Aglink-Cosimo Model Documentation

A partial equilibrium model
of world agricultural markets

OECD

Food and Agriculture Organization of the United Nations

Aglink-Cosimo:
A brief overview

Aglink-Cosimo is an economic model that analyses supply and demand of world agriculture. It is managed by the Secretariats of the OECD and Food and Agriculture Organization of the United Nations (FAO), and used to generate the *OECD-FAO Agricultural Outlook* and policy scenario analysis.

Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to simulate developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide. The Aglink-Cosimo country and regional modules covering the whole world, and projections are developed and maintained by the OECD and FAO Secretariats in conjunction with country experts and national administrations. Several key factors or assumptions are as follows:

- World markets for agricultural commodities are competitive, with buyers and sellers acting as price takers. Market prices are determined through a global or regional equilibrium in supply and demand.

- Domestically produced and traded commodities are viewed to be homogeneous and thus perfect substitutes by buyers and sellers. In particular, importers do not distinguish commodities by country of origin as Aglink-Cosimo is not a spatial model. Imports and exports are nevertheless determined separately. This assumption will affect the results of analysis in which trade is a major driver.

- Aglink-Cosimo is a "partial equilibrium" model for the main agricultural commodities. Non-agricultural markets are not modelled and are treated exogenously to the model. As non-agricultural markets are exogenous, hypotheses concerning the paths of key macroeconomic variables are predetermined with no accounting of feedback from developments in agricultural markets to the economy as a whole.

- Aglink-Cosimo is recursive-dynamic. Thus, each year is modelled over the projection period and depends on the outcome of previous years. Aglink-Cosimo models ten years into the future.

The primary aim of this document is to consolidate the information regarding Aglink-Cosimo and provide a reference manual for the Aglink-Cosimo model explaining the equations, variables and model properties. A second objective is to provide insights into how the model captures interactions among international commodity markets, and market responses to various shocks to facilitate greater transparency in understanding model results, and to confirm model design and attributes. The Aglink-Cosimo model continues to evolve and changes occur annually, particularly with policies that affect market changes. This document explains the core structure of the model and should serve as a reference guide. Chapter 1 describes the main equations that underlie Aglink-Cosimo and Chapter 2 briefly describes the process used to generate the *OECD-FAO Agricultural Outlook*. It also provides a short introduction to the partial stochastic use of Aglink-Cosimo.

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CHAPTER 1

AGLINK-COSIMO MODEL IN DETAIL

Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to analyse the supply and demand of world agriculture. Chapter 1 describes the main equations that underlie Aglink-Cosimo and Chapter 2 briefly describes the process used to generate the OECD-FAO Agricultural Outlook. It also provides a short introduction to the partial stochastic use of Aglink-Cosimo.

The primary aim of this document is to consolidate the information regarding Aglink-Cosimo and provide a reference manual for the Aglink-Cosimo model explaining the equations, variables and model properties. A second objective is to provide insights into how the model captures interactions among international commodity markets, and market responses to various shocks to facilitate greater transparency in understanding model results, and to confirm model design and attributes. A previous documentation of Aglink-Cosimo dates from 2006 (OECD, 2007). A fundamental review of the model was undertaken in 2009 with several further adjustments taking place thereafter. Some of these changes have been documented in the methodology chapters of the *OECD-FAO Agricultural Outlook* (e.g. OECD/FAO, 2015) as well as other publications (OECD, 2008 and European Commission, 2015). The Aglink-Cosimo model continues to evolve and changes occur annually, particularly with policies that affect market changes. This document explains the core structure of the model and should serve as a reference guide.

The model integrates OECD's Aglink and FAO's Cosimo sub-modules. It is used to simulate developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide. Aglink-Cosimo covers 93 commodities on the supply side (Annex A), 40 world market clearing prices (Annex B) and market balances in each region it covers. The fish and seafood model is separate to Aglink-Cosimo and interacts via the exchange of key assumptions and outcomes. The Aglink-Cosimo country and regional modules, and projections are developed and maintained by the OECD and FAO Secretariats in conjunction with country experts and national administrations. Specifically, the Aglink component of the model consists of 14 modules: ten OECD countries and regions (Australia, Canada, European Union (EU), Switzerland, Norway, Japan, Korea, Mexico, New Zealand and the United States)[1] and four non-OECD countries (Argentina, Brazil, the People's Republic of China (hereafter 'China') and the Russian Federation). The EU module consists of the 28 Member States and is composed of two endogenous modules, one with the former 15 Member States and a second with the 13 "New" Member States which acceded to the EU in 2004 or later. The Cosimo component of the model consists of 42 endogenous modules: three OECD members (Chile, Israel and Turkey), a further 27 single countries, and 12 regional aggregates (Annex C).

This documentation describes the general features and logic behind Aglink-Cosimo. A flow-chart of the main linkages within the model (Annex D) offers a rapid overview but cannot describe all equations of the model. This chapter covers some of the specific treatments but not all the specificities. For details on the specific equations, including the treatment of national policies, it is advised to use the equation-viewer (Annex E).

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- World markets for agricultural commodities are competitive, with buyers and sellers acting as price takers. Market prices are determined through a global or regional equilibrium in supply and demand.

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1.   The modules of Switzerland and Norway include only exogenous commodity balances.

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Box 1.1. Technical structure of variables and coefficients

In Aglink-Cosimo, variables contain four dimensions: "regions", "commodities", "items" and "years". Usually, the dimensions "regions" and "commodities" serve as identifiers for behavioural equations, with the dimension "items" defining the equation. The dimension "years" is omitted in the variable name which has the structure: Region_Commodity_Item. Variables in the model can be endogenous and exogenous. Endogenous variables need to be declared as such and are calculated during the model simulation. In most equations endogenous variables are on the left hand side of the equations, but may also appear on the right hand side of other equations. All other variables are exogenous and fixed for the run of the simulation, but can take different values for each year. Specific exogenous variables are residuals or so-called r-factors which are identified by a preceding 'R.' in the variable name. Residuals are considered exogenous variables during simulation exercises and endogenous variables during calibration. They are used to calibrate Aglink-Cosimo to *ex post* data and in the process to produce the medium-term baseline. Aglink-Cosimo is very flexible in this respect since residuals are different per behavioural equation and year allowing perfect calibration to any historical data point.

Model-coefficients are, in contrast to variables, constant for all years of the simulation. There are two general forms: parameters and constants. All coefficients in the model start with 'C.' for identification and have to be declared as parameters or constants. Parameters are used in many behavioural equations to link variables. They often represent elasticities, as a large share of the behavioural equations is specified in double-log form.* Parameters have to fulfil economic conditions and are sourced from literature or calculated based on historic information. The constants in Aglink-Cosimo are typically re-estimated to scale the residuals (error terms) close to 1 and should therefore be interpreted carefully.

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* Double-log is a convenient linear transformation of a logarithmic function and popular for estimating production and demand functions. In these functions both the explanatory and the explained variables are expressed in logarithmic terms: $\log(Y) = \alpha + \beta * \log(X)$. This is generally appropriate when Y experiences diminishing marginal returns with respect to increases in X. This is only altered by the introduction of an intercept (α) and slope (β), which we call respectively "constant" and "elasticity".

For the equations in this document a specific nomenclature is used.

- α indicates equation-specific constants.
- β indicates equation-specific parameters, a subscript is used to distinguish different parameters in one equation.

- γ indicates conversion factors, technical parameters, etc., which are equation-specific and could be time varying, which would be indicated by a 't' in the subscript.
- 'R' refers to the equation-specific and year-specific residual.
- The main variable name refers to the subject of the variable a superscript is used for additional specifications.

Subscripts refer to specific regional, commodity and time dimension in this order; the letters 'r', 'c' and 't' are used if multiple dimensions are possible. In some cases, groups of commodities are used, which is indicated by the subscript 'c(group)'.

1.1 World price clearing

Aglink-Cosimo assumes homogeneity on the world market for all commodities. All modelled countries can import from this market and/or export to that market. The market is cleared by an equilibrium world price for each commodity that ensures world demand is equal to world supply.

$$0 = NT_{WLD,c,t} - SD_{WLD,c,t} \tag{1}$$

Where:

NT = net trade
SD = statistical difference
WLD = world

The statistical difference is the amount of a product which is assumed to be lost between leaving one country and entering another – either physical or in statistical accounting. It is set in accordance with historical observations. World net trade is the sum of the net trade of all countries.

$$NT_{WLD,c,t} = \sum_r NT_{r,c,t} \tag{2}$$

For pigmeat, and beef and veal, Aglink-Cosimo is based on a segmented market approach with the foot and mouth disease (FMD)-free Pacific market, the FMD-controlled Atlantic market and the residual FMD market handled separately. The last two markets are defined according to the World Organisation for Animal Health (OIE) classifications, and geographical trade patterns. These markets generally clear separately, but some market players are active on different markets and selling to a less restrictive market is possible.

The world price is directly converted into an import and export price in the national currency of each country and commodity.

$$IMP_{r,c,t} = XP_{WLD,c,t} * XR_{r,c,t} \tag{3}$$

$$EXP_{r,c,t} = XP_{WLD,c,t} * XR_{r,c,t} \tag{4}$$

Where:

IMP = import price in domestic currency
EXP = export price in domestic currency
XP = world price in USD
XR = exchange rate of domestic currency *vis-à-vis* USD
WLD = world

The equations are foreseen to include a transport equivalent from the domestic to the world market, but this has not been introduced so far due to lack of robust transport cost information.

1.2 Domestic markets

Next to the world market clearing, the Aglink-Cosimo model has a second market clearing price in each domestic market. This means domestic prices are not traceable through a set of transmission equations, as is sometimes the case in partial equilibrium models. Domestic market clearance[2] in country c for each commodity is assured through a producer price in domestic currency, $PP_{r,c,t}$, which satisfies

$$0 = QP_{r,c,t} - QC_{r,c,t} + IM_{r,c,t} - EX_{r,c,t} + ST_{r,c,(t-1)} - ST_{r,c,t} \tag{5}$$

Where:

QP = quantity produced domestically

QC = quantity consumed domestically

IM = imports

EX = exports

ST = year-end stocks

Each of these items of the domestic clearance equation is discussed below, with some details on variations across commodities and on standard policy incorporation.

For dairy and eggs, the general approach for domestic market clearing is slightly altered. There is a two-step procedure for domestic price clearance for dairy products: first, markets for milk fat and non-fat solids are cleared (equations 6 and 7) and, secondly, based on this a milk producer price is derived (equation 8).

$$0 = \left(QP_{r,MK,t} - FU_{r,MK,t}\right) * FAT_{r,MK,t} - \Sigma_{c(dairy)} QP_{r,c,t} * FAT_{r,c,t} - QP_{r,OFP,t} \tag{6}$$

$$0 = \left(QP_{r,MK,t} - FU_{r,MK,t}\right) * NFS_{r,MK,t} - \Sigma_{c(dairy)} QP_{r,c,t} * NFS_{r,c,t} - QP_{r,ONP,t} \tag{7}$$

$$PP_{r,MK,t} = \frac{PP_{r,MK,t}^{FAT} * FAT_{r,MK,t} + PP_{r,MK,t}^{NFS} * NFS_{r,MK,t}}{PM_{r,MK,t}} * R \tag{8}$$

Where:

QP = production quantity

FU = farm use of milk

FAT = fat content of milk

NFS = non-fat solid content of milk

PP = producer price in domestic currency

PP^{FAT} = milk-fat price at dairy factory in domestic currency

PP^{NFS} = non-fat solid price based on Skimmed Milk Powder in domestic currency

PM = processor margin, a multiplier for the value of dairy products in relation to the farm gate milk price

c(dairy) = dairy commodities: fresh dairy products, butter, cheese, SMP, WMP, whey and casein powder

OFP = other milk-fat

ONP = other non-fat solids

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2. For several smaller products (e.g. beet pulp, cereal brans, dried distillers grains) in markets of lower importance, it is assumed that the domestic producer price is directly linked to the world market price and an adjustment for the net-trade position is included. In these cases, net trade is closing the balance.

In the case of eggs, domestic price clearing is not possible as no world market price is modelled and the domestic producer price is based on the cost development of feed.

$$\log(PP_{r,EG,t}) =$$
$$\alpha + \beta_1 * \log(0.5 * FECI_{r,NR,(t-1)} + 0.5 * FECI_{r,NR,t}) + (1 - \beta_1) * \log(GDPD_{r,t}) + \beta_2 * TRD + \log(R) \tag{9}$$

Where:

PP = producer price in domestic currency
FECI = feed cost per tonne of feed
TRD = trend
EG = eggs
NR = non-ruminants

Production

In the case of production, no general principle exists. Instead, several apply and often groups of commodities are modelled similarly. In addition, due to the nature of agricultural policies, most policy specifications can be found in the modelling of agricultural production.

Changes in production costs, returns and policy measures are an important factor for farmers' decisions concerning crop and livestock production quantities. While supply in Aglink-Cosimo is largely determined by gross returns, production costs are represented in the model in the form of a cost index used to deflate gross production revenues. In other words, supply equations in the model in most cases depend on gross returns per unit of activity (such as returns per hectare or the meat price) relative to the overall production cost level as expressed by the index.

Energy prices can significantly impact international markets for agricultural products as production costs for both crops and livestock products are highly dependent on energy costs. Fuel is required for tractors and other machinery, as well as heating and other forms of energy that are directly used in the production process. In addition, other inputs such as fertilisers and pesticides have high energy content, and costs for these inputs are driven to a significant extent by energy prices. It is therefore important to explicitly consider energy prices in the representation of production costs. The production cost index is different for each *crop product* and is constructed from five sub-indices representing seeds inputs, fertiliser inputs, energy inputs, other tradable inputs, and non-tradable inputs. The production cost indices employed in Aglink-Cosimo for livestock products is constructed from three sub-indices representing non-tradable inputs, energy inputs, and other tradable inputs. While the non-tradable sub-index is approximated by the domestic GDP deflator, the energy sub-index is affected by changes in the world crude oil price and the country's exchange rate. Finally, the tradable sub-index is linked to global inflation (approximated by the US GDP deflator) and the country's exchange rate.

$$CPCI_{r,c,t} = CPCS_{r,c,t}^{NT} * \frac{GDPD_{r,t}}{GDPD_{r,2008}} + CPCS_{r,c,t}^{EN} \frac{XP_{wld,OIL,t}*XR_{r,t}}{XP_{wld,OIL,2008}*XR_{r,2008}} + CPCS_{r,c,t}^{TR} * \frac{GDPD_{USA,t}*XR_{r,t}}{GDPD_{USA,2008}*XR_{r,2008}} +$$
$$CPCS_{r,c,t}^{FT} \frac{XP_{wld,FT,t}*XR_{r,t}}{XP_{wld,FT,2008}*XR_{r,2008}} + CPCS_{r,c,t}^{SD} * \frac{PP_{r,c,(t-1)}}{PP_{r,c,2007}} \tag{10}$$

Where:

CPCI = commodity production cost index
$CPCS^{NT}$ = share of non-tradable input in commodity production costs
$CPCS^{EN}$ = share of energy in commodity production costs
$CPCS^{TR}$ = share of other tradable input in total base commodity production costs
$CPCS^{FT}$ = share of fertiliser in commodity production costs (only crops)

CPCS^{SD} = share of seeds input in commodity production costs (only crops)

GDPD = deflator for the gross domestic product

XP = world price in US Dollar

PP = producer price in domestic currency

XR = nominal exchange rate with respect to the US Dollar

OIL = crude oil

FT = fertiliser

The shares of the various cost categories are country specific and always sum to one. They were estimated based on historic cost structures in individual countries. Shares vary depending on the development stages of the countries and regions. Developed countries tend to have higher shares of energy, fertiliser and tradable inputs than developing nations. The fertiliser price used is an index based on several components (Urea (Black Sea) price (62%), US Diammonium Phosphate price (20%), Canada Potassium Chloride price (16%) and Triple Superphosphate price (2%)). In Aglink-Cosimo, the fertiliser price for the projection period is represented by an equation responding to lagged fertiliser, crude oil and crop prices.

The production equations are described for groups of commodities and provide a general overview. For further commodity and country-specific details, reference should be made to an available equation-viewer (Annex E).

Crops

The modelling of crop production occurs at the disaggregated level, e.g. maize, barley, soybeans, and rapeseed instead of coarse grains and oilseeds. Field pea production is considered exogenous in Aglink-Cosimo.

$$QP_{r,c(crop),t} = AH_{r,c(crop),t} * YLD_{r,c(crop),t} \tag{11}$$

Where:

QP = quantity produced

AH = area harvested

YLD = yield

c(crop) = crop commodity

Crop yields are calculated with the following equation.

$$log(YLD_{r,c,t}) = \alpha + \beta_1 * log\left(\frac{PP_{r,c,(t-1)}+EPY_{r,c,(t-1)}}{\gamma_c*CPCI_{r,c,(t-1)}+(1-\gamma_c)*CPCI_{r,c,t}}\right) + \beta_2 * TRD + log(R) \tag{12}$$

Where:

PP = producer price in domestic currency

EPY = policy variable (in domestic currency per ton)

CPCI = cost of production index (2008 = 1)

γ_c = share of *production cost occurring in the previous marketing year*

The area harvested is determined by the return per hectare for all annual crops. Ideally this should be the area planted but only for the United States is a separation between planted and harvested area included in Aglink-Cosimo. In the yield and the area equations, an element referring to subsidies is included and calculated on an individual basis according to the specific agricultural policy in place.

$$log(AH_{r,c,t}) = \alpha + \beta_1 * log(AH_{r,c,(t-1)}) + \sum_{c1(crop)} \beta_{c1} * log\left(\frac{RH_{r,c,(t-1)} + EPA_{r,c,(t-1)}}{\gamma_c * CPCI_{r,c,(t-1)} + (1-\gamma_c) * CPCI_{r,c,t}}\right) + \beta_2 * TRD + log(R) \tag{13}$$

Where:

RH = market returns per hectare

EPA = policy variable affecting area (in domestic currency per hectare)

CPCI = cost of production index (2008 = 1)

γ_c = *share of production cost occurring in the previous marketing year*

The modelling of perennial crops differs from annual crops. For sugarcane, additional lags are introduced for the core element of the function. In the case of coconuts, jatropha and oil palm, area is calculated as production divided by yields. The production of jatropha is assumed to be equal to the consumption which is based on the demand for jatropha as a biofuel feedstock. Palm oil and coconut production depend on the lagged production, a trend and the prices for oils and meal.

$$log(QP_{r,PL,t}) = \alpha + \beta_1 * log(QP_{r,PL,(t-1)}) + \beta_2 * log\left(\frac{PP_{r,PL,t}}{CPCI_{r,PL,t}}\right) + \beta_3 * TRD + log(R) \tag{14}$$

$$log(QP_{r,CN,t}) = \alpha + \beta_1 * log(QP_{r,CN,(t-1)}) + \beta_2 * log\left(\frac{PP_{r,PM,t}}{CPCI_{r,CN,t}}\right) + \beta_3 * log\left(\frac{PP_{r,VL,t}}{CPCI_{r,CN,t}}\right) + \beta_4 * TRD + log(R) \tag{15}$$

Where:

QP = production quantity

CPCI = cost of production index

PP = producer price in domestic currency

TRD = trend

PL = palm oil

CN = coconuts

PM = protein meal

VL = vegetable oil

The calculated return per hectare includes only market returns and refers to the actual and the last two years with a greater weight being given to the most recent years.

$$RH_{r,c,t} = RH_{r,c,t}^{spec} + 0.5 * YLD_{r,c,t} * PP_{r,c,t} + 0.3 * YLD_{r,c,(t-1)} * PP_{r,c,(t-1)} + 0.2 * YLD_{r,c,(t-2)} * PP_{r,c,(t-2)} \tag{16}$$

Where:

RH^{spec} = specific returns per hectare mostly derived from by-products, e.g. cottonseed in case of cotton

YLD = yield

PP = producer price in domestic currency

The specific term can be largely extended in several cases depending on how by-product returns have been incorporated into the model. There is no general approach for all by-products and regions. In exceptional cases, policy prices are incorporated in the return per hectare equation, e.g. cotton for selected countries, EU sugar beet.

[11]

Sugar and by-products

The production of sugarcane and sugar beet follows the same structure for crops described above. The production of sugar itself is the difference between the joint production of sugar and molasses (which can be interpreted as the juice in the first processing stage of beets and cane which is then processed to sugar and molasses at the next stage) and molasses production. The former is based on the use of sugarcane and beet for processing to sugar.

$$QP_{r,SU,t} = QP_{r,SUMOL,t} - QP_{r,MOL,t} \qquad (17)$$

Where:

QP = production quantity
SU = sugar
SUMOL = sugar and molasses
MOL = molasses

$$QP_{r,SUMOL,t} = SU_{r,SCA,t} * YLD^{SCA}_{r,SUMOL,t} + SU_{r,SBE,t} * YLD^{SBE}_{r,SUMOL,t} \qquad (18)$$

Where:

QP = production quantity
SU = feedstock used for sugar production
YLD = sugar content per tonne of feedstock
SUMOL = sugar and molasses
SCA = sugarcane
SBE = sugar beet

The use of sugarcane and beet for the production of sugar is the residual between the respective production and use as biofuel feedstock.

$$SU_{r,c,t} = QP_{r,c,t} - BF_{r,c,t} \qquad (19)$$

Where:

SU = feedstock used for sugar production
QP = production quantity
BF = use for biofuel

The respective sugar contents depend on the feedstock price and a trend.

$$\log(YLD^{SCA}_{r,SUMOL,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,SCA,t}}{GDPD_{r,t}}\right) + \beta_2 * TRD + \log(R) \qquad (20)$$

$$\log(YLD^{SBE}_{r,SUMOL,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,SBE,t}}{GDPD_{r,t}}\right) + \beta_2 * TRD + \log(R) \qquad (21)$$

Where:

PP = producer price in domestic currency
GDPD = GDP deflator
YLD = sugar content per tonne of feedstock
TRD = trend
SUMOL = sugar and molasses
SCA = sugarcane
SBE = sugar beet

[12]

Prices for sugarcane and beet are derived from the prices of the products and by-products which are adjusted by a processing margin. The following equation illustrates the approach for sugar beet without ethanol production.

$$PP_{r,SBE,t} = (\gamma_1 * PP_{r,SUW,t} + \gamma_2 * PP_{r,MOL,t} + \gamma_3 * PP_{r,BP,t}) * MAR_{r,SBE,t} \tag{22}$$

Where:

PP = producer price in domestic currency
MAR = processing margin
SBE = sugar beet
SUW = white sugar
BP = beet pulp
MOL = molasses
γ = technical conversion factors from sugar beet into products

This equation becomes more complicated when part of the sugarcane or sugar beet is used for processing into ethanol. Additional conversion factors must be applied to convert product prices into feedstock price. In the case of the European Union, the separation of the sugar market into an in- and out-of quota market is especially impacting the price for sugar beet.

Molasses production is based on the price ratio between sugar and molasses, the total joint production and a trend.

$$\log(QP_{r,MOL,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,SUW,t}}{PP_{r,MOL,t}}\right) + \log(QP_{r,SUMOL,t}) + \beta_2 * TRD + \log(R) \tag{23}$$

Where:

QP = production quantity
PP = producer price in domestic currency
TRD = trend
SUW = white sugar
SUMOL = sugar and molasses
MOL = molasses

Beet pulp is a by-product in the processing of sugar beet and a simple technical coefficient is applied for its production. The use is as feed component.

$$QP_{r,BP,t} = \gamma * QP_{r,SBE,t} \tag{24}$$

Where:

BP = beet pulp
SBE = sugar beet
γ = technical conversion factor 0.058 tons of beet pulp are obtained from each ton of sugar beet

Meat production does not follow one template approach and each type of meat has its own specific approach. In addition, several variations occur in the modelling of meat production.

In the case of beef and veal, pigmeat, and sheep and goat meat a domestic slaughter production is calculated. Live trade is not recorded for poultry and consequently the production quantity and the domestic slaughter production are considered equal.

$$QPS_{r,c,t} = QP_{r,c,t} - EXL_{r,c,t} + IML_{r,c,t} \tag{25}$$

Where:

QPS = production of meat from domestic slaughtering

QP = production quantity

EXL = export of live animals

IML = import of live animals

For additional calculations, a livestock inventory is derived from the poultry, pigmeat, and sheep and goat meat production. This follows a more simplified approach than for cattle which follows in the specific subsection.

$$\log(LI_{r,c,t}) = \alpha + \log(QP_{r,c,t}) + \beta * TRD + \log(R) \tag{26}$$

Where:

LI = livestock inventory

QP = production quantity

TRD = trend

Beef and veal

The determinants of beef and veal (BV) production are complex due to joint production with milk, the long-time production horizon, the use of animals for draught, and their ruminant nature which requires significant arable land or pasture for roughage feed.

$$\log(QP_{r,c,t}) =$$
$$\alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}+EPQ_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log\left(\frac{PP_{r,c,(t-1)}+EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 * \log\left(\frac{PP_{r,c,(t-2)}+EPQ_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) +$$
$$\beta_4 * \log\left(\frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_5 * \log\left(\frac{FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) + \beta_6 * \log(CI_{r,c,(t-1)}) + \beta_7 * \log(CI_{r,MK,(t-1)}) + \beta_8 *$$
$$\log(QP_{r,c,(t-1)}) + \beta_9 * TRD + \log(R) \tag{27}$$

Where:

QP = production quantity

PP = producer price in domestic currency

EPQ = subsidy based on quantity produced

CPCI = cost of production index

FECI = feed cost per tonne of feed

CI = cow inventory

TRD = trend

MK = dairy

For some countries, additional lags (especially for cow inventories) and the inclusion of grazing costs is achieved by a variation to the standard approach. For Aglink countries, the reference inventory is the inventory for suckler cows.

$$\log(CI_{r,c,t}) =$$

$$\alpha + \beta_1 * \log\left(\frac{PP_{r,c,t} + EPI_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log\left(\frac{PP_{r,c,(t-1)} + EPI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 * \log\left(\frac{PP_{r,c,(t-2)} + EPI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) + \beta_4 *$$

$$\log\left(\frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_5 * \log\left(\frac{FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) + \beta_6 * \log(CI_{r,c,(t-1)}) + \beta_7 * \log(CI_{r,MK,(t-1)}) + \beta_8 *$$

$$TRD + \log(R) \tag{28}$$

Where:

> CI = cow inventory
> PP = producer price in domestic currency
> EPI = subsidy per suckler cow
> CPCI = cost of production index
> FECI = feed cost per tonne of feed
> TRD = trend
> *MK = dairy*

In the case of Cosimo countries, a general livestock inventory for cattle is calculated in a slightly different form of the suckler cow inventory in Aglink countries, and is also used as a reference in the production equation. For Aglink countries, this inventory is calculated based on the cow inventories for dairy and suckler cows, as well as an assumption of additional cattle.

Pigmeat

Pigmeat (PK) production is influenced by lagged prices, feed costs, lagged own production and a trend.

$$\log(QP_{r,c,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,c,(t-1)} + EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_2 * \log\left(\frac{0.5 * FECI_{r,c,(t-1)} + 0.5 * FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 *$$

$$\log(QP_{r,c,(t-1)}) + \beta_4 * TRD + \log(R) \tag{29}$$

Where:

> QP = production quantity
> PP = producer price in domestic currency
> EPQ = subsidy based on quantity produced
> CPCI = cost of production index
> FECI = feed cost per tonne of feed
> TRD = trend

The feed cost element is in some cases adjusted and refers only to the previous year. In the European Union, pigmeat production is modelled as the product of carcass weight and slaughtering.

[15]

The production of sheep and goat meat (SH) in Cosimo is influenced by the own price and the opportunity cost of grazing, approximated by the return per hectare of wheat.

$$\log(QP_{r,c,t}) =$$
$$\alpha + \beta_1 * \log\left(\frac{PP_{r,c,(t-1)}+EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_2 * \log\left(\frac{RH_{r,WT,(t-1)}}{CPCI_{r,WT,(t-1)}}\right) + \beta_3 * \log(QP_{r,c,(t-1)}) + \beta_4 * TRD +$$
$$\log(R) \tag{30}$$

Where:

> QP = production quantity
> PP = producer price in domestic currency
> EPQ = subsidy based on quantity produced
> CPCI = cost of production index
> TRD = trend
> *WT = wheat*

Most Aglink countries follow a similar approach for the production of sheep and goat meat as for pigmeat, driven by the own price and the feed cost development. In the case of Argentina, the own price is a composite of the meat and the wool price.

$$\log(QP_{r,c,t}) =$$
$$\alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}+EPQ_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log\left(\frac{PP_{r,c,(t-1)}+EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 * \log\left(\frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) +$$
$$\beta_4 * \log\left(\frac{FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) + \beta_5 * \log(QP_{r,c,(t-1)}) + \log(R) \tag{31}$$

Where:

> QP = production quantity
> PP = producer price in domestic currency
> EPQ = subsidy based on quantity produced
> CPCI = cost of production index
> FECI = feed cost per tonne of feed
> TRD = trend

For Australia and New Zealand, specific approaches are chosen which reflect the integration with the production of wool and the competition with beef and veal production for pastures. In the case of New Zealand, production is broken down into lamb and mutton. Wool is not included in the model but for Argentina, Australia and New Zealand an exogenous wool price influences sheep and goat meat production.

Poultry production (PT) is typically modelled separately for chicken and often exogenous other poultry. In some cases, the feed cost refers only to the current year and not the average of the current and previous years, reflecting the relatively short production process.

$$\log(QP_{r,c,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}+EPQ_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log(\frac{0.5*FECI_{r,c,t}+0.5*FECI_{r,c,(t-1)}}{CPCI_{r,c,t}}) + \beta_3 *$$
$$\log(QP_{r,c,(t-1)}) + \beta_4 * TRD + \log(R) \tag{32}$$

Where:

QP = production quantity
PP = producer price in domestic currency
EPQ = subsidy based on quantity produced
CPCI = cost of production index
FECI = feed cost per tonne of feed
TRD = trend

Eggs

Egg production (EG) is modelled as closing the commodity balance. Further developments to the model could include a world price for eggs. Only for Canada is a livestock inventory calculated for laying hens and this is done in the same way as for poultry.

Milk and dairy products

Milk production is modelled in a similar way to crops, with a yield component and a cow inventory. In China and the European Union, other milk is added exogenously to this equation.

$$QP_{r,MK.t} = YLD_{r,MK,t} * CI_{r,MK,t} \qquad (33)$$

Where:

QP = production quantity
YLD = milk yield in tonnes per dairy cow
CI = cow inventory

The milk yield depends on output prices, subsidies, feed costs and a trend factor. In the case of Cosimo, the feed cost is the average of the current and previous year. For Canada, yield is calculated as residual and the production is linked to demand for fluid milk and processing.

$$\log(YLD_{r,c,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}+EPY_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log\left(\frac{FECI_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_3 * TRD + \log(R) \qquad (34)$$

Where:

YLD = milk yield in tonnes per dairy cow
PP = producer price in domestic currency
CPCI = cost of production index
FECI = feed cost per tonne of feed
TRD = trend

The cow inventory for dairy cows is calculated as follows. This is a simplification of the general form given that for milk and beef prices up to two lags exist and for feed cost up to three lags. On the other hand, in several cases some of the elasticities are set to zero and subsequently the respective section does not have any influence. For Aglink countries, these sections are often deleted to reduce the complexity of the equation.

$$\log(CI_{r,c,t}) =$$

$$\alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}+EPI_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 * \log\left(\frac{PP_{r,c,(t-1)}+EPI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 * \log\left(\frac{PP_{r,BV,t}+EPI_{r,BV,t}}{CPCI_{r,BV,t}}\right) + \beta_4 *$$

$$\log\left(\frac{PP_{r,BV,(t-1)}+EPI_{r,BV,(t-1)}}{CPCI_{r,BV,(t-1)}}\right) + \beta_5 * \log\left(\frac{FECI_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_6 * \log\left(\frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_7 * \log(CI_{r,c,(t-1)}) +$$

$$\beta_8 * TRD + \log(R) \tag{35}$$

Where:

> CI = cow inventory
> PP = producer price in domestic currency
> EPI = subsidy based on animal numbers
> CPCI = cost of production index
> FECI = feed cost per tonne of feed
> TRD = trend
> *BV = beef and veal*

Dairy products contain different levels of fat and non-fat solids. Consequently, the processing equation needs to assure that demand for both ingredients is balanced.

$$\log(QP_{r,c,t}) = \alpha + \beta * \log\left(\frac{PP_{r,c,t}}{PP_{r,MK,t}^{FAT}*FAT_{r,c,t}+PP_{r,MK,t}^{NFS}*NFS_{r,c,t}}\right) + \log(R) \tag{36}$$

Where:

> QP = production quantity
> PP^{FAT} = milk-fat price
> FAT = milk-fat content
> PP^{NFS} = non-fat solids price
> NFS = non-fat solids content

The elasticity β should be the same for all dairy products in one country as this assures stability for the fat and non-fat balances.

Fresh dairy products (FDP) production is matching consumption. Whey powder (WYP) production is modelled as a by-product of cheese.

Biofuels

Modelling the production of biofuels within Aglink countries does not follow a strict template. Cosimo countries follow a template which is similar for both ethanol and biodiesel. Total biofuel production consists of an endogenous and an exogenous part:

$$QP_{r,BF,t} = QP_{r,BF,t}^{ENDO} + 0.9 * QP_{r,BF,t}^{BASE} \tag{37}$$

Where:

> QP = production quantity
> *BF = biofuel (biodiesel or ethanol)*

The exogenous one is dependent on mandates and biofuel use in the base year:

$$QP_{r,BF,t}^{BASE} = Max(0, MBD_{r,BF,t} - BF_{r,BF,t}^{YEAR}) \qquad (38)$$

QP = production quantity
BF = use as biofuel, *in subscript biofuel commodity*
MBD = mandated blending quantity

The idea behind this is that although most targets are defined on the demand side, they must influence production through other means than prices only. As the specific policy instruments are not incorporated explicitly, this exogenous element guarantees that production will follow changes in mandates. The endogenous part is a function of lagged production, the relation between output prices and feedstock costs and a trend component:

$$\log(QP_{r,BF,t}^{ENDO}) = \alpha + \beta_1 * \log(QP_{r,BF,(t-1)}) + \beta_2 * \log\left(\frac{PP_{r,BF,t}}{FPIW_{r,BF,t}}\right) + \beta_3 * TRD + \log(R) \qquad (39)$$

Where:

QP = production quantity
PP = producer price in domestic currency
FPIW = production weighted average feedstock cost per biofuel
TRD = trend
BF = biofuel (biodiesel or ethanol)

In a second step, biodiesel and ethanol are distributed to the respective feedstocks determined by lagged shares and the price competiveness compared to the average feedstock.

The biofuel modelling in Aglink countries is currently under review. A detailed modelling based on the OECD (2008) approach is currently implemented for Canada, the European Union, and the United States.

Processing and by-products

Protein meal and vegetable oil

The crushing of oilseeds is covered systematically in Aglink-Cosimo and is driven by the crush margin which is described in the demand section. The calculation for the production of protein meal and vegetable oil is a simple conversion. In most cases, crushing is calculated at the aggregate level of oilseeds and not at the individual levels of soybeans, rapeseed, sunflower seed and groundnuts. This approach requires a clear monitoring of extraction rates, which differ considerably across oilseeds.

$$QP_{r,c(oilmeal),t} = CR_{r,c(oilseed),t} * YLD_{r,c(oilmeal),t} \qquad (41)$$
$$QP_{r,c(oilseed\ oil),t} = CR_{r,c(oilseed),t} * YLD_{r,c(oilseed\ oil),t} \qquad (42)$$

Where:

QP = quantity produced
CR = crushing into meal and oil
$YLD_{c(oilmeal)}$ = extraction of ton of oilmeal per ton of oilseed crushed
$YLD_{c(oilseed\ oil)}$ = extraction of ton of oilseed oil per ton of oilseed crushed

Cottonseed, palm kernels and copra are crushed in a similar way into their meal and oil components. In most cases, the conversion into meal and oil is linked to total domestic production. This approach assumes no trade with the respective seeds.

The production of cottonseed is calculated as a ratio of cotton production, which is influenced by prices and a trend.

$$QP_{r,CSE,t} = QP_{r,CT,t} * YLD_{r,CSE,t} \qquad (43)$$

Where:

QP = quantity produced
YLD = is the ratio between cotton and cottonseed production
CSE = cottonseed
CT = cotton

Palm kernel production is a fixed ratio in relation to palm oil production.

$$QP_{r,PKL,t} = \gamma * QP_{r,PL,t} \qquad (44)$$

Where:

QP = quantity produced
PKL = palm kernels
PL = palm oil
γ = ration between palm oil and palm kernel production

Balances, including trade and producer prices, are only modelled at the aggregate level of vegetable oil and protein meal. This is an unweighted sum of all vegetable oils and protein meal. Soybean, rapeseed, sunflower and groundnut oil and meal are grouped into oilseed oil (OL) and oilseed meal (OM).

$$QP_{r,VL,t} = QP_{r,OL,t} + QP_{r,PL,t} + QP_{r,KL,t} + QP_{r,CL,t} + QP_{r,CSL,t} \qquad (45)$$

$$QP_{r,PM,t} = QP_{r,OM,t} + QP_{r,KM,t} + QP_{r,CM,t} + QP_{r,CSM,t} \qquad (46)$$

Where:

QP = quantity produced

High Fructose Corn Syrup (isoglucose) and corn gluten feed

High Fructose Corn Syrup (isoglucose) is a cereal-based sweetener which competes with sugar. Production is mainly based on maize.

$$\log(QP_{r,HFCS,t}) = \alpha + \beta_1 * \log\left(\frac{MAR_{r,HFCS,t}}{GDPD_{r,t}}\right) + \beta_2 * \log(QP_{r,HFCS,(t-1)}) + \log(R) \qquad (47)$$

$$MAR_{r,HFCS,t} = \frac{\gamma_1 * PP_{r,HFCS,t} + \gamma_2 * PP_{r,PM,t} + \gamma_3 * PP_{r,VL,t} + \gamma_4 * PP_{r,CGF,t}}{PP_{r,CG,t}} \qquad (48)$$

Where:

QP = quantity produced
MAR = margin per tonne of HFCS in domestic currency
GDPD = deflator
PP = producer price in domestic currency
HFCS = High Fructose Corn Syrup (isoglucose)
γ₁ = tonnes of HFCS produced from one tonne of coarse grain (normally 0.6)
γ₂ = tonnes of corn gluten meal produced in the conversion of one tonne of coarse grain to HFCS (normally 0.06)

γ_3 = tonnes of corn oil produced in the conversion of one tonne of coarse grain to HFCS (normally 0.03)

γ_4 = tonnes of corn gluten feed produced in the conversion of one tonne of coarse grain to HFCS (normally 0.24)

Corn gluten feed is considered a by-product from the processing of coarse grains into HFCS (isoglucose).

$$QP_{r,CGF,t} = \gamma * HFCS_{r,CG,t} \tag{49}$$

Where:

QP = quantity produced
HFCS = coarse grains used for HFCS production
CGF = corn gluten feed
CG = coarse grains
γ = tonnes of corn gluten feed produced in the conversion of one tonne of coarse grain to HFCS (normally 0.24)

Dried distillers grains (DDG)

The production of dried distillers grains (DDG) is directly linked to the production of ethanol. A specific conversion for the different feedstocks used for production is applied. This conversion ratio is time dependent as the process is still in the innovation phase. DDGs are used in the feed module and are traded, and the balance is closed for major countries. Otherwise, the domestic price is derived from the world market price and trade closes the balance.

$$QP_{r,DDG,t} = \gamma_{1,t} * QP_{r,ET,t}^{CG} * 10 + \gamma_{2,t} * QP_{r,ET,t}^{WT} * 10 + \gamma_{3,t} * QP_{r,ET,t}^{RT} * 10 \tag{50}$$

Where:

QP = quantity produced
DDG = dried distillers grains
ET = ethanol
CG = production based on coarse grains
WT = production based on wheat
RT = production based on roots and tubers
γ = tonnes of DDG extracted per 100 litres of ethanol produced from specific feedstock

The production of other protein feed (PF) and energy feed (EF) as a by-product of ethanol is carried out in a similar way for the United States and Canada. Both are used only in the calculation of the net production cost of ethanol.

Milling by-products and cereal brans

Milling by-products and cereal brans are a by-product in the processing of cereals for human consumption.

$$\log(QP_{r,CEB,t}) = \alpha + \beta_1 * \log(FO_{r,CG,t} + FO_{r,RI,t} + FO_{r,WT,t}) + \beta_2 * TRD + \log(R) \tag{51}$$

Where:

> QP = production quantity
> FO = food use
> TRD = trend
> *CEB = milling by-products, cereal bran*
> *CG = coarse grains*
> *RI = rice*
> *WT = wheat*

The elasticity β_1 has a value between 0.8 and 1 to reflect the strong direct linkage between the food use of cereals and the production of milling by-products and cereal brans (CEB). CEB are used in the feed module and are traded globally. The balance is closed with a domestic market price for major countries (Argentina, Australia, Canada, the People's Republic of China, European Union, Korea, New Zealand, Russian Federation and the United States). Otherwise, the domestic price is derived from the world market price and trade is closing the balance.

Meat and bone meal

The calculation of meat and bone meal (MBM) production is problematic. Being able to calculate the data directly from beef and veal, pigmeat, sheep meat and poultry slaughter production has the advantage of avoiding the annual collection of data that is difficult to find. As an example, the equation for MBM rendering from pigmeat is used. A similar equation applies to the other meats and total MBM production is the sum.

$$QP_{r,MBM,t}^{PK} = \frac{QPS_{r,PK,t}}{CY_{r,c,t}} * \gamma * \left(QP_{r,c,t}^{FD} + \left(1 - QP_{r,c,t}^{FD}\right) * 0.5\right) \tag{52}$$

Where:

> QP = production quantity
> QPS = domestic slaughter quantity
> CY = conversion between carcass and live weight
> QP^{FD} = production share of dedicated farming
> *PK = pigmeat*
> *MBM = meat and bone meal*
> *γ = conversion factor*

Conversion factors (γ) were obtained from livestock experts and the results were compared to sparsely available data. For backyard livestock production, it is assumed that 50% are not subject to rendering. As Aglink-Cosimo only includes the share of dedicated farming in total production, this is a more complicated term in the equation. For sheep and goat meat, a single conversion factor is applied in only a few countries: Australia, the European Union and New Zealand.

Domestic disappearance

Aglink-Cosimo uses the concept of domestic disappearance that implies a closing of the commodity balance. But actual consumption for feed or human nutrition might be lower due to processing, losses, etc. Domestic disappearance is the sum of different consumption components which are only populated where significant.

$$QC_{r,c,t} = FO_{r,c,t} + FE_{r,c,t} + BF_{r,c,t} + CR_{r,c,t} + SWG_{r,c,t} + OU_{r,c,t} \tag{53}$$

Where:

> QC = domestic disappearance
> FE = feed use
> FO = human consumption
> BF = use as feed stock for the production of biofuels or use as biofuels
> CR = crushing into meal and oil
> SWG = processing of grains into sweetener
> OU = other use (e.g. industrial use, seed, losses)

Each of the components is treated differently and therefore each one is briefly described below.

Food use

Food use is a core item of the domestic disappearance. Aglink-Cosimo has shifted towards consumer prices instead of producer prices to better account for the driver of consumer decisions, which include references to the nominal producer prices and the deflator of the gross domestic product. The consumer prices refer to observed food prices for core products. If limited observations are available, the consumer price index is used to fill gaps.

$$\log(CP_{r,c,t}) = \alpha + \beta * \log(GDPD_{r,t}) + (1 - \beta) * \log(PP_{r,c,t}) + \log(R) \tag{54}$$

Where:

> CP = consumer price in domestic currency
> GDPD = deflator of the gross domestic product
> PP = producer price in domestic currency

Consumer prices in the case of biofuels and fuels are the technical conversion of producer prices and include applicable fuel taxes.

The equation for food demand incorporates relationships between all food items.

$$\log(FO_{r,c,t}) = \alpha + \sum_{c1(food)} \beta_{c1} * \log\left(\frac{CP_{r,c1,t}}{CPI_{r,t}}\right) + \beta_1 * \log\left(\frac{GDPI_{r,t}}{POP_{r,t}/POP_{r,2005}}\right) + \log(POP_{r,t}) + \beta_2 * TRD + \log(R) \tag{55}$$

Where:

> FO = human consumption
> CP = consumer price in domestic currency
> CPI = consumer price index (2010 =1)
> GDPI = gross domestic product index (2010 =1)
> TRD = trend
> POP = population
> *c1(food) = commodities with food use*
> *β_{c1} = cross- and own-price elasticities[3]*

---

3.   The cross- and own-price elasticities should fulfil several conditions: 1) own-price elasticity should be negative; 2) the sum of all cross- and own price elasticities per product should be zero (homogeneity of degree 0: if all product prices change by the same percentage the food demand mix does not change, a different value can be assumed if changes in the food demand mix are expected); 3) substitutes should have a positive cross-price elasticity; 4) the mirror elasticity should be the same (symmetry).

Food demand is expected to grow linearly with population growth if everything else remains constant. In some countries, consumer price subsidies are included, e.g. Mexico and Canada.

Feed module

A recent addition to Aglink-Cosimo is the new feed module which is based on similar principles to the food demand module. A closer link to animal production has been incorporated and the commodity coverage has been extended to incorporate several by-products.

$$\log(FE_{r,c(feed),t}) = \alpha + \beta_1 * \log(QP_{r,SH,t}) + \beta_2 * \log(QP_{r,BV,t}) + \beta_3 * \log(QP_{r,MK,t}) + \beta_4 * \log(FE_{r,FHA,t}) + (1 - \beta_1 - \beta_2 - \beta_3 - \beta_4) * \log(FE_{r,NR,t}) + \sum_{c1(feed)} \beta_{c1} * \log(\frac{PP_{r,c1,t}}{GDPD_{r,t}}) + \beta_5 * \log(\frac{PP_{r,c,t}}{GDPD_{r,t}}) + \beta_6 * TRD + \log(R) \tag{56}$$

Where:

> FE = feed use
> QP$_{SH}$ = sheep and goat meat produced
> QP$_{BV}$ = beef and veal produced
> QP$_{MK}$ = milk produced
> FE$_{FHA}$ = feed used for fish and aquaculture (link to fish module)
> FE$_{NR}$ = feed used for non-ruminants
> PP = producer price in domestic currency
> *c1(feed) = feed commodities*
> *β$_{c1}$ = cross and own price elasticities[4]*

The following three categories of feed exist in the model:

- Low protein feed (LPF): coarse grains, wheat, rice, cereal bran, dried beet pulp, molasses and manioc.

- Medium protein feed (MPF): corn gluten feed, dried distillers grains (DDG), field (dry) peas and whey powder.

- High protein feed (HPF): protein meal, meat and bone meal (MBM), fish meal and skim milk powder (SMP).

For each of these categories and their sum (average protein feed (APF)), production-weighted prices are calculated. At present, the feed cost per tonne of feed is assumed to be the same for each category of livestock production.

$$FECI_{r,c,t} = PP_{r,APF,t} \tag{57}$$

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4. The cross- and own-price elasticities should fulfil several conditions: 1) own-price elasticity should be negative; 2) the sum of all cross- and own price elasticities per product should be zero (homogeneity of degree 0; in case of the feed demand system an additional parameter (β5) is included to capture the implicit interaction with fodder feeds); 3) substitutes should have a positive cross-price elasticity; 4) the mirror elasticity should be the same (symmetry).

Where:

> FECI = feed cost per tonne of feed
> PP = producer price in domestic currency
> *APF = average protein* feed

The balance between supply and demand in the case of feed allows variation in feed intensity. Due to the use of other feed, e.g. grazing, silage, food processing and consumption waste, and the use of animals not only for the production of meat, milk and eggs, it is impossible to derive the actual requirements for feed covered in Aglink-Cosimo by the animal sector. The total available feed is allocated to different animal categories.

$$FE_{r,RU,t} = FE_{r,APF,t} - FE_{r,NR,t} - FE_{r,FHA,t} \tag{58}$$

Where:

> FE = feed quantity
> *RU = ruminants*
> *APF = average protein feed*
> *NR = non-ruminants*
> *FHA = fish and aquaculture*

The feed use for fish and aquaculture is exogenous and comes from a separate fish and aquaculture model. The feed use for non-ruminants is based on feed conversion rates.

$$FE_{r,NR,t} = FCR_{r,PK,t} * \frac{QP_{r,PK,t}}{CY_{r,PK,t}} + FCR_{r,PT,t} * \frac{QP_{r,PT,t}}{CY_{r,PT,t}} + FCR_{r,EG,t} * QP_{r,EG,t} \tag{59}$$

Where:

> FE = feed quantity
> FCR = feed conversion ratio
> QP = production quantity
> CY = conversion between carcass and live weight
> *NR = non-ruminants*
> *PK = pigmeat*
> *PT = poultry*
> *EG = eggs*

The feed conversion ratios are assumed exogenously for Aglink countries and are influenced in Cosimo countries by the share of backyard production in total production.

For Aglink countries a feed conversion ratio for ruminants is calculated using different weights to convert sheep and goat meat and milk into beef and veal equivalents. The ruminant feed conversion ratio helps to control the relation between feed supply and demand.

Biofuel use

In the case of biofuels, the use item is applied in two different formats: first, the use as feed stock for the production of biofuels; and, secondly, the use as biofuel directly in the case of biodiesel and ethanol. With regard to the former, a similar technical conversion is applied.

$$BF_{r,c,t} = \frac{QP_{r,BF,t}^c}{\gamma_t} \tag{60}$$

Where:

BF = biofuel use; *in subscript biofuel commodity*

QP = production quantity

γ_t = *time-dependent technical factor for the conversion of feedstock into biofuel*

The technical factor is time-dependent; this is considered appropriate as biofuel processing is still rather new and technical progress in the conversion rate can be expected.

The consumption of biofuels has two main components: a market-driven part and a mandate-driven part. Final biofuel consumption is generally the higher of the two components.

$$BF_{r,c(BF),t} = \max\left(MBD_{r,c(BF),t}, \exp\left(\alpha + \beta * \log\left(\frac{CP_{r,c(BF),t}}{CP_{r,c(FUEL),t}}\right) + \log(R)\right)\right) \tag{61}$$

Where:

BF = biofuel use; *in subscript biofuel commodity*

MBD = mandated quantity

CP = consumer price in domestic currency

FUEL = related fossil fuel commodity

This general template is altered substantially to reflect specific policies. As the biofuel modelling of Aglink is presently under review, a detailed description is omitted here.

Crushing

Crushing is specific to oilseeds and means the conversion of oilseeds into vegetable oil and protein meal. For cottonseed, an adjustment is carried out to account for the link with cotton. The main driver of crushing is the development of the crush margin that is depicted as the ratio between the income for the protein meal and vegetable oil produced over the price for oilseeds.

$$\log(CR_{r,OS,t}) = \alpha + \beta_1 * \log(CRMAR_{r,OS,t}) + \beta_2 * \log(CR_{r,OS,(t-1)}) + \log(R) \tag{62}$$

$$\log(CR_{r,CSE,t}) = \alpha + \beta_1 * \log(QP_{r,CT,t}) + \beta_2 * \text{TRD} + \log(R) \tag{63}$$

$$CRMAR_{r,OS,t} = \frac{PP_{r,PM,t}*YLD_{r,OM,t}+PP_{r,VL,t}*YLD_{r,OL,t}}{PP_{r,OS,t}} \tag{64}$$

Where:

CR = crushing

CRMAR = crush margin

YLD = yield, here calculated as the content of vegetable oil or protein meal in oilseeds

TRD = trend

OS = oilseeds (soybeans, rapeseed, sunflower seed and groundnuts)

CSE = cottonseed

CT = cotton

PM = protein meal

OM = protein meal based on oilseeds

VL = vegetable oil

OL = vegetable oil based on oilseeds

Processing of grains into sweetener (SWG)

Processing of coarse grains or maize for High Fructose Corn Syrup (isoglucose) depends on the production of High Fructose Corn Syrup (isoglucose) and is only divided by the technical conversion factor γ (in this case for all countries 0.6). This implies that 0.6 tons of High Fructose Corn Syrup (isoglucose) can be obtained from each ton of coarse grain or maize.

$$SWG_{r,c,t} = \frac{QP_{r,HFCS,t}}{\gamma} \tag{65}$$

Where:

SWG = processing of grains into sweetener
QP = production quantity
HFCS = High Fructose Corn Syrup (isoglucose)
γ = constant technical factor for the conversion of feedstock into HFCS

Other uses

Other use is not clearly specified and contains a number of different components. In short, it includes what is not covered in any other consumption item, e.g. losses, seed use, processing not covered. The specific situation for each product in each region implies how much emphasis is placed on each of the parameters in the equation, in several cases many of these are zero.

$$\log(OU_{r,c,t}) = \alpha + \beta_1 * \log\left(\frac{PP_{r,c,t}}{CPI_{r,t}}\right) + \beta_2 * \log(GDPI_{r,t}) + \beta_3 * TRD + \log(R) \tag{66}$$

Where:

OU = other use
PP = producer price in domestic currency
CPI = consumer price index
GDPI = gross domestic product index (2010=1)

Trade

Aglink-Cosimo is not a spatial trade model which means that each country or region trades with the world market and not with a bilateral partner. Imports and exports are generally modelled in the same way and react on the difference between the domestic producer price and the import or export price multiplied by the *ad valorem* equivalent import tariff or export tax.

$$\log(IM_{r,c,t}) = \alpha + \beta * \log\left(\frac{PP_{r,c,t}}{IMP_{r,c,t}*(1+TAVI_{r,c,t}/100)}\right) + \log(R) \tag{67}$$

$$\log(EX_{r,c,t}) = \alpha + \beta * \log\left(\frac{PP_{r,c,t}}{EXP_{r,c,t}*(1+TAVE_{r,c,t}/100)}\right) + \log(R) \tag{68}$$

Where:

IM = imports
EX = exports
PP = producer price in domestic currency
IMP = import price in domestic currency
EXP = export price in domestic currency
TAVI = import tariff in *ad valorem* equivalent (in %)
TAVE = export tax in *ad valorem* equivalent (in %)

The β parameters of the equations are negative for exports and positive in the case of imports. A larger absolute value results in stronger integration of local markets into world markets and a closer link between world markets and domestic prices. In the Cosimo submodule, these parameters are determined endogenously in the model, allowing for stronger reactions if the difference between world and domestic markets is substantial. These parameters indicate how closely the domestic producer price of a specific commodity follows the world market price of that commodity. A high absolute value indicates stronger integration between both markets, but may result in strong swings in trade quantities.

In several cases, different approaches are used to derive exports and imports. In the case of no or very small trade volumes, the respective trade flow is considered to be exogenous. For beet pulp, milling by-products, corn gluten feed, and other individual cases where prices are derived via price transmission equations, trade is residual and closes the balance.

In the case of sugar, international trade is separated into raw and white sugar trade. Nevertheless, all quantities are presented in raw sugar equivalent and the trade quantities are added to the domestic balance of total sugar.

For pigmeat, sheep and goat meat, as well as beef and veal, a separation is made between trade in live animals and meat. Trade in meat is calculated generally in the standard format and trade in live animals is exogenous (exceptions only for pigmeat and beef and veal in North America). Subsidised exports, food aid or selected import quotas are modelled on an *ad hoc* basis and need to be checked in the specific code.

Export taxes (TAVE) are generally exogenous and only two exceptions exist: Argentine biodiesel and Russian molasses. The *ad valorem* equivalent import tariffs used within the import equations are calculated from specific and *ad valorem* tariffs.

$$TAVI_{r,c,t} = TAV_{r,c,t} + 100 * \frac{TSP_{r,c,t}}{IMP_{r,c,t}} \tag{69}$$

Where:

TAVI = import tariff in *ad valorem* equivalent (in %)

TAV = *ad valorem* import tariff (in %)

TSP = specific import tariff in domestic currency per tonne

IMP = import price in domestic currency

An alteration of this equation occurs in the case of tariff rate quotas.

$$TAVI_{r,c,t} = TAVI_{r,c,t}^{IQS} + \frac{\exp\left\{\min\left[0, \frac{(IM-TRQ)}{TRQ} * \gamma\right]\right\}}{1 + \exp\left\{-\frac{abs[IM-TRQ]}{TRQ} * \gamma\right\}} * \left(TAVI_{r,c,t}^{OQS} - TAVI_{r,c,t}^{IQS}\right) \tag{70}$$

Where:

TAVI^{IQS} = in-quota import tariff in *ad valorem* equivalent (in %)

TAVI^{OQS} = out of quota import tariff in *ad valorem* equivalent (in %)

TRQ = tariff rate quota

γ = transition factor between in-quota and out of quota tariff

As in the standard equation, the import tariff in *ad valorem* equivalent is a function of the import level itself. Theoretically, the effective import tariff is equal to the in-quota tariff as long as imports are strictly below the tariff rate quota (TRQ) level, and equal to the over-quota tariff, if imports are above the TRQ level[5]. However, this relation only holds for the individual tariff lines. The relationship between

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5. Other trade measures, such as specific tariffs, are also incorporated in the model after their translation into *ad valorem* equivalents, but were left out here to reduce the equation's complexity.

import levels and the effective tariff rate will not strictly be like this when tariff lines are aggregated. In this situation the relation between in-quota and out of quota tariffs is approximated (transition factor γ), in order to make the jump in tariffs less steep when imports increase. When the value of the transition factor γ increases the approximated function approaches the effective main tariff line. Hence, the choice of γ depends on the properties of the trade measures in place for the modelled (aggregated) commodity. The values for γ range between 0.1 and 200 with the majority around 100.

Stocks

Stocks are not covered for all commodities in all countries. In this case, it is assumed that no stock changes occur. The following equation includes the behavioural link for private stocks.

$$
\log(ST_{r,c,t}) = \alpha + \beta_1 * \log(QP_{r,c,t} + ST_{r,c,(t-1)}) + \beta_2 * \log(QC_{r,c,t})
$$
$$
+\beta_3 * \frac{3*PP_{r,c,t}}{PP_{r,c,(t-1)}+PP_{r,c,(t-2)}+PP_{r,c,(t-3)}} + \beta_4 * TRD + \log(R) \tag{71}
$$

Where:

ST = year-end stocks
PP = producer price in domestic currency
QP = production quantity
QC = domestic disappearance
TRD = trend

In contrast to all other commodities, stock changes are used for dairy products in the market clearing balance. In some cases, in addition to private stocks, there are administered stocks which need to be included in order to obtain total stocks. Examples of administered stocks are intervention stocks in the EU and Indian cereal stocks.

CHAPTER 2.

OUTLOOK PROCESS AND PARTIAL STOCHASTIC APPLICATION

Aglink-Cosimo is used annually to derive the data surrounding the *OECD-FAO Agricultural Outlook*. The model is used for additional scenario work and partial stochastic analysis.

2.1 Producing the *OECD-FAO Agricultural Outlook*

The projections presented and analysed in the *OECD-FAO Agricultural Outlook* (e.g. OECD-FAO, 2015) are the result of a process that brings together information from a large number of sources. The use of the Aglink-Cosimo model facilitates consistency in this process. A large amount of expert judgement, however, is applied at various stages of the Outlook process. The *Agricultural Outlook* presents a single, unified assessment judged by the OECD and FAO Secretariats to be plausible given the underlying assumptions, the procedure of information exchange (outlined below), and the information to which they had access.

The starting point of the Outlook process is the replies by OECD countries (and some non-member countries) to an annual questionnaire circulated in the fall of the previous year. These questionnaires allow the OECD Secretariat to obtain information on future commodity market developments and on the evolution of each country's agricultural policies. The starting projections for the country modules handled by the FAO Secretariat are developed through model-based projections and consultations with FAO commodity specialists. External sources, such as the IMF, the World Bank and the UN, are also used to complete the view of the main economic forces determining market developments. This part of the process aims to create a first insight into possible market developments and to establish the key assumptions which will condition the Outlook. The main economic and policy assumptions are summarised in the overview chapter and in specific commodity tables of the published report.

As a next step, Aglink-Cosimo is used to facilitate the consistent integration of this information and to derive an initial set of global market projections (baseline). In addition to quantities produced, consumed and traded, the baseline also includes projections for nominal prices (in local currency units) for the commodities concerned. The data series for the projections are drawn from OECD and FAO databases. For the most part, information in these databases has been taken from national statistical sources. For further details on a particular series, enquiries should be sent to the OECD and FAO Secretariats (tad.contact@oecd.org and EST-Projections@fao.org).

The model provides a comprehensive dynamic economic and policy-specific representation of the main temperate-zone commodities, as well as for rice, cotton and vegetable oils. The Aglink and Cosimo country and regional modules are developed by the OECD and FAO Secretariats in conjunction with country experts and, in some cases, with the assistance of other national administrations. The initial baseline results for the countries under the OECD Secretariat's responsibility are compared with those obtained from the questionnaire replies; issues that arise from this comparison are discussed in bilateral exchanges with country experts identified by the OECD Secretariat or nominated by national authorities. The initial projections for individual country and regional modules developed by the FAO Secretariat are reviewed by in-house and international experts. At this stage, a global projection picture emerges and refinements are made according to a consensus view of OECD and FAO Secretariats and external advisors. On the basis of these discussions and updated information, a second baseline is produced. The information generated is used to prepare market assessments for biofuels, cereals, oilseeds, sugar, meats, fish and sea food, dairy products and cotton over the course of the Outlook period, which is discussed at the annual meetings of the Group on Commodity Markets of the OECD Committee for Agriculture. Following the receipt of comments and final data revisions, a last revision is

made to the baseline projections. The revised projections form the basis of a draft of the present Agricultural Outlook publication, which is discussed by the Senior Management Committee of FAO's Department of Economic and Social Development and the OECD's Working Party on Agricultural Policies and Markets of the Committee for Agriculture, in May, prior to publication. In addition, the Outlook is used as a basis for analysis presented to the FAO's Committee on Commodity Problems and its various Intergovernmental Commodity Groups.

The Outlook process implies that the baseline projections presented are a combination of projections developed by collaborators for countries under the OECD Secretariat's responsibility, original projections for the 42 countries and regions under the FAO Secretariat's responsibility, and the use of Aglink-Cosimo to ensure consistency across these projections. The use of Aglink-Cosimo reconciles inconsistencies between individual country projections, ensures they are all based on the same underlying assumptions, and provides a global equilibrium for all commodity markets. The review process ensures that judgement of country experts is brought to bear on the projections and related analyses. However, the final responsibility for the projections and their interpretation rests with the OECD and FAO Secretariats.

Box 2.1. Sources and assumptions for the macroeconomic projections

Population estimates from the United Nations Population Prospects database provide the population data used for all countries and regional aggregates. For the projection period, the medium variant set of estimates is selected from the four alternative projection variants (low, medium, high and constant fertility). The UN Population Prospects database was chosen because it represents a benchmark source which includes data and estimates for all countries reflected in the model. For reasons of consistency, the same source is used for both the historical population estimates and the projection data.

The other macroeconomic series used in Aglink-Cosimo are real GDP, the GDP deflator, the private consumption expenditure (PCE) deflator and exchange rates expressed as the local currency value of one USD. Historical data for these series in OECD countries as well as Brazil, Argentina, China and the Russian Federation are consistent with those published in the latest *OECD Economic Outlook* (www.oecd.org/eco/economicoutlook.htm). For other economies, historical macroeconomic data were obtained from the *World Economic Outlook* database of the International Monetary Fund (IMF). Assumptions for future years are based on the recent medium-term macroeconomic projections of the OECD Economics Department, projections of the *OECD Economic Outlook* and projections of the IMF.

The model uses indices for real GDP development, consumer prices (PCE deflator) and producer prices (GDP deflator) which are constructed with the base year 2005 normalised to 1. When no information is available, it is assumed that real exchange rates remain constant, which implies that a country with higher (lower) inflation relative to the oil price (Brent crude oil price in US dollars per barrel) is based on information from the latest *OECD Economic Outlook* for the history and the first two projection years while its growth rate for subsequent years follows the projections of the International Energy Agency (IEA) (World Energy Outlook) for future paths. The United States (as measured by the US GDP deflator) will have a depreciating (appreciating) currency and therefore an increasing (decreasing) nominal exchange rate over the projection period, given the above mentioned exchange rate definition. The calculation of the nominal exchange rate uses therefore the percentage growth of the ratio "country-GDP deflator/US GDP deflator".

2.2 Partial stochastic use of Aglink-Cosimo

Partial stochastic analysis examines the sensitivity of future baseline projections to this uncertainty. The approach presented here is based on a methodology developed at the European Commission (Burrell and Nii-Naate, 2013).

The stochastic analysis can be summarized in three steps.

1. For the yield drivers that are treated stochastically, historical deviations around trends are calculated. For macro-economic drivers that are treated stochastically, historical deviations around expected values are calculated.

2. From these deviations, the stochastic behaviour of the drivers is formalised and 1 000 sets of future alternative values for these drivers, based on their stochastic behaviour, are generated.

3. The Aglink-Cosimo model is simulated for each of the alternative values of the drivers.

These steps are explained in more detail below.

Step (1): Estimating variability based on historical data

For the macroeconomic variables, deviations from expected values are computed as the ratio of the one-year-ahead forecast to the observed outcome. The forecasts come from past *OECD Economic Outlooks* and from the International Monetary Fund, and are available from 2003 onwards. This generates a time series of forecast errors from 2004 to 2014. Table 2.1 gives the coefficient of variation (CV) of the errors.

The deviations around expected yield are measured as the ratio of the estimated yield to the observed outcome, where the estimated yield is obtained by an OLS regression over the period 1996-2014 using the same yield equations as in Aglink-Cosimo. The distribution is truncated so that yields more extreme than the largest and smallest deviations cannot occur.

Table 2.1. Macroeconomic variables treated as uncertain
and the calculated CV of the one-year-ahead forecast errors (in %)

	AUS	BRA	CAN	CHN	EUN	IND	JPN	NZL	RUS	USA	WLD
Consumer Price Index (CPI)	2.0	6.9	1.4	4.8	1.7	9.9	1.7	2.6	6.6	1.2	
Gross Domestic Product Deflator (GDP)	3.8	5.6	2.2	10.2	2.4	6.9	2.0	2.5	11.4	2.2	
Gross Domestic Product (GDP)	3.8	5.6	2.2	10.2	2.4	6.9	2.0	2.5	11.4	2.2	
Exchange rate (national currency/USD)	12.6	19.6	8.2	5.2	10.3	13.5	13.6	12.5	11.7		
Crude oil price											32.4

Note: Countries are denoted as follows, (AUS) Australia, (BRA) Brazil, (CAN) Canada, (EUN) European Union, (IND) India, (JPN) Japan, (NZL) New Zealand, (USA) United States, and (WLD) World.
Source: OECD and FAO Secretariats.

Table 2.2. Commodity yields treated as uncertain and the calculated CV (in %)

	EU		Eurasia			South America				North America			South East Asia				Others			
	E15	NMS	KAZ	UKR	RUS	ARG	BRA	PRY	URY	CAN	MEX	USA	IND	MYS	THA	VNM	AUS	CHN	IND	NZL
Wheat																				
Soft	4.4	10.7	21.3	20.6	10.1	8.1	13.4	18.4	25.6	12.8	6.1	7.0	4.1				19.3	2.9	4.1	
Durum	12.4	14.5																		
Coarse grains																				
C. Grains				12.2				15.3	12.8											
Barley	4.9	9.2				16.3				11.5							19.4			
Maize	5.6	19.5					8.3	9.0		9.2	2.1	5.9						3.5		
Oats	5.4	10.0								9.3										
Rye	9.5	9.0																		
Other cereals	6.0	8.3																		
Oilseeds																				
Oilseed			29.2	12.4				11.9												
Rape	7.3	14.0								10.1							21.1			
Soybean	9.4	22.9				12.3	7.7			16.3		6.0								
Sunflower	4.9	11.9			9.1	6.2														
Others																				
Rice	3.5											3.8	5.3		2.7	2.2		1.6	5.3	
Palm oil														7.9						
Sugar beet	4.6	5.6			8.7							6.3						8.6		
Sugarcane						9.0	2.8					6.1	6.7		10.3		10.3	9.1	6.7	
Dairy																				
Milk																	3.0			5.3
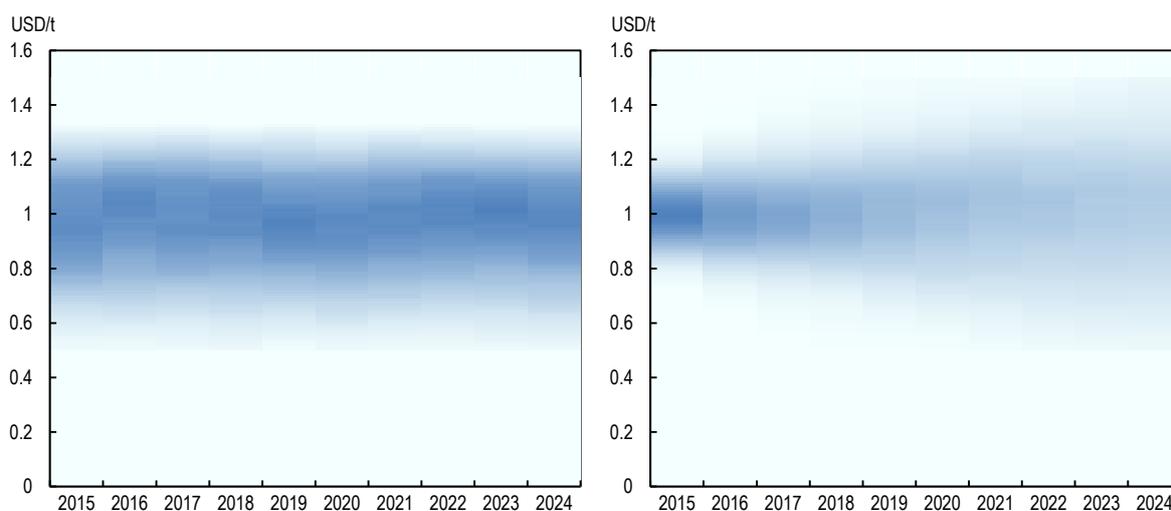
Step (2): Deriving the stochastic behaviour of the drivers and generating 1 000 sets of alternative values of the stochastic terms that mimic this stochastic behaviour

This step is performed by the software R. Step (2) uses the deviations and errors estimated in step (1), and in step (2) the 1 000 alternative values are generated for each year of the projection period. The assumptions underlying these steps are: (a) deviations and errors are normally distributed and (b) the covariance between exogenous drivers is relevant information. Estimated covariances are used only for the macroeconomic drivers and for yields within each regional block (e.g. the European Union), but not between regional blocks. Thus, covariances between yield uncertainties in different regional blocks and covariances between macroeconomic drivers and yield uncertainties are assumed to be zero. For the macroeconomic variables, the stochastic deviation is assumed to increase over time; for the simulation of the crude oil and exchange rate stochastic terms a correction factor of 0.8 was used. By contrast, yield uncertainty is assumed not to cumulate over time.

Then, R is run with these underlying assumptions and its output provides the final stochastic terms. A comparison of the two panels of Figure 2.1 illustrates the consequences of these two approaches to simulating the stochastic terms of macroeconomic and yield variables.

Figure 2.1. Distribution of the multiplicative stochastic terms of Australian wheat (left figure) and Russian GDP (right figure) (2015-2024)

Source: OECD and FAO Secretariats.

Step (3): Running the AGLINK-COSIMO model for each of the 1 000 alternative uncertainty scenarios

The stochastic terms are incorporated as multiplicative factors into the equations in which one of the stochastic drivers appears. This has the effect of shifting the relevant function above or below its "central" position in the deterministic baseline run. The model is run for each of the 1 000 alternative sets of stochastic drivers, providing 1 000 sets of different possible sets of the model's output variables.

For most of the scenarios presented, not all the 1 000 sets yield to a solution. Table 2.2 summarises the rate of success for each of the three scenarios presented in the overview chapter.

Table 2.2. Rate of success in the solutions for the three scenarios

Scenario	Rate of success (%)
Crop + milk yield uncertainty	97
Macroeconomic uncertainty	89
Macroeconomic + yield (crop & milk) uncertainty	90

Source: OECD and FAO Secretariats.

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ANNEX A
List of commodities in AGLINK-COSIMO

CEREALS		SUGARS AND SWEETENERS		DAIRY PRODUCTS	
Wheat	WT	Sugar beet	SBE	Milk	MK
- Durum wheat	WTD	Sugarcane	SCA	Other fat products	OFP
- Soft wheat	WTS	Sugar and molasses	SUMOL	Other non-fat solid products	ONP
Coarse grains	CG	Sugar	SU	Butter	BT
- Barley	BA	Raw sugar	SUR	Cheese	CH
- Maize	MA	White sugar	SUW	Whole milk powder	WMP
- Oats	OT	Molasses from sugar	MOL	Skim milk powder	SMP
- Sorghum	SO	High fructose corn syrup (isoglucose)	HFCS	Fresh dairy products	FDP
- Rye	RY	Sweetener	SW	Other dairy products (ice cream, yoghurt, evaporated milk, cottage cheese)	ODP
- Millet	MT			Whey powder	WYP
- Other cereals	OC			Casein	CA
Rice	RI				

OILSEEDS & PRODUCTS		OTHER CROPS		ANIMAL PRODUCTS	
Oilseeds	OS	Cotton	CT	Beef and Veal	BV
- Soybean	SB	Cotton seed	CSE	Pigmeat	PK
- Rapeseed	RP	Roots and tubers	RT	Poultry meat	PT
- Sunflower seed	SF	Beans	BN	- Other poultry	OP
- Groundnuts	GN	Field peas	FP	- Chicken	CK
Protein meals	PM	Jatropha	JA	-- Chicken white	CKW
- Palm kernel meal	KM			-- Chicken brown	CKB
- Copra (coconut) meal	CM	**ENERGY RELATED PRODUCTS**		Sheep meat	SH
- Cotton seed meal	CSM	Biofuels	BF	- Mutton	MU
- Oil meals	OM	Ethanol	ET	- Lambs	LA
-- Groundnut meal	GM	Biodiesel	BD	Wool	WL
-- Soybean meal	SM	Crude oil	OIL	Eggs	EG
-- Rapeseed meal	RM	Diesel	DIE	Fish and Aquaculture	FHA
-- Sunflower meal	SFM	Gasoline	GAS		
Vegetable oils	VL	Fertilizer	FT	**FEED PRODUCTS**	
- Palm oil	PL			Cereal brans	CEB
- Palm kernel oil	KL			Corn Gluten Feed	CGF
- Copra (coconut) oil	CL			Dried distillers grains	DDG
- Cotton seed oil	CSL			Protein feed	PF
- Oilseed oils	OL			Dried beet pulp	BP
-- Soybean oil	SL			Manioc	MN
-- Rapeseed oil	RL			Meat and bone meal	MBM
-- Sunflower oil	SFL			Fish meal	FM
-- Groundnut oil	GL			Fish oil	FL

World market clearing prices in Aglink-Cosimo

Cereals	
Wheat	No.2 hard red winter wheat, ordinary protein, United States f.o.b. Gulf Ports (June/May), less EEP payments where applicable
Coarse grains	No.2 yellow corn, United States f.o.b. Gulf Ports (September/August)
Rice	Milled, 100%, grade b, Nominal Price Quote, NPQ, f.o.b. Bangkok (January/December)
Oilseeds	
Oilseeds	Weighted average price of soybean, rapeseed and sunflower, European port
Protein meals	Weighted average price of soybean, rapeseed and sunflower meal, European port
Vegetable oils	Weighted average price of soybean, rapeseed, sunflower and palm oil, European port
Fibre crops	
Cotton	Cotlook A index, Middling 1 3/32", c.f.r. far Eastern ports (August/July)
Feed products	
Dried distillers grains	Wholesale price, Central Illinois
Dried beet pulp	Beet pulp price, United States.
Cereal brans	Wheat middlings in Buffalo, NY
Meat and bone meal	Ruminant meat and bone meal, Central United States (R-T)
Corn Gluten Feed	Corn gluten feed, 21% protein, Midwest
Roots and tubers	Thailand, Bangkok, Cassava (flour), Wholesale
Sweeteners	
Raw sugar	Raw sugar world price, ICE contract No11 nearby, October/September.
White sugar	Refined sugar price, Euronext, Liffe, Contract No. 407 London, Europe, October/September
High fructose corn syrup	United States wholesale list price HFCS-55, October/September
Molasses	Unit import price, Europe, October/September

Meats

Beef and Veal, Pacific	US Choice steers, 1100-1300 lb lw, Nebraska – lw to dw conversion factor 0.63
Beef and Veal, Atlantic	Brazil average beef producer price
Pigmeat, Pacific	US Barrows and gilts, No1-3, 230-250 lb lw, Iowa/South Minnesota - lw to dw conversion factor 0.74
Pigmeat, Atlantic	Brazil average pigmeat producer price
Poultry	Brazil average chicken producer price ready to cook
Sheep meat	New Zealand lamb schedule price, all grade average

Fish and Seafood

Fish	World unit value of trade (sum of exports and imports)
Fish from aquaculture	World unit value of aquaculture fisheries production (live weight basis)
Fish from capture	FAO estimated value of world ex vessel value of capture fisheries production excluding for reduction
Fish meal	Fish meal, 64-65% protein, Hamburg, Germany
Fish oil	Fish oil any origin, N.W. Europe

Dairy products

Butter	F.o.b. export price, butter, 82% butterfat, Oceania
Cheese	F.o.b. export price, cheddar cheese, 39% moisture, Oceania
Skim milk powder	F.o.b. export price, non-fat dry milk, 1.25% butterfat, Oceania
Whole milk powder	F.o.b. export price, WMP 26% butterfat, Oceania
Whey powder	Dry whey, West region, United States
Casein	Export price, New Zealand

Biofuels

Ethanol	Wholesale price, United States, Omaha
Biodiesel	Producer price Germany net of biodiesel tariff and energy tax

Regions and countries covered by Aglink Cosimo

Countries in Aglink

OECD countries

Australia	AUS
Canada	CAN
Switzerland	CHE
Japan	JPN
Korea	KOR
Mexico	MEX
Norway	NOR
New Zealand	NZL
United States	USA

OECD aggregates

European Union	EUN
- 15 older Member States	E15
- New Member States after 2004	NMS

Non-OECD countries

Argentina	ARG
Brazil	BRA
People's Republic of China	CHN
Russian Federation	RUS

Countries in Cosimo

OECD countries

Chile	CHL
Israel	ISR
Turkey	TUR

Non-OECD countries

Algeria	DZA
Bangladesh	BGD
Colombia	COL
Egypt	EGY
Ethiopia	ETH
Ghana	GHA
Indonesia	IDN
India	IND
Iran (Islamic Republic of)	IRN
Kazakhstan	KAZ
Mozambique	MOZ
Malaysia	MYS
Nigeria	NGA
Pakistan	PAK
Peru	PER
Philippines	PHL
Paraguay	PRY
Saudi Arabia	SAU
Sudan	SDN
Thailand	THA
United Republic of Tanzania	TZA
Ukraine	UKR
Uruguay	URY
Viet Nam	VNM
South Africa	ZAF
Zambia	ZMB
Haiti	HTI

Cosimo aggregates

LDC Oceania	OCL
Other Oceania	OCE
Other South America and Caribbean	SAC
LDC Sub-Saharan Africa	AFL
Other Sub-Saharan Africa	AFS
Other North Africa	AFN
LDC Asia	ASL
Other Asia Developing	ASA
Other Asia Developed	ASD
Other Middle East	MLE
Other Eastern Europe	EUE
Other Western Europe	EUW

OVERVIEW FLOW-CHART OF AGlink-Cosimo

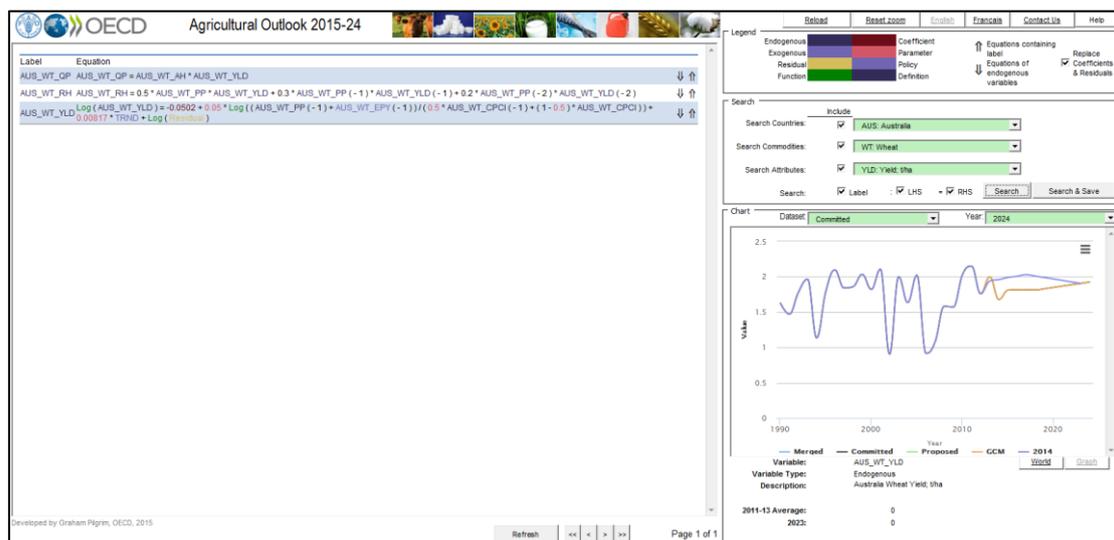|	
CPCI	Cost of production index
CPI	Consumer price index
EX	Export
EXP	Export price in domestic currency
FE	Feed use
FECI	Feed cost per tonne of feed
FO	Human consumption
GDPD	Deflator for the gross domestic product
GDPI	Gross domestic product index
IM	Import
IMP	Import price in domestic currency
NT	Net trade
OU	Other use
POP	Population
PP	Producer price in domestic currency
QC	Domestic disappearance
QP	Production quantity
ST	Year-end stocks
TAVE	Export tax in ad valorem equivalent
TAVI	Import tariff in ad valorem equivalent
XP	WORLD price in USD
XR	Exchange rate in relation to USD

Equation-viewer

If you are interested in specific equations, the most accessible reference is the equation-viewer available in the collaborator section at www.agri-outlook.org. The primary aim is to allow model users to verify equations and to understand the linkages between variables and parameters. The viewer and the model used to construct the latest *OECD-FAO Agricultural Outlook* are updated annually. The equation-viewer is based on Microsoft Excel and uses visual basic commands.

The equation-viewer contains four sections (Figure E.1). There are three sections on the right-and one on the left. The uppermost section on the right side contains the legend for the colour codes used for the variables and the parameters that are displayed. This section also contains the language selection, the resetting of the zoom, and the help button. The middle section on the right-hand side is the core search mask to manage your selection. You can enter either the description or the Aglink-Cosimo code. Matching options will then be displayed below; you select one of these options by clicking on it. With the filters you can select which of the three dimensions should be fixed. It can also be specified which elements of an equation should be searched; label, left-hand side or right-hand side.

The left-hand side contains a table listing the equations which match your search criteria. The first column contains the label of the equation. The second shows the equation itself. The variables are coloured according to the legend. Coefficients and parameters are presented in value terms and when the equation contains a residual this is only shown as text. The description of the variable is given when you hover your mouse over the variable. It contains the variable name, variable type, description, average value in the reference period, and the value in the final year of the projection. When clicking on the variable, if it is a time series variable then the same information and a line chart will be populated on the lower right-hand side of the page. The last column of the equation table contains the up and down arrows to explore how the equations are interlinked. The up arrow will display equations which include the label and the down arrow will display equations of the endogenous variables in the equation.

Figure E.1. Screenshot of the equation-viewer

AGLINK COSIMO MODEL DOCUMENTATION

A partial equilibrium model of world agricultural markets

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OECD

Food and Agriculture Organization of the United Nations