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## Documentation of the Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM Version 1.0)

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# DISCUSSION PAPER

## Institute of Agricultural Development in Central and Eastern Europe

### DOCUMENTATION OF THE CENTRAL AND EASTERN EUROPEAN COUNTRIES AGRICULTURAL SIMULATION MODEL (CEEC-ASIM VERSION 1.0)

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**ABSTRACT**

The Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM) has been developed at IAMO. It is a partial equilibrium model for the agricultural sectors of 14 countries including demand of domestic consumers and is designed to analyse the impacts of agricultural policies on important target variables like producer and consumer prices, supply and input demand of agriculture, food demand, net trade and welfare. Particular efforts were undertaken to implement also the policy instruments of the Common Agricultural Policy of the European Union. These besides the market price support measures also include the different forms of domestic support as for example area payments and beef premiums. Also the set-aside obligations and production quotas can be taken into account.

This discussion paper serves as a model documentation and describes the structure of the model along with the basic modelling assumptions. The model is essentially based on neo-classical theory. The main hypotheses are perfect markets, profit maximisation of producers and utility maximisation of consumers.

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JEL: C 69, Q 18

Keywords: Sector Modelling, Agricultural Sector, Partial Equilibrium Model, Policy Analyses

**ZUSAMMENFASSUNG**

Das Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM) ist am IAMO entwickelt worden. Es ist ein partiales Gleichgewichtsmodell für die Agrarsektoren von 14 Ländern und umfasst auch die Nachfrage der Verbraucher. Insbesondere ist es für die Analyse der Auswirkungen von Agrarpolitiken auf wichtige Zielgrößen wie die Erzeuger- und Verbraucherpreise, Angebots- und Faktornachfragemengen der Landwirtschaft, Konsumentennachfrage, Nettohandel und Wohlfahrt erstellt worden. Besondere Anstrengungen sind unternommen worden, die Instrumente der Gemeinsamen Agrarpolitik der Europäischen Union in das Modell einzubeziehen. Diese umfassen neben den Maßnahmen der Marktpreisstützung auch verschiedene Formen der internen Stützung wie zum Beispiel die Flächenzahlungen und Prämien im Rindfleischbereich. Auch können Flächenstilllegungsverpflichtungen sowie Produktionsquoten berücksichtigt werden.

Dieses Diskussionspapier dient als Dokumentation und beschreibt die Struktur des Modells sowie die grundlegenden Modellannahmen. Das Modell basiert im Wesentlichen auf der neoklassischen Theorie. Die zentralen Hypothesen sind vollständige Märkte, gewinnmaximierende Produzenten und nutzenmaximierende Konsumenten.

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JEL: C 69, Q 18

Schlüsselwörter: Sektormodellierung, Agrarsektor, partielles Gleichgewichtsmodell, Politik Analyse



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**LIST OF ABBREVIATIONS**

CAP	Common Agricultural Policy
CEASIM	Central European Agricultural Simulation Model
CEEC	Central and Eastern European Countries
CEEC-ASIM	Central and Eastern European Countries Agricultural Simulation Model
CIS	Commonwealth of Independent States
EU	European Union
GAMS	General Algebraic Modeling System
IAMO	Institut für Agrarentwicklung in Mittel- und Osteuropa
MMIUF	Money metric indirect utility function
NPR	Nominal protection rate
NQEF	Normalised Quadratic Expenditure Function
NQ-QES	Normalized Quadratic – Quadratic Expenditure System
OECD	Organisation for Economic Development
PSE	Producer Subsidy/Support Equivalent
SGMFP	Symmetric Generalized McFadden Profit Function

**LIST OF VARIABLES, PARAMETERS AND INDICES**

ani	Index for livestock output commodities
BASEAREA	Base area
basy	Base year of projection
crop	Index for crop output commodities
cury	Current projection year
d,e	Indices for consumer good
E	Expenditure function
ED	Price elasticity of demand
ED0	Initial value for price elasticity of demand
ES	Price elasticity of supply and input demand
ES0	Initial value for price elasticity of supply and input demand
feed	Index for feed input commodities
FEED	Aggregated feed input elasticity weighted by energy content
FERTS	Aggregated crop output elasticity weighted by fertiliser input requirement

FERTU	Weights: fertiliser requirement per unit of crop output
FLUES	Aggregated livestock output elasticity weighted by feed energy requirement
FLU	Weights: feed energy intake per unit of animal output or energy content per unit of feed input, respectively
g	Index for 'grandes cultures' commodities
GRTP	Annual rate of technical progress
<i>ieb</i>	Bounds around initial income elasticities
IED	Income elasticity of demand
IED0	Initial value for income elasticity of demand
inp	Index for input commodities
l	Index for livestock commodities
LABS	Aggregated output elasticity weighted by labour input requirement
LABU	Weights: labour requirement per unit of output
<i>lb</i>	Bounds around initial price elasticities
LEVL	Area cultivated with specific crop or herd size related to specific livestock output
LEVLP	Area payment per hectare or average premium per animal in the herd
LIMCOMP	Maximum number of eligible animals
LPAYGRAN	Relative loss of area payments
LPAYNGRA	Relative loss on livestock premiums
m	Money metric indirect utility function
M	Number of consumer goods
MAXPAYGRAN	Maximum budget amount available for area payments
MAXPAYNGRA	Maximum budget amount available for livestock premiums
mult	Incentive fraction of PSE
N	Number of output and input commodities
NETREV	Net revenue
NPR_D	Desired nominal protection rate
NX	Net trade
oup	Index for agricultural output
oup, feed	Index for feed input item mapped to output oup
PD	Retail price
PFG	Farm gate price of output or purchase price of input
PFG_M	Minimum farm gate price
POP	Population
PQUOTA	Supply quota rent
PS	Producer incentive price
PSE	Producer subsidy/support equivalent per quantity unit
$PSE^C$	Area payment or livestock premium per quantity unit
PSEC	Livestock premium per quantity unit



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PSECST	Initial value (full amount) of area payment per hectare or livestock premium per animal
PSER	Area payment per ton of reference yield
PW	Border price
QD	Demand quantity
QDPHD	Per-capita demand quantity
QD_H	Compensated (Hicksian) demand
QS	Supply quantity (if QS>0) or input demand quantity (if QS<0)
QSETA	Supply shifted by set-aside requirement
REDGRAN	Reduction factor for area payments per hectare
RM	Retail margin
RYIELD	Reference yield
s, t	Indices for output and input commodities
SETA	Set-aside rate
SETALE	Area set aside
SETAP	Set-aside premium per hectare
SQUOTA	Supply quota
SUMBUD	Government budget expenditure
Superscripts:	D Direct subsidies
	G General subsidies
	I Input subsidies
T	Set of feasible production plan
U	Utility
w	User defined weights for price elasticities
iw	User defined weights for demand elasticities
Y	Per-capita total food expenditure
YIELD	Output per animal or per-hectare
$\alpha, \beta, \zeta$	Parameters of the profit function
$\alpha, a, b, B$	Parameters of the expenditure function
$\Delta$	Exogenous shifter
$\pi$	Profit
$\upsilon$	Indirect utility function

## 1 BACKGROUND AND AIMS OF CEEC-ASIM

Soon after the Institute of Agricultural Development in Central and Eastern Europe (IAMO) had taken up research after its foundation in 1994 it became clear that – in addition to basic research – economic modelling would have to play an important role in understanding the various impediments for and the implications of the transformation process and re-orientation to the Western hemisphere of the Central and Eastern European Countries (CEEC).

Therefore IAMO started its economic modelling at two different levels. At the market level, two different types of equilibrium models are used, General Equilibrium Models and Partial Equilibrium Models. Questions and issues regarding farm management are investigated at the farm level with appropriate models<sup>1</sup>.

The partial equilibrium model 'Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM)', described in this paper and developed at IAMO<sup>2</sup>, is especially designed for comparative-static analysis of the impacts of alternative agricultural and trade policies on agriculture and food demand and the resulting welfare impacts<sup>3</sup>.

CEEC-ASIM is a system of 14 individual country models, one for each of the CEECs (see Table 2.1) with a detailed list of agricultural output and input items including labour. The deep commodity breakdown is a pre-condition for the realistic depiction of the multi-input-multi-output nature of agricultural production and for the analysis of product specific agricultural policies.

There exist several other partial equilibrium models for policy analysis with a rather detailed commodity breakdown. Some of these do, however, not yet cover CEECs (SPEL<sup>4</sup>) Others include only a reduced number of these or consider them as country aggregates (GAPsi<sup>5</sup>, ESIM<sup>6</sup>, MISS<sup>7</sup>, GTAP<sup>8</sup>, WATSIM<sup>9</sup>).

Apart from different country and product aggregation and coverage a special feature of CEEC-ASIM is its strong microeconomic foundation. All theoretical conditions implied by the assumption that rationally behaving producers and consumers maximise profits and utility, respectively, are fulfilled.

CEEC-ASIM can depict a wide range of policies. All major agricultural policy instruments used in the corresponding countries are part of the model. The policy variables of the model encompass nominal protection rates, minimum prices and domestic support as direct payments and input subsidies. Particular efforts were made to include instruments of the Common Agricultural Policy (CAP) into the models of the acceding countries. These comprise also the area payments and the premiums in the beef and milk sector. Quantity control policies like quotas and set-aside are also taken into account.

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<sup>1</sup> See for example MOTHEs and WENDT (1999).

<sup>2</sup> CEEC-ASIM is a further development of the model Central European Agricultural Simulation Model CEASIM) which is described in FROHBERG et al. (1997).

<sup>3</sup> See for first applications WEBER et al. (2000) and WAHL et al. (1999).

<sup>4</sup> See HENRICHSMEYER (1995) and WEBER (1995).

<sup>5</sup> See FRENZ AND MANEGOLD (1988).

<sup>6</sup> See BANSE AND MÜNCH (1998).

<sup>7</sup> See GUYOMARD AND MAHÉ (1994).

<sup>8</sup> See BROCKMEIER (1999).

<sup>9</sup> See VON LAMPE (1999).

The model's complete sectoral coverage allows to abstract from the single farm experience and by that provides relevant results for policy makers. Thus CEEC-ASIM is a self-contained tool for economic agricultural policy analysis forming a link between very specific farm models and economy-wide General Equilibrium Models.

The purpose of this discussion paper is to provide detailed background information on the methodological approach and the underlying modelling assumption of CEEC-ASIM.

## 2 DESCRIPTION OF THE MODEL

CEEC-ASIM covers supply of 12 agricultural goods and food demand (list of commodities in Table 2.2). Also the use of 5 intermediate inputs as well as agricultural labour input are determined. Feed demand for wheat, coarse grains and potatoes is included explicitly.

Outputs are mainly represented in terms of raw agricultural products. Exceptions are milk and sugar beet. Milk output is expressed in whole milk equivalent and output of sugar beet growing in refined sugar. A residual output item 'rest of agricultural output' comprises all output not explicitly included in the commodity list. 'Rest of food expenditure' represents expenditure on food consumption which is not spent on the products included explicitly.

**Table 2.1: Countries of CEEC-ASIM**

<b>EU accession candidates</b>	<b>Commonwealth of Independent States</b>
Bulgaria	Belarus
Czech Republic	Kazakhstan
Estonia	Russian Federation
Hungary	Ukraine
Latvia	
Lithuania	
Poland	
Romania	
Slovak Republic	
Slovenia	

### *Assumptions in terms of model structure*

The model is essentially based on neo-classical assumptions. Producers are modeled as maximizing profit and consumers as that of utility. They have perfect knowledge about technical and market conditions. Transaction costs do not occur explicitly and exchange of goods is carried out frictionless and instantaneously. Markets are competitive, i.e. producers and consumers are price takers.

Commodities are considered to be homogenous. Hence, intra-industry trade is not depicted by the model. In other words, the difference between supply and demand is considered to be traded with the rest of the world. In addition, the countries are modelled as being price takers on the world market. This reflects the assumption that they are too small to affect world market prices. The appropriateness of this assumption is, however, questionable for some commodities in some CIS countries.

**Table 2.2: Commodities of CEEC-ASIM**

Supply system	Demand system
<i>Outputs</i>	
Wheat	Wheat
Coarse grains	Coarse grains
Potatoes	Potatoes
Oilseeds	Oilseeds
Sugar	Sugar
Vegetables	Vegetables
Milk	Milk
Beef	Beef
Pork	Pork
Poultry	Poultry
Eggs	Eggs
Rest of agricultural output	Rest of food expenditure
<i>Inputs</i>	
Fodder wheat	
Fodder coarse grains	
Fodder potatoes	
Fertiliser	
Rest of intermediate input	
Labour	

In CEEC-ASIM three main blocks of model equations can be distinguished:

- *Supply system*: The quantity of each output and input (netput) depends not only on its own price but also on all other netput prices and on a shift variable representing technological progress. The supply and input demand equations are derived from a Symmetric Generalised McFadden Profit Function (SGMPF), which belongs to the class of functional forms that are flexible up to the second order derivatives with respect to the prices. The supply system fulfils all theoretical conditions implied by the assumption of producers which maximise profits by producing multiple outputs using a bundle of inputs.
- *Demand system*: Consumer demand for a commodity is a function of all retail prices and income. Demand is shifted by autonomous population growth. The demand functions are derived from a Normalised Quadratic Expenditure Function (NQEF), which belongs to the class of functional forms that are flexible up to the second order derivatives with respect to the prices. All theoretical conditions implied by the assumption of utility maximisation are fulfilled by the demand system.
- *Price transmission*: Price transmission equations provide links between the various prices used in the model. To the latter belong those at the border, farm gate, and retail level. In addition, producer incentive prices are determined on which producers base their decisions. Due to the small-country-assumption made border prices are exogenous to the model. Also various agricultural policy variables enter the specification of the price transmission block like nominal protection rates, minimum prices and specific subsidies.

### Welfare measurement

The model calculates how welfare of producers and consumers is affected by alternative policy scenarios. In addition, also the budgetary implications (government) of agricultural policies are estimated.

Subsequently the different parts of the model are described in detail along with the underlying model assumptions.

## 2.1 Supply and Input Demand

Supply and input demand are modelled on the basis of a system of output supply and input demand functions derived from a profit function. The profit function is a mathematical representation of the solution to an enterprise's optimisation problem (CHAMBERS 1988, p. 121). From a set of feasible production plans  $T$  a combination of supply quantities and input demands  $QS$  is chosen that maximises profit  $\pi$  at given prices  $PS$  for  $N$  commodities<sup>10</sup>:

Eq. 2.1-1<sup>1)</sup>:

$$\pi(\mathbf{PS}) = \max_{QS_s} \left\{ \sum_s PS_s \cdot QS_s \mid QS_s \in T \quad \forall s \right\};$$

$\pi$	profit function
$PS_s$	producer incentive price
$QS_s$	supply (if $QS_s > 0$ ) or input demand (if $QS_s < 0$ )
$T$	set of feasible production plans
$s = 1, \dots, N$	index for output and input commodities
$N$	number of output and input commodities

The solution of the optimisation problem shown above leads to a profit function in which only prices are the determining variables. Quantities of netputs are at their optimal level and substituted for by prices. To be a profit function an algebraic representation must meet the following regularity conditions (VARIAN 1992, p. 41):

- (1) continuity in output and input prices,
- (2) non-decreasing in output prices and non-increasing input prices,
- (3) homogeneity of degree 1 in prices,
- (4) convexity in prices.

As a functional form for the profit function CEEC-ASIM employs the Symmetric Generalised McFadden Profit Function (SGMPF) (see eq. 2.1-2) described by DIEWERT and WALES (1987) in the context of cost minimisation.

<sup>10</sup> Vectors and Matrices are written in bold letters.

Eq. 2.1-2:

with

$$\pi(\mathbf{PS}) = \sum_s \beta_s \cdot PS_s + \frac{1}{2} \frac{\sum_s \sum_t \zeta_{s,t} \cdot PS_s \cdot PS_t}{\sum_s \alpha_s \cdot PS_s} + \sum_s \Delta_s \cdot PS_s; \quad s, t=1, \dots, N$$

$\Delta_s$  exogenous shift variable

$$\zeta_{s,t} = \zeta_{t,s}; \quad \alpha_s \geq 0; \quad \sum_s \alpha_s \cdot PS_s > 0; \quad \sum_t \zeta_{s,t} \cdot PS_t = 0;$$

$\alpha_s, \beta_s, \zeta_{s,t}$  parameters of the profit function

$s, t = 1, \dots, N$  indices for output and input commodities

Regularity conditions (1) to (3) are fulfilled by the SGMPF. Convexity in prices is imposed globally by restricting the matrix of the  $\zeta$  parameters to be positive semidefinite. This is achieved using the Cholesky decomposition of this matrix (see Annex 2.1).

DEWERT and WALES (1987) show that the Symmetric Generalized McFadden is a flexible functional form in that it can approximate any unknown twice-continuously differentiable function representing an optimisation problem. In this sense it does not impose prior constraints on the economic effects: level of profit, the  $N$  derived supply and input demands and the  $N(N+1)/2$  derived supply and factor demand responses. Imposing convexity on the SGMPF does not destroy flexibility. The SGMPF is (only) flexible with regard to the price point  $\mathbf{PS}^*$  (DEWERT and WALES 1987, p. 54).

Applying Hotelling's Lemma (Chambers, 1988, p. 126) one obtains the system of  $N$  output supplies and input demands as the first order partial derivatives of the SGMPF with respect to the prices:

Eq. 2.1-3:

$$\frac{\partial \pi(\mathbf{PS})}{\partial PS_s} = QS_s(\mathbf{PS}) = \beta_s + \frac{\sum_t \zeta_{s,t} \cdot PS_t}{\sum_s \alpha_s \cdot PS_s} - \frac{1}{2} \frac{\alpha_s \sum_s \sum_t \zeta_{s,t} \cdot PS_s \cdot PS_t}{\left(\sum_s \alpha_s \cdot PS_s\right)^2} + \Delta_s, \quad \forall s$$

$QS_s(\mathbf{PS})$  supply function of output or demand function of input  $s$

The resulting supply and input demand functions are homogenous of degree 0. Therefore only relative prices matter in our model and there is no money illusion. Exogenous shifters  $\Delta$  can move the supply and input demand functions in order to account for effects that are assumed to be independent of prices (e.g. technological progress).

## 2.2 Final Demand

Demand is modelled based on the assumption that the consumer chooses a consumption bundle which maximises his utility at given prices subject to a budget constraint. This optimisation problem can be restated by an indirect utility function which gives the maximum utility achievable at given prices and income (VARIAN 1992, p. 99). The system of demand functions is derived from an expenditure function  $E$  - the inverse of the indirect utility

function -, which gives the minimum cost of achieving a fixed level of utility  $U$  at given retail prices  $\mathbf{PD}$  (VARIAN 1992, p. 103):

Eq. 2.2-1:

$$E(\mathbf{PD}, U(\mathbf{QDPHD})) = \min_{\mathbf{QDPHD}_d} \left\{ \sum_d PD_d \cdot QDPHD_d \mid U(\mathbf{QDPHD}_d) \geq U \right\};$$

$E$	expenditure function
$PD_d$	retail price
$QDPHD_d$	per-capita demand quantity
$U$	utility
$d = 1, \dots, M$	index for consumer goods
$M$	number of consumer goods

To be an expenditure function an algebraic representation must meet the following regularity conditions (VARIAN 1992, p. 105):

- (1) continuity in prices,
- (2) non-decreasing in prices,
- (3) homogeneity of degree 1 in prices,
- (4) concavity in prices.

As a functional form for the expenditure function CEEC-ASIM employs the Normalised Quadratic Expenditure Function (NQEF) described by DIEWERT and WALES (1988):

Eq. 2.2-2:

$$E(\mathbf{PD}, U) = \sum_d a_d \cdot PD_d + \left[ \sum_d b_d \cdot PD_d + \frac{1}{2} \frac{\sum_d \sum_e B_{d,e} \cdot PD_d \cdot PD_e}{\sum_d \alpha_d \cdot PD_d} \right] \cdot U; \quad d, e = 1, \dots, M$$

with

$$\mathbf{1}^T \cdot \mathbf{PD}_{basy} = 1; \quad \mathbf{a} = \frac{\mathbf{QDPHD}_{basy}}{Y_{basy}}; \quad \mathbf{a}^T \cdot \mathbf{PD}_{basy} = 0; \quad \mathbf{B} = \mathbf{B}^T; \quad \mathbf{B} \cdot \mathbf{PD}_{basy} = 0; \quad \mathbf{PD}_{basy}^T \cdot \mathbf{b} = 1$$

$Y$	per-capita total food expenditure
$\alpha_d, a_d, b_d, B_{d,e}$	parameters of the expenditure function
$basy$	base year of projection
$d, e$	indices for consumer goods
$M$	number of consumer goods

Regularity conditions (1) to (3) are fulfilled by the NQEF. Concavity in prices can be imposed globally by restricting the matrix  $\mathbf{B}$  of parameters to be negative semidefinite (DIEWERT and WALES 1988). This is achieved using the Cholesky decomposition of this matrix (see Annex 1.2).

The NQEF is a flexible functional form in that it can approximate any twice-continuously differentiable expenditure function (DIEWERT and WALES 1988). This means, that the NQEF can depict  $\frac{1}{2}(M+1)(M+2)$  independent effects for a given price-income<sup>11</sup> situation without a-priori constraints on income and price elasticities (BROSIG 2000, p. 35, DIEWERT 1974). Furthermore, since 'local money metric utility scaling' with reference to base period prices<sup>12</sup> holds one can measure utility in nominal income terms. An advantage of the 'local money metric scaling' is that imposing concavity in prices will not destroy the flexibility property.

Applying Shepard's Lemma to the expenditure function one obtains the system of the consumer's compensated (Hicksian) demand functions as the first order partial derivatives of the expenditure function with respect to the consumer prices (VARIAN 1992, p. 105). These functions determine the expenditure-minimising demand bundle given the level of utility (real income) as a function of prices.

Eq. 2.2-3:

$$\frac{\partial E(\mathbf{PD}, U)}{\partial PD_d} = h_d(PD, U) = a_d + \left[ b_d + \frac{\sum_e B_{d,e} \cdot PD_e}{\sum_d \alpha_d \cdot PD_d} - \frac{1}{2} \frac{\alpha_d \cdot \sum_d \sum_e B_{d,e} \cdot PD_d \cdot PD_e}{\left( \sum_d \alpha_d \cdot PD_d \right)^2} \right] \cdot U, \forall d$$

$h_d(\mathbf{PD}, U)$  Hicksian demand function for consumer good d

Solving the expenditure function for the level of utility consistent with a given nominal expenditure and substituting the resulting indirect utility function into the system of compensated demand functions, yields the system of uncompensated (Marshallian) demand functions. This system determines the utility maximising demand bundle at given prices and nominal income.

The system of uncompensated demand functions derived from the NQEF by using Roy's identity has the following form (DIEWERT and WALES 1988):

<sup>11</sup> The terms 'expenditure' and 'income' are used interchangeable.

<sup>12</sup> A more detailed description of the money metric scaling see DIEWERT and WALES (1988, p. 307) or MCKENZIE (1985).



Eq. 2.2-4:

$$(a) \quad QDPHD_d = a_d + \left[ b_d + \frac{\sum_e B_{d,e} \cdot V_e}{\sum_d \alpha_d \cdot V_d} - \frac{1}{2} \frac{\alpha_d \cdot \sum_d \sum_e B_{d,e} \cdot V_d \cdot V_e}{\left( \sum_d \alpha_d \cdot V_d \right)^2} \right] \cdot \frac{1 - \sum_d a_d \cdot V_d}{\sum_d b_d V_d + \frac{1}{2} \frac{\sum_d \sum_e B_{d,e} \cdot V_d \cdot V_e}{\sum_d \alpha_d \cdot V_d}}, \quad \forall d$$

with

$$V_d = PD_d / Y, \quad \forall d$$

$$(b) \quad QD_d = QDPHD_d \cdot POP$$

$QDPHD_d$	per-capita demand quantity of good d
$Y$	per-capita total food expenditure (exogenously determined)
$QD_d$	demand quantity of good d
$POP$	population (exogenously determined)

These demand functions are homogenous of degree 0 in prices and income, which means that only the structure of retail prices normalised by income  $V$  matter.

The NQEF has an important disadvantage in terms of model assumptions. The Engel curves derived from it are linear in income (DIEWERT and WALES 1988, pp. 306). RYAN and WALES (1996) describe a Normalised Quadratic – Quadratic Expenditure System (NQ-QES) with Engel curves quadratic in income and with the NQEF and its linear Engel curves nested as a special case. Work is underway at IAMO to implement the NQ-QES into CEEC-ASIM (FROHBERG and WINTER 2001).

## 2.3 Price definitions

CEEC-ASIM links prices at different levels, i.e. border prices, farm gate prices, producer incentive prices and consumer prices.<sup>13</sup>

### 2.3.1 Transmission of border prices onto the domestic market

It is assumed that foreign demand absorbs any surplus and that foreign supply meets any deficit in the commodity balances of the CEECs at given international prices. This so-called small country assumption is justified if the shares of the country in international agricultural trade are low. The border prices can then be treated as exogenous model variables. The appropriateness of this assumption is, however, questionable for some commodities in some CIS countries.

<sup>13</sup> All prices are in national currencies.

In the absence of policy interventions border prices could be seen as the incentives on which farmers base their decision on input use and output supply. However, governments intervening on agricultural markets establish wedges between border prices and farm gate prices.

The nominal protection rate (NPR) is a measure of the policy induced gap between farm gate and border prices. It can be an exogenous or endogenous variable depending on the type of market intervention the government pursues. For example, in a system with fixed administered prices the NPR rate is viewed as being endogenously determined. On the other hand, with ad-valorem-import-tariffs changes in border prices are transmitted onto the domestic market, the NPR would be an exogenous policy variable reflecting the level of border protection.

The price transmission equations employed in the model allow to combine both types of market and trade policies (see also eq. 2.3.1-1):

- If no politically desired minimum farm gate price exists ( $PFG\_M = 0$ ), farm gate prices  $PFG$  equal the corresponding border prices  $PW$  times a desired nominal protection factor ( $NPR\_D + 1$ ) kept up by policy interventions as for example ad-valorem import tariffs.
- Under a policy aiming at ensuring a certain minimum farm gate price ( $PFG\_M > 0$ ) the realised  $PFG$  would equal  $PW$  if the latter is at least as high as the  $PFG\_M$ . The realised  $NPR$  would be endogenous in the model in this case.
- With both, a politically desired nominal protection rate and a minimum farm gate price given, the farm gate price would be no lower than the minimum price but equal the border price times the desired nominal protection factor if this is higher than the minimum price.

Hence, the price transmission equations allow to switch from scenarios with import tariffs to options with minimum prices (e.g. intervention prices) or to any combination of the two.

Eq. 2.3.1-1:

$$PFG_s = \text{MAX} (PW_s \cdot (NPR\_D_s + 1); PFG\_M_s), \quad \forall s$$

$PFG_s$	farm gate price
$PW_s$	border price (exogenously determined)
$NPR\_D_s$	desired nominal protection rate (exogenously determined)
$PFG\_M_s$	minimum farm gate price (exogenously determined)

### 2.3.2 Price transmission between farm gate and consumer level

The costs of processing, wholesale and retail services are assumed to be perfectly inelastic with respect to demand for these services. Therefore, the margins between prices at producer and consumer level are exogenous to the model. The price transmission between producer and consumer level is given by the following equation:

Eq. 2.3.2-1:

$$PD_d = PFG_d + RM_d, \quad \forall d$$

$PFG_d$	farm gate price
$RM_d$	retail margin (exogenously determined)
$PD_d$	retail price

### 2.3.3 Other support instruments and producer incentive prices

In the absence of subsidies farm gate prices would be the relevant incentives for the producers' decisions on output supply and input demand. However, there are agricultural policy measures that do not influence market prices but nevertheless distort production incentives. OECD's statistics on producer subsidy/support equivalents provide a grouping of these non market support subsidies according to which CEEC-ASIM distinguishes between direct payments, reduction of input costs and general services. In order to capture the impact of these subsidies on production decisions we have defined in CEEC-ASIM so-called producer incentive prices  $PS$ . These take into account the farm gate prices plus some fractions of direct payments, input subsidies and general services (see eq. 2.3.3-1) which are assumed to influence producers' decisions. Also quota rents enter the definition of the incentive prices if applicable (see chapter 2.4 for the treatment of quotas).

Eq. 2.3.3-1:

$$PS_s = PFG_s + mult^D \cdot PSE_s^D + mult^I \cdot PSE_s^I + mult^G \cdot PSE_s^G - PQUOTA_s$$

$PS_s$	producer incentive price
$PFG_s$	farm gate price
$PQUOTA_s$	supply quota rent
$PSE_s$	producer subsidy/support equivalent per quantity unit (exog. determined)
$mult$	incentive fraction of PSE (exogenously determined)
Superscripts: $I$	input subsidies
$D$	direct subsidies
$G$	general subsidies

## 2.4 Policy Implementation

CEEC-ASIM is designed for policy analysis. A description of how different policy measures are introduced into the model is given below.

### 2.4.1 Market price and other support

Market price support can be implemented into a simulation by setting values for the desired nominal protection rates and for the minimum farm gate prices in the price transmission equations 2.3.1-1.

The level of direct payments, input subsidies and general services per unit of output can be exogenously set as scenario assumption and enter equation 2.3.3-1.

## 2.4.2 Specific instruments of the Common Agricultural Policy

Since the model is used also in the context of EU accession, we have introduced specific measures of the CAP into the model: production quotas, area payments, animal premiums, and area set-aside.

### 2.4.2.1 Production quotas

Production quotas are implemented as upper bounds on the output quantities in the system of supply and input demand equations, which means that output quantities are not allowed to exceed the quota but may be below the quota (eq. 2.4.2.1-1). If the quota becomes binding, the rent for the quota *PQUOTA* is calculated, which enters the equation determining the producer incentive prices (eq. 2.3.3-1). Hence, the incentive prices for all those products for which a quota is binding are adjusted downwards. This is necessary because the incentive prices determine the allocation of the inputs and the output mix.

Eq. 2.4.2.1-1:

(a) Quota case:  $QS_s \leq SQUOTA_s$  and  $PQUOTA_s \geq 0$

(b) Non-quota case:  $PQUOTA_s = 0$

$QS_s$  supply quantity

$SQUOTA_s$  supply quota

$PQUOTA_s$  quota rent

### 2.4.2.2 Area payments

Area payments of the CAP for 'grandes cultures'<sup>14</sup> are part of 'direct subsidies'. In CEEC-ASIM they are treated separately from other direct payments since their amount per quantity unit depends on output quantities and is therefore not set exogenously.

EU regulations specify that area payments for 'grandes cultures' and set-aside is not to exceed a certain amount corresponding to a predetermined area under 'grandes cultures' and set-aside, called base area. This requirement is specified at regional or national level but not for individual farms at which the decisions on land allocation are made. If farmers apply for area payments for more than this base area, area payments per hectare will be reduced.

The payment per hectare is influenced by three policy instruments: the payment per tonne of reference yield, the reference yield and the base area.

The regulation specifies that the payments per hectare are reduced proportionally to the percentage the base area is exceeded. Since the payment per hectare is not increased if applications for payments are below the base area, the equation for the area payments per hectare would be discontinuous in the allocation of land to 'grandes cultures' crops and set-aside. Implementing a discontinuous function is possible, creates, however, additional computational difficulties. Therefore area payments actually transferred are calculated in a way that dampens the effects of discontinuity.

<sup>14</sup> Cereals, oilseeds and pulses.

The payments per tonne of reference yield **PSE<sub>R</sub>** (exogenously given as scenario assumption) are multiplied with the reference yields **RYIELD** (exogenously given as scenario assumption) resulting in an initial value **PSECST** for the payment per hectare (see eq. 2.4.2.2-1a). In setting **PSE<sub>R</sub>** it is assumed that not more than 50% of actual payments are used. This assumption is based on the fact that here is a high share of land rented which farmers cultivate in most of the accession counties. Direct payments on land increase the rental price. Hence, some of these subsidies go to the lessor of the land and do not remain in the pockets of the tenants. If 70% of the direct payments are transferred in this way and about 70% of the land cultivated is leased then only 51% remains with the cultivator of the land.

The maximum budget amount available for area payments  $MAXPAYGRAN^{GC}$  is calculated from the base area  $BASEAREA^{GC}$  (exogenously given as scenario assumption) and **PSECST** (see eq. 2.4.2.2-1c) assuming that the agricultural sector will not receive area payments for more than the base area.

**PSECST** corresponds to the financial transfer per hectare if the base area is not exceeded by actual area under 'grandes cultures' and set-aside. In our model a reduction factor  $REDGRAN^{GC}$  links **PSECST** to the area payments per hectare **LEVLP** (see eq. 2.4.2.2-1b). This factor is an endogenously determined variable and it is bound to take values between zero and one, with the latter serving as a starting value.

The model also computes the relative 'loss' of area payments  $LPAYPGRAN^{GC}$  (see eq. 2.4.2.2-1d). If this variable takes a value of zero actual payments equal  $MAXPAYGRAN^{GC}$ . If it takes a value of one farmers receive no payments. If it would be below zero  $MAYPAYGRAN^{GC}$  would be exceeded. If the result  $LPAYPGRAN^{GC} < 0$  is obtained, the reduction factor  $REDGRAN^{GC}$  is reduced by a very small amount and the model is solved again. This is repeated until a solution is achieved where  $MAXPAYGRAN^{GC}$  is not exceeded by actual payments. Thus area payments per hectare cannot be higher than **PSECST** but may be lower. This makes the area payment per hectare to be actually an endogenous variable in the model.

The area payment per hectare is recalculated to a payment per quantity unit **PSE<sup>C</sup>** (see eq. 2.4.2.2-1e), which – after aggregation with other direct subsidies – enters equation 2.3.3-1 determining the incentive prices.

Eq. 2.4.2.2-1:

(a) 
$$PSECST_g = PSE R_g \cdot RYIELD_g$$

(b) 
$$LEVLP_g = PSECST_g \cdot REDGRAN^{GC}; \quad 0 \leq REDGRAN^{GC} \leq 1$$
  
$$SETAP^{GC} = LEVLP_{WHEAT}$$

(c) 
$$MAXPAYGRAN^{GC} = BASEAREA^{GC} \cdot B \frac{\sum_g PSECST_g \cdot LEVL_{g,basy}}{\sum_g LEVL_{g,basy} bagald}$$

$$LPAYGRAN^{GC} = 1 - \frac{\sum_g LEVL_g \cdot LEVLP_g - SETALE^{GC} \cdot SETAP^{GC}}{MAXPAYGRAN^{GC}};$$

(d)

$$\text{with } 0 \leq LPAYGRAN^{GC} \leq 1$$

$$LEVLP_g = QS_g / YIELD_g;$$

$$YIELD_g = (1 + GRTP_g)^{(cury-basy)} \cdot YIELD_{g,basy}$$

(e) 
$$PSE_g^C = LEVLP_g / YIELD_g$$

$PSECST_g$	initial value (full amount) of area payment per hectare
$PSE R_g$	area payment per ton of reference yield (exogenously determined)
$RYIELD_g$	reference yield (exogenously determined)
$LEVLP_g$	area payment per hectare
$SETAP^{GC}$	set-aside premium per hectare
$REDGRAN^{GC}$	reduction factor for area payment per hectare
$BASEAREA^{GC}$	base area (exogenously determined)
$MAXPAYGRAN^{GC}$	maximum budget amount available for area payments
$LPAYGRAN^{GC}$	relative loss of area payments
$SETALE^{GC}$	area set aside
$LEVLP_g$	area cultivated with specific crop
$YIELD_g$	output per-hectare
$GRTP_g$	annual rate of technical progress (exogenously determined)
$PSE_g^C$	area payment per quantity unit
<i>basy</i>	base year of projection
<i>cury</i>	current year of projection
<i>index:</i>	
<i>g</i>	index for grandes cultures commodities; wheat, coarse grains, oilseeds
<i>GC</i>	index for the set of grandes cultures commodities

### 2.4.2.3 Beef premiums

The beef premiums of the CAP are part of the 'direct subsidies'. In CEEC-ASIM they are treated separately from other direct payments since their amount per output quantity is not set exogenously. They are paid only up to a certain number of animals, the so-called national envelope.

The initial (full) premium per animal  $PSECST_i$  and the number of eligible animals  $LIMCOMP^{AP}$  are exogenously set as part of the policy scenario. The maximum budget available for the premiums  $MAXPAYNGRA^{AP}$  is calculated by multiplying  $PSECST_i$  with  $LIMCOMP^{AP}$  (see eq. 2.4.2.2-2a). This means that the agricultural sector will not receive payments for an amount higher than the one based on the national envelopes.

$PSECST_i$  corresponds to the financial transfer per animal if  $LIMCOMP^{AP}$  is not exceeded by the actual herd size  $LEVLP_i$ . The model computes a value for the relative 'loss' of premiums  $LPAYPNGRA^{AP}$  (see eq. 2.4.2.2-2b). If this variable takes a value of zero actual payments equal  $MAXPAYNGRA^{AP}$ . If it takes a value of one farmers receive no payments. If it would be below zero  $MAYPAYNGRA^{AP}$  would be exceeded. If the result  $LPAYPNGRA < 0$  is obtained, the average premium per animal  $LEVLP_i$  (which has been given a starting value equal to  $PSECST_i$ ) is reduced by a small amount and the model is solved again. This is repeated until a solution is obtained for which  $MAXPAYNGRA^{AP}$  is not exceeded by actual payments. Thus the premium per animal cannot be higher than  $PSECST$  but may be lower. This makes the premium per animal to be actually an endogenous variable in the model. The average premium per animal is recalculated to a payment per quantity unit  $PSE_i^C$  (see eq. 2.4.2.2-2c), which – after aggregation with other direct subsidies – enters equation 2.3.3-1 determining the incentive prices.

### 2.4.2.4 Set-aside

The set-aside obligation concerns only the so-called professional producers. Since CEEC-ASIM does not distinguish farm types, the effective set-aside rate has to be set exogenously as part of the scenario.

Set-aside is implemented as an additional shifter of the supply equations for grandes cultures. This implies that yield levels are not affected by the set-aside rate.

Eq. 2.4.2.2-2:

- (a)  $MAXPAYNGRA^{AP} = LIMCOMP^{AP} \cdot PSECST_l$
- (b)  $LPAYNGRA^{AP} = 1 - \frac{LEVL_l \cdot LEVLP_l}{MAXPAYNGRA^{AP}}; \quad 0 \leq LPAYNGRA^{AP} \leq 1$   
 $LEVL_l = QS_l / YIELD_l;$   
 $YIELD_l = (1 + GRTP_l)^{(cury - basy)} \cdot YIELD_{l,basy}$
- (c)  $PSE_l^C = LEVLP_l / YIELD_l$

$PSE_l^C$	livestock premium per quantity unit
$PSECST_l$	initial (full amount of) premium per animal (exogenously determined)
$LIMCOMP^{AP}$	maximum number of eligible animals (exogenously determined)
$MAXPAYNGRA^{AP}$	maximum budget amount available for livestock premiums
$LPAYNGRA^{AP}$	relative loss of livestock premiums
$LEVLP_l$	average premium per animal in the herd
$LEVL_l$	herd size
$YIELD_l$	output per animal
$GRTP_l$	annual rate of technical progress (exogenously determined)
<i>basy</i>	base year of projection
<i>cury</i>	current year of projection
<i>index:</i>	
<i>l</i>	index for livestock commodities receiving premium payments; beef
AP	index for set of animals receiving premium payments

Eq. 2.4.2.3-1:

$$QSETA_g = \left[ \beta_g + \frac{\sum_t \zeta_{g,t} \cdot PS_t}{\sum_s \alpha_s \cdot PS_s} - \frac{1}{2} \frac{\alpha_g \sum_t \zeta_{g,t} \cdot PS_g \cdot PS_t}{\left( \sum_s \alpha_s \cdot PS_s \right)^2} + \Delta_g \right] \cdot [1 - SETA^{GC}]$$

with  $0 < SETA^{GC} < 1$

$SETA^{GC}$	set-aside rate (exogenously determined)
$QSETA_g$	supply shifted due to set aside requirement
<i>s, t</i>	indices for output and input commodities
<i>g</i>	index for "grandes cultures" commodities
	other symbols as defined above

As the equation is specified  $SETA$  refers to that portion of land which must be set aside due to the area planted with 'grandes cultures'. The set aside area  $SETALE^{GC}$  is calculated according to eq. 2.4.2.3-2.



Eq. 2.4.2.3-2:

$$SETALE^{GC} = \sum_g \frac{QSETA_g}{YIELD_g} \cdot \frac{SETA^{GC}}{(1 - SETA^{GC})}$$

$SETALE^{GC}$  area set aside, in ha

Introducing just an additional shifter into the supply equations cannot capture the impact of the set-aside on other product supplies and on input demand. Therefore implementing set-aside in a way similar to the one for quotas might be preferred. However, implementing set-aside via an upper bound on supply (as in the quota case) would not reflect EU regulations since these do not allow to produce other crops on the area set aside<sup>15</sup>. For CEEC-ASIM we have therefore developed a two-step procedure. In the first step the supply system employing the supply shifter as depicted in equation 2.4.2.3-1 is solved. In a further step the supply system without set-aside shifters is solved, however, with the results obtained in the first step for each crop supply set as upper bounds. This way of modelling set-aside is comparable to the one in the quota-case: the model generates 'quota rents' for the crops entering the incentive price calculations. Hence, changing the set-aside requirement results in adjustments of the incentive prices for the crops and hence via the cross price terms in new input allocation and livestock output.

## 2.5 Welfare

Different policy regimes implemented by the government have an impact on producer and consumer decisions on supply, input demand and final demand for agricultural commodities. These changes influence the welfare position of the economic actors including the government's budget and thus total welfare.

Producer welfare is measured by net revenue including market income and subsidies:

Eq. 2.5-1:

$$NETREV = \sum_s (PFG_s + PSE_s^D + PSE_s^I) \cdot QS_s + SETAP \cdot SETALE$$

$NETREV$	net revenue
$PFG_s$	farm gate price of output or purchase price of input
$PSE_s$	producer subsidy/support equivalent per quantity unit
$QS_s$	supply or input demand quantity
$SETAP$	set-aside premium per hectare
$SETALE$	area set aside
Superscripts: $I$	input subsidies
$D$	direct subsidies

<sup>15</sup> With the exception of limited possibilities to produce renewable resources, which, however, is omitted in the model.

The consumer welfare calculations follow the concept of the money metric indirect utility functions (MMIUF) (VARIAN 1992, pp. 108). The MMIUF determines the minimum income necessary at base year prices  $\mathbf{PD}_{basy}$  to be as well off as facing (current) prices  $\mathbf{PD}$ . Since the MMIUF is a monotonic transformation of the indirect utility function (see eq. 2.5-2) it can be shown that it is a theoretically consistent welfare measure (DIEWERT and WALES 1988, pp. 307).

Eq. 2.5-2:

$$m(\mathbf{PD}_{basy}; \mathbf{PD}, Y) = E(\mathbf{PD}_{basy}, v(\mathbf{PD}, Y))$$

$m$	money metric indirect utility function
$E$	expenditure function
$v$	indirect utility function
$\mathbf{PD}_{basy}$	vector of retail prices at base year
$\mathbf{PD}$	vector of retail prices
$Y$	per capita total food expenditure
$basy$	index indicating the base year in the projection

The indirect utility function corresponding to the NQEF and its money metric are then:

Eq 2.5-3:

$$U = v(\mathbf{V}) = \frac{\left(1 - \sum_d a_d \cdot V_d\right)}{\sum_d b_d \cdot V_d + \frac{1}{2} \frac{\sum_d \sum_e B_{d,e} \cdot V_d \cdot V_e}{\sum_d \alpha_d \cdot V_d}}$$

$$m = POP \left[ \left( \sum_d a_d \cdot V_{d,basy} \right) + \left( V_{d,basy} + \frac{1}{2} \frac{\sum_d \sum_e B_{d,e} \cdot V_{d,basy} \cdot V_{e,basy}}{\sum_d \alpha_d \cdot V_{d,basy}} \right) \cdot U_{basy} \right] \cdot U$$

with

$$V_d = PD_d / Y$$

$U$	utility
$POP$	population
$\alpha_d, a_d, b_d, B_{d,e}$	parameters of the expenditure function

The new utility level of consumers at an alternative price vector is expressed in income/expenditure terms necessary to attain this new utility level at base year prices. This corresponds with the value of the expenditure function at the new utility level. One can compare now the impact of different policies to the consumers welfare position by calculating

the equivalent variation. This measure asks what income change at base year prices would be equivalent to the change in utility:<sup>16</sup>

Eq 2.5-4:

$$EV = (m - Y_{basy}) \cdot POP$$

*EV* equivalent variation

Finally the governments' budget expenditures are computed. The components of the budgets are in our case export subsidies, direct payments, input subsidies, and general services<sup>17</sup>.

The budgetary expenditure for direct payments, input subsidies, and general services is obtained by multiplying the payments per quantity unit with the quantities produced. For direct payments also the payments for set aside are taken into account. In CEEC-ASIM exports are implicitly set off against imports (net trade). Therefore its results on budgetary expenditure on export or import subsidies (if negative sign) or revenues from export and import tariff (if positive sign) have to be interpreted with some care: these positions are simply the gap between farm gate and border prices multiplied with net trade quantities. The sum over all components and commodities gives the total budget expenditures or revenues:

Eq 2.5-5:

$$SUMBUD = \sum_{oup} \left( (PSE_{oup}^D + PSE_{oup}^I + PSE_{oup}^G) \cdot QS_{oup} + NX_{oup} \cdot (PFG_{oup} - PW_{oup}) \right) + SETAP \cdot SETALE$$

with

$$NX_{oup} = QS_{oup} - QS_{oup,feed} - QD_{oup}$$

<i>SUMBUD</i>	gouvernement budget expenditure
<i>NX<sub>oup</sub></i>	net trade
<i>PFG<sub>oup</sub></i>	farm gate price
<i>PW<sub>oup</sub></i>	border price
<i>PSE</i>	producer subsidy/support equivalent per quantity unit
<i>QS<sub>oup</sub></i>	supply quantity
<i>QD<sub>d</sub></i>	demand quality
<i>SETAP</i>	set-aside premium per hectare
<i>SETALE</i>	area set aside
<i>oup</i>	index for agricultural output
<i>oup,feed</i>	index for feed input item mapped to output <i>oup</i>
Superscripts: <i>I</i>	input subsidies
<i>D</i>	direct subsidies
<i>G</i>	general subsidies

Adding producer and consumer welfare as well as budget expenditure leads to the total welfare. The impact of a policy variation is analysed by changes in the welfare components.

<sup>16</sup> For more details see MACKENZIE (1985) or HARTMANN (1991).

<sup>17</sup> For direct payments, input subsidies, and general services we use the definition of the OECD.

**ANNEX 1: LIST OF VARIABLES**

<b>Endogenous variables</b>	
<b>Quantities</b>	
QS	Supply or input demand quantity
QSETA	Supply shifted by set-aside requirement
LEVL	Area cultivated with specific crop or herd size related to specific animal output
YIELD	Output quantity per hectare or per animal
QD	Demand quantity
QDPHD	Per-capita demand quantity
<b>Prices</b>	
PS	Producer incentive price
PD	Retail price
PFG	Farm gate price
PQUOTA	Supply quota rent
<b>Policy variables</b>	
PSECST	Initial (full amount of) area payment per hectare or livestock premium per animal (CAP)
MAYPAYGRAN	Maximum budget amount for area payments (CAP)
SETALE	Area set aside (CAP)
SETAP	Set aside premium (CAP)
LEVL_P	Area payment per hectare or average premium per animal (CAP)
LPAYGRAN	Relative loss of area payments (CAP)
LPAYNGRA	Relative loss of livestock premiums (CAP)
REDGRAN	Reduction factor for area payment per hectare (CAP)
MAYPAYNGRA	Maximum budget amount for livestock premiums (CAP)
<b>Welfare</b>	
NETREV	Net revenue
EV	Equivalent variation
SUMBUD	Government budget expenditure
NX	Net trade
<b>Exogenous variables</b>	
<b>Prices</b>	
PW	Border price
RM	Retail margin
<b>Policy variables</b>	
NPR_D	Desired nominal protection rate
PFG_M	Minimum farm gate price
PSE	Producer subsidy/support equivalent per quantity unit
SQUOTA	Production quota
BASEAREA	Base area (CAP)
PSER	Area payment per ton of reference yield (CAP)
RYIELD	Reference yield (CAP)
LIMCOMP	Maximum number of animals eligible for premiums (CAP)
SETA	Set aside rate (CAP)
<b>Other</b>	
G RTP	Annual rate of technical progress
Y	Per-capita total food expenditure
POP	Population size

## ANNEX 2: CALIBRATION OF SUPPLY AND DEMAND EQUATIONS

Since there is a lack of time series data in all Central and Eastern European Countries, it is still difficult to estimate the necessary parameters of the profit function and of the expenditure function completely by econometric methods. Therefore calibration procedures have been developed that determine the parameters of these functions as to reproduce the base year quantities at base year prices taking into account all of the theoretical constraints described above (see section 2.1 for the supply system and section 2.2 for the demand system) and using expert knowledge on plausible ranges for supply and demand elasticities.

For the calibration of the profit and expenditure functions initial sets of supply/input demand elasticities and demand elasticities have to be determined based on expert knowledge. These initial sets can be drawn also from econometric studies if available in literature or from other research activities. Initial elasticity sets need not be consistent with micro-economic theory but should give some indication of the magnitude of the supply and input demand reaction to changing prices and of the food demand reaction to changing prices and income.

The calibration procedures adjust the initial uncalibrated elasticities in order to make them comply with micro-economic theory. This means that the matrix of the second order derivatives of the profit function with respect to the prices (Hessian Matrix) is symmetric and positive semidefinite and that the supply and input demand function are homogenous of degree zero. On the demand side compliance with micro-economic theory means that the matrix of the second order derivatives of the expenditure function with respect to the prices is symmetric and negative semidefinite, the uncompensated (or Marshallian) demand functions are homogenous of degree zero and the expenditure shares for the commodities add-up to one.

All these constraints are implemented within a non-linear programming approach, which seeks to minimise the deviations of the final calibrated elasticity sets from the initial uncalibrated ones.

Following the calibration of the supply side of the model is explained first and then the calibration of the demand side of the model.

### ANNEX 2.1: SUPPLY SIDE CALIBRATION

The calibration of the supply side pursues a step-wise procedure using the result of the former steps as starting values of the following steps and introducing additional constraints. This has proven to solve the optimisation problem more easily than the calibration of the profit function in one single step.

#### First step

The first calibration step takes into account as micro-economic constraints the symmetry and homogeneity properties only.

#### *Symmetry*

The matrix of the second order derivatives of the profit function with respect to the prices is symmetric (CHAMBERS 1988, p. 162). This means that the derivative of the supply or input demand function for commodity  $s$  with respect to commodity price  $t$   $\delta QS_s / \delta PS_t$  equals the derivative of the supply or input demand function for commodity  $t$  with respect to commodity price  $s$   $\delta QS_t / \delta PS_s$ . The symmetry constraint can be expressed in terms of elasticities  $ES$  (see eq. A.2.1-1a).

Eq. A.2.1-1:

$$(a) \quad ES_{s,t} = ES_{t,s} \cdot \frac{QS_t \cdot PS_t}{QS_s \cdot PS_s}; \quad s = 1, \dots, N$$

$$(b) \quad \sum_t ES_{s,t} = 0$$

$$(c) \quad ES0_{s,t} (1 - lb_{s,t} / 100) \leq ES_{s,t} \leq ES0_{s,t} (1 + lb_{s,t} / 100)$$

$QS_s$	supply (if $QS > 0$ ) or input demand (if $QS < 0$ ) quantity
$PS_s$	producer incentive price
$ES_{s,t}$	calibrated elasticity of supply or input demand
$ES0_{s,t}$	initial (uncalibrated) elasticity of supply or input demand
$lb_t$	ranges around initial elasticities
$s, t$	index for output and input commodities
$N$	number of output and input commodities

### Homogeneity

From the profit function being homogenous of degree 1 in prices it follows that the supply and input demand function are homogenous of degree 0 in prices. Expressed in terms of elasticities this means that the sum of the elasticities for a commodity with respect to its own price and all cross prices is zero (eq. A.2.1-1b).

### Upper and lower bounds on individual elasticities

For each of the single elasticities one has to set upper and lower bounds defining the range of what might be considered as a plausible supply and input demand reaction on price changes. They have to be entered into the calibration procedure as ranges in percentage terms  $lb$  around the initial elasticities  $ES0$  (see eq. A.2.1-1c).

### The objective function: minimisation of the deviations from initial elasticities

The elasticity set  $ES$  is then calibrated in a way that minimises its deviations from the initial set  $ES0$  subject to the constraints and bounds established by eq. A.2.1-1. More specifically, the reduced gradient algorithm CONOPT2 available with the GAMS software package minimises an objective function value of squared deviations between these two sets of elasticities (eq. A.2.1-2a). The calibration procedure allows the user to choose between two specification of the objective function: (1) minimising the sum of absolute squared deviations (eq. A.2.1-2b) or (2) minimising the sum of relative squared deviations (eq. A.2.1-2c). The first option minimises deviations between  $ES$  and  $ES0$  independently of the magnitude of the  $ES0$ , whereas the second option 'punishes' the same absolute deviation for smaller  $ES0$  values stronger than for higher ones. Another way to influence the optimisation result is to set weights  $w$  for each of the deviations between  $ES$  and  $ES0$ . If for example, one has relatively high confidence in the own price elasticities of the initial set but less in the cross price elasticities, one can set higher weights to the own price elasticities.

Eq. A.2.1-2:

$$(a) \quad \min!: OBJ = WD_X + DFEED + DFERT + DLABO,$$

with either  $WD_X = WD_A$  or  $WD_X = WD_R$

$$(b) \quad WD_A = \sum_{s,t} w \cdot (ES_{s,t} - ES0_{s,t})^2$$

$$(c): \quad WD_R = \sum_{s,t} w \cdot \frac{(ES_{s,t} - ES0_{s,t})^2}{ES0_{s,t}^2}$$

$$(d) \quad DFEED = \sum_t (FLUES_t - FEED_t)^2$$

$$(e) \quad DFERT = \sum_t (FERTS_t - ES_{FERT,t})^2$$

$$(f) \quad DLABO = \sum_t (LABS_t - ES_{LABO,t})^2$$

and

$$FLUES_t = \sum_{ani} ES_{ani,t} \cdot \frac{QS_{ani} \cdot FLU_{ani}}{\sum_{ani} QS_{ani} \cdot FLU_{ani}} \quad FEED_t = \sum_{feed} ES_{feed,t} \cdot \frac{QS_{feed} \cdot FLU_{feed}}{\sum_{feed} QS_{feed} \cdot FLU_{feed}}$$

$$FERTS_t = \sum_{crop} ES_{crop,t} \cdot \frac{QS_{crop} \cdot FERTU_{crop}}{\sum_{crop} QS_{crop} \cdot FERTU_{crop}}$$

$$LABS_t = \sum_{oup} ES_{oup,t} \cdot \frac{QS_{oup} \cdot LABU_{oup}}{\sum_{oup} QS_{oup} \cdot LABU_{oup}}$$

<i>FLUES</i>	aggregated livestock output elasticity weighted by feed energy requirement
<i>FEED</i>	aggregated feed input elasticity weighted by energy content
<i>FERTS</i>	aggregated crop output elasticity weighted by fertiliser input requirement
<i>LABS</i>	aggregated output elasticity weighted by labour input requirement
<i>FLU</i>	relative feed energy intake per unit of animal output or relative energy content per unit of feed input, respectively
<i>FERTU</i>	relative fertilizer requirement per unit of crop output
<i>LABU</i>	relative labour requirement per unit of output
<i>oup</i>	index for output commodities
<i>ani</i>	index for livestock output commodities
<i>crop</i>	index for crop output commodities
<i>feed</i>	index for feed input commodities
<i>FERT</i>	commodity code: fertiliser
<i>LABO</i>	commodity code: labour

Besides the micro-economic properties it is also possible to take into account technical relationships. For fodder, fertiliser and labour a kind of balancing procedure is introduced. Terms are added to the objective function in order to minimise the sum of deviations between

aggregated supply elasticities and (aggregated) input demand elasticities (see *DFEED*, *DFERT* and *DLABO* in eq. A.2.1-2d,e,f).

Relative input requirements are used as weights to compile the aggregated supply elasticities, relative energy contents are used to aggregate feed input elasticities.<sup>18</sup> The deviations between aggregated supply and input demand elasticities have to be interpreted in terms of production technologies. If, for example, the deviation between the aggregated animal supply and the aggregated feed input elasticity is zero a one-per-cent increase in aggregate livestock output would result in a one-per-cent increase in aggregate feed input (the special case of a Leontief production function at aggregate level).

### Second step

The second step introduces the positive semidefiniteness of the Hessian Matrix (CHAMBERS 1988, p. 127), which follows from profit maximisation and corresponds to the convexity of the profit function. This is achieved using the Cholesky decomposition (DIEWERT and WALES 1987, p. 52) of the Hessian Matrix  $\mathbf{H}$  containing the elements  $\partial QS_s / \partial PS_t$  (see eq. A.2.1-3). The elements of  $\mathbf{H}$  are connected to the calibrated elasticities *ES*.

Eq. A.2.1-3:

$$\mathbf{H} = \mathbf{L} \cdot \mathbf{L}^T; \quad \mathbf{H} = \left[ \frac{\partial QS_s}{\partial PS_t} \right]; \quad \mathbf{L} = [l_{s,t}]; \quad l_{s,t} = 0 \text{ for } s < t$$

with

$$\frac{\partial QS_s}{\partial PS_t} = ES_{s,t} \cdot \frac{QS_s}{PS_t}$$

<b>H</b>	Hessian matrix
<b>L</b>	lower triangular matrix
Superscript <i>T</i>	transpose matrix

All constraints and bounds on elasticity values already established in the first calibration step are maintained during the second step and the same objective function is used, i.e. the objective function value *OBJ* of eq. A.2.1-2 is minimised subject to constraints A.2.1-1 and A.2.1-3. The calibrated elasticities of the first step are used as starting points for this second calibration step.

### Third step

In the second step we already arrive at a set of elasticities which is consistent in the sense of micro-economic theory, i.e. it complies with all theoretical constraints derived from the

<sup>18</sup> For animal output supply elasticities and feed input elasticities livestock and grain units *FLU* are used as weights. One livestock unit is assumed to intake 20 grain units where one grain unit corresponds to 100kg of cereals or 20kg of potatoes. Output elasticities of crops are aggregated by using expert knowledge and farm management data on the relative amount of fertiliser used for the different crops (*FERTU*). For balancing of labour input all output elasticities are aggregated using expert knowledge and farm management data on relative labour input (*LABU*).



assumption of profit maximisation. Now the parameters of the profit function are to be calibrated using the results of the second step as starting points.

The Symmetric Generalized Mac Fadden Profit Function (SGMPF) is convex in prices if the Hessian Matrix formed by its second derivatives with respect to the prices (eq. A.2.1-4a, see also section 2.1) is symmetric and positive semidefinite. This is the case if matrix **C** consisting of the parameters  $\zeta$  is symmetric and positive semidefinite (compare DIEWERT and WALES, 1987). Positive semi-definiteness of **C** is imposed using the Cholesky decomposition (eq. A.2.1-4b). Because of the singularity conditions (eq. A.2.1-4c) it is sufficient to decompose the first principal minor of **C** dropping the  $N^{\text{th}}$  column and  $N^{\text{th}}$  row.

Eq. A.2.1-4:

(a)

$$\frac{\pi(\mathbf{PS})}{\partial PS_t \partial PS_t} = \frac{\partial QS_s}{\partial PS_t} =$$

$$\frac{\zeta_{s,t}}{SAP} - \frac{\alpha_s \cdot \sum_t \zeta_{s,t} \cdot PS_t - \alpha_t \cdot \sum_s \zeta_{t,s} \cdot PS_s}{SAP^2} + \frac{\alpha_s \cdot \alpha_t \sum_s \left( \left( \sum_t \zeta_{s,t} \cdot PS_t \right) \cdot PS_s \right)}{SAP^3}$$

with

$$SAP = \sum_s \alpha_s \cdot PS_s; \quad \alpha_{oup} = QS_{oup}; \quad \alpha_{inp} = -QS_{inp}$$

(b)

$$\mathbf{C} = \mathbf{L}\mathbf{L}^T; \quad \mathbf{C} = [\zeta_{s,t}]; \quad \mathbf{L} = [l_{s,t}]; \quad l_{s,t} = 0 \text{ for } s < t$$

(c)

$$\sum_t \zeta_{s,t} \cdot PS_t = 0$$

(d)

$$\frac{\partial QS_s}{\partial PS_t} = ES_{s,t} \cdot \frac{QS_s}{PS_t}$$

The second order derivatives of the profit function are linked to the elasticities using base year prices and quantities (eq. A.2.1.-4d).

The bounds on the elasticities already used in the first and second step (see eq. A.2.1.-1) are maintained for the third step. Also the same objective function is employed. This means that the objective function value *OBJ* (see eq. A.2.1-2) is minimised subject to the constraints in eq. A.2.1-1 and eq. A.2.1-4. An explicit constraint on the homogeneity property is not used in the third step since the functional form of the SGMPF guarantees homogeneity of degree zero of the derived supply and input demand system. The base year values for prices and quantities, the initial elasticities and the bounds around these are the fixed parameters and the elements of the matrices **C** and **L** as well as the final elasticities *ES* are the variables to be adjusted during calibration.

With the parameters of the SGMPF calibrated at base year prices and quantities the parameters  $\beta$  of the SGMPF represents base year quantities thus reproducing base year profits.

In the future, the model parameters will be calibrated based not only on initial elasticities and theoretical constraints but also on most recent observations on demand, income and prices. A mixed procedure will be used with an objective representing terms as indicated in eq. A.2.1-2 plus the sum of squared deviations between observed and estimated demand quantities.

## **ANNEX 2.2: CALIBRATION OF THE DEMAND SIDE<sup>19</sup>**

The calibration of the expenditure function is similar to the calibration of the supply side of the model. Also a step-wise procedure is employed.

### **First step**

The first calibration step takes into account as micro-economic constraints the symmetry, homogeneity and adding-up properties only.

#### *Symmetry*

The symmetry property derives from the fact that the matrix of the second order derivatives of the expenditure function with respect to the prices is symmetric. Therefore the derivative of the compensated (Hicksian) demand function for commodity  $e$  with respect to commodity price  $d$   $\delta QD\_H_d/\delta PD_e$  equals the derivative of the compensated demand function for commodity  $e$  with respect to commodity price  $d$   $\delta QD\_H_e/\delta PD_d$ . This symmetry property can be expressed in terms of the uncompensated (Marshallian) price elasticities of demand  $ED$  and the expenditure elasticities of demand  $IED$  (eq. A.2.2-1a).

#### *Homogeneity and adding-up*

The uncompensated demand functions are homogenous of degree 0 in prices and total food expenditure (see section 2.2). Expressed in terms of elasticities this means that the sum of elasticities for a commodity with respect to the prices of all other commodities and to total food expenditure is zero (eq. A.2.2-1b). The adding-up condition for total food expenditure is also ensured during this first calibration step (eq. A.2.2-1c).

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<sup>19</sup> A modified calibration procedure used now is described in Frohberg and Winter (2001).

Eq. A.2.2-1:

$$(a) \quad ED_{d,e} = ED_{e,d} \cdot \frac{QDPHD_e}{PD_d} \cdot \frac{PD_e}{QDPHD_d} + (IED_e - IED_d) \cdot \frac{QDPHD_e \cdot PD_e}{\sum_d QDPHD_d \cdot PD_d}; \quad d, e = 1, \dots, M$$

$$(b) \quad \sum_e ED_{d,e} + IED_d = 0$$

$$(c) \quad \sum_e IED_e \cdot \frac{PD_e \cdot QDPHD_e}{\sum_e PD_e \cdot QDPHD_e} = 1$$

$$(d) \quad ED0_{d,e} \cdot (1 - lb_{d,e} / 100) \leq ED_{d,e} \leq ED0_{d,e} \cdot (1 + lb_{d,e} / 100)$$

$$IED0_e \cdot (1 - ieb_e / 100) \leq IED_e \leq IED0_e \cdot (1 + ieb_e / 100)$$

$ED_{d,e}$	price elasticity of demand
$IED_e$	income elasticity of demand
$ED0_{d,e}$	initial value for price elasticity of demand
$IED0_d$	initial value for income elasticity of demand
$QDPHD_d$	per-capita demand quantity
$PD_d$	retail price
$lb_{d,e}$	bounds around initial price elasticities
$ieb_e$	bounds around initial income elasticities
$d, e$	indices for consumer goods

#### *Upper and lower bounds on individual elasticities*

For each of the single price and total food expenditure elasticities  $ED$  and  $IED$  in the demand elasticity set one has to set upper and lower bounds defining the range of what might be considered as a plausible demand reaction to price and income changes. Upper and lower bounds are entered into the calibration procedure as ranges in percentage terms  $lb$  around the initial price elasticities  $ED0$  and as percentage terms  $ieb$  around the initial total food expenditure elasticities  $IED0$  (see eq. A.2.2.-1d).

#### *The objective function: minimisation of the deviations from initial elasticities*

The elasticity sets  $ED$  and  $IED$  are then calibrated as to minimise their deviations from the initial sets  $ED0$  and  $IED0$  subject to the constraints and bounds established by eq. A.2.2-1. The procedure is comparable to the one already explained for the calibration of the supply side elasticities (see also Annex 2.1) and described by eq. A.2.2-2.

Eq. A.2.2-2:

(a)  $\min!: OBJ = WD_x$

with either

$$WD_x = WD_A$$

or  $WD_x = WD_R$

(b)  $WD_A = \sum_{d,e} w_{d,e} \cdot (ED_{d,e} - EDO_{d,e})^2 + \sum_e iw_e \cdot (IED_e - IEDO_e)^2$

(c)  $WD_R = \sum_{d,e} w_{d,e} \cdot \frac{(ED_{d,e} - EDO_{d,e})^2}{EDO_{d,e}^2} + \sum_e iw_e \cdot \frac{(IED_e - IEDO_e)^2}{IEDO_e^2}$

$w, iw$  user defined weights

### Second to fourth step

During the second and third steps starting values for the calibration of the parameters of the expenditure function are determined. These two steps shall not be described in this documentation since they are of a mere technical nature. They do not establish any links between the elasticity sets and the parameters of the expenditure. The values for the parameters of the expenditure function computed in these two steps as well as the elasticity values computed in the first step serve as starting values for the fourth calibration step that links the expenditure function's parameters to the demand elasticity sets, however, still without imposing concavity as required by the theory of the consumer. The results of the fourth step then go as starting values into the fifth calibration step, which in addition to linking the expenditure function's parameters to the elasticity set imposes the concavity property of the expenditure function as required by demand theory. This last calibration step shall be described in detail below.

### Fifth step

The first order derivatives of the expenditure function with respect to consumer prices form the compensated (Hicksian) demand functions. Solving these with respect to the utility consistent with income yields the observable uncompensated (Marshallian) demand functions with prices and income (or total food expenditure)<sup>20</sup> as independent variables. The uncompensated demand function has already been derived from the Normalised Quadratic Expenditure Function (NQEF) in section 2.2, but, for convenience, is repeated below:

The first order derivative of the uncompensated demand function with respect to each of the prices  $\delta QDPHD_d / \delta PD_e$  and with respect to total food expenditure  $\delta QDPHD_d / \delta Y$  (eq. A.2.2-3a) are linked to the elasticities using base year quantities, prices and incomes (see eq. A.2.2-3b).

<sup>20</sup> Since the model's demand system is confined to food terms 'income' and 'total food expenditure' are used interchangeable.

To establish a concave expenditure function consistent with consumer demand theory, the matrix  $\mathbf{C}$  containing the parameters  $\mathbf{B}$  of the NQEF has to be symmetric and negative semidefinite. This property is imposed by using the Cholesky decomposition (see eq. A.2.2-3c).

Adding-up, homogeneity and symmetry have not to be imposed explicitly. These properties are fulfilled by the functional form used (the NQEF) and by the constraints described above.

The bounds on the elasticities already used in the first step are maintained throughout the calibration of the NQEF during the third step. Also the same objective function is employed as in the first step with the results of step 1 for the elasticities being used as starting points. This means that the objective function value  $OBJ$  of eq. A2.2-2 is minimised subject to constraints A.2.2-3. The base year values for prices and quantities, the initial elasticities and the bounds around these are the fixed parameters and the elements of the matrices  $\mathbf{C}$  and  $\mathbf{L}$ , the  $a$  and  $b$  parameters of the NQEF as well as the final elasticities  $ED$  and  $IED$  are the variables to be adjusted during calibration.

Eq. A.2.2-3:

(a)

$$\frac{\partial QDPHD_d(\mathbf{PD}, Y)}{\partial PD_e} = \frac{1}{Y} \cdot (F_{d,e} - G_{d,e}) \quad \text{and} \quad \frac{\partial QDPHD_d(\mathbf{PD}, Y)}{\partial Y} = \frac{E_d}{Y}$$

with

$$F_{d,e} =$$

$$\frac{\left( \frac{B_{d,e}}{ALFAV} - \frac{BMV_d \cdot \alpha_e - BMV_e \cdot \alpha_d + VBMV \cdot \alpha_d \cdot \alpha_e}{ALFAV^2} + \frac{VBMV \cdot \alpha_d \cdot \alpha_e}{ALFAV^3} \right) \cdot (1 - AV)}{BV + \frac{VBMV}{2 \cdot ALFAV}}$$

$$- \frac{\left( b_d + \frac{BMV_d}{ALFAV} + \frac{VBMV^2 \cdot \alpha_d}{2 \cdot ALFAV^2} \right) \cdot a_e}{BV + \frac{VBMV}{2 \cdot ALFAV}}$$

$$G_{d,e} = \frac{\left( b_d + \frac{BMV_d}{ALFAV} - \frac{VBMV \cdot \alpha_d}{2 \cdot (ALFAV^2)} \right) \cdot (1 - AV) \cdot \left( b_e + \frac{BMV_e}{ALFAV} - \frac{VBMV \cdot \alpha_e}{2 \cdot (ALFAV^2)} \right)}{BV + \frac{VBMV}{2 \cdot ALFAV}};$$

$$E_d = QDPHD_d - \alpha_d + \frac{AV \cdot (QDPHD_d - \alpha_d)}{1 - AV}$$

and

$$ALFAV = \sum_d \alpha_d \cdot V_d; \quad BMV_e = \sum_e B_{d,e} \cdot V_e; \quad VBMV = \sum_d \sum_e B_{d,e} \cdot V_e; \quad AV = \sum_d a_d \cdot V_d;$$

$$BV = \sum_d b_d \cdot V_d$$

where

$$\mathbf{1}^T \cdot \mathbf{PD}_{basy} = 1; \quad \mathbf{a} = \mathbf{QDPHD}_{basy} / Y_{basy}; \quad \mathbf{a}^T \cdot \mathbf{PD}_{basy} = 0; \quad \mathbf{B} = \mathbf{B}^T; \quad \mathbf{B} \cdot \mathbf{PD}_{basy} = 0;$$

$$\mathbf{PD}_{basy}^T \mathbf{b} = 1$$

(b)

$$ED_{d,e} = \frac{\partial QDPHD_d}{\partial PD_e} \frac{PD_e}{QDPHD_d}; \quad IED_d = \frac{\partial QDPHD_d}{\partial Y} \frac{Y}{QDPHD_d}$$

(c)

$$\mathbf{C} = -\mathbf{L} \cdot \mathbf{L}^T; \quad \mathbf{C} = [B_{d,e}]; \quad \mathbf{L} = [l_{d,e}]; \quad l_{d,e} = 0 \text{ for } d < e$$

### **ANNEX 3: DATA SOURCES AND DATA PREPARATION**

All country models of CEEC-ASIM have the same structure as regards the equations of the models. The country models differ only by data and parameters.

The model can deal with any base year provided that the data set for this year is complete.

A short description of the data domains of the model is given following. The data are available in spreadsheet format.

#### **Output and input quantities**

Most of the agricultural output items of the model (see also list of commodities in Table 2.2) are represented in terms of raw product. However, whole milk equivalents stand for milk and refined sugar for sugar beets. Output volumes of the explicit output items are measured in quantity units (1000 tons). The residual item 'rest of agricultural output' comprises all agricultural output not covered by the explicit ones. It is measured in currency units at constant prices (million national currencies) and calculated by subtracting the output values for the explicit output items from the total agricultural output (gross agricultural output).

Output is defined as gross production minus seed use and waste (net production). For those products for which feed use is not explicitly covered by the model (e.g. milk) also the quantities fed are deducted from gross production figures.

Intermediate input quantities measured in quantity units (1000 tons) except for the item 'rest of intermediate input'. The latter is a residual derived from figures on total intermediate input use. It is expressed in currency units at constant prices (million national currencies). Labour input is given in 1000 manyears.

The model can easily accommodate other definitions of the commodity items. For example, output figures for oilseeds may also be defined in terms of oil. It is then, however, important that the price data reflect oil and not oilseeds.

An exhaustive description of the data sources used is not presented in this documentation since there is no unique database for all countries and items. Output and input quantities are mainly taken from the FAOSTAT data base. This is supplemented by data from OECD and national statistical offices and ministries. Nevertheless, missing data elements have often to be estimated by using related time series, overlaying with data from different sources, aggregating data items or calculating residuals. This task is supported by a data preparation module. This module is, however, subject to frequent revisions because of changes in the statistical sources and shall therefore not be a subject of this documentation.

#### **Production activity levels**

These are data on the areas under each of the crops (in 1000 ha) and on the number of animals. For milk the production activity level is defined as the number of cows (in 1000 heads). For pork, beef, and poultry it is the number of slaughtered animals (in 1000 heads for beef and pork and in million heads for poultry) and for eggs the number of laying hens (in million heads). The main source for these figures is FAOSTAT.

#### **Demand quantities**

Demand contains final domestic consumption of agricultural and food products (not including seed use, feed use and waste). Demand volumes are expressed in quantity units (1000 tons) for all products (see commodity list in Table 2.2) except for the item 'rest of food expenditure' which is measured in currency units at constant prices (million national currencies). This

residual item comprises all food expenditure not covered by the explicit food commodities of the model. It is calculated by subtracting expenditure for the explicit food items from total food expenditure. The main source for these data is FAOSTAT supplemented by national statistics.

### **Farm gate and purchase prices**

Output prices should be defined as prices 'at the farm gate' received by agricultural enterprises for selling their products. When collecting and compiling these data attention should be paid to the level of processing. For example, if production of sugar is defined as refined sugar, the refined sugar price cannot be used directly as 'farm gate price' since it already covers processing costs. Instead, one has to deduct the value added share of processing from the refined sugar price to arrive at a 'farm gate price' for sugar. Alternatively, one can also use sugar beet prices and use processing coefficients to express sugar beet prices in terms of refined sugar. The main source for price data are national statistics.

### **Data on domestic support**

Data on domestic support per output unit of the different products is needed to compile the so-called producer incentive prices (see section 2.3.3). Domestic support data used in the model follow the definitions of the OECD concerning the measurement of producer subsidy/support equivalents (PSE). They are broken down into direct subsidies, input subsidies and general subsidies.

### **Consumer prices**

Consumer prices in absolute values as needed by the model are often difficult to obtain from official statistics. They should reflect the retail level. For wheat, for example, retail prices of flour can be used to represent 'retail prices' for wheat. In this case the consumer price of wheat already includes costs for transport, for the first processing level (e.g. milling) and for retailing but not the costs for the second level (e.g. bread and pasta making) and further processing activities. These additional processing costs have to be included in the residual item 'rest of food expenditure'. A similar procedure has to be adopted for other products like sugar, oilseeds and milk

### **World market prices**

World market prices for the model should be defined as border prices in national currency units. Since CEEC-ASIM looks at net-trade flows only and not on intra-industrial trade, it is often difficult to decide whether to use import or export prices or some average of these prices. Often this decision depends on data availability.

### **Nominal protection coefficients**

The nominal protection coefficients (NPR) express the percentage gaps between farm gate prices and world market prices. To compile these figures the OECD's PSE statistics on market support is useful. For countries for which this information is not available data on tariffs and trade subsidies might be used to establish the figures on NPRs. However, to compile NPRs from this information can easily become a difficult and time-consuming task since tariffs are often differentiated deeply according to tariff nomenclatures and origin.



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