The attached document is tabled for INFORMATION under item 4.b of the 65th Session of the Working Party on Agricultural Policies and Markets.

Aglink-Cosimo model developments are mandated under the 2015-16 PWB of the CoAg Under Expected Output Result 3.2.2.1.2. This document contains the documentation of the model used for the OECD-FAO Agricultural Outlook 2015-2024.

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CHAPTER 1 – INTRODUCTION

1. Aglink-Cosimo is an economic model for supply and demand of world agriculture and is managed by the OECD and the Food and Agriculture Organization of the United Nations (FAO) Secretariats. Aglink-Cosimo is used in the generation of the OECD-FAO Agricultural Outlook and for policy scenario analysis.

2. The latest available documentation of Aglink-Cosimo dates from 2006\(^1\) and is available via the website www.agri-outlook.org. Since then, Aglink-Cosimo has gone through a fundamental review in 2009 and other adjustments have been carried out. Some of these changes have been documented in the methodology chapters of the OECD-FAO Agricultural Outlook and in other places e.g. biofuels in OECD (2008)\(^2\), partial stochastics in European Commission (2013)\(^3\).

3. The primary aim of this documentation is to consolidate the information regarding Aglink-Cosimo and to provide a reference manual for the Aglink-Cosimo model that documents 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. Such documentation is required by those in national agencies who use this model. More widely, documentation is also critical to facilitate greater transparency in understanding model results, to confirm model design and attributes and to identify areas for further work. The Aglink-Cosimo model continues to evolve and changes occur from one year to the next, in particular as policies affecting markets change. Nevertheless, this documentation explains the core structure of the model and should serve as a reference for some time.

4. The reminder of the first chapter summarises Aglink-Cosimo. The second chapter describes the main equations underlying Aglink-Cosimo. Chapter three describes briefly the process followed to generate the OECD-FAO Agricultural Outlook and provides a short introduction into the partial stochastic use of Aglink-Cosimo.

1.1 Aglink-Cosimo model in short

5. Aglink-Cosimo is a recursive-dynamic, partial equilibrium model for supply and demand of world agriculture. The model integrates the OECD’s Aglink and FAO’s Cosimo sub-modules. It is managed by the OECD and FAO Secretariats. The model 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 1) and 40 world market clearing prices (Annex 2) 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: 10 OECD countries/regions (Australia, Canada, European

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\(^1\) Documentation of the Aglink-Cosimo Model (AGR/CA/APM(2006)16/FINAL), 14 March 2007


\(^3\) European Commission (2013) Partial stochastic analysis with the European Commission’s version of the AGLINK-COSIMO model. EUR 25898 – Joint Research Centre – Institute for Prospective Technological Studies. Authors: Alison Burrell, Zebedee Nii-Naate
Union (EU), Switzerland, Norway, Japan, Korea, Mexico, New Zealand and the United States\(^4\) and 4 non-OECD countries (Argentina, Brazil, China and Russia). The EU module consists of the currently 28 Member States and is composed of two endogenous modules, one with the former 15 Member States and another one with the 13 “New” Member States, acceded to the EU in 2004 or later. The Cosimo component of the model consists of 42 endogenous modules: 3 OECD members (Chile, Israel and Turkey), a further 27 single countries and 12 regional aggregates (Annex 3).

\(^4\) The modules of Switzerland and Norway include only exogenous commodity balances.
CHAPTER 2 – AGLINK-COSIMO MODEL IN DETAIL

6. This document describes the general features as well as the logic behind Aglink-Cosimo. A flow-chart of the main linkages within the model (Annex 4) serves as a fast overview but cannot describe all equations of the model by any means. In the following, some specific treatments will be covered but not all specificities. For the details on the specific equations, including the treatment of national policies, it is advised to use the equation-viewer developed (Annex 5).

7. Several key factors or assumptions are as follows:

1. 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.

2. 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. Nevertheless, imports and exports are determined separately. This assumption will affect the results of analysis in which trade is a major driver.

3. Aglink-Cosimo is a "partial equilibrium" model for the main agricultural commodities. Non-agricultural markets are not modelled and are treated exogenously to the models. 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.

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

8. For the equations in this document a specific nomenclature is used and should be kept in mind;

- $\alpha$ indicates equation-specific constants;
- $\beta$ indicates equation-specific parameters, a subscript is used to distinguish different parameters in one equation;
- $\gamma$ 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 item dimension, 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)’.
Box 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 (LHS) 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 of course 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 (LHS-) 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. Please note that 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 the 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 are 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.

2.1 World price clearing

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

\[ 0 = NT_{WLD,c,t} - SD_{WLD,c,t} \]  \hspace{1cm} (1)

Where:
- \( NT \) = net trade
- \( SD \) = statistical difference
- \( WLD \) = world

10. The statistical difference is the amount of products 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. The world net trade is the sum of the net trade of all countries.

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5 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 we believe that the underlying relationship between \( Y \) and \( X \) resembles a logarithmic function (e.g. \( Y \) experiences diminishing marginal returns with respect to increases in \( X \)). This is only altered by the introduction of an intercept (\( \alpha \)) and slope (\( \beta \)), which we call respectively 'constant' and 'elasticity'.
\[ N_{\text{WLD},c,t} = \sum_r N_{r,c,t} \] (2)

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

12. The world price is directly converted into an import and export price in national currency for each country and commodity\(^6\).

\[
\text{IMP}_{r,c,t} = X_P^{\text{WLD},c,t} \ast X_R^{r,c,t} \quad (3)
\]

\[
\text{EXP}_{r,c,t} = X_P^{\text{WLD},c,t} \ast X_R^{r,c,t} \quad (4)
\]

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

2.2 Domestic markets

13. 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\(^7\) in country \(c\) for each commodity is assured through a producer price in domestic currency, \(P_{P, c, t}\), which satisfies

\[ 0 = Q_{P,r,c,t} - Q_{C,r,c,t} + I_{M,r,c,t} - E_{X,r,c,t} + S_{T,r,c,(t-1)} - S_{T,r,c,t} \] (5)

Where:
- \(QP\) = quantity produced domestically
- \(QC\) = quantity consumed domestically
- \(IM\) = imports
- \(EX\) = exports
- \(ST\) = year-end stocks

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

15. For dairy and eggs the general approach for domestic market clearing is slightly altered. The domestic price clearance for dairy products is done in a two-step procedure; first, markets for milk fat and

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\(^6\) The equations have been 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.

\(^7\) 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.
non-fat solids are cleared equations 6 and 7) and secondly, based on this a milk producer price is derived (equation 8).

\[ 0 = \left( Q_{P, MK,t} - F_{U, MK,t} \right) \times F_{AT, MK,t} - \sum_{c(dairy)} Q_{P, c,t} \times F_{AT, c,t} - Q_{P, OFP, t} \]  

\[ 0 = \left( Q_{P, MK,t} - F_{U, MK,t} \right) \times N_{FS, MK,t} - \sum_{c(dairy)} Q_{P, c,t} \times N_{FS, c,t} - Q_{P, ONP, t} \]  

\[ P_{P, MK,t} = \frac{P_{P, FAT} \times F_{AT, MK,t} + P_{P, NFS} \times N_{FS, MK,t}}{P_{M, MK,t}} \times R \]  

Where:

- \( Q_P \) = production quantity
- \( F_U \) = farm use of milk
- \( F_A T \) = fat content of milk
- \( N_{FS} \) = non-fat solid content of milk
- \( P_P \) = producer price in domestic currency
- \( P_{P, FAT} \) = milk-fat price at dairy factory in domestic currency
- \( P_{P, NFS} \) = non-fat solid price based on Skimmed Milk Powder in domestic currency
- \( P_{M} \) = 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

16. In the case of eggs, a 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.

\[ \log(P_{P, EG, t}) = \alpha + \beta_1 \times \log(0.5 \times F_{ECI, NR, (t-1)} + 0.5 \times F_{ECI, NR, t}) + (1 - \beta_1) \times \log(GDP_{D, t}) + \beta_2 \times TRD + \log(R) \]  

Where:

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

2.2.1 Production

17. In case of production no general principle exists. Instead, several principles 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.

18. Changes in production costs are an important variable for farmers’ decisions of crop and livestock production quantities, in addition to output returns and, if applicable, policy measures. 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.
19. 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. Fuels for tractors and other machinery, as well as heating and other forms of energy 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.

\[
\begin{align*}
CPCI_r,c,t & = \text{CPCS}_{r,c,t}^{NT} \cdot \frac{\text{GDPD}t}{\text{GDPD},2008} + \text{CPCS}_{r,c,t}^{EN} \cdot \frac{\text{XP}_{\text{wild,OIL},t} \times \text{XR}_{t}}{\text{XP}_{\text{wild,OIL},2008} \times \text{XR}_{t,2008}} + \text{CPCS}_{r,c,t}^{TR} \cdot \frac{\text{GDPD}_{\text{USA},t} \times \text{XR}_{t}}{\text{GDPD}_{\text{USA},2008} \times \text{XR}_{t,2008}} + \\
\text{CPCS}_{r,c,t}^{FT} & \cdot \frac{\text{XP}_{\text{wild,FT},t} \times \text{XR}_{t}}{\text{XP}_{\text{wild,FT},2008} \times \text{XR}_{t,2008}} + \text{CPCS}_{r,c,t}^{SD} \cdot \frac{\text{PP}_{r,c,t(1)}}{\text{PP}_{r,c,2007}}
\end{align*}
\]

Where:

- CPCI = commodity production cost index
- \(\text{CPCS}^{NT}\) = share of non-tradable input in commodity production costs
- \(\text{CPCS}^{EN}\) = share of energy in commodity production costs
- \(\text{CPCS}^{TR}\) = share of other tradable input in total base commodity production costs
- \(\text{CPCS}^{FT}\) = share of fertiliser in commodity production costs (only crops)
- \(\text{CPCS}^{SD}\) = share of seeds input in commodity production costs (only crops)
- \(\text{GDPD}\) = deflator for the gross domestic product
- \(\text{XP}\) = world price in US Dollar
- \(\text{PP}\) = producer price in domestic currency
- \(\text{XR}\) = nominal exchange rate with respect to the US Dollar
- \(\text{OIL}\) = crude oil
- \(\text{FT}\) = fertiliser

20. The shares of the various cost categories are country specific and always add up 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. In Aglink-Cosimo, the fertiliser price for the projection period is represented by an equation responding to lagged fertiliser, crude oil and crop prices.

21. 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 5).

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8 Urea (Black Sea) price (62%), US Diammonium Phosphate price (20%), Canada Potassium Chloride price (16%) and Triple Superphosphate price (2%).
Crops

22. The modelling of crop production occurs at the disaggregated level, e.g. maize, barley, soybeans, rapeseed instead of coarse grains and oilseeds.

\[ Q_{P,r,c(crop),t} = A_{H,r,c(crop),t} \cdot Y_{LD,r,c(crop),t} \]  
\( (11) \)

Where:
- \( Q_P \) = quantity produced
- \( A_H \) = area harvested
- \( YLD \) = yield
- \( c(crop) \) = crop commodity

23. Crop yields are calculated with the following equation.

\[ \log(Y_{LD,r,c,crop}) = \alpha + \beta_1 \cdot \log\left( \frac{P_{P,r,c,crop}(t-1) + E_{PY,r,c,crop}(t-1)}{Y_c \cdot C_{PCI,r,c,crop}(t-1) + (1-Y_c) \cdot C_{PCI,r,c,crop}} \right) + \beta_2 \cdot TRD + \log(R) \]  
\( (12) \)

Where:
- \( P_{P} \) = producer price in domestic currency
- \( E_{PY} \) = policy variable (in domestic currency per ton)
- \( C_{PCI} \) = cost of production index (2008 = 1)
- \( \gamma_c \) = share of production cost occurring in the previous marketing year

24. 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 subsides is included and calculated on individual basis according to the specific agricultural policy in place.

\[ \log(A_{H,r,c,crop}) = \alpha + \beta_1 \cdot \log(A_{H,r,c,crop}(t-1)) + \sum_{c1(crop)} \beta_{c1} \cdot \log\left( \frac{R_{H,r,c,crop}(t-1) + E_{PA,r,c,crop}(t-1)}{Y_c \cdot C_{PCI,r,c,crop}(t-1) + (1-Y_c) \cdot C_{PCI,r,c,crop}} \right) + \beta_2 \cdot TRD + \log(R) \]  
\( (13) \)

Where:
- \( R_{H} \) = market returns per hectare
- \( E_{PA} \) = policy variable affecting area (in domestic currency per hectare)
- \( C_{PCI} \) = cost of production index (2008 = 1)
- \( \gamma_c \) = share of production cost occurring in the previous marketing year

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

\[ \log(Q_{P,r,PL,t}) = \alpha + \beta_1 \cdot \log(Q_{P,r,PL,(t-1)}) + \beta_2 \cdot \log\left( \frac{P_{P,r,PL,t}}{C_{PCI,r,PL,t}} \right) + \beta_3 \cdot TRD + \log(R) \]  
\( (14) \)

\footnote{Field pea production is considered exogenous in Aglink-Cosimo.}
\[ \log(Q_{P, CN,t}) = \alpha + \beta_1 \log(Q_{P, CN,(t-1)}) + \beta_2 \log\left(\frac{PP_{P,PM,t}}{CPCI_{r, CN,t}}\right) + \beta_3 \log\left(\frac{PP_{V,VL,t}}{CPCI_{r, CN,t}}\right) + \beta_4 \cdot TRD + \log(R) \]

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

26. The calculated return per hectare includes only market returns and refers to the actual and the last two years with weighting the actual year the most.

\[ RH_{r,c,t} = RH_{r,c,t}^{\text{spec}} + 0.5 \cdot YLD_{r,c,t} \cdot PP_{r,c,t} + 0.3 \cdot YLD_{r,c,(t-1)} \cdot PP_{r,c,(t-1)} + 0.2 \cdot YLD_{r,c,(t-2)} \cdot PP_{r,c,(t-2)} \]

Where:
- RH$^{\text{spec}}$ = specific returns per hectare mostly derived from by-products, e.g. cottonseed in case of cotton
- YLD = yield
- PP = producer price in domestic currency

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

**Sugar and by-products**

28. The production of sugar cane and sugar beet is done as for all crops. The sugar production 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 in the next stage) and the molasses production. The former is based on the use of sugar cane and beet for processing to sugar.

\[ Q_{P, SU,t} = Q_{P, SUMOL,t} - Q_{P, MOL,t} \]

Where:
- QP = production quantity
- SU = sugar
- SUMOL = sugar and molasses
- MOL = molasses

\[ Q_{P, SUMOL,t} = SU_{r, SCA,t} \cdot YLD_{r, SUMOL,t}^{SCA} + SU_{r, SBE,t} \cdot YLD_{r, SUMOL,t}^{SBE} \]

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

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

\[ SU_{r,c,t} = QP_{r,c,t} - BF_{r,c,t} \] (19)

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

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

\[
\log(YLD_{r,SCA,SUMOL,t}) = \alpha + \beta_1 \ast \log\left(\frac{PP_{r,SCA, t}}{GDP_{r,t}}\right) + \beta_2 \ast TRD + \log(R) \] (20)

\[
\log(YLD_{r,SBE,SUMOL,t}) = \alpha + \beta_1 \ast \log\left(\frac{PP_{r,SBE, t}}{GDP_{r,t}}\right) + \beta_2 \ast TRD + \log(R) \] (21)

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

31. Prices for sugar cane and beet are derived from 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.

\[ PP_{r,SBE,t} = (\gamma_1 \ast PP_{r,SUW,t} + \gamma_2 \ast PP_{r,MOL,t} + \gamma_3 \ast PP_{r,BP,t}) \ast MAR_{r,SBE,t} \] (22)

Where:
- PP = producer price in domestic currency
- MAR = processing margin
- SBE = sugar beet
- SUW = white sugar
- BP = beet pulp
- MOL = molasses
- \( \gamma \) = technical conversion factors from sugar beet into products

32. This equation becomes more complicated when part of the sugar cane or sugar beet is used for the processing into ethanol. Additional conversion factors have to 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.

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

$$\log(Q_{P, MOL,t}) = \alpha + \beta_1 \times \log\left(\frac{P_{P, SUW,t}}{P_{P, MOL,t}}\right) + \log(Q_{P, SUMOL,t}) + \beta_2 \times TRD + \log(R)$$  \hspace{1cm} (23)

Where:
- \(QP = \text{production quantity}\)
- \(PP = \text{producer price in domestic currency}\)
- \(TRD = \text{trend}\)
- \(SUW = \text{white sugar}\)
- \(SUMOL = \text{sugar and molasses}\)
- \(MOL = \text{molasses}\)

34. 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.

$$Q_{P, BP,t} = \gamma \times Q_{P, SBE,t}$$  \hspace{1cm} (24)

Where:
- \(BP = \text{beet pulp}\)
- \(SBE = \text{sugar beet}\)
- \(\gamma = \text{technical conversion factor 0.058 tons of beet pulp are obtained from each ton of sugar beet}\)

**Meat and eggs**

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

36. 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 is considered equal.

$$Q_{PS, r, c,t} = Q_{P, r, c,t} - EXL_{r, c,t} + IML_{r, c,t}$$  \hspace{1cm} (25)

Where:
- \(QPS = \text{production of meat from domestic slaughtering}\)
- \(QP = \text{production quantity}\)
- \(EXL = \text{export of live animals}\)
- \(IML = \text{import of live animals}\)

37. 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.

$$\log(L_{r, c,t}) = \alpha + \log(Q_{P, r, c,t}) + \beta \times TRD + \log(R)$$  \hspace{1cm} (26)

Where:
LI = livestock inventory
QP = production quantity
TRD = trend

Beef and veal

38. 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 character, which implies large requirements for produced on arable land or pasture.

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

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

39. For some countries additional lags (especially for cow inventories) and the incorporation of grazing costs is done as a variation to the standard approach. For Aglink countries the reference inventory is the inventory for suckler cows.

\[
\log(CI_{r,c,t}) = 
\alpha + \beta_1 * \log \left( \frac{PP_{r,c,t}+EPI_{r,c,t}}{CPCI_{r,c,t}} \right) + \beta_2 * \log \left( \frac{PP_{r,c,(t-1)}+EPI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}} \right) + \beta_3 * \log \left( \frac{PP_{r,c,(t-2)}+EPI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}} \right) + \beta_4 * \\
\log \left( \frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}} \right) + \beta_5 * \log \left( \frac{FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}} \right) + \beta_6 * \log(CI_{r,c,(t-1)}) + \beta_7 * \log(CI_{r, MK,(t-1)}) + \beta_8 * \text{TRD} + \\
\log(R) \tag{28}
\]

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
40. In case of Cosimo countries a general livestock inventory for cattle is calculated in a slightly variant form of the suckler cow inventory in Aglink countries and also used as 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

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

\[
\log(Q_{P,c,t}) = \alpha + \beta_1 \cdot \log\left(\frac{PP_{r,c,(t-1)} + EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_2 \cdot \log\left(\frac{0.5 \cdot FECI_{r,c,(t-1)} + 0.5 \cdot FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 \cdot \log(Q_{P,r,c,(t-1)}) + \beta_4 \cdot TRD + \log(R) \tag{29}
\]

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

42. 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.

Sheep and goat meat

43. 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.

\[
\log(Q_{P,c,t}) = \alpha + \beta_1 \cdot \log\left(\frac{PP_{r,c,(t-1)} + EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_2 \cdot \log\left(\frac{RH_{r,Wt,(t-1)}}{CPCI_{r,Wt,(t-1)}}\right) + \beta_3 \cdot \log(Q_{P,r,c,(t-1)}) + \beta_4 \cdot TRD + \log(R) \tag{30}
\]

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

44. Most of the 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 case of Argentina the own price is a composite of the meat and the wool price.

\[
\log(Q_{P,c,t}) = \alpha + \beta_1 \cdot \log\left(\frac{PP_{r,c,t} + EPQ_{r,c,t}}{CPCI_{r,c,t}}\right) + \beta_2 \cdot \log\left(\frac{PP_{r,c,(t-1)} + EPQ_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_3 \cdot \log\left(\frac{FECI_{r,c,(t-1)}}{CPCI_{r,c,(t-1)}}\right) + \beta_4 \cdot \log\left(\frac{FECI_{r,c,(t-2)}}{CPCI_{r,c,(t-2)}}\right) + \beta_5 \cdot \log(Q_{P,r,c,(t-1)}) + \log(R) \tag{31}
\]
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
45. For Australia and New Zealand specific approaches are chosen which incorporate the jointness of the production with 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

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

\[
\log(Q_{P, r, c, t}) = 
\alpha + \beta_1 \cdot \log\left(\frac{P_{P, r, c, t} + EPQ_{r, c, t}}{CPCI_{r, c, t}}\right) + \beta_2 \cdot \log\left(\frac{0.5 \cdot FECI_{r, c, t} + 0.5 \cdot FECI_{r, c, (t-1)}}{CPCI_{r, c, t}}\right) + \beta_3 \cdot \log(Q_{P, r, c, (t-1)}) + \beta_4 \cdot TRD + \log(R)
\]

(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

47. Egg production (EG) is modelled as closing the commodity balance. This might be reconsidered when a world price for eggs would be incorporated and price clearance could be introduced. 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

48. 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.

\[
QP_{r, MK, t} = YLD_{r, MK, t} \cdot CI_{r, MK, t}
\]

(33)

Where:
- \(QP\) = production quantity
- \(YLD\) = milk yield in tonnes per dairy cow
- \(CI\) = cow inventory

49. The milk yield is depending 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 the previous year. For Canada yield is calculated as residual and the production is linked to demand for fluid milk and processing.

\[
\log(YLD_{r, c, t}) = \alpha + \beta_1 \cdot \log\left(\frac{P_{r, c, t} + EPY_{r, c, t}}{CPCI_{r, c, t}}\right) + \beta_2 \cdot \log\left(\frac{FECI_{r, c, t}}{CPCI_{r, c, t}}\right) + \beta_3 \cdot TRD + \log(R)
\]

(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

50. The cow inventory for dairy cows is calculated as follows. Even this is a simplification of the general form as for milk and beef prices up to two lags exist and for feed cost up to three lags exist. 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.

\[
\log(CI_{r,c,t}) = \alpha + \beta_1 \cdot \log\left(\frac{PP_{r,c,t} + \text{EPI}_{r,c,t}}{\text{CPCI}_{r,c,t}}\right) + \beta_2 \cdot \log\left(\frac{PP_{r,c,(t-1)} + \text{EPI}_{r,c,(t-1)}}{\text{CPCI}_{r,c,(t-1)}}\right) + \beta_3 \cdot \log\left(\frac{PP_{r,BV,t} + \text{EPI}_{r,BV,t}}{\text{CPCI}_{r,BV,t}}\right) + \beta_4 \cdot \log(R) + \ldots + \beta_8 \cdot \log(R) 
\]

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

51. Dairy products contain different levels of fat and non-fat solids than milk. Consequently, the processing needs to assure that both ingredients are consumed in a similar way to result in a balance as introduced in the domestic market clearing section.

\[
\log(QP_{r,c,t}) = \alpha + \beta \cdot \log\left(\frac{PP_{r,c,t}}{PP_{r,MK,t} \cdot \text{FAT}_{r,c,t} + PP_{r,MK,t} \cdot \text{NFS}_{r,c,t}}\right) + \log(R) 
\]

Where:
- QP = production quantity
- PP\text{FAT} = milk-fat price
- FAT = milk-fat content
- PP\text{NFS} = non-fat solids price
- NFS = non-fat solids content

52. The elasticity \( \beta \) should be the same for all dairy products in one country as this assures stability for the fat and non-fat balances.

53. Fresh dairy products (FDP) production is matching consumption. Whey powder (WYP) production is modelled as a by-product of cheese with no template approach existing.
Biofuels

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

\[ Q_{P, t}^{RE} = Q_{P, t}^{ENDO} + 0.9 \times Q_{P, t}^{BASE} \]  

Where:
- \( Q_P \) = production quantity
- \( BF \) = biofuel (biodiesel or ethanol)

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

\[ Q_{P, t}^{BASE} = \max(0, MBD_{t} - BF_{t}^{YEAR}) \]  

\( Q_P \) = production quantity
\( BF \) = use as biofuel, \( \text{in subscript biofuel commodity} \)
\( MBD \) = mandated blending quantity

56. 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:

\[ \log(Q_{P, t}^{ENDO}) = \alpha + \beta_1 \times \log(Q_{P, t}^{(t-1)}) + \beta_2 \times \log(PP_{t}^{FPIW}) + \beta_3 \times TRD + \log(R) \]  

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

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

58. The biofuel modelling in Aglink countries is currently under review. Thus, the description here does not cover details. In Argentina, biodiesel production is determined by the production margin.

\[ \log(Q_{P, t}^{BD}) = \alpha + \beta_1 \times \log\left(\frac{MAR_{t} + MAR_{t-1} + MAR_{t-2}}{3}\right) + \beta_2 \times \log(Q_{P, t}^{BD,(t-1)}) + \log(R) \]  

Where:
- \( Q_P \) = production
- \( MAR \) = production margin (producer price divided by variable net costs)
- \( BD \) = biodiesel
The ethanol production in Aglink countries depends on the competitiveness of feedstocks. And only for three countries, Canada, the European Union and the United States, a detailed modelling following the approach of OECD (2008) is done. Also in these cases the total production includes an exogenous part.

**Processing and by-products**

**Protein meal and vegetable oil**

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.

\[ Q_{P,r,c(oilmeal),t} = CR_{r,c(oilseed),t} \times YLD_{r,c(oilmeal),t} \]  
\[ Q_{P,r,c(oilseed oil),t} = CR_{r,c(oilseed),t} \times YLD_{r,c(oilseed oil),t} \]  

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\(^{10}\).

\[ Q_{P,r,CSE,t} = Q_{P,r,CT,t} \times YLD_{r,CSE,t} \]  

Where:
- \( QP \) = quantity produced
- \( CSE \) = cottonseed
- \( CT \) = cotton

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

\[ Q_{P,r,PKL,t} = \gamma \times Q_{P,r,PL,t} \]  

Where:
- \( QP \) = quantity produced
- \( PKL \) = palm kernels
- \( PL \) = palm oil
- \( \gamma \) = ratio between palm oil and palm kernel production

\(^{10}\) In some cases this ratio is introduced as a fixed number (ARG, AUS, BRA, CHN, MEX and USA).
64. Balances, including trade and producer prices are only modelled at the aggregate level of vegetable oil and protein meal. This is an un-weighted 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).

\[
Q_{P,VL,t} = Q_{P,OL,t} + Q_{P,PL,t} + Q_{P,KL,t} + Q_{P,CL,t} + Q_{P,CS,t} \tag{45}
\]
\[
Q_{P,PM,t} = Q_{P,OM,t} + Q_{P,KM,t} + Q_{P,CM,t} + Q_{P,CSM,t} \tag{46}
\]
Where:
- \( Q_P \) = quantity produced

High Fructose Corn Syrup (isoglucose) and corn gluten feed

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

\[
\log(Q_{P,HFCS,t}) = \alpha + \beta_1 \log(MAR_{HFCS,t}) + \beta_2 \log(Q_{P,HFCS,(t-1)}) + \log(R) \tag{47}
\]
\[
MAR_{HFCS,t} = \frac{\gamma_1 \cdot PP_{HFCS,t} + \gamma_2 \cdot PP_{PM,t} + \gamma_3 \cdot PP_{VL,t} + \gamma_4 \cdot PP_{CGF,t}}{PP_{CG,t}} \tag{48}
\]
Where:
- \( Q_P \) = 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)
- \( \gamma_1 \) = tonnes of HFCS produced from one tonne of coarse grain (normally 0.6)
- \( \gamma_2 \) = tonnes of corn gluten meal produced in the conversion of one tonne of coarse grain to HFCS (normally 0.06)
- \( \gamma_3 \) = tonnes of corn oil produced in the conversion of one tonne of coarse grain to HFCS (normally 0.03)
- \( \gamma_4 \) = tonnes of corn gluten feed produced in the conversion of one tonne of coarse grain to HFCS (normally 0.24)

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

\[
Q_{P,CGF,t} = \gamma \cdot HFCS_{CG,t} \tag{49}
\]
Where:
- \( Q_P \) = quantity produced
- \( HFCS \) = coarse grains used for HFCS production
- \( CGF \) = corn gluten feed
- \( CG \) = coarse grains
- \( \gamma \) = tonnes of corn gluten feed produced in the conversion of one tonne of coarse grain to HFCS (normally 0.24)

Dried distillers grains (DDG)
67. The production of dried distillers grains (DDG) is directly linked to the production of ethanol. A specific conversion for the different feedstocks used for the production is applied. This conversion ratio is time dependent as the process is still in an 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.

\[ Q_{P,DDG,t} = \gamma_{1,t} \times Q_{P,ET,t} + 10 + \gamma_{2,t} \times Q_{P,W,T,t} + 10 + \gamma_{3,t} \times Q_{P,RT,t} + 10 \]  

(50)

Where:
- \( Q_P \) = 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
- \( \gamma \) = tonnes of DDG extracted per 100 litres of ethanol produced from specific feedstock

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

Milling by-products and cereal brans

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

\[ \log(Q_{P,CEB,t}) = \alpha + \beta_1 \times \log(F_O_{r,CG,t} + F_O_{r,RI,t} + F_O_{r,W,T,t}) + \beta_2 \times TRD + \log(R) \]  

(51)

Where:
- \( Q_P \) = production quantity
- \( F_O \) = food use
- \( TRD \) = trend
- \( CEB \) = milling by-products, cereal bran
- \( CG \) = coarse grains
- \( RI \) = rice
- \( WT \) = wheat

70. The elasticity \( \beta_1 \) 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 is traded globally. The balance is closed with a domestic market price for major countries (Argentina, Australia, Canada, China, European Union, Republic of 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

71. 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 collection on an annual basis of data difficult to discover. 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.

\[
Q_{P_{MBM,t}}^{PK} = \frac{Q_{PS_{PK},t}}{CY_{r,c,t}} \cdot \gamma \cdot \left( Q_{P^{FD},t} + (1 - Q_{P^{FD},t}) \cdot 0.5 \right) \tag{52}
\]

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
- \( \gamma \) = conversion factor

72. Conversion factors (\( \gamma \)) 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 the 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.

### 2.2.2 Domestic disappearance

73. 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.

\[
Q_{C_{r,c,t}} = F_{O_{r,c,t}} + F_{E_{r,c,t}} + B_{F_{r,c,t}} + C_{R_{r,c,t}} + S_{WG_{r,c,t}} + O_{U_{r,c,t}} \tag{53}
\]

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\(^{11}\)
- \( OU \) = other use (e.g. industrial use, seed, losses)

74. Each of the components is treated differently and therefore in the following each one will be shortly described.

#### Food use

75. 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 decision, which includes references to the nominal producer prices and the deflator of the gross domestic product. The

\(^{11}\) In some case HFCS (High Fructose Corn Syrup) is used instead of SWG.
consumer prices refer to observed food prices for core products. If limited observations are available the consumer price index is used to fill gaps.

\[
\log(CP_{r,c,t}) = \alpha + \beta \log(GDPD_{r,t}) + (1 - \beta) \log(PP_{r,c,t}) + \log(R)
\]

Where:
- CP = consumer price in domestic currency
- GDPD = deflator of the gross domestic product
- PP = producer price in domestic currency

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

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

\[
\log(FO_{r,c,t}) = \alpha + \sum_{c1(food)} \beta_{c1} \log\left(\frac{CP_{r,c1,t}}{CP_{r,t}}\right) + \beta_1 \log\left(\frac{GDPD_{r,t}}{POP_{r,t}/POP_{r,2005}}\right) + \log(POP_{r,t}) + \beta_2 \cdot TRD + \log(R)
\]

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
- \(\beta_{c1}\) = cross- and own-price elasticities

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

Feed module

79. 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.

\[
\log(FE_{r,c(feed),t}) = \alpha + \beta_1 \log\left(QP_{r,SH,t}\right) + \beta_2 \log\left(QP_{r,BV,t}\right) + \beta_3 \log\left(QP_{r,MAK,t}\right) + \beta_4 \log\left(PP_{r,c1,t} \cdot GDPD_{r,t}\right) + \beta_5 \log\left(PP_{r,c2,t} \cdot GDPD_{r,t}\right) + \beta_6 \cdot TRD + \log(R)
\]

Where:
- FE = feed use

\(\beta_{c1}\) are 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).
80. 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).

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

\[ F_{ECI,T} = PP_{R,APF,T} \]  

(57)

Where:
- \( F_{ECI} \) = feed cost per tonne of feed
- \( PP \) = producer price in domestic currency
- \( APF \) = average protein feed

82. 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.

\[ FE_{R,RU,T} = FE_{R,APF,T} - FE_{R,NR,T} - FE_{R,FHA,T} \]  

(58)

Where:
- \( FE \) = feed quantity
- \( RU \) = ruminants
- \( APF \) = average protein feed
- \( NR \) = non-ruminants

13 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 (\( \beta_5 \)) 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).
83. 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.

\[
FE_{r,NR,t} = FCR_{r,PK,t} \frac{QP_{r,PK,t}}{CY_{r,PK,t}} + FCR_{r,PT,t} \frac{QP_{r,PT,t}}{CY_{r,PT,t}} + FCR_{r,EG,t} QP_{r,EG,t}
\]

(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

84. 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.

85. 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

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

\[
BF_{r,c,t} = \frac{QP_{r,BF,t}}{\gamma_t}
\]

(60)

Where:
- \( BF \) = biofuel use; in subscript biofuel commodity
- \( QP \) = production quantity
- \( \gamma_t \) = time-dependent technical factor for the conversion of feedstock into biofuel

87. 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.

88. 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.

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

(61)

Where:
- \( BF \) = biofuel use; in subscript biofuel commodity
- \( MBD \) = mandated quantity
- \( CP \) = consumer price in domestic currency
FUEL = related fossil fuel commodity

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

Crushing

90. 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.

\[
\log(CR_{r,OS,t}) = \alpha + \beta_1 \cdot \log(CRMAR_{r,OS,t}) + \beta_2 \cdot \log(CR_{r,OS,(t-1)}) + \log(R)
\]

\[
\log(CR_{r,CSE,t}) = \alpha + \beta_1 \cdot \log(QP_{r,CT,t}) + \beta_2 \cdot TRD + \log(R)
\]

\[
CRMAR_{r,OS,t} = \frac{PP_{r,PM,t} \cdot YLD_{r,OM,t} + PP_{r,VL,t} \cdot YLD_{r,OL,t}}{PP_{r,OS,t}}
\]

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)

91. 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 \( \gamma \) (in this case for all countries 0.6). This implies that from each ton of coarse grain or maize 0.6 tons of High Fructose Corn Syrup (isoglucose) can be obtained.

\[
SWG_{r,c,t} = \frac{QP_{r,HFCS,t}}{\gamma}
\]

Where:
- SWG = processing of grains into sweetener
- QP = production quantity
- HFCS = High Fructose Corn Syrup (isoglucose)
- \( \gamma \) = constant technical factor for the conversion of feedstock into HFCS
Other use

92. 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.

\[
\log(OU_{r,ct}) = \alpha + \beta_1 \log\left(\frac{PP_{r,ct}}{CPI_{r,ct}}\right) + \beta_2 \log(GDP_{r,ct}) + \beta_3 \cdot TRD + \log(R) \tag{66}
\]

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

2.2.3 Trade

93. 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 \textit{ad valorem} equivalent import tariff or export tax.

\[
\log(IM_{r,ct}) = \alpha + \beta \log\left(\frac{PP_{r,ct}}{IMP_{r,ct} \cdot (1 + TAVI_{r,ct}/100)}\right) + \log(R) \tag{67}
\]

\[
\log(EX_{r,ct}) = \alpha + \beta \log\left(\frac{PP_{r,ct}}{EXP_{r,ct} \cdot (1 + TAVE_{r,ct}/100)}\right) + \log(R) \tag{68}
\]

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 \textit{ad valorem} equivalent (in %)
- \(TAVE\) = export tax in \textit{ad valorem} equivalent (in %)

94. The \(\beta\) 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 in world markets and a closer link between world market and domestic prices. In the Cosimo sub module, 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 rather strong swings in trade quantities.

95. 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.
96. 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.

97. 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 the 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.

98. Export taxes (TAVE) are generally exogenous and only two exceptions exist, Argentine biodiesel and Russian molasses. Ad valorem equivalent import tariffs are calculated from specific and ad valorem tariffs.

\[
TAVI_{r,c,t} = TAV_{r,c,t} + 100 \frac{TSP_{r,c,t}}{IMP_{r,c,t}}
\]

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

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

\[
TAVI_{r,c,t} = TAVI^{IQS}_{r,c,t} + \frac{\exp\left\{\min\left[0,\frac{IM - TRQ}{TRQ}\right]\right\} \cdot \left(TAVI^{OQS}_{r,c,t} - TAVI^{IQS}_{r,c,t}\right)}{1 + \exp\left\{-\frac{\left|IM - TRQ\right|}{TRQ}\right\}}
\]

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
- \( \gamma \) = transition factor between in-quota and out of quota tariff

100. 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\(^{14}\). However, this relation only holds for the individual tariff lines. The relationship between 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 \( \gamma \)), in order to make the jump in tariffs less steep when imports increase. When the value of the transition factor \( \gamma \) increases the approximated function approaches the effective main tariff line. The choice of \( \gamma \) hence depends on the properties of the trade measures in place for the modelled (aggregated) commodity.\(^{15}\)

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\(^{14}\) 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.

\(^{15}\) The values for \( \gamma \) range between 0.1 and 200 with the majority around 100.
2.2.4 Stocks

101. 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.

\[
\log(S_{T,c,t}) = \alpha + \beta_1 \log(Q_{P,r,c,t} + S_{T,c,(t-1)}) + \beta_2 \log(Q_{C,r,c,t}) + \beta_3 \log(3^{P_{P,r,c,t}}) + \beta_4 TRD + \log(R) \tag{71}
\]

Where:
- \(ST = \) year-end stocks
- \(PP = \) producer price in domestic currency
- \(QP = \) production quantity
- \(QC = \) domestic disappearance
- \(TRD = \) trend

102. 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 3 – OUTLOOK PROCESS AND PARTIAL STOCHASTIC APPLICATION

103. Aglink-Cosimo is used annually to derive the OECD-FAO Agricultural Outlook which forms the basis of additional scenario work conducted. The partial stochastic use of Aglink-Cosimo has in recent years added to the analytical use.

3.1 The generation of the OECD-FAO Agricultural Outlook

104. The projections presented and analysed in the OECD-FAO Agricultural Outlook 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.

105. The starting point of the outlook process is the reply by OECD countries (and some non-member countries) to an annual questionnaire circulated in the fall. Through these questionnaires, the OECD Secretariat obtains information from these countries on future commodity market developments and on the evolution of their 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 is aimed at creating a first insight into possible market developments and at establishing the key assumptions which condition the outlook. The main economic and policy assumptions are summarised in the Overview chapter and in specific commodity tables of the published report.
Box 2: 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 consistency reasons, 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 Russia are consistent with those published in the latest OECD Economic Outlook. 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”.

As a next step, Aglink-Cosimo is used to facilitate a 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.  

The model provides a comprehensive dynamic economic and policy specific representation of the main temperate-zone commodities as well as rice, cotton and vegetable oils. The Aglink and Cosimo country and regional modules are all developed by the OECD and FAO Secretariats in conjunction with country experts and, in some cases, with assistance from 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 and issues arising 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 a circle of in-house and international experts. In this stage, the global projection picture emerges and refinements are made according to a consensus view of both Secretariats and external advisors. On the basis of these discussions and of 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

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16 The OECD Economic Outlook is available under [http://www.oecd.org/eco/economicoutlook.htm](http://www.oecd.org/eco/economicoutlook.htm)

17 For further details on particular series, enquiries should be directed to the OECD and FAO Secretariats.
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.

108. 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 that 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.

3.2 Partial stochastic use of Aglink-Cosimo

109. 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 behavior of the drivers is formalised and 1 000 sets of future alternative values for these drivers, based on their stochastic behavior, are generated.

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

110. These steps are explained in more detail below.

Step (1): Estimating variability based on historical data

111. 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. The coefficient of variation (CV) of the errors is given in Table 1.

Table 1. Macroeconomic variables treated as uncertain and the calculated CV of the one-year-ahead forecast errors (in %)

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

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

<table>
<thead>
<tr>
<th></th>
<th>EU</th>
<th>Eurasia</th>
<th>South America</th>
<th>North America</th>
<th>South East Asia</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E15 NMS KAZ UKR RUS</td>
<td>CAN MEX USA</td>
<td>IND MYS THA VNM</td>
<td>AUS CHN IND NZL</td>
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<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft</td>
<td>4.4</td>
<td>10.7</td>
<td>21.3 20.6 10.1</td>
<td>8.1 13.4 18.4 25.6</td>
<td>12.8 6.1 7.0</td>
<td>4.1 19.3 2.9 4.1</td>
</tr>
<tr>
<td>Durum</td>
<td>12.4</td>
<td>14.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse grains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Grains</td>
<td>12.2</td>
<td>15.3 12.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>4.9</td>
<td>9.2</td>
<td>16.3</td>
<td>11.5</td>
<td></td>
<td>19.4</td>
</tr>
<tr>
<td>Maize</td>
<td>5.6</td>
<td>19.5</td>
<td>8.3 9.0</td>
<td>9.2 2.1 5.9</td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td>Oats</td>
<td>5.4</td>
<td>10.0</td>
<td></td>
<td>9.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rye</td>
<td>9.5</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other cereals</td>
<td>6.0</td>
<td>8.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oilseeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rape</td>
<td>7.3</td>
<td>14.0</td>
<td>10.1</td>
<td></td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>9.4</td>
<td>22.9</td>
<td>12.3 7.7</td>
<td>16.3 6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>4.9</td>
<td>11.9</td>
<td>9.1</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>3.5</td>
<td></td>
<td>3.8</td>
<td>5.3 2.7 2.2</td>
<td>1.6 5.3</td>
<td></td>
</tr>
<tr>
<td>Palm oil</td>
<td></td>
<td></td>
<td></td>
<td>7.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>4.6</td>
<td>5.6</td>
<td>8.7</td>
<td>6.3</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td></td>
<td></td>
<td></td>
<td>9.0 2.8</td>
<td>6.1 6.7</td>
<td>10.3 9.1 6.7</td>
</tr>
<tr>
<td>Dairy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
<td></td>
<td>3.0 5.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The following abbreviations are used:

Sources: OECD and FAO Secretariats.

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 2015-2024. 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 EU), 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.

114. Then, R is run with these underlying assumptions and its output provides the final stochastic terms. A comparison of the two panels of Figure 1 illustrates the consequences of these two approaches to simulating the stochastic terms of macroeconomic and yield variables.

**Figure 1. Distribution of the multiplicative stochastic terms of Australian wheat (left figure) and Russian GDP (right figure) (2014-2023)**

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

115. 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.

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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Rate of Success (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop + milk yield uncertainty</td>
<td>97</td>
</tr>
<tr>
<td>Macroeconomic uncertainty</td>
<td>89</td>
</tr>
<tr>
<td>Macroeconomic + yield (crop &amp; milk) uncertainty</td>
<td>90</td>
</tr>
</tbody>
</table>

Source: OECD and FAO Secretariats.
ANNEX

ANNEX 1: list of commodities in Aglink-Cosimo

<table>
<thead>
<tr>
<th>CEREALS</th>
<th>SUGARS AND SWEETENERS</th>
<th>DAIRY PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Wheat</td>
<td>Milk</td>
</tr>
<tr>
<td>- Durum wheat</td>
<td>WTD</td>
<td>Other fat products</td>
</tr>
<tr>
<td>- Soft wheat</td>
<td>WTS</td>
<td>Other non-fat solid products</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>CG</td>
<td>Beer</td>
</tr>
<tr>
<td>- Barley</td>
<td>BA</td>
<td>Cow</td>
</tr>
<tr>
<td>- Maize</td>
<td>MA</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Oats</td>
<td>OT</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Sorghum</td>
<td>SO</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Rye</td>
<td>RY</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Millet</td>
<td>MT</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Other cereals</td>
<td>OC</td>
<td>Sheep</td>
</tr>
<tr>
<td>Rice</td>
<td>RI</td>
<td>Sheep</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OILSEEDS &amp; PRODUCTS</th>
<th>OTHER CROPS</th>
<th>ENERGY RELATED PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseeds</td>
<td>Cotton</td>
<td>Biofuels</td>
</tr>
<tr>
<td>- Soybean</td>
<td>Cotton seed</td>
<td>Ethanol</td>
</tr>
<tr>
<td>- Rapeseed</td>
<td>Roots and tubers</td>
<td>Biodiesel</td>
</tr>
<tr>
<td>- Sunflower seed</td>
<td>Beans</td>
<td>Crude oil</td>
</tr>
<tr>
<td>- Groundnuts</td>
<td>Field peas</td>
<td></td>
</tr>
<tr>
<td>Protein meals</td>
<td>Jatropha</td>
<td></td>
</tr>
<tr>
<td>- Palm kernel meal</td>
<td>CM</td>
<td></td>
</tr>
<tr>
<td>- Copra (coconut)</td>
<td>CSM</td>
<td></td>
</tr>
<tr>
<td>- Cotton seed meal</td>
<td>OM</td>
<td></td>
</tr>
<tr>
<td>- Oil meals</td>
<td>GM</td>
<td></td>
</tr>
<tr>
<td>-- Groundnut meal</td>
<td>SM</td>
<td></td>
</tr>
<tr>
<td>-- Soybean meal</td>
<td>RM</td>
<td></td>
</tr>
<tr>
<td>-- Rapeseed meal</td>
<td>SPM</td>
<td></td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>VL</td>
<td></td>
</tr>
<tr>
<td>- Palm oil</td>
<td>PL</td>
<td></td>
</tr>
<tr>
<td>- Palm kernel oil</td>
<td>KL</td>
<td></td>
</tr>
<tr>
<td>- Copra (coconut)</td>
<td>CL</td>
<td></td>
</tr>
<tr>
<td>- Cotton seed oil</td>
<td>CSL</td>
<td></td>
</tr>
<tr>
<td>- Oilseed oils</td>
<td>OL</td>
<td></td>
</tr>
<tr>
<td>-- Soybean oil</td>
<td>SL</td>
<td></td>
</tr>
<tr>
<td>-- Rapeseed oil</td>
<td>RL</td>
<td></td>
</tr>
<tr>
<td>-- Sunflower oil</td>
<td>SFL</td>
<td></td>
</tr>
<tr>
<td>-- Groundnut oil</td>
<td>GL</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANIMAL PRODUCTS</th>
<th>FEED PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef and Veal</td>
<td>Cereal brans</td>
</tr>
<tr>
<td>Pigmeat</td>
<td>Corn Gluten</td>
</tr>
<tr>
<td>Poultry meat</td>
<td>Feed</td>
</tr>
<tr>
<td>- Other poultry</td>
<td>CGB</td>
</tr>
<tr>
<td>- Chicken</td>
<td>CKB</td>
</tr>
<tr>
<td>-- Chicken white</td>
<td>CKB</td>
</tr>
<tr>
<td>Sheep meat</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Mutton</td>
<td>Sheep</td>
</tr>
<tr>
<td>- Lambs</td>
<td>Sheep</td>
</tr>
<tr>
<td>Wool</td>
<td>Sheep</td>
</tr>
<tr>
<td>Eggs</td>
<td>Eggs</td>
</tr>
<tr>
<td>Fish and Aquaculture</td>
<td>Fish</td>
</tr>
<tr>
<td>FEED PRODUCTS</td>
<td>CEB</td>
</tr>
<tr>
<td>Cereal brans</td>
<td>Corn Gluten</td>
</tr>
<tr>
<td>Dried distillers grains</td>
<td>DDD</td>
</tr>
<tr>
<td>Protein feed</td>
<td>Protein feed</td>
</tr>
<tr>
<td>Dried beet pulp</td>
<td>Protein feed</td>
</tr>
<tr>
<td>Manioc</td>
<td>Protein feed</td>
</tr>
<tr>
<td>Meat and bone meal</td>
<td>Protein feed</td>
</tr>
<tr>
<td>Fish meal</td>
<td>Protein feed</td>
</tr>
<tr>
<td>Fish oil</td>
<td>Protein feed</td>
</tr>
</tbody>
</table>

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ANNEX 2: world market clearing prices in Aglink-Cosimo

<table>
<thead>
<tr>
<th>Cereals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>No.2 hard red winter wheat, ordinary protein, United States f.o.b. Gulf Ports (June/May), less EEP payments where applicable.</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>No.2 yellow corn, United States f.o.b. Gulf Ports (September/August).</td>
</tr>
<tr>
<td>Rice</td>
<td>Milled, 100%, grade b, Nominal Price Quote, NPQ, f.o.b. Bangkok (January/December).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oilseeds</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseeds</td>
<td>Weighted average price of soybean, rapeseed and sunflower, European port.</td>
</tr>
<tr>
<td>Protein meals</td>
<td>Weighted average price of soybean, rapeseed and sunflower meal, European port.</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>Weighted average price of soybean, rapeseed, sunflower and palm oil, European port.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fiber crops</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Cotlook A index, Middling 1 3/32”, c.f.r. far Eastern ports (August/July)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feed products</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried distillers grains</td>
<td>Wholesale price, Central Illinois</td>
</tr>
<tr>
<td>Dried beet pulp</td>
<td>Beet pulp price, United States.</td>
</tr>
<tr>
<td>Cereal brans</td>
<td>Wheat middlings in Buffalo, NY</td>
</tr>
<tr>
<td>Meat and bone meal</td>
<td>Ruminant meat and bone meal, Central United States (R-T)</td>
</tr>
<tr>
<td>Corn Gluten Feed</td>
<td>Corn gluten feed, 21% protein, Midwest</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>Thailand, Bangkok, Cassava (flour), Wholesale</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sweeteners</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sugar</td>
<td>Raw sugar world price, ICE contract No11 nearby, October/September.</td>
</tr>
<tr>
<td>High fructose corn syrup</td>
<td>United States wholesale list price HFCS-55, October/September.</td>
</tr>
<tr>
<td>Molasses</td>
<td>Unit import price, Europe, October/September</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Dairy products</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>F.o.b. export price, butter, 82% butterfat, Oceania.</td>
</tr>
<tr>
<td>Cheese</td>
<td>F.o.b. export price, cheddar cheese, 39% moisture, Oceania.</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>F.o.b. export price, non-fat dry milk, 1.25% butterfat, Oceania.</td>
</tr>
<tr>
<td>Whole milk powder</td>
<td>F.o.b. export price, WMP 26% butterfat, Oceania.</td>
</tr>
<tr>
<td>Whey powder</td>
<td>Dry whey, West region, United States.</td>
</tr>
<tr>
<td>Casein</td>
<td>Export price, New Zealand.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biofuels</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>Wholesale price, United States, Omaha.</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Producer price Germany net of biodiesel tariff and energy tax.</td>
</tr>
</tbody>
</table>
## ANNEX 3: list of regions

### Countries in Aglink

#### OECD countries

- **Australia**: AUS
- **Canada**: CAN
- **Switzerland**: CHE
- **Japan**: JPN
- **South-Korea**: KOR
- **Mexico**: MEX
- **Norway**: NOR
- **New Zealand**: NZL
- **United States of America**: USA

#### OECD country aggregates

- **European Union**: EUN
  - 15 older Member States: E15
  - new Member States after 2004: NMS

#### Non-OECD countries

- **Argentina**: ARG
- **Brazil**: BRA
- **China**: CHN
- **Russian Federation**: RUS

### Countries in Cosimo

#### OECD countries

- **Chile**: CHL
- **Israel**: ISR
- **Turkey**: TUR

#### Non-OECD countries

- **Bangladesh**: BGD
- **Colombia**: COL

#### Cosimo aggregates

- LDC Oceania: OCL
- Other Oceania: OCE
- Other South America and Caribbean: SAC
- LDC Subsaharan Africa: AFL
- Other Subsaharan 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
ANNEX 4: 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 vis-à-vis USD
ANNEX 5: equation-viewer

117. If you are interested to single equations the easiest reference is the equation-viewer which is available in the collaborators section of the www.agri-outlook.org website. The main aim is to allow model user to check equations and to understand the linkages between variables and parameters. It is updated with the model used to construct the latest OECD-FAO Agricultural Outlook. The equation-viewer is based on Microsoft Excel and uses visual basic commands.

118. The equation-viewer contains four sections as can be seen from the figure. On the right hand side are three sections and on the left hand side one. The uppermost section on the right hand side contains the legend for the colour code used for the variables and parameters displayed. This section also contains the selection of language, 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 either enter either the description or the Aglink-Cosimo code. Matching options will then be displayed below; you select one of these options by clicking. With the filters you can select which of the three dimensions should be fixed. In addition it can be selected where in the equation, label, left hand side or right hand side the search should be conducted.

119. The left hand side contains a table with the list of equations which match your search criteria. The first column contains the label of the equation. The second column shows the equation itself. The variables are coloured according the legend. Coefficients and parameters are presented in value terms and when the equation contains a residual this is only shown as a text. The description of the variable is given when you hover your mouse over the variable. It contains the variable name, variable type, the description, the average value in the reference period and the value in the final year of the projection. On clicking 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 down and up 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 2. Screenshot of the equation-viewer