

Brief Description of an Agricultural Sector Model

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Country Agricultural Simulation Model (*Cou*-ASIM)
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Synopsis

Base year	free
Type of model	<ul style="list-style-type: none"> – static, partial equilibrium – for agriculture and food industry – for comparative static policy analysis – constant elasticity model
Year of policy comparison	free, but preferable in the medium range
Geographic aggregation	<i>Cou</i> country
Agricultural output aggregation	13 products and product aggregates (wheat, coarse grains, potatoes, oilseeds, sugar, vegetables, milk, beef, pork, eggs, poultry, mutton, rest of agriculture)
Agricultural input aggregation	5 inputs (wheat for feed, coarse grains for feed, potatoes for feed, rest of variable inputs, labor)
Principal endogenous variables	<p>Base year:</p> <ul style="list-style-type: none"> – calibrated elasticities for supply and demand – constant factors in the supply and demand functions <p>Year of comparison:</p> <ul style="list-style-type: none"> – quantities supplied and demanded – net exports – budget expenditures – producer and consumer surplus
Principal exogenous variables	<ul style="list-style-type: none"> – price elasticities of supply and price and income elasticities of demand; all for medium-term response – world market prices – subsidies paid to agriculture, broken down by commodity and into direct payments, input and general subsidies – food expenditure – population – development of world market prices – development of technical progress
Elasticities	– synthetic
Primary assumptions	<ul style="list-style-type: none"> – exogenous variables as described above – development of food expenditure, population growth – elasticities
Policy variables	<ul style="list-style-type: none"> – border protection as tariff factors – domestic support to agriculture – retail food prices
Principal statistical sources	<ul style="list-style-type: none"> – various national statistical yearbooks – technical information

1 Supply module

1.1 Supply function

$$Q_i^s = \alpha_i^*(t) \prod_{j=1}^n (p_j^i)^{\mathcal{E}_{ij}}$$

$$\alpha_i^*(t) = \alpha_i * f(t)$$

$f(t)$ = technical progress

The following relation is used in the model

$$f(t) = (1 + r_i^s)^{(t-1994)}$$

with

r_i^s = annual rate of technical progress for production of good i

Q_i^s = amount of supply or input use of good i

p_j^i = incentive price of good j

\mathcal{E}_{ij} = own price elasticity of good i to price i: if $i = j$
cross price elasticity of good i to price j: if $i \neq j$

α_i = constant term of good i

i = an index of outputs and inputs

s = superscript s refers to supply side

Π = multiplication operator

n = number of goods

t = the year for which the simulation is carried out.

1.2 Incentive price

$$\begin{aligned}
 p_i^i &= FGP_i + mul_i^D * PSE - D_i \\
 &+ mul_i^I * PSE - I_i \\
 &+ mul_i^G * PSE - G_i
 \end{aligned}$$

FGP_i = farm gate price of commodity i
 $PSE - D_i$ = direct payments per unit of output i
 $PSE - I_i$ = subsidies per unit of input i
 $PSE - G_i$ = general subsidies per unit of good i

$$mul_i^J = \left\{ \begin{array}{ll} J = D & \text{Direct multiplier} \\ J = I & \text{Input multiplier} \\ J = G & \text{General multiplier} \end{array} \right\}$$

$mul_i^D = 0.0$ (currently no direct subsidies are paid)

$mul_i^I = 0.0$ (these types of subsidies have not been separated from the general subsidies)

$mul_i^G = 0.6$

i, the index over outputs and inputs contains the following items

outputs: wheat
 coarse grains
 potatoes
 oilseeds
 sugar
 vegetables
 milk
 beef
 pork
 poultry
 mutton
 eggs
 rest of agriculture
 inputs: feed wheat
 feed coarse grains
 feed potatoes
 rest of variable inputs

labor

Rest of agriculture is calculated as the value of total agricultural output minus the one of those agricultural commodities explicitly considered in the model. This difference is used as quantity (in 1994 billion rubles), and the price is set accordingly; i.e. in this case to unity.

1.3 Calculation of feed use

Feed use depends on two sets of factors; on relative prices of feed item and on livestock production. The way both influences feed use is described in this sub-section:

- i) Aggregate animal indexes, called feed livestock units (FLU), are calculated to reflect the change in feed use due to the level of livestock production. For this purpose, the indexes reflect the weighed sum of production of all animal types with the weights representing the relative demand of each animal category on the specific feed item. Two such indexes are calculated; one for 'grains' which is used for determining feed demand of wheat and coarse grains and the other one for 'vegetable' which is used for determining the other feed stuff; in this model potatoes.
- ii) use of each feed stuff per unit of aggregate livestock; i.e. per FLU will be determined according to substitution possibilities among the various feed stuffs based on relative prices of the feed items. in the second phase, total feed consumption is determined by multiplying each individual feed stuff - as determined in step a) - by the aggregate animal index.
- iii) After the quantity of each feed item used per feed livestock unit is arrived at, the total use of each feed item is calculated as the product of feed use per feed livestock unit times the number of feed livestock units.

on i)

The aggregate animal indexes, FLU are determined as follows.

$$FLU_k = \left(\sum_i weil_i * Q_{i,94}^s \right) / LIVSUM$$

$$LIVSUM = \sum_i Q_{i,94}^s$$

with $weil_{ik}$ = weighing factor for animal type i and feed stuff k

$Q_{i,94}^s$ = production of animal type i in the base year (1994)

FLU_k = feed livestock unit for feed types k

i = index of animal type

k = index of the feed type (grains, vegetable)

It is to be noted that LIVSUM is used only for scaling purposes to let FLU not deviate too much from unity, otherwise, scaling of the values might be a problem for numerical reasons.

In the next step, feed use per FLU, q_{ik}^s , is calculated

$$q_{i_k}^s = Q_{i_k}^s / FLU_k$$

with k = index of the feed type (grains and vegetable)

if k = grains then we are dealing with feed wheat and feed coarse grains

if k = vegetable then we are dealing with feed potatoes

On iii)

The final step consists of multiplying feed use per FLU by the aggregate index in scenario runs to obtain total feed use, i.e.

$$FLU_{k,sc} = \left(\sum_i weil_i * Q_{i_k,sc}^s \right) / LIVSUM$$

$$Q_{i_k,sc}^s = q_{i_k,sc}^s * FLU_{k,sc}$$

with

$q_{i_k}^s$ = use of feed item i belonging to feed group k in scenario sc per unit of FLU k

sc = an index for scenarios which are used for policy analysis

i_k = an index referring to feed item i of subgroup k

2 Demand module

$$q_i^D = \beta_i^*(t) * \prod_j^m (p_j^D)^{\eta_{ij}} * I^{\eta_{il}}$$

$$\beta_i^*(t) = \beta_i * g(t)$$

$g(t)$ = a function of habit change

$$g(t) = (1 + r_i^D)^{(t-1994)}$$

with

r_i^D = annual rate of habit change for demand of good i

q_i^D = per-caput human consumption of good i

p_i^D = retail price of good i

β_i = constant term of good i

I = income per caput

η_{ij} = elasticity of demand of good i with respect to price j

(if $i = j$ own price elasticity
if $i \neq j$ cross price elasticity)

η_{il} = income elasticity of good i

i = an index of goods consumed

D= superscript D refers to demand side

Π = multiplication operator

m = number of goods included at the demand side

Total consumption is calculated as per-caput consumption times population, i.e.

$$Q_i^D = q_i^D * POPUL$$

with

Q_i^D = total consumption of good i

POPUL = population

i = index of consumption goods

wheat
 c. grains
 potatoes
 oilseeds
 sugar
 vegetables
 milk
 beef
 pork
 poultry
 mutton
 eggs
 rosp = rest of spending

Rest of spending on food by the entire population (ROSP) is defined as expenditures for all those food items not explicitly considered.

It is calculated as follows:

$$\text{ROSP} = \text{total income times share of expenditure for food} \\ - \text{spending of explicitly considered food items.}$$

Rest of spending per caput (rosp) is derived at by dividing ROSP by the population.

Total expenditures on consumption of good i =

retail value of good i including processing value of that good
 where

$$\text{retail value of good } i = P_i^D * Q_i^D$$

Rest of spending includes other food items like fruits, spices as well as some animal products like meat of goats etc.

3 Net export

Net export of good i is given as follows:

$$NE_i = Q_i^s - Q_i^D \text{ for all food items which do not include feed}$$

$$NE_i = Q_i^s - Q_i^D - FEED_i \text{ where feed stands for the quantity of feed used of this commodity}$$

(this is the case for wheat, coarse grains and potatoes)

4 Budgetary outlays and welfare calculation

Budgetary outlays are calculated by using net exports and multiplying them with the difference between world market price and adjusted domestic price.

The last calculation the model performs concerns consumer and producer surplus. The surplus is always calculated as difference between an alternative scenario and the base scenario. Some approximating method is used for calculating the change of the triangles below the demand and above the supply curve. This is necessary because usually more than one price is changed between an alternative scenario and the base scenario.

5 Some theoretical considerations

5.1 On production

i) Homogeneity condition

Homogeneity is imposed as to make the

$$\sum_j e_{ij} = 0 \quad \text{for any } i$$

The economic interpretation of this condition is

- a) only relative prices matter,
- b) if all prices change by the same percentage, output and input quantities will not change,
- c) no money illusion exists.

ii) Symmetry condition

- a) For effects of changes in an output price on an output quantity or an input price on an input quantity

$$\frac{\partial Q_i^s}{\partial p_j^i} = \frac{\partial Q_j^s}{\partial p_i^i}$$

- b) For effects of changes in an output price on an input quantity or an input price on an output quantity

$$\frac{\partial Q_i^s}{\partial p_j^i} = - \frac{\partial Q_j^s}{\partial p_i^i}$$

The symmetry condition leads to the following relations:

Given the definition of an elasticity as

$$\varepsilon_{ij} = \frac{\partial Q_i^s}{\partial p_j^i} \frac{p_j^i}{Q_i^s} = \frac{\frac{\partial Q_i^s}{Q_i^s}}{\frac{\partial p_j^i}{p_j^i}}$$

and

$$\varepsilon_{ji} = \frac{\partial Q_j^s}{\partial p_i^i} \frac{p_i^i}{Q_j^s}$$

or rearranging

$$\frac{\partial Q_j^s}{\partial p_i^i} = \varepsilon_{ji} \frac{Q_j^s}{p_i^i}$$

Substituting the last expression into the symmetry condition (for output-output or input-input) yields

$$\frac{\partial Q_i^s}{\partial p_j^i} = \varepsilon_{ji} \frac{Q_j^s}{p_i^i}$$

and multiplying both sides by

$$\frac{p_j^i}{Q_i^s}$$

results in

$$\frac{\partial Q_i^s}{\partial p_j^i} \frac{p_j^i}{Q_i^s} = \varepsilon_{ji} \left(\frac{Q_j^s * p_j^i}{p_i^i * Q_i^s} \right)$$

or

$$\varepsilon_{ij} = \varepsilon_{ji} \left(\frac{Q_j^s * p_j^i}{Q_i^s * p_i^i} \right)$$

In the case of an output-input or input-output relation the minus sign has to be included into the symmetry condition;

$$\varepsilon_{ij} = - \varepsilon_{ji} \left(\frac{Q_j^s * p_j^i}{Q_i^s * p_i^i} \right)$$

5.2 On demand

i) Homogeneity condition

$$\sum_{j=1} \eta_{ij} + \eta_{ii} = 0 \quad \text{for all } i$$

ii) Symmetry condition

$$\frac{\partial Q_i^D}{\partial p_j^D} = \frac{\partial Q_j^D}{\partial p_i^D}$$

This condition holds only for prices.

6 Running the model

6.1 The initial data base

A) The following data of the **base year** are to be put into the Excel-File “*Cou-i.xls*”¹:

- a) as information on quantities
 - supply and input use; in Table Q(P,M) of the Excel-File “*Cou-i.xls*”
 - quantities of demand; in Table Q(P,M) of the Excel-File “*Cou-i.xls*”
- b) as information on prices
 - farm gate prices for outputs and inputs; in Table FGP(P) of the Excel-File “*Cou-i.xls*”
 - world market prices; in Table PW(P) of the Excel-File “*Cou-i.xls*”
 - retail prices; in Table PD(P) of the Excel-File “*Cou-i.xls*”
- c) as information on policies
 - subsidies paid to agriculture, by output and input, broken down according to PSE-calculations; in Table PSE0(P,SUB) of the Excel-File “*Cou-i.xls*”
- d) as general information
 - income level; in Table PD(P) of the Excel-File “*Cou-i.xls*”
 - population; in Table Population of the Excel-File “*Cou-i.xls*”
 - initial price elasticities of supply; in Table ES0(P,PP) of the Excel-File “*Cou-i.xls*”
 - initial price and income elasticities of demand; in Table ED0(D,DD) of the Excel-File “*Cou-i.xls*”
 - weights for calibrating price elasticities of supply; in Table WEIS(P,PP) of the Excel-File “*Cou-w.xls*”
 - weights for calibrating price and income elasticities of demand; in Table WEID(D,DD) of the Excel- File “*Cou-w.xls*”
 - weights for calculating feed livestock units; in Table WEIL(LI,U) of the Excel- File “*Cou-w.xls*”
- e) some information is calculated internally by the model for the base year
 - incentive prices; not printed
 - calibrated elasticities used for the simulation runs of supply; in Table ES1(P,PP) of the Excel-File “*Cou-int.xls*”, except the row sum of these elasticities which has to be calculated with the Excel program each time again
 - calibrated elasticities used for the simulation runs of demand; in Table ED1(D,DD) of the Excel-File “*Cou-int.xls*”, except the row sum of these elasticities which has to be calculated with the Excel program each time again

B) Any **simulation of a year later than 1994** requires information of the following kind

¹ The abbreviation “CIS” stands for any country and should be replaced by an appropriate abbreviation of the country for which data are gathered in the file.

- the ‘target’ year for which the simulation is to be done as difference between the ‘target’ year and 1994; in Table DUMMY of the Excel-File “*Cou*-i.xls”
 - the exchange rate; in Table DUMMY(DUM) of the Excel-File “*Cou*-i.xls”
 - annual growth rates of world market prices; in Table PWCH(PI) of the Excel-File “*Cou*-i.xls”
 - annual growth rate of population; in Table GR(RATE) of the Excel-File “*Cou*-i.xls”
 - annual growth rate of food expenditure; in Table GR(RATE) of the Excel-File “*Cou*-i.xls”
 - annual rates of autonomous technical progress of agricultural outputs; used in the function $f(t)$; in Table GRTC(P) of the Excel-File “*Cou*-i.xls”
 - annual rates of technical progress of agricultural inputs (improvements in efficiency); used in the function $f(t)$; in Table GRTC(P) of the Excel-File “*Cou*-i.xls”
 - annual rates of habit changes in human consumption; used in the function $g(t)$; in Table GRHC(D) of the Excel-File “*Cou*-i.xls”
- C) The specification of **alternative policies** is also to be provided in the Excel-File “*Cou*-i.xls”; these are optional data depending on the policy scenario chosen:
- subsidies paid to agriculture, by output and input, broken down according to PSE-calculations; in Table PSE05(P,SC,SUB) of the Excel-File “*Cou*-i.xls” (this table may be used for specifying several scenario runs)
 - alternative assumptions on nominal assistance coefficients; in Table NAC(P) of the Excel-File “*Cou*-i.xls”
 - alternative assumptions on autonomous technical progress; in Table GRTC(P) of the Excel-File “*Cou*-i.xls”
 - alternative assumptions on habit changes; in Table GRHC(D) of the Excel-File “*Cou*-i.xls”
- D) The results of **alternative policies** are written into the Excel-File “*Cou*-o.xls”;
- a) as information on quantities
 - supply and input use; in Table Q05S(P,SC) of the Excel-File “*Cou*-o.xls”
 - quantities of demand; in Table Q05D(P,SC) of the Excel-File “*Cou*-o.xls”
 - quantities of net exports; in Table NX(PI,SC) of the Excel-File “*Cou*-o.xls”
 - b) as information on prices
 - incentive prices for outputs and inputs; in Table P05S(P,SC) of the Excel-File “*Cou*-o.xls”
 - retail prices; in Table P05D(P,SC) of the Excel-File “*Cou*-o.xls”
 - world market prices; in Table PW(P) of the Excel-File “*Cou*-o.xls”
 - c) as information on budget outlays
 - budget expenditure; in Table BUD(P,SC) of the Excel-File “*Cou*-o.xls”
 - d) as information on welfare **changes to base run**
 - welfare changes of producers; in Table WS(S,SC) of the Excel-File “*Cou*-o.xls”
 - welfare changes of consumers; in Table WD(D,SC) of the Excel-File “*Cou*-o.xls”

6.2 Calibration of elasticities

A) Calibrating supply elasticities

The following steps are involved in the calibration process of supply elasticities:

- 1) Initial elasticities, \mathcal{E}_{ij}^0 , are to be specified in the Excel-File “*Cou*-i.xls”; but only for $j \geq i$;

In the case $i = 1, 2, 3$ this means

$$\begin{bmatrix} \mathcal{E}_{11}^0 & \mathcal{E}_{12}^0 & \mathcal{E}_{13}^0 \\ 0 & \mathcal{E}_{22}^0 & \mathcal{E}_{23}^0 \\ 0 & 0 & \mathcal{E}_{33}^0 \end{bmatrix}$$

- 2) the calibration of supply elasticities is carried out in the model as follows:

- a) based on the symmetry condition the lower triangle of the initial supply elasticities, \mathcal{E}_{ij}^0 , is determined
- b) the elasticities used in the simulation, \mathcal{E}_{ij}^1 , are calibrated based on the following algorithm

$$\underset{\mathcal{E}_{ij}^1}{\text{MIN}} \quad \sum_i \sum_j \frac{(\mathcal{E}_{ij}^1 - \mathcal{E}_{ij}^0)^2}{\omega_{ij}}$$

subject to the homogeneity conditions and
the symmetry conditions

with

ω_{ij} = weight to be placed on the fit of elasticity \mathcal{E}_{ij}^1 with the one initially set, \mathcal{E}_{ij}^0

- 3) The constant term in each supply equation, α_i is calibrated given the data of the base year (e.g. 1994)

$$\alpha_i = \frac{Q_{it}^s}{\prod_{j=1}^i (p_{jt}^i)^{\mathcal{E}_{ij}}} \quad \text{with } t = \text{base year (1994)}$$

$f(t)$ is set to unity in the base year, 1994

B) Calibrating demand elasticities

Calibration of demand elasticities is based on the same steps as that for supply elasticities. Based on a set of initial elasticities a new set of elasticities is calibrated by minimizing the weighed squared deviations of the two sets of elasticities and subject to the homogeneity and symmetry conditions.

The constant term in each demand equation is calibrated according to the following equation:

$$\beta_i = \frac{Q_{it}^D}{\prod_{j=1} (P_{jt}^D)^{\eta_{ij}} * I^{\eta_{ii}}} \quad \text{with } t = \text{base year (1994)}$$

$g(t)$ is set to unity in the base year, 1994

6.3 Running the model for some year in the future, say 2005

1) **Determining the incentive price, p_{it}^i**

a) for the base scenario

The incentive price for the year 2005 is called PØ5S_i in the model. It is determined by the following steps:

Set the difference between farm gate price and world market price; i.e. the level of (absolute) border protection as

$$\Delta p_{i,1994} = FGP_{i,1994} - PW_{i,1994}$$

with

$FGP_{i,1994}$ = farm gate price of commodity i in 1994

$PW_{i,1994}$ = world market price of good i in 1994

and set the difference between the ‘target’ year for simulation and the base year as

$dt = 2005 - 1994$

The incentive price for the target year; in this case 2005, is arrived at according to the specification given below. It is to be noticed that this calculation assumes that the absolute difference between world market price and farm gate price also holds for the “base scenario”;

$$P05S_i = (PW_{i,1994}) \left(1 + PWCH_i\right)^{dt} + \Delta P_{i,1994}$$

$$+ mul_i^D * PSE-D_i$$

$$+ mul_i^I * PSE-I_i$$

$$+ mul_i^G * PSE-G_i$$

with

$PWCH_i$ = annual rate of change of world market price of good i

b) for any specific scenario

For any policy scenario except the base scenario farmers' incentive price is calculated according to the following specification which includes a tariff rate

$$P05S_{i,sc} = (PW_{i,1994}) \left(1 + PWCH_i \right) dt$$

$$+ PW_{i,1994} * (NAC_{i,1994} - 1)$$

$$- \left(p_{i,1994}^D - FGP_{i,1994} \right)$$

$$+ mul_i^D * PSE-D_{i,sc}$$

$$+ mul_i^I * PSE-I_{i,sc}$$

$$+ mul_i^G * PSE-G_{i,sc}$$

with

$NAC_{i,sc}$ = nominal assistance coefficient (to be interpreted as tariff factor) of commodity i for scenario sc

sc = an index over scenarios which are used for policy analysis

2) **Determining the retail price**

a) for the base scenario

The retail price for the year 2005 is called $P05D_i$ in the model. It is determined by the following relation:

$$P05D_i = (PW_{i,1994}) \left(1 + PWCH_i \right) dt$$

$$- PW_{i,1994} + p_{i,1994}^D$$

b) for any specific scenario

$$P05D_{i,sc} = (PW_{i,1994}) \left(1 + PWCH_i \right)^{dt}$$
$$+ PW_{i,1994} * (NAC_{i,sc} - 1)$$