Methodology

This section provides information on the methodological aspects of the generation of the present *Agricultural Outlook*. It discusses the main aspects in the following order: First, a general description of the agricultural baseline projections and the *Outlook* report is given. Second, the compilation of a consistent set of the assumptions on macroeconomic projections is discussed in more detail. A third part presents how production costs are taken into account in the model's supply equations. Then the fourth part presents the methodology developed for the stochastic analysis conducted with the AGLINK-COSIMO model.

The generation of the OECD-FAO *Agricultural Outlook*

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

The starting point of the outlook process is the response by OECD countries (and some non-member countries) to an annual questionnaire circulated at mid-year. 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 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 present report. The sources and assumptions for those assumptions are discussed in more detail further below.

As a next step, the modelling framework jointly developed by the OECD and FAO Secretariats 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. Unless otherwise stated, prices referred to in the text are also in nominal terms. The data series for the projections is drawn from

OECD and FAO databases. For the most part information in these databases has been taken from national statistical sources. For further details on particular series, enquiries should be directed to the OECD and FAO Secretariats.

The model provides a comprehensive dynamic economic and policy specific representation of major world producing and trading countries for the main temperate-zone commodities as well as rice 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. The initial projections for individual country and regional modules developed by the FAO Secretariat are reviewed by a wider 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, meats, dairy products and sugar 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 2012, prior to publication. In addition, the *Outlook* will be used as a basis for analysis presented to the FAO's *Committee on Commodity Problems* and its various *Intergovernmental Commodity Groups*.

The Outlook process implies that the baseline projections presented in this report are a combination of projections developed by collaborators for countries under the OECD Secretariat's responsibility and original projections for the 42 countries and regions under the FAO Secretariat's responsibility. The use of a formal modelling framework reconciles inconsistencies between individual country projections and forms 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.

Sources and assumptions for the macroeconomic projections

Population estimates from the 2010 Revision of the *United Nations Population Prospects Database* provide the population data used for all countries and regional aggregates in the *Outlook*. For the projection period, the medium variant set of estimates was selected for use from the four alternative projection variants (low, medium, high and constant fertility). The *UN Population Prospects Database* was chosen because it represents a comprehensive source of reliable estimates which includes data for non-OECD developing countries. For consistency reasons, the same source is used for both the historical population estimates and the projection data.

The other macroeconomic series used in the AGLINK-COSIMO model are real GDP, the GDP deflator, the private consumption expenditure (PCE) deflator, the Brent crude oil price (in US dollars per barrel) and exchange rates expressed as the local currency value of

USD 1. Historical data for these series in OECD countries (except Turkey, Chile and Israel) as well as Brazil, Argentina, China and the Russian Federation are consistent with those published in the *OECD Economic Outlook* No. 90, December 2011 and No. 89. For other economies, historical macroeconomic data were obtained from the IMF, *World Economic Outlook*, September 2011. Assumptions for 2012-2021 are based on the recent medium term macroeconomic projections of the OECD Economics Department, projections of the *OECD Economic Outlook No. 89* and projections of the IMF.

The model uses indices for real GDP, consumer prices (PCE deflator) and producer prices (GDP deflator) which are constructed with the base year 2005 value being equal to 1. The assumption of constant real exchange rates implies that a country with higher (lower)inflation relative to the United States (as measured by the US GDP deflator) will have a depreciating (appreciating) currency and therefore an increasing (decreasing) exchange rate over the projection period, since the exchange rate is measured as the local currency value of 1 USD. The calculation of the nominal exchange rate uses the percentage growth of the ratio "country-GDP deflator/US GDP deflator".

The oil price used to generate the *Outlook* is based on information from the *OECD Economic Outlook No. 90* until 2012 (short term update) and the growth rate of the *OECD Economic Outlook No. 89* for future paths.

The representation of production costs in AGLINK-COSIMO

Changes in production costs are an important variable for farmers' decisions on 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. Consequently, equations for harvested areas in crop production and for livestock production quantities take the following general forms:

$$AH = f\left(\frac{RH}{CPCI}\right);\ QP = f\left(\frac{PP}{CPCI}\right)$$

with:

AH	area harvested (crop production)
RH	returns per hectare (crop production)
CPCI	commodity production cost index
QP	production quantity (livestock production)
PP	producer price (livestock production)

Among others, energy prices, increased by rising crude oil prices, have fostered attention to agricultural production costs in agricultural commodity models. Energy prices can significantly impact on 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 indices employed in AGLINK-COSIMO for *livestock products* is constructed from three sub-indices representing non-tradable inputs, energy inputs, and other tradable inputs, respectively. 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. This relationship is shown in the following equation:

$$\begin{aligned} CPCI_{r,t} = {} & CPCS^{NT}_{r,t} * GDPD_{r,t} / GDPD_{r,bas} \\ & + CPCS^{EN}_{r,t} * \left(XP^{OIL}_{t} * XR_{r,t}\right) / \left(XP^{OIL}_{bas} * XR_{r,bas}\right) \\ & + \left(1 - CPCS^{NT,I}_{r,t} - CPCS^{EN,I}_{r,t}\right) * \left(XR_{r,t} * GDPD_{USA,t}\right) / \left(XR_{r,bas} * GDPD_{USA,bas}\right) \end{aligned}$$

with:

CPCI	commodity production cost index for livestock
$CPCS^{NT}$	share of non-tradable input in total base commodity production costs
$CPCS^{EN}$	share of energy in total base commodity production costs
GDPD	deflator for the gross domestic product
XP^{OIL}	world crude oil price
XR	nominal exchange rate with respect to the US Dollar
r,t	region and time index, respectively
bas	base year (2000 or 2005 or 2008) value

The production cost index is different for each *crop products* and is constructed from five sub-indices representing seeds inputs, fertiliser inputs, energy inputs, other tradable inputs and non-tradable inputs, respectively.

$$\begin{aligned} CPCI^{c}_{r,t} = {} & CPCS^{NT}_{r,t} * GDPD_{r,t} / GDPD_{r,bas} \\ & + CPCS^{EN}_{r,t} * \left(XP^{OIL}_{t} * XR_{r,t}\right) / \left(XP^{OIL}_{bas} * XR_{r,bas}\right) \\ & + CPCS^{FT}_{r,t} * \left(XP^{FT}_{t} * XR_{r,t}\right) / \left(XP^{FT}_{bas} * XR_{r,bas}\right) \\ & + CPCS^{TR}_{r,t} * \left(XR_{r,t} * GDPD_{USA,t}\right) / \left(XR_{r,bas} * GDPD_{USA,bas}\right) \\ & + CPCS^{SD}_{r,t} * PP^{c}_{r,t}(-1) / PP^{c}_{r,bas} \end{aligned}$$

with:

$CPCI^{C}$	commodity production cost index for crop product c
$CPCS^{NT}$	share of non-tradable input in total base commodity production costs
$CPCS^{EN}$	share of energy in total base commodity production costs
$CPCS^{FT}$	share of fertiliser in total base commodity production costs
$CPCS^{TR}$	share of other tradable input in total base commodity production costs
$CPCS^{SD}$	share of seeds input in total base commodity production costs
GDPD	deflator for the gross domestic product
XP^{OIL}	world crude oil price
XP^{FT}	world fertiliser price
PP^{c}	producer price for crop product c

XR nominal exchange rate with respect to the US Dollar

c Crop product

r,t region and time index, respectively

bas base year (2000 or 2005 or 2008) value

The shares of the various cost categories are country specific. They were estimated based on historic cost structures in individual counties. 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 Fertilizer price is constructed by FAO fertiliser analysts as following:

XP^{FT} = 0.2*DAP + 0.16*MOP + 0.02*TSP + 0.62*Urea

With:

US Diammonium Phosphate (DAP)

Can Potassium Chloride (MOP)

Triple superphosphate (TSP)

Urea (Black Sea)

And is represented by an equation in the AGLINK-COSIMO model:

$$\log(XP_t^{FT}) = CON + elas_{FT}^{OIL} * \log(XP_t^{OIL}) + elas_{FT}^{crop} * \log(0.5 * XP_{t-1}^{CG} + 0.2 * XP_{t-1}^{WT} + 0.2 * XP_{t-1}^{OS} + 0.1 * XP_{t-1}^{RI})$$

With:

XP^{OIL} world crude oil price

XP^{FT} world fertiliser price

XP^{CG} world coarse grain price

XP^{WT} world wheat price

XP^{OS} world oilseed price

XP^{RI} world rice price

The methodology of stochastic simulations with AGLINK-COSIMO

The AGLINK-COSIMO model is a forward-looking medium term economic model which is used to perform simulations over a 10-year horizon. It is necessary to feed into the model a set of assumptions for exogenous variables. While a single set of assumptions is used for deterministic baseline, multiple sets of exogenous variables generated by random samplings, are fed into the model for stochastic experiments. The model is simulated for each set of assumptions and, thus, multiple sets of solutions are obtained. Implications of uncertainties for the baseline projections can be inferred from statistical information of the random outputs of the simulations.

Recently, analyses using the AGLINK-COSIMO stochastic model have been undertaken with an emphasis on risk and uncertainties in terms of price volatility (OECD, 2011, OECD, 2012). The methodology used in the present Outlook was developed and improved in the course of these works. The exogenous assumptions that are challenged in the stochastic framework relate to yields and macroeconomic variables. The methodology to obtain stochastic assumptions is detailed below.

Yields

Yields of coarse grains, rice and wheat for the modelled countries are made stochastic. Countries are sorted into eleven regional groups (Africa, East Asia, Europe, etc.) and the detrended yields in a region are assumed to follow multivariate normal distribution. Variance covariance matrices of the distributions, which reflect the magnitude of production shocks and the tendencies of crops in a region to be affected by a common risk factor, are calculated over historical data. Random samplings from the estimated distributions replicate the historically observed variation in yield projections.

Crude oil, fertiliser prices and macroeconomic variables

Crude oil prices are simulated using a truncated normal distribution that has been calibrated on past historical trends. The international fertiliser price is modeled as a function of the crude oil price calibrated on historical data. A simple macroeconomic model of GDP changes and consumer price index for leading economies (Brazil, China, European Union, India, Japan, the Russian Federation and the United States) was also developed and calibrated over historical data. The crude oil price being one of the variables of this simple model, random draws for macroeconomic variables are obtained by solving this macroeconomic model on random draws for the crude oil price.