from crops residues and atmospheric deposition in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: P <sub>2</sub> O <sub>5</sub> retained by crop in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: P <sub>2</sub> O <sub>5</sub> at tail applied in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: P <sub>2</sub> O <sub>5</sub> from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: P <sub>2</sub> O <sub>5</sub> from crop residues in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: P <sub>2</sub> O retained by crop in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: K <sub>2</sub> O at tail applied in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: K <sub>2</sub> O from mineral fertilizer in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: K <sub>2</sub> O from crop residues in kg per ha and activity	kg/ha	Not endorsed
NUTS scale: Level of agricultural production activities	1000 ha or 1000 heads	Not endorsed
NUTS scale: Subsidies received through agricultural production activities	Euro/ha	Not endorsed
NUTS scale: Main yield of agricultural production activities	kg/ha or kg/head	Not endorsed
NUTS scale: Income per hectare of agricultural production activities	Euro/ha	Endorsed
NUTS scale: Revenue per hectare of agricultural production activities	Euro/ha	Not endorsed
NUTS scale: Subsidy cut factor per activity	none	Not endorsed
NUTS scale: Costs per hectare of agricultural production activities	Euro/ha	Not endorsed

Source: SEAMLESS-IF. Variables stored in the SEAMLESS DB table indicatorvalueactivitygroupnutsregion

### 3.3 Technical details

In this section we report the file structure of a standard seamcap run in terms of changes to a standard CAPRI simulation. The main file that has to be evoked is the same in both cases (called capmod.gms located in the Capri\gams directory), but in the case of SEAMCAP some things have to be considered. When calling gams some global variables have to be amended in the following way:

```
gams capmod %argumenst%
```

The following arguments have to be set which is done by the CAPRI wrapper

smdir %directory%	a scratch directory for gams intermediate files
o=%file%	definition of the gams listing file
--mode SEAMCAP	global variable to set SEAMCAP mode
--simcode %mycode%	sets the experimentdirectory
--smdir %directory%	a scratch directory for CAPRI intermediate files
--itnum 15	number of iterations set to 15
--simyear 13	simulation year
--terminatingtime 5	maximal execution time in hours
--timdat ddmmyyyy.hhmmss	date and time
--G20 %/ON/OFF%	is trade reform proposal set or not

In the following we give an overview of the files included in a SEAMCAP run with a short description. We only show those that are directly included in capmod.gms and refrain from showing nested include files to keep the overview. The main execution file as well as those specific for SEAMCAP are printed in bold letters.

#### **CAPRI\gams\CAPMOD.gms**

*This is the main steering file for CAPRI simulations*

.CAPRI\gams\util\global\_settings.gms

*Inclusions of some global settings*

.CAPRI\gams\acronyms.gms

*Definition of acronyms*

.CAPRI\gams\sets.gms

*Definition of sets necessary for a CAPRI simulation*

#### **.CAPRI\gams\SEAMrun.gms**

*This file substitutes for the file fortran.gms which is normally created by the CAPRI GUI. It is a frozen version of such a file with some changes according to the global variables set by the gams call.*

.CAPRI\gams\capmod\define\_regional\_sets.gms

*Definition of regional hierarchy used in a simulation.*

.CAPRI\gams\capmod\load\_base\_data\_and\_trends.gms

*Inclusion of the CAPRI database*

.CAPRI\gams\capmod\define\_inputs.gms

*Adjustment of input costs according to yield growth.*

.CAPRI\gams\policy\policy\_sets.gms

*Set definitions for the policy representation.*

.CAPRI\gams\arm\arm\_sets.gms

*Set definition for the multi commodity model*

.CAPRI\gams\reports\rep\_sets.gms

*Set definitions for reporting*

**.CAPRI\gams\seamcap\seampar.gms**

*This file contains all parameters that are added in the SEAMCAP version (or mode) of CAPRI.*

**..CAPRI\gams\SeamCap\Indicatorsets.gms**

*Definition of SEANLESS indicators and model variables.*

.CAPRI\gams\policy\smal\_pshar.gms

*Definition of the regional share of small producers.*

.CAPRI\gams\sugar\techf.gms

*Definition of different technologies.*

.CAPRI\gams\pol\_input\agenda.gms

*Agenda2000 policy definition.*

.CAPRI\gams\policy\mtr\_market.gms

*Definition of market related policy parameters under CAP2003 reform.*

.CAPRI\gams\envind\ammo.gms

.CAPRI\gams\envind\gascoeff.gms

.CAPRI\gams\envind\del\_emiscalc.gms

*All three files deal define emission coefficients.*

.CAPRI\gams\feed\reqsets.gms

*Definition of sets needed for feed requirements.*

.CAPRI\gams\supply\supply\_model.gms

*Definition of equations for the regional supply models.*

.CAPRI\gams\supply\simu\_yani\_model.gms

*Definition of the young animal trading module equations.*

.CAPRI\gams\capmod\load\_feed.gms

*Read in feed requirement coefficients.*

.CAPRI\gams\arm\market1.gms

*Setting the multi commodity model environment.*

.CAPRI\gams\capmod\load\_fertilizer.gms

*Read in fertilisation coefficients.*

.CAPRI\gams\pol\_input\mtrstd.gms

*Read in the standard CAP2003 policy file.*

**.CAPRI\gams\SEAMCAP\SET\_POL.gms**

*Interface to SEAMLESS-IF. Inclusion of policy and outlook parameters as defined by the SEAMLESS-IF user as well as elasticities from EXPAMOD.*

.CAPRI\gams\policy\calc\_mtr\_top.gms

*Calculation of regional flat rates reflecting modulation etc.*

.CAPRI\gams\sugar\breakdown\_quotes.gms

*Regional breakdown of sugar quotas*

.CAPRI\gams\capmod\inflation\_and\_trend\_interpolation.gms

*Interpolation between base and final simulation year – more relevant for recursive dynamic version:*

.CAPRI\gams\policy\def\_policy.gms

.CAPRI\gams\policy\policy.gms

.CAPRI\gams\policy\del\_policy.gms

*These three files contain final policy parameter calculations.*

.CAPRI\gams\capmod\def\_fert\_and\_requirements.gms

*Adjustments to feed requirements and fertilisation coefficients.*

.CAPRI\gams\envind\gases.gms

*Recalculation of gaseous emission coefficients.*

.CAPRI\gams\arm\prep\_market.gms

*Some calculations necessary for the market module-*

**----- Start of the iteration loop**

.CAPRI\gams\capmod\calculate\_premiums.gms

*Calculate premiums reflecting ceilings etc.*

.CAPRI\gams\supply\simu\_supply\_grid.gms

*Execute regional supply optimisation models*

**..CAPRI\gams\seamcap\adjustPMP.gms**

*Adjustment of regional cost curves according to elasticities from expamod (only executed in the first iteration loop).*

.CAPRI\gams\supply\calculate\_hessian.gms

*Calculation of hessian matrix to approximate supply response of regional supply models in the national young animal trading model.*

.CAPRI\gams\supply\simu\_yanip\_new.gms

*Execution of young animal trading model.*



.CAPRI\gams\arm\simu\_market.gms

*Execution of the multi commodity market model.*

.CAPRI\gams\capmod\price\_forecast.gms

*Interpolation of prices over iterations.*

**----- End of the iteration loop**

.CAPRI\gams\reports\sol\_simy.gms

*Reporting.*

.CAPRI\gams\reports\feoga.gms

*Calculate results for FEOGA positions.*

.CAPRI\gams\reports\welfare.gms

*Calculate welfare positions.*

.CAPRI\gams\reports\aggreg\_res.gms

*Aggregation of supply model results to regional product aggregates.*

..CAPRI\gams\reports\aggreg\_res\_mrk.gms

*Aggregation of market model results.*

.CAPRI\gams\reports\aggreg\_pp.gms

*Regional aggregation of policy parameters.*

.CAPRI\gams\reports\def\_indic.gms

*Definition of some indicators.*

.CAPRI\gams\capmod\set\_and\_store\_dataout.gms

*Define and store the CAPRI output cube.*

**.CAPRI\gams\seamcap\seamrep.gms**

*Calculation of indicators and model variables according to the SEAMLESS-IF definitions*



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## Glossary

<i>Integrated framework</i>	An application which allows the evaluation of agricultural systems accounting for technical, environmental, economic and social indicators. One or more integrated frameworks will be the main deliverables of the integrated project.
<i>SEAMLESS-IF</i>	SEAMLESS – Integrated Framework. The final version of models used for the final (Project) version of the framework was due December 2008.
<i>Model Variable</i>	This is the expression for model results made available to SEAMLESS-IF. Some of those are also defined as indicators.