Unité de recherche en prospective et politique agricole
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Prototype of multilevel analysis tool

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Résumé

Cette article présente un outil d'aideà la décision en matière de politique agricole. Il s'agit d'un modèle mathématique de simulation des comportements des agents économiques dont la principale originalité réside dans la prise en compte, dans un même cadre, de trois niveaux d'analyse : micro, méso et macro-économique.

Le modèle que nous présentons correspond à une maquette réalisée pour l'analyse des politiques concernant la production et de la transformation du soja en Indonésie. En effet, plusieurs organismes internationaux insistent sur la nécessité de libéraliser le marché indonésien du soja dont la production interne est très subventionnée. En effet, d'après la théorie économique, la libéralisation des importations diminuerait les distorsions du marché, et améliorerait l'efficacité des processus de transformation, avec des effets positifs sur l'emploi et sur l'économie en général.

Cependant,ce type de mesure est généralement accompagné d'externalités dont les effets peuvent être importants : les producteurs agricoles, les paysans sans terre, les transformateurs, les habitants des villes verront leur situation modifiée suite à une liberalisation, les liaisons entre régions, les migrations peuvent être affectées. La modélisation du comportement des acteurs permet l'évaluation des conséquences d'une modification des politiques sur chaque type d'agents comme au niveau global, pour une approche intégrée.

Abstract

The purpose of this paper is to present a mathematical model built up to help policy makers in the context of economic changes faced by South-East Asian countries. The main characteristic of the model is that it includes in the same frame three different levels of analysis: micro, meso and macro-economics.

The model being presented here corresponds to a prototype made for the specific case of soybean production and processing in Indonesia. International institutions insist on Indonesia government to liberalize the soybean market, in order to allow lower internal prices that would favour consumption. The effects on employment and the global economy would thus be positive. However, it is necessary to remark that this type of policies produces very often unexpected effects, sometimes relevant and many times with negative impacts. The externalities can be produced at the different levels: farmers, landless farmers, processors, urban population and concern also regional linkages, like migrations, etc. This reinforces the need to represent the specific behaviour of the different actors in an integrated way to avoid to predetermine the results of the model with exogenous variables and thus improve the conclusions of the model.

Introduction

The objective of this paper is to present a mathematical model[1] defined to provide agricultural policy advices in the context of rapid economic changes faced by several countries in south est Asia. The main feature of this model corresponds to the integration of three different levels of economic analysis : farming systems, commodity chains and macro-economic variables.

This paper is methodological. Even if it will be first applied for the analysis of soybean production and transformation in Indonesia, the model is defined in a very flexible way: other products can be analysed and/or the model can be applied to other countries in the region.

Soybean production in Indonesia

Soybean is an important component of Indonesian agriculture. Since the mid eighties, agricultural policies were focused on the possibility of raising domestic production to meet increasing demand and thus avoid dependency on international markets. Government controls imports of this product to increase local farmers' competitivity. However, despite several projects oriented to improve yields as well as to increase area of the soybean production (SYGAP 1992), national production increased of only 1.1 percent during the last five years while imports rose 5 percent annually[2]. Now, in the spirit of GATT negotiations, some economists argue that a liberalisation of the trade would decrease distortions, improve processing activities, allow specialization based on comparative advantages and thus have a positive influence on employment and the whole economy. Soybean commodity is thus a good example to test a model involving three levels of analysis mentioned above.

The model will be used as a tool for agricultural policy advise, to test the hypothesis preconized by market economists as well as other possible interventions. In this case, the questions to be addressed are :

- Possibility of increasing soybean production and the impact of such evolution on farmers, on the commodity chain and on macroeconomic variables such as level of employment and external trade.

- Positives consequences or externalities to be expected from different policies, specially liberalization of soybean trade.

Also, substancial attention is devoted to poverty impact, rural and urban income gap, and employment.

Model prototype

Two important aspects are original in this model. The first is the integration of a precise description of farming systems, the processing industry and the macroeconomic viewpoint. Thus the main characteristics of farmers decision making process as described in Biswanger and Rosenweig (1988) as well as the characteristics of the processing industry, marketing aspects

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1

Several agricultural sector models or GEM for the case of Indonesia exist with different purposes. See Altemeier, et al. (1989), Altemeier and Bottema (1991), Deaton (1990)m Kasryno et al. (1985), Rosgrant (1987), Trewin et al. (1993) SOW (1988, 1991).

2

Declaration of Amin Kahar (Director general of edible plantation and horticulture), Jakarta Post, June 14m 1994, p 8.

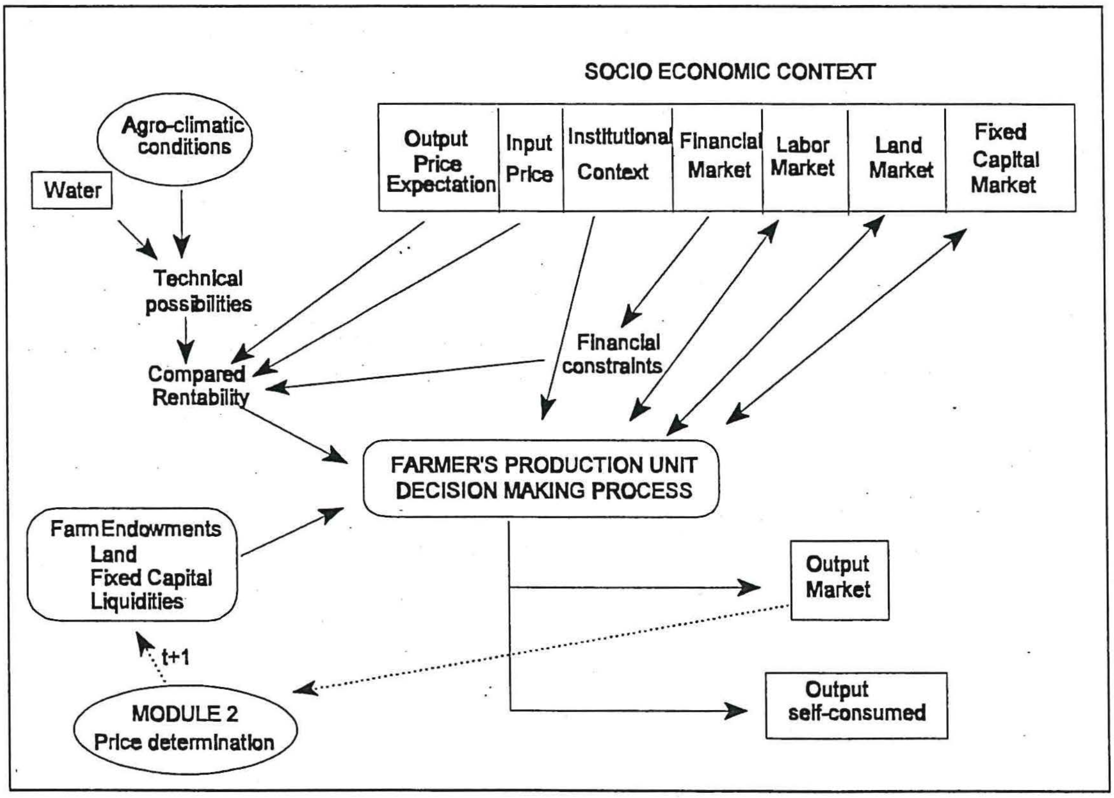
and some macro economic variables are taken into consideration.

The second is the use of two types of prices in the model. For the optimization process, the model uses farmers' price expectations[3]. The "actual" prices are formed by the confrontation of global supply from the farmers and imports, and total demand at the village and the town level, based on consumer's behaviour.
The following description will present the characteristics of the different levels: farming systems, the link between farms at the village level, the commodities's chain representation as a function of consummer's behaviour, the relation at a regional level between town and village and relationships between regions.Macro economic impacts are calculated as a combination of the results of the precedent modules in a specific section. More details on the formulation process can be found in the appendix[4].

Modelling farmer's decision making process

Farmers' behaviours for each farm type are represented by a mathematical function. Figure 1 shows a schematic representation of the main decisions variables and constraints considered.

Figure 1 : Agricultural Module



3 As mentioned in Gérard (1991), different possibilities are proposed in the litterature. It is possible to calculate them as a result of past values of price in a more or less complex way (Cagan 1956 ; Nerlove 1958 ; Gouriéroux 1983). Other ways are to assume rational expectations (Muth 1961), that is, that economic agents make the best expectation allowed by current information on price formation (process and state of the variables) ; or expectations calculated from a limited rationality process mainly governed by habits (Keynes 1921 ; Simon 1958). Evidently the type chosen is very important for model results and has to be adapted according with access to information, market regulation, types of economic actors. Surveys will be conducted to determine the type of method to be used.

4 The general framework of the sectoral modelling is widely inspired from Deybe (1994).

It is supposed that each farmer chooses among activities those which maximize wealth utility under simultaneous constraints.

Wealth is defined as the total value of the assests at end of the year, (including land, equipement, livestock, cash, savings). In order to consider farmer's risk attitude[5], wealth utility increases with expected wealth and decreases with its variance (Markowitz,1959).

The constrains concern :

- land availability ;
- input ;
- mechanisation and traction requirements ;
- labour ;
- animal availability and forage requirements ;
- credit determined as total availability or structurally oriented ;
- cash flow, considering interest rate, and based on "actual" prices as confronted between demand and supply.

The decision process led to:

- land allocation among crops ;
- livestock activity level ;
- investment, saving and borrowing ;
- labour allocation between farm and off-farm activities.

Production level is calculated and used as input in the processing/consumption module.

Because of the possibility of three cropping seasons in Indonesia, most of the constraints are formalised on a seasonal basis.

Village level formalization of the main linkages between farmers and landless farmers

Main transfers at the village level on the agricultural sector are :

- water for irrigation is managed at this level and water allocation between farm types is optimized by the model ;
- farmers supply and demand commodities for consumption ;
- other links are formalized by balancing supply and demand on markets of :
  - agricultural labour
  - livestock (selling and renting)
  - land (selling and renting).

We suppose here price rigidities : quantity variations led to the equilibrium, except for land whose price is endogenously determined.

Data used for this model was collected by SYGAP project in two soybean producer villages in center and east Java (Dauphin et al, 1988, Irawan et Lançon, 1992). Other data comes from Gonzalez (1987), Deaton (1990), and Nanseki et al. (1992).

Agricultural products processing/consumption level

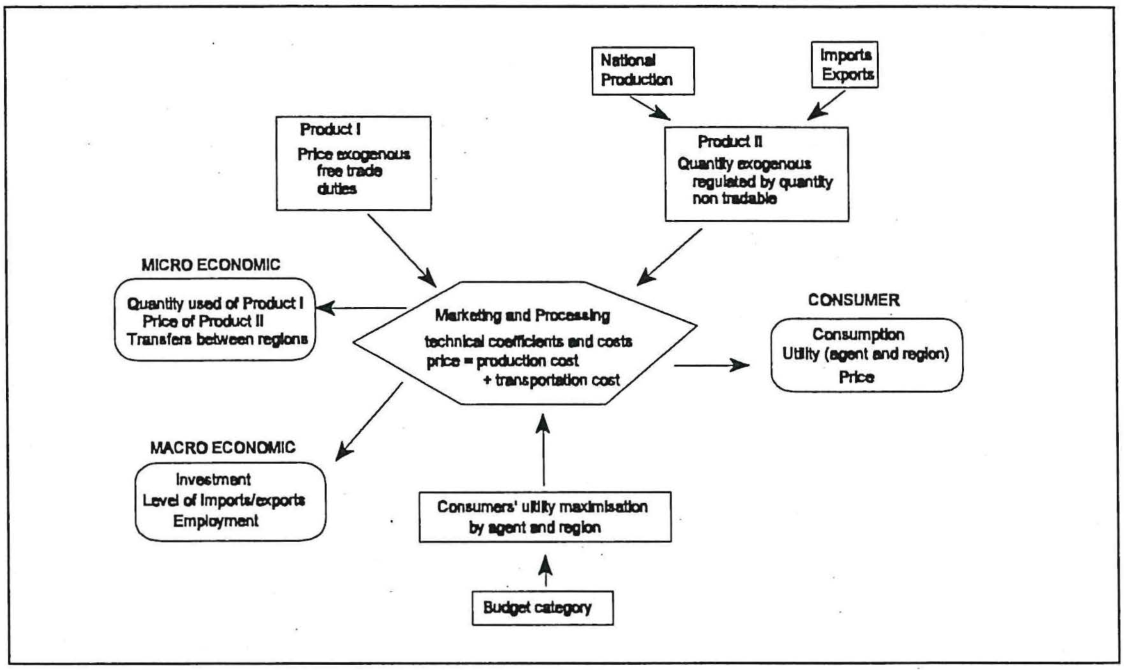
The optimisation at this level is based on the maximisation of consumer's consumption utility under revenu constraints, represented by a Cobb-Douglas function where the exponential expresses consumer's preferences. Substitution among products is thus possible as a response to prices. The optimisation determines processed quantity for consumption and therefore external trade, with the consequent price as a function of both of them.

5

Risk aversion, specially in agriculture, has an important impact in decision making process (Boussard, 1987).

Agriculture output (computed in module 1) is introduced as an exogenous variable. For each product, alternative processing activities are represented by transformation coefficients (rough inputs, capital, labor, other variable costs). Total cost equalizes price.
External trade policies influence either internal price or quantity consumed. In the case of import's quota, or non tradeble goods, price is the result of consumer's utility maximization given product availability. In the case of internal price regulation through public storage, price is exogenously determined between prestablished bounds and the quantity consumed are endogenously calculated. Finally, in the case of fixed duties or free trade, price equalizes international price including transaction costs. Consequent imports or exports are the result of this balance.
Processing activity level determines employment in the sector (figure 2).

Figure 2 : Processing module



Data for this level of analysis comes from Timmer and Alderman (1979) and Holland (1991).

National level

The regional commodities market are linked in order to allow product flows between excedentary and deficitary regions as well as imports or exports on the international market . Both production and processing localisation are taken into account in estimating transportation cost.

Macro economic level

This module has two main characteristics (figure 3) :

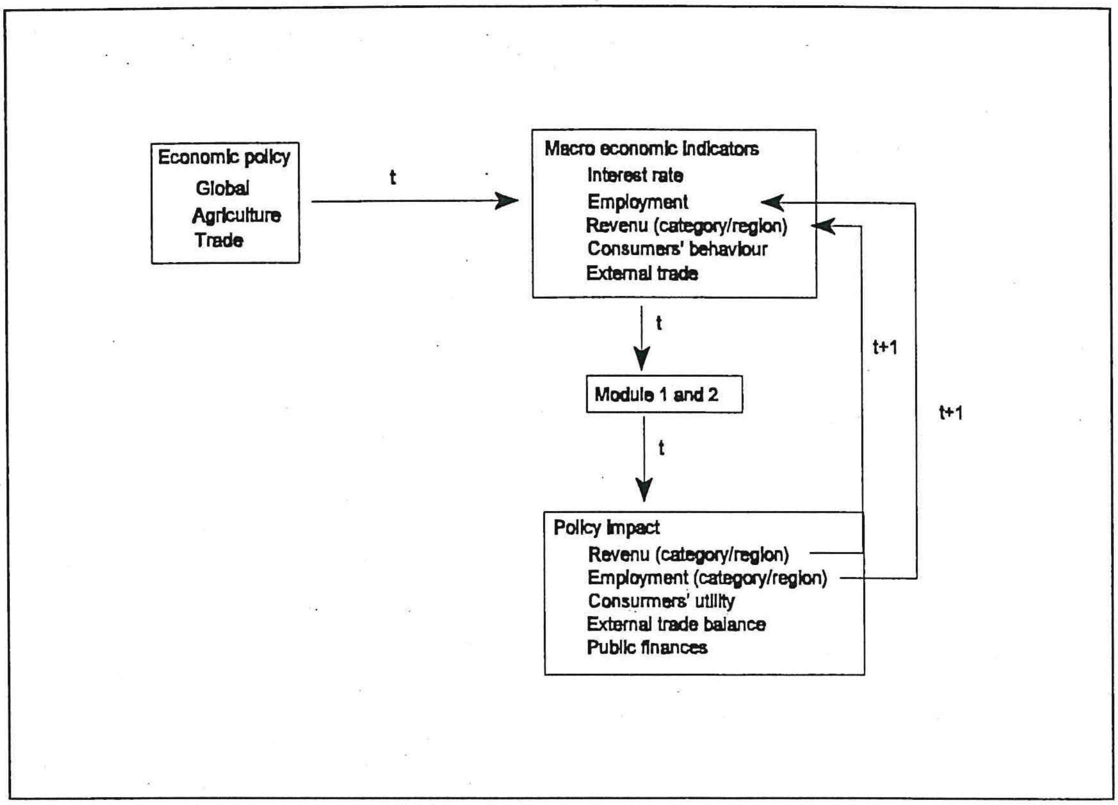
It provides the context for the two other modules,

general economic context define the structural environment confronted by economic agents: interest rate, employment opportunity, salary level, input availability, access to the market, land market, consumers' behaviour...

policies determine the kind of regulations and the specific environment that can be faced by the agents: credit, trade, minimum salaries...

It summarizes the results of the two previous modules, given indications on the impact on the revenu and utility by type of agent, employment, imports/exports.

Figure 3 : Macro economic module



Recursive modelling

As described above, the model is static. However, policy evaluation requires an extended point of view because agents' reaction are not instant. The model will thus be transformed in recursive as done by Day (1965) by using the results of each year as exogenous parameters for the following period[6] :

Computed "actual" prices from module 2 will be used to correct next period rentability expectations and consumption costs ;
Past results of the farm and current state of the financial market will determine liquidity constraint and fixed input endowment ;
Impacts on revenu modify individual propension to consume and thus the level of food consumption expenditures (used in module 2) ;
Results of the processing module related to employment will be introduced as off-farm labor oportunity in the agricultural module.

Other improvements will also be included in the model: inter-regional migration, share of imported inputs in the national market, global storage, and environmental impacts.

6 This methodology was used for a model of french agriculture by Boussard et Gérard (1992) and by Deybe et al. (1993) in a village model for Burkina Faso.

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APPENDIX

LAND (reg, exp, t,s)
Land allocation constraint

$$\sum_{j,tec,equi} AL_{reg,exags,t,j,tec,equi,s} + ALE_{reg,exags,t,je,tec,equi,s} + FAL_{reg,exags,j,t,jf,tec,equi,s}$$
$$+LS_{reg,exags,ts} - LP_{reg,exags,ts} - LRIN_{reg,exags,ts} + LROUT_{reg,exags,ts} - LAOWN_{reg,exags,t,s}$$

LALIM(reg,ex,t,s)

$$-LAOWN_{reg,ex,t,s} + LS_{reg,ex,t,s} + LROUT_{reg,ex,t,s} - LP_{reg,ex,t,s} = 0$$

For each region (reg), agricultural actor (exags), type of land (t), technology used (tec), equipment type (equi) and season (s) land allocation for crop (AL) , fodder (ALE) and forced crop (FAL) can not exceed land availability (LAVA). The allocation is defined for farms groups within each region.

LAVAIL (reg,ex,t,s)
Land availability

$$LAOWN_{reg,ex,t,s} + LS_{reg,ex,t,s} - LP_{reg,ex,t,s} = LAOWN_{reg,ex,t,s-1}$$

Maximum Land available by actor (LMAX) is defined by taking into account last period availability as well as selling (LS, LSC), purchasing (LP) and renting activity (LRIN,LROUT). For practical reasons, LMAX is defined by each type of agent (ex, which includes village agents, with or without land (exags), and town agent (ext)) and multiplied by the scale coefficient (NFA), representing the number of agents in each group.

FORCEL (reg, exags,t,jf,s)
Forced land allocation

$$\sum_{tec,equi} FAL_{reg,exags,t,jf,tec,equi,s} = LANFORC_{reg,exags,t,jf,s}$$

Some allocation of land is forced (LANDFORC) by institutional constraint for given crops (jf)

TRANLOUT (reg,t,s)
Balance on renting land

$$\sum_{ex} LRIN_{reg,ex,t,s} = \sum_{ex} LROUT_{reg,ex,t,s}$$

Demand of land for rent (LRIN) cannot exceed supply (LROUT)

SELLOUT (reg, t, s)
Land sell balance

$$\sum_{ex} LP_{reg,ex,t,s} = \sum_{ex} LS_{reg,ex,t,s} + \sum_{ex} NFA_{reg,n} * LMAX_{reg,ex,t,\text{"S1"}} * SLAND_{reg,t}$$

Demand of land for purchase (LP) cannot excess offer (LS) . All agents (rural and urban) can buy land.

LIMTOWN (reg, t)
Limite on land purchase by town actors

$$\sum_{ext,s} LP_{reg,ext,t,s} = \sum_{exag,s} LMAX_{reg,exag,t,s} * SARE_{reg} * NFA_{reg,exag}$$

Purchase of land by town inhabitants is limited by an exogeneous proportion coefficient (SARE) of total land availability. This assumption has to be checked.

WATER (reg,exags,tti,s)
Calcul of water requirement

$$\Big(\sum_{jj,tteci,equi} AL_{reg,exags,tti,j,tteci,equi,s} + ALE_{reg,exag,tti,je,tteci,equi,s}$$
$$+ FAL_{reg,exags,tti,jf,tteci,equi,s} \Big) * WR_{reg,ex,tti,jj,tteci,equi,s}$$
$$= WAT_{reg,exags,tti,equi,s}$$

Total water (WAT) requirement is defined by cropping activities(jj) and seasons (s) according to technologie (tteci), equipment used (equi) and type of irrigated land (tti)

WATOT (reg, tti, s)
Water balance by region

$$\sum_{exags,equi} WAT_{reg,exags,tti,equi,s} + WATRA_{reg,tti,equi,s}$$
$$\leq WAINI_{reg,tti,equi,\text{"SIA"}} + RAIN_{reg,s} * RR_{reg,s} + \sum_{equi} WATRA_{reg,tti,equi,s-1}$$

Water requirement is limited by availability defined by initial dotation (WAINI), the transfer from previous seasons (WATRA s-1) and climate (RAIN) adjusted by a stochastic coefficient (RR), excedents can be transfered to the next season (WATRA s). We suppose there is no water transfer among years.

INPUTS (reg,exags,s,inp)
Input balance

$$
\begin{aligned}
&\Big(\sum_{tjj,tec,equi} AL_{reg,exags,t,j,tec,equi,s} + ALE_{reg,exags,t,je,tec,equi,s} \\
&\quad + FAL_{reg,exags,t,jf,tec,equi,s}\Big) * CO_{reg,exags,t,j,tec,equi,s,inp} \\
&+ INTRA_{reg,exags,s,inp} = INTRA_{reg,exags,s-1,inp} + INU_{reg,exags,s,inp}
\end{aligned}
$$

Input requirement by cropping activities is exegeneously determined (technical coefficient (CO)) and covered with purchases (INU) and interseasonal transfers (INTRA)

PRODU (reg,exags,jj,s)
Commodity produced.

$$
\begin{aligned}
&PRODUCT_{reg,exags,jj,s} = \sum_{t,tec,equi} AI_{reg,exags,t,j,tec,equi,s} \\
&* MEY_{reg,exags,t,j,tec,equi,s} + FAL_{reg,exags,t,jf,tec,equi,s} * MEY_{reg,exags,t,jf,tec,equi,s}
\end{aligned}
$$

Production is calculated by multipliing yields (MEY) by land allocation.

CONS (reg, s, pro)
Consumption balance

$$
\begin{aligned}
&\sum_{exags,ag,gen} LAVAI_{reg,exags,s,ag,gen} * CON_{ag,gen,pro} * NFA_{reg,exags} \\
&\quad - \sum_{exags,jjc} PROPU_{reg,exags,jjc,s} * QUAL_{jjc,pro} \\
&+ \sum_{ext,ag,gen} LAVAI_{reg,ext,s,ag,gen} * CON_{ag,gen,pro} * NFA_{reg,ext} \\
&\quad - \sum_{ext,jjc} PROPU_{reg,ext,jjc,s} * QUAL_{jjc,pro} \\
&+ \sum_{ex,ag,gen} LAVAI_{reg,ex,s,ag,gen} * CON_{ag,gen,pro} * NFA_{reg,ex} \\
&\quad - \sum_{ex,outws} PROPU_{reg,ex,outws,s} * QUAL_{outws,pro} = 0
\end{aligned}
$$

The consumption requirement for the family of each farm type (LAVAI) is calculated by age (ag), gender (gen) and urban (ext) / rural (exags) using a coefficient (CON) representing calories and proteins requirements. Consumption requierements are filled by agricultural product consumption (PROPU) multiplied by a coefficient of quality (QUAL) representing proteins and calories values.

MECH (reg, exags,me,s)

$$\sum_{t,jj,tec} (AL_{reg,exags,t,j,tec,"MEC",s} + ALE_{reg,exags,t,je,tec,"MEC",s} + FAL_{reg,exags,t,jf,tec,"MEC",s}) \cdot MN_{reg,exags,t,jj,tec,s,me} \le MAV_{reg,exags,s,me} \cdot MAD_{s,me}$$

The mecanisation requirement by cropping activity is estimated with a coefficient (MN). The requirements are covered with avalaibility on the farm and purchases. Conversion of machine availability in hours is made by multipliing with a coefficient (MAD)

MECHAV (reg, exags, s, me)
Equipment Balance

$$MINI_{reg,exags,"S1A",me} \cdot NFA_{reg,exags} + MAV_{reg,exags,s-1,me} + MAPU_{reg,exags,s,me} = MAV_{reg,exags,s,me}$$

Equipment availibility by season (MAV(s)) is calculated by adding up initial availability (MINI) multiplied by the scale coefficient (NFA) and purchases (MAPU).

TRAC (reg, exags, s)

$$\sum_{t,jj,tec} AL_{reg,exags,t,j,tec,"tra",s} + ALE_{reg,exags,t,je,tec,"TRA",s} + FAL_{reg,exags,t,jf,tec,"TRA",s} \cdot AN_{reg,exags,t,jj,tec,s} = \sum_{cab} ANAVA_{reg,ex,s,cab} \cdot ANW_{s,cab}$$

Traction requirement (ANAVA) is defined by cropping activity, technical schedeule and season using a coefficient (AN). Conversion of animal stock into traction hours is made with a coefficient (ANW).

ANLOTR (reg,exags,s,cab)

$$ANAVA_{reg,exags,s,cab} = ANSTO_{reg,exags,s,cab} + ANLOC_{reg,exags,s,cab} - ANRENT_{reg,exags,s,cab}$$

Animal traction requirement is covered with the stock on the farm (ANSTO), and rent (ANRENT). Location of animals outside the farm is possible (ANLOC).

LOTR (reg,s,cab)
Balance on renting animals

$$\sum_{exags} ANRENT_{reg,exags,s,cab} = \sum_{exags} ANLOC_{reg,exags,s,cab}$$

Animals rented in cannot exceed the animals rented out.

TRAPU (reg, , s,cab)

$$\sum_{exags} ANPU_{reg,exags,s,cab} = \sum_{exags} ANSA_{reg,exags,s,cab}$$

Demand of animals for purchase (ANPU) cannot excess sales (ANSA).

INV(reg,exags,s)

Investment on land, equipment and traction can be financed by long term credit (AGGRLT), land sale, saving (SINI for the first period, SA for the following) and livestock sales.

$$\sum_{me} MAPU_{reg,exags,s,me} * EP_{me} + \sum_{ca} ANPU_{reg,exags,s,ca} * ANP_{s,ca} - \sum_{CA} ANS_{reg,exags,s,ca} * AP_{s,ca} - MS_{reg,exags,s} = 0$$

EXCRE (reg,exags,s)

$$AGCRELT_{reg,exags,s} \leq CREEX_{reg,exags,s}$$

Structural credit policy.

LAB (reg,exags,s,ag,gen)

$$\Big(\sum_{t,jj,tec,equi} AL_{reg,exags,t,j,tec,equi,s} + ALE_{reg,exags,t,je,tec,equi,s} + FAL_{reg,exags,t,jf,tec,equi,s}\Big) * LUSE_{reg,exags,t,jj,tec,equi,s,ag,gen}$$

$$+ LAS_{reg,exags,s,ag,gen} - LARIN_{reg,exags,s,ag,gen} + LAROUT_{reg,exags,s,ag,gen} + LAOFF_{reg,exags,s,ag,gen} = LA_{reg,exags,s,ag,gen}$$

The requirement of labour for cropping activities, forage and forced allocation is represented by a coefficient (LUSE) and filled by family and external labour (LA and LARIN). Family labour can be used in other farms (LAROUT) or in off-farm activities, certain (LAS) and uncertain (LAOFF).

LTOT (reg,exags,s,ag,gen)

$$\sum_j LA_{reg,exags,s,j,ag,gen} + LAS_{reg,exags,s,j,ag,gen} + LAOFF_{reg,exags,s,j,ag,gen} \leq LAMAX_{reg,exags,s,ag,gen} * NFA_{reg,exags}$$

Labour availability for each farm (LAMAX) is multiplied by the scale coefficient.

TOTLANAT (s)

$$\sum_{reg} \sum_{exags,ag,gen} LA_{reg,exags,s,ag,gen} + \sum_{exv,ag,gen} LAS_{reg,exv,s,ag,gen} + LAOFF_{reg,exv,s,ag,gen} \leq \sum_{reg,ex,ag,gen} POPACT_{reg,ex,s,ag,gen} * NDAY_{ag,gen}$$

National labour requirements for agricultural (LA) and non-agicultural (LAS, LAOFF) sectors are covered with active population (LAVAI*NFA) multiplied by the number of days worked by season (NDAY).

LABOUT (reg,s, ag,gen)
Balance for agricultural labour at the regional level

$$\sum_{exags} LARIN_{reg,exags,s,ag,gen} = \sum_{exags} LAROUT_{reg,exags,s,ag,gen}$$

The demand of agricultural labour can not exceed the supply.

OFF (reg,ex,s,ag,gen)

$$LAS_{reg,ex,s,ag,gen} + LAOFF_{reg,ex,s,ag,gen} \leq TRLA_{reg,ex,s,ag,gen} + OTLA_{reg,ex,s,ag,gen} + \sum_{jj} OFEED_{jj,s} * TRFEED_{jj,s}$$

Off-farm activity can be: processing for human consumption (TRLA), other sectors (OTLA) and feed processing (OFEED * TRFEED).

OFFTO (s,ag,gen)

$$\sum_{reg} \sum_{ex} OTLA_{reg,ex,s,ag,gen} \leq \sum_{reg} TOF_{reg,s,ag,gen}$$

Non agricultural activies (beside processing) are limited by the economy of the nation (other sectors' demand of labour) (TOF).

OFFO (reg,s,ag, gen)

$$\sum_{ex} LAOFF_{reg,ex,s,ag,gen} \leq \sum_{ex} OTOLA_{reg,ex,s,ag,gen}$$

Non agricultural temporary activities are exogeneously limited (OTOLA).

FEEDBA (jj,s)

$$\sum_{reg,exag} FEEDCUM_{reg,exag,jj,s,qa} = FEED_{jj,s} * FEEDTR_{jj}$$

Soybean used for feed (FEED) multiplied by a transformation coefficient (FEEDTR) offers total feed availability (FEEDCUM).

ANTO (reg,exag,s,ca)

$$\begin{aligned} & ANSTO_{reg,exag,s,ca} + ANS_{reg,exag,s,ca} + ANSA_{reg,exag,s,ca} \\ & = ANPU_{reg,exag,s,ca} + ANINI_{reg,exag,s,ca} * NFA_{reg,exag} \end{aligned}$$

Animal availability (ANSTO) is calculated by adding up purchases (ANPU), initial endowment (ANINI * NFA) and substracting ordinary (ANS) and extraordinary (ANSA) sales. Extraordinary sales finance investments.

FOBA(reg,exag,s,qa)

$$\begin{aligned} & \sum_{ca} ANSTO_{reg,exag,s,ca} * ANEED_{reg,exag,s,ca,qa} \\ & = \Big(\sum_{t,jj,tec,equi} AL_{reg,exag,t,j,tec,equi,s} + ALE_{reg,exag,t,je,tec,equi,s} + FAL_{reg,exag,t,jf,tec,equi,s} \Big) \\ & * FOPR_{reg,exag,t,jj,tec,equi,s,qa} + \sum_{jj} \big(FEEDCUM_{reg,exag,jj,s,qa} + FEEDTRA_{exag,jj,s-1,qa} - FEEDTRA_{exag,jj,s,qa} \big) \end{aligned}$$

Feed requirements are calculated by applying a coefficient (ANEED) to animal stock and covered with forage, purchase of feed (FEEDCUM) and transfers between seasons (FEEDTRA). Forage availability is the result of applying a coefficient (FOPR) to cropping activities, forced allocation and forage crops.

AMEQ(reg,exags,me)
Machine depreciation

$$AM_{reg,exags,me} = MAV_{reg,exags,"S3b",me} * EP_{me} / yan_{me}$$

Depreciation (AM) is estimated by applying a coefficient (EP) on machine endowment and dividing it by the depreciation period (YAN me)

AMATR(reg,exag,cav)
Animal depreciation.

$$AAM_{reg,exag,cav} = ANINI_{reg,exag,"S1A",cav} * NFA_{reg,exag} + \sum_{s} ANPU_{reg,exag,s,cav} - ANS_{reg,exag,s,cav} - ANSA_{reg,exag,s,cav}) * AP_{cav} / yan(cav)$$

Animal depreciation is calculated by applying a coefficient (APcav) on traction animal stock (cav) and dividing it by the depreciation period (YANcav).

SAVING(reg,exags,s)

$$SINI_{reg,exags,"S1"} * NFA_{reg,exags} + SA_{reg,exags,s} = SAVS_{reg,exags,s}$$

CASH(reg,exags,s)
Cash flow

$$
\begin{aligned}
CU_{reg,exags,s} = &\sum_{j} PRODUCT_{reg,exags,jj,s-1} * FPR_{reg,jj,s} - \sum_{inp} INU_{reg,exags,s,\epsilon} * inpr_{reg,s,inp} \\
&\sum_{jj,qa} FEEDCUM_{reg,exags,jj,s,qa} * PRFEED_{reg,exags,jj,s,qa} + \sum_{ca} ANS_{reg,exag,s,ca} * AP_{s,ca} \\
&+ \sum_{ag,gen} LAROUT_{reg,exags,s,ag,gen} * AGWA_{reg,s,ag,gen} - \sum_{ag,gen} LARIN_{reg,exags,s,ag,gen} * AGWA_{reg,s,ag,gen} \\
&+ \sum_{ag,gen} (LAS_{reg,exags,s-1,ag,gen} + LAOFF_{reg,exags,s-1,ag,gen}) * NAGWA_{reg,s,ag,gen} \\
&- \sum_{out} PROPU_{reg,exags,out,s} * FPR_{reg,out,s} \\
&- AGCRELT_{reg,exags,s} * ilycr + AGCREST_{reg,exags,s} - (1 + ict) * AGCREST_{reg,exags,"S3B"} \\
&- \sum_{ag,gen} OTCON_{reg,exags,s,ag,gen} * LAVA_{reg,exags,s,ag,gen} * NFA_{reg,exags} \\
&+ \sum_{t} LAROUT_{reg,exags,t,s} * r_{reg,t,s} * .99 \\
&- \sum_{t} LARIN_{reg,exags,t,s} * r_{reg,t,s} \\
&+ \sum_{t} LS_{reg,exags,t,s} * lpr_{reg,exags,t} * .8 \\
&- \sum_{cab} ANLOC_{reg,exags,s,cab} * ANRE_{reg,s,cab} \\
&+ \sum_{cab} ANRENT_{reg,exags,s,cab} * ANRE_{reg,s,cab} * .9 \\
&+ CU_{reg,exags,s-1} + INIC_{reg,exags,s} \\
&- MS_{reg,exags,s} + 0.8 * savs_{reg,exags,s}
\end{aligned}
$$

Seasonal costs can be covered by income, land sale (LSC), short term credit (AGCREST) or by cash transfer (CU) from previous seasons, for each group of farms.

CRST(reg)
Total credit use, short term

$$
\sum_{exags,s} AGCREST_{reg,exags,s} + \sum_{ex,s} TRCRST_{reg,ex,s} \leq TOCRST_{reg}
$$

Total short term credit availability (TOCRST) can be used by the agricultural or transformation branchs.

WEALTH(reg,exags)

$$
\begin{aligned}
&CU_{reg,exags,"S3"} + \sum_{t} LAOWN_{reg,exags,t,"S3"} * 1.2 * LPR_{reg} \\
&+ \sum_{ca} ANSTO_{reg,exags,"S3",ca} * AP_{S3,ca} + \sum_{me} MAV_{reg,exags,"S3",me} * EP_{me} - AM_{reg,exags,me} \\
&- AGGRELT_{reg,exags,s} + SA_{reg,exags,t,"S3"} = WH_{reg,exags}
\end{aligned}
$$

VARIANCE

$$\sum_{jj2,s} PRODUCT_{reg,exags,jj2,s} * EXPR_{reg,exags,jj2} * SIGC^{2}_{jj2,s}$$
$$\sum_{s,ca} ANSTO_{reg,exags,"S3",ca} * AP_{S3,ca} * SIGb^{2}_{ca}$$
$$\sum_{t,s} LAOWN_{reg,exags,t,"S3"} * LPR_{reg} * SIGL^{2}_{t} = VAR_{reg,exags}$$

FONCTION

$$\sum_{reg,exags} WH^{\alpha}_{reg,exags} + \frac{\alpha}{2}(\alpha-1) * Var_{reg,exags} * WH^{\alpha-2}_{reg,exags} = FONC$$

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