CAMINÌ A Model documentation (January 2000)

1. Model structure and data used

CAMINÌ A is a mathematical programming spatial partial equilibrium model (Takayama and Judge, 1971). It expands on Anania and McCalla (1991), Anania, Bohman and Carter (1992), and SOLAGRAL (1998).

To allow for an assessment of the GATT "Agreement on agriculture", the base model time reference is 1994, the final year before the beginning of the implementation of the agreement.

Only one commodity is considered, wheat[1], which is assumed to be a homogeneous product. All values are expressed in US dollars and exchange rates are exogenous to the model. All quantities are expressed in metric tons. With the exception of the distortions which are explicitly considered in the model, perfect competition conditions are assumed to hold both in domestic and international markets.

Domestic production and consumption are explicitly modeled; demand and supply functions are assumed to be linear (or to be well approximated by a linear function in their portion which is relevant for the model simulations) and are obtained from observed produced and consumed quantities[2], producer and consumer prices[3], and supply and demand elasticities at the equilibrium in the base year in each country or region (Table 1).

Producer prices are farm gate prices; consumer prices are intended to be net of consumer subsidies, if any. In each country the per unit transportation and handling cost for moving wheat from the farm gate to domestic consumers is assumed to be the same as the cost for moving wheat to be exported from the farm gate to the border, or for moving imported wheat from the border to domestic consumers. International transportation and handling costs represent the costs of moving the wheat from border to border[4]. Domestic and international per unit transportation and handling costs are assumed to be constant, i.e. not to change either with the volume exchanged or over time.

Stock changes are incorporated in the model through country specific stock release functions.[5] In each country/region stock changes are assumed to be a linear function of producer price. These functions have been obtained from stock releases in 1994 as given by FAO, observed producer prices in the same year and stock release elasticities (Table 1).

Domestic markets in 19 countries and regions (all major importing and exporting countries and regional aggregations of remaining countries) are modeled.[6]

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[1] This includes both soft and durum wheat, as well as wheat flour.

[2] The data source for production and utilization in 1994 is the FAO "Food Balance Sheet" database for "wheat & products". Although the term "consumption" is often used interchangeably for "utilizations", the latter would be more appropriate, "consumption" including food, feed, seed and other uses as well as wastes.

[3] The source for production prices for most countries has been IWC (1995). Information produced by FAO and OECD has been used as well. Most consumer prices have been determined based on prices of bread as listed in IWC (1995).

[4] These have been obtained based on information provided in IWC (1995).

[5] A negative release implying an increase in stocks.

[6] The 19 countries or regions considered are: the European Union (15 members); the United States; Canada; Argentina; Australia; China; Japan; South Africa; the countries of the former Soviet Union, apart from Estonia; Turkey; the other Mediterranean countries; the other European countries; Mexico and the other Central American and Caribbean countries; the other South American countries; the other African countries; the other countries of the Near East; the other countries of the Far East; the other countries of Oceania; the candidate countries most likely to become members of the EU in the near future (Cyprus, Estonia, Poland, the Czech Republic, Slovenia and Hungary). Although the time reference of the "Base" model is 1994, a European Union of 15 members has been assumed in order to facilitate comparisons with other scenarios.

Compensatory payments in the EU are assumed to be fully "decoupled". The "compulsory set aside" percentage is implicitly defined in the model as the "rotational" equivalent, assuming a 15% set aside percentage being equivalent to the maximum allowed non-rotational percentage (17.5%).

Support granted by deficiency payments in the US is assumed to be fully "decoupled".

Minimum guaranteed market prices in the US and EU are given by the "loan rate" ($2.45/bu.) and the "intervention price" (115.49 Ecu/t), respectively; minimum guaranteed farm gate prices are lower by the per unit domestic handling and transportation costs incurred by farmers to deliver the wheat to the intervention.

EU variable "export restitutions" are endogenously determined as the export subsidies which make EU exports competitive on the different markets, based on the EU reference threshold export price, which is exogenous to the model. In the 1994 base scenario, where EU export subsidies are not subject to any constraint, restitutions make producer price in the EU equal to the farm gate reference export threshold price ($162/t[7]), and EU production in excess of domestic consumption, net of the change in stocks, exported.

The per unit export subsidy in Canada is given by the average subsidy provided under the Western Train Transportation Act. US per unit EEP export subsidies by country/region of destination are based on average bonuses paid in 93/94; subsidies are assumed to be paid in cash and subsidized exports are assumed to be unconstrained. Finally, per unit export subsidies used by Turkey and South Africa are those applied in 1994, as listed by the WTO.

For countries that subsidized wheat exports in 1994 which are not individually considered in the model (Hungary, for example), rather than modeling the export subsidy by forcefully extending its use to all countries of the region, the choice has been not to take the subsidy into account.

EU market protection in 1994 has been modeled through a "variable levy". The levies are endogenously determined as the difference between the exogenous import "threshold price" (172.74 Ecu/t) and the (potential) c.i.f. export prices at the EU border for each of the other countries.

The protection granted to its domestic market by Japan through JFA, a state trading enterprise, is represented by a constraint on its imports (a quota) equal to the observed volume of wheat imports in 1994.

Trading between US and Canada is assumed to be tariff free due to the NAFTA. For the same reason Canada and US exports to the Central America region, which includes Mexico, are subject to a preferential import tariff (10.5%, rather than 67%).

Existing bilateral agreements in 1994 involving commitments in wheat trading, as listed in IWC (1995), have been imposed as minimum constraints in bilateral trade flows.

Arbitraging - a country importing and exporting at the same time to take advantage of import tariffs and export subsidies differentiated by source of imports or destination of exports, respectively - is made impossible (Anania e McCalla, 1991) for all countries but South Africa (which was a net importer in 1994 while at the same time subsidizing exports) and the Central and Eastern European candidates to join the EU (which, as a region, were in 1994 a marginal exporter).

2. Calibration

Calibration of the "Base 1994" model turned out to be quite satisfactory. The average percent difference, in absolute value, between the values observed and those produced by the model in the 19 countries/regions was, in fact, 2.6% for the quantities produced and 3.1% for those consumed.

[7] This is given by 110% of the intervention price, which was equal to 115.49 ECU/t (117 ECUs minus the agrimonetary correction) times the "switch-over" coefficient (1.21), divided by the average ECU/$ exchange rate in 1994 (.8431), less domestic transportation and handling costs in the EU ($20/t).

3. Simulations

Simulations have been produced with respect to three different time horizons: 2001, 2002 and 2005. In 2001 the implementation period of the GATT agreement by developed countries was completed, and these had to fulfill the export subsidy commitments as indicated in their schedules, i.e. without being able to use any "credit" accumulated in previous years, if any; in addition, in 2001 the first step of the implementation of the EU wheat policy changes introduced with "Agenda 2000" took place. 2002 has been considered to assess the full implementation of the EU policy reform for wheat. Finally, the 2005 time horizon has been chosen to provide a medium term assessment of what one should expect from "Agenda 2000" as regards its capability to make reformed EU wheat policies "compatible" with current commitments deriving from the GATT agreement and with those which could possibly derive from the conclusion of the WTO negotiations.

The "Base" 2001, 2002 and 2005 scenarios

The Base 2001, 2002 and 2005 scenarios are "reference" scenarios. They differ from the "Base 1994" as follows: the demand and supply functions have been modified to take into account expected changes in population, per capita incomes and yields; the model now includes the implementation of the 1994 GATT "Agreement on agriculture", the FAIR (Federal Agricultural Improvement and Reform) Act of the United States, and the full implementation of the 1992 reform of wheat policies in the European Union.

The demand functions have been modified on the basis of expected population and per capita income, and on the income elasticities of utilizations (Table 1). It has been assumed that per capita (food and feed) utilizations, ceteris paribus, do not change between 1994 and the three time horizons considered. Expected population has been obtained by applying to the population in each country in 1994 (World Bank, 1996) the percent annual growth rate between 1990 and 2000, as forecasted by the United Nations (Alexandratos, 1995; Table A.1). Per capita income has been assumed to change at the same annual rate as that observed between 1985 and 1995, as estimated by the World Bank (World Bank, 1997).

Supply functions have been modified on the basis of expected yields in 2001, 2002 and 2005. For each country/region these have been obtained by fitting a linear trend by OLS to observed yields between 1980 and 1994 (FAO). It has been assumed that, ceteris paribus, wheat area does not change.

GATT "domestic support" commitments are assumed not to be a constraint for any country/region.

Tariff levels are based on country schedules. For many importing developing countries observed tariff rates in 1994 were lower than bound rates listed in their schedules. When this was the case, tariffs were assumed to be the same as in 1994. Tariffs applied by countries that are not members of WTO - China for example - have been assumed not to change.

The preferential tariff imposed by "Central America" on its imports from USA and Canada has been reduced to 6% (from 10.5% in the "Base 1994" scenario), as a result of the implementation of NAFTA.

Relevant information for the European Union is based on the "schedules" for EU-15. The "tariffication" of the EU variable levy being subject to the additional constraint that the tariff inclusive import price cannot exceed 155% of the intervention price is assumed to leave the EU protecting its domestic market by using a variable levy, as it was before the implementation of the GATT agreement (Josling and Tangermann, 1995; Tangermann and Josling, 1994). However, the reference threshold price used to compute the variable levy is now lower ($219.1/t, equivalent to 155% of the new intervention price, compared to the $248/t threshold price in the "Base 1994"

scenario) and the levy is constrained so as not to exceed the ceiling indicated in the EU "schedules" ($112.7/t, the equivalent of 95 ECU/t).

Japan's protectionist policies are assumed not to change. Based on expected changes between 1994 and 2001, 2002 and 2005 in domestic production and utilizations due to changes in per capita income, population and yields, and assuming that protection to farmers in Japan is driven by the goal of maintaining the domestic price at a chosen level (assumed not to change), the constraint on the volume of imported wheat has been increased from 6.048 million tons in the "Base 1994" scenario to 6.350 in 2001, to 6.403 in 2002, and to 6.550 in 2005.

Reduced tariff "minimum" and "current" import quotas are explicitly modeled. As stated by the agreement, countries are not forced to fill the quotas; instead, they are assumed to allow imports at the reduced tariff rate indicated in their "schedules" up to the quota, as long as these imports are economically profitable.[8] The model allows imports over "minimum" and "current" quotas to occur at the standard above-quota tariff rates.

GATT "export competition" commitments are explicitly modeled as well. Constraints are included for subsidized exports and export subsidy expenditures not to exceed the maximum values indicated in the "schedules". If either one of the two constraints - that on the volume of subsidized exports, or that on the export subsidy expenditure - becomes binding, the model allows for non-subsidized exports to occur, if profitable.

The EU variable export restitution mechanism is assumed not to be modified as a result of the GATT agreement; however, it is subject to the commitments, and the reference price used to compute the restitutions is now lower ($155.5/t compared to $182/t) as a result of the lower intervention price.

It is assumed that the elimination of the (implicit) export subsidy under the Western Train Transportation Act implied the abolition of wheat export subsidization in Canada.

The implementation of the 1996 FAIR Act is represented in the model by (a) the elimination of the target price and the deficiency payments; (b) an increase of wheat acreage by 3.35%[9]; and (c) by assuming the loan rate in 2001 being equal to its maximum possible level ($2.58/bu.). US direct payments are assumed to be fully decoupled.

Export subsidy commitments for the US are those listed in the "schedules", as foreseen in the Act for 2001.[10] US per unit export subsidies are assumed to be automatically reduced if the constraint on the export subsidy expenditure is binding while that on subsidized exports is not. This reflects the goal of US in using export subsidies to maximize the volume of exports (within the given constraints).

EU wheat policies are modeled assuming that set aside "slippage" does not change, and that the percentage of land under the "simplified scheme" decreases from 30% to 20% of the total land where wheat is grown benefiting from compensatory payments.

To take into account the likely effects of changes in the set aside rate on both yields (the lower the land set aside, the lower the yields) and voluntary set aside participation (the lower the mandatory set aside, the higher the voluntary set aside), it is assumed that the production effect of a change in cultivated land with respect to the base scenario is equal to only 80% of what should be expected ceteris paribus.

The intervention price is equal to $141.4 (the equivalent of 119.19 ECU/t; it was $166/t in the "Base 1994" model) as a result of the full implementation of the 1992 CAP reform.

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8 The source for the quotas is the WTO, that for the in-quota tariff rates is OECD (1995).

9 As forecasted by USDA (1997) for harvested wheat area between 93/94 and 00/01. The change derives from the increase of farmed land as a result of the elimination of set aside as a condition for access to the direct payments, and from the removal of distortions in land allocation decisions as a result of the decoupled nature of the support.

10 For the years before 2000 the allocation to export subsidies in the Act is lower than the maximum export subsidy expenditure allowed by GATT commitments.

The "Agenda 2000" 2001, 2002 and 2005 scenarios

The "Agenda 2000" scenario at 2001 differs from the "Base 2001" only in the modeling of EU wheat policy, reflecting the changes decided in March 1999.

Intervention price is now lower by 7.5% (110.25 ECU/t instead of 119.19; 130.8 $/t instead of 141.4). As a result, both the reference price for calculating the export restitutions (which is equal to 110% of the intervention price) and the reference threshold price for calculating the variable import tariffs (which is given by 155% of the intervention price) are now lower (the former decreases from 155.5 $/t to 143.9; the latter from 219.1 $/t to 202.7).

The "Agenda 2000" and the "Base" scenarios at 2002 and 2005 differ only for the modeling of EU wheat policy. The intervention price is now lower by an additional 7.5% with respect to the "Agenda 2000" scenario at 2001 (down to 101.31 ECU/t, or 120.2 $/t); the threshold reference price for calculating the restitutions is now 132.2 $/t and that used to compute the variable import tariffs 186.3 $/t.

4. The basic structure of CAMINÌ A

The model solution is found by maximizing a "quasi-welfare" function (Samuelson, 1952) subject to a set of constraints[11]:

$$(1)\quad \text{Max } W(NSX_{i,j}, SX_{i,j}, I_i) = \sum_i \int_0^{q^d_i} D_i(q)\,dq - \sum_i \int_0^{q^s_i} S_i(q)\,dq -$$

$$- \sum_i \sum_j (tc_{ij} + t_{ij} - cs_j)\, X_{ij} + \sum_i \sum_j es_{ij}\, SX_{ij} + \sum_i (ip_i - dthc_i)\, I_i .$$

subject to:

$$(2)\quad q^s_i = \sum_j X_{ij} - SR_i + I_i \;;$$

$$(3)\quad q^d_i = \sum_j X_{ji} \;;$$

$$(4)\quad p^s_i = si_i + ss_i\, q^s_i \;;$$

$$(5)\quad p^d_i = di_i + ds_i\, q^d_i \;;$$

$$(6)\quad p^s_i = sri_i + srs_i\, SR_i \;;$$

$$(7)\quad X_i = \sum_j (X_{ij} - X_{ji}) \;;$$

$$(8)\quad X_{ij} = SX_{ij} + NSX_{ij} \;;$$

$$(9)\quad tc_{ij} = ithc_{ij} + dthc_i + dthc_j \;,\; \forall\, i \neq j \;;\; tc_{ii} = dthc_i \;;$$

$$(10)\quad fsx_{ij} = \sigma[SX_{ij}]\,\sigma[1 + \sigma[(1 + SX_{ij})/(1 + X_{ij}) - 1] \;;$$

$$(11)\quad \text{if } [\sum_i X_{ij} - X_{jj} \leq miq_j] \Rightarrow pt_{ij} = miqpt_{ij} \;;$$

[11] A recursive procedure has been used to overcome the computational complexity of the model.

(12) $t_{ij} = (pt_{ij} / 100) (p^s_i + tc_{ij} - dthc_j - fsx_{ij}\ es_{ij}) \ , \ \forall\ j \neq EU \ ;$

(13) $t_{i\ EU} = euirtp - [\ p^s_i + tc_{i\ EU} - dthc_{EU} - es_{i\ EU}\ ] \ , \forall\ i \neq EU \ ; \ t_{EU\ EU} = 0 \ ;$

(14) $t_{j\ EU} \leq maxeuit \ ;$

(15) $X_{ij} \geq bax_{ij} \ ;$

(16) $\Sigma_i\ [\ X_{i\ JAPAN} - X_{JAPAN\ i}\ ] = xjap \ ;$

(17) $es_{EU\ j} = euertp - [p^d_i - tc_{EU\ j} + dthc_{EU} - t_{EU\ j} + cs_j\ ] \ , \forall\ j \neq EU \ ; \ es_{EU\ EU} = 0 \ ;$

(18) if $[\ \Sigma_j\ SX_{USA\ j}\ es_{USA\ j} = maxese_{USA}\ ] \Rightarrow$

$$\Rightarrow \quad es_{USA\ j} = es_{USA\ j}\ [\ (\Sigma_j\ SX_{USA\ j}\ ) / maxevol_{USA}\ ] \ ;$$

(19) if $[\ X_j \geq 0\ ] \Rightarrow \Sigma_i\ X_{ij} - X_{jj} \leq miq_j \ ;$

(20) if $[\ X_j < 0\ ] \Rightarrow \Sigma_j\ X_{ij} - X_{ii} = 0 \ ;$

(20) $\sum_j SX_{ij}\ es_{ij} \leq maxese_i \ ;$

(21) $\sum_j SX_{ij} \leq maxevol_i \ ;$

(22) $NSX_{ij} \geq 0 \ ;$

(23) $SX_{ij} \geq 0 \ ;$

(24) $I_i \geq 0 \ ;$

where:

q^d_i	quantity consumed (utilizations) in country i (i = 1, 2, …, n) ;
q^s_i	quantity produced in country i ;
p^d_i	domestic consumer price in country i, net of consumer subsidies, if any;
p^s_i	(farm gate) domestic producer price in country i ;
$D_i\ (q)$	inverse demand function in country i ;
$S_i\ (q)$	inverse supply function in country i ;
X_{ij}	trade flow from country i to country j (i , j = 1, 2, …, n) ;
X_i	net trade position of country i ;

SX_{ij}	subsidized exports from country i to country j ;
NSX_{ij}	non subsidized exports from country i to country j ;
SR_i	stock release in country i ;
bax_{ij}	minimum exports from country i to country j as from existing bilateral trade agreement(s);
xjap	Japan's imports (exogenously determined) ;
pt_{ij}	percent import tariff imposed by country j on imports from country i ;
$miqpt_{ij}$	percent import tariff imposed by country j on imports from country i within the GATT "minimum" and/or "current" import quota;
t_{ij}	per unit import tariff imposed by country j on imports from country i ;
cs_i	per unit consumer subsidy in country i;
es_{ij}	per unit export subsidy paid by country i for exports to country j ;
ip_i	intervention price in country i ;
$ithc_{ij}$	per unit international (border to border) transportation and handling costs from country i to country j ($ithc_{ii} = 0$) ;
$dthc_i$	per unit domestic transportation and handling costs in country i ;
tc_{ij}	total per unit transportation and handling costs from producers in country i to consumers in country j;
I_i	quantity bought at intervention price by the public sector in country i ;
euirtp	EU import reference threshold price for determining variable levies;
euertp	EU export reference threshold price for determining export restitutions.
miq_i	GATT "minimum" and/or "current" import quota commitment by country i;
$maxese_i$	GATT maximum constraint on export subsidy expenditure in country i;
$maxsevol_i$	GATT maximum constraint on subsidized exports by country i;
maxeuit	GATT maximum constraint on the per unit import tariff imposed by the EU;
$\sigma(a)$	it is equal to -1 if $a \leq 0$; to 0 if $a = 0$; and to 1 if $a \geq 0$;
$fsx_{i,j}$	flag on non subsidized marginal exported unit; it is equal to 1 if all exports are subsidized; to 0 if either (a) subsidized exports are equal to 0, or (b) non subsidized exports occur.

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Table 1 - Main variables in the model data bases.

	Supply elasticities	Demand elasticities	Stock change elasticities	Consumer subsidies ($/t)	Import tariffs (%)	Export subsidies ($/t)	Demand income elasticities	GDP ave-rage annual growth rate (%)	Population 1994 (mill)	Population 2005 (mill)	Yields 1994 (100 kg x ha)	Yields 2005 (100 kg x ha)	In / out quota import tariffs (%)	Export subsidies ($/t)
EU	0,4	-0,3	2	0	var. levy	var. rest.	0,1	1,8	371,3	379,6	54,1	65,6	var. levy / 0	var. rest.
USA	0,6	-0,7	2	0	4,6*	****	0,07	1,3	260,6	278,3	25,3	26,2	2*	****
CANADA	0,5	-0,8	2	0	85,5**	22	0,1	0,4	29,2	31,5	21,3	23,6	77** / 1**	0
ARGENTINA	0,45	-0,15	2	0	0	0	0,15	1,8	34,2	39	21,7	25,3	0	0
AUSTRALIA	0,4	-0,2	2	0	0	0	0,1	1,4	17,8	20,1	11,4	20,4	0	0
CHINA	0,7	-0,25	3	15	15	0	0,25	8,3	1190,9	1372,7	34,3	44,7	15	0
JAPAN	0,2	-0,2	2	0	quota	0	0,1	2,9	125	130,6	37,2	41,2	quota	0
SOUTH AFR	0,3	-0,3	2	0	99	48,1	0,35	-1,1	40,5	51,5	17,6	22,3	99 / 20	48,1
EX-USSR	0,15	-0,85	3	10	0	0	0,4	-6,8	291,6	314,9	14,4	21,4	0	0
TURKEY	0,3	-0,15	3	40	90	59	0,3	2,2	60,8	74	17,9	22,1	90	59
OTH MEDIT	0,3	-0,3	2	55	15	0	0,3	0,3	154,1	200	21,8	25,2	15 / 5	0
OTH EUROPE	0,5	-0,4	2	0	30	0	0,2	-2,4	73,1	76,4	30,7	33,2	25 / 10	0
MEX OCAC	0,4	-0,8	3	20	67***	0	0,35	0	155,8	193,7	42,7	42,7	62*** / 35***	0
OTH S AMER	0,4	-0,4	3	0	30	0	0,35	0,2	281,6	346,3	19,1	26	30 / 10	0
OTH AFRICA	0,3	-0,5	3	10	0	0	0,4	0	531,1	759,1	15,4	18,8	0	0
OTH NE EAST	0,3	-0,4	3	10	0	0	0,3	-1,5	145,5	205,8	16,3	22	0	0
OTH FA EAST	0,4	-0,4	3	30	5	0	0,5	3,6	1744,9	2169,6	21,7	27,1	5 / 0	0
OTH OCEAN	0,4	-0,3	2	0	0	0	0,1	1,6	10,2	11,1	54,4	60,9	0	0
EU CANDID	0,7	-0,45	2	10	30	0	0,2	0,2	63,4	66,2	38	41,2	26 / 10	0

* : a preferential tariff is imposed on imports from Canada and Mexico.

** : a preferential tariff is imposed on imports from USA and Mexico.

*** : a preferential tariff is imposed on imports from Canada and USA.

**** : per unit subsidies differ by country of destination of exports.