SPEL system

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Vol. 2: MFSS

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NOTE ON THE FORMULA NOTATION

In order to facilitate the reading of formulas, several conventions regarding the character format of variables, parameters and sub- and superscripts are followed throughout this documentation:

	Case	Points	Example
Variables of the ABTA, MAC and Additional Demand Component	upper case	12pt	$LEVL$
Variables of NLP equations	upper case	18pt	CP
Coefficients of NLP equations	lower case	12pt	ae
Super- and Subscripts	lower case or upper cas	7pt	k

The equations in the text are followed by explanations of the symbols. If a symbol occurs more than once in a chapter and the meaning of the symbol does not change the explanation is not repeated.

In some formulas, codes of the ABTA and Additional Demand Component and/or codes referring to NLP activities and constraints are used. In this case the reader can refer to the code explanations given in Annexes IV and V.

ABBREVIATIONS USED

ABTA	Activity-based Table of Account
act.	activity
bal.	balance
behav.	behavioural
BM	Base Model
CAP	Common Agricultural Policy
ch.	chapter
coeff.	coefficient
const.	constant
constr.	constraint
ECU	European Currency Unit
eq.	equation
GDP	Gross Domestic Product
interm.	intermediate
MAC	Matrix of Activity Coefficients
MFSS	Medium-term Forecast and Simulation System
MS	Member State
NC	National Currency
NLP	Non-linear Programming
prod.	production
RHS	Right Hand Side
ROW	Rest of World
SFSS	Short-term Forecast and Simulation System
SPEL	Sectoral Production and Income Model for Agriculture
Subsc.	Subscript

1. BACKGROUND

Development of the SPEL System began in the early 1980s. The initial brief was to develop a Sectoral Production and Income Model for Agriculture (hence the German acronym SPEL) for producing

- updates and short-term forecasts of income trends, together with
- estimates of the immediate impact of agricultural policy.

The remit also included making the SPEL-Model user-friendly, so that once it had been developed and tested it could be installed in the Statistical Office of the European Communities (Eurostat) in Luxembourg, continuously updated and used for forecasts and policy-related analyses (Pfähler, 1988).

However, checks on the database and initial comparative analyses soon showed that a great deal of work would have to be done if internal consistency was to be achieved between data from the various sectors of agricultural statistics, as well as sufficient comparability between the Member States. Work in the first few years thus concentrated on developing an integrated data system that brought together data from various sources into a single and consistent framework. This work resulted in the so-called *SPEL Base System (SPEL/EU-BS)*, which provides detailed ex-post descriptions of the structure, intensity and use of agricultural production and income generation in the Member States (for more details on BM, see Vol. 1 of the methodological documentation[1]).

Once the database had been consolidated and improved, development of the *Short-term Forecast and Simulation System (SPEL/EU-SFSS)* began in 1984. In accordance with the original brief, this system was designed to meet the specific requirements of Eurostat and DG VI, i.e. to analyse the income situation, forecast short-term developments and simulate the (short-term) impact of agricultural policy scenarios. As with the Base System, the SFSS was installed in Luxembourg. It is updated there several times each year, and is used for policy-related analyses (see Wolf, 1995).

Once SFSS had proved itself in practice, the Commission expressed an interest in a model for medium-term forecasts and policy simulations. This led to a simplified version of a *Medium-term Forecast and Simulation System (SPEL/EU-MFSS)*. This model was expanded on a piecemeal basis, and is now a tried and tested forecasting and simulation instrument. Over the past few years it has been used mainly for the comparative analysis of various options relating to the reform of the Common Agricultural Policy and for assessing the likely impact of the agricultural reform decided on in 1992 by the Council of Ministers.

It should be clear from these preliminary remarks that the SPEL System including MFSS is designed as a *policy information system* comprising both an integrated data storage system and various versions of policy-related forecasting and simulation models.

1 Wolf, W. (1995): SPEL System - Methodological documentation, Vol. 1: Basics, BS, SFSS. Eurostat, Statistical document, Theme 5: Agriculture, forestry and fisheries, Series E: Methods, Luxembourg.

2. AIMS AND REQUIREMENTS

SPEL/EU-MFSS was designed for forecasts, simulations and *policy-oriented* modelling. More particularly, it was designed to simulate the response of the agricultural sector to changes in the national economy, the world economy and agricultural policy.

The idea was to create a model for agricultural administration purposes and to promote dialogue with policy-makers. This resulted in the following requirements:

- the MFSS had to be *transparent*, so that policy-makers could follow the workings of the model and the data flow;
- it had to be *highly detailed* (activity-based approach), so that account could be taken of individual variables relating to policy objectives and instruments;
- it also had to be *up to date* and *flexible*, so that the latest data could be input and the reference year for forecasts and simulations would reflect the current situation;
- above all, however, the model had to have *sound forecasting qualities*, so that it could not only explain basic links, but would also provide highly accurate numerical forecasts for the most important variables relating to policy objectives.

3. METHODOLOGICAL DESIGN OF SPEL/EU-MFSS - GENERAL OVERVIEW

The requirements described in chapter 2 have largely determined the methodological design and basic structure of the MFSS. Important features are the activity-based approach, the modular structure and the flexible possibilities to integrate expert knowledge where available.

3.1. Activity-based accounting system

SPEL/EU-MFSS is designed to work within the SPEL sectoral accounting and market balancing framework, which complies with the principles of the Economic Accounts for Agriculture (EAA). The accounting identities are represented by an Activity-Based Table of Account (ABTA) and the market balances by an Additional Demand Component.

The methodological background, the structure, the type of information contained and the ex-post specification of the ABTA, derived Matrix of Activity Coefficients (MAC) and Additional Demand Component for the ex-post period are described in Vol. 1 of the methodological documentation of the SPEL System (see Wolf, 1995). The reader is referred to this documentation for more details.

The MFSS forecasts and policy simulations are projections of the ABTA, MAC and Additional Demand Component for the ex-ante period. The placing of MFSS within the SPEL activity-based accounting system has several advantages:

- The detailed breakdown of agricultural production with respect to production activities, product and input items provides the possibility to explore the effects of a wide range of agricultural policies. Complex agricultural policy instruments (e.g. set-aside measures, premium payments per hectare or per animal unit) can be included. Target variables of considerable interest for policy makers can be analysed (e.g. volume of agricultural production, agricultural value added, agricultural prices, domestic demand for agricultural and processed products, surplus situation on agricultural markets).
- The activity-based approach, the representation of non-consolidated ("gross") output and input flows between the production and use activities of the agricultural sectors, and the differentiated depiction of Output Generation, Output Use, Input Generation and Input Use are helpful for the review of the results by experts, who have specialised knowledge in certain fields. Since the model works at Member State level, country-specific, expert know-how can also be used when making forecasts. At this disaggregated level, the results may be more adequately evaluated by experts than at a more aggregated level.
- The compliance with the accounting approach guarantees consistency in respect of both physical and monetary cyclical links, and ensures the comparability of data and model results with the definitions used in the EAA.

3.2. Modular structure

The design of MFSS (see figure 1) is characterised by a modular approach: the complete model is divided into individual components and sub-models (unit construction principle). Each of the components and sub-models represents a sub-system of sectoral interactions, which were produced piecemeal and can be combined to an overall system. This modularization contributes to the transparency of the system.

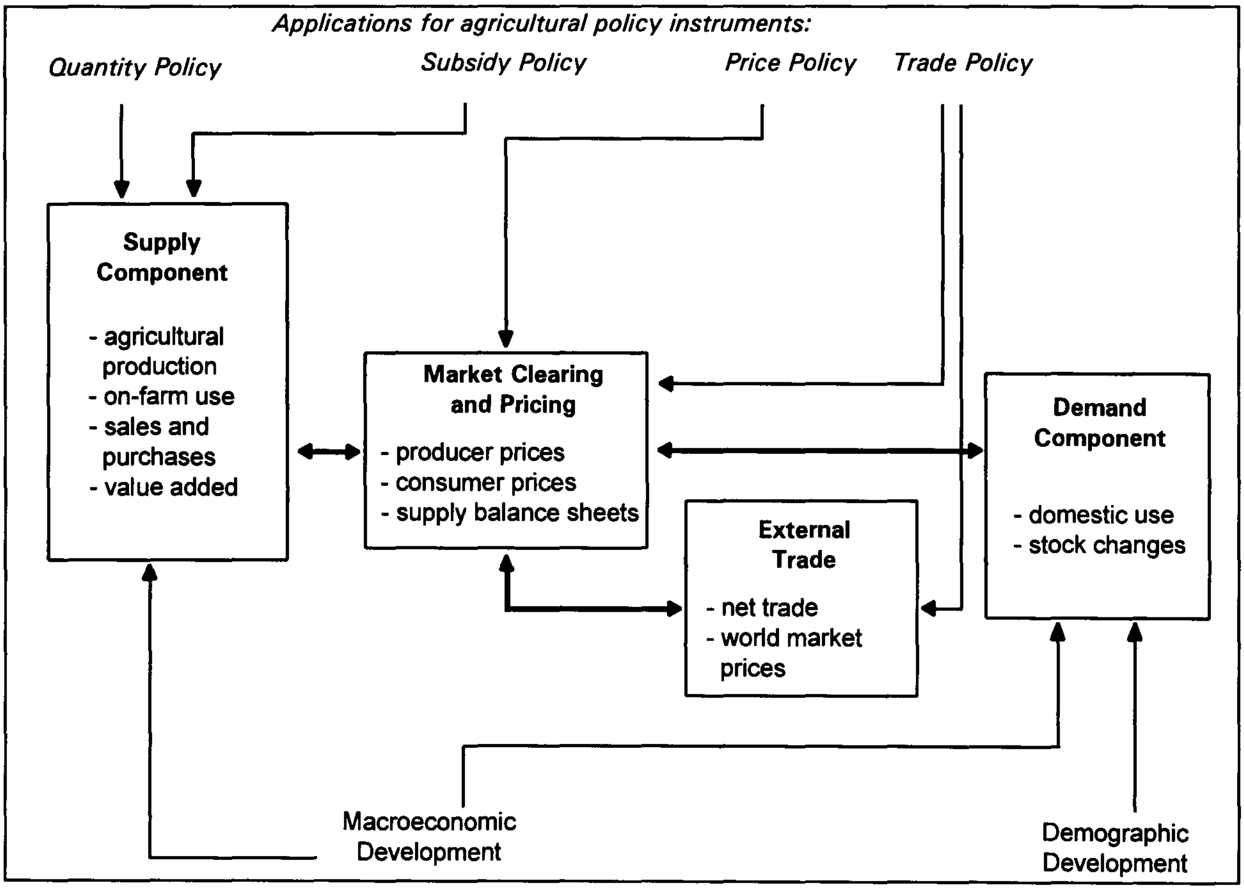
MFSS contains the following components (for more detail see chapter 4):

- The *supply component* forecasts agricultural production and input use, and models the effects of changes in the political, economic and technological environment on agricultural supply and factor demand.
- The *demand component* forecasts the domestic intersectoral use of the agricultural raw and processed products, and models the influence of price and income changes on demand.
- The *external trade component* depicts net trade (i.e. exports minus imports) at aggregate EUR level with Rest of World (ROW). The response of net import demand and net export supply by ROW on changes in the world market prices is modelled.

All components are parts of a comprehensive agricultural sector model. Within this system, the *market clearing and price formation* process is modelled by the interplay of domestic supply and demand and external trade (see ch. 5).

The ABTA, MAC and Additional Demand Component are computed from the results of these model components (see ch. 6). Information on sectoral value addeds is comprised in the ABTA and MAC.

Figure 1: Design of the complete SPEL/EU-System



3.3. Mutual dialogue and incorporation of external information

The SPEL System is designed as a tool for policy-oriented analyses, which can be used in dialogues and mutual interaction between model-builders, statisticians, policy-makers and officials (see Henrichsmeyer and Wolf, 1992). One characteristic of MFSS is that external information coming from experts and other studies can be flexibly incorporated in order to make use of specialised knowledge. Incorporation of external information can be applied to the exogenous variables as well as to the parameters of the model.

External information which enters the model as ***exogenous variables*** comprises information about the policy and macroeconomic environment, the demographic development, and the factor markets.

Policy environment: Forecasts and simulations depend on assumptions about future agricultural policy. The policy scenario determines administered prices, tariff equivalents, quotas, acreage set-aside, direct income transfers and production taxes.

Macroeconomic environment: Agricultural supply and demand and external trade also depend on trends of the macroeconomic environment. Macroeconomic variables such as exchange rates, GDP price indices and total consumer expenditure are exogenous. They are specified from external information from macroeconomic projections or experts.

Demographic development: Demand for agricultural products also depends on population growth. Trend extrapolations of the population growth are provided, which can be replaced by external information from specialised studies if these are more reliable.

Factor markets: Movements in the price of inputs influence agricultural supply and value addeds. MFSS can use trend extrapolations or external information from specialised studies and experts.

Furthermore, for many model variables the model user can (depending on the scenario) choose whether a variable should be determined exogenously or endogenously. If a variable is defined as being exogenous (by the user), one can define an overlay structure with a certain priority sequence which determines the exogenous variable from trend-extrapolations, expert proposals or from the base year of projection (for more technical details, see Zintl and Greuel, 1995).

External information which enters the model via the ***parameters*** can comprise agronomic engineering information, empirical evidence and expert knowledge about the behaviour of the agricultural producers, consumers, marketing agencies and the international trading partners.

Engineering information: There are several possibilities to incorporate agronomic engineering information into the forecasts and simulations. For example, special knowledge from crop experts can be used to review the parameters of the yield functions. This could become especially important, if, for example, major changes in the administered prices have to be simulated, which might lead to the adoption of new technologies or an adjustment of the rates of technical progress.

Behavioural parameters: The production response (with regard to the level of the production activities and substitutions between the production activities) is modelled by the concept of value added elasticities. The demand response is modelled by the concept of price and income elasticities. The import demand and the export supply response of ROW to changing world market prices is represented by net trade elasticities. Sets of elasticities can be derived from own estimates, results from other studies or expert knowledge. To rule out arbitrariness in the specification of the elasticity sets and thus ensure plausible overall supply and demand response, the elasticity sets can be calibrated by restrictions resulting from microeconomic theory and plausibility considerations (see Annex I).

4. THE COMPONENTS OF SPEL/EU-MFSS

In this chapter the model components are described in detail. Special attention is paid to

- the modelling assumptions,
- the scope for using MFSS in the mutual dialogue between policy makers, administration and model analysts,
- the complete description of all model equations.

4.1. The supply component

The supply component is a tool for forecasting output generation and input use, output use and input generation of the agricultural sector, and for analysing the possible effects of changes in the political, technological and economic environment on agricultural production and factor input.

The basic modelling assumptions

Production and factor input respond to farmers' expectations about the output and variable input prices and to their expectations about the profits per unit of the production activities, bearing in mind that these expectations are formed by past experience.

The medium-term response to changing price and profit expectations is modelled as if farmers were solving a two-stage decision problem:

- In the first stage, farmers decide about the quantities of the variable inputs per unit of the production activities (e.g. nitrogenous fertilizer input per hectare of barley). These influence the yields per unit of the production activities. The decisions are determined by the farmers' anticipations about future output and input prices.
- In the second stage of the decision process, farmers decide about the levels of the production activities (e.g. the acreage of barley). The decisions are determined by the anticipated value addeds per unit of the production activities.

Sub-models of the supply component

The modularization of the supply component reflects the basic modelling assumptions described above. The supply component consists of several sub-models: a *price and gross value added expectation model*, a *yield model*, and an *activity model*.

4.1.1. Expectation model

The production processes in agriculture show a noticeable time-lag between the decisions about the factor input, their initialisation and the availability of the products. The expectations of the farmers about future prices of agricultural products and variable inputs and their anticipations about the value addeds per unit of the production activities are considered to be the relevant incentives for the farmer's medium-term supply response.

Adaptive expectations

An expectation model taking into account specific technological characteristics of the production activities can be numerically specified on the basis of annual sectoral data by rough estimations of technological and behavioural parameters (see Weber, 1993, pp. 29-33).

The expectation model of MFSS has, however, the more simple structure of the adaptive price expectation model (see Nerlove, 1958). This model has been proved to be a useful hypothesis and is also widely used in econometric supply analyses.

The following paragraphs describe the adaptive expectation model with the example of the output use prices. The expectation model for the input prices and for the value addeds of the production activities have the same structure.

The basic assumption of the adaptive expectation model is that farmers revise each year their price expectations according to the difference between their expected prices and the actual prices of the previous year:

$$PU^{*}_{a,b,S} = PU^{*}_{a,b,S-1} + \lambda\left(PU_{a,b,S-1} - PU^{*}_{a,b,S-1}\right) \qquad 0 < \lambda \leq 1$$
$$= \sum_{k=1}^{\infty} \lambda(1-\lambda)^{k-1} PU_{a,b,S-k}$$

PU^{*}: Expected output use price
PU: Output use price, ABTA
λ: Expectation coefficient
a: Subsc., ABTA, price element
b: Subsc., ABTA, product
S: Subsc., current simulation year
S-1: Subsc., previous year

The expected price appears as a linear combination of the past annual actual prices. As $0<\lambda\leq 1$, the weights (λ, $\lambda(1-\lambda)$, $\lambda(1-\lambda)^2$ and so on) decrease exponentially and sum up to 1. As a result, the price of a year S-k is more important for the farmers' expectations about the price in S than the prices of the years before S-k.

MFSS uses an approximation of the above expectation model. The price expectations are deflated by the GDP price index and are converted into ECU to make them comparable between the Member States.

Eq. 4.1.1.-1

$$PU^{*}_{a,b,S} = \left(\sum_{k=1}^{4} \lambda(1-\lambda)^{k-1} PU_{a,b,S-k} + \left(1 - \sum_{k=1}^{4} \lambda(1-\lambda)^{k-1}\right) PU_{a,b,S-5}\right) \frac{PEAVNAGG_S}{NAGGNVAF_S}$$

PEAVNAGG: Exchange rate ECU/NC, ABTA
NAGGNVAF: Price index of gross domestic product, ABTA

The expectation coefficients λ are derived from empirical studies or expert assessment. The parameters λ can be set specifically for the different production activities, if information is available on this. Econometric supply analyses show that time-lags hardly exceed 3 years (see Wolfgarten, 1991).[2] For the determination of the ECU exchange rate and the GDP price index, see ch. 6.1.6.5.

4.1.2. Yield model

The yield model aims at forecasting the output and input coefficients of the production activities and at simulating the effects of changes in the price ratios between outputs and variable inputs on these coefficients.

But not all output and input coefficients of the MAC are directly determined in the yield model:

- In the case of nitrogen, phosphate and potassium, the yield model determines only the pure nutrient requirements of the crop production activities. The balancing of the requirements with the supply from manure and mineral fertilizers takes place in the fertilizer module of the activity model (see ch. 4.1.3.3.). The manure and mineral nitrogen, phosphate and potassium input coefficients of the MAC are derived from the results of the activity model (see ch. 6.1.1.2.2.).
- The balancing of the nutrient requirements of the animal production activities with supply from fodder input items takes place in a special module of the activity model, i.e the feed module. The fodder input coefficients of the MAC are derived from the results of the activity model (see ch. 6.1.1.2.2.). The nutrient requirements, however, depend on the output coefficients of the animal production activities, which are determined in the yield model.
- Also, some of the animal output coefficients - the beef, dairy and suckler cow output coefficients of the production activities "dairy cows", "suckling calves" and "heifers" - are derived from the results of the activity model (see ch. 6.1.1.2.1.).

Modelling assumptions

Yield functions depict the influence of the yield increasing input (nitrogen, phosphate, potassium, lime fertilizer, plant protection) on output coefficients[3]. For the modelling of the yield and input response to changing price ratios, it is assumed that farmers determine variable input per unit of a production activity according to profit-maximizing principles. Under this assumption the input per unit of a production activity should be increased to a level at which the marginal profit per unit of a production activity is equal to zero, or in other words to a level at which the marginal yields equal the price ratios between inputs and outputs.

Alternative approaches

MFSS contains two alternative types of yield model. These differ in the way the parameters of the yield functions are determined: (1) *Constructed yield functions:* The parameters are derived under the assumption of profit-maximizing behaviour and incorporate agronomic engineering information. The time shifts of the yield functions are estimated from trend-based yield and input data. Simulation results based on this model look plausible, even compared with studies based on farm accounting and experimental data (see Weber, 1993, p. 120). (2) *Econometrically based yield functions:* Yield functions have also been estimated on the basis of the SPEL/EU-Data by regression methods because this is preferable from a methodological viewpoint if the yield function can be better validated. The parameters of the econometric yield model, too, are estimated under the assumption of profit-maximizing behaviour. The results are checked against agronomic engineering information. Time shift parameters are included if significant.

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2 E.g. with λ set at 0.55, the total weight of the 3 past annual prices is more than 90 %.

3 The remaining inputs (e. g. energy, repair) are not included in the list of yield increasing inputs because it is assumed that they do not have a direct effect on the yield coefficients of the production activities.

As an alternative to endogenous yield and input modelling by the use of yield functions, MFSS also offers to define output and input coefficients as exogenous variables and to determine the output and input coefficients by *expert proposals* or *trend extrapolations*.

Why alternative approaches?

There are two main reasons for offering the two types of yield function (constructed and econometric): (1) Although explorative tests with econometrically-based yield functions were satisfactory for many production activities (see Annex II), econometric estimation has led in some cases to implausible results. (2) Econometric estimation can be preferable from a methodological viewpoint but is very time consuming. Because of that, econometrically estimated parameters cannot be up-dated each time the database is up-dated. This is not a serious problem if technologies do not change abruptly. But if they do, the parameters of the yield functions must be adjusted. This is done more easily and faster with constructed than with econometric functions.

There may be objections against the assumption of profit-maximizing behaviour. Some people may feel that it is too rigid to assume that the agricultural sector would optimise average sectoral factor input per unit of a production activity in order to maximize average profits per unit of a production activity. Expert proposals and trend extrapolations are flexible instruments to incorporate external expert knowledge. They can be used if yield functions and profit maximizing assumptions are not considered to be a good choice for modelling yield and factor input. For perennial crop production activities, intermediate crop production activities and animal production activities, expert proposals and trend extrapolations seem to be more appropriate for the estimation of yield coefficients.

4.1.2.1. Exogenous output and input coefficients

Exogenous output and input coefficients can be specified from expert proposals, trend extrapolations or from the base year of projection. A user defined overlay structure can be established for these sources.

Expert proposals are a mean of incorporating specialised agronomic engineering information into the forecasts and simulations. This becomes important if the effects of new technologies have to be analysed, because new technologies can lead to abrupt changes of the productivities and factor intensities which cannot be forecast satisfactorily by time series analyses. The use of expert proposals means paying special attention to the plausibility of the forecast, because yield and input coefficients are not simultaneously determined by a production function. Expert proposals must therefore be based on profound technological and economic analysis.

Trend extrapolations are not very sophisticated but they often succeed rather well in forecasting yield and input developments. This is especially the case if productivities are dominated by technical progress. A major shortcoming of trend extrapolations is that they do not allow analyses of the effects of changing price ratios between outputs and inputs on production and input demand. Another shortcoming is, as in the case of expert proposals, that the yield and input coefficients are not simultaneously determined.

Expert proposals and trend extrapolations can be integrated into the model by assigning specific values to the output and input coefficients of the production activities:

Eq. 4.1.2.1.-1

$$XMG_{a,b,S} = XMG_{a,b,E \wedge T \wedge B} \qquad YMU_{a,k,S} = YMU_{a,k,E \wedge T \wedge B}$$

XMG: Output Generation, MAC, physical component
YMU: Input Use, MAC, physical component
a: Subsc., ABTA, production activity
b: Subsc., ABTA, product
k: Subsc., ABTA, input item
S: Subsc., current simulation year
E: Subsc., expert proposal
T: Subsc.: trend-based
B: Subsc., base year of projection

The pure nutrient requirements of the crop production activities can also be specified by expert proposals or trend-extrapolations:

Eq. 4.1.2.1.-2

$$YMUN_{a,S} = \left(YMU_{a,NITF} + YMU_{a,NITM} AVF_a\right)_{E \wedge T \wedge B}$$
$$YMUP_{a,S} = \left(YMU_{a,PHOF} + YMU_{a,PHOM}\right)_{E \wedge T \wedge B}$$
$$YMUK_{a,S} = \left(YMU_{a,POTF} + YMU_{a,POTM}\right)_{E \wedge T \wedge B}$$

YMUN: Pure nitrogen requirement per unit of a production activity
YMUP: Pure phosphate requirement per unit of a production activity
YMUK: Pure potassium requirement per unit of a production activity
AVF: Availability factor for nitrogen from manure (%/100)[4]
NITF,NITM,PHOF,...: Subsc., ABTA, input items

4.1.2.2. Endogenous output and input coefficients

Output and input coefficients can be endogenously determined under the assumption of profit-maximizing behaviour and the use of yield functions.

Yield functions are available in MFSS only for one-period final crop production activities. For intermediate crops, permanent crops and animal production activities expert proposals or trend extrapolations must be used (see chapter 4.1.2.1.).

The specification of the yield function is of crucial importance, especially if the effects of drastic price changes are analysed. As a functional form, *polynoms of degree 2* are chosen for several reasons: (1) They are often used in experimental studies. This facilitates comparing the model parameters with empirical evidence and agronomic engineering information. (2) A polynom of degree 2 is a plausible functional form from an agronomic viewpoint: it shows a unique maximum yield level, it generates decreasing marginal yields, and exceeding a certain input level leads to negative marginal yields. (3) Since it is a linear function, it has simple mathematical properties.

[4] Since nitrogen from manure is less absorbed than the mineral nitrogen, a special availability factor for manure is used. This factor is based upon rough estimates taken from planning data (see Wolf, 1995).

In the two following chapters the structures of the alternative types of yield model (constructed and econometric) are described along with the underlying assumptions and the methods to determine their parameters.

The user can define priorities steering the use of these two alternative yield models (see Zintl and Greuel, 1995).

4.1.2.2.1. Constructed yield model

Structure

The yield polynoms have as dependent variables the output coefficients of the production activities and as independent variables activity-specific input aggregates of yield-increasing inputs. Since no weather variables are included, average conditions are implicitly assumed.

Eq. 4.1.2.2.1.-1

$$XMG_{a,a,S} = \alpha + \beta YMUA_{a,S} + \gamma YMUA_{a,S}^{2} \qquad \alpha,\beta > 0 > \gamma$$

XMG: Output Generation, MAC, physical component
YMUA: Input aggregate
α,β,γ: Parameters of the yield function
a: Subsc., ABTA, production activity and product[5]
S: Subsc., current simulation year

The economically optimum level of input is achieved when the marginal yield is equal to the ratio between the price of the input aggregate and the price of the product. The level of the input aggregate can therefore be determined from the parameters of the yield polynom and the expected prices:

Eq. 4.1.2.2.1.-2

$$\beta + 2\gamma YMUA_{a,S} = \frac{QGA^{*}_{a,S}}{PU^{*}_{PRIC,a,S}} \Leftrightarrow YMUA_{a,S} = \frac{\dfrac{QGA^{*}_{a,S}}{PU^{*}_{PRIC,a,S}} - \beta}{2\gamma}$$

QGA*: Expected price of the input aggregate YMUA
PU*: Expected output use price
PRIC: Subsc., ABTA, price element: farmgate price

The input aggregate (YMUA) integrates the so-called "yield increasers", i.e. the four fertilizer nutrients (nitrogen, phosphate, potassium and lime) and plant protection. It is represented by a quantity index:

5 For the final crop products, there is a one-to-one correspondence between production activities and final crop products, since each crop production activity generates one and only one final crop product. The output coefficient $XMG_{a,b}$ of product b in activity a can therefore be written as $XMG_{a,a}$ since a=b.

Eq. 4.1.2.2.1.-3

$$YMUA_{a,S} = f\left(YMUN_{a,S},\ YMUP_{a,S}, YMUK_{a,S}, YMU_{a,CAOF,S}, YMU_{a,PLAP,S}\right)$$

YMU: Input use, MAC, physical component
YMUN: Pure nitrogen requirement per unit of a production activity
YMUP: Pure phosphate requirement per unit of a production activity
YMUK: Pure potassium requirement per unit of a production activity
CAOF,PLAP: Subsc., ABTA, input items: lime fertilizer and plant protection

The expected price of the input aggregate (QUA*) is represented by a Laspeyres price index:

Eq. 4.1.2.2.1.-4

$$QGA^{*}_{a,S} = \sum_{k} \theta_{a,k} QG^{*}_{PRIC,k,S} \qquad k = NITF, PHOF, POTF, CAOF, PLAP$$

QG*: Expected input generation price
θ: Parameter of the price index for the input aggregate YMUA (quantity weight)
k: Subsc., ABTA, input item

Using the Laspeyres index implies the simplification that the composition of the input aggregate is not influenced by price changes and is determined for a given year by a linear-limitational technology. The ratios of the individual yield increasers within the input aggregate remain constant. The total pure nitrogen, phosphate and potassium requirements, the lime fertilizer and plant protection input coefficients can therefore be determined by the following equations:

Eq. 4.1.2.2.1.-5

$$YMUN_{a,S} = YMUA_{a,S}\ \theta_{a,NITF} \qquad YMUP_{a,S} = YMUA_{a,S}\ \theta_{a,PHOF}$$
$$YMUK_{a,S} = YMUA_{a,S}\ \theta_{a,POTF} \qquad YMU_{a,CAOF,S} = YMUA_{a,S}\ \theta_{a,CAOF}$$
$$YMU_{a,PLAP,S} = YMUA_{a,S}\ \theta_{a,PLAP}$$

Determination of the parameters

Trend extrapolations capture the effects of technological progress and structural changes on sectoral productivities and input intensities, and are used to create a reference situation for possible adjustments of the input coefficients. The construction of this reference situation is based on the assumption that, for given product and input price trends, trend-based input and output coefficients would represent an economic optimum at a sectoral level. In other words: the trend-based bundle of input and output coefficients is interpreted as being an optimal choice on a given yield function, under the condition that prices develop according to past trends. If prices deviate from past trends, MFSS simulates the profit-maximizing adjustments on the given yield function. Under this assumption, the parameters of the yield function and of the input price index are determined in the manner described in the following paragraphs.

Yield function

With YMUA scaled to 1 for the trend-based projection ($YMUA_T$:=1), the yield function (eq. 4.1.2.2.1.-1) and the optimum condition (eq. 4.1.2.2.1.-2) are both solved for β and then equated:

$$\beta = XMG_{a,a,T} - \gamma - \alpha = \frac{QGA^{*}_{a,T}}{PU^{*}_{PRIC,a,T}} - 2\gamma$$

T: Subsc., trend-based

From this, γ and β emerge as:

Eq. 4.1.2.2.1.-6

$$\gamma = -XMG_{a,a,T} + \frac{QGA^{*}_{a,T}}{PU^{*}_{PRIC,a,T}} + \alpha \qquad \beta = 2XMG_{a,a,T} - \frac{QGA^{*}_{a,T}}{PU^{*}_{PRIC,a,T}} - 2\alpha$$

The parameter α, which represents yield without yield-increasing inputs, is first given an initial value derived from external information (experimental data, expert proposal). After having determined β and γ by eq. 4.1.2.2.1.-6, the model carries out plausibility checks: it verifies whether γ is negative, and whether the maximum of the yield function and its corresponding level of aggregate input do not exceed certain plausibility values. External information (experimental data, expert proposals) can be used to specify these values. If the plausibility conditions are not met, the initial value of α is reduced and β and γ are recalculated until the function complies with the plausibility requirements.

Eq. 4.1.2.2.1.-6 demonstrate how the effects of technical progress are integrated into the constructed yield model. If, for example, the trend-based yield coefficient (XMG_T) increases during the projection period, the parameter β increases whereas γ decreases. In this way the slope of the yield function becomes steeper, so that average and marginal yields with respect to a given factor input increase.

Input price index

The expected price of the input aggregate is represented by a Laspeyres price index (see eq. 4.1.2.2.1.-4). With YMUA scaled to 1 for the trend-based projection ($YMUA_T$:=1), the quantity weights are the trend-based quantities of the yield increasers:

Eq. 4.1.2.2.1.-7

$$\theta_{a,NITF} = \left(YMU_{a,NITF} + YMU_{a,NITM} AVF_a\right)_T \qquad \theta_{a,PHOF} = \left(YMU_{a,PHOF} + YMU_{a,PHOM}\right)_T$$

$$\theta_{a,POTF} = \left(YMU_{a,POTF} + YMU_{a,POTM}\right)_T \qquad \theta_{a,CAOF} = YMU_{a,CAOF,T}$$

$$\theta_{a,PLAP} = YMU_{a,PLAP,T}$$

4.1.2.2.2. Econometric yield model

Structure

The yield polynoms have as dependent variables the yield coefficients and as independent variables the pure nitrogen requirements per unit of the production activities. Since no weather variables are included, average conditions are assumed:

$$XMG_{a,a,S} = \alpha + \beta YMUN_{a,S} + \gamma YMUN_{a,S}^{\ 2} \qquad \alpha,\beta > 0 > \gamma$$

XMG: Output Generation, MAC, physical component
YMUN: Pure nitrogen requirement per unit of a production activity
α,β,γ: Parameters of the yield function
a: Subsc., ABTA, production activity and product
S: Subsc., current simulation year

The effects of technical progress are captured by introducing a time trend into the yield function. The model differentiates between two types of technical progress: (1) Technical progress shifts the yield function vertically without changing the slope of the curve. In this case technical progress is independent of the input level. (2) Technical progress changes the slope of the yield curve. In this case, the effects of technical progress depend also on the input level.

According to this, technical progress can be modelled by introducing a time shift into the parameters α and β. The yield function is then:

Eq. 4.1.2.2.2.-1

$$XMG_{a,a,S} = \alpha_0 + \alpha_1 TS + \beta_0 YMUN_{a,S} + \beta_1 (TS * YMUN_{a,S}) + \gamma YMUN_{a,S}^{\ 2}$$

TS: Time shift

The economically optimum nitrogen input is achieved when the marginal yield equals the ratio between the marginal costs of the nitrogen input and the product price. The pure nitrogen requirements can therefore be determined from the parameters of the yield polynom, the expected marginal costs and the expected product price:

Eq. 4.1.2.2.2.-2

$$\beta_0 + \beta_1 TS + 2\gamma YMUN_{a,S} = \frac{MC^*_{a,S}}{PU^*_{PRIC,b,S}} \Leftrightarrow YMUN_{a,S} = \frac{\dfrac{MC^*_{a,S}}{PU^*_{PRIC,a,S}} - \beta_0 - \beta_1 TS}{2\gamma}$$

MC*: Expected marginal costs of nitrogen input
PU*: Expected output use price
PRIC: Subsc., ABTA, price element: farmgate price

As in the case of the constructed yield model it is assumed that the input ratios between the five yield increasing inputs nitrogen, phosphate, potassium, lime, and plant protection of a given production activity and year are determined by linear-limitational technologies and are therefore not influenced by price changes. Under this assumption the marginal costs of the nitrogen input can be represented by a Laspeyres index of the five yield increasers as a sum of the nitrogen price plus the proportionate costs for the other yield increasing inputs:

Eq. 4.1.2.2.2.-3

$$MC^{*}_{a,S} = QG^{*}_{PRIC,NITF,S} + \sum_{k} \theta_{a,k} QG^{*}_{PRIC,k,S} \qquad k = PHOF, POTF, CAOF, PLAP$$

QG^{*}: Expected input generation price
θ: Parameter of the marginal cost index of nitrogen input (quantity weight)
k: Subsc., ABTA, input item

Using the Laspeyres marginal cost index implies the simplification that the factor intensities between the individual yield increasers remain constant. The total pure phosphate and potassium requirements, the lime fertilizer and plant protection input coefficients are therefore determined by the following equations:

Eq. 4.1.2.2.2.-4

$$YMUP_{a,S} = YMUN_{a,S}\theta_{a,PHOF} \qquad YMUK_{a,S} = YMUN_{a,S}\theta_{a,POTF}$$
$$YMU_{a,CAOF,S} = YMUN_{a,S}\,\theta_{a,CAOF} \qquad YMU_{a,PLAP,S} = YMUN_{a,S}\,\theta_{a,PLAP}$$

YMU : Input use, MAC, physical component
YMUP: Pure phosphate requirement per unit of a production activity
YMUK: Pure potassium requirement per unit of a production activity

Determination of the parameters of the yield function and of the marginal cost index

Yield function

Yield functions have been estimated in an explorative study. The econometric estimations integrate the hypotheses of profit-maximizing behaviour. Multivariate, non-linear least-squares estimation has been used. The estimation procedure is briefly described in Annex II.

Marginal cost index

The parameters of the marginal cost index (the quantity weights) are trend-based:

Eq. 4.1.2.2.2.-5

$$\theta_{a,PHOF} = \left(\frac{YMU_{a,PHOF} + YMU_{a,PHOM}}{YMUN_a}\right)_T \qquad \theta_{a,POTF} = \left(\frac{YMU_{a,POTF} + YMU_{a,POTM}}{YMUN_a}\right)_T$$

$$\theta_{a,CAOF} = \left(\frac{YMU_{a,CAOF}}{YMUN_a}\right)_T \qquad \theta_{a,PLAP} = \left(\frac{YMU_{a,PLAP}}{YMUN_a}\right)_T$$

where:

$$YMUN_a = YMUN_{a,NITF} + YMU_{a,NITM}AVF_a$$

4.1.3. Activity Model

The activity model takes account of many interdependencies within the agricultural sector and links the supply component with the demand component by intersectoral transfer activities (sales and purchases). The main functions of the activity model are:

- The levels of the production activities are forecast and their medium-term response to their expected value addeds per unit of the production activities is modelled. Dynamic interdependencies between the animal production activities (in the beef and dairy sector) are taken into account by intertemporal balancing equations for live animal outputs and inputs (calves, heifers, bulls, cows).
- The nutrient requirements of the crop production activities are balanced with the nutrient supplies from manure and mineral fertilizers.
- Feed per unit of the animal production activities is determined on the basis of output dependent nutrient requirement functions and historical feed mixes.
- Physical output generation and output use as well as physical input use and input generation are balanced.
- A total area balance ensures that production does not exceed the land capacity.

Why use an NLP framework?

The activity model is solved in the framework of a non-linear programming (NLP) approach with linear and quadratic elements in the objective function and exclusive linear constraints (see figure 2). The emphasis lies on the usage of NLP structures as tools for solving systems of equations and for balancing the generation and use of products and inputs, and not on normative optimisation as in traditional programming approaches. Optimisation is only limited to a subset of the problems[6], and maximizes expected net revenue of the agricultural sector subject to the specified constraints. Preference is given to the empirical specification of the model by behavioural parameters (e.g. elasticities) and shift-factors, both integrated into the NLP by constraints.

The main arguments for the use of the NLP framework are: (1) Problems are represented by a transparent matrix structure consisting of variables (activities represented by matrix columns), equations or inequalities (constraints represented by matrix rows) and parameters (activity coefficients represented by matrix cells).[7](2) The NLP approach is a tool for solving problems and model components simultaneously. (3) Within the single model components, systems of equations can be more flexible and efficiently formulated within the NLP framework than with "sequential" techniques.[8].Before going into the details of the activity model, the reader should bear in mind that an "NLP activity" need not necessarily have a one-to-one correspondence to a "production activity" or a "use activity" of the ABTA/MAC. Similarly, an "NLP activity coefficient" need not necessarily have a one-to-one correspondence to an "element" of the ABTA/MAC. However, the NLP activities and activity coefficients are, of course, linked to the ABTA/MAC, because the latter serve as a datapool for the activity model and the results of the activity model are made available within the definitions of the ABTA/MAC (see ch. 6).

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6 E.g. minimization of the feeding costs.

7 This transparency is of great advantage for users, model analysts, programmers and operators and contributes to the realization of the block building approach and the linkage of the model components.

8 A "sequential" realization of programs which can reorganize systems of equations with respect to the question of which variables are viewed as exogenous and which are viewed as endogenous would lead to rather complex program structures. In the NLP framework, this is realized more easily simply by defining bounds on the exogenous variables and no bounds on the endogenous variables.

Figure 2 : Simplified representation of the NLP matrix within the activity model of the supply component

	Final crop production activities	Intermediate crop production activities	Final animal production activities	Intermediate animal production activities	Output-output-transfers	Fertilizing activities	Feeding activities	Intrasectoral transfers	Intersectoral transfers	Value addeds per unit of production activities	Area deficit	Dynamic interdepen-dence variables for animal sector		RHS
Behavioural equations for crop production	(-)									(+)			=	(-)
Behavioural equations for animal production			(-)							(+)			=	(-)
Nutrient requirement balances for crop production	(-)	(-)				(+)							≥	0
Diatetic constraints for animal production			(-)	(-)			(+)						≥ = ≤	0
Stock balances for live animals								(-)					=	(-)
Constraints on intrasectoral transfers	(+)	(+)	(+)	(+)	(+)			(-)					≤	0
Total area balance	(-)	(-)									(+)		≤	(-)
Dynamic interdependence balances in animal sector								(+)				(+),(-)	=	0
Output balances	(+)	(+)	(+)	(+)	(+)			(-)	(-)				≥	0
Input balances	(-)	(-)	(-)	(-)		(-)	(-)	(+)	(+)				≥	0
Objective function	(+),(-)	(+),(-)	(+),(-)	(+),(-)					(+),(-)		(-)			

4.1.3.1. Determination of the level of the final production activities

One purpose of the activity model is to forecast the level of the production activities and to simulate how the sectoral production programme is influenced in the medium-term perspective by changes in the profitability of the different production activities.

Modelling assumptions

Because of the long-term character of decisions about primary factor input, the autonomous land supply development, and the relatively stable institutional framework in which farmers operate, only limited possibilities to adjust agricultural production exist in the medium-term perspective: farmers can restructure their production programme and adjust the degree to which given production capacities are used within a relatively fixed factor endowment. These considerations lead to the idea that trend-based activity levels produce a plausible projection of the production programme for a medium-term perspective, provided that the profitabilities of the production activities develop according to past trends and no restrictive production-control regime is pursued by policy. The trend-based projection of the production activity levels serves as a reference situation from which possible adjustments are derived.

The response of the production activity levels to changing value addeds of the production activities is modelled by *behavioural equations*. Within these functions, own and cross value added elasticities give the percentage changes of the activity levels over the trend reference situation with respect to the percentage changes in the farmers' expected value addeds over the trend reference situation.

Alternative approaches

For the "normal" modelling case, the activity levels are endogenous and the expected value addeds per unit are predetermined in the expectation model of the supply component (see ch. 4.1.1.).

Alternatively, the model also offers the possibility to define the final production activities as exogenous variables and to determine their levels by *trend extrapolations* or *expert proposals*.

Why alternative approaches?

Agricultural policies have in the past exercised much control over prices. Policies now tend more and more to control production quantities, too. This is done by production-regime control variables, such as quotas and set-aside requirements. This development makes it more and more difficult to forecast and simulate agricultural production on the basis of empirical evidence about how farmers react to changing prices and profitabilities. The model therefore offers the possibility to set the production activity levels exogenously by *expert proposals* or *trend extrapolations*.

The following sections deal with these two alternatives: endogenous determination of production activity levels by behavioural equations, and exogenous production activities. The specification of the behavioural equations is described first. As the reader will notice later, expert proposals and trend extrapolations can be brought into the model within the system of behavioural equations.

4.1.3.1.1. Behavioural equations

Behavioural equations are specified for those 41 final production activities of the activity model which have a one-to-one correspondence to the 41 final production activities of the ABTA.[9]

9 The ABTA production activity "heifers" corresponds to two production activities of the activity module: "heifers for fattening" (final production) and "heifers for breeding" (intermediate production).

Structure

The effects of changes in the value addeds per unit of the production activities on the level of the production activities are incorporated via value added elasticities. The basic modelling assumptions described above can be translated into a mathematical expression in the following way:

$$LEVL_{a,S} = \left(1 + \sum_b \varpi_{b,a} \frac{\Delta GVA_{b,S}}{100}\right) LEVL_{a,T} \quad a,b = 1,\ldots,n$$

LEVL: Level of production activity, ABTA

ΔGVA: Deviation between the expected value added for S and T (in %)

ϖ: Production activity level elasticity with respect to expected value added

a,b: Subsc., ABTA, final production activities

S: Subsc., current simulation year

T: Subsc., trend-based

In order to express the above equation as a linear constraint of the NLP, it is rearranged. Eq. 4.1.3.1.1.-1 determines the levels of the final production activities depending on expected own and cross value addeds. The coefficients (ae) give the unit changes of the activity levels resulting from an increase of the expected value addeds by one unit. The right-hand side of the constraint is the constant term of the behavioural equation.

Thus eq. 4.1.3.1.1.-1. is a system of 41 behavioural equations with 41 unknown (endogenous) and 41 known (exogenous) variables. In the "normal" case the expected value addeds per unit of the production activities, which are predetermined in the expectation model (see ch. 4.1.1.), will be exogenous and the levels of the production activities will emerge as the 41 endogenous variables. But the system is also solvable if one assigns exogenous values to one or more production activity levels (for the special case of exogenous production activities, see ch. 4.1.3.1.2.).

To anyone familiar with traditional programming approaches it might seem somewhat peculiar to see value added (GV) defined as an "activity". However, readers should bear in mind what has been said about the rationale behind using the NLP framework: from this, GV appears as a variable of a system of behavioural equations. The behavioural equations operate as constraints of the NLP problem, and the optimisation algorithms present a solution which contains the values of the variables of the system of behavioural equations as a solution to this sub-problem.

Eq. 4.1.3.1.1.-1

Final crop production activities:

$$-CP_{i_1} + \sum_{k_1=GVSW}^{GVOT} ae_{k_1,i_1} GV_{k_1} + \sum_{k_2=GVDC}^{GVAN} ae_{k_2,i_1} GV_{k_2} = c_{i_1} \qquad i_1 = CPSW, CPDW, \ldots, CPOT$$

Final animal production activities:

$$-AP_{i_2} + \sum_{k_1=GVSW}^{GVOT} ae_{k_1,i_2} GV_{k_1} + \sum_{k_2=GVDC}^{GVAN} ae_{k_2,i_2} GV_{k_2} = c_{i_2} \qquad i_2 = APDC, APBU, \ldots, APAN$$

Planned final animal production activities, year t+1:

$$-A1_{i_2} + \sum_{k_1=GVSW}^{GVOT} ae_{k_1,i_2} GV_{k_1} + \sum_{k_2=GVDC}^{GVAN} ae_{k_2,i_2} GV_{k_2} = c_{i_2} \qquad i_2 = A1DC, A1BU$$

Planned final animal production activities, year t+2:

$$-A2_{i_2} + \sum_{k_1=GVSW}^{GVOT} ae_{k_1,i_2} GV_{k_1} + \sum_{k_2=GVDC}^{GVAN} ae_{k_2,i_2} GV_{k_2} = c_{i_2} \qquad i_2 = A2DC$$

CP: Crop production activity
AP: Animal production activity
A1: "Planned" animal production activity, year t+1
A2: "Planned" animal production activity, year t+2
GV: Expected value added per unit of a production activity
ae: Coefficients of the behavioural equations for final production activities
c: Constant terms of the behavioural equations for final production activities

Special consideration of dynamic interdependencies in the beef and dairy sector

In the animal production sector, especially in the beef and dairy sector, supply response is much restricted by population dynamics. Population growth is controlled by the farmers' choices about production of calves, raising of calves to heifers and bulls, fattening and slaughtering of calves and bulls, breeding of heifers to cows, and slaughtering of heifers and cows. In the short-run, the choices about the production activities "male adult cattle for fattening" and "dairy cows" are strongly constrained by previous decisions about the intermediate animal production activities "calves, rearing", "heifers for breeding" and "suckling calves" and the slaughterings of cows. Therefore, the level of "male adult cattle for fattening" and "dairy cows" for a current simulation year t are not determined by behavioural equations but by the interplay of the input balances for live animals (see ch. 4.1.3.5.2.11.) with the animal stock balances (see ch. 4.1.3.6.1.).

In order to determine the current year's levels of the intermediate production activities "calves, rearing", "heifers for breeding" and "suckling calves" and the slaughterings of cows, the model determines, during the model run for year t, already "planned" activity levels for "dairy cows" for t+1 and t+2 and "planned" activity levels for "male adult cattle for fattening" for t+1. In the case of these production activities the "planned" levels replace the current levels in the behavioural equations (see eq. 4.1.3.1.1.-1).

In this context, it must be stressed that the "planned" activity levels are adjusted during the model runs for the years t+1 and t+2 due to price and profitability changes. But the decisions taken in t about the "planned" levels of the production activities restrict the choices in t+1 and t+2. This reflects the multi-period production characteristic in the beef and dairy sector. The reader will gain a better insight into how the model deals with this characteristic after having studied the dynamic interdependence equations for the beef and dairy sector (see ch. 4.1.3.6.).

Specification

The response coefficients (ae) are calculated from the corresponding activity elasticities (ϖ). According to the modelling assumptions (see ch. 4.1.3.1.), ϖ is defined as the percentage change of the production activity level from its trend-based value in response to a one-percent-change of the value added from its trend-based value. Trend-based values are, therefore used to transform the elasticities into linear coefficients and the constant term is calculated as follows:

Eq. 4.1.3.1.1.-2

$$ae_{k,i} = \varpi_{b,a} \frac{LEVL_{a,T}}{GVA^{*}_{b,T}} \qquad c_i = -\left(LEVL_{a,T} - \sum_{b} ae_{k,i} GVA^{*}_{b,T} \right)$$

a,b: Subsc., ABTA, production activities (corresponding to NLP activities i and k)

Determination of the activity elasticities sets

The specification of the behavioural equations requires a matrix of activity elasticities.

Microeconomic theory has developed a consistent theoretical building on which empirical supply analyses are based. But sure knowledge about exact values of elasticities does not exist.

Short-term supply elasticities are relatively inelastic. Elasticities are more elastic in the medium-term, since more and more production factors turn from being fixed to being variable if the time horizon is broadened. This should be reflected when medium-term elasticities are specified.

Because of the heterogeneity of the results of empirical supply analyses, it seems advisable for applied policy analyses to bring together the results from different studies and expert judgement and to specify the elasticity matrices in a synthetic way after careful evaluation of the gathered material. This procedure is based on the idea that a summary evaluation of the available information will be more 'objective' than a single empirical study, which is very often based on specific views of the individual analysts and on specific questions.

A method has been developed which facilitates bringing together information from different sources, carrying out plausibility checks and calibrating this information in the light of considerations derived from microeconomics. This calibration approach allows us to define ranges for plausible values of elasticities, to impose constraints on the homogeneity and symmetry characteristics of the supply response, and to incorporate evidence and plausibility considerations regarding the total land response to a changing profitability of agricultural production. The calibration approach is technically effected within an NLP framework. It is described in more detail in Annex I.

Systems of behavioural equations

For each of the 41 final production activities, one corresponding behavioural equation is specified. The levels of each of these production activities depend principally on the value Adidas of all final production activities. Therefore, eq. 4.1.3.1.1.-1 constitute a system of 41 behavioural equations with 41 unknown and 41 known variables describing the response of the 41 activities to the expected value Adidas of the 41 activities.

4.1.3.1.2. Exogenous vs. endogenous production activities

In the "normal" case of endogenous activity levels, the expected value Adidas are predetermined in the expectation model of the supply component (see ch. 4.1.1.). The predetermined values are set as bounds on the NLP activity "expected value added" (GV).

For some production activities, it can be appropriate to determine their levels exogenously. Exogenous activity levels can be specified from expert proposals, trend extrapolations or from the base year of projection, according to a user-defined priority sequence for these sources. If a production activity level is defined as exogenous, a bound is set on the respective NLP activity:

Eq. 4.1.3.1.2.-1

$$CP_{i_1} = LEVL_{a,E \wedge T \wedge B} \qquad AP_{i2} = LEVL_{a,E \wedge T \wedge B} \qquad A1_{i_2} = A2_{i_2} = LEVL_{a,E \wedge T \wedge B}$$

E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc., base year of projection

In order to operate with exogenous activity levels, the structure of the system of behavioural equations need not be changed. To understand this, remember that the behavioural equations create a system of 41 equations with 41 unknown (endogenous) and 41 known (exogenous) variables. However, which of the variables are defined as endogenous and which as exogenous is not predetermined by the model structure. The user of MFSS has to decide on this when the scenario is specified. For the "normal" case, the expected value Adidas per unit of the production activities, which are predetermined in the expectation model (see chapter 4.1.1.), will be the exogenous variables of the activity model, and the production activities will emerge as the 41 endogenous variables. But the system is also solvable if one assigns exogenous values to one or more production activity levels and lets the corresponding expected value Adidas take any values which solve the system.

This approach can have an economic interpretation. Let us assume, that the level of a production activity is predetermined by a restrictive production control system imposed by policy. In this case, one would have to attribute a certain value to the activity level and let the corresponding expected value added take any value which solves the system. The corresponding expected value added would emerge as an endogenous variable, the value of which could be interpreted as the shadow profitability of that production activity. Changing exogenously the level of a production activity means that the shadow profitability of the activity adopts new values, and this also leads - via the cross value added elasticities - to changes in the levels of the other production activities.

4.1.3.1.3. Special case: heifers for fattening

For the final animal production activity "heifers for fattening", the activity model possesses no behavioural equation, since this activity is not defined in the ABTA. Thus, its value added, which is needed for the specification of a behavioural equation, is not known.

Because "heifers for fattening" is of minor importance for the total agricultural sector, it is simply assumed that its level is constant during the projection period and that it takes the value of the base year of projection:

Eq. 4.1.3.1.3.-1

$$AP_{APHF} = A1_{A1HF} = LEVL_{HEIF,B}\left(1 - XMG_{HEIF,DCOW,B} - XMG_{HEIF,SCOW,B}\right)$$

XMG: Output Generation, MAC, physical component
APHF: Subsc., NLP activity, animal production activity: heifers for fattening
A1HF: Subsc., NLP activity, animal production activity: heifers for fattening, year t+1
HEIF: Subsc., ABTA, animal production activity: heifers
DCOW,SCOW: Subsc., ABTA, intermediate animal products: dairy cows and suckler cows

4.1.3.2. Determination of the level of the intermediate production activities

Intermediate production activities are activities which produce intermediate products as their main products (see Annex IV). The activity model has three intermediate crop production activities ("other root crops", "grass/grazing" and "fodder plants on arable land") and four intermediate animal production activities ("suckling calves", "calves, rearing", "heifers for breeding" and "pig breeding"). The intermediate products are transferred by intrasectoral transfer activities into fodder or live animal input items.

4.1.3.2.1. Intermediate animal production activities

The intermediate animal production activities are mainly determined by the interplay between the behavioural equations for the animal production activities and the stock, input and output balances for live animals (see ch. 4.1.3.6., 4.1.3.5.2.11. and 4.1.3.5.1.4.).

The "planned" levels of "suckling calves" for t+1 and t+2 are derived from expert proposals, trend extrapolations or from the base year of projection:

Eq. 4.1.3.2.1.-1

$$A1_{A1SC} = A2_{A2SC} = LEVL_{CALV,E\wedge T\wedge B}$$

A1: "Planned" animal production activity, year t+1
A2: "Planned" animal production activity, year t+2
LEVL: Level of production activity, ABTA
A1SC,A2SC: Subsc., NLP act., animal production activity: suckling calves, year t+1 and t+2
CALV: Subsc., ABTA, animal production activity: suckling calves
E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc., base year of projection

4.1.3.2.2. Intermediate crop production activities

MFSS offers the possibility to define the 3 intermediate crop production activities as exogenous variables and determine their levels by expert proposals, trend extrapolations or from the base year of projection:

Eq. 4.1.3.2.2.-1

$$CP_j = LEVL_{a,E\wedge T\wedge B}$$

CP: Crop production activity
a: Subsc., ABTA, crop production activity (corresponding to NLP activity j)

If the intermediate crop production activities are not defined as exogenous they are endogenously determined by the interplay between the constraints on animal production activities (see ch. 4.1.3.1. and 4.1.3.2.1.), the feed module (see 4.1.3.4.), the balances for fodder input items (see ch. 4.1.3.5.2.8. and 4.1.3.5.2.9.) and the output balances for intermediate crop products (see ch. 4.1.3.5.1.2.) within a certain flexibility range around trend-based values.

4.1.3.3. The fertilizer module

The purpose of the fertilizer module is to balance the nutrient requirements of the crop production activities as determined in the yield model (see ch. 4.1.2.) with the supply of nutrients from manure and mineral fertilizers, and in this way to determine the manure and mineral fertilizer input coefficients of the production activities. This balancing affects the relative profitability of the different crop production activities.

Modelling assumptions and design

Balancing the nitrogen, potassium and phosphate requirements for each single crop production activity (activity-specific) with the supply of manure and mineral fertilizers would lead to an over-complex structure of the fertilizer module, which would not be justified by an appropriate gain. A design which is both sufficiently being realistic and operational is described in the following paragraphs.

For each of the crop production activities, one corresponding *mineral fertilizing activity* and one corresponding *organic fertilizing activity* is defined. The fertilizing activities deliver to the crop production activities the fertilizer nutrients which they take from the input balances for fertilizer (see ch. 4.1.3.5.2.1.). The fertilizing activities contain the different nutrients (nitrogen, potassium and phosphate) in fixed proportions for a given simulation year. This simplification is supported by the fact that the nutrients are not supplied independently of each other (manure and compound fertilizers) and that it leaves the model operational.

The nutrient requirements are balanced with the supply of the nutrients from the fertilizing activities. Two types of *balancing* are possible: (1) specific balancing for each of the single crop production activities, (2) balancing only at the sectoral level.

In MFSS specific balancing is carried out only for nitrogen because it is from an economic, technological and environmental viewpoint, the most crucial nutrient. It has relatively high cost shares and is less persistent in the soil than the other fertilizer nutrients.

Phosphate and potassium are balanced at the sectoral level only. This is a simplification leading to the result that the model can compensate too little phosphate and potassium in one activity by excess-fertilizing in another activity. But the problem is not too serious because it is, to a certain extent, possible to accumulate "stocks" of potassium and phosphate in the soil which can be used-up in following years.

Ratios between mineral and total nitrogen requirements of the crop production activities ensure a minimum share of mineral nitrogen in total nitrogen requirements.

The design described above is effected within the NLP framework of the activity model. The nutrient requirement balances and the ratios between mineral and organic fertilizing activities are incorporated as constraints. Subject to these constraints and subject to the behavioural and technological constraints specified in the other modules of the activity model, the maximization of expected net revenue (see ch. 4.1.3.11.) implies the minimisation of the fertilizer costs.

The following chapters describe in detail the constraints of the fertilizer module.

4.1.3.3.1. Activity-specific nitrogen balances

Balances, which are specific for each of the single crop production activities, are established only for nitrogen.

Structure

The balances are formulated as minimum requirement balances, such that the nitrogen requirements of the crop production activities are satisfied:

Eq. 4.1.3.3.1.-1

$$nr_{j_1,i}\,CP_{j_1} + nr_{j_2,i}\,MI_{j_2} + nr_{j_3,i}\,OR_{j_3} \geq 0 \qquad j_1 = j_2 = j_3 = i$$

CP: Crop production activity
MI: Mineral fertilizing activity: specific to crop production activity
OR: Organic fertilizing activity: specific to crop production activity
nr: Coefficients of the activity-specific nitrogen requirement balances

Specification

The nitrogen requirements per unit of a production activity are predetermined by the yield model (see ch. 4.1.2.).

The mineral and organic fertilizing activities are defined on the basis of one unit of pure nitrogen. Therefore, the coefficients of these activities are unity. Since nitrogen from manure is less absorbed than nitrogen from mineral fertilizer, a special availability factor for nitrogen from manure (AVF) is used.[10]

Eq. 4.1.3.3.1.-2

$$nr_{j_1,i} = -YMUN_{a,S} \qquad nr_{j_2,i} = 1 \qquad nr_{j_3,i} = AVF_a$$

YMUN: Pure nitrogen requirement per unit of a production activity
AVF: Availability factor for nitrogen from manure (in %/100)
a: Subsc., ABTA, crop production activity (corresponding to NLP production activity j_1)
S: Subsc., current simulation year

4.1.3.3.2. Sectoral phosphate and potassium balances

At the sectoral level, two nutrient balances are needed: for phosphate and potassium.

[10] This factor is based upon rough estimates taken from planning data (see Wolf, 1995).

Structure

The balances are formulated as inequalities. The nutrient requirements of the crop production activities are satisfied in total by the activity-specific fertilizing activities and - in the case of phosphate and potassium - by non-specific fertilizing activities. The non-specific fertilizing activities cover that part of the phosphate and potassium requirements which is not satisfied by activity-specific fertilizer application. The non-specific fertilizing activities may be interpreted as phosphate and potassium input which is necessary to maintain a longer term sectoral nutrient balance.

Eq. 4.1.3.3.2.-1 presents the structure of the sectoral nutrient balances for phosphate and potassium:

Eq. 4.1.3.3.2.-1

$$\sum_{j_1} to_{j_1,i}\, CP_{j_1} + \sum_{j_2} to_{j_2,i}\, MI_{j_2} + \sum_{j_3} to_{j_3,i}\, OR_{j_3} + DF_i \geq 0$$

DF: Mineral fertilizing activity: non-specific to crop production activity
to: Coefficients of the sectoral fertilizer nutrient balances

Specification

The nutrient requirements per unit of a production activity are predetermined by the yield model (see ch. 4.1.2.).

The specification of the coefficients of the mineral and organic fertilizing activities is based on the assumption that the activity-specific nutrient-mix is not subject to major variations in the short and medium term. Therefore the coefficients of the mineral fertilizing activities are calculated as the ratios of the input of mineral phosphate and mineral potassium to the input of mineral nitrogen for a specific crop production activity in the base year of projection. The coefficients of the organic fertilizing activities are determined analogously.

Eq. 4.1.3.3.2.-2

$$to_{j_1,TOTP} = -YMUP_a \qquad to_{j_1,TOTK} = -YMUK_a$$

$$to_{j_2,TOTP} = \left(\frac{YMU_{a,PHOF}}{YMU_{a,NITF}}\right)_B \qquad to_{j_2,TOTK} = \left(\frac{YMU_{a,POTF}}{YMU_{a,NITF}}\right)_B$$

$$to_{j_3,TOTP} = \left(\frac{YMU_{a,PHOM}}{YMU_{a,NITM}}\right)_B \qquad to_{j_3,TOTK} = \left(\frac{YMU_{a,POTM}}{YMU_{a,NITM}}\right)_B$$

YMUP: Pure phosphate requirement per unit of a production activity
YMUK: Pure potassium requirement per unit of a production activity
YMU: Input Use, MAC, physical component
TOTP,TOTK: Subsc., NLP constraints, sectoral fertilizer requirement balances
a: Subsc., ABTA, crop production activity (corresponding to NLP activities j_1, j_2, j_3,)
NITF,NITM,PHOF,...: Subsc., ABTA, input items
B: Subsc., base year of projection

4.1.3.3.3. Activity-specific minimum ratios between mineral and total nitrogen requirements

35 minimum mineral nitrogen requirement balances are specified for the 35 crop production activities.

Structure

Eq. 4.1.3.3.3.-1

$$or_{j,i}\, CP_{j_1} + MI_{j_2} \geq 0 \qquad j_1 = j_2 = i$$

or: Coefficients of the activity-specific mineral nitrogen requirement balances

Specification

The minimum share of mineral nitrogen in total nitrogen requirements is set at a certain percentage of the share in the base year of projection.

Eq. 4.1.3.3.3.-2

$$or_{j,i} = -\left(\frac{YMU_{a,NITF}}{YMU_{a,NITF} + YMU_{a,NITM} AVF}\right)_B YMUN_a \phi$$

ϕ: percentage factor (%/100)

4.1.3.4. The feed module

In the ABTA, seven feedingstuff input items are distinguished: fodder cereals, rich protein fodder, rich energy, milk and milk products fodder, dried fodder, fresh and ensilaged fodder and other fodder. The feed module determines the quantities of the feedingstuff input items used in the different animal production activities (the feed input coefficients) and models the response of the feed composition to changing price ratios. It balances the dietetic requirements of the animal production activities with the feedingstuff supply.

Modelling assumptions and design

The feed module is based on engineering information about the nutrient requirements of the animal production activities, on the nutrient contents of the feedingstuffs and on historical data about the composition of the feed mixes. All this information is integrated into the NLP approach of the activity model.

For each of the 14 animal production activities, 9 different *feeding activities* are defined. Within these 9 feeding activities, each one refers to feeding with rich protein fodder, rich energy fodder, raw milk fodder, milk products fodder, dried fodder, fresh and ensilaged fodder, and other fodder. For cereals, two feeding activities are defined in order to allow substitutions between the different cereal subpositions (soft wheat, durum wheat, rye, barley, oats, grain maize, other cereals, rice). The feeding activities are linked to the different feedingstuffs through input balances (see ch. 4.1.3.5.) and deliver the nutrient contents of the feedingstuffs to the animal production activities.

Nutrient requirement functions depict the energy, protein and dry matter needs per unit of each of the animal production activities. They determine the basic requirements for survival and the requirements for production (e.g. growth and milk secretion) and replacement. The functions are derived from literature on animal nutrition. The energy and protein requirements are the most important dietetic constraints which farmers and the feed industry face when they decide about the composition of the feed mixes. They are therefore explicitly considered in MFSS. The results of the dry matter requirement functions are rough estimates about the total feed requirements. Since they do not take into account the digestibility and nutrient composition of the feed mix (e.g crude fibre, crude protein, crude fat, starch, sugar, essential amino acids, vitamins, minerals), the true feed requirements of the animals will be in a certain range around the requirements specified by the functions.

The energy and protein requirements of the animal production activities are balanced with the nutrient supply of the feeding activities by minimum *requirement balances*. For dry matter *minimum and maximum requirement balances* are established.

The energy, protein and dry matter requirements are not a sufficient description of the feed technology of the agricultural sector on which forecasts about the feed mix and simulations of the feed demand response could be based. Other important factors, for example the minimum roughage needs of ruminants, the digestibility of the dry matter, and the needs for essential fat and amino acids, vitamins and minerals, are not covered explicitly. Additional *minimum and maximum shares* of the single feedingstuffs are therefore defined in order to arrive at plausible forecasts and simulation results.

The design of the feed module is effected within the NLP framework of the activity model. The nutrient requirement balances and the maximum and minimum shares are constraints of the NLP. Subject to these constraints and to the behavioural and technological constraints of the other modules of the activity model, the maximization of expected net revenue (see ch. 4.1.3.11.) implies the minimisation of the feed costs.

In the following sections, the structure and specification of the different constraints imposed by the feed module are described in more detail.

4.1.3.4.1. Nutrient requirement balances

4.1.3.4.1.1. Energy

MFSS contains for each of the 14 animal production activities of the activity model one corresponding minimum energy requirement balance.

Structure

Eq. 4.1.3.4.1.1.-1

$$en_{j,i}\,AP_j + en_{k_1,i}\,C1_{k_1} + en_{k_2,i}\,C2_{k_2} + en_{k_3,i}\,PR_{k_3} + en_{k_4,i}\,EN_{k_4} +$$
$$en_{k_5,i}\,RM_{k_5} + en_{k_6,i}\,MP_{k_6} + en_{k_7,i}\,DR_{k_7} + en_{k_8,i}\,FS_{k_8} + en_{k_9,i}\,OT_{k_9} \geq 0 \quad j = k_m = i$$

AP: Animal production activity
C1: Feeding with cereal-mix 1
C2: Feeding with cereal-mix 2
PR: Feeding with rich protein fodder
EN: Feeding with rich energy fodder
RM: Feeding with raw milk
MP: Feeding with milk products
DR: Feeding with dried fodder
FS: Feeding with fresh and ensilaged fodder
OT: Feeding with other fodder
en: Coefficients of the minimum energy requirement balances

Specification

The energy requirements are expressed in terms of metabolizable energy or in terms of net energy lactation[11]. The minimum requirement coefficients are the sum of the basic requirements for survival and the requirements for production (see eq. 4.1.3.4.1.1.-2). The basic requirements of the animals depend mainly on the actual liveweight. The requirements for production depend on the output quantity and its composition (weight increase, milk secretion, egg production, replacement). The connection between the output coefficients of the animal production activities and the energy requirements are depicted by energy requirement functions which are based on engineering information available in specialised literature on animal nutrition. MFSS uses the same requirement functions as are used by SPEL/EU-BM (for details see Wolf, 1995).

Eq. 4.1.3.4.1.1.-2

$$en_{j,i} = -REQ_{a,r} = \mathrm{f}(LW) + \mathrm{f}(\mathbf{XMG}_a)$$

REQ: Requirements per head
LW: Liveweight
XMG: Output Generation (vector of output coefficients), MAC, physical component
a: Subsc., ABTA, animal production activity (corresponding to NLP activity j)
r: Subsc., ABTA, net energy lactation or metabolizable energy

The energy contents of the activities "feeding with rich protein fodder", "feeding with rich energy fodder", "feeding with raw milk fodder", "feeding with milk products fodder", "feeding with dried

[11] The concepts of metabolizable energy and net energy are widely used in scientific and practical animal nutrition and are explained in modern literature on animal nutrition (e.g. in M. Kirchgessner, 1987).

fodder", "feeding with fresh and ensilaged fodder", and "feeding with other fodder" are identical to the nutrient contents of the corresponding ABTA feed aggregates:

Eq. 4.1.3.4.1.1.-3

$$en_{k_m,i} = C_{r,q} \qquad m = 3,4,\dots,9$$

C: Energy content of a fodder input item, ABTA
q: Subsc., ABTA, fodder input item (corresponding to NLP activity k_m)

The two cereal feeding activities differ in their composition of soft wheat, durum wheat, barley, rye, oats, grain maize, other cereals and rice. The energy contents of the cereal feeding activities are aggregated from the energy contents of the cereal subpositions (see eq. 4.1.3.4.1.1-4). The energy contents of the subposition are the same as used by SPEL/EU-BM (see Wolf, 1995). The shares of the cereal subpositions within the two cereal feeding activities (r) are generated by specific percentage margins around the shares of the base year of projection. The shares sum up to 1 for each of the two mixes.

Eq. 4.1.3.4.1.1.-4

$$en_{k_m,i} = \sum_b r_{k_m,b} C_{r,b} \qquad m = 1,2$$

$$r_{k_1,b} = \frac{\left(\frac{XU_{FEEP,b} + DU_{PFEE,b}}{YG_{FEEP,FCER} + DU_{PFEE,FCER}}\right)_B (1 + v_b)}{\sum_b \left(\left(\frac{XU_{FEEP,b} + DU_{PFEE,b}}{YG_{FEEP,FCER} + DU_{PFEE,FCER}}\right)_B (1 + v_b)\right)}$$

$$r_{k_2,b} = \frac{\left(\frac{XU_{FEEP,b} + DU_{PFEE,b}}{YG_{FEEP,FCER} + DU_{PFEE,FCER}}\right)_B (1 - v_b)}{\sum_b \left(\left(\frac{XU_{FEEP,b} + DU_{PFEE,b}}{YG_{FEEP,FCER} + DU_{PFEE,FCER}}\right)_B (1 - v_b)\right)}$$

C: Energy content of a cereal subposition
r: Share of a cereal subposition in the cereal feeding activity
XU: Output Use, ABTA, physical component
YG: Input Generation, ABTA, physical component
DU: Uses, Additional Demand Component
v: Percentage margin for the shares of the cereal subpositions in the cereal feeding act. (%/100)
b: Subsc., ABTA, product item (cereal subposition)
FEEP: Subsc., ABTA, intrasectoral use activity, animal feed on farm
PFEE: Subsc., Additional Demand Component, animal feed on market
FCER: Subsc., ABTA/Additional Demand Component, input item, fodder: cereals
B: Subsc., base year of projection

4.1.3.4.1.2. Crude protein

MFSS contains for each of the 14 animal production activities of the activity model one corresponding minimum crude protein requirement balance.

Structure

Eq. 4.1.3.4.1.2.-1

$$cp_{j,i} AP_j + cp_{k_1,i} C1_{k_1} + cp_{k_2,i} C2_{k_2} + cp_{k_3,i} PR_{k_3} + cp_{k_4,i} EN_{k_4} +$$
$$cp_{k_5,i} RM_{k_5} + cp_{k_6,i} MP_{k_6} + cp_{k_7,i} DR_{k_7} + cp_{k_8,i} FS_{k_8} + cp_{k_9,i} OT_{k_9} \geq 0 \quad j = k_m = i$$

cp: Coefficients of the crude protein requirement balances

Specification

The crude protein requirement coefficients are the sum of the basic requirements for survival and the requirements for production and are determined analogously to the energy requirement coefficients (see ch. 4.1.3.4.1.1):

Eq. 4.1.3.4.1.2.-2

$$cp_{j,i} = -REQ_{a,CRPR} = \mathrm{f}(LW) + \mathrm{f}(\mathbf{XMG}_a)$$

CRPR: Subsc., ABTA, crude protein

The crude protein contents of the activities "feeding with rich protein fodder", "feeding with rich energy fodder", "feeding with raw milk fodder", "feeding with milk products fodder", "feeding with dried fodder", "feeding with fresh and ensilaged fodder", and "feeding with other fodder" are identical to the crude protein contents of the corresponding ABTA fodder input items:

Eq. 4.1.3.4.1.2-3

$$cp_{k_m,i} = C_{CRPR,q} \quad m = 3,4,\ldots,9$$

C: Crude protein contents of the fodder input items, ABTA

The crude protein content coefficients of the cereal subposition are determined analogously to the energy content coefficients (see ch. 4.1.3.4.1.1.):

Eq. 4.1.3.4.1.2.-4

$$cp_{k_m,i} = \sum_b r_{k_m,b} C_{CRPR,b} \quad m = 1,2$$

C: Crude protein content of a cereal subposition

4.1.3.4.1.3. Minimum and maximum dry matter requirements

MFSS contains for each of the 14 animal production activities of the activity model one corresponding minimum dry matter requirement balance and one corresponding maximum balance. In order to ensure that the maximum dry matter constraints do not cause infeasibilities, the inequalities for the maximum dry matter intake contain a surplus variable (EXDX). In the objective function, EXDX is given a high negative value such that the maximum dry matter intake can only be exceeded under high cost; i.e. only in cases which would result in an otherwise infeasible solution.

Structure

Eq. 4.1.3.4.1.3-1

$$dm_{j,i}\,AP_j + dm_{k_1,i}\,C1_{k_1} + dm_{k_2,i}\,C2_{k_2} + dm_{k_3,i}\,PR_{k_3} + dm_{k_4,i}\,EN_{k_4} + dm_{k_5,i}\,RM_{k_5} + dm_{k_6,i}\,MP_{k_6} + dm_{k_7,i}\,DR_{k_7} + dm_{k_8,i}\,FS_{k_8} + dm_{k_9,i}\,OT_{k_9} \geq 0 \qquad j = k_m = i$$

$$dx_{j,i}\,AP_j + dm_{k_1,i}\,C1_{k_1} + dm_{k_2,i}\,C2_{k_2} + dm_{k_3,i}\,PR_{k_3} + dm_{k_4,i}\,EN_{k_4} + dm_{k_5,i}\,RM_{k_5} + dm_{k_6,i}\,MP_{k_6} + dm_{k_7,i}\,DR_{k_7} + dm_{k_8,i}\,FS_{k_8} + dm_{k_9,i}\,OT_{k_9} - EXDX \leq 0 \qquad i = j = k_m = i$$

EXDX: Exceeding maximum dry matter intake
dm: Coefficients of the minimum and maximum dry matter requirement balances
dx: Coefficients of the maximum dry matter requirement balances

Specification

Dry matter requirement functions determine the basic requirements for survival and the requirements for production (see eq. 4.1.3.4.1.3.-2). MFSS uses the same requirement functions as are used by SPEL/EU-BM, which are described in detail in Vol. 1 of the methodological documentation (Wolf, 1995).

The dry matter requirements do not take into account the digestibility of the dry matter and the nutrient contents of the feed mix. The true feed intake of the animals will therefore be in a certain range around the requirements specified by the functions. Plausible ranges are represented by specific factors which are also used by SPEL/EU-BM in order to create the ex-post representation of the feed input coefficients (see Wolf, 1995).

Eq. 4.1.3.4.1.3-2

$$dm_{j,i} = -REQ_{a,DRMA}\,z_{a,\min} \text{ and } dx_{j,i} = -REQ_{a,DRMA}\,z_{a,\max}$$

where

$$REQ_{a,DRMA} = \mathrm{f}(LW) + \mathrm{f}(XMG_a)$$

z: Specific factor
a: Subsc., ABTA, production activity (corresponding to NLP production activity j)
DRMA: Subsc., ABTA, dry matter

The dry matter contents of the feeding activities for rich protein fodder, rich energy fodder, raw milk fodder, milk products fodder, dried fodder, fresh and ensilaged fodder, and other fodder are identical to the dry matter contents of the ABTA feed aggregates, which are calculated for the ex-post period by SPEL/EU-BM (see Wolf, 1995):

Eq. 4.1.3.4.1.3.-3

$$dm_{k_m,i} = C_{DRMA,q} \qquad m = 3,4,\ldots,9$$

C: Dry matter contents of the fodder input items, ABTA

The dry matter content coefficients of the cereal subpositions are determined analogously to the energy content coefficients (see ch. 4.1.3.4.1.1.):

Eq. 4.1.3.4.1.3.-4

$$dm_{k_m,i} = \sum_b r_{k_m,b} C_{DRMA,b} \qquad m = 1,2$$

C: Dry matter content of a cereal subposition

4.1.3.4.2. Minimum and maximum feedingstuff shares

Minimum and maximum input share constraints of the seven ABTA feedingstuff input items (in dry matter) are specified for each of the 14 animal production activities in order to determine a plausible range for the feedingstuff input coefficients. In order to ensure that the maximum share constraints do not cause infeasibilities, the inequalities for the maximum cereal intake contain a variable which makes it possible for the maximum cereal to be exceeded (CXDX). In the objective function, CXDX is given a high negative value such that the maximum cereal intake is only exceeded in cases which would otherwise result in an infeasible solution.

Structure

The minimum and maximum input shares are effected as minimum and maximum constraints for the various feeding activities in terms of dry matter content. Eq. 4.1.3.4.1.3.-4 presents the structure of these constraints.

Eq. 4.1.3.4.1.3.-4

$$xc_{j,i}\,AP_j + dm_{k_1,i}\,C1_{k_1} + dm_{k_2,i}\,C2_{k_2} \geq 0$$
$$xp_{j,i}\,AP_j + dm_{k_3,i}\,PR_{k_3} \geq 0$$
$$xe_{j,i}\,AP_j + dm_{k_4,i}\,EN_{k_4} \geq 0$$
$$xm_{j,i}\,AP_j + dm_{k_5,i}\,RM_{k_5} + dm_{k_6,i}\,MP_{k_6} \geq 0$$
$$xd_{j,i}\,AP_j + dm_{k_7,i}\,DR_{k_7} \geq 0$$
$$xf_{j,i}\,AP_j + dm_{k_8,i}\,FS_{k_8} \geq 0$$
$$xo_{j,i}\,AP_j + dm_{k_9,i}\,OT_{k_9} \geq 0$$
$$j=i=k_m$$

$$nc_{j,i}\,AP_j + dm_{k_1,i}\,C1_{k_1} + dm_{k_2,i}\,C2_{k_2} - CXDX \leq 0$$
$$np_{j,i}\,AP_j + dm_{k_3,i}\,PR_{k_3} \leq 0$$
$$ne_{j,i}\,AP_j + dm_{k_4,i}\,EN_{k_4} \leq 0$$
$$nm_{j,i}\,AP_j + dm_{k_5,i}\,RM_{k_5} + dm_{k_6,i}\,MP_{k_6} \leq 0$$
$$nd_{j,i}\,AP_j + dm_{k_7,i}\,DR_{k_7} \leq 0$$
$$nf_{j,i}\,AP_j + dm_{k_8,i}\,FS_{k_8} \leq 0$$
$$no_{j,i}\,AP_j + dm_{k_9,i}\,OT_{k_9} \leq 0$$
$$j=i=k_m$$

xc,nc: Coefficients of the minimum and maximum cereal share constraint
xp,np: Coefficients of the minimum and maximum rich protein share constraint
xe,ne: Coefficients of the minimum and maximum rich energy share constraint
xm,nm: Coefficients of the minimum and maximum milk and milk products share constraint
xd,nd: Coefficients of the minimum and maximum dried fodder share constraint
xf,nf: Coefficients of the minimum and maximum fresh and ensilaged fodder share constraint
xo,no: Coefficients of the minimum and maximum other fodder share constraint
dm: Coefficients of the min. and max. dry matter requirement balances (see eq. 4.1.3.4.1.3.-3/4)

Specification

The minimum and maximum shares are specified from the base year's input values of the feedingstuff items measured in dry matter. The base year's values are multiplied by factors representing the change of total dry matter input against the base year and the flexibility range for the substitution between the single feedingstuff items:

Eq. 4.1.3.4.2.1.-2

$$xc_{j,i} = YMU_{a,FCER,B} C_{DRMA,FCER,B} \frac{REQ_{a,DRMA,S}}{REQ_{a,DRMA,B}} \left(1 - flex_{a,FCER}\right)$$

for $xe_{j,i}$, $xp_{j,i}, xe_{j,i}, xm_{j,i}, xd_{j,i}, xo_{j,i}$ analogous.

$$nc_{j,i} = YMU_{a,FCER,B} C_{DRMA,FCER,B} \frac{REQ_{a,DRMA,S}}{REQ_{a,DRMA,B}} \left(1 + flex_{a,FCER}\right),$$

for $ne_{j,i}$, $np_{j,i}, ne_{j,i}, nm_{j,i}, nd_{j,i}, no_{j,i}$ analogous.

flex: Flexibility range for substitutions between fodder input items

4.1.3.5. Farm balances for outputs and inputs

Physical output generation is balanced with physical output use, and physical input use with physical input generation. The identity between physical output (input) generation and output (input) use is a precondition for consistent monetary flows according to the SPEL accounting concept.

The balancing module is also important for depicting intra- and intersectoral interdependencies:

- It contains the link-up of the supply component to the demand component in the form of intersectoral sales of products and purchases of inputs.
- It establishes interdependencies between final and intermediate production by intrasectoral transfer activities (e.g. animal feed on farm) which link output balances (e.g. for silage) with input balances (e.g. for fresh and ensilaged fodder).

The concept of the balances is effected within the NLP framework of the activity model.

The next two chapters describe first the output balances and then the input balances.

4.1.3.5.1. Output balances

4.1.3.5.1.1. Final crop products

<u>Structure</u>

The balances are formulated as minimum constraints, such that gross production of final crop products covers the intra- and the intersectoral use of these products. Intrasectoral use comprises the following positions: losses on farm, human consumption on farm (only for the 7 cereal items, potatoes, cauliflower, tomatoes, other vegetables, apples, other fruits and table grapes), animal feed on farm (only for the 7 cereal items, pulses, potatoes, sugarbeets, cauliflower, tomatoes and other vegetables), seed use on farm (only for the 7 cereal items and potatoes) and stock changes on farm (only for the 7 cereal items and potatoes). That part of production which is not used within the agricultural sector is sold to the other sectors of the economy (intersectoral transfers)[12].

[12] The sales of the agricultural sector comprise also fodder and seeds used by the agricultural sector ("animal feed on market", "seed use on market"). The difference between intra- and intersectoral feed (seed) use is that the former contains all quantities which are used directly within the "national" farm whereas the latter contains all quantities which are first sold by the farm sector to the other sectors of the economy, then traded or processed within the other sectors and finally purchased and used by the farm sector.

The maximization of expected net revenue which values the sales of the agricultural sector with expected farmgate prices (see ch. 4.1.3.11.) ensures the identity between production and use of final crop products.

Eq. 4.1.3.5.1.1.-1

$$\sum_j fo_{j,i} CP_j - LF_i - FF_i - SF_i - CF_i - HF_i - SA_i \geq 0$$

CP: Crop production activity
LF: Intrasectoral transfer - losses on farm
FF: Intrasectoral transfer - animal feed on farm
SF: Intrasectoral transfer - seed on farm
CF: Intrasectoral transfer - stock changes on farm
HF: Intrasectoral transfer - human consumption on farm
SA: Intersectoral transfer - sales
fo: Coefficients of the output balances for crop products

Specification

The coefficients of the crop production activities are predetermined by the yield model (see ch. 4.1.2.):

Eq. 4.1.3.5.1.1.-2

$$fo_{j,i} = XMG_{a,b,S}$$

XMG: Output Generation, MAC, physical component
a: Subsc., ABTA, crop production activity (corresponding to NLP activity j)
b: Subsc., ABTA, final crop product (corresponding to NLP constraint i)
S: Subsc., current simulation year

4.1.3.5.1.2. Intermediate crop products

Structure

The intermediate crop products are used for feeding only. Production of these crop products covers the intrasectoral use of these products.

Eq. 4.1.3.5.1.2.-1

$$\sum_j fo_{j,i} CP_j - FF_i \geq 0$$

Specification

The coefficients of the crop production activities are determined analogous to eq. 4.1.3.5.1.1.-2.

4.1.3.5.1.3. Final animal products

Structure

The balances are formulated as minimum constraints such that gross production of final animal products covers the intra- and the intersectoral use of these products.

The resources for production are the animal production activities and the slaughtering activities for dairy cows and suckler cows. The slaughtering activities link the output balances for dairy and suckler cows (see eq. 4.1.3.5.1.4.-1) with those for beef. The slaughtering activities are necessary in the concept of the activity model in order to model the population dynamics in the beef and dairy sector: it would be too restrictive to depict the cows' meat production and the transition of cows into the next year just by predetermined meat and live animal output coefficients of the activities "dairy cows" and "suckling calves".

The slaughterings of all other animals (bulls, heifers, pigs, lambs, ewes and goats, poultry and laying hens) are not depicted by special slaughtering activities but by meat output coefficients of the animal production activities.

The intrasectoral use of the final animal products comprises the following positions: losses on farm, human consumption on farm (only for milk of cows, beef, veal, pork, milk of ewes and goats, sheep and goat meat, eggs and poultry meat) and animal feed on farm (only for milk of cows and milk of ewes and goats). That part of production which is not used within the agricultural sector is sold to the other sectors of the economy (intersectoral transfers).

The maximization of the objective function, which values the sales of the agricultural sector with expected farmgate prices (see ch. 4.1.3.11.), ensures the identity between gross production and use of final animal products.

Eq. 4.1.3.5.1.3.-1

$$\sum_{j} fo_{j,i}\,AP_j - LF_i - FF_i + \sum_{q=SLDC}^{SLSC} fo_{q,i}\,SL_q - HF_i - SA_i \geq 0$$

AP: Animal production activity
SL: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows
fo: Coefficients of the output balances for final animal products

Specification

Most of the output coefficients of the animal production activities are predetermined by the yield model (see ch. 4.1.2.) and correspond directly to a MAC output coefficient.

However, not all output coefficients have a one-to-one correspondence to the MAC because the structure of the output coefficient matrix of the activity model is different from that of the MAC in two respects:

- The MAC depicts the beef production of the activities "dairy cows" and "suckling calves" by beef output coefficients which can be interpreted as the product of the slaughtering rates and the slaughtering weights. The activity model of MFSS, in contrast, depicts the beef production of dairy and suckler cows by special slaughtering activities. The beef output coefficients of "dairy cows" and "suckling calves" are therefore zero in the activity model, and the beef output coefficients of the slaughtering activities are the slaughtering weights of dairy and suckler cows.

- For the ABTA, only one heifers production activity is defined, which is a mixed activity for breeding and fattening. The MAC beef output coefficient of "heifers" can therefore be interpreted as the product of the slaughtering rate and the slaughtering weight. The activity model, in contrast, distinguishes between the activities "heifers for breeding" and "heifers for fattening." The beef output coefficient of "heifers for breeding" is zero and the beef output coefficient of "heifers for fattening" equals the slaughtering weight of heifers.

Eq. 4.1.3.5.1.3.-2

Dairy cows and suckling calves:

$$fo_{j,i} = XMG_{a,b,S} \qquad \text{for all } i \neq FOBE$$

Heifers for fattening and heifers for breeding

$$fo_{APHF,FOBE} = \left(\frac{XMG_{HEIF,BEEF}}{1 - XMG_{HEIF,DCOW} - XMG_{HEIF,SCOW}} \right)_B$$

$$fo_{APHB,FOBE} = 0$$

Other production activities:

$$fo_{j,i} = XMG_{a,b,S}$$

Slaughtering activities:

$$fo_{q,FOBE} = \left(\frac{XMG_{a,BEEF}}{1 - XMG_{a,c}} \right)_B$$

a: Subsc., ABTA, animal production activities (corresponding to NLP activities j and q)
b: Subsc., ABTA, final animal products (corresponding to NLP constraint i)
c: Subsc., ABTA, intermediate products: live animals (corresponding to NLP activity q)
B: Subsc., base year of projection

4.1.3.5.1.4. Intermediate animal products: live animals

The activity model distinguishes between the 8 different live animal outputs of the ABTA (calves, heifers, dairy cows, suckler cows, piglets, lambs, chicks, and bulls) and an additional item "young cows". The additional item is necessary in the design of the activity model because the yield model does not predetermine what proportion of the heifers for breeding are raised to dairy cows and what proportion to suckler cows. It is the solution of the activity model which gives this ratio.

Structure

The balances are formulated as equalities, i.e. gross production of live animal products is equal to the intrasectoral use.

The resources for gross production are the animal production activities and output-output transfers between animal categories (only for dairy and suckler cows). The output-output transfers link the output balance for young cows produced by the activity "heifers for breeding" to those for dairy and suckler cows. The output-output transfers are necessary to determine the ratio of "heifers for breeding" producing dairy or suckler cows.

The use of live animal products comprises the following activities: the output-output transfers between animal categories (only for young cows), the slaughterings (only for dairy and suckler cows) and intrasectoral transfers which link the live animal output balances to the live animal input balances (see also ch. 4.1.3.5.2.11.). The difference between gross production and use are the stock changes of live animals. Stock changes are only accounted for heifers, dairy cows, suckler cows and bulls.

Eq. 4.1.3.5.1.4.-1

Calves:

$$\sum_j fo_{j,i} AP_j - IA_r - CF_w \geq 0 \qquad i = FOCV;\ r = IACV;\ w = CFCV;\ j = APDC, APSC$$

Bulls and heifers:

$$fo_{j,i} AP_j - IA_r - CF_w = 0 \qquad j = APRC \text{ and}$$

$$r = w = i \text{ for all } r = IABU, IAHE \quad w = CFBU, CFHE \quad i = FOBU, FOHE$$

Dairy and suckler cows:

$$AP_j + TF_v - SL_q - IA_r - CF_w = 0 \qquad j = v = q = r = w \text{ for all } j = APDC, APSC$$

$$v = TFDC, TFSC \quad q = SLDC, SLSC \quad r = IADC, IASC$$

$$w = CFDC, CFSC \quad i = FOOD, FOOS$$

Young cows:

$$AP_j - \sum_v TF_v = 0 \qquad j = APHB; \quad v = TFDC, TFSC$$

Piglets, lambs and chicks:

$$fo_{j,i} AP_j - IA_r \geq 0 \qquad j = r = i \text{ for all } j = APSO, APEW, APLH$$

$$r = IAPG, IALB, IACH \quad i = FOPG, FOLB, FOCH$$

IA: Intrasectoral transfer - output-input-transfer: intermediate live animals
CF: Intrasectoral transfer - stock changes on farm: intermediate live animals
TF: Intrasectoral transfer - output-output-transfer: transition of young cows
SL: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows
fo: Coefficients of the output balances for intermediate live animals

Specification

Most of the live animal output coefficients of the activity model are predetermined by the yield model (see ch. 4.1.2.) and correspond directly to a MAC output coefficient. This applies to the calves coefficients of the activities "dairy cows" and "suckling calves", the bulls and heifers coefficients of "calves, rearing", the piglets coefficient of "pig breeding", the lambs coefficient of "ewes and goats" and the chicks coefficient of "laying hens".

Eq. 4.1.3.5.1.4.-2

$$fo_{j,i} = XMG_{a,b,S}$$

a: Subsc., ABTA, animal production activity (corresponding to NLP activity j)
b: Subsc., ABTA, intermediate live animals (corresponding to NLP constraint i)

4.1.3.5.1.5. Intermediate animal products: manure

For each of the 3 manure nutrients (nitrogen, phosphate, potassium) the model has a corresponding balance.

Structure

The balances are formulated as inequalities, i.e. production of manure covers intrasectoral use.

The resources for manure production are the animal production activities. Intrasectoral transfer activities link the output balances for manure with the corresponding input balances for manure nutrients (see ch. 4.1.3.5.2.1.):

Eq. 4.1.3.5.1.5.-1

$$\sum_j fo_{j,i}\, AP_j - MA_i \geq 0$$

MA: Intrasectoral transfer - output-input-transfer: manure
fo: Coefficients of the output balances for nutrients from manure

Specification

The manure nutrient output coefficients of the activity model are predetermined by the yield model (see ch. 4.1.2.) and correspond directly to a MAC output coefficient:

Eq. 4.1.3.5.1.5.-2

$$fo_{j,i} = XMG_{a,b,S}$$

b: Subsc., ABTA, intermediate animal product: nutrients from manure (corresp. to NLP constr. i)

4.1.3.5.2. Input balances

4.1.3.5.2.1. Fertilizer

Structure

The balances for mineral fertilizer nutrients and for lime fertilizer are formulated as inequalities such that the use by the fertilizing activities or the crop production activities is covered by purchases. The use of nutrients from manure by the organic fertilizing activities is equal to the intrasectoral transfers.

Eq. 4.1.3.5.2.1.-1

Lime fertilizer:

$$\sum_{j_1} fi_{j_1,FILF}\, CP_{j_1} + PU_{PULF} \geq 0$$

Nitrogenous mineral fertilizer:

$$\sum_{j_2} fi_{j_2,FINF}\, MI_{j_2} + PU_{PUNF} \geq 0$$

Phosphate and potassium mineral fertilizer:

$$\sum_{j_2} fi_{j_2,i}\, MI_{j_2} - DF_k + PU_l \geq 0 \quad i = FIPF, FIKF \quad k = DFPF, DFKF \quad l = PUPF, PUKF \quad i = k = l$$

Nutrients from manure:

$$\sum_{j_3} fi_{j_3,i}\, OR_{j_3} + MA_m = 0 \quad i = FINM, FIPM, FIKM \quad m = MANM, MAPM, MAKM \quad i = m$$

MI: Mineral fertilizing activity: specific to crop production activity
OR: Organic fertilizing activity: specific to crop production activity
DF: Mineral fertilizing activity: non-specific to crop production activity
CP: Crop production activity
MA: Intrasectoral transfer- output-input-transfer: manure
PU: Intersectoral transfer - purchases
fi: Coefficients of the input balances for fertilizer and manure

Specification

The coefficients of the mineral and organic fertilizing activities are equal to their nutrient contents, which are already specified for the sectoral fertilizer nutrient balances of the fertilizer module (see ch. 4.1.3.3.1. and 4.1.3.3.2.). The lime fertilizer input coefficients of the crop production activities are predetermined by the yield model (see ch. 4.1.2.).

Eq. 4.1.3.5.2.1.-2

Crop production activities:

$$fi_{j_1,FILF} = -YMU_{a,CAOF,S}$$

Mineral fertilizing activities:

$$fi_{j_2,FINF} = -1 \quad fi_{j_2,FIPF} = -to_{j_2,TOTP} \quad fi_{j_2,FIKF} = -to_{j_2,TOTK}$$

Organic fertilizing activities:

$$fi_{j_3,FINM} = -1 \quad fi_{j_3,FIPM} = -to_{j_3,TOTP} \quad fi_{j_3,FIKM} = -to_{j_3,TOTK}$$

YMU: Input Use, MAC, physical component
a: Subsc., ABTA, crop production activity (corresponding to NLP production activity j)
CAOF: Subsc., ABTA, input item: lime fertilizer
to: Coefficients of the sectoral fertilizer nutrient balances (see eq. 4.1.3.2.2.-3)

4.1.3.5.2.2. Plant protection

Structure

The balance is formulated as an inequality, such that the use of plant protection by the crop production activities is covered by purchases:

Eq. 4.1.3.5.2.2.-1

$$\sum_j fi_{j,FIPP} CP_j + PU_{PUPP} \geq 0$$

fi: Coefficients of the input balances for plant protection

Specification

The plant protection input coefficients of the crop production activities are predetermined by the yield model (see ch. 4.1.2.):

Eq. 4.1.3.5.2.2.-2

$$fi_{j,FIPP} = -YMU_{a,PLAP,S}$$

a: Subsc., ABTA, crop production activity (corresponding to NLP activity j)
PLAP: Subsc., ABTA, input item: plant protection

4.1.3.5.2.3. Seeds

Whereas the ABTA has only one aggregate seed input item in constant prices, the activity model distinguishes between 14 single seed input items in physical units. This stronger differentiation of the activity model is necessary in order to analyse the effects of production and input use changes on the output use. For each of the 14 physical seed input items (7 cereal items, paddy rice, pulses, potatoes, 4 oilseeds items), the model has a corresponding balance.

To ensure monetary consistency, a balance for the aggregate seed input item in constant prices is also necessary, since the 14 single seed input items do not cover the total seed costs of the agricultural sector.

Structure

The balances are formulated as inequalities, such that the use of the seed input items is covered by the intrasectoral seed use (on-farm seed use) and by the purchases of seeds. The intrasectoral seed use and the purchases of the single input items in physical units are the resources in both types of balances, for the single seed input items and for the aggregate seed input item. The balance for the aggregate seed input is accomplished by purchases of a residual seed input item (PSOT).

Eq. 4.1.3.5.2.3.-1

Single seed input items (in physical units):

$$fs_{j,i}\, CP_j + SF_k + PS_l \geq 0 \qquad j = k = l = i$$

Aggregate seed input (in constant prices):

$$\sum_j fs_{j,FSOT}\, CP_j + \sum_{k=1}^{14} fs_{k,FSOT}\, SF_k + \sum_{l=1}^{14} fs_{l,FSOT}\, PS_l + PS_{PSOT} \geq 0$$

SF: Intrasectoral transfer - seed on farm
PS: Intersectoral transfer - purchases of seeds
fs: Coefficients of the input balances for seed inputs

Specification

The input coefficients for seeds in constant prices are predetermined by the yield model (see ch. 4.1.2.).

The coefficients for the single seed input items in physical units are derived from that in constant prices by application of base year ratios between seed input in physical units and seed input in constant prices.

Eq. 4.1.3.5.2.3.-2 presents the calculation of these coefficients.

Eq. 4.1.3.5.2.3.-2

Aggregate seed input (in constant prices):

$$fs_{j,FSOT} = -YMU_{a,SEEP,S}$$

Single seed input items (in physical units):

$$fs_{j,i} = -\frac{YMU_{a,SEEP,S}}{YMU_{a,SEEP,B}} \frac{XU_{SEEP,b,B} + DU_{PSEE,b,B}}{LEVL_{a,B}}$$

XU: Output Use, ABTA, physical component
DU: Uses, Additional Demand Component
LEVL: Level of production activity, ABTA
SEEP: Subsc., ABTA, input item, seed input (in constant prices)
SEEP: Subsc., ABTA, use activity, seed on farm
PSEE: Subsc., Additional Demand Component, seed use on market
a: Subsc., ABTA, crop production activity (corresponding to NLP activity j)
b: Subsc., ABTA/Add. Demand Component, final crop product (corresp. to NLP constr. i)
S: Subsc., current simulation year
B: Subsc., base year of projection

The single input items in physical units are transmitted into the balance for the aggregate seed input item in constant prices by valuing them at the prices of the ABTA base year (1985):

Eq. 4.1.3.5.2.3.-3

$$fs_{k,FSOT} = PU_{PRIN,a,85} \qquad fs_{l,FSOT} = PU_{PRIC,a,85}$$

PU: Output use price, ABTA
PRIN, PRIC: Subsc., ABTA, price elements: internal use price and farmgate price

4.1.3.5.2.4. *Fodder cereals*

For each of the eight fodder cereal inputs of the activity model (soft wheat, durum wheat, rye, barley, oats, maize, other cereals and rice), the model has a corresponding balance.

Structure

The balances are formulated as inequalities, such that the use of fodder cereals is covered by intrasectoral transfers (only soft wheat, durum wheat, rye, barley, oats, maize and other cereals) and purchases. The intrasectoral transfer activities establish a link between the input balances and the output balances for cereals (see also eq. 4.1.3.5.1.1.-1).

Eq. 4.1.3.5.2.4.-1

$$\sum_{k_1} ff_{k_1,i} C1_{k_1} + \sum_{k_2} ff_{k_2} C2_{k_2} + FF_i + PF_i \geq 0$$

C1: Feeding with cereal-mix 1
C2: Feeding with cereal-mix 2
FF: Intrasectoral transfer - animal feed on farm
PF: Intersectoral transfer - purchases of fodder
ff: Coefficients of the input balances for fodder cereals

Specification

The shares of the cereal subpositions in the two cereal feeding activities have already been specified for the nutrient requirement balances of the feed module (see ch. 4.1.3.4.1.1.). The coefficients of the cereal feeding activities in the input balances are equal to these shares:

Eq. 4.1.3.5.2.4.-2

$$ff_{k_m,i} = -r_{k_m,b} \qquad m = 1,2$$

r: Share of a cereal subposition in a cereal feeding activity (see also eq. 4.1.3.3.1.1.-4)
b: Subsc., ABTA, product item (cereal subposition) (corresponding to NLP constraint i)

4.1.3.5.2.5. Rich protein fodder

The activity model distinguishes two rich protein fodder categories: pulses, which can be fed directly on the farm or purchased from the market, and other rich protein fodder, which can be purchased from the market only. Two balances are needed for the two rich protein fodder inputs.

Structure

The balances are formulated as inequalities such that the use of rich protein fodder is covered by intrasectoral transfers (animal feed on farm) and purchases. The intrasectoral transfer activities establish a link between the input balance for fodder pulses and the output balance for pulses (see also eq. 4.1.3.5.1.1.-1).

The structure of these two balances is presented by eq. 4.1.3.5.2.5.-1.

Eq. 4.1.3.5.2.5.-1

Pulses:

$$\sum_{k_3} ff_{k_3,FFPU}\, PR_{k_3} + FF_{FFPU} + PF_{PFPU} \geq 0$$

Other rich protein fodder:

$$\sum_{k_3} ff_{k_3,FFOP}\, PR_{k_3} + PF_{PFOP} \geq 0$$

PR: Feeding with rich protein fodder
ff: Coefficients of the input balance for rich protein fodder

Specification

The coefficients of the activities "feeding with rich protein fodder" are specified under the simplifying assumption that the ex-post ratio between pulses and other rich protein fodder remains constant:

Eq. 4.1.3.5.2.5.-2

$$ff_{k_3,FFPU} = -\frac{XU_{FEEP,PULS,B} + DU_{PFEE,PULS,B}}{YG_{FEEP,FPRO,B} + DU_{PFEE,FPRO,B}} \qquad ff_{k_3,FFOP} = -1 - ff_{k_3,FFPU}$$

XU: Output Use, ABTA, physical component
YG: Input Generation, ABTA, physical component
DU: Uses, Additional Demand Component
PFEE: Subsc., Additional Demand Component, animal feed on market
FEEP: Subsc., ABTA, use activity, animal feed on farm
FPRO: Subsc., ABTA/Additional Demand component, fodder: rich protein
PULS: Subsc., ABTA/Additional Demand component, product : pulses
B: Subsc., base year of projection

4.1.3.5.2.6. Rich energy fodder

The activity model and the ABTA have one aggregated position for rich energy fodder, which contains some important feedingstuffs as manioc, cassava and various by-products of the processing industry (for more details, see Wolf, 1995).

Structure

The balance is formulated as an inequality such that the use of rich energy fodder is covered by purchases:

Eq. 4.1.3.5.2.6.-1

$$-\sum_{k_4} EN_{k_4} + PF_{PFEN} \geq 0$$

EN: Feeding with rich energy fodder

4.1.3.5.2.7. Raw milk fodder and milk products fodder

The activity model distinguishes between three milk fodder items: milk of cows, milk of ewes and goats and milk products fodder, the latter being an aggregate of various types of milk powder and whey (for more details, see Wolf, 1995). For each of these items, the model has a corresponding balance.

Structure

For each of the animal production activities two different milk fodder feeding activities are defined: "feeding with raw milk fodder" (milk of cows and milk of ewes and goats) and "feeding with milk products fodder". The balances are formulated as inequalities, such that the use of milk fodder is covered by intrasectoral transfers (only for milk of cows and milk of ewes and goats) and purchases. The intrasectoral transfer activities establish a link between the input balances and the output balances for the final animal products milk of cows and milk of ewes and goats (see ch. 4.1.3.5.1.3.).

Eq. 4.1.3.5.2.7.-1

Milk of cows and milk of ewes and goats:

$$\sum_{k_5} ff_{k_5,i} RM_{k_5} + FF_i + PF_i \geq 0$$

Milk products:

$$-\sum_{k_6} MP_{k_6} + PF_{PFMP} \geq 0$$

RM: Feeding with raw milk fodder
MP: Feeding with milk products fodder
ff: Coefficients of the input balances for milk of cows and milk of ewes and goats

Specification

The coefficients of the raw milk feeding activities are specified under the simplifying assumption that the ratio between milk of cows and milk of ewes and goats in the feed mix remains constant:

Eq. 4.1.3.5.2.7.-2

$$ff_{k_5,FFMI} = -\frac{XU_{FEEP,MILK,B} + DU_{PFEE,MILK,B}}{XU_{FEEP,MILK,B} + DU_{PFEE,MILK,B} + XU_{FEEP,MUTM,B} + DU_{PFEE,MUTM,B}}$$

$$ff_{k_5,FFMU} = -1 - ff_{k_5,FFMI}$$

MILK,MUTM: Subsc., ABTA/Add. Demand Component : milk of cows and milk of ewes and goats

4.1.3.5.2.8. Dried fodder

Structure

The balance is formulated as an inequality, such that the use of dried fodder is equal to the intrasectoral transfers (animal feed on farm). The intrasectoral transfer activities establish a link between the input balance and the output balances for the intermediate crop products hay and straw (see ch. 4.1.3.5.1.2.).

Eq. 4.1.3.5.2.8.-1

$$-\sum_{k_7} DR_{k_7} + FF_{FFDH} + FF_{FFST} = 0$$

DR: Feeding with dried fodder
ff: Coefficients of the input balance for dried fodder

4.1.3.5.2.9. Fresh and ensilaged fodder

The activity model distinguishes three fresh and ensilaged fodder items: other root crops, green fodder, silage. For each of these items, the model has a corresponding input balance.

Structure

The balances are formulated as equalities, such that the use of fresh and ensilaged fodder is covered by intrasectoral transfers (animal feed on farm). The intrasectoral transfer activities establish a link between the input balances for other root crops, green fodder and silage and the output balances for the intermediate crop products other root crops, green fodder and silage (see also ch. 4.1.3.5.1.2.).

Eq. 4.1.3.5.2.9.-1

$$\sum_{k_8} ff_{k_8,i} FS_{k_8} + FF_i = 0$$

FS: Feeding with fresh and ensilaged fodder
ff: Coefficients of the input balance for fresh and ensilaged fodder items

Specification

The coefficients of the activities "feeding with fresh and ensilaged fodder" are specified under the simplifying assumption that the ex-post ratios between other root crops, green fodder and silage remain constant:

Eq. 4.1.3.5.2.9.-2

$$ff_{k_8,FFOR} = -\frac{XU_{FEEP,OROO,B}}{YG_{FEEP,FFSI,B}} \quad ff_{k_8,FFGR} = -\frac{XU_{FEEP,GRAS,B}}{YG_{FEEP,FFSI,B}} \quad ff_{k_8,FFSI} = -1 - ff_{k_8,FFOR} - ff_{k_8,FFGR}$$

FFSI: Subsc., ABTA/Additional demand component, input item: fresh and ensilaged fodder
OROO,GRAS: Subsc., ABTA/Additional Demand Component : other root crops and green fodder

4.1.3.5.2.10. Other fodder

The activity model and the ABTA have an aggregated input item "other fodder" (for more details, see Wolf, 1995).

Structure

The balances are formulated as inequalities such that the use of "other fodder" is covered by intrasectoral transfers and purchases. The intrasectoral transfer activities establish a link between the input balance for "other fodder" and the output balances for the 5 final crop products "potatoes", "sugarbeets", "cauliflower", "tomatoes" and "other vegetables" (see also eq. 4.1.3.5.1.1.).

Eq. 4.1.3.5.2.10.-1

$$-\sum_{k_9} OT_{k_9} + \sum_{l=1}^{5} FF_l + PF_{PFOT} \geq 0$$

OT: Feeding with other fodder

4.1.3.5.2.11. Live animals

The activity model distinguishes between 8 different live animal input items: calves, heifers, dairy cows, suckler cows, piglets, lambs, chicks and bulls. For each of these items, there exists a corresponding input balance.

Structure

The balances are formulated as equalities such that the use of live animals as inputs for the animal production activities is equal to the intrasectoral transfers and purchases (see eq. 4.1.3.5.2.11.-1). The intrasectoral transfer activities establish a link between the input balances for live animals and the output balances for live animals (see also ch. 4.1.3.5.1.4.).

Eq. 4.1.3.5.2.11.-1

Calves:

$$\sum_j fi_{j,FIIC}\, AP_j + IA_{IACV} + PU_{PUIC} = 0 \qquad j = APCA, APRC$$

Heifers:

$$\sum_j fi_{j,FIIH}\, AP_j + IA_{IAHE} + PU_{PUIH} = 0 \qquad j = APHF, APHB$$

Bulls, dairy cows, suckler cows:

$$fi_{j,i}\, AP_j + IA_r + PU_t = 0 \qquad j = r = t = i$$

for all $j = APBU, APDC, APSC$ $\quad r = IABU, IADC, IASC$ $\quad t = PUIB, PUIS, PUID$ $\quad i = FIIB, FIID, FIIS$

Piglets:

$$\sum_j fi_{j,FIIP}\, AP_j + IA_{IAPG} + PU_{PUIP} = 0 \qquad j = APPI, APSO$$

Lambs:

$$\sum_j fi_{j,FIIL}\, AP_j + IA_{IALB} + PU_{PUIL} = 0 \qquad j = APSH, APEW$$

Chicks:

$$\sum_j fi_{j,FIIC}\, AP_j + IA_{IACH} + PU_{PUIC} = 0 \qquad j = APLH, APPL$$

AP: Animal production activity
IA: Intrasectoral transfer - output-input-transfer: intermediate live animals
PU: Intersectoral transfer - purchases of live animal inputs
fi: Coefficients of the input balances for live animals

Specification

The input coefficients of the animal production activities are predetermined by the yield model (see ch. 4.1.2.):

Eq. 4.1.3.5.2.11.-2

$$fi_{j,i} = -YMU_{a,b,S}$$

YMU: Output Use, MAC, physical component
a: Subsc., ABTA, animal production activity (corresponding to NLP activity j)
b: Subsc., ABTA, input item, live animals (corresponding to NLP constraint i)
S: Subsc., current simulation year

4.1.3.5.2.12. Costs of animal imports (EAA) and pharmaceutical inputs

Structure

The balances are formulated as inequalities, such that the use of these inputs by the animal production activities is covered by purchases:

Eq. 4.1.3.5.1.12.-1

$$\sum_j fi_{j,i} AP_j + PU_i \geq 0$$

fi: Coefficients of the input balances for animal imports and pharmaceutical inputs

Specification

The input coefficients of the animal production activities are determined analogous to eq. 4.1.3.5.2.11.-2.

4.1.3.5.2.13. Variable costs and overheads for repairs, energy and other inputs

Structure

The balances are formulated as inequalities, such that the use of these inputs by the crop and animal production activities is covered by purchases:

Eq. 4.1.3.5.2.13.-1

$$\sum_j fi_{j_1,i} CP_{j_1} + \sum_{j_2} fi_{j_2,i} AP_{j_2} + PU_i \geq 0$$

fi: Coefficients of the input balances for repairs, energy and other inputs

Specification

The input coefficients of the animal production activities are determined analogous to eq. 4.1.3.5.2.11. -2.

4.1.3.6. Dynamic interdependence equations in the beef and dairy sector

As already mentioned in chapter 4.1.3.1.1., the farmers' choices about the levels of the production activities "male adult cattle for fattening", "dairy cows" and "suckling calves" for the current simulation year t are strongly constrained by the decisions about the intermediate animal production activities "calves, rearing", "heifers for breeding", and "suckling calves" and the slaughterings of cows in t-1. This is depicted in the activity model by the interplay of the live animal input balances (see ch. 4.1.3.5.2.11.) with the corresponding animal stock balances (see ch. 4.1.3.6.1.).

In order to determine the levels of the intermediate animal production activities "calves, rearing", "heifers for breeding" and "suckling calves" and the slaughterings of cows for the current year t, behavioural equations determine, during the model run for t, already "planned" levels of "dairy cows" for t+1 and t+2 and a "planned" level of "male adult cattle for fattening" for t+1 (see also ch. 4.1.3.1.1.). The planned levels of these production activities restrict the possible choices about the levels of the intermediate animal production activities and the slaughterings of cows in t by the interplay between the input balances for live animals in t+1 and t+2 (see ch. 4.1.3.6.2. and 4.1.3.6.3.), the output balances for live animals in t and in t+1 (see ch. 4.1.3.5.1.4. and ch. 4.1.3.6.2) and the animal stock balances in t+1 and t+2 (see ch. 4.1.3.6.2. and 4.1.3.6.3.).

4.1.3.6.1. Stock balances for live animals

Animal stock balances for heifers, dairy cows, suckler cows and male adult cattle capture the intertemporal linkage between the use of these animal categories as inputs for the current simulation year t and their gross production in t-1. For each of the above live animal categories the model has a corresponding stock balance.

Structure

The balances are formulated as equalities, such that intrasectoral transfers of intermediate animals are equal to gross production of live animals in the previous year. In this way, the intrasectoral transfers in the output and input balances for live animals (see eq. 4.1.3.5.1.4.-1 and eq. 4.1.3.5.2.12.-1) are uniquely defined.

Eq. 4.1.3.6.1.-1

$$-IA_r = -PROP_{t-1,b}$$

IA: Intrasectoral transfer - output-input-transfer: intermediate live animals
PROP: Gross production, ABTA
b: Subsc., ABTA, intermediate animal product (corresponding to NLP activity r)

4.1.3.6.2. Stock, input and output balances for live animals, year t+1

Structure

Already during the model run for the current simulation year t, the model takes into account stock balances for t+1 for heifers, dairy cows, suckler cows and male adult cattle in order to capture the linkage between the use of these animal categories as inputs in t+1 and their gross production in t.

Output and input balances for t+1 ensure the identity between "planned" output generation and output use and "planned" input use and input generation.

Input balances for heifers, dairy cows, suckler cows and male adult cattle balance the "planned" use of these animal categories in year t+1 with the generation of these inputs by intrasectoral transfers and "planned" purchases.

For each of the above live animal categories, the model also has a corresponding stock balance for t+1, which ensures that intrasectoral transfers of intermediate animals in t+1 (I1) equal production in t (IA+CF) (see also eq. 4.1.3.5.1.4.-1).

Output balances for cows ensure the identity between "planned" gross production and their "planned" use for slaughterings, intrasectoral transfers and stock changes in t+1.

Eq. 4.1.3.6.2.-1

Stock balances for live animals, t+1:

heifers, suckler cows, dairy cows, male adult cattle:

$$IA_r + CF_w - I1_s = 0 \qquad r = w = s \text{ for all } r = IAHE, IASC, IADC, IABU$$
$$w = CFHE, CFSC, CFDC, CFBU \quad s = I1HE, I1SC, I1DC, I1BU$$

Input balances for live animals, t+1:

a) heifers:

$$-\sum_j A1_j + I1_{I1HE} + P1_{P1IH} = 0 \qquad j = A1HF, A1HB$$

b) dairy cows, suckler cows and male adult cattle:

$$-A1_j + I1_s + P1_t = 0 \qquad j = s = t \text{ for all } j = A1SC, A1DC, A1BU$$
$$s = I1SC, I1DC, I1BU \quad t = P1IS, P1ID, P1IB$$

Output balances for live animals, t+1:

a) dairy cows and suckler cows:

$$A1_j + T1_v - S1_q - I1_s - F1_n = 0 \qquad j = v = q = s = n$$

for all $j = A1DC, A1SC \quad v = T1DC, T1SC \quad s = I1DC, I1SC \quad n = F1DC, F1SC$

b) young cows:

$$A1_{A1HB} - \sum_v T1_v = 0 \qquad v = T1DC, T1SC$$

A1: Animal production activity, year t+1
CF: Intrasectoral transfer - stock changes on farm: intermediate live animals
I1: Intrasectoral transfer - output-input-transfer: intermediate live animals, year t+1
P1: Intersectoral transfer - purchases: intermediate live animals, year t+1
T1: Intrasectoral transfer - output-output-transfer: transition of young cows, year t+1
S1: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows, year t+1
F1: Intrasectoral transfer - stock changes on farm, year t+1

4.1.3.6.3. Stock and input balances for live animals, year t+2

Already during the model run for the current simulation year t, the model takes into account stock balances for t+2 for dairy and suckler cows in order to capture the linkage between the use of these animal categories as inputs in t+2 and their gross production in t+1.

Input balances for t+2 ensure the identity between "planned" input use and input generation.

Structure

Input balances for dairy cows and suckler cows balance the "planned" use of these animal categories in year t+2 with the generation of these inputs by intrasectoral transfers and "planned" purchases.

For each of the above live animal categories, the model has a corresponding stock balance for t+2, which ensures that intrasectoral transfers of intermediate animals in t+2 equal the "planned" gross production in t+1 (I1+F1) (see also eq. 4.1.3.6.2.-1).

Eq. 4.1.3.6.3.-1

Stock balances for live animals, t+2:

suckler cows and dairy cows:

$$I1_s + F1_n - I2_u = 0 \qquad s = n = u \text{ for all } s = I1SC, I1DC \quad n = F1SC, F1DC \quad u = I2SC, I2DC$$

Input balances for live animals, t+1:

suckler cows and dairy cows:

$$-A2_j + I2_u + P2_t = 0 \qquad j = u = t \text{ for all } j = A2SC, A2DC \quad u = I2SC, I2DC \quad t = P2IS, P2ID$$

A2: Animal production activity, year t+2
I2: Intrasectoral transfer: output-input-transfer: intermediate live animals, year t+2
F1: Intrasectoral transfer - stock changes on farm, year t+1
P2: Intersectoral transfer - purchases: intermediate animals, year t+2

4.1.3.7. Constraints on intrasectoral transfers of final products

Output use of final products comprises intersectoral transfers (sales) and intrasectoral transfers (losses on farm, human consumption on farm, animal feed on farm, seed use on farm and stock changes on farm). Each of these intrasectoral transfer activities has also a corresponding market use activity (see ch. 5). The difference between 'on-farm' and 'on-market' use is that the former contains all output quantities used directly within the "national" farm sector, whereas use 'on market' contains all output quantities which have been sold by the farm sector to the other sectors of the economy before being consumed.

"Losses on farm" and "human consumption on farm" are determined by constant ratios to gross production (see ch. 4.1.3.7.1.). For "animal feed on farm", maximum ratios to total feed use and absolute upper bounds are imposed (see ch. 4.1.3.7.2.). "Seed use on farm" is constrained by absolute upper bounds (see ch. 4.1.3.7.3.). "Stock changes on farm" can only be determined by exogenous assumptions.

4.1.3.7.1. Losses on farm and human consumption on farm

For each of the 42 final crop and animal products, the activity model contains one constraint for losses on farm. For each of those 22 final crop and animal products for which the activity "human consumption on farm" is defined (see ch. 4.1.3.5.1.1. and 4.1.3.5.1.3) one constraint for human consumption is formulated. It is assumed that on-farm losses and on-farm human consumption depend on gross production.

Structure

The constraints for losses on farm are formulated as inequalities. Using inequalities instead of identities ensures that the model does not become infeasible if an upper bound is imposed on the sales (see 4.1.3.8.). The constraints for human consumption are identities.

Eq. 4.1.3.7.1.-1

Final crop products :

$$\sum_{j_1} lf_{j_1,i}\, CP_{j_1} - LF_i \leq 0 \qquad\qquad \sum_{j_1} hf_{j_1,i}\, CP_{j_1} - HF_i = 0$$

Final animal products :

$$\sum_{j_2} lf_{j_2,i}\, AP_{j_2} + \sum_{q} lf_{q,i}\, SL_q - LF_i \leq 0$$

$$\sum_{j_2} hf_{j_2,i}\, AP_{j_2} + \sum_{q} hf_{q,i}\, SL_q - HF_i \leq 0$$

CP: Crop production activity
AP: Animal production activity
SL: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows
LF: Intrasectoral transfer - losses on farm
HF: Intrasectoral transfer - human consumption on farm
lf: Coefficients of the constraints for losses on farm
hf: Coefficients of the constraints for human consumption on farm

Specification

It is assumed that losses on farm and human consumption on farm occur as constant shares of gross production taking the base year of projection as a reference. The coefficients of eq. 4.1.3.7.1.-1 can be calculated from corresponding output coefficients of the production and slaughtering activities and corresponding ABTA data (see eq. 4.1.3.7.1.-2):

Eq. 4.1.3.7.1.-2

Crop production activities:

$$lf_{j_1,i} = fo_{j_1,i} \frac{XU_{PLOF,b,B}}{PROP_{b,B}} \qquad hf_{j_1,i} = fo_{j_1,i} \frac{XU_{PCOF,b,B}}{PROP_{b,B}}$$

Animal production activities:

$$lf_{j_2,i} = fo_{j_2,i} \frac{XU_{PLOF,b,B}}{PROP_{b,B}} \qquad hf_{j_2,i} = fo_{j_2,i} \frac{XU_{PCOF,b,B}}{PROP_{b,B}}$$

Slaughtering activities:

$$lf_{q,LFBE} = fo_{q,FOBE} \frac{XU_{PLOF,a,B}}{PROP_{a,B}} \qquad hf_{q,HFBE} = fo_{q,FOBE} \frac{XU_{PCOF,a,B}}{PROP_{a,B}}$$

XU: Output Use, ABTA, physical component
PROP: Gross production, ABTA
fo: Coefficients of the output balance for final products (see ch. 4.1.3.5.1.1. and 4.1.3.5.1.3.)
LFBE: Subsc., NLP constraint, losses on farm: beef
HFBE: Subsc., NLP constraint, human consumption on farm: beef
FOBE: Subsc., NLP constraint, output balance: beef
PLOF: Subsc., ABTA, use activity, losses on farm
PCOF: Subsc., ABTA, use activity, human consumption on farm
b: Subsc., ABTA, product (corresponding to NLP constraint i)

4.1.3.7.2. *Animal feed on farm*

For each of the 13 final crop products and 2 final animal products which can be consumed as fodder inputs (see 4.1.3.5.1.1. and. 4.1.3.5.1.3.), the model contains one constraint for animal feed on farm and one upper bound.

Structure

The constraints are formulated as inequalities. They operate as upper limits on the ratio between on-farm feed use and total feed use.

Eq. 4.1.3.7.2.-1

Cereals:

$$\sum_{k_1} fa_{k_1,i} C1_{k_1} + \sum_{k_2} fa_{k_2,i} C2_{k_2} - FF_i \geq 0$$

Pulses:

$$\sum_{k_3} fa_{k_3,i} PR_{k_3} - FF_i \geq 0$$

Milk:

$$\sum_{k_5} fa_{k_5,i} RM_{k_5} - FF_i \geq 0$$

Other final crop products:

$$\sum_{k_9} fa_{k_9,i} OT_{k_9} - FF_i \geq 0$$

C1: Feeding with cereal-mix 1
C2: Feeding with cereal-mix 2
PR: Feeding with protein rich fodder
OT: Feeding with other fodder
RM: Feeding with raw milk fodder
FF: Intrasectoral transfer - animal feed on farm
fa: Coefficients of the constraints for animal feed on farm

In order to avoid implausible increases in the on-farm feed use absolute upper bounds on on-farm feed use are also imposed. It is assumed that on-farm feed use does not increase by more than 10 % p.a.:

Eq. 4.1.3.7.2.-2

$$FF_i \leq \left(XU_{FEEP,b,S-1}\right)1.1$$

b: Subsc., ABTA, final product (corresponding to NLP constraint i)
FEEP: Subsc., ABTA, use activity, animal feed on farm
S-1: Subsc., previous year

Specification

Base year ratios are used to specify the maximum ratios between on-farm feed use and total feed use:

Eq. 4.1.3.7.2.-3

$$fa_{k_m,i} = ff_{k_m,i} \frac{XU_{FEEP,b,B}}{XU_{FEEP,b,B} + DU_{PFEE,b,B}} \qquad m = 1,2,3,5,9$$

DU: Uses, Additional Demand Component
PFEE: Subsc., Additional Demand Component, animal feed on market
ff: Coeff. of the input bal. for fodder input items (see ch. 4.1.3.5.2.5-6., 4.1.3.5.2.8., 4.1.3.5.2.11.)
B: Subsc., base year of projection

4.1.3.7.3. Seed use on farm and stock changes on farm for final crop products

"Seed use on farm" of the 7 cereal items and potatoes is determined by the maximization of expected net revenue (see ch. 4.1.3.11.) subject to the output balances and the seed input balances (see ch. 4.1.3.5.2.3.). In addition to these constraints, upper bounds on "seed use on farm" are imposed.

"Stock changes on farm" of the 7 cereal items and potatoes can only be determined exogenously by expert proposals. If no expert proposal exists, MFSS assumes that on-farm stocks do not change.

Eq. 4.1.3.7.3.-1

Seed use on farm:

$$SF_i \leq XU_{SEEP,b,B}$$

Stock changes on farm for crop products:

$$CF_i = XU_{PCSF,b,E} \succ 0$$

SF: Intrasectoral transfer - seed use on farm
CF: Intrasectoral transfer - stock changes on farm
FS: Final stocks, ABTA
SEEP: Subsc., ABTA, use activity, seed on farm
PCSF: Subsc., ABTA, use activity, stock changes on farm
b: Subsc., ABTA, final crop product (corresponding to NLP activity i)
E: Subsc., expert proposal

4.1.3.8. Bounds on intersectoral transfers

4.1.3.8.1. Sales

For the "normal" case, sales are determined by the maximization of net revenue (see ch. 4.1.3.11.) subject to the constraints of the activity model. But for policy analyses it might be the case that one wants to specify upper bounds on the sales for a specific product, if for example a quota on sales exists. If no expert proposal exists, the upper bound is infinite.

Eq. 4.1.3.8.1.-1

$$SA_i \leq XU_{TRAP,b,E} \succ \infty$$

SA: Intersectoral transfers - sales
XU: Output use, ABTA, physical component
TRAP: Subsc., ABTA, use activity, sales
b: Subsc., ABTA, final product (corresponding to NLP activity i)
E: Subsc., expert proposal

4.1.3.9. Constraints on slaughterings of intermediate animals

4.1.3.9.1. Slaughterings in the current simulation year

A plausibility range for the slaughterings of dairy and suckler cows is defined by upper and lower bounds. The lower bound is determined in a way such that at least 20 % of the gross production of dairy and suckler cows of the previous year is slaughtered in the current simulation year. If the slaughtering rate of the previous year is lower than 20 %, the slaughtering rate of the previous year is used to define the lower bound. The upper bound for the slaughtering rate is 100 %.

Eq. 4.1.3.9.1.-1

$$PROP_{SCOW,S-1} \geq SL_{SLSC} \geq PROP_{SCOW,S-1}\left(1-\max\left\{0.8, XMG_{CALV,SCOW,S-1}\right\}\right)$$

$$PROP_{DCOW,S-1} \geq SL_{SLDC} \geq PROP_{DCOW,S-1}\left(1-\max\left\{0.8, XMG_{MILK,DCOW,S-1}\right\}\right)$$

SL: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows
PROP: Gross production, ABTA
XMG: Output Generation, MAC, physical component
MILK: Subsc., ABTA, production activity, dairy cows
CALV: Subsc., ABTA, production activity, suckling calves
DCOW: Subsc., ABTA, intermediate animal product : dairy cows
SCOW: Subsc., ABTA, intermediate animal product : suckler cows
S-1: Subsc., previous year

4.1.3.9.2. Planned slaughterings in year t+1

The "planned" slaughtering rates for dairy and suckler cows for t+1 are assumed to be equal to the lower bound on the slaughterings rate in t:

Eq. 4.1.3.9.2-1

$$r1_{R1SD,APDC}AP_{APDC} + r1_{R1SD,TFDC}TF_{TFDC} - S1_{S1DC} = 0$$

$$r1_{R1SS,APSC}AP_{APSC} + r1_{R1SS,TFSC}TF_{TFSC} - S1_{S1SC} = 0$$

where

$$r1_{R1SD,APDC} = r1_{R1SD,TFDC} = \left(1-\max\left\{0.8, XMG_{MILK,DCOW,S-1}\right\}\right)$$

$$r1_{R1SS,APSC} = r1_{R1SS,TFSC} = \left(1-\max\left\{0.8, XMG_{CALV,SCOW,S-1}\right\}\right)$$

AP: Animal production activity
TF: Intrasectoral transfer - output-output-transfer: transition between animal categories
S1: Intras. transfer - output-output-transfer: "planned" slaughterings of dairy and suckler cows, year t+1

4.1.3.10. Total land balance

<u>Structure</u>

The total land balance is formulated as an inequality, such that the land use by crop production activities and fallow land is covered by the total availability of land plus a land deficit variable.

MFSS offers two possibilities to determine the total land availability: expert proposals and trend extrapolations. Expert proposals have first priority, trend extrapolations second priority. If neither expert proposals nor trend extrapolations exist, MFSS uses base year values.

The deficit variable is introduced into the land balance in order to ensure that the model cannot become infeasible. For the "normal" case, the land deficit will be zero, since the realisation of the deficit variable is punished by very high costs (see objective function in 4.1.3.11). It will only be for those cases greater than zero that the specification of the total land availability is inconsistent with the other modelling assumptions and specifications of the activity model.

Eq. 4.1.3.10.-1

$$-\sum_{j} CP_j - OPFA + AREA \geq -PROPLEVL_{E \wedge T \wedge B}$$

CP: Crop production activity
OPFA: Fallow land
AREA: Area deficit
PROPLEVL: Total land availability, ABTA
E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc. base year of projection

4.1.3.11. The objective function

The activity model maximizes expected net revenue of the agricultural sector subject to the constraints described in the previous chapters. The objective function values the sales and purchases of the agricultural sector with the expected farmgate prices for outputs and inputs. The area deficit variable (AREA) is given a very high non-linear objective value in order to ensure that its value is zero for all specifications of the activity model which are feasible within the total land availability (see also ch. 4.1.3.10.). A similar rationale is behind the objective value for the variables which allow to exceed the maximum dry matter and cereal intake (EXDX and CXDX).

The reader should bear in mind, that explicit maximization in the activity model is strongly constrained especially by the use of behavioural equations. In this sense, MFSS is not a normative model, it is an empirical model.

Following the structure and the specification of the objective function are described in detail.

Structure

Eq. 4.1.3.11.-1

$$\sum_R \left(\sum_p ob_{R,p} SA_{R,p} \right) +$$

$$\sum_R \left(\sum_t ob_{R,t} PU_{R,t} + \sum_l ob_{R,l} PS_{R,l} + \sum_v ob_{R,v} PF_{R,v} \right) +$$

$$+ \sum_R ob_{R,EXDX} EXDX_R + \sum_R ob_{R,CXDX} CXDX + \sum_R ob_{R,AREA} AREA_R = \max!$$

SA: Intersectoral transfer - sales
PU: Intersectoral transfer - purchases
PS: Intersectoral transfer - purchases of seeds
PF: Intersectoral transfer - purchases of fodder
EXDX: Exceeding maximum dry matter intake
CXDX: Exceeding maximum cereal intake
AREA: Area deficit
R: Subsc., Member State (region)
ob: Coefficients of the objective function

Specification

(1) Sales:

The farmgate prices for the output items of the activity model are directly available in the ABTA for the ex-post period. The farmers' expectations about these prices are modelled in the expectation model (see ch. 4.1.1.). The sales are valued with these expectations:

Eq. 4.1.3.11.-2

$$ob_p = PU^*_{PRIC,b,S}$$

PU^*: Expected output use price
PRIC: Subsc., ABTA, price element : farmgate price
b: Subsc., ABTA, product (corresponding to NLP activity p)
S: Subsc., current simulation year

(2) Purchases of seeds:

The prices of the 14 physical seed input items of the activity model (see also ch. 4.1.3.5.2.3.) are not directly available from the ABTA, since the ABTA has only one aggregate seed input item in constant prices. The model estimates the prices of the physical seed input items for the ABTA base year (1985)[13] from the price of the aggregate seed input item. In order to arrive at expected prices for the physical seed input items, it is assumed that the ratio between the expected price of the physical seed input item (e.g. barley seeds) and the expected farmgate price of the corresponding output item (e.g. barley) is equal to the price ratio in the ABTA base year:

13 The ABTA base year is 1985. All price indices and monetary values in constant prices refer to this base year.

Eq. 4.1.3.11.-3

$$ob_l = SP_{l,85} \frac{PU^*_{PRIC,b,S}}{PU_{PRIC,b,85}} \qquad \text{with}$$

a) for single seed input items (physical units):

$$SP_{l,85} = \frac{QU_{SEEP,85} YMU_{a,SEEP,85} - \dfrac{XU_{SEEP,b,85} PU_{PRIN,b,85}}{LEVL_{a,85}}}{\dfrac{DU_{PSEE,b,85}}{LEVL_{a,85}}}$$

b) for residual seed input item (constant prices):

$$SP_{PSOT,85} = QG_{PRIC,SEEP,85}$$

PU: Output use price, ABTA
QU: Input use price (unit value), ABTA
QG: Input generation price, ABTA
SP: Estimated purchase price for the single seed input item
YMU: Input Use, MAC, physical component
XU: Output Use, ABTA, physical component
DU: Uses, Additional Demand Component
LEVL: Level of production activity, ABTA
PSEE: Subsc., Additional Demand Component, seed use on market
PRIN: Subsc., ABTA, price element: internal use price
SEEP: Subsc. ABTA, use activity, seed on farm or input item: seeds (in constant prices 1985)
a: Subsc., ABTA, crop production activity
b: Subsc., ABTA, crop product (corresponding to NLP activity l)

(3) Purchases of fodder:

The prices of the 8 fodder cereal input items of the activity model are not available from the ABTA, since the ABTA has only one aggregate fodder cereal input item (see also ch. 4.1.3.5.2.3.). The model estimates the expected prices of the fodder cereal subpositions from the expected farmgate output price for the cereal subpositions, scaled by an estimated margin between farmgate prices for cereal outputs and fodder cereals for the base year of projection. It is assumed that this margin is the same for all cereal subpositions and remains constant during the projection period.

The expected prices for the milk fodder subpositions (milk of dairy cows, milk of ewes and goats, and other milk fodder) are estimated in a similar way from the expected prices of the corresponding farmgate output prices.

The farmgate prices for all other fodder input items of the activity model are directly available in the ABTA for the ex-post period. The farmers' expectations about these prices are modelled in the expectation model (see ch. 4.1.1.). The purchases are valued with these expectations.

Eq. 4.1.3.11.-4

Cereals:

$$ob_v = \frac{PU^*_{PRIC,b,S}}{\dfrac{\sum_b PU_{PRIC,b,B} DU_{PFEE,b,B} + PU_{PRIC,PARI,B} \dfrac{DU_{PPRO,PARI,B}}{DR_{MAPR,RICE,B}} DU_{PFEE,RICE,B}}{QG_{PRIC,FCER,B} DU_{PFEE,FCER,B}}}$$

b = $SWHE, DWHE, \ldots, OCER$

Rich protein fodder:

$$ob_{PFPU} = PU^*_{PRIC,PULS,S} \qquad ob_{PFOP} = QG^*_{PRIC,FPRO,S\ S}$$

Rich energy fodder:

$$ob_{PFEN} = QG^*_{PRIC,FENE,S}$$

Milk fodder:

$$ob_v = \frac{PU^*_{PRIC,b,S}}{\dfrac{\sum_b PU_{PRIC,b,B} DU_{PFEE,b,B} + QG_{PRIC,FMIL,B}\left(DU_{PFEE,FMIL,B} - \sum_b DU_{PFEE,b,B}\right)}{QG_{PRIC,FMIL,B} DU_{PFEE,FMIL,B}}}$$

$b = MILK, MUTM$

Other fodder:

$$ob_{PFOT} = PU^*_{PRIC,FOTH,S}$$

PFEE: Subsc., Additional Demand Component, animal feed on market
b: Subsc., ABTA, product (corresponding to NLP activity v)
FCER,FPRO,...: Subsc., ABTA/Additional Demand Component, fodder input items

(4) Purchases of mineral fertilizer, plant protection, live animals, animal imports (EAA), pharmaceutical inputs, variable costs and overheads for repair, energy, water and other inputs:

The farmgate prices for these input items are directly available in the ABTA for the ex-post period. The farmers' expectations about these prices are modelled in the expectation model (see ch. 4.1.1.). The purchases are valued with these expectations:

Eq. 4.1.3.11.-5

$$ob_t = QG^{*}_{PRIC,k,S}$$

k: Subsc., ABTA, input item (corresponding to NLP activity t)

(5) Area deficit:

As already mentioned in ch. 4.1.3.10., the area deficit variable may only attain a value greater than zero if the specifications of the activity model are not consistent with the total land availability. To ensure this, the area deficit variable is "punished" by a very high "costs". In order to punish high values of the deficit variable with higher "costs" than low values, a quadratic objective function value is specified (see eq. 4.1.3.11.-6). The parameter τ is set proportional to the average sectoral gross value added at market prices per hectare.

Eq. 4.1.3.11.-6

$$ob_{AREA} = \tau + 0.1\tau AREA$$

(6) Exceeding maximum dry matter and maximum cereal intake:

As already mentioned in ch. 4.1.3.4.1.3. and 4.1.3.4.2., the variables EXDX and CXDX may only attain a value greater than zero in cases which would otherwise result in an infeasible solution. To ensure this, these variables are "punished" by very high "costs". In order to punish high values of these variables with higher "costs" than low values, a quadratic objective function value is specified (see eq. 4.1.3.11.-7). The parameters ι and κ are given a value proportional to the feed prices.

Eq. 4.1.3.11.-7

$$ob_{EXDX} = \kappa + 0.1\kappa EXDX \qquad ob_{CXDX} = \iota + 0.1\iota CXDX$$

4.2. The demand component

The demand component is a tool for forecasting market demand of agricultural and processed products and analysing the possible effects of changes in the policy environment on demand for raw and processed agricultural products. Together with the supply component and the external trade component of MFSS, the demand component plays a central role in modelling endogenous price formation (see ch. 5).

The demand component covers, for each of the Member States (regions), the physical resource and use categories of agricultural products outside the agricultural sector and the net trade.

The demand component is linked to the supply component by the definition of the resource category "marketable production" for raw products, which is equal to the "sales" of final products of the supply component, and by the definition of the use categories "animal feed on market" and "seed on market", which are equal to the "purchases" of feed and seeds of the supply component. A further linkage between demand and supply is established by the definition of consumer price elasticities with respect to raw product costs, which allows consumer prices to be derived from farmgate prices and vice versa.

The demand component is linked to the external trade component via an "EUR-pool" model, which balances Member States' net trade with aggregate net trade at EUR level and transmits prices at EUR level into Member States' prices by regional price transmission equations.

The basic modelling assumptions

Total domestic demand for agricultural raw and processed products depends on the prices at consumer level and consumer income, the costs for the transfer of raw products into consumable goods, the demand for chemical, technical and energetic use (industrial use), and on agricultural production (seed and feed use).

Why use an NLP framework?

The demand component is solved in the framework of a non-linear programming approach (see figure 3). The main reasons for using the NLP framework are identical to those for the activity model of the supply component (see ch. 4.1.3): the NLP approach is a tool for solving systems of equations and for balancing product flows. Optimisation is limited to a subset of the problems and maximizes quasi social-welfare (see ch. 4.2.4.).

Before going into the details of the demand component, the reader should keep in mind that an "NLP" activity need not necessarily have a one-to-one correspondence to a "use activity" or a "resource activity" of the Additional Demand Component. However, the NLP activities are, of course, linked to the Additional Demand Component, because the latter serves as a datapool for the activity model of the demand component and the results are made available within the definitions of the Additional Demand Component (see ch. 6).

Figure 3 : Simplified representation of the regional constraints of the NLP matrix within the demand component

	Marketable production	Stock changes on market	Human consumption on market	Seeds on market	Losses on market	Industrial use	Processing	Animal feed on market	Regional prices	Regional net exports	EC-pool prices		RHS
Behavioural equations for human consumption on market			(-)						(+)			=	(-)
Behavioural equations for stock changes on market		(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)			=	(+,-)
Price transmission equations EC-pool and region									(+)		(-)	=	0
Market balances for raw products	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)		(-)		>=	0
Market balances for processed products		(-)	(-)		(-)	(-)	(+)	(-)		(-)		>=	0
Market balances for feedingstuffs	(+)	(-)						(-)				>=	0
Objective function			(+)				(-)						

4.2.1. Determination of the regional resource and use quantities

4.2.1.1. Regional resources of raw products

The domestic market resources contain a Member State's "marketable production".

The "marketable production" of the raw products of the Additional Demand Component is equal to the sales of the agricultural sector, which are determined in the supply component of MFSS (see section 4.1.3.8.1.):

Eq. 4.2.1.1.-1

$$MA_i = SA_i$$

MA: Marketable production
SA: Intersectoral transfer - sales

4.2.1.2. Regional uses

The domestic uses outside the agricultural sector contain the following use activities: human consumption on market, processing, industrial use, animal feed on market, losses on market, seed use on market.

4.2.1.2.1. Human consumption on market

One target of the demand component is to forecast human consumption of agricultural raw and processed products and to simulate how consumption is influenced in the medium-term by changes in the consumer prices.

Modelling assumptions

MFSS forecasts and simulations assume for each Member State a representative consumer who determines his consumption bundle depending on his preferences, the product prices he faces and his budget endowment.

Empirical work on consumer behaviour in developed countries suggests that the price and income response of demand for agricultural products is rather limited. Limited demand response is explained by the stable macroeconomic environment, traditional consumer behaviour and by the fact that expenditure on agricultural products constitutes only a small share of total consumer expenditure. This supports the idea that trend-based, per-capita human consumption quantities would produce a plausible projection for a medium-term perspective if consumer prices and incomes developed according to past trends. The trend-based projection serves as a reference situation from which possible adjustments are derived.

The response of human consumption to changing consumer prices and incomes is modelled by *behavioural functions*. Within these functions, own and cross price elasticities give the percentage changes of the per-capita demand over the trend reference situation with respect to the percentage price changes over the trend reference situation. Similarly, income elasticities depict the income response of human consumption.

4.2.1.2.1.1. Behavioural equations

Structure

The effects of changes in consumer prices and incomes on human consumption are incorporated via elasticities with respect to consumer prices and total consumer expenditure. The basic modelling assumptions described above can be translated into a mathematical expression in the following way:

$$DU_{PCOM,a,S} = \left(1 + \sum_{b=1}^{n} \varepsilon_{b,a} \frac{\Delta CPRI_{b,S}}{100} + \eta_a \frac{\Delta EXPENAGG_S}{100}\right)\left(\frac{DU_{PCOM}}{INHANAGG}\right)_{a,T} INHANAGG_S$$

$$\text{where} \quad \Delta CPRI_{b,S} = 100\left(\frac{CPRI_{b,S}}{CPRI_{b,T}} - 1\right) \quad \text{and} \quad \Delta EXPENAGG_S = 100\left(\frac{EXPENAGG_S}{EXPENAGG_T} - 1\right)$$

DU: Uses, Additional Demand Component
CPRI: Consumer price, Additional Demand Component
EXPENAGG: Total consumer expenditure, Additional Demand Component
INHANAGG: Population, Additional Demand Component
ε: Per-capita human consumption elasticity with respect to consumer price
η: Per-capita human consumption elasticity with respect to total consumer expenditure
a,b: Subsc., Additional Demand Component, product
PCOM: Subsc., Additional Demand Component, human consumption on market
S: Subsc., current simulation year
T: Subsc., trend-based

In order to express the above equation as a linear constraint of the NLP it is rearranged. Eq. 4.2.1.2.1.1.-1 determines human consumption depending on own and cross consumer prices, total consumer expenditure and population. The coefficients (de) give the unit changes of human consumption resulting from an increase of the consumer price by one unit. In order to simplify the model structure, and bearing in mind that empirical evidence about cross price effects is rare, the left-hand side of the equation contains only the own price response. If necessary, lagged cross price effects can be incorporated into the-right hand side, the constant term, of the behavioural function.

Eq. 4.2.1.2.1.1.-1

$$de_i \, HM_i + de_{k,i} \, RP_k = c_i \qquad k = i$$

HM: Human consumption on market
RP: Regional consumer price
de: Coefficient of the behavioural equation for human consumption on market
c: Constant term of the behavioural equation for human consumption on market

Specification

The constant term of the behavioural equation is given on a per-capita basis (see eq. 4.1.3.1.1.-3). In order to arrive at total consumption, the coefficient of the use activity "human consumption" is defined as the inverse of the population number:

Eq. 4.2.1.2.1.1.-2

$$de_i = -\frac{1}{INHANAGG_S}$$

E: Subsc., expert proposal
B: Subsc., base year of projection

The price and income response coefficients are calculated from the corresponding elasticities. According to the modelling assumptions (see above), ε and η give the percentage change of human consumption from its trend-based value in response to a one-percent-change of the regional consumer prices and total expenditure from their trend-based values. Trend-based values are therefore used to transform the elasticities into linear coefficients. Income and lagged cross price effects on demand can be incorporated into the constant term of the behavioural function.

Eq. 4.2.1.2.1.1.-3

Price response:

$$de_{k,i} = \varepsilon_{a,b} \frac{\left(\frac{DU_{PCOM}}{INHANAGG}\right)_{a,T}}{CPRI_{b,T}}$$

Income response:

$$de_i = \eta_a \frac{\left(\frac{DU_{PCOM}}{INHANAGG}\right)_{a,T}}{EXPENAGG_T}$$

Constant term:

$$c_i = -\left(\frac{DU_{PCOM}}{INHANAGG}\right)_{a,T} + de_{k,i(k=i)} CPRI_{a,T} - \sum_b de_{k,i(k\neq i)}\left(CPRI_{b,S} - CPRI_{b,T}\right)$$
$$- de_i\left(EXPENAGG_S - EXPENAGG_T\right)$$

The population number and total consumer expenditure are exogenous variables and are determined as described in chapter 6.2.4.4..

Determination of the demand elasticities sets

Microeconomic theory has developed a consistent theoretical structure on which empirical demand analyses are based. But - comparable to the problems on the supply side (see ch. 4.1.3.1.1.) - sure knowledge about the elasticity values does not exist.

It therefore seems advisable for applied policy analyses to bring together the results from different studies and expert judgement and to specify the elasticity matrices in a synthetic way. Analogous to the supply component, a calibration approach for the demand elasticities has been developed which allows us to define ranges for plausible values of elasticities and to impose constraints on the homogeneity, symmetry and additivity characteristics of the demand response. The calibration approach is technically effected within an NLP framework. It is described in more detail in Annex I.

4.2.1.2.1.2. Exogenous vs. endogenous human consumption

In the "normal" case, human consumption is endogenously determined via the behavioural equation dependent on the regional consumer prices.

But the relatively low share of agricultural products in the consumer's budget or special events can make it difficult to forecast human consumption by an elasticity-based approach. This is why MFSS also offers the possibility to define human consumption as an exogenous variable.

Exogenous human consumption can be specified from expert proposals, trend extrapolations or from the base year of projection according to a user-defined priority sequence.

Eq. 4.2.1.2.1.2.-1

$$HM_i = DU_{PCOM,a,E \wedge T \wedge B}$$

Exogenous human consumption is effected within the NLP framework by setting the exogenous value as a bound on the human consumption variable. For the case of exogenous human consumption, MFSS does not operate with a corresponding price transmission equation between the region and the EUR-pool (see ch. 4.2.3.1.) and does not allow use of an exogenous consumer price. This enables the model to determine endogenously a regional consumer price consistent with the parameters of the behavioural equation.

4.2.1.2.2. Processing

The activity model of the demand component distinguishes between 12 processing activities for those 10 raw products for which derived processed products are defined in the Additional Demand Component (e.g. the product sunflower oil derived from the product sunflowers). Processing of raw products is endogenously determined by the maximization of the quasi social-welfare function, subject to the demand and net trade of processed products, the market balances for raw and processed products and the processing costs (see ch. 4.2.4.).

4.2.1.2.3. Industrial use

The activity model contains industrial use activities for all raw and processed products.

The demand for agricultural products as input to industrial production or as energy suppliers depends not only on the prices for agricultural products but also on the prices for the competing non-agricultural inputs, conversion costs and revenues for joint products. Modelling endogenously industrial use behaviour is therefore beyond the current scope of the SPEL/EU-model. But MFSS can incorporate *expert proposals* from specialised studies on industrial use of agricultural products, if available, or it can use trend extrapolations:

Eq. 4.2.1.2.3.-1

$$IN_i = DU_{PIND,a,E \wedge T \wedge B}$$

IN: Industrial use
DU: Uses, Additional Demand Component
PIND: Subsc., Additional Demand Component, industrial use
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc., base year of projection

4.2.1.2.4. Animal feed on market

As already mentioned above, the use category "animal feed on market" is equal to the purchases of feedingstuffs of the supply component (see also ch. 4.1.3.5.2.4.-4.1.3.5.10.):

Eq. 4.2.1.2.4.-1

$$MF_i = PF_i$$

MF: Animal feed on market
PF: Intersectoral transfer - purchases of fodder

4.2.1.2.5. Losses on market

It is assumed that "losses on market" for the raw products occur as constant shares of marketable production:

Eq. 4.2.1.2.5.-1

$$LM_i = \left(\frac{DU_{PLOS,a}}{DR_{MAPR,a}} \right)_B SA_i$$

LM: Losses on market
DU: Uses, Additional Demand Component
DR: Resources, Additional Demand Component
SA: Intersectoral transfer - sales
PLOS: Subsc., Additional Demand Component, losses on market
MAPR: Subsc., Additional Demand Component, marketable production
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
B: Subsc., base year of projection

4.2.1.2.6. Seed use on market

As already mentioned above, the use category "seed on market" is equal to the purchases of single seed input items of the supply component (see also ch. 4.1.3.5.2.3.):

Eq. (4.2.1.2.6.-1)

$$SM_i = PS_i$$

SM: Seed use on market
PS: Intersectoral transfer - purchases of seeds

4.2.1.2.7. Stock changes on market

For private stock-holding a distinction can be drawn between speculative and transaction motives. The transaction motive indicates that the amount of a commodity stored at any time is determined by the level of current production or consumption, while the speculative motive indicates that the stored quantities depend on the difference between current and expected prices. The optimal level of storage can be analytically determined by equating this price gap to the marginal costs of storage.

Against the background of the rudimentary stock data, and in view of the importance of public stock-holding, which is strongly determined by political decisions exogenous to MFSS, an analytical approach seems to be too sophisticated. A simplified procedure is more suitable for the purpose of MFSS.

MFSS contains behavioural equations determining stock changes on market depending on domestic use, prices and exogenous shifts. The model allows us to define target stock levels in ratio to domestic use. In addition to this, the equations have a built-in price stabilising mechanism, which increases (decreases) target stocks when prices are falling (rising). This effect is incorporated into the model by elasticities of stocks with respect to prices:

$$PFSM_S - PFSM_{S-1} = tPDOM_s + PFSM_{S-1}\left(\tau \frac{\Delta CPRI}{100} - 1\right) + \Delta PFSM_E$$

$$\text{where} \quad \Delta CPRI = 100\left(\frac{CPRI_S}{CPRI_{S-1}} - 1\right)$$

PFSM: Stocks on market
ΔPFSM: Exogenous shift for stocks on market
PDOM: Domestic use
CPRI: Consumer price
t: Target level for stocks on market (in ratio to domestic use)
τ: Elasticity of stock level with respect to price
S: Subsc., current simulation year
S-1: Subsc., previous simulation year
E: Subsc., expert proposal

In order to express the above equation as a linear constraint of the NLP, it is rearranged. Eq. 4.2.1.2.7.-1 determines "stock changes on market" depending on the level of the domestic use activities and prices. The coefficients t are the target stock levels in ratio to domestic use, and the coefficients cm give the unit changes of "stocks on market" resulting from an increase of the price by one unit. The coefficients mo of the "processing" activities (PR) are the coefficients of "processing" in the regional market balances for raw products (see ch. 4.2.2.1.), and the coefficients mo of the use activities "animal feed on market" (MF) are the coefficients of "animal feed on market" in the market balances of raw and processed products (see ch. 4.2.2.1. and 4.2.2.2.). Exogenous shifts can be incorporated into the constant term (c) of the behavioural equation.

Eq. 4.2.1.2.7.-1

$$-CM_i + t_i\left(HM_i + SM_i + LM_i + IN_i + \sum_{j=1}^{12} mo_{j,i} PR_j + \sum_{k=1}^{15} mo_{k,i} MF_k\right)$$
$$+cm_i RP_i = c_i$$

CM: Stock changes on market
HM: Human consumption on market
SM: Seed use on market
LM: Losses on market
IN: Industrial use
PR: Processing
MF: Animal feed on market
RP: Regional consumer price
mo: Coefficients of the regional market balances
cm: Price reaction coefficient of the behavioural equation for stock changes on market
c: Constant term of the behavioural equation for stock changes on market

Specification

The target levels for stocks on market in ratio to domestic use can be specified exogenously by expert proposals or by assuming that target levels are equal to the ratio of the previous year:

Eq. 4.2.1.2.7.-2

$$t_i = t_{i,E} \wedge t_i = \frac{PFSM_{a,S-1}}{PDOM_{a,S-1}} \text{ with } PDOM_a = \sum_c DU_{c,a} \quad c = PCOM, PFEE, \ldots, PPRO$$

DU: Uses, Additional Demand Component
a: Subsc., Additional Demand Component, product (corresponding to NLP constraint i)
c: Subsc., Additional Demand Component, use activity

The price-response coefficients are calculated from the corresponding elasticities. τ gives the percentage change of stocks on market from its previous year's value in response to a one-percent-change of the regional consumer price from its previous year's value. Previous year's values are therefore used to transform the elasticities into linear coefficients. Exogenously specified shifts can be incorporated into the constant term of the behavioural function.

Eq. 4.2.1.2.7.-3

Price response:

$$cm_i = \tau_a \frac{PFSM_{a,S-1}}{CPRI_{a,S-1}}$$

Constant term:

$$c_i = PFSM_{a,S-1} + cm_i CPRI_{a,S-1} - \Delta PFSM_{a,E}$$

4.2.1.3. Regional net trade

Regional net trade is defined as the difference between a Member State's marketable production and domestic uses and stock changes.

Regional net trade over all Member States is balanced by aggregate EUR net trade, and serves therefore as a physical product flow link between the regions via the EUR-pool (see ch. 4.2.3.2.).

Regional net trade is endogenously determined.

4.2.2. Regional market balances

For each Member State the model has a regional market balance for each of the product and feedingstuff items. All balances are formulated as minimum constraints, such that the resources cover domestic use, stock changes and net trade. The maximization of the objective function (quasi social welfare) ensures the identity between resources and the sum of domestic uses, stock changes and net trade.

4.2.2.1. Raw products

Structure

For each of the 42 balances for raw products, the corresponding use and resource activities "marketable production", "stock changes on market", "human consumption on market", "seed use on market", "losses on market", "industrial use", "net trade" exist. The lists of "processing" and "animal feed on market" activities are smaller.

Eq. 4.2.2.1.-1

$$MA_i - CM_i - HM_i - SM_i - LM_i - IN_i - \sum_{j=1}^{12} PR_j - \sum_{j=1}^{11} mo_{k,i}\, MF_k - NT_i \geq 0$$

MA: Marketable production
CM: Stock changes on market
HM: Human consumption on market
SM: Seed use on market
LM: Losses on market
IN: Industrial use
PR: Processing
MF: Animal feed on market
NT: Net trade
mo: Coefficients of the regional market balances for raw products

Specification

The use activities "animal feed on market" are aggregates containing one or more raw product items. The coefficients of these activities in the market balances for raw products are the shares of the raw products items in the respective aggregates. For simplicity, it is assumed that the shares are constant:

Eq. 4.2.2.1.-2

Cereals, pulses and milk:

$$mo_{k,i} = 1 \qquad k = i \text{ for all } k = MFSW, MFDW, MFRY, MFBA, MFOA, MFMA, MFOC, MFPU, MFMI, MFMU$$
$$\text{and } \; i = MOSW, MODW, MORY, MOBA, MOOA, MOMA, MOOC, MOPU, MOMI, MOMU$$

Other fodder:

$$mo_{MFOT,i} = \left(\frac{DU_{PFEE,a}}{DU_{PFEE,FOTH}} \right)_B \qquad a = i \text{ for all } a = POTA, SUGB, \ldots, OCRO \text{ and } i = MOPO, MOSU, \ldots, MOOT$$

DU: Uses, Additional Demand Component
PFEE: Subsc., Additional Demand Component, animal feed on market
FOTH: Subsc., Additional Demand Component, fodder: other
a: Subsc., Additional Demand Component, raw crop product
B: Subsc., base year of projection

4.2.2.2. Processed products

Structure

For each of the 17 balances for processed products the following corresponding use activities exist: "stock changes on market", "human consumption on market", "losses on market", "industrial use" and "net trade". The "processing" activities for raw products deliver the resources to the market balances for processed products. The balances are formulated as minimum constraints, such that production of processed products covers the domestic use, stock changes on market and the net trade of these products.

Eq. 4.2.2.2.-1

$$-CM_i - HM_i - LM_i - IN_i + \sum_{j=1}^{12} mo_{j,i} PR_j - \sum_{k=1}^{4} mo_{k,i} MF_k - NT_i \geq 0$$

CM: Stock changes on market
HM: Human consumption on market
SM: Seed use on market
LM: Losses on market
IN: Industrial use
PR: Processing
MF: Animal feed on market
NT: Member State (regional) net trade
mo: Coefficients of the regional market balances for processed products

Specification

The coefficients of the "processing" activities for raw products in the market balances for processed products are the processing coefficients, which are defined as the output-input-ratio between the processed and the raw product (e.g. between sugar and sugarbeets). The specification of the processing coefficients is described in ch. 5.1. .

Eq. 4.2.2.1.-2

$$mo_{j,i} = PRCE_{a,S}$$

PRCE: Processing coefficient (see eq. 5.1.-3)
a: Subsc., Additional Demand Component, processed product (corresponding to NLP constraint i)
S: Subsc., current simulation year

The 4 use activities "animal feed on market" are aggregates containing one or more processed product items. The coefficients of these activities in the market balances for processed products are the shares of the processed products in the respective aggregate. Constant shares are assumed:

Eq. 4.2.2.1.-3

Milled rice:

$$mo_{MFRI,MORI} = 1$$

Other rich protein fodder:

$$mo_{MFOP,i} = \frac{DU_{PFEE,a,B}}{DU_{PFEE,FPRO,B} - DU_{PFEE,PULS,B}}$$

$a = i$ for all $a = RAPC, SUNC, \ldots, OTHC$ and $i = MORC, MOSC, \ldots, MOOK$

Energy rich protein:

$$mo_{MFEN,i} = \frac{DU_{PFEE,a,B}}{DU_{PFEE,FENE,B}}$$ $a = i$ for all $a = MOLA, STAR, SUGA$ and $i = MOMO, MOPS, MOSG$

Milk products:

$$mo_{MFMP,i} = \frac{DU_{PFEE,a,B}}{DU_{PFEE,FMIL,B} - DU_{PFEE,MILK,B} - DU_{PFEE,MUTM,B}}$$

$a = i$ for all $a = MIPO, BUTT, OMPR$ and $i = MOMW, MOBT, MOPM$

DU: Uses, Additional Demand Component
PFEE: Subsc., Additional Demand Component, animal feed on market
a: Subsc., Add. Demand Component, processed products (corresponding to NLP constraint i)
PULS,MILK,MUTM: Subsc., Additional Demand Component, raw products
FPRO,FENE,...: Subsc., Additional Demand Component, fodder items
B: Subsc., base year of projection

4.2.2.3. Feedingstuffs

For each of the 15 balances for fodder items, the corresponding resource and use activities "marketable production", "stock changes on market" and "animal feed on market" exist:

Eq. 4.2.2.3.-1

$$MA_k - FC_k - MF_k \geq 0$$

MA: Marketable production
FC: Stock changes on market for feedingstuffs
MF: Animal feed on market

4.2.3. Linkages between regions and EUR pool

The product flow and price linkages between the Member States (regions) are depicted by an EUR-pool model.

The EUR-pool model is based on the following thinking:

- The Member States export their surpluses into a common pool. The quantities delivered to the pool can be used for imports to those Member States which have a supply-demand-deficit. The residual between Member States' net exports and net imports is covered by aggregate EUR net trade. Thus, the model depicts net trade over all Member States, but not trade between each pair of Member States.
- The operation of a Common Market makes it necessary to model price formation on aggregate EUR level. Prices at EUR level are referred to as "EUR-pool prices", which are average prices over regions. Price transmission equations establish a link between EUR-pool prices and prices at Member State level.

4.2.3.1. Price transmission between regions and EUR-pool

For each of the raw and processed products, the model has, potentially, a corresponding regional price transmission equation which determines the prices in the Member States dependent on the prices at EUR level.

Structure

The price transmission coefficient (pe) gives the unit change of the regional price resulting from a unit change of the EUR-pool price:

Eq. 4.2.3.1.-1

$$RP_i - pe EP_i = 0$$

RP: Regional consumer price
EP: EUR-pool price

Specification

The price transmission coefficients are calculated from the percentage price gaps between the Member States and the EUR-pool, and take into account the current ECU exchange rate. The price gaps can be specified from different sources according to a user-defined overlay structure:

- expert proposals,
- price gaps calculated from regional prices and EUR-pool prices of the current year if both are defined as exogenous variables, or
- base year's values.

Eq. 4.2.3.1.-2

$$pe_i = -\frac{1 + INHA_{a,E \wedge S \wedge B}}{PEAVNAGG_S z}$$

with $z = 1$ for absolute prices and $z = \dfrac{1}{PEAVNAGG_{1985}}$ for price indices

where

$$INHA_{a,x} = 100\left(\frac{CPRI_{R,a,x} PEAVNAGG_x}{CPRI_{EUR,a,x}} - 1\right) \qquad x = E, S, B$$

INHA: Price gap between Member State and EUR-pool (%)
CPRI: Consumer price, Additional Demand Component
PEAVNAGG: Exchange rate ECU/NC, ABTA
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
R: Subsc., Member State (region)
EUR: Subsc., EUR level
E: Subsc., expert proposal
S: Subsc., current year of simulation
B: Subsc., base year of projection

If the price gap is not defined as exogenous or if "human consumption on market" is defined as exogenous (see ch. 4.2.1.2.1.2.), the model works without the respective regional price transmission equation.

4.2.3.2. EUR net trade balances

Structure

For each of the raw and processed products, the model has a corresponding EUR net trade balance.

The balances are formulated as minimum constraints, such that the sum of net exports over the regions cover aggregate EUR net exports. The balances serve as a product flow link between the Member States and the EUR-pool.

Eq. 4.2.3.1.-1

$$\sum_{R} NT_{R,i} - TE_i \geq 0$$

NT: Member State (regional) net exports
TE: Aggregate net exports on EUR level
R: Subsc., Member State (region)

4.2.4. The objective function

The activity model of the demand component maximizes a quasi social welfare function subject to the constraints described in the previous chapters. The objective function measures utility as the area under the demand curve, and takes into account the costs for the transfer of raw agricultural products into consumable goods.

Structure

Eq. 4.2.4.-1

$$\sum_{R=1}^{12}\left(\sum_{i} ob_{R,i} HM_{R,i} + \sum_{j} ob_{R,j} PR_{R,j}\right) = \max!$$

HM: Human consumption on market
PR: Processing
R: Subsc., Member State (region)
ob: Coefficients of the objective function

Specification

(1) Human consumption on market:

The quasi social welfare impact of human consumption is measured via a non-linear function with quadratic elements of the quantities consumed (see eq. 4.1.4.-2) The underlying assumption is that consumers maximize utility, which is measured as the area under the linear price-demand curve described above (see ch. 4.2.1.2.1.1.).

In addition to utility, the costs for transferring raw products into consumable goods are also taken into account for human consumption of raw products. The difference between the consumer price and the raw product costs in the base year of projection, augmented by the inflation rate, serves as an estimate for the transfer costs. For processed products, these costs are incorporated into the objective values of the processing activities (see below).The calculation of the raw products costs is described by eq. 5.1.-2.

Eq. 4.2.4.-2

Utility:

$$U_i = \left(-\frac{c_i}{de_{i,k}} + \frac{1}{2de_{i,k}} HM_i \right) PEAVNAGG_S \qquad i = k$$

Transfer costs for raw products:

$$K_i = \left(CPRI_{a,B} - RAWP_{a,B} \right) \frac{NAGGNVAF_S}{NAGGNVAF_B} PEAVNAGG_S$$

Objective value:

$$ob_i = U_i - K_i$$

de: Coefficient of the behavioural equation for human consumption on market
c: Constant term of the behavioural equation for human consumption on market
HM: Human consumption on market
CPRI: Consumer price, Additional Demand Component
RAWP: Raw product costs (see eq. 5.1.-2)
PEAVNAGG: Exchange rate ECU/NC, ABTA
NAGGNVAF: Price index of gross domestic product
a: Subsc., Additional Demand Component, raw product (corresponding to NLP activity i)
B: Subsc., base year of projection
S: Subsc., current simulation year

(2) Processing:

The costs of processing raw agricultural products are estimated from the difference between the consumer prices of the processed products and the raw product costs in the base year of projection augmented by the inflation rate. The processing costs can be adjusted via scale effects, which can be incorporated into the model by assumed elasticities of processing costs with respect to the processing quantities. The calculation of the raw product costs for the base year of projection is described by eq. 5.1.-2.

Eq. 4.2.4.-3

Processing costs in base year of projection:

$$K_j = \left(CPRI_{a,B} - RAWP_{a,B}\right)PRCE_{a,B}\frac{NAGGNVAF_S}{NAGGNVAF_B}PEAVNAGG_S$$

Objective value:

$$ob_j = K_j\left(\kappa_j - 1\right) - K_j\kappa_j\frac{PR_j}{DU_{PPRO,b,B}}$$

PRCE: Processing coefficient (see eq. 5.1.-3)
DU: Uses, Additional Demand Component
PPRO: Subsc., Additional Demand Component, processing
κ: Elasticity of processing costs with respect to processing quantity
a: Subsc., Additional Demand Component, processed product (corresp. to raw product b)
b: Subsc., Additional Demand Component, raw product (corresponding to NLP activity j)

4.3. The external trade component

The product flow and price linkages between the EUR-pool and the Rest of World (ROW) are modelled by the external trade component. In the present version of MFSS, ROW net trade against the EUR-pool is depicted without further regional disaggregation within ROW.

The basic modelling assumptions

The external trade component is based on the following assumptions:

- At a global level all markets clear, such that EUR net exports (net imports) equal ROW net imports (net exports).
- ROW net imports (net exports) depend on world market prices.
- Prices at EUR level (EUR pool prices) can differ from world market prices. Price transmission equations establish a link between EUR-pool prices and world market prices.

NLP framework

The external trade component is also integrated into the NLP framework. Product flow balances, behavioural functions for ROW net trade and price transmission equations are effected as constraints. ROW net trade and world market prices are the variables (activities) of this section of the NLP. The objective function maximizes quasi social welfare (see also figure 4).

Alternative model links

The ROW net trade activities and the price transmission equations also serve as interfaces for possible linkages with more detailed models of agricultural trade, such as the SPEL-Trade Model.

Figure 4 : Simplified representation of the sectoral constraints of the NLP matrix within the demand and external trade component

	Regional net exports, Member State 1		Regional net exports, Member State 2	EUR net exports	ROW net imports	EC-pool prices	ROW prices		RHS
EUR net trade balances	(+)	...	(-)	(-)				=	0
ROW net trade balances				(-)	(-)			=	0
Behavioural equations for ROW net imports					(-)		(-)	=	(-)
Price transmission equations between EUR-pool and ROW						(-)	(-)	=	0
Objective function					(-),(+)				

4.3.1. ROW net trade balances

For all raw and processed products corresponding ROW net trade balances exist, such that net imports (net exports) of ROW are covered by net exports (net imports) at aggregate EUR level.

Eq. 4.3.1.-1

$$TE_i - TR_i = 0$$

TE: Aggregate net exports at EUR level
TR: ROW net imports

4.3.2. Behavioural equations for ROW net trade

Behavioural equations determine net imports (net exports) of ROW dependent on world market prices.

The world market price response is incorporated via net trade elasticities:

$$ROWI_S = \left(1 + \pi \frac{\Delta WPRI}{100}\right) ROWI_B \qquad \text{where} \quad \Delta WPRI = 100\left(\frac{WPRI_S}{WPRI_B} - 1\right)$$

ROWI: ROW net imports
WPRI: World market price
π: Elasticity of ROW net imports with respect to world market prices
S: Subsc., current simulation year
B: Base year of projection

In order to express the above equation as a linear constraint of the NLP it is rearranged. The coefficients (te) give the unit changes of ROW net imports (net exports) resulting from an increase of the world market price by one unit:

Eq. 4.3.2.-1

$$-TR_i + te_i WP_i = c_i$$

TR: ROW net imports
WP: World market price
te: Coefficient of the behavioural equation for ROW net import
c: Constant term of the behavioural equation for ROW net import

<u>Specification</u>

The price response coefficients are calculated from the corresponding elasticities. According to the modelling assumptions (see above), π gives the percentage change of ROW net imports (net exports) from its base year value in response to a one-percent-change of the world market price from its base year value. Base year values are therefore used to transform the elasticities into linear coefficients.

Eq. 4.3.2.-2

Price response: Constant term:

$$te_i = \pi_a \frac{ROWI_{a,B}}{WPRI_{a,B}} \qquad c_i = -ROWI_{a,B} + te_i WP_{a,B}$$

a: Subsc., Additional Demand Component, product (corresponding to NLP constraint i)

If the world market price is defined as an exogenous variable, MFSS does not operate with a corresponding behavioural equation for ROW net trade (see also ch. 5.2.1.1.).

4.3.3. Price transmission between EUR-pool and ROW market

For each of the raw and processed products, the model has, potentially, a corresponding price transmission equation which determines EUR-pool prices dependent on world market prices.

Structure

The price transmission coefficient (pw) gives the unit change of the EUR-pool price resulting from a unit change of the world market price:

Eq. 4.3.3.-1

$$EP_i - pw_i WP_i = 0$$

WP: World market price
EP: EUR-pool price

Specification

The price transmission coefficients can be specified from expert proposals about the price gaps or by assuming that the price gaps will stay at their base year's values.

Eq. 4.2.3.1.-2

$$pw_i = -\frac{1 + PWD_{a,E \wedge S}}{EX_S} \quad \text{with} \quad PWD_{a,S} = \frac{CPRI_{EUR,a,B} EX_B}{WPRI_{a,B}} - 1$$

PWD: Price gap between EUR-pool and world market (%)
WPRI: World market price (in US-$)
CPRI: Consumer price, Additional Demand Component
EX: Exchange rate US-$/ECU
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
EUR: Subsc., EUR level
E: Subsc., expert proposal
S: Subsc., current year of simulation
B: Subsc., base year of projection

If the EUR-pool price or EUR net trade are defined as exogenous variables, the model operates without the respective price transmission equation (see also ch. 4.3. and 5.2.2.1.).

4.3.4. The objective function

The external trade component maximizes a quasi social welfare function, subject to the constraints described. The objective function measures utility (production costs) as the area under the net import curve (net export curve).

Structure

Eq. 4.3.4.-1

$$\sum_i ob_i TR_i = \max!$$

ob: Coefficients of the objective function

Specification

The quasi social welfare impact of net imports (net exports) is measured via a non-linear function with quadratic elements. Utility is measured as the area under the linear net import (net export) curve described above (see ch. 4.3.2.).

Eq. 4.3.4.-2

$$ob_i = \left(-\frac{c_i}{te_i} + \frac{1}{2te_i} TR_i \right) EX_S$$

te: Coefficient of the behavioural equation for ROW net trade (see eq. 4.3.2.-2)
c: Constant term of the behavioural equation for ROW net trade (see eq. 4.3.2.-3)
TR: ROW net import
EX: Exchange rate US-$/ECU
S: Subsc., current simulation year

5. LINKAGE OF THE MODEL COMPONENTS AND PRICE FORMATION

In chapter 4 the MFSS components were described in detail.

In the present version of MFSS, the linkage of the supply, demand and external trade component follows the dynamic coupling principle. Beginning with the first year of the projection period (t+1), the model solves the supply component, with expected prices assumed as the relevant incentives for the supply response of the agricultural sector in t+1. The solution of the supply component gives information about the sales and purchases of the agricultural sector in t+1. The sales and purchases are model input to the next step, the simultaneous solution of the demand and external trade component for t+1. The solution of the demand and external trade components comprise the consumer prices for t+1. The farmgate prices for t+1 are derived from the consumer prices for t+1 and influence the price expectations for t+2. For the second and further projection years, this coupling procedure is repeated.

The linkage between consumer prices and farmgate prices is described in chapter 5.1.

Price formation depends mainly on the assumed market policy for a specific model simulation run. The model allows us to specify several different types of price formation, which are described in chapter 5.2.

5.1. Linkage between consumer and farmgate prices

Consumer and farmgate prices are linked by consumer price elasticities with respect to raw product costs, which are defined as the percentage change in consumer prices with respect to a one-percent-change in raw product costs:

Eq. 5.1.-1

$$CPRI_{a,x} = CPRI_{a,B}\left(1+\frac{\phi_a \Delta RAWP_a}{100}\right) \quad \text{where } \Delta RAWP_a = \left(\frac{RAWP_{a,x}}{RAWP_{a,B}}-1\right)100 \qquad x = S,T,B$$

CPRI: Consumer price, Additional Demand Component
RAWP: Raw product costs
ϕ: Elasticty of consumer price with respect to raw product costs
a: Subsc., Additional Demand Component, product
S: Subsc., current simulation year
T: Subsc., trend-based
B: Subsc., base year of projection

The raw product costs are derived from farmgate prices and processing coefficients:

Eq. 5.1.-2

$$RAWP_{a,x} = \frac{PU_{PRIC,b,x}}{PRCE_{a,x}} \qquad x = S,T,B$$

PU: Output use price, ABTA
PRCE: Processing coefficient
PRIC: Subsc., ABTA, price element : farmgate price
b: Subsc., ABTA, final product (corresponding to product a of the Add. Demand Component)

For processed products, the processing coefficients are defined as the output-input-ratio between the processed and the corresponding raw products and can be specified from expert proposals or are estimated from the data of the base year of projection. For raw products, the processing coefficients are unity:

Eq. 5.1.-3

Raw products

$$PRCE_{a,x} = 1 \qquad x = S,T,B$$

Processed products

$$PRCE_{a,x} = PRCE_{a,E} \succ \left(\frac{DR_{MAPR,a}}{DU_{PPRO,b}}\right)_B \qquad x = S,T,B$$

DU: Uses, Additional Demand Component
DR: Resources, Additional Demand Component
MAPR: Subsc., Additional Demand Component, marketable production
PPRO: Subsc., Additional Demand Component, processing
b: Subsc., Additional Demand Component, raw product corresponding to processed product a
E: Subsc., expert proposal

The elasticities of consumer prices with respect to raw product costs can be specified by expert proposals (first priority) or are calculated by assuming a constant absolute difference between the consumer prices and the raw product costs against the base year of projection:

Eq. 5.1.-4

$$\phi_a = \phi_{a,E} \succ \frac{RAWP_{a,B}}{CPRI_{a,B}}$$

5.2. Price formation

5.2.1. Exogenous vs. endogenous world market price

5.2.1.1. Exogenous world market price

If a world market price is defined as exogenous, the model does not work with a corresponding behavioural equation for ROW net trade. ROW net trade is then completely elastic with respect to world market prices, and therefore completely adjusts in order to cover any supply-demand-deficits or to absorb any supply-demand-surpluses of the EUR aggregate. Such a scenario might be plausible for products for which the EUR aggregate has only a small share in total world trade.

An exogenous world market price can be specified from expert proposals or from the base year of projection:

Eq. 5.2.1.1.-1

$$WP_i = WPRI_{a,E \wedge B}$$

WP: World market price
WPRI: World market price (in US -$)
a: Subsc., product (corresponding to NLP activity i)
E: Subsc., expert proposal
B: Subsc., base year of projection

Exogenous world market prices are effected within the NLP framework by setting bounds on the world market price variables.

5.2.1.2. Endogenous world market price

If a world market price is not defined as exogenous, the model works with a corresponding behavioural equation for ROW net trade which determines ROW net trade dependent on world market prices. MFSS operates on that world market price which clears the ROW net trade balance.

5.2.2. Exogenous vs. endogenous EUR-pool price

5.2.2.1. Exogenous EUR-pool price

If an EUR-pool price is defined as an exogenous variable, the model operates without the corresponding price transmission equation between the EUR-pool and the world market. The EUR-pool price does not then depend on the world market price. In defining EUR-pool prices as exogenous, one can simulate the effects of market policies which aim at guaranteeing fixed prices at aggregate EUR level (e.g. intervention price regime with variable levies and export refunds).

If EUR net trade is defined as an exogenous variable, MFSS does not allow one to work with exogenous EUR-pool prices, in order to avoid inconsistencies or infeasibilities of the model.

The EUR-pool price can be specified from expert proposals or calculated from raw product costs according to the linkage equations described in chapter 5.1.

Eq. 5.2.2.1.-1

$$EP_i = CPRI_{EUR,a,E \wedge S}$$

EP: EUR-pool price
CPRI: Consumer price, Additional Demand Component
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
EUR: Subsc., EUR aggregate
E: Subsc., expert proposal
S: Subsc., current simulation year

In order to calculate the raw product costs at EUR level, EUR farmgate prices are aggregated from regional farmgate prices. The regional farmgate prices can be specified by expert proposals, trend extrapolations or from the base year of projection.

Eq. 5.2.2.1.-3

$$PU_{R,PRIC,b,S} = PU_{R,PRIC,b,E \wedge T \wedge B}$$

PU: Output use price, ABTA
PRIC: Subsc., ABTA, price element : farmgate price
b: Subsc., ABTA, product
R: Subsc., Member State (region)
T: Subsc., trend-based
B: Subsc., base year of projection

Exogenous EUR-pool prices are effected within the NLP framework by setting bounds on the EUR-pool price variables.

5.2.2.2. Endogenous EUR-pool price

If an EUR-pool price is not defined as an exogenous variable, the model operates with the corresponding price transmission equation between the EUR-pool and the world market so that the EUR-pool price depends on the world market price. Endogenous EUR-pool prices might be a plausible scenario for products for which no market price intervention aiming at fixed prices exist.

5.2.3. Exogenous vs. endogenous regional consumer prices

5.2.3.1. Exogenous regional consumer price

In defining regional prices as exogenous, one can simulate the effects of market policies which aim at guaranteeing fixed prices at Member State level.

If the model works with price transmission equations between the region and the EUR-pool, MFSS does not allow one to work with an exogenous regional consumer price, in order to avoid inconsistencies and infeasibilities of the model. For this case, an exogenous regional consumer price can only come indirectly into effect if the EUR-pool price is also exogenous and no expert proposal on the exogenous price gap is specified (see ch. 4.2.3.1.).

An exogenous regional consumer price can be specified from expert proposals or calculated from raw product costs according to the linkage equations described in chapter 5.1.. The regional farmgate prices needed for the linkage equations are in this case specified as described in ch. 5.2.2.1. (see eq. 5.2.2.1.-3):

Eq. 5.2.3.1.-1

$$RP_i = CPRI_{R,a,E\wedge S}$$

RP: Regional consumer price
CPRI: Consumer price, Additional Demand Component
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
R: Subsc., Member State (region)
E: Subsc., expert proposal
S: Subsc., current simulation year

Exogenous regional consumer prices are effected within the NLP framework by setting bounds on the regional consumer price variables.

5.2.3.2. Endogenous regional consumer price

If a regional consumer price is not defined as an exogenous variable, the regional consumer price depends on the EUR-pool price via the corresponding price transmission equation between the Member State (region) and the EUR-pool. Endogenous regional consumer prices might be a plausible scenario for products for which there is no market price intervention aiming at fixed prices.

6. COMPUTATION OF THE ABTA, MAC AND ADDITIONAL DEMAND COMPONENT

The structure and contents of the ABTA, MAC and Additional Demand Component are described in detail in Vol. 1 of the methodological documentation (Wolf, 1995). This chapter of Vol. 2 of the methodological documentation focuses on the computation of the ABTA, MAC and Additional Demand Component from the projection results of the model components of MFSS.

6.1. ABTA and MAC

The ABTA and MAC consist of physical components from which the valued components are calculated by multiplication with price elements. The aggregation of the valued ABTA component across the production and use activities gives the sectoral monetary aggregates (e.g. sectoral gross value added at market prices.) The aggregation of the valued MAC component across product and input items gives the activity-specific monetary aggregates (e.g. gross value added at market prices per unit of production activity).

6.1.1. Physical components

6.1.1.1. Production activity levels

The ABTA production activities have a one-to-one correspondence to those of the activity model of the supply component, except for "heifers", which is aggregated from "heifers for fattening" and "heifers for breeding".

Eq. 6.1.1.1.-1

Crop production activities:

$$LEVL_a = CP_i$$

Animal production activities:

Heifers:

$$LEVL_{HEIF} = AP_{APHF} + AP_{APHB}$$

Others:

$$LEVL_a = AP_i$$

Fallow land:

$$LEVL_{FALL} = OPFA$$

LEVL: Level of production activity, ABTA
CP: Crop production activity
AP: Animal production activity
OPFA: Fallow land
a: Subsc., ABTA, production activity (corresponding to NLP activity i)

6.1.1.2. Output Generation and Input Use of the MAC

The Output Generation and Input Use data of the MAC comprise the output and input coefficients of the production activities per unit of the production activities.

6.1.1.2.1. Output Generation

The crop output coefficients and most of the animal output coefficients of the MAC have a one-to-one correspondence to the crop output coefficients of the yield model of the MFSS supply component.

However, the beef, dairy cow and suckler cow output coefficients of the production activities "dairy cows" and "suckling calves" are not determined in the yield model. They are derived from the results of the activity model of the supply component for the slaughterings and slaughtering weights.

Also the beef, dairy cow and suckler cow output coefficients of "heifers" are not determined in the yield model, but from the results of the activity model.

Eq. 6.1.1.2.1.-1 describe the determination of the MAC output coefficients:

Eq. 6.1.1.2.1.-1

Crop output coefficients:

$$XMG_{a,b} = XMG_{a,b,S}$$

Beef output coefficients of production activities "dairy cows" and "suckling calves":

$$XMG_{a,b} = \frac{SL_q fo_{q,i}}{LEVL_a} \quad b = BEEF,\ i = FOBE, \text{ and } a = q \text{ for all } a = MILK, CALV \text{ and } q = SLDC, SLSC$$

Dairy and suckler cow output coefficients of production activities "dairy cows" and "suckling calves":

$$XMG_{a,b} = 1 - \frac{SL_q}{LEVL_a} \quad a = b = q \text{ for all } a = MILK, CALV,\ b = DCOW, SCOW \text{ and } q = SLDC, SLSC$$

Beef output coefficient of production activity "heifers":

$$XMG_{a,b} = \frac{AP_j fo_{j,i}}{LEVL_a} \quad a = HEIF,\ b = BEEF,\ j = APHF,\ i = FOBE$$

Dairy and suckler cow output coefficients of production activity "heifers":

$$XMG_{a,b} = \frac{TF_v}{LEVL_a} \quad a = HEIF \text{ and } b = v \text{ for all } b = DCOW, SCOW \text{ and } v = TFDC, TFSC$$

All other animal output coefficients:

$$XMG_{a,b} = XMG_{a,b,S}$$

XMG: Output Generation, MAC, physical component
SL: Intrasectoral transfer - output-output-transfer: slaughterings of dairy and suckler cows
TF: Intras. transf. - output-output-transf.: transition of young cows into dairy a. suckler cows
fo: Coefficients of the NLP output balances (see eq. 4.1.3.5.1.3.-2 and 4.1.3.5.1.3.-3)
a: Subsc., ABTA, production activity
b: Subsc., ABTA, product
i: Subsc., NLP constraints, output balances
S: Subsc., current simulation year

6.1.1.2.2. Input Use

The manure and mineral nitrogen, phosphate and potassium input coefficients are derived from the results of the fertilizer module of the activity model. The fertilizer input to a production activity is equal to the level of the activity-specific fertilizing activity (MI or OR) multiplied by the nutrient content of the fertilizing activity (fi). For mineral phosphate and potassium an additional term (z) estimates the share of the production activity in the non-specific fertilizing activity (DF). Eq. 6.1.1.2.2.-1 presents the formulas for the calculation of the fertilizer input coefficients of the MAC:

Eq. 6.1.1.2.2.-1

Mineral fertilizer:

$$YMU_{a,k} = \frac{MI_{j_2} fi_{j_2,i} + z_k}{LEVL_a}$$

for $k = NITF$: $\quad z_k = 0$

for $k = PHOF, POTF$: $\quad z_k = DF_l \dfrac{MI_{j_2} + OR_{j_3} AVF}{\sum\limits_{j_2} MI_{j_2} + \sum\limits_{j_3} OR_{j_3} AVF}$

Fertilizer from manure:

$$YMU_{a,k} = \frac{OR_{j_3} fi_{j_3,i}}{LEVL_a}$$

YMU: Input Use, MAC, physical component
LEVL: Level of production activity, ABTA
MI: Mineral fertilizing activity: specific to crop production activity
OR: Organic fertilizing activity: specific to crop production activity
DF: Mineral fertilizing activity: non-specific to crop production activity
AVF: Availability factor for nitrogen from manure (%/100)
fi: Coefficients of the input balances for fertilizer and manure (see eq. 4.1.3.5.2.1.-2)
a: Subsc., ABTA, production activity
k: Subsc., ABTA, input item
i: Subsc., NLP constraint, input balances for fertilizer or manure (corresp. to input item k)
$j_2 j_3$: Subs., NLP act., specific mineral and organic fertilizing act. (corresp. to prod. activity a)
l: Subsc., NLP activity, non-specific fertilizing activity (corresponding to input item k)

The fodder input coefficients are derived from the results of the feed module of the activity model (see eq. 6.1.1.2.2.-2):

Eq. 6.1.1.2.2.-2

Fodder input items:

$$YMU_{a,k} = \frac{Z_{a,k}}{LEVL_a}$$

with

$$Z_{a,FCER} = C1_{l_1} + C2_{l_2} \quad Z_{a,FPRO} = PR_{l_3} \quad Z_{a,FENE} = EN_{l_4}$$

$$Z_{a,FMIL} = RM_{l_5} + MP_{l_6} \quad Z_{a,FDRY} = DR_{l_7} \quad Z_{a,FFSI} = FS_{l_8} \quad Z_{a,FOTH} = FS_{l_9}$$

C1: Feeding with cereal-mix 1
C2: Feeding with cereal-mix 2
PR: Feeding with rich protein fodder
EN: Feeding with rich energy fodder
RM: Feeding with raw milk fodder
MP: Feeding with milk products fodder
DR: Feeding with dried fodder
FS: Feeding with fresh and ensilaged fodder
OT: Feeding with other fodder
l_X: Subsc., NLP act., feeding activity (corresponding to production activity a and input item k)

The input coefficients for lime fertilizer, plant protection, live animal inputs, animal imports (EAA), pharmaceutical input, general input items and fixed input items are directly available from the yield model of the supply component:

Eq. 6.1.1.2.2.-3

Lime fertilizer, plant protection, live animal inputs, animal imports (EAA), pharmaceutical input, general and fixed input items:

$$YMU_{a,k} = YMU_{a,k,S}$$

S: Subsc., current simulation year

6.1.1.3. Output Generation and Output Use, Input Use and Input Generation of the ABTA

Physical production of ABTA product items (Output Generation) is calculated from the MAC output coefficients and the production activity levels:

Eq. 6.1.1.3.-1

$$XG_{a,b} = XMG_{a,b} LEVL_a$$

XG: Output Generation, ABTA, physical component
XMG: Output Generation, MAC, physical component
a: Subsc., ABTA, production activity
b: Subsc., ABTA, product

Output use consists of intersectoral and intrasectoral use. Intersectoral sales of ABTA product items have a one-to-one correspondence to the sales activities of the activity model of the supply component:

Eq. 6.1.1.3.-2

$$XU_{TRAP,b} = SA_i$$

XU: Output Use, ABTA, physical component
SA: Intersectoral transfer - sales
TRAP: Subsc., ABTA, intersectoral interaction - sales

Intrasectoral uses of ABTA product items have a one-to-one correspondence to the intrasectoral transfer activities of the activity model of the supply component. Therefore, the use categories "animals feed on farm", "stock changes on farm" and "human consumption on farm" are directly taken over from the solution of the activity model of the supply component. "Losses on farm" are calculated as the difference between production, sales and intrasectoral uses (see eq. 6.1.1.3.-3).

Eq. 6.1.1.3.-3

Animal feed on farm:

$$XU_{FEEP,b} = FF_i$$

Seed on farm:

$$XU_{SEEP,b} = SF_i$$

Intermediate animal products:

$$XU_{MANN,MANN} = MA_{MANN} \qquad XU_{MANK,MANK} = MA_{MANK} \qquad XU_{MANP,MANP} = MA_{MANP}$$

$$XU_{CALP,CALV} = IA_{IACV} \qquad XU_{HEIP,HEIF} = IA_{IAHE} \qquad XU_{COWP,DCOW} = IA_{IADC}$$

$$XU_{COWP,SCOW} = IA_{IASC} \qquad XU_{PIGP,PIGL} = IA_{IAPG} \qquad XU_{BULP,BULL} = IA_{IABU}$$

$$XU_{LAMP,LAMB} = IA_{IALB} \qquad XU_{CHIP,CHIC} = IA_{IACH}$$

Stock changes on farm:

$$XU_{PCSF,b} = CF_i$$

Human consumption on farm:

$$XU_{PCOF,b} = HF_i$$

Losses on farm:

$$XU_{PLOF,b} = \sum_a XG_{a,b} - \sum_c XU_{c,b} - XU_{TRAP,b} \quad c = FEEP, SEEP, \ldots, PCOF$$

FF: Intrasectoral transfer - animal feed on farm
SF: Intrasectoral transfer - seed on farm
MA: Intrasectoral transfer - nutrients from manure
IA: Intrasectoral transfer - intermediate animals
CF: Intrasectoral transfer - stock changes on farm
HF: Intrasectoral transfer - human consumption on farm
FEEP,SEEP...: Subsc., ABTA, intrasectoral uses

Physical intermediate input of ABTA input items (Input Use) is calculated from the MAC input coefficients and the production activity levels:

Eq. 6.1.1.3.-4

$$YU_{a,k} = YMU_{a,k} LEVL_a$$

YU: Input Use, ABTA, physical component
YMU: Input Use, MAC, physical component
k: Subsc., ABTA, input item

Input Generation consists of intersectoral purchases and intrasectoral input generation. Intersectoral purchases of ABTA input items are computed from corresponding purchase activities of the activity model of the supply component:

Eq. 6.1.1.3.-5

Seed inputs:

$$YG_{TRAP,SEEP} = \sum_{l} PS_l SP_{l,85}$$

Fodder input items:

$$YG_{TRAP,FCER} = \sum_{v=PFSW}^{PFRI} PF_v \qquad YG_{TRAP,FPRO} = \sum_{v=PFPU}^{PFOP} PF_v$$

$$YG_{TRAP,FENE} = PF_{PFEN} \qquad YG_{TRAP,FMIL} = \sum_{v=PFMI}^{PFMP} PF_v \qquad YG_{TRAP,FOTH} = PF_{PFOT}$$

Other input items:

$$YG_{TRAP,k} = PU_r$$

YG: Input Generation, ABTA, physical component
SP: Estimated price for the single seed input item (see eq. 4.1.3.11.-3)
TRAP: Subsc., ABTA, purchases
PS: Intersectoral transfer - purchases of seeds
PF: Intersectoral transfer - purchases of fodder
PU: Intersectoral transfer - purchases

Intrasectoral generation of ABTA input items is compiled from the data on intrasectoral use of ABTA product items (see eq. 6.1.1.3.-6). In the case of animal feed the intrasectoral generation of the input items is calculated by an aggregation across the more differentiated product list (e.g. the intrasectoral generation of fodder cereals is calculated by adding the intrasectoral feed use of the seven cereal product items). Intrasectoral generation of the seed input item is calculated by weighting the seed use quantities of the product items by the internal use prices of the base year.

Eq. 6.1.1.3.-6

Animal feed on farm:

$$YG_{FEEP,k} = \sum_b XU_{FEEP,b}$$

Seed on farm:

$$YG_{SEEP,SEEP} = \sum_b XU_{SEEP,b} PU_{PRIN,b,85}$$

Intermediate animal products:

$$YG_{MANN,NITM} = XU_{MANN,MANN} \quad YG_{MANP,PHOM} = XU_{MANP,MANP}$$

$$YG_{MANK,POTM} = XU_{MANK,MANK}$$

$$YG_{CALP,ICAL} = XU_{CALP,CALV} \quad YG_{HEIP,IHEI} = XU_{HEIP,HEIF} \quad YG_{PIGP,IPIG} = XU_{PIGP,PIGL}$$

$$YG_{COWP,ICOW} = XU_{COWP,SCOW} + XU_{COWP,DCOW}$$

$$YG_{BULP,IBUL} = XU_{BULP,BULL} \quad YG_{LAMP,ILAM} = XU_{LAMP,LAMB} \quad YG_{CHIP,ICHI} = XU_{CHIP,CHIC}$$

Losses on farm:

$$YG_{PLOF,PLOF} = \sum_b YG_{PLOF,b} PU_{PRIN,b,85}$$

6.1.2. Price elements of the ABTA

ABTA related prices are divided into three categories:

- Farmgate prices represent the prices received (paid) per unit of a product (input) item in intersectoral sales (purchases). Farmgate prices are used to value the sales (purchases), stock changes on farm and human consumption on farm, which are the physical equivalents to the production value (intermediate input) of the EAA.
- Internal use prices are used for valuing all other intrasectoral output uses and input generations.
- Unit value prices are weighted averages of the farmgate and internal use prices.

6.1.2.1. Farmgate prices

The consumer prices for raw and processed product of the Additional Demand Component, which can be defined as exogenous or endogenous model variables (see ch. 5.2.2. and 5.2.3.), are obtained from the solution of the demand component:

Eq. 6.1.2.1.-1

$$CPRI_a = RP_i$$

CPRI: Consumer price, Additional Demand Component
RP: Regional consumer price
a: Subsc., Additional Demand Component, product (corresponding to NLP activity i)

The farmgate prices for final products are derived from the consumer prices by a transformation of the price linkage equations (5.1.-1) and (5.1.-2):

Eq. 6.1.2.1.-2

$$PU_{PRIC,b} = RAWP_a PRCE_{a,S}$$

$$RAWP_a = \left(\frac{\Delta RAWP_a}{100} - 1\right) RAWP_{a,B} \quad \text{where } \Delta RAWP_a = \frac{1}{\phi_a}\left(\frac{CPRI_a}{CPRI_{a,B}} - 1\right)100$$

PU: Output use price, ABTA
RAWP: Raw product costs (see eq. 5.1.-2)
PRCE: Processing coefficient (see eq. 5.1.-3)
ϕ: Elasticity of consumer price with respect to raw product costs (see eq. 5.1.-4)
PRIC: Subsc., ABTA, price element: farmgate price
b: Subsc., ABTA, final product (corresp. to product a of the Additional Demand Component)
S: Subsc., current simulation year
B: Subsc., base year of projection

The farmgate prices for input items can be specified from expert proposals, trend extrapolations or from the base year of projection according to the user-defined overlay structure.

Eq. 6.1.2.1.-3

$$QG_{PRIC,k} = QG_{PRIC,k,E \wedge T \wedge B}$$

QG: Input generation price, ABTA
k: Subsc., ABTA, input item
E: Subsc., expert proposal
T: Subsc., trend-based

6.1.2.2. Internal use prices

The internal use prices of final products, live animal outputs and nutrients from manure are calculated assuming constant ratios between farmgate and internal use prices. If farmgate prices are not available, the internal use prices are determined from trend extrapolations or from the base year of projection.

The internal use prices of intermediate crop products are based on production costs (see Wolf, 1995). MFSS therefore calculates them by assuming a constant ratio to production costs.

Eq. 6.1.2.2.-1

Final products and live animal outputs:

$$PU_{PRIN,b} = PU_{PRIC,b} \frac{PU_{PRIN,b,B}}{PU_{PRIC,b,B}} \succ PU_{PRIN,b,T\wedge B}$$

Nutrients from manure:

$$PU_{PRIN,b} = PU_{PRIC,k} \frac{PU_{PRIN,b,B}}{QG_{PRIC,k,B}} \succ PU_{PRIN,b,T\wedge B}$$

$b = k$ for all $b = MANN, MANK, MANP$ and $k = NITF, POTF, PHOF$

Intermediate crop products:

$$PU_{PRIN,OROO} = \frac{\dfrac{IMU_{OROO,TOIN}}{XMG_{OROO,OROO}}}{\dfrac{IMU_{OROO,TOIN,B}}{XMG_{OROO,OROO,B}}} PU_{PRIN,OROO,B}$$

$$PU_{PRIN,b} = \frac{\dfrac{\sum_a IMU_{a,TOIN} LEVL_a}{\sum_a \sum_c XG_{a,c} C_{DRMA,c}}}{\dfrac{\sum_a IMU_{a,TOIN,B} LEVL_{a,B}}{\sum_a \sum_c XG_{a,c} C_{DRMA,c,B}}} PU_{PRIN,b,B} \frac{C_{DRMA,b}}{C_{DRMA,b,B}}$$

$a=OROO,GRAS,SILA$ and $c=GRAS,SILA,DHAY$ for all $b=GRAS,SILA,DHAY,STRA$

PU: Output use price, ABTA
QG: Input generation price, ABTA
IMU: Input use, MAC, value component (see eq. 6.1.5.-1)
XMG: Output Generation, MAC, physical component
XG: Output Generation, ABTA, physical component
LEVL: Level of production activity, ABTA
C: Dry matter contents of fodder input items, ABTA
PRIC, PRIN: Subsc., ABTA, price elements: farmgate price and internal use price
TOIN: Subsc., ABTA, total intermediate input
a: Subsc., ABTA, production activity
b,c: Subsc., ABTA, product
k: Subsc., ABTA input item
B: Subsc., base year of projection

The internal use prices of input items are aggregated from the internal use prices of the corresponding product items:

Eq. 6.1.2.2.-2

$$QG_{PRIN,k} = \frac{\sum_{c} XU_{c,b} PU_{PRIN,b}}{YG_{c,k}}$$

XU: Output Use, ABTA, physical component
YG: Input Generation, ABTA, physical component
c: Subsc., ABTA, intrasectoral uses (corresponding to input item k)

6.1.2.3. Unit value prices

The unit value prices for product and input items are weighted averages of the farmgate and internal use prices:

Eq. 6.1.2.3.-1

$$PG_b = \frac{\sum_{c_1} XU_{c_1,k} PU_{PRIC,b} + \sum_{c_2} XU_{c_2,b} PU_{PRIN,b}}{\sum_{c_1} XU_{c_1,b} + \sum_{c_2} XU_{c_2,b}}$$

$$QU_k = \frac{\sum_{c_1} YG_{c_1,k} QG_{PRIC,k} + \sum_{c_2} YG_{c_2,k} QG_{PRIN,k}}{\sum_{c_1} YG_{c_1,k} + \sum_{c_2} YG_{c_2,k}}$$

$c_1 = TRAP, PCOF, PCSF$ and $c_2 = PLOF, FEEP, ..., CHIP$

PG: Output generation price (unit value), ABTA
QU: Input use price (unit value), ABTA
QG: Input generation price, ABTA
PU: Output use price, ABTA
XU: Output Use, ABTA, physical component
YG: Input Generation, ABTA, physical component
PRIC, PRIN: Subsc., ABTA, price elements: farmgate price and internal use price
k: Subsc., ABTA input item

6.1.3. Value Components of the ABTA and MAC

All elements of the physical components of the ABTA and MAC are determined according to the equations described in ch. 6.1.1 and all price elements according to the equations described in ch. 6.1.2.. The value components are calculated by multiplying the elements of the physical components with the corresponding price elements:

Eq. 6.1.3.-1

ABTA:

$$OG_{a,b} = XG_{a,b}PG_b \qquad OU_{c,b} = XU_{c,b}PU_{c,b}$$
$$IG_{c,k} = YG_{c,k}QG_{c,k} \qquad IU_{a,k} = YU_{a,k}QU_k$$

MAC:

$$OMG_{a,b} = \frac{OG_{a,b}}{LEVL_a} \qquad IMU_{a,k} = \frac{IU_{a,k}}{LEVL_a}$$

OG: Output Generation, ABTA, value component
OU: Output Use, ABTA, value component
IG: Input Generation, ABTA, value component
IU: Input Use, ABTA, value component
XG: Output Generation, ABTA, physic. comp.
XU: Output Use, ABTA, physic. comp.
YG: Input Generation,ABTA physic. comp.
YU:Input Use, ABTA physic. comp.
PG: Output generation price (unit value), ABTA
QU: Input use price (unit value), ABTA
QG: Input generation price, ABTA
PU: Output use price, ABTA
OMG: Output Generation, MAC, value component
IMU: Input use, MAC, value component
LEVL: Level of production activity, ABTA
a: Subsc., ABTA, production activity
b: Subsc., ABTA product
c: Subsc., ABTA, use activity and price element corresponding to use activity
k: Subsc., ABTA input item

6.1.4. Sectoral monetary aggregates: production, intermediate input and gross value added at market prices

For the measurement of monetary production and intermediate input, two concepts are distinguished in the ABTA:

- The SPEL concept looks at non-consolidated ("gross") flows between the activities, i.e. the production value also includes intrasectoral transfers (within the "national farm") of product items (e.g. barley) into input items (e.g. fodder cereals).
- The EAA concept looks at consolidated ("net") flows.

6.1.4.1. SPEL concept

Sectoral monetary production (intermediate input) according to the SPEL concept is calculated by multiplying physical Output Use (physical Input Use) with corresponding unit value prices (see eq. 6.1.3.-1) and subsequent aggregation across production activities:

Eq. 6.1.4.1.-1

in current prices:

$$PROV_b = \sum_a OG_{a,b} \qquad PROV_{PROV} = \sum_b PROV_b$$

$$PROV_k = \sum_a IU_{a,k} \qquad PROV_{TOIN} = \sum_k PROV_k$$

$$PROV_{GVAM} = PROV_{PROV} - PROV_{TOIN}$$

in constant prices:

$$PROC_b = \sum_a XG_{a,b}\, PG_{b,85} \qquad PROC_k = \sum_a YU_{a,k}\, QU_{k,85}$$

$$PROC_{PROV} = \sum_b PROC_b \qquad PROC_{TOIN} = \sum_k PROC_k$$

$$PROC_{GVAM} = PROC_{PROV} - PROC_{TOIN}$$

PROV: Gross production and intermediate input, SPEL concept, in current prices,
PROC: Gross production and intermediate input, SPEL concept, in constant prices
OG: Output Generation, ABTA, value component
IU: Input Use, ABTA, value component
PG: Output generation price (unit value), ABTA
QU: Input use price (unit value), ABTA
XG: Output Generation, ABTA, physical component
YU: Input Use, ABTA, physical component
b: Subsc., ABTA product
k: Subsc., ABTA input item
PROV: Subsc., ABTA, gross production valued
TOIN: Subsc., ABTA, total intermediate input
GVAM: Subsc., ABTA, gross value added at market prices

6.1.4.2. EAA concept

Sectoral monetary production (intermediate input) according to the EAA concept is calculated by multiplying the sum of physical sales (purchases), stock changes on farm and human consumption on farm with farmgate prices:

Eq. 6.1.4.2.-1

in current prices:

$$PEAV_b = \sum_c XU_{c,b}\, PU_{PRIC,b} \qquad PEAV_{PROV} = \sum_b PEAV_b$$

$$PEAV_k = \sum_c YG_{c,k}\, QG_{PRIC,k} \qquad PEAV_{TOIN} = \sum_k PEAV_k$$

$$PEAV_{GVAM} = PEAV_{PROV} - PEAV_{TOIN}$$

$c = TRAP, PCOF, PCSF$

in constant prices:

$$PEAC_b = \sum_c XU_{c,b}\, PU_{PRIC,b,85} \qquad PEAC_{PROV} = \sum_b PEAC_b$$

$$PEAC_k = \sum_c YG_{c,k}\, QG_{PRIC,k,85} \qquad PEAC_{TOIN} = \sum_k PEAC_k$$

$$PEAC_{GVAM} = PEAC_{PROV} - PEAC_{TOIN}$$

$c = TRAP, PCOF, PCSF$

PEAV: Final production or intermediate input, EAA concept, in current prices
PEAC: Final production or intermediate input, EAA concept, in constant prices
XU: Output Use, ABTA, physical component
YG: Input Generation,ABTA, physical component
QG: Input generation price, ABTA
PU: Output use price, ABTA
b: Subsc., ABTA product
c: Subsc., ABTA, use activities (corresponding to EAA concept)
k: Subsc., ABTA input item
PROV: Subsc., ABTA, gross production valued
TOIN: Subsc., ABTA, total intermediate input
GVAM: Subsc., ABTA, gross value added at market prices

6.1.5. Activity-specific monetary aggregates: production, intermediate input and gross value added at market prices

Valued gross production (total intermediate input) by production activity is calculated by aggregating valued MAC Output Generation across all product (input) items. Gross value added at market prices per activity is the difference between valued gross production and total intermediate input:

Eq. 6.1.5.-1

Production activities:

$$OMG_{a,PROV} = \sum_b OMG_{a,b} \qquad IMU_{a,TOIN} = \sum_k IMU_{a,k}$$

$$IMU_{a,GVAM} = OMG_{a,PROV} - IMU_{a,TOIN}$$

Sectoral interactions:

$$OU_{c,PROV} = \sum_b OU_{c,b} \qquad IG_{c,TOIN} = \sum_k IG_{c,k}$$

$$IG_{c,GVAM} = OU_{c,PROV} - IG_{c,TOIN}$$

OMG: Output Generation, MAC, value component
IMU: Input Use, MAC, value component
OU: Output Use, ABTA, value component
IG: Input Generation, ABTA, value component
a: Subsc., ABTA, production activity
c: Subsc., ABTA, use activity and price element corresponding to use activity
b: Subsc., ABTA product item
k: Subsc., ABTA input item
PROV: Subsc., ABTA, gross production valued
TOIN: Subsc., ABTA, total intermediate input
GVAM: Subsc., ABTA, gross value added at market prices

6.1.6. Additional information

6.1.6.1. Additional agricultural value added information

Production-factor-related subsidies and taxes

The ABTA supplies additional information on the production-factor-related subsidies and production taxes related to the CAP reform (e.g. ha premiums). These positions are determined as described in Annex III. Taking into account production-factor-related subsidies and taxes a modified gross value added per unit of production activity is calculated. Also a sectoral aggregation of this information is provided by MFSS:

Eq. 6.1.6.1.-1

Production activities:

$$IMU_{a,MGVA} = IMU_{a,GVAM} + \sum_{c_1} OMG_{a,c_1} - \sum_{c_2} IMU_{a,c_2}$$

Sectoral aggregation:

$$PROV_{c_1} = \sum_{a} OMG_{a,c_1} LEVL_a \qquad PROV_{c_2} = \sum_{a} IMU_{a,c_2} LEVL_a$$

$$PROV_{MGVA} = PROV_{GVAM} + PROV_{c_1} - PROV_{c_2}$$

OMG: Output Generation, MAC, value component
IMU: Input Use, MAC, value component
LEVL: Level of production activity, ABTA
MGVA: Subsc., ABTA, modified gross value added at market prices
GVAM: Subsc., ABTA, gross value added at market prices
a: Subsc., ABTA, production activity
c_1,c_2: Subsc., ABTA, production factor related subsidies and taxes

Disaggregated subsidies and taxes

It is also planned that the ABTA structure should split up total sectoral subsidies and production taxes by production activities. But information on disaggregated subsidies and taxes is not yet available for the ex-post period. For MFSS, the following procedures are foreseen for the determination of activity differentiated subsidies and taxes:

- If they are defined as exogenous variables, expert proposals, trend-based values or the values of the base year of projection can be used.
- If they are not defined as exogenous, the differences of the production-factor-related subsidies and taxes between the current and the base year of projection are added to the activity-differentiated subsidies and taxes of the base year of projection. As long as disaggregated subsidies and taxes are not available for the ex-post period, they must be interpreted, for the projection period, as the difference of the production-factor-related subsidies and taxes between the current year and the base year of projection.

Eq. 6.1.6.1.-2

Production activities:

if exogenous:

$$OMG_{a,d_1} = OMG_{a,d_1,E \wedge T \wedge B} \qquad IMU_{a,d_2} = IMU_{a,d_2,E \wedge T \wedge B}$$

if not exogenous:

$$OMG_{a,d_1} = OMG_{a,d_1,B} - \sum_{c_1} OMG_{a,c_1,B} + \sum_{c_1} OMG_{a,c_1}$$

$$IMU_{a,d_2} = IMU_{a,d_2,B} - \sum_{c_2} IMU_{a,c_2,B} + \sum_{c_2} IMU_{a,c_2}$$

Sectoral aggregation:

$$PROV_{d_1} = \sum_a OMG_{a,d_1} LEVL_a \qquad PROV_{d_2} = \sum_a IMU_{a,d_2} LEVL_a$$

d_1,d_2: Subsc., ABTA, disaggregated subsidies or taxes
E: Expert proposal
T: Trend-based
B: Base year of projection

Total sectoral subsidies and taxes

The following alternatives are foreseen for the determination of the total sectoral subsidies and production taxes:

- Total sectoral subsidies and taxes can be defined as exogenous variables and determined from expert proposals, trend-based values or from the base year of projection.
- If they are not defined as exogenous, the differences of the activity-differentiated subsidies and taxes between the current and the base year of projection are added to the total sectoral subsidies and taxes of the base year of projection. This results in the following: as long as disaggregated subsidies and taxes are not available for the ex-post period and are not defined as exogenous variables, the change of total subsidies and production taxes equals the change of the production-factor-related subsidies and taxes.

Eq. 6.1.6.1.-3

if exogenous:

$$PEAV_{SUBS} = PEAV_{SUBS,E\wedge T\wedge B} \qquad PEAV_{TAXE} = PEAV_{TAXE,E\wedge T\wedge B}$$

if not exogenous:

$$PEAV_{SUBS} = PEAV_{SUBS,B} - \sum_{d_1} PROV_{d_1,B} + \sum_{d_1} PROV_{d_1}$$

$$PEAV_{TAXE} = PEAV_{TAXE,B} - \sum_{d_2} PROV_{d_2,B} + \sum_{d_2} PROV_{d_2}$$

SUBS: Subsc., ABTA, subsidies
TAXE: Subsc., ABTA, taxes linked to production

Total sectoral gross value added at factor costs

The sectoral gross value added at market prices is calculated according to the EAA concept by eq. 6.1.4.2.-1. Gross value added at factor costs is derived from this by adding subsidies and subtracting production taxes:

Eq. 6.1.6.1.-4

$$PEAV_{GVAF} = PEAV_{GVAM} + PEAV_{SUBS} - PEAV_{TAXE}$$

GVAF: Subsc., ABTA, gross value added at factor costs

Total sectoral net value added at factor costs

Primary factor input is not endogenously modelled by MFSS. Depreciation is therefore defined as an exogenous variable. The value of depreciation can be alternatively determined from expert proposals, trend estimations and from the base year of projection according to the user-defined priority. With given depreciation, total sectoral net value added at factor costs can be calculated:

Eq. 6.1.6.1.-5

Depreciation:

$$PEAV_{DEPB} = PEAV_{DEPB,E\wedge T\wedge B} \qquad PEAV_{DEPM} = PEAV_{DEPM,E\wedge T\wedge B}$$

Net value added at factor costs:

$$PEAV_{NVAF} = PEAV_{GVAF} - PEAV_{DEPB} - PEAV_{DEPM}$$

DEPB: Subsc., ABTA, depreciation buildings
DEPM: Subsc., ABTA, depreciation machinery

6.1.6.2. Aggregate physical production and intermediate input

Aggregate physical production (intermediate input) per product (input) item is calculated by aggregation of physical Output Generation (Input Use) across production activities:

Eq. 6.1.6.2.-1

$$PROP_b = \sum_a XG_{a,b} \qquad PROP_k = \sum_a YU_{a,k}$$

PROP: Aggregate physical production and intermediate input, ABTA
XU: Output Use, ABTA, physical component
YG: Input Generation, ABTA, physical component
b: Subsc., ABTA product item
k: Subsc., ABTA input item

6.1.6.3. Total land use

Total land use is aggregated from the crop production activity levels and the fallow land activity level:

Eq. 6.1.6.3.-1

$$PROPLEVL = \sum_a LEVL_a + LEVL_{FALL}$$

PROPLEVL: Total land use
LEVL: Level of production activity, ABTA
FALL: Subsc., ABTA, activity - fallow land
a: Subsc., ABTA, crop production activity

6.1.6.4. Agricultural labour input

Since primary factor input is not endogenously modelled in MFSS, it must be defined as exogenous if one wants, for example, to compute sectoral value Adidas per labour input:

Eq. 6.1.6.4.-1

$$PROPLABO = PROPLABO_{E \wedge T \wedge B}$$

PROPLABO: Total labour (annual work unit)
E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc., base year of projection

6.1.6.5. Macroeconomic variables

Macroeconomic (exchange rates, gross domestic product, price index of gross domestic product and total consumer expenditure) and demographic variables are exogenous to MFSS. They can be determined from different sources (expert proposals, trend extrapolations and the base year of projection).

6.2. Additional Demand Component

6.2.1. Domestic resources

Marketable production of raw products has a one-to-one correspondence to the NLP resource activities. Therefore, it can be directly taken over from the solution of the demand component (see eq. 6.2.1.-1).

Marketable production of processed products is derived from the NLP processing activities and the processing coefficients (for the calculation of the processing coefficients, see eq. 5.1.-3).

Marketable production of aggregated feed products is aggregated from corresponding NLP activities.

Eq. 6.2.1.-1

Raw products:

$$DR_{MAPR,b} = MA_i$$

Processed products:

$$DR_{MAPR,a} = PR_j PRCE_a$$

Aggregated feed products:

$$DR_{MAPR,FCER} = \sum_{k=FMSW}^{FMRI} FM_k$$

$$DR_{MAPR,FPRO} = \sum_{k=FMPU}^{FMOP} FM_k$$

$$DR_{MAPR,FENE} = FM_{FMEN}$$

$$DR_{MAPR,FMIL} = \sum_{k=FMMI}^{FMMP} FM_k$$

$$DR_{MAPR,FOTH} = FM_{FMOT}$$

DR: Resources, Additional Demand Component
MA: Marketable production of products
FM: Marketable production of aggregated feed products
PR: Processing
PRCE. Processing coefficient (see eq. 5.1.-3)
MAPR: Subsc., Additional Demand Component, marketable production
a: Subsc., Additional Demand Component, processed product (corresponding to NLP activity j)
b: Subsc., Additional Demand Component, raw product (corresponding to NLP activity i)
FCER,FPRO,...: Subs., Add. Dem. Comp., aggregate feed products (corresp. to NLP act. k)

6.2.2. Domestic uses

Domestic uses of products have a one-to-one correspondence to the NLP use activities. Therefore, they can be directly taken over from the solution of the demand component (see eq. 6.2.2.-1).

Domestic uses of aggregated feed products are aggregated from corresponding NLP activities.

Eq. 6.2.2.-1

Raw and processed products:

$$DU_{PCOM,b} = HM_i \qquad DU_{PFEE,b} = MF_k \qquad DU_{PSEE,b} = SM_i$$

$$DU_{PLOS,b} = LM_i \qquad DU_{PIND,b} = IN_i \qquad DU_{PPRO,b} = PR_i$$

$$DU_{PCSM,b} = CM_i$$

Aggregate feed products:

$$DU_{PFEE,FCER} = \sum_{k=MFSW}^{MFRI} MF_k \qquad DU_{PCSM,FCER} = \sum_{k=FCSW}^{FCRI} FC_k$$

$$DU_{PFEE,FPRO} = \sum_{k=MFPU}^{MFOP} MF_k \qquad DU_{PCSM,FPRO} = \sum_{k=FCPU}^{FCOP} FC_k$$

$$DU_{PFEE,FENE} = MF_{MFEN} \qquad DU_{PCSM,FENE} = FC_{FCEN}$$

$$DU_{PFEE,FMIL} = \sum_{k=MFMI}^{MFMP} MF_k \qquad DU_{PCSM,FMIL} = \sum_{k=FCMI}^{FCMP} FC_k$$

$$DU_{PFEE,FOTH} = MF_{MFOT} \qquad DU_{PCSM,FOTH} = FC_{FCOT}$$

DU: Uses, Additional Demand Component
HM: Human consumption on market
MF: Animal feed on market
SM: Seed use on market
LM: Losses on market
IN: Industrial use
PR: Processing
CM: Stock changes on market of products
FC: Stock changes on market of aggregated feed products
PCOM,PFEE,...: Subsc., Additional Demand Component, use activities
b: Subsc., Add. Dem. Comp., raw and processed products (corresp. to NLP activities i and k)
FCER,FPRO,...: Subs., Add. Dem. Comp., aggregate feed products (corresp. to NLP act. k)

6.2.3. External trade

With respect to a region' s external trade, the MFSS demand component looks only at the net trade position. It does not differentiate between intra-EUR and extra-EUR trade. It therefore does not fill up the Additional Demand Component's positions of intra- and extra-EUR imports and exports. Only a region's total exports and imports are determined. If the region is a net exporter (net importer) of a product in the base year of projection, it is assumed that total imports (exports) are at the base year of projection level.

Eq. 6.2.3.-1

Net exporter:

$$PIMT_b = PIMT_{b,B} \qquad PEXT_b = PIMT_{b,B} + NT_i$$

Net importer:

$$PEXT_b = PEXT_{b,B} \qquad PIMT_b = PEXT_{b,B} - NT_i$$

PEXT: Use aggregate - total exports, Additional Demand Component,
PIMT: Resource aggregate - total imports, Additional Demand Component
NT: Net trade
b: Subsc., Additional Demand Component, product (corresponding to NLP activity i)
B: Subsc., base year of projection

6.2.4. Additional information

6.2.4.1. Statistical adjustment

The market resources and uses must be in balance, i.e. the difference between domestic resources and domestic use and net trade should be zero. MFSS computes this difference and makes it available for checking purposes as "statistical adjustment" in the Additional Demand Component.

Eq. 6.2.4.1.-1

$$DU_{PADJ,b} = DR_{MAPR,b} - \sum_{u=PCSM}^{PPRO} DU_{u,b} + PIMT_b - PEXT_b$$

DR: Resources, Additional Demand Component
DU: Uses, Additional Demand Component
PEXT: Use aggregate - total exports, Additional Demand Component
PIMT: Resource aggregate - total imports, Additional Demand Component
PADJ: Subsc., Additional Demand Component, statistical adjustment
MAPR: Subsc., Additional Demand Component, marketable production
r: Subsc., Additional Demand Component, resource activities
u: Subsc., Additional Demand Component, use activities
b: Subsc., Additional Demand Component, products and aggregated feed products

6.2.4.2. Total domestic use

Total domestic use is aggregated from single domestic use activities comprising human consumption on market, animal feed on market, seed use on market, losses on market, industrial use and processing.

Eq. 6.2.4.2.-1

$$PDOM_b = \sum_{u=PCOM}^{PPRO} DU_{u,b}$$

PDOM: Use aggregate - total domestic use, Additional Demand Component
DU: Uses, Additional Demand Component
u: Subsc., Additional Demand Component, use activities
b: Subsc., Additional Demand Component, products and aggregated feed products

6.2.4.3. Consumer prices and expenditure for raw and processed agricultural products

The consumer prices are given by the solution of the MFSS demand component (see eq. 6.1.2.). The consumer prices multiplied by the human consumption quantities give the consumer expenditure (see equation 6.2.4.3.-1).

Eq. 6.2.4.3.-1

$$EXPE_b = CPRI_b DU_{PCOM,b}$$

CPRI: Consumer price, Additional Demand Component
EXPE: Consumer expenditure, Additional Demand Component
DU: Uses, Additional Demand Component
RP: Regional consumer prices
PCOM: Subsc., Additional Demand Component, use activity - human consumption on market
b: Subsc., Additional Demand Component, product item

6.2.4.4. Population and total consumer expenditure

Population and total consumer expenditure are exogenous variables. They can be determined from expert proposals, trend extrapolations or from the base year of projection according to the user-defined priority sequence.

6.3. Regional Aggregation

The work described so far on numerical specification of the physical and valued ABTA and MAC is implemented for each agricultural sector of the EU. The aggregation of these ABTAs and MACs for the Member States to EUR level is done after the calculation steps described in the previous sections.

For MFSS, the same aggregation procedure is used as for SPEL/EU-BM, and the reader is referred to Vol. 1 of the methodological documentation (see Wolf, 1995).

7. SUMMARY

Purpose of MFSS

The Medium-term Forecast and Simulation System (SPEL/EU-MFSS) is part of the SPEL System which is a *policy information system* comprising both an integrated data storage system and various versions of policy-related forecasting and simulation models.

MFSS is designed for forecasts of sectoral production, income and demand developments for an ex-ante period of about 6 years, and for simulations and policy-oriented modelling. It is created as a model for agricultural administration purposes and can be used in dialogue and mutual interaction between model-builders, statisticians, policy-makers and officials. Over the past few years it has been used mainly for the comparative analysis of various options relating to the reform of the Common Agricultural Policy and for assessing the likely impact of the agricultural reform decided on in 1992 by the Council of Ministers.

Position within the SPEL System

MFSS is based on the ex-post data created by the Base System (SPEL/EU-BS), which ensures the internal consistency of the ex-post descriptions of the structure, intensity and use of agricultural production and income generation in the Member States. Forecasts and simulations with MFSS start on the latest available statistical data and can also use the information provided by the Short-term Forecast and Simulation System (SPEL/EU-SFSS). Since BS, SFSS and MFSS have identical data structures and definitions, the results of the three systems are directly comparable.

The policy orientation of the model constitutes the basic requirements which also apply to the other model parts: it has to be transparent, highly detailed, up to date and flexible. These requirements have largely determined the methodological design and basic structure of MFSS. Important features are the activity-based approach, the modular structure and the flexible possibilities to integrate expert knowledge where available.

Activity-based accounting framework

Like the other models of the SPEL System, MFSS is designed to work within a *sectoral accounting* and market balancing framework complying with the principles of the Economic Accounts for Agriculture (EAA). The accounting identities are represented by an Activity-based Table of Account (ABTA) and a derived Matrix of Activity Coefficients (MAC), and the market balances by an Additional Demand Component.

For the ex-post period, the ABTA, MAC and Additional Demand Component are numerically specified by the Base System. The MFSS forecasts and policy simulations are projections of the ABTA, MAC and Additional Demand Component for the ex-ante period. The placing of MFSS within the SPEL activity-based accounting system has several advantages:

- The detailed breakdown of agricultural production with respect to production activities, product and input items provides the possibility to explore the effects of a wide range of agricultural policies.
- The differentiated depiction of Output Generation, Output Use, Input Generation and Input Use is helpful for the review of the results by experts, who have specialised knowledge in certain fields. At a disaggregated level expert knowledge may be more adequately incorporated than at a more aggregated level.

- The compliance with the accounting approach guarantees consistency in respect of both physical and monetary cyclical links, and ensures the comparability of data and model results with the definitions used in the EAA.

Modular approach

The complete model is divided into individual components and sub-models (unit construction principle). Each of the components and sub-models represents a sub-system of sectoral interactions. MFSS contains the following model components:

- The *supply component* forecasts agricultural production and input use, and models the effects of changes in the political, economic and technological environment on agricultural supply and factor demand.
- The *demand component* forecasts the domestic intersectoral use of the agricultural raw and processed products, and models the influence of price and income changes on demand.
- The *external trade component* depicts net trade at aggregate EUR level with Rest of World (ROW). The response of net import demand and net export supply by ROW on changes in the world market prices is modelled.

All components are parts of a comprehensive agricultural sector model. Within this system, the *market clearing and price formation* process is modelled by the interplay of domestic supply and demand and external trade.

The ABTA, MAC and Additional Demand Component are derived from the results of these model components.

Incorporation of external information

External information coming from experts and other studies can be incorporated in order to make use of specialised knowledge. Incorporation of external information can be applied to the exogenous variables as well as to the parameters of the model.

External information which enters the model as *exogenous variables* comprises information about the macroeconomic environment (exchange rates, inflation, total consumer expenditure), demographic trends, the policy environment (policy-determined prices, quotas, direct income transfers, etc.) and the factor markets (input prices). For many model variables, the model user can (depending on the scenario) decide whether a variable should be determined exogenously or endogenously. If a variable is defined as being exogenous, the user can define an overlay structure with a certain priority sequence which determines the exogenous variable from trend-extrapolations, expert proposals or from the base year of projection.

External information which enters the model via the *parameters* can comprise agronomic engineering information, empirical evidence and expert knowledge about the behaviour of the agricultural producers, consumers, marketing agencies and the international trading partners.

The basic model assumptions

On the supply side, production and factor input respond to farmers' expectations about the output and variable input prices and to farmers' expectations about the profits per unit of the production activities, bearing in mind that these expectations are formed by past experience.

The medium-term response to changing price and profit expectations is modelled as if farmers were solving a two-stage decision problem:

- In the first stage, farmers decide about the quantities of the variable inputs per unit of the production activities (e.g. nitrogenous fertilizer input per hectare of barley). These influence the yields per unit of the production activities. The decisions are determined by the farmers' anticipations about future output and input prices.
- In the second stage of the decision process, farmers decide about the levels of the production activities (e.g. the acreage of barley). The decisions are determined by the anticipated value Adidas per unit of the production activities.

Total domestic demand for agricultural raw and processed products depends on the prices at consumer level and consumer income, the costs for the transfer of raw products into consumable goods, the demand for chemical, technical and energetic use (industrial use), and on agricultural production (seed and feed use).

Markets are cleared at Member State level, aggregate EUR level and at a global level through the operation of price adjustments, such that EUR net exports (net imports) equal ROW net imports (net exports). ROW net trade depends on world market prices. World market price changes are transmitted to an aggregate "EUR-pool" and from there to the Member States, depending on the assumed policy scenario.

The price formation is a result of the interplay of domestic supply and demand and external trade constrained by the market clearing requirement, and depends mainly on the assumed type of price formation (exogenous or endogenous formation of regional (Member State) prices, EUR-pool prices and world market prices).

Dynamic coupling

The linkage of the supply, demand and external trade components follows the dynamic coupling principle. Beginning with the first year of the projection period (t+1) the model solves the supply component, with expected prices assumed as the relevant incentives for the supply response of the agricultural sector in t+1. The solution of the supply component gives information about the sales and purchases of the agricultural sector in t+1. The sales and purchases are model input to the next step, i.e. the simultaneous solution of the demand and external trade components for t+1. The solution of the demand and external trade components comprises the consumer prices for t+1. The farmgate prices for t+1 are derived from the consumer prices for t+1 and influence the price expectations for t+2. For the second and further projection years, this coupling procedure is repeated.

Model parameters

The technological and behavioural parameters of the model equations are not determined by a single method. Econometric estimation as well as information based on literature is applied.

Special attention is given to the fact that the comparison of quantitative studies shows a considerable uncertainty as to the exact numerical specification of supply and demand elasticities. A calibration method can be used in order to integrate in a consistent manner knowledge from microeconomic theory and empirical work and that of experts.

ANNEXES

I. NON-LINEAR PROGRAMMING APPROACH TO THE CALIBRATION OF THE MATRIX OF PRODUCTION ACTIVITY ELASTICITIES AND HUMAN CONSUMPTION ELASTICITIES

The quality of supply and demand forecasts and of policy simulations depends largely on the accuracy of the modelling of the supply and demand response to economic signals such as price, profit and income changes.

Microeconomic theory has developed a consistent body of theory on which to base, to a greater or lesser degree, empirical analyses of supply and demand behaviour. The comparison of quantitative studies shows, however, that there is considerable uncertainty as to the exact numerical specification of elasticities.

It is therefore appropriate to compare various studies and expert valuations. The own and cross price elasticities and the income elasticities should, as a whole, present a plausible and rational overall supply and demand response. What is understood by 'plausible' and 'rational' can be answered differently depending on the specific question and viewpoint of the analyst. It is, however, important to reveal the assumptions underlying the elasticity set, to examine the mutual consistency of the elasticities and take into account simultaneously external information and own estimates about the range of the elasticities, plausibility considerations and theoretical restrictions.

A method is described below which facilitates the calibration of elasticity sets (see also Weber, 1993 and Schein, 1993). It is used to bring together in a consistent manner knowledge from theoretical and empirical work and that of experts. It is based on a non-linear programming approach with a constraint section in which requirements as regards homogeneity properties, additivity and symmetry conditions are defined and upper and lower limits for individual elasticities are numerically specified. The deviation from the exogenously proposed numerical specification of the elasticity set is minimised subject to the constraints.

The type of constraint which can be employed optionally during the calibration procedure and the objective function to be minimised are described below. A description of the corresponding software is available in Vol. 2 of the technical documentation of the SPEL System (Zintl and Greuel, 1995).

Objective function

The calibration of elasticities is based on a quadratic programming approach which minimises the relative quadratic differences between the elasticities of the non calibrated (input) and calibrated elasticity set (output):

Eq. I.-1

$$\min \sum_i \sum_j \left(\frac{\varepsilon_{ij} - \varepsilon_{ij}^*}{\varepsilon_{ij}^*} \right)^2 + \sum_i \left(\frac{\eta_i - \eta_i^*}{\eta_i^*} \right)^2 \quad i, j = 1, .., n$$

ε: Elasticity of production activity i (human consumption of product i) with respect to value added per unit of production activity j (consumer price of product j)
η: Elasticity of production activity i (human consumption of product i) with respect to the price of the aggregate primary factor input (total expenditure)
*: Superscript, calibrated elasticity
i,j: Subsc., product and production activity

Constraints for the calibration of activity elasticities

On the supply side, the elasticities describe the response of the agricultural sector in the production activity levels to changes in the value Adidas per unit of the production activities. The restrictions which can be taken into account during the calibration procedure are the following:

Homogeneity

Microeconomic theory forms the basis for the specification of the homogeneity property. In the profit maximization model, the supply functions - taking into account the prices of all variable outputs and inputs as exogenous variables - are homogenous of degree zero (Varian, 1984, p. 46). It is therefore likely, for a production activity, that the sum of the elasticities with respect to the own and cross value Adidas and with respect to the price of the aggregate variable primary factor input will be zero:

Eq. I.-2

$$\sum_j \varepsilon_{ij}^* + \eta_i^* = 0$$

Symmetry

Symmetry conditions are also based on microeconomic theory. It can be shown that the cross price responses which emerge as the second derivatives of the profit function are symmetric (Varian, 1984, p. 52 et seq.).

On the simplifying assumption that the simultaneous response of the yield coefficients of a production activity to a change of the value added of any other production activity is zero, one can derive the following symmetry conditions for the activity elasticities:

Eq. I.-3

$$\varepsilon_{ij}^* \frac{IMU_{i,k} LEVL_i}{\sum_j IMU_{j,k} LEVL_j} = \varepsilon_{ji}^* \frac{IMU_{j,k} LEVL_j}{\sum_j IMU_{j,k} LEVL_j}$$

IMU: Input Use, MAC, value component
LEVL: Level of production activity (in hectare or herd size)
k: Subsc., ABTA, value added

Total area elasticity

Because of the fundamental significance of the production factor land for agricultural production, constraints on the total area elasticity should be appropriately built into the calibration approach.

The total area elasticity is defined here as the percentage change in the total area in the event of a 1% increase in the value added of a production activity. The plausible assumption that total area will not decrease if the value added of a production activity increases is formulated as follows:

Eq. I.-4

$$\sum_{i_1} \varepsilon^*_{i_1 j} \frac{LEVL_{i_1}}{PROPLEVL} \geq 0$$

PROPLEVL: Total agricultural area
i_1: Subsc., crop production activity

Non-negativity of own value added response:

A necessary condition for the convexity of the profit function is that the own price responses of supply are non-negative. From this it can be deduced that also the own value added elasticities should be non-negative:

Eq. I.-5

$$\varepsilon^*_{ii} \geq 0$$

Constraints for the calibration of human consumption elasticities

On the demand side, the elasticities describe the response of human consumption of agricultural raw and processed products to consumer price changes. The restrictions which can be taken into account during the calibration procedure are the following:

Homogeneity

In the utility maximization model, the demand functions - taking into account all prices and total expenditure of the demand system - are homogenous of degree zero (see Seel, 1991 p. 140 et seq.). It is therefore likely for the consumption of a good, that the sum of the elasticities with respect to the own and cross consumer prices and with respect to total expenditure will be zero:

Eq. I.-6

$$\sum_j \varepsilon^*_{ij} + \eta^*_i = 0$$

Symmetry

Symmetry conditions are also based on microeconomic theory. It can be shown that the matrix of substitution terms of the compensated or Hicksian demand functions are symmetric (Varian, 1984, p.

133). If one decomposes the effect of a price change into a substitution and income effect as described by the Slutsky equation (Varian 1984, p.130), one can write the following symmetry condition for the demand elasticities:

Eq. I.-7

$$\varepsilon_{ij}^{*} w_i + w_i w_j \eta_i = \varepsilon_{ji}^{*} w_j + w_i w_j \eta_j \qquad \text{with}$$

$$w_i = \frac{DU_{PCOM,i} CPRI_i}{\sum_j DU_{PCOM,i} CPRI_i}$$

DU: Uses, Additional Demand Component
CPRI: Consumer price, Additional Demand Component
PCOM: Subsc., Additional Demand Component, human consumption on market

Additivity

The sum of all elasticities with respect to total expenditure of the demand system weighted with the budget shares must be equal to unity (see Varian, 1984, p. 128):

Eq. I.-8

$$\sum_i w_i \eta_i^{*} = 1$$

Non-positivity of own price elasticities

Only for the rarely observed Giffen case, where the positive income effect of an inferior good can outweigh the negative substitution effect, is the sign of the own price elasticity positive (see Varian, 1993, p. 142 et seq.). In the "normal" case, the own price elasticity should be non-positive:

Eq. (I.-9)

$$\varepsilon_{ii}^{*} \leq 0$$

II. EXPLORATION STUDY ON THE ECONOMETRIC ESTIMATION OF YIELD FUNCTIONS

As explained in chapter 4.1.2., yield functions depict the influence of the yield-increasing input (nitrogen, phosphate, potassium, lime fertilizer, plant protection) on output coefficients. As one alternative of yield modelling, *econometrically-based yield functions* have been estimated on the basis of the SPEL/EU-Data by a multivariate non-linear least square method. The parameters of the econometric yield model are estimated on the assumption of profit-maximizing behaviour. The results are checked against agronomic engineering information. Time shift parameters are included if significant.

The following paragraphs describe in brief the estimation procedure and give a rough overview of the estimation results.

Estimation procedure

(1) Complete model

The complete yield model consists of the following equations for the yield and pure nitrogen requirements of the final crop production activities:

Eq. II.-1

$$XMG_{a,a} = \alpha_0 + \alpha_1 TS + \beta_0 YMUN_a + \beta_1 (TS * YMUN_a) + \gamma YMUN_a^{\ 2}$$

$$YMUN_a = \frac{\frac{MC_a^*}{PU_{PRIC,a}^*} - \beta_0 - \beta_1 TS}{2\gamma}$$

XMG: Output Generation, MAC, physical component
YMUN: Pure nitrogen requirement per unit of a production activity
MC^*: Expected marginal costs of nitrogen input
PU^*: Expected output use price
PRIC: Subsc., ABTA, price element : farmgate price
$\alpha_0, \alpha_1, \beta_0, \beta_1, \gamma$: Parameters of the yield function
a: Subsc., ABTA, production activity and product
TS: Time shift

As described in chapter 4.1.2.2.2., the effects of technical progress are captured by introducing a time trend into the yield function. The model differentiates between two types of technical progress: (1) Technical progress shifts the yield function vertically without changing the slope of the curve (parameter α_1). In this case, technical progress is independent of the input level. (2) Technical progress changes the slope of the yield curve (parameter β_1). In this case, the effects of technical progress depend also on the input level.

The equation for the pure nitrogen requirement is derived from the profit-maximization assumption (see chapter 4.1.2.2.2. and eq. 4.1.2.2.2.-1). Pure nitrogen input depends on the ratio of the marginal costs of nitrogen input to the output price, and on the time shift. The marginal costs of nitrogen input are calculated as described in chapter 4.1.2.2.2. (see eq. 4.1.2.2.2.-3).

Eq. II.-1 is a system of non-linear equations having restrictions across the equations. The estimation of the parameters of the system is done by a multivariate non-linear least square method.

(2) Model without time shift in the absolute term of the yield function

After the estimation of the complete model, checks were made to see whether the absolute term (α) and the coefficient of the linear term (β) were non-negative and the coefficient of the quadratic term (γ) was non-positive. If the plausibility requirements were not fulfilled, the model was estimated without the time shift of the absolute term:

Eq. II.-2

$$XMG_{a,a} = \alpha_0 + \beta_0 YMUN_a + \beta_1 (TS * YMUN_a) + \gamma YMUN_a^{\;2}$$

$$YMUN_a = \frac{\dfrac{MC_a^*}{PU_{PRIC,a}^*} - \beta_0 - \beta_1 TS}{2\gamma}$$

(3) Model without time shift in the coefficient of the linear term of the yield function

After the 2nd estimation, the plausibility check was carried out again. If the requirements were not fulfilled, the model was estimated without the time shift in the coefficient of the linear term:

Eq. II.-3

$$XMG_{a,a} = \alpha_0 + \alpha_1 TS + \beta_0 YMUN_a + \gamma YMUN_a^{\;2}$$

$$YMUN_a = \frac{\dfrac{MC_a^*}{PU_{PRIC,a}^*} - \beta_0}{2\gamma}$$

(4) Model without absolute term

If the plausibility check was not positive after the 3rd estimation, a model without absolute term of the yield function was estimated:

Eq. II.-4

$$XMG_{a,a} = \beta_0 YMUN_a + \beta_1 (TS * YMUN_a) + \gamma YMUN_a^{\,2}$$

$$YMUN_a = \frac{\dfrac{MC_a^*}{PU_{PRIC,a}^*} - \beta_0 - \beta_1 TS}{2\gamma}$$

(5) Model without absolute term and without time shift in the coefficient of the linear term of the yield function

If the plausibility check was not positive after the 4th estimation, the following model was estimated:

Eq. II.-5

$$XMG_{a,a} = \beta_0 YMUN_a + \gamma YMUN_a^{\,2}$$

$$YMUN_a = \frac{\dfrac{MC_a^*}{PU_{PRIC,a}^*} - \beta_0}{2\gamma}$$

If the plausibility check was not positive after the 4th estimation, the estimation process was stopped and a respective econometrically based yield function is not available in MFSS.

Estimation results

Since the estimation of yield functions has been tried for all one-year-period final crop production activities for 12 regions, the result cannot be shown in detail in this documentation. But Table II-1 presents an overview showing for which production activities econometrically estimated yield functions are available and indicating which of the above described 5 variants of the yield model was finally chosen for MFSS (corresponding to the numbers in the matrix cells).

Table II.-1: Availability of econometrically estimated yield functions

	BL	D11	DK	E	F	GR	I	IRL	NL	P	UK
barley	2	2	2		2			1	2		2
cauliflower	4	2							2	4	
durum wheat					1		2			2	
maize		2			2	2	4			2	
oats			2		2			1		4	2
other cereals											
other vegetables					1	2		1	4		2
paddy rice					2	1	1			1	
potatoes		3	2		2	4		2	4		2
pulses		4			2				2		1
rape seed		4	2		2		4				1
rye	2		2		2	2				4	2
soya beans											
sugar beets			4							4	2
sunflower seed											
soft wheat	2	2			2		2	1	2	2	2
tomatoes		4			1		1		2		2

1 = complete model
2 = without time shift in the absolute term of the yield function
3 = without time shift in the coefficient of the linear term of the yield function
4 = without absolute term

III. INCORPORATION OF THE CAP REFORM MEASURES INTO SPEL/EU-MFSS

The policy measures of the CAP reform made necessary several extensions of the model.

Crop production

Under the CAP reform, farmers receive compensatory payments for the price cuts for cereals, oilseeds and pulses.

Professional producers benefit from the compensatory payments only if they set aside a certain percentage of their area under "grandes cultures" (cereals, pulses, oilseeds). All farmers receive compensatory payments for their set-aside obligations under the CAP reform.

Total per-ha payments are limited (for cereals, pulses, oilseeds, set-aside) up to a certain so-called base area. If the base area is exceeded, the payments are proportionally reduced.

The modelling of the set-aside and the limitation of the payments made it necessary to add three new constraints and variables ("activities") to the activity model of the supply component for the case of a CAP reform simulation (see eq. III.-1):

- One constraint was necessary for the incorporation of the set-aside requirement. With each hectare of "grand culture", a certain acreage of agricultural area (ra) must be set aside if farmers participate in the compensatory payments scheme. An additional variable for the acreage under CAP reform set-aside (SETA) is introduced.
- The CAP reform base area is exogenous and depends on the policy scenario. It is incorporated into the model by a further constraint. This constraint ensures that the acreage under "grandes cultures" (CP) plus the CAP reform set-aside (SETA), minus a second additional variable which takes into account production beyond the base area (EXBA), is not greater than the base area (base). EXBA is also an entry in the above-mentioned constraint for set-aside requirement because production of "grandes cultures" outside the compensation scheme is free from set-aside obligations.
- A third additional constraint links the "CAP reform set-aside" with the activity "fallow land".
- A third additional variable (ADJU) is introduced into the behavioural equations for the determination of the "grandes cultures" production activities in order to allow for CAP-reform-induced shifts.

Eq. III.-1

Constraint for the set-aside requirement:

$$-\sum_i raCP_i + raEXBA + SETA \geq 0 \quad \text{with} \quad \mathrm{ra} = \frac{\mathrm{seta}(\%/100)}{1-\mathrm{seta}(\%/100)}$$

Constraint for the base area:

$$-\sum_i CP_i + EXBA - SETA \geq -base$$

Constraint for fallow land:

$$OPFA - SETA \geq 0$$

CAP reform shift for "grand culture" production activities:

$$\ldots -ae_{ADJU,i}ADJU + \ldots \geq \ldots$$

CP: "Grand culture" production activity
EXBA: Exceeding CAP reform base area
SETA: CAP reform set-aside
OPFA: Fallow land
ADJU: CAP reform shift for "grand culture" production activities
base: base area
ra: set aside requirement per hectare of "grand cultures"
seta: set-aside obligation (in %)
ae: Coefficient of the behavioural equations for "grand culture" production activities

For the modelling of the compensatory payments scheme the objective function is expanded by further entries (see eq. III.-3):

- The compensatory payments are recorded under the ABTA heading "basic production-factor-related-subsidies" (see also ch. 6.1.6.1.). These subsidies are exogenous policy variables and can be determined from expert proposals, trend extrapolations or from the base year of projection. The payments are incorporated into the objective function (net revenue) by respective entries for "grand cultures" production activities and the CAP reform set-aside.

  When specifying the compensatory payments for a simulation run, it must be borne in mind that MFSS deals with sectoral averages. Modulations of the payments with respect to region, farm size, etc. cannot therefore be treated endogenously in MFSS. One must incorporate such modulations into the expert proposal.

- The limitation of the total compensatory payments by the base area is incorporated in a cost term for the activity "exceeding base area". The costs for EXBA are derived from the compensatory payments, i.e. compensatory payment is paid only for the acreage within the base area limit.

Eq. III.-2

$$\sum_i ob_{R,i} CP_{R,i} + \ldots + ob_{R,EXBA} EXBA + ob_{R,SETA} SETA + \ldots = \max! \text{ with}$$

$$ob_{R,i} = IMU^{*}_{R,a,PFSB,E \wedge T \wedge B}$$

$$ob_{R,EXBA} = -\max\left\{ IMU^{*}_{R,a,PFSB,E \wedge T \wedge B} \right\}$$

$$ob_{R,SETA} = IMU^{*}_{R,FALL,PFSB,E \wedge T \wedge B}$$

IMU: Input Use, MAC, value component
*: Superscript, expected value
R: Subsc., Member State (region)
a: Subsc., ABTA, production activity (corresponding to NLP activity i)
FALL: Subsc., ABTA, fallow land
PFSB: Subsc., ABTA, basic production factor related subsidies
E: Subsc., expert proposal
T: Subsc., trend-based
B: Subsc., base year of projection
ob: Coefficient of the objective function

For the case of CAP reform scenarios, the computation of the ABTA must be supplemented by the modulation of the sectoral average per-ha compensation according to the limitation of the payments by the base area. Per percentage of base area exceeded, the per-ha compensation is reduced by one percent:

Eq. III.-3

$$IMU_{R,a,PFSB} = IMU^{*}_{R,a,PFSB,E \wedge T \wedge B} \left(1 - \frac{EXBA_R}{base_R} \right)$$

Premiums in the beef sector

As a compensation for the reduction of the beef price, premiums are paid on a per-capita basis for male adult cattle and suckler cows. However, the premiums are limited by herd-size and stocking rates. Since the SPEL-data do not comprise the relevant structural data the average sectoral premiums must be derived from external information (e.g. expert proposals). MFSS can only handle the sectoral averages.

The average premiums per head in the production activities "male adult cattle for fattening" and "suckling calves" are recorded under the ABTA heading "basic production-factor-related-subsidies" and are incorporated into the objective function (net revenue):

Eq. III.-4

$$...+ob_{R,i}AP_{R,i}+...=\max! \text{ with}$$

$$ob_{R,i}=IMU^{*}_{R,a,PFSB,E\wedge T\wedge B}$$

AP: Animal production activity

IV. CODES OF THE ABTA AND ADDITIONAL DEMAND COMPONENT

Supply table Lines (SL)

	Line Code	Line No	Main/Joint product
Products (SL) [14]			
Crop products (SL)			
Final crop products (SL)			
Soft Wheat	SWHE	01	Main
Durum Wheat	DWHE	02	Main
Rye and Meslin	RYE	03	Main
Barley	BARL	04	Main
Oats	OATS	05	Main
Maize	MAIZ	06	Main
Other Cereals (excl. Rice)	OCER	07	Main
Paddy Rice	PARI	08	Main
Pulses	PULS	09	Main
Potatoes	POTA	10	Main
Sugar Beets	SUGB	11	Main
Rape and Turnip Rape Seed	RAPE	12	Main
Sunflower Seed	SUNF	13	Main
Soya Beans	SOYA	14	Main
Olives for Oil	OLIV	15	Main
Other Oilseeds and Oleaginous Fruit	OOIL	16	Main
Flax and Hemp	FLAX	17	Main
Tobacco Unmanufactured	TOBA	18	Main
Other Industrial Crops	OIND	19	Main
Cauliflowers	CAUL	20	Main
Tomatoes	TOMA	21	Main
Other Vegetables	OVEG	22	Main
Apples, Pears and Peaches	APPL	23	Main
Other Fruits	OFRU	24	Main
Citrus Fruits	CITR	25	Main
Table Grapes	TAGR	26	Main
Table Olives	TABO	27	Main

[14] Agricultural products are grouped into crop and animal products. In the SPEL/EU-Model, 58 products (37 crop and 21 animal products) are distinguished, each of them shown as a final or intermediate product. Final products are produced mainly for consumption outside the agricultural sector. Intermediate products are used only inside the sector. Both, final and intermediate products are further divided into main and joint products. Joint products (by-products) are technically related to the production of a main product. Depending on the production activity definition, a product is a main product for one activity and a joint product for another activity. The beef product for example is the main product for the "male adult cattle for fattening" activity and related to the "Dairy cow" activity a joint product. This product differentiation applies to the lines of the ABTA and of the MAC.

	Line Code	Line No	Main/Joint product
Grapes for Table Wine	TWIN	28	Main
Grapes for Other Wine	OWIN	29	Main
Nursery Plants	NURS	30	Main
Flowers, Ornamental Plants etc.	FLOW	31	Main
Other Final Crop Products	OCRO	32	Main
Intermediate crop products (SL)			
Other Root Crops	OROO	33	Main
Green Fodder	GRAS	34	Main, Joint
Silage	SILA	35	Main, Joint
Hay (dry weight)	DHAY	36	Joint
Straw Fed	STRA	37	Joint
Animal products (SL)			
Final animal products (SL)			
Milk of cows	MILK	38	Main, Joint
Beef	BEEF	39	Main, Joint
Veal	VEAL	40	Main
Pork	PORK	41	Main, Joint
Milk of Ewes and Goats	MUTM	42	Main
Sheep- and Goatmeat	MUTT	43	Main, Joint
Eggs	EGGS	44	Main
Poultry Meat	POUL	45	Main, Joint
Other Animal Products	OANI	46	Main
Raw Wool	WOOL	55	Joint
Intermediate animal products(SL)			
Calves	CALV	47	Main, Joint
Heifers	HEIF	48	Main
Dairy cows	DCOW	49	Joint
Piglets	PIGL	50	Main
Lambs	LAMB	51	Joint
Chicks	CHIC	52	Joint
Male adult cattle	BULL	53	Joint
Other cows	SCOW	54	Joint
Nitrogen from Manure	MANN	56	Joint
Phosphate from Manure	MANP	57	Joint
Potassium from Manure	MANK	58	Joint
Production adjustment (SL)			
Production Adjustment (related to EAA adjustments)	PRAD	59	
Contract work and new plantation	COWO	60	

	Line Code	Line No
Input items (SL)[15]		
Variable input items (SL)		
Specific crop input items (SL)		
Nitrogenous mineral Fertilizer	NITF	61
Phosphatic mineral Fertilizer	PHOF	62
Potassic mineral Fertilizer	POTF	63
Lime fertilizer	CAOF	64
Nitrogen from Manure	NITM	65
Phosphate from Manure	PHOM	66
Potassium from Manure	POTM	67
Seed Inputs	SEEP	68
Plant Protection	PLAP	69
Specific animal input items (SL)		
Fodder : cereals (incl. rice)	FCER	70
Fodder : rich protein	FPRO	71
Fodder : rich energy	FENE	72
Fodder : milk and milk products	FMIL	73
Fodder : dried (not marketable)	FDRY	74
Fodder : fresh and ensilaged (not marketable)	FFSI	75
Fodder : other	FOTH	76
Input Calves	ICAL	77
Input Heifers	IHEI	78
Input Cows	ICOW	79
Input Piglets	IPIG	80
Input Bulls	IBUL	81
Input Lambs	ILAM	82
Input Chicks	ICHI	83
Input Animal Imports (EAA)	IAIM	84
Pharmaceutical Input	IPHA	85

15 Variable and fixed inputs (costs) are both shown. The variable inputs are grouped into specific crop and animal input items. The fixed input items include farm overheads. The primary factor costs are additional sectoral aggregates, which are not allocated to individual production activities. This input differentiation applies to both the lines of the ABTA and those of the MAC, excluding the primary factor cost items.

	Line Code	Line No
General input items (SL)		
Losses on farm	PLOF	86
Variable Costs Repairs	REPV	87
Variable Costs Energy	ENEV	88
Variable Costs Water	WATV	89
Variable Costs Other Inputs	INPV	90
Fixed input items (SL)		
Overheads (SL)		
Overheads Repairs	REPO	91
Overheads Energy	ENEO	92
Overheads Other Inputs	INPO	93
Primary factor cost items (SL)		
Subsidies, crop production (EAA)	SUBC	94
Subsidies, animal production (EAA)	SUBA	95
Subsidies, other production (EAA)	SUBO	96
Taxes linked to crop production (EAA)	TAXC	97
Taxes linked to animal production (EAA)	TAXA	98
Taxes linked to production (EAA)	TAXO	99
Depreciation Buildings	DEPB	100
Depreciation Machinery	DEPM	101
Interest Paid	INTE	102
Rent Paid	RENT	103
Wages Paid	WAGE	104
Input adjustment (SL)		
Input Adjustment (related to EAA adjustments)	INAD	105
Value added tax, undercompensation	VATU	106

	Line Code	Line No
Aggregates and value added (SL)[16]		
Aggregates (SL)		
Gross Production, valued	PROV	107
Total intermediate input	TOIN	108
Total Variable Inputs	TOVA	109
Total Overheads	TOOV	110
Subsidies	SUBS	111
Taxes linked to production	TAXE	112
Value added tax, overcompensation	VATO	113
Value added (SL)		
Gross Margin	GRMA	114
Gross Value Added Mark.Pric.	GVAM	115
Gross Value Added Fact.Cost	GVAF	116
Net Value Added Factor Cost	NVAF	117
Activity levels and production factor stocks (SL)[17]		
Levels of Production Activities	LEVL	118
Capital Stocks Land	CALA	119
Capital Stocks Buildings	CABU	120
Capital Stocks Machinery	CAMA	121
Capital Crop / Livestock	CACL	122
Total Labour (annual work unit)	LABO	123
Non-Family Labour (annual work unit)	LABN	124

16 These aggregates are additional to the ABTA and MAC data. Only the table line Gross Value Added at Market prices (GVAM) is linked to the ABTA and MAC definition, which contains the gross payments for primary factors (land, labour and capital). Depending on the related column, the listed aggregates are available by activity or as sectoral aggregates.

17 The table line Levels of production activities (LEVL) is used to calculate the MAC. The group "production factor stocks" is additional information as a sectoral aggregate.

	Line Code	Line No
Additional policy oriented information, CAP (SL)[18]		
Basic factor related subsidies (CAP)	PFSB	125
Additional factor related subsidies (CAP)	PFSA	126
Basic factor related taxes (CAP)	PFTB	127
Additional factor related taxes (CAP)	PFTA	128
"Modified" gross value a. m. pr. (CAP)	MGVA	129
National aggregates (SL) [19]		
National aggregates	NAGG	130

[18] Additional, non harmonised data for subsidies and taxes linked to production factor determined by CAP changes of 1992 are added to calculated a modified gross value added at market price figure per production activity unit.

[19] The exchange rate data (ECU/NC, Dollar/NC and Purchasing Power Standards) are placed in the line "NAGG".

Supply table Columns (SC)

	Column Code	Column No
Production activities (SC)[20]		
Crop production activities (SC)		
For final crop products (SC)		
Soft Wheat	SWHE	01
Durum Wheat	DWHE	02
Rye and Meslin	RYE	03
Barley	BARL	04
Oats	OATS	05
Maize	MAIZ	06
Other Cereals (excl. Rice)	OCER	07
Paddy Rice	PARI	08
Pulses	PULS	09
Potatoes	POTA	10
Sugar Beets	SUGB	11
Rape and Turnip Rape Seed	RAPE	12
Sunflower Seed	SUNF	13
Soya Beans	SOYA	14
Olives for Oil	OLIV	15
Other Oilseeds	OOIL	16
Flax and Hemp	FLAX	17
Tobacco Unmanufactured	TOBA	18
Other Industrial Crops	OIND	19
Cauliflowers	CAUL	20
Tomatoes	TOMA	21
Other Vegetables	OVEG	22
Apples, Pears and Peaches	APPL	23
Other Fruits	OFRU	24
Citrus Fruits	CITR	25
Table Grapes	TAGR	26
Table Olives	TABO	27
Table Wine	TWIN	28
Other Wine	OWIN	29
Nursery Plants	NURS	30
Flowers, Ornamental Plants etc.	FLOW	31
Other Final Crop Products	OCRO	32

20 The agricultural production activities are grouped into crop and animal activities. In the SPEL/EU-Model, 49 production activities (35 crop; 13 animal production activities and a fallow land activity) are distinguished. Each of them is shown as producing final and/or intermediate products. A single activity produces one to four products, depending on the kind of product.
This production activity differentiation applies to the column of the ABTA as well as to that of the MAC.

	Column Code	Column No
For intermediate crop products (SC)		
Other Root Crops	OROO	33
Grass/Grazings	GRAS	34
Fodder Plants on Arable Land	SILA	35
Animal production activities (SC)		
For final animal products (SC)		
Dairy Cows	MILK	36
Male Adult Cattle for Fattening	BEEF	37
Calves for Fattening	CALF	38
Pigs for Fattening	PORK	39
Ewes and Goats	MUTM	40
Sheep and Goats for Fattening	MUTT	41
Laying Hens	EGGS	42
Poultry for Fattening	POUL	43
Other Animals	OANI	44
For intermediate animal products (SC)		
Other cows	CALV	45
Calves, rearing	RCAL	46
Heifers	HEIF	47
Pig Breeding	PIGL	48
Other activities (SC)		
Fallow Land	FALL	49

	Column Code	Column No
Sectoral interactions(SC)[21]		
Intrasectoral (SC)		
Losses: on farm	PLOF	50
Animal Feed: on farm	FEEP	51
Seed: on farm	SEEP	52
Nitrogen from Manure	MANN	53
Phosphate from Manure	MANP	54
Potassium from Manure	MANK	55
Calves	CALP	56
Heifers	HEIP	57
Cows	COWP	58
Piglets	PIGP	59
Bulls	BULP	60
Lambs	LAMP	61
Chicks	CHIP	62
Stock Changes: on farm	PCSF	63
Human Consumption: on farm	PCOF	64
Intersectoral (SC)		
Sales/Purchases	TRAP	65
Physical aggregates (SC)		
Gross Interactions (production, input)	PROP	66

21 The sectoral interactions (flows) are grouped into intrasectoral and intersectoral flows. The intrasectoral flows reflect intra-agricultural movements and intersectoral flows extra-agricultural movements.In total, 16 interactions (use activities or flows) are shown, 15 of which are intra-agricultural interactions and one extra-agricultural (sales or purchases).The ABTA sectors "Output Use" and "Input Generation" are subdivided in the columns with these interactions.

	Column Code	Column No
Prices and price elements (SC)[22]		
Prices (SC)		
Unit Value	UVAL	67
Farm Gate Price	PRIC	68
Internal Use Price	PRIN	69
Additional prices (SC)		
Price Index	PRII	70
Administered Price	PRAD	71
Price elements (SC)		
Levies	LEVI	72
Subsidies (Price-side)	SUBP	73
Parities, product related[23]		
Green parity	GRPA	74
Budget parity	BUPA	75
Double parity	DOPA	76
Monetary aggregates (SC)		
Aggregates in current prices (SC)		
Gross Interactions	PROV	77
Final Production, EAA	PEAV	78
Aggregates in constant prices (1990) (SC)		
Gross Interactions	PROC	79
Final Production, EAA	PEAC	80

22 The prices are broken down into ABTA and MAC related prices and additional prices. The price elements are included to take possible administrative aspects into account. In the supply oriented table the prices and price elements are shown separately in the columns. In the context of ABTA and MAC the "Unit value" column represents the price vector for valuing the "Output Generation" and "Input Use" of ABTA and MAC. The "Farm Gate Price" column is used to value the intersectoral interactions and the "Internal Use Price" column to value the intrasectoral interactions of "Output Use" and "Input Generation" of ABTA.

23 Additional, non harmonised data for parities related to CAP changes of 1992.

	Column Code	Column No
National economy-complementary aggregates (SC)[24]		
National aggregates	NAGG	81
Nutrient content of feed aggregates (SC)[25]		
Net energy (lactation)	ENNE	82
Metabolizable energy (ruminants)	ENMR	83
Metabolizable energy (pigs)	ENMP	84
Metabolizable energy (chicken)	ENMC	85
Metabolizable energy (horses)	ENMH	86
Crude protein	CRPR	87
Dry matter	DRMA	88

24 The gross domestic product (GDP) data (valued at current prices, Price index and Quantity index) are placed in the column "NAGG".

25 The weighted nutrient content per unit of feed aggregate is used to calculate the feed input per animal production activity.

Demand table Lines (DL)

	Line Code	Line No
Products (DL)[26]		
Raw products (DL)		
Crop products (DL)		
Soft Wheat	SWHE	01
Durum Wheat	DWHE	02
Rye and Meslin	RYE	03
Barley	BARL	04
Oats	OATS	05
Maize	MAIZ	06
Other Cereals (excl. Rice)	OCER	07
Paddy Rice	PARI	08
Pulses	PULS	09
Potatoes	POTA	10
Sugar Beets	SUGB	11
Rape and Turnip Rape Seed	RAPE	12
Sunflower Seed	SUNF	13
Soya Beans	SOYA	14
Olives for Oil	OLIV	15
Other Oilseeds and Oleaginous Fruit	OOIL	16
Flax and Hemp	FLAX	17
Tobacco Unmanufactured	TOBA	18
Other Industrial Crops	OIND	19
Cauliflowers	CAUL	20
Tomatoes	TOMA	21
Other Vegetables	OVEG	22
Apples, Pears and Peaches	APPL	23
Other fresh Fruits	OFRU	24
Citrus Fruits	CITR	25
Table Grapes	TAGR	26
Table Olives	TABO	27

[26] The lines of the demand table are divided into raw and processed products. Both are grouped into crop and animal products. The demand components are divided into 43 raw products (32 crop and 10 animal products) and 17 processed products (14 crop and 3 animal products).
In addition, 7 aggregated feed products are shown (corresponding to the supply table), to calculate the intersectoral purchases of agriculture.
For additional national aggregates a line (NAGG) is added.

	Line Code	Line No
Table Wine	TWIN	28
Other Wine	OWIN	29
Nursery Plants	NURS	30
Flowers, Ornam. Plants etc.	FLOW	31
Other final Crop Products	OCRO	32
Animal products (DL)		
Milk of dairy cows	MILK	33
Beef	BEEF	34
Veal	VEAL	35
Pork	PORK	36
Milk of Ewes and Goats	MUTM	37
Sheep- and Goatmeat	MUTT	38
Eggs	EGGS	39
Poultry Meat	POUL	40
Other Animal Products	OANI	41
Raw Wool	WOOL	42
Processed products (DL)		
Processed crop products (DL)		
Rice (milled rice equivalent)	RICE	43
Molasses	MOLA	44
Potato Starch	STAR	45
Sugar	SUGA	46
Vegetable Fats and Oil		
Rape and Turnip Rape	RAPO	47
Sunflower	SUNO	48
Soya	SOYO	49
Olives	OLIO	50
Others	OTHO	51
Oilcake - Rape and Turnip Rape	RAPC	52
Oilcake - Sunflower	SUNC	53
Oilcake - Soya	SOYC	54
Oilcake - Olives	OLIC	55
Other Oilcakes	OTHC	56
Processed animal products (DL)		
Milk powder	MIPO	57
Butter	BUTT	58
Other products of milk	OMPR	59

	Line Code	Line No
Aggregated feed products (DL)		
Fodder : cereals (incl. rice)	FCER	60
Fodder : rich protein	FPRO	61
Fodder : rich energy	FENE	62
Fodder : milk and milk products	FMIL	63
Fodder : dried (not marketable)	FDRY	64
Fodder : fresh and ensilaged (not marketable)	FFSI	65
Fodder : other	FOTH	66
Additional economic aggregate (DL)		
National Aggregates	NAGG	67

Demand table Columns (DC)

	Column Code	Column No
Resource and use activities (DC)[27]		
Use activities (DC)		
Exports, intra EUR12	PEXE	01
Exports, extra EUR12	PEXW	02
Change in Stocks: Market	PCSM	03
Human Consumption: Market	PCOM	04
Animal Feed: Market	PFEE	05
Seed: Market	PSEE	06
Losses: Market	PLOS	07
Industrial Use	PIND	08
Processing	PPRO	09
Statistical adjustments	PADJ	10

[27] The rows of the demand table show separately resource/use activities, which make up the market balance.

	Column Code	Column No
Resource activities (DC)		
Marketable Production	MAPR	11
Imports: intra EUR 12	PIME	12
Imports: extra EUR 12	PIMW	13
Demand aggregates (DC) [28]		
Resource aggregates (DC)		
Imports: Total	PIMT	14
Final/Initial Stocks: Market	PFSM	15
Use aggregates (DC)		
Total domestic use	PDOM	16
Exports, Total	PEXT	17
National aggregates (DC)		
Consumer prices	CPRI	18
Expenditure	EXPE	19
Population	INHA	20

28 The additional aggregates combining resource and use activities are defined as table columns.

V. CODES OF THE NLP MATRICES

This annex gives an overview of the activities and constraints of the NLP matrices along with the corresponding codes and their explanations.

Each activity and each constraint code consists of four characters. The tables presented in this annex have two dimensions: the table columns show the first and second characters and the table lines show the third and fourth characters. The combination of table columns and lines give the complete code.

V.I. Codes of the NLP matrix of the supply component

V.I.I. Activities

Table V.I.I.-1: Codes related to crop production and fallow land

		CP crop production activities	OP other production activities	MI mineral fertilizing activities: specific to production activities	OR organic fertilizing activities: specific to production activities	DF mineral fertilizing activities: non-specific to production activities	GV value addeds of production activities
SW	soft wheat	x		x	x		x
DW	durum wheat	x		x	x		x
RY	rye	x		x	x		x
BA	barley	x		x	x		x
OA	oats	x		x	x		x
MA	maize	x		x	x		x
OC	other cereals	x		x	x		x
PA	paddy rice	x		x	x		x
PU	pulses	x		x	x		x
PO	potatoes	x		x	x		x
SU	sugar beets	x		x	x		x
RA	rape seed	x		x	x		x
SF	sunflower seed	x		x	x		x
SB	soya beans	x		x	x		x
OL	olives for oil	x		x	x		x
OO	other oilseeds	x		x	x		x
FL	flax and hemp	x		x	x		x
TO	tobacco	x		x	x		x
OI	other industrial crops	x		x	x		x
CL	cauliflower	x		x	x		x
TM	tomatoes	x		x	x		x
OV	other vegetables	x		x	x		x
AP	apples, pears, peaches	x		x	x		x
OF	other fruits	x		x	x		x
CF	citrus fruits	x		x	x		x
TG	table grapes	x		x	x		x
TA	table olives	x		x	x		x
TW	table wine	x		x	x		x
OW	other wine	x		x	x		x
NU	nursery plants	x		x	x		x
FW	flowers, etc.	x		x	x		x
OT	other final crop products	x		x	x		x
OR	other root crops	x		x	x		
GR	grass/grazing	x		x	x		
SI	fodder plants on arable l.	x		x	x		
FA	fallow land		x				x
PF	phosphate					x	
KF	potassium					x	

Table V.I.I.-2: Codes related to animal production activities

		AP animal production activities	**C1** feeding with cereal mix 1	**C2** feeding with cereal mix 2	**PR** feeding with protein rich fodder	**EN** feeding with energy rich fodder	**RM** feeding with raw milk
DC	dairy cows	x	x	x	x	x	x
BU	male adult cattle f.f.[1]	x	x	x	x	x	x
CA	calves f.f.[1]	x	x	x	x	x	x
PI	pigs f.f.[1]	x	x	x	x	x	x
EW	ewes and goats	x	x	x	x	x	x
SH	sheep and goats f.f.[1]	x	x	x	x	x	x
LH	laying hens	x	x	x	x	x	x
PL	poultry f.f.[1]	x	x	x	x	x	x
AN	other animals	x	x	x	x	x	x
HF	heifers f.f.[1]	x	x	x	x	x	x
SC	suckling calves	x	x	x	x	x	x
RC	calves, rearing	x	x	x	x	x	x
HB	heifers for breeding	x	x	x	x	x	x
SO	pig breeding	x	x	x	x	x	x

		MP feeding with milk products	**DR** feeding with dried fodder	**FS** feeding with fresh and en-silaged fodder	**OT** feeding with other fodder	**DX** exceeding maximum fodder intake	**GV** value added
DC	dairy cows	x	x	x	x		x
BU	male adult cattle f.f.[1]	x	x	x	x		x
CA	calves f.f.[1]	x	x	x	x		x
PI	pigs f.f.[1]	x	x	x	x		x
EW	ewes and goats	x	x	x	x		x
SH	sheep and goats f.f.[1]	x	x	x	x		x
LH	laying hens	x	x	x	x		x
PL	poultry f.f.[1]	x	x	x	x		x
AN	other animals	x	x	x	x		x
HF	heifers f.f.[1]	x	x	x	x		
SC	suckling calves	x	x	x	x		
RC	calves, rearing	x	x	x	x		
HB	heifers for breeding	x	x	x	x		
SO	pig breeding	x	x	x	x		
EX	dry matter					x	
CX	cereals					x	

1) f.f.=for fattening

Table V.I.I.-3: Intrasectoral transfers

		LF losses on farm	FF animal feed on farm	SF seed on farm	HF human consumption on farm	CF stock changes on farm
SW	soft wheat	x	x	x	x	x
DW	durum wheat	x	x	x	x	x
RY	rye	x	x	x	x	x
BA	barley	x	x	x	x	x
OA	oats	x	x	x	x	x
MA	maize	x	x	x	x	x
OC	other cereals	x	x	x	x	x
PA	paddy rice	x			x	x
PU	pulses	x	x		x	x
PO	potatoes	x	x	x	x	x
SU	sugar beets	x	x		x	x
RA	rape seed	x			x	x
SF	sunflower seed	x			x	x
SB	soya beans	x			x	x
OL	olives for oil	x			x	x
OO	oth. oilseeds a. oleag. fr.	x			x	x
FL	flax and hemp	x			x	x
TO	tobacco	x			x	x
OI	other industrial crops	x			x	x
CL	cauliflower	x	x		x	x
TAM	tomatoes	x	x		x	x
OVA	other vegetables	x	x		x	x
AP	apples, pears, peaches	x			x	x
OF	other fruits	x			x	x
CF	citrus fruits	x			x	x
TG	table grapes	x			x	x
TA	table olives	x			x	x
TWO	grapes for table wine	x			x	x
AU	grapes for other wine	x			x	x
GNU	nursery plants	x			x	x
FEW	flowers, etc.	x			x	x
OT	other final crop products	x	x		x	x
OR	other root crops		x			
GR.	green fodder		x			
IS	silage		x			
DH	hay		x			
ST	straw fed		x			
MI	milk of cows	x	x		x	
BE	beef	x			x	
VET	veal	x			x	
PK	pork	x			x	
MU	milk of ewes and goats	x	x		x	
MT	sheep- and goatmeat	x			x	
EG	eggs	x			x	
PL	poultry meat	x			x	
AN	other animal products	x			x	
WO	raw wool	x			x	
		TF output-output transfers: young cows into	**SL** slaughtering	**IA** output-input- transfers: intermediate live animals	**CF** stock changes on farm	**MA** output-input transfers: manure
CV	calves			x		
HE	heifers			x	x	
DC	dairy cows	x	x	x	x	
SC	suckler cows	x	x	x	x	
PG	piglets			x		
BU	bulls			x		
LB	lambs			x		
CH	chicks			x		
NN	nitrogen from manure					x
NP	phosphate from manure					x
NK	potassium from manure					x

Table V.I.I.-4: Intersectoral transfers

		SA sales	PU purchases	PS purchases of seeds	PF purchases of fodder
SW	soft wheat	x		x	x
DW	durum wheat	x		x	x
RY	rye	x		x	x
BA	barley	x		x	x
OA	oats	x		x	x
MA	maize	x		x	x
OC	other cereals	x		x	x
PA	paddy rice	x		x	
PU	pulses	x		x	x
PO	potatoes	x		x	
SU	sugar beets	x			
RA	rape seed	x		x	
SF	sunflower seed	x		x	
SB	soya beans	x		x	
OL	olives for oil	x			
OO	other oilseeds	x		x	
FL	flax and hemp	x			
TO	tobacco	x			
OI	other industrial crops	x			
CL	cauliflower	x			
TM	tomatoes	x			
OV	other vegetables	x			
AP	apples, pears, peaches	x			
OF	other fruits	x			
CF	citrus fruits	x			
TG	table grapes	x			
TA	table olives	x			
TW	grapes for table wine	x			
OW	grapes for other wine	x			
NU	nursery plants	x			
FW	flowers, etc.	x			
OT	other final crop product	x		residual	other fodder
MI	milk of cows	x			x
BE	beef	x			
VE	veal	x			
PK	pork	x			
MU	milk of ewes and goats	x			x
MT	sheep- and goatmeat	x			
EG	eggs	x			
PL	poultry meat	x			
AN	other animal products	x			
WO	raw wool	x			
NF	nitrogenous mineral fert.		x		
PF	phosphatic mineral fert.		x		
KF	potassic mineral fert.		x		
LF	lime fertilizer		x		
PP	plant protection		x		
IC	input: calves		x		
IH	input: heifers		x		
ID	input: dairy cows		x		
IS	input: suckler cows		x		
IP	input: piglets		x		
IB	input: bulls		x		
IL	input: lambs		x		
IK	input: chicks		x		
IA	animal imports (EAA)		x		
PI	pharmaceutical inputs		x		
RV	variable costs repair		x		
EV	variable costs energy		x		
WV	variable costs water		x		
IV	variable costs oth. inputs		x		
RO	overheads repair		x		
EO	overheads energy		x		
IO	overheads other inputs		x		
RI	rice (milled equivalent)				x
OP	other protein rich fodder				x
EN	energy rich fodder				x

Table V.I.I.-5: Dynamic interdependence variables in the animal sector

		A1 "planned" animal production activities (t+1)	A2 "planned" animal production activities (t+2)	T1 "planned" output-output-transfers (t+1): young cows into	S1 "planned" slaughtering (t+1)	I1 "planned" output-input transfers (t+1): intermediate live animals	F1 "planned" stock changes on farm (t+1)
DC	dairy cows	x	x	x	x	x	x
BU	male adult cattle f.f.	x				x	
HF	heifers f.f.	x					
SC	suckler cows	x	x	x	x	x	x
HB	heifers for breeding	x					
HE	heifers					x	

		P1 "planned" purchases (t+1)	P2 "planned" purchases (t+2)
IH	input :heifers	x	
ID	input :dairy cows	x	x
IS	input :suckler cows	x	x
IB	input :bulls	x	

V.I.II. Constraints

Table V.I.II.-1: Balances for crop product items

		FO output balances	FS seed input balances	FF fodder input balances
SW	soft wheat	x	x	x
DW	durum wheat	x	x	x
RY	rye	x	x	x
BA	barley	x	x	x
OA	oats	x	x	x
MA	maize	x	x	x
OC	other cereals	x	x	x
PA	paddy rice	x	x	
PU	pulses	x	x	x
PO	potatoes	x	x	
SU	sugar beets	x		
RA	rape seed	x	x	
SF	sunflower seed	x	x	
SB	soya beans	x	x	
OL	olives for oil	x		
OO	other oilseeds	x	x	
FL	flax and hemp	x		
TO	tobacco	x		
OI	other industrial crops	x		
CL	cauliflower	x		
TM	tomatoes	x		
OV	other vegetables	x		
AP	apples, pears, peaches	x		
OF	other fruits	x		
CF	citrus fruits	x		
TG	table grapes	x		
TA	table olives	x		
TW	grapes for table wine	x		
OW	grapes for other wine	x		
NU	nursery plants	x		
FW	flowers, etc.	x		
OT	other final crop products	x	x1)	x2)
OR	other root crops	x		x
GR	green fodder	x		x
SI	silage	x		x
DH	hay	x		x3)
ST	straw fed	x		

1) aggregate seed input in constant prices
2) inclusive sugarbeets, potatoes oilseeds, fruits and vegetables
3) inclusive straw

Table V.I.II.-2: Balances for animal product items

		FO output balances	FF fodder input balances
MI	milk of cows	x	x
BE	beef	x	
VE	veal	x	
PK	pork	x	
MU	milk of ewes and goats	x	x
MT	sheep- and goatmeat	x	
EG	eggs	x	
PL	poultry meat	x	
AN	other animal products	x	
WO	raw wool	x	
CV	calves	x	
HE	heifers	x	
OD	dairy cows (>2 years)	x	
OS	suckler cows (>2 years)	x	
YC	young cows	x	
PG	piglets	x	
LB	lambs	x	
CH	chicks	x	
BU	bulls	x	
NN	nitrogen from manure	x	
NP	phosphate from manure	x	
NK	potassium from manure	x	

Table V.I.II.-3: Balances for input items

		FI input balances	FF fodder input balances	ST stock balances
NF	nitrogenous mineral fert.	x		
PF	phosphatic mineral fert.	x		
KF	potassic mineral fert.	x		
LF	lime fertilizer	x		
NM	nitrogen from manure	x		
PM	phosphate from manure	x		
KM	potassium from manure	x		
PP	plant protection	x		
IC	input: calves	x		
IH	input: heifers	x		x
ID	input: dairy cows	x		x
IS	input: suckler cows	x		x
IP	input: piglets	x		
IB	input: bulls	x		x
IL	input: lambs	x		
IK	input: chicks	x		
IA	animal imports (EAA)	x		
PI	pharmaceutical inputs	x		
RV	variable costs repair	x		
EV	variable costs energy	x		
IV	variable costs oth. inputs	x		
RO	overheads repair	x		
EO	overheads energy	x		
IO	overheads other inputs	x		
RI	rice (milled equivalent)		x	
OP	other protein rich fodder		x	
EN	energy rich fodder		x	
MP	milk fodder		x	

Table V.I.II.-4: Dynamic interdependence balances in the animal sector

		O1 output balances (t+1)	I1 input balances (t+1)	S1 stock balances (t+1)	I2 input balances (t+2)	S2 stock balances (t+2)
OD	dairy cows (>2 years)	x				
OS	suckler cows (>2 years)	x				
YC	young cows	x				
IH	input: heifers		x	x		
ID	input: dairy cows		x	x	x	x
IS	input: suckler cows		x	x	x	x
IB	input: bulls		x	x		

Table V.I.II.-5: Constraints of the fertilizer module

		NR activity-specific minimum nitrogen requirements	OR activity-specific minimum mineral nitrogen requirements	TO sectoral nutrient balances
SW	soft wheat	x	x	
DW	durum wheat	x	x	
RY	rye	x	x	
BA	barley	x	x	
OA	oats	x	x	
MA	maize	x	x	
OC	other cereals	x	x	
PA	paddy rice	x	x	
PU	pulses	x	x	
PO	potatoes	x	x	
SU	sugar beets	x	x	
RA	rape seed	x	x	
SF	sunflower seed	x	x	
SB	soya beans	x	x	
OL	olives for oil	x	x	
OO	other oilseeds	x	x	
FL	flax and hemp	x	x	
TO	tobacco	x	x	
OI	other industrial crops	x	x	
CL	cauliflower	x	x	
TM	tomatoes	x	x	
OV	other vegetables	x	x	
AP	apples, pears, peaches	x	x	
OF	other fruits	x	x	
CF	citrus fruits	x	x	
TG	table grapes	x	x	
TA	table olives	x	x	
TW	grapes for table wine	x	x	
OW	grapes for other wine	x	x	
NU	nursery plants	x	x	
FW	flowers, etc.	x	x	
OT	other final crop products	x	x	
OR	other root crops	x	x	
GR	grass/grazing	x	x	
SI	silage	x	x	
TP	phosphate			x
TK	potassium			x

Table V.I.II.-6: Constraints of the feed module

		DM min. dry matter intake	DX max. dry matter intake	EN min. energy intake	CP min. crude protein intake	XC min. fodder cereals intake	XP min. rich protein fodder intake
DC	dairy cows 1)	x	x	x	x	x	
BU	male adult cattle f.f.	x	x	x	x	x	x
CA	calves f.f. 1)	x	x	x	x	x	x
PI	pigs f.f. 1)	x	x	x	x	x	x
EW	ewes and goats	x	x	x	x	x	x
SH	sheep and goats f.f. 1)	x	x	x	x	x	x
LH	laying hens	x	x	x	x	x	x
PL	poultry f.f. 1)	x	x	x	x	x	x
AN	oth. fin. animal products	x	x	x	x	x	x
HF	heifers f.f. 1)	x	x	x	x	x	x
SC	suckling calves	x	x	x	x	x	x
RC	calves, rearing	x	x	x	x	x	x
HB	heifers for breeding	x	x	x	x	x	x
SO	pig breeding	x	x	x	x	x	x
		XE min. rich energy fodder intake	XM min. milk fodder intake	XD min. dried fodder intake	XF min. fresh a. ensilaged fodder intake	XO min. other fodder intake	NC max. fodder cereal intake
DC	dairy cows 1)	x	x	x	x	x	
BU	male adult cattle f.f.	x	x	x	x	x	x
CA	calves f.f. 1)	x	x	x	x	x	x
PI	pigs f.f. 1)	x	x	x	x	x	x
EW	ewes and goats	x	x	x	x	x	x
SH	sheep and goats f.f. 1)	x	x	x	x	x	x
LH	laying hens	x	x	x	x	x	x
PL	poultry f.f. 1)	x	x	x	x	x	x
AN	oth. fin. animal products	x	x	x	x	x	x
HF	heifers f.f. 1)	x	x	x	x	x	x
SC	suckling calves	x	x	x	x	x	x
RC	calves, rearing	x	x	x	x	x	x
HB	heifers for breeding	x	x	x	x	x	x
SO	pig breeding	x	x	x	x	x	x
		NP max. rich protein fodder intake	NE max. rich energy fodder intake	NM max.. milk fodder intake	ND max. dried fodder intake	NF max. fresh a. ensilaged fodder intake	NO max. other fodder intake
DC	dairy cows 1)	x	x	x	x	x	
BU	male adult cattle f.f.	x	x	x	x	x	x
CA	calves f.f. 1)	x	x	x	x	x	x
PI	pigs f.f. 1)	x	x	x	x	x	x
EW	ewes and goats	x	x	x	x	x	x
SH	sheep and goats f.f. 1)	x	x	x	x	x	x
LH	laying hens	x	x	x	x	x	x
PL	poultry f.f. 1)	x	x	x	x	x	x
AN	oth. fin. animal products	x	x	x	x	x	x
HF	heifers f.f. 1)	x	x	x	x	x	x
SC	suckling calves	x	x	x	x	x	x
RC	calves, rearing	x	x	x	x	x	x
HB	heifers for breeding	x	x	x	x	x	x
SO	pig breeding	x	x	x	x	x	x

1) f.f. = for fattening

Table V.I.II.-7: Constraints on intrasectoral transfers

		LF losses on farm	FA animal feed on farm	HF human consumption on farm
SW	soft wheat	x	x	x
DW	durum wheat	x	x	x
RY	rye	x	x	x
BA	barley	x	x	x
OA	oats	x	x	x
MA	maize	x	x	x
OC	other cereals	x	x	x
PA	paddy rice	x		x
PU	pulses	x	x	x
PO	potatoes	x	x	x
SU	sugar beets	x	x	x
RA	rape seed	x		x
SF	sunflower seed	x		x
SB	soya beans	x		x
OL	olives for oil	x		x
OO	other oilseeds	x		x
FL	flax and hemp	x		x
TO	tobacco	x		x
OI	other industrial crops	x		x
CL	cauliflower	x	x	x
TM	tomatoes	x	x	x
OV	other vegetables	x	x	x
AP	apples, pears, peaches	x		x
OF	other fruits	x		x
CF	citrus fruits	x		x
TG	table grapes	x		x
TA	table olives	x		x
TW	grapes for table wine	x		x
OW	grapes for other wine	x		x
NU	nursery plants	x		x
FW	flowers, etc.	x		x
OT	other final crop products	x	x	x
MI	milk of cows	x	x	x
BE	beef	x		x
VE	veal	x		x
PK	pork	x		x
MU	milk of ewes and goats	x	x	x
MT	sheep- and goatmeat	x		x
EG	eggs	x		x
PL	poultry meat	x		x
AN	other animal products	x		x
WO	raw wool	x		x

Table V.I.II.-8: Behavioural equations

		AE levels of production activities	A1 "planned" levels of production activities (t+1)	A2 "planned" levels of production activities (t+2)
SW	soft wheat	x		
DW	durum wheat	x		
RY	rye	x		
BA	barley	x		
OA	oats	x		
MA	maize	x		
OC	other cereals	x		
PA	paddy rice	x		
PU	pulses	x		
PO	potatoes	x		
SU	sugar beets	x		
RA	rape seed	x		
SF	sunflower seed	x		
SB	soya beans	x		
OL	olives for oil	x		
OO	other oilseeds	x		
FL	flax and hemp	x		
TO	tobacco	x		
OI	other industrial crops	x		
CL	cauliflower	x		
TM	tomatoes	x		
OV	other vegetables	x		
AP	apples, pears, peaches	x		
OF	other fruits	x		
CF	citrus fruits	x		
TG	table grapes	x		
TA	table olives	x		
TW	grapes for table wine	x		
OW	grapes for other wine	x		
NU	nursery plants	x		
FW	flowers, etc.	x		
OT	other final crop products	x		
FA	fallow land	x		
DC	dairy cows		x	x
BU	male adult cattle f.f.		x	
CA	calves f.f.	x		
PI	pigs f.f.	x		
EW	ewes and goats	x		
SH	sheep and goats f.f.	x		
LH	laying hens	x		
PL	poultry f.f.	x		
AN	other animal products	x		
HF	heifers f.f.	x		

V.II. Codes of the NLP matrix of the demand component

V.II.I. Activities

Table V.II.I.-1a: Regional variables

		MA marketable production	FM marketable production of feed	CM stock changes on market	FC stock changes on market of feed	HM human consumption on market	SM seed use on market
SW	soft wheat	x	x	x	x	x	x
DW	durum wheat	x	x	x	x	x	x
RY	rye	x	x	x	x	x	x
BA	barley	x	x	x	x	x	x
OA	oats	x	x	x	x	x	x
MA	maize	x	x	x	x	x	x
OC	other cereals	x	x	x	x	x	x
PA	paddy rice	x		x		x	x
PU	pulses	x	x	x	x	x	x
PO	potatoes	x		x		x	x
SU	sugar beets	x		x		x	
RA	rape seed	x		x		x	x
SF	sunflower seed	x		x		x	x
SB	soya beans	x		x		x	x
OL	olives for oil	x		x		x	
OO	other oilseeds	x		x		x	x
FL	flax and hemp	x		x		x	
TO	tobacco	x		x		x	
OI	other industrial crops	x		x		x	
CL	cauliflower	x		x		x	
TM	tomatoes	x		x		x	
OV	other vegetables	x		x		x	
AP	apples, pears, peaches	x		x		x	
OF	other fruits	x		x		x	
CF	citrus fruits	x		x		x	
TG	table grapes	x		x		x	
TA	table olives	x		x		x	
TW	grapes for table wine	x		x		x	
OW	grapes for other wine	x		x		x	
NU	nursery plants	x		x		x	
FW	flowers, etc.	x		x		x	
OT	other final crop products	x	x	x	x	x	
MI	milk of cows	x	x	x	x	x	
BE	beef	x		x		x	
VE	veal	x		x		x	
PK	pork	x		x		x	
MU	milk of ewes and goats	x	x	x	x	x	
MT	sheep- and goatmeat	x		x		x	
EG	eggs	x		x		x	x
PL	poultry meat	x		x		x	
AN	other animal products	x		x		x	
WO	raw wool	x		x		x	
RI	rice (milled equivalent)		x	x	x	x	
MO	molasses			x		x	
PS	potato starch			x		x	
SG	sugar			x		x	
RO	rape oil			x		x	
SO	sunflower oil			x		x	
YO	soya oil			x		x	
ZO	olive oil			x		x	
OH	other oils and fats			x		x	
RC	rape oilcake			x		x	
SC	sunflower oilcake			x		x	
YC	soya oilcake			x		x	
ZC	olive oilcake			x		x	
OK	other oilcakes			x		x	
MW	milk powder			x		x	
BT	butter			x		x	
PM	other milk products			x		x	
OP	other protein rich fodder		x		x		
EN	energy rich fodder		x		x		
MP	milk product fodder		x		x		

Table V.II.I.-1b: Regional variables

		LM losses on market	IN industrial use	PR processing	MF animal feed on market	NI net export into EUR-pool	RP regional consumer price
SW	soft wheat	x	x		x	x	x
DW	durum wheat	x	x		x	x	x
RY	rye	x	x		x	x	x
BA	barley	x	x		x	x	x
OA	oats	x	x		x	x	x
MA	maize	x	x		x	x	x
OC	other cereals	x	x		x	x	x
PA	paddy rice	x	x	x		x	x
PU	pulses	x	x		x	x	x
PO	potatoes	x	x	x		x	x
SU	sugar beets	x	x	x		x	x
RA	rape seed	x	x	x		x	x
SF	sunflower seed	x	x	x		x	x
SB	soya beans	x	x	x		x	x
OL	olives for oil	x	x	x		x	x
OO	other oilseeds	x	x	x		x	x
FL	flax and hemp	x	x			x	x
TO	tobacco	x	x			x	x
OI	other industrial crops	x	x			x	x
CL	cauliflower	x	x			x	x
TM	tomatoes	x	x			x	x
OV	other vegetables	x	x			x	x
AP	apples, pears, peaches	x	x			x	x
OF	other fruits	x	x			x	x
CF	citrus fruits	x	x			x	x
TG	table grapes	x	x			x	x
TA	table olives	x	x			x	x
TW	grapes for table wine	x	x			x	x
OW	grapes for other wine	x	x			x	x
NU	nursery plants	x	x			x	x
FW	flowers, etc.	x	x			x	x
OT	other final crop products	x	x		x	x	x
MI	milk of cows	x	x		x	x	x
MB	milk of cows to			butter		x	x
MM	milk of cows to			milk powder		x	x
MH	milk of cows to			oth. m. prod.		x	x
BE	beef	x	x			x	x
VE	veal	x	x			x	x
PK	pork	x	x			x	x
MU	milk of ewes and goats	x	x		x	x	x
MT	sheep- and goatmeat	x	x			x	x
EG	eggs	x	x			x	x
PL	poultry meat	x	x			x	x
AN	other animal products	x	x			x	x
WO	raw wool	x	x			x	x
RI	rice (milled equivalent.)	x	x		x	x	x
MO	molasses	x	x			x	x
PS	potatoe starch	x	x			x	x
SG	sugar	x	x			x	x
RO	rape oil	x	x			x	x
SO	sunflower oil	x	x			x	x
YO	soya oil	x	x			x	x
ZO	olive oil	x	x			x	x
OH	other oils and fats	x	x			x	x
RC	rape oilcake	x	x			x	x
SC	sunflower oilcake	x	x			x	x
YC	soya oilcake	x	x			x	x
ZC	olive oilcake	x	x			x	x
OK	other oilcakes	x	x			x	x
MW	milk powder	x	x			x	x
BT	butter	x	x			x	x
PM	other milk products	x	x			x	x
OP	other protein rich fodder				x		
EN	energy rich fodder				x		
MP	milk products fodder				x		

Table V.II.I.-2: Sectoral variables

		TE EUR net exports	EP EUR-pool price	TR ROW net import	WP EUR-border price
SW	soft wheat	x	x	x	x
DW	durum wheat	x	x	x	x
RY	rye	x	x	x	x
BA	barley	x	x	x	x
OA	oats	x	x	x	x
MA	maize	x	x	x	x
OC	other cereals	x	x	x	x
PA	paddy rice	x	x	x	x
PU	pulses	x	x	x	x
PO	potatoes	x	x	x	x
SU	sugar beets	x	x	x	x
RA	rape seed	x	x	x	x
SF	sunflower seed	x	x	x	x
SB	soya beans	x	x	x	x
OL	olives for oil	x	x	x	x
OO	other oilseeds	x	x	x	x
FL	flax and hemp	x	x	x	x
TO	tobacco	x	x	x	x
OI	other industrial crops	x	x	x	x
CL	cauliflower	x	x	x	x
TM	tomatoes	x	x	x	x
OV	other vegetables	x	x	x	x
AP	apples, pears, peaches	x	x	x	x
OF	other fruits	x	x	x	x
CF	citrus fruits	x	x	x	x
TG	table grapes	x	x	x	x
TA	table olives	x	x	x	x
TW	grapes for table wine	x	x	x	x
OW	grapes for other wine	x	x	x	x
NU	nursery plants	x	x	x	x
FW	flowers, etc.	x	x	x	x
OT	other final crop products	x	x	x	x
MI	milk of cows	x	x	x	x
BE	beef	x	x	x	x
VE	veal	x	x	x	x
PK	pork	x	x	x	x
MU	milk of ewes and goats	x	x	x	x
MT	sheep- and goatmeat	x	x	x	x
EG	eggs	x	x	x	x
PL	poultry meat	x	x	x	x
AN	other animal products	x	x	x	x
WO	raw wool	x	x	x	x
RI	rice (milled equivalent)	x	x	x	x
MO	molasses	x	x	x	x
PS	potato starch	x	x	x	x
SG	sugar	x	x	x	x
RO	rape oil	x	x	x	x
SO	sunflower oil	x	x	x	x
YO	soya oil	x	x	x	x
ZO	olive oil	x	x	x	x
OH	other oils and fats	x	x	x	x
RC	rape oilcake	x	x	x	x
SC	sunflower oilcake	x	x	x	x
YC	soya oilcake	x	x	x	x
ZC	olive oilcake	x	x	x	x
OK	other oilcakes	x	x	x	x
MW	milk powder	x	x	x	x
BT	butter	x	x	x	x
PM	other milk products	x	x	x	x

V.II.II. Constraints

Table V.II.II.-1: Regional constraints

		MO market balances	MF market balances for feed	DE behavioural equations for human consumption on market	CM behavioural equations for stock changes on market	PE price transmission equations: EUR-pool to MS
SW	soft wheat	x	x	x	x	x
DW	durum wheat	x	x	x	x	x
RY	rye	x	x	x	x	x
BA	barley	x	x	x	x	x
OA	oats	x	x	x	x	x
MA	maize	x	x	x	x	x
OC	other cereals	x	x	x	x	x
PA	paddy rice	x		x	x	x
PU	pulses	x	x	x	x	x
PO	potatoes	x		x	x	x
SU	sugar beets	x		x	x	x
RA	rape seed	x		x	x	x
SF	sunflower seed	x		x	x	x
SB	soya beans	x		x	x	x
OL	olives for oil	x		x	x	x
OO	other oilseeds	x		x	x	x
FL	flax and hemp	x		x	x	x
TO	tobacco	x		x	x	x
OI	other industrial crops	x		x	x	x
CL	cauliflower	x		x	x	x
TM	tomatoes	x		x	x	x
OV	other vegetables	x		x	x	x
AP	apples, pears, peaches	x		x	x	x
OF	other fruits	x		x	x	x
CF	citrus fruits	x		x	x	x
TG	table grapes	x		x	x	x
TA	table olives	x		x	x	x
TW	grapes for table wine	x		x	x	x
OW	grapes for other wine	x		x	x	x
NU	nursery plants	x		x	x	x
FW	flowers, etc.	x		x	x	x
OT	other final crop products	x	x	x	x	x
MI	milk of cows	x	x	x	x	x
BE	beef	x		x	x	x
VE	veal	x		x	x	x
PK	pork	x		x	x	x
MU	milk of ewes and goats	x	x	x	x	x
MT	sheep- and goatmeat	x		x	x	x
EG	eggs	x		x	x	x
PL	poultry meat	x		x	x	x
AN	other animal products	x		x	x	x
WO	raw wool	x		x	x	x
RI	rice (milled equivalent)	x	x	x	x	x
MO	molasses	x	x	x	x	x
PS	potato starch	x	x	x	x	x
SG	sugar	x	x	x	x	x
RO	rape oil	x	x	x	x	x
SO	sunflower oil	x	x	x	x	x
YO	soya oil	x	x	x	x	x
ZO	olive oil	x	x	x	x	x
OH	other oils and fats	x	x	x	x	x
RC	rape oilcake	x	x	x	x	x
SC	sunflower oilcake	x	x	x	x	x
YC	soya oilcake	x	x	x	x	x
ZC	olive oilcake	x	x	x	x	x
OK	other oilcakes	x	x	x	x	x
MW	milk powder	x	x	x	x	x
BT	butter	x	x	x	x	x
PM	other milk products	x	x	x	x	x

Table V.II.II.-3: Sectoral constraints

		ET EUR-pool market balances	RT ROW net trade balances	TE behavioural equations for ROW net imports	PW price transmission equations: EUR-border to EUR-pool
SW	soft wheat	x	x	x	x
DW	durum wheat	x	x	x	x
RY	rye	x	x	x	x
BA	barley	x	x	x	x
OA	oats	x	x	x	x
MA	maize	x	x	x	x
OC	other cereals	x	x	x	x
PA	paddy rice	x		x	x
PU	pulses	x	x	x	x
PO	potatoes	x		x	x
SU	sugar beets	x		x	x
RA	rape seed	x		x	x
SF	sunflower seed	x		x	x
SB	soya beans	x		x	x
OL	olives for oil	x		x	x
OO	other oilseeds	x		x	x
FL	flax and hemp	x		x	x
TO	tobacco	x		x	x
OI	other industrial crops	x		x	x
CL	cauliflowers	x		x	x
TM	tomatoes	x		x	x
OV	other vegetables	x		x	x
AP	apples, pears, peaches	x		x	x
OF	other fruits	x		x	x
CF	citrus fruits	x		x	x
TG	table grapes	x		x	x
TA	table olives	x		x	x
TW	grapes for table wine	x		x	x
OW	grapes for other wine	x		x	x
NU	nursery plants	x		x	x
FW	flowers, etc.	x		x	x
OT	other final crop products	x	x	x	x
MI	milk of cows	x	x	x	x
BE	beef	x		x	x
VE	veal	x		x	x
PK	pork	x		x	x
MU	milk of ewes and goats	x	x	x	x
MT	sheep- and goatmeat	x		x	x
EG	eggs	x		x	x
PL	poultry meat	x		x	x
AN	other animal products	x		x	x
WO	raw wool	x		x	x
RI	rice (milled equivalent)	x	x	x	x
MO	molasses	x	x	x	x
PS	potato starch	x	x	x	x
SG	sugar	x	x	x	x
RO	rape oil	x	x	x	x
SO	sunflower oil	x	x	x	x
YO	soya oil	x	x	x	x
ZO	olive oil	x	x	x	x
OH	other oils and fats	x	x	x	x
RC	rape oilcake	x	x	x	x
SC	sunflower oilcake	x	x	x	x
YC	soya oilcake	x	x	x	x
ZC	olive oilcake	x	x	x	x
OK	other oilcakes	x	x	x	x
MW	milk powder	x	x	x	x
BT	butter	x	x	x	x
PM	other milk products	x	x	x	x

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Series E: Methods

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