No 2015-10 – July

Working Paper

CEPII

Atlantic versus Pacific Agreement in Agri-food Sectors: Does the Winner Take it All?

Anne-Célia Disdier, Charlotte Emlinger & Jean Fouré

Appendix

RESEARCH AND EXPERTISE
ON THE WORLD ECONOMY

MIRAGE (Online appendix)

This document presents the key elements of the MIRAGE[1] model's structure. The model's equations are presented below. The documentation of the model consists of three papers:

- Bchir, H., Decreux, Y., Guérin, J.-L., and Jean, S. (2002), 'MIRAGE, a computable general equilibrium model for trade policy analysis' CEPII Working Paper no 2002-17.
- Decreux, Y., and Valin, H. (2007), 'MIRAGE, an updated version of the model for trade policy analysis Focus on agriculture and dynamics' CEPII Working Paper no 2007-15.
- Fontagné, L., Fouré, J. and Ramos, M.-P. (2013) 'MIRAGE-e: a general equilibrium long-term path of the world economy' CEPII Working Paper no 2013-39.

Supply Side On the supply side, each sector in MIRAGE is modeled as a representative firm, which combines value-added and intermediate consumption in fixed shares. Value-added is a CES bundle of imperfectly substitutable primary factors (capital, skilled and unskilled labor, land and natural resources). Firm's demand for production factors is organized as a CES aggregation of land, natural resources, unskilled labor, and a bundle of the remaining factors. This bundle is a nested CES aggregate of skilled labor and capital (that are considered as relatively more complementary).

MIRAGE assumes full employment of primary factors. Population, participation in the labor market and human capital evolve in each country (or region of the world economy) according to the demographics embedded in the macro projections. This determines the labor force as well as its skill composition (skilled/unskilled). Skilled and unskilled labor is perfectly mobile across sectors, but immobile between countries. Natural resources are sector specific, while land is mobile between agricultural sectors. Natural resources and total land for agricultural sectors are set at their 2007 levels: prices adjust demand to this fixed supply.

Installed capital is assumed to be immobile (sector-specific), while investments are allocated across sectors according to their rates of return. The overall stock of capital evolves by combining capital formation and a constant depreciation rate of capital of 6% that is the same as in the long-term growth models. Gross investment is determined by the combination of saving (the saving rate from the growth model, applied to the national income) and the current account. Finally, while total investment is saving-driven, its allocation is determined by the rate of return on investment in the various activities. For simplicity, and because we lack reliable data on foreign direct investment at country of origin, host and sectoral levels, international capital flows only appear through the current account imbalances, and are not explicitly modeled.

Demand side On the demand side, a representative consumer from each country/region maximizes instantaneous utility under a budget constraint and saves a part of its income, determined by saving rates projected in the long-term growth model. Expenditure is allocated to commodities and services according to a LES-CES (Linear Expenditure System – Constant Elasticity of Substitution) function. This implies that, above a minimum consumption of goods produced by each sector, consumption choices among goods produced by different sectors are made according to a CES function. This representation of preferences is well suited to our purpose as it is flexible enough to deal with countries at different levels of development.

Within each sector, goods are differentiated by their origin. A nested CES function allows for a particular status for domestic products according to the usual Armington hypothesis (Armington, 1969): consumer's and firm's choices are biased towards domestic production, and therefore domestic and foreign

[1] This version is nicknamed MIRAGE-e 1.0 (1.0.1 – revision 97).

goods are imperfectly substitutable, using a CES specification. We use Armington elasticities provided by the GTAP database and estimated by Hertel et al. (2007). Total demand is built from final consumption, intermediate consumption and investment in capital goods.

Dynamics Dynamics in MIRAGE are of two kinds: the total factor productivity is calibrated in a baseline exercise, while production factors dynamics are set exogenously. Both are built in MIRAGE using macroeconomic projections from the MaGE model documented in Fouré et al. (2013).

Total factor productivity is based on the combination of three mechanisms. First, agri-food productivity is projected separately, as detailed in Fontagné et al. (2013). Second, a 2 percentage point growth difference between TFP in manufactures and services is assumed (as in van der Mensbrugghe, 2005). Third, the aggregate country-level TFP is calibrated in the baseline exercise in order to match both production factors and GDP projections resulting from the aggregate growth model, given the exogenous agri-food productivity and the productivity gap between manufacturing and services.

Dynamics in MIRAGE is implemented in a sequentially recursive way. That is, the equilibrium can be solved successively for each period, given the exogenous trajectory for sector-specific TFP calibrated as described above, the accumulation of production factors – savings, current accounts, active population and skill level – coming from the growth model. Simulations extend up to 2025. Finally, MIRAGE is calibrated on the GTAP dataset version 8.1, with 2007 as a base year.

References

Armington, P.S. (1969), 'A Theory of Demand for Products Distinguished by Place of Production', *Staff Papers - International Monetary Fund*, 16(1): 159–178.

Fontagné, L., Fouré, J. and Ramos, M.-P. (2013) 'MIRAGE-e: a general equilibrium long-term path of the world economy' CEPII Working Paper no 2013-39.

Fouré, J., Bénassy-Quéré, A., and Fontagné, L. (2013) 'Modelling the world economy at the 2050 horizon', *Economics of Transition*, 21(4): 617–654.

Hertel, T.W., Hummels, D., Ivanic, M., and Keeney, R. (2007) 'How confident can we be of CGE-based assessments of Free Trade Agreements?, *Economic Modelling*, 24(4): 611-635.

Van der Mensbrugghe, D. (2005) *LINKAGE Technical Reference Document*, World Bank, Washington DC.

Options not included:

- Energy in the value-added bundle.
- Quality differentiation depending on the origin of goods.
- Imperfect competition.
- Carbon policy.

1 Notation

1.1 Variable names

Any variable X in MIRAGE will be associated with its price P^X, unless explicited otherwise. In addition, we use several conventions:

- $EVoleX$ will denote the counterpart of variable X measured in energy quantity (Mtoe)
- $EmCO2X$ will denote the counterpart of variable X measured in quantity of CO_2 emissions ($MtCO_2$)
- $X^\star$ will denote variable X measured at initial prices (ex. : $GDP_{r,t}$ and $GDP^\star_{r,t}$).

1.2 Indexes

Regarding indexes, we will use the following notations:

- i and j will refer to sectors. i will be used preferentially for goods while j will represent sectors.
- r and s will represent regions.When appropriate r will denote the origin while s will represent the destination. r^* will correspond to the reference region (the first one).
- t will denote time (in years). The reference year is indexed by t_0.

1.3 Functional forms

Any relation between two variables A and B forming a bundle X will be parametrized by share or scale coefficients α^A and α^B. When appropriate, the elasticity of substitution between A and B inside X will be noted σ_X.

In a nutshell, we will use the following abreviations for functional forms:

- $X \equiv Leontief\left[A;B\right]$ for Leontief-like relationships,
- $X \equiv CES^{\sigma_X}\left[A;B\right]$ for Constant Elasticity of Substitution,
- and $X \equiv CD\left[A;B\right]$ for Cobb-Douglas.

More than two components Our functional form will in many case have more than two componants. We then will add the other components in the notation, as in $CD\left[\left(A,P^A\right);\left(B,P^B\right);\left(C,P^C\right)\right]$. However, if these components can be indexed by subscript k, then we will write $\left(X,P^X\right) \equiv CES_k^{\sigma_X}\left[A_k,P_k^A\right]$, $Leontief_k\left[A_k,P_k^A\right]$ or $CD_k\left[A_k,P_k^A\right]$.

1.4 Booleans

We differentiate sectors by using booleans. For instance, if SET represents only some sectors, $SET\left(i\right)$ will be $true$ only for sectors in SET. ($false$ otherwise) We can also write $i \in SET$ or $i \notin SET$ to denote inclusion of i in SET.

2 Parameters

Booleans

$TrT(i)$	i is a transportation sector
$Agri(i)$	i is an agricultural sector
$Serv(i)$	i is a services sector

Supply

σ_i^{IC}	Elasticity of substitution between intermediate consumption ($\sigma_i^{IC} = 0.6$)
σ_i^{VA}	Elasticity of substitution between first-level value added ($\sigma_i^{VA} = 1.1$)
σ_i^{VAQL}	Elasticity of substitution between second-level value added components (σ_i^{VAQL} from GTAP)
σ_i^{Q}	Elasticity of substitution between Skilled Labor and Capital ($\sigma_i^{Q} = 0.6$)

Demand

$cmin_{i,r}$	Minimal consumption level for LES-CES (calibrated)
$\mu_{j,r,s}$	Transport demand per unit of volume (calibrated)
PWO_i	Normalisation parameter for world average price (calibrated)
σ_r^C	Elasticity of substitution between final consumptions (calibrated)
σ^{KG}	Elasticity of substitution between capital goods ($\sigma^{KG} = 0.6$)
σ_i^{IMP}	Elasticity of substitution between foreign origins (σ_i^{IMP} from GTAP)
σ_i^{ARM}	Elasticity of substitution between domestic and foreign good ($\sigma_i^{ARM} = (\sigma_i^{IMP} - 1)/\sqrt{2}) + 1$)

Factor markets

$TotalLand_r^0$	Initial land supply (from GTAP)
σ^{Land}	Land elasticity of transformation ($\sigma^{Land} = 0.5$)
δ_r	Capital depreciation rate ($\delta_r = 0.06$)

Taxes and equivalents

$tax^{IC}_{i,j,r,t}$	Tax on intermediate consumption
$tax^{C}_{i,r,t}$	Tax on intermediate consumption
$tax^{KG}_{i,r,t}$	Tax on capital good consumption
$tax^{P}_{i,r,t}$	Tax on production
$subf^{Land}_{i,r,t}$	Subsidy to land use
$subf^{UnSkL}_{i,r,t}$	Subsidy to unskilled labor
$subf^{SkL}_{i,r,t}$	Subsidy to skilled labor
$subf^{Capital}_{i,r,t}$	Subsidy to capital
$Tariff_{i,r,s,t}$	Import duty (and tariff-equivalent for NTMs when appropriate)
$tCost_{i,r,s,t}$	Iceberg cost (for time spent in customs, NTMs, etc.)
$tax^{EXP}_{i,r,s,t}$	Export tax from GTAP (and export tax equivalent for NTMs when appropriate)
$tax^{AMF}_{i,r,s,t}$	Export tax equivalent to Multi-fiber agreement quotas (from GTAP)

Energy and CO_2 emissions

$\varepsilon^{Y}_{e,r}$	Conversion coefficient for energy content of production (Mtoe)
$\varepsilon^{C}_{e,r}$	Conversion coefficient for energy content of final consumption (Mtoe)
$\varepsilon^{IC}_{e,j,r}$	Conversion coefficient for energy content of intermediate consumption (Mtoe)
$\varepsilon^{D}_{e,r}$	Conversion coefficient for energy content of domestic demand (Mtoe)
$\varepsilon^{DEM}_{e,j,r}$	Conversion coefficient for energy content of foreign demand (Mtoe)
$\kappa^{H}_{e,r}$	Conversion coefficient for CO_2 content of final consumption ($MtCO_2$)
$\kappa^{IC}_{e,j,r}$	Conversion coefficient for CO_2 content of intermediate consumption ($MtCO_2$)

Revenues and macroeconomic closure

$Sav_{r,t}$	Savings rate
$a_{i,r,s}$	Investment initial scale coefficient
α	Elasticity of investment to return on capital ($\alpha = 40$)

Dynamics

$g^{L}_{r,t}$	Exogenous growth rate of unskilled labor (from EconMap)
$g^{H}_{r,t}$	Exogenous growth rate of skilled labor (from EconMap)
$\Delta Savings_{r,t}$	Exogenous variation in savings rate (pct. of GDP, from EconMap)
$g^{EProd}_{r,t}$	Exogenous growth rate of energy productivity (from EconMap)
$g^{GDP}_{r,t}$	Exogenous growth rate of GDP (from EconMap)
$TFPAgri_{j,r,t}$	Exogenous growth rate of agricultural TFP
Δg^{TFP}_{j}	Exogenous gap between industry and services productivity growth rate ($\Delta g^{TFP}_{j} = 0.02$ if $j \in Serv$, $\Delta g^{TFP}_{j} = 0$ otherwise)
$\Delta CABal_{r,t}$	Exogenous variation in current account balance (pct. of world GDP, from EconMap)

3 Variables

Supply

First Level

$Y_{i,r,t}$	Output of sector i
$VA_{i,r,t}$	Value added
$CNTER_{i,r,t}$	Aggregate intermediate consumption

Factors

$Land_{i,r,t}$	Land factor
$NatRes_{i,r,t}$	Natural resources
$RESV_{i,t}$	Natural resources adjustment coefficient
$UnSkL_{i,r,t}$	Unskilled labor
$SkL_{i,r,t}$	Skilled labor
$Capital_{i,r,t}$	Capital

Aggregates

$VAQL_{i,r,t}$	Unskilled labor and Q aggregate
$Q_{i,r,t}$	Skilled labor and Capital aggregate

Intermediate consumption

$IC_{i,j,r,t}$	Intermediate consumption of good i by sector j

Demand

Final demand

$U_{r,t}$	Consumer utility
$C_{i,r,t}$	Final consumption of good i
$BUDC_{r,t}$	Budget allocated to consumption

Capital good

$INVTOT_{r,t}$	Total investment in region r
$INV_{i,r,s,t}$	Investment from r to sector i in s
$KG_{i,r,t}$	Capital demand for good i

Aggregate demand

$DEMTOT_{i,s,t}$	Total demand for good i in region s
$M_{i,s,t}$	Demand for imported good i
$D_{i,s,t}$	Domestic demand for good i
$DEM_{i,r,s,t}$	Demand in region s for good i from region r
$TRADE_{i,r,s,t}$	Exports of good i from region r to region s

Transport

$TR_{i,r,s,t}$	Transport demand to route good i from r to s
$TRMode_{j,i,r,s,t}$	Demand for transport type j to route good i from r to s
$TRSupply_{j,r,t}$	Supply of transport type j
$WorldTR_{j,t}$	Aggregate supply of transport mode j

Prices

$P^{FOB}_{i,r,s,t}$	Free On Bord price
$P^{CIF}_{i,r,s,t}$	Price including Cost, Insurance and Freight
$P^{WORLD}_{i,t}$	World average price for good i

Factor markets

$TotalUnSkL_{r,t}$	Total supply of unskilled labor
$TotalSkL_{r,t}$	Total supply of skilled labor
$TotalLand_{r,t}$	Total supply for land
$TotalCapital_{r,t}$	Total capital supply
$w^{Land}_{j,r,t}$	Land return rate in sector j
$w^{TotalLand}_{j,r,t}$	Land return rate
$w^{Capital}_{j,r,t}$	Capital return rate in sector j
$w^{TotalCapital}_{r,t}$	Capital return rate
$w^{UnSkL}_{r,t}$	Wage for unskilled labor
$w^{SkL}_{r,t}$	Wage for skilled labor

Energy and CO_2 emissions

Energy in Mtoe

$AgCons_{e,r,t}$	Quantity conservation adjustment coefficient (consumption side)
$AgDem_{e,r,t}$	Quantity conservation adjustment coefficient (demand side)
$EVoleY_{e,r,t}$	Production of energy e (Mtoe)
$EVoleC_{e,r,t}$	Final consumption of energy e (Mtoe)
$EVoleIC_{e,j,r,t}$	Intermediate consumption of energy e (Mtoe)
$EVoleCons_{e,r,t}$	Total consumption of energy e in region r (Mtoe)
$EVoleD_{e,r,t}$	Domestic demand for energy e (Mtoe)
$EVoleDEM_{e,r,s,t}$	Foreign demand for energy e (Mtoe)
$EVoleDEMTOT_{e,s,t}$	Total demand for energy e in region s
$EVoleDEMfromReg_{e,r,t}$	Total demand for energy e from region r

CO_2 emissions

$EmCO_2IC_{e,j,r,t}$	CO_2 emissions from intermediate consumption of energy e in sector j ($MtCO_2$)
$EmCO_2H_{e,r,t}$	CO_2 emissions from finale consumption of energy e ($MtCO_2$)

Revenues and macroeconomic closure

Revenues

$ProdTaxREV_{i,r,t}$	Revenue from production tax
$ExpTaxREV_{i,r,t}$	Revenue from export tax
$TariffREV_{i,s,t}$	Revenue from tariffs
$ConsTaxREV_{i,s,r}$	Revenue from consumption tax
$TaxREV_{s,t}$	Total tax revenues
$REV_{r,t}$	Total revenues

Closure

$B_{r,t}$	Investment scale coefficient
$CABal_{r,t}$	Current account balance

GDP and numeraire

$D^{NA}_{i,r,t}$	Domestic demand (National Accounts method)
$DEM^{NA}_{i,r,s,t}$	Foreign demand (National Accounts method)
$DEMTOT^{NA}_{i,s,t}$	Total demand (National Accounts method)
$DEMTOT^{NA^\star}_{i,s,t}$	Total demand at initial prices (National Accounts method)
$KG^{NA}_{i,r,t}$	Capital good demand (National Accounts method)
$C^{NA}_{i,r,t}$	Final consumption (National Accounts method)
$TFPJ_{j,r,t}$	Sector-specific component of TFP
$TFP_{r,t}$	National component of TFP
$GDP_{r,t}$	Gross Domestic Product
$GDP^{\star}_{i,r,t}$	Gross Domestic Product at initial prices
$WGDPVAL_t$	World GDP

4 Equations

4.1 Supply

First-stage in production function

$$Y_{i,r,t} \equiv Leontief\left[VA_{i,r,t}; CNTER_{i,r,t}\right] \tag{1}$$

Intermediate consumption

$$CNTER_{i,r,t} \equiv CES_j^{\sigma_i^{IC}}\left[IC_{i,j,r,t}\right] \tag{2}$$

$$P^{IC}_{i,j,r,t} = P^{DEMTOT}_{i,r,t}\left(1 + tax^{IC}_{i,j,r,t}\right) \tag{3}$$

Value added

$$\frac{VA_{i,r,t}}{\left(TFP_{r,t}TFPJ_{j,r,t}\right)^{\sigma_i^{VA}}} \equiv CES^{\sigma_i^{VA}}\left[Land_{i,r,t}; NatRes_{i,r,t}RESV_{i,t}; VAQL_{i,r,t}\right] \tag{4}$$

$$VAQL_{i,r,t} \equiv CES^{\sigma_i^{VAQL}}\left[UnSkL_{i,r,t}; Q_{i,r,t}\right] \tag{5}$$

$$Q_{i,r,t} \equiv CES^{\sigma_i^{Q}}\left[SkL_{i,r,t}; Capital_{i,r,t}\right] \tag{6}$$

$$P^{EIC}_{i,j,r,t} = P^{DEMTOT}_{i,r,t}\left(1 + tax^{IC}_{i,j,r,t}\right) \tag{7}$$

4.2 Demand

Final demand

$$U_{r,t} \equiv CES_i^{\sigma^C}\left[C_{i,r,t} - cmin_{i,r}\right] \tag{8}$$

$$BUDC_{r,t} = \sum_i P^C_{i,r,t}C_{i,r,t} \tag{9}$$

$$P^C_{i,r,t} = P^{DEMTOT}_{i,r,t}\left(1 + tax^C_{i,r,t}\right) \tag{10}$$

Capital good

$$INVTOT_{s,t} \equiv CES_i^{\sigma^{KG}}\left[KG_{i,s,t}\right] \tag{11}$$

$$P^{KG}_{i,r,t} = P^{DEMTOT}_{i,r,t}\left(1 + tax^{KG}_{i,r,t}\right) \tag{12}$$

Aggregate demand

$$DEMTOT_{i,s,t} = C_{i,s,t} + \sum_j IC_{i,j,s,t} \tag{13}$$

$$DEMTOT_{i,r,s} \equiv CES^{\sigma^{ARM}}\left[D_{i,s,t}; M_{i,s,t}\right] \tag{14}$$

$$M_{i,r,s} \equiv CES_r^{\sigma_i^{IMP}}\left[DEM_{i,r,s,t}\right] \tag{15}$$

Transport

$$TRADE_{i,r,s,t} = DEM_{i,r,s,t} \tag{16}$$

$$TR_{j,r,s,t} = \mu_{j,r,s}\left(1 + tCost_{i,r,s,t}\right) TRADE_{j,r,s,t} \tag{17}$$

$$TR_{j,r,s,t} \equiv CD_{i \in TrT}\left[TRMode_{i,j,r,s,t}\right] \tag{18}$$

$$WorldTR_{i,t} \equiv CD_r\left[TRSupply_{i,r,t}\right] \text{ if } i \in TrT \tag{19}$$

$$WorldTR_{i,t} = \sum_{j,r,s} TRMode_{i,j,r,s} \text{ if } i \in TrT \tag{20}$$

Prices

$$P_{i,r,s,t}^{FOB} = P_{i,r,t}^{Y}\left(1 + tCost_{i,r,s,t}\right)\left(1 + tax_{i,r,t}^{P}\right)\left(1 + tax_{i,r,s,t}^{EXP} + tax_{i,r,s,t}^{AMF}\right) \tag{21}$$

$$P_{i,r,s,t}^{CIF} = P_{i,r,s,t}^{FOB} + \mu_{i,r,s} P_{i,r,s,t}^{TR}\left(1 + tCost_{i,r,s,t}\right) \tag{22}$$

$$P_{i,r,t}^{D} = P_{i,r,t}^{Y}\left(1 + tax_{i,r,t}^{P}\right) \tag{23}$$

$$P_{i,r,s,t}^{DEM} = P_{i,r,s,t}^{CIF}\left(1 + Tariff_{i,r,s,t}\right) \tag{24}$$

$$P_{i,t}^{WORLD} = \frac{1}{PWO_i}\left[\prod_{r,s}\left(P_{i,r,s,t}^{CIF}\right)^{TRADE_{i,r,s,t}}\right]^{\frac{1}{\sum_{r,s} TRADE_{i,r,s,t}}} \tag{25}$$

Commodity market equilibrium

$$Y_{i,r,t} = \begin{cases} D_{i,r,t} + \sum_s DEM_{i,r,s,t} & \text{if } i \notin TrT \\ D_{i,r,t} + \sum_s DEM_{i,r,s,t} + TRM_{i,r,t} & \text{if } i \in TrT \end{cases} \tag{26}$$

4.3 Factor markets

Labor

$$TotalUnSkL_{r,t} = \sum_j UnSkL_{j,r,t} \tag{27}$$

$$TotalSkL_{r,t} = \sum_j SkL_{j,r,t} \tag{28}$$

Land

$$TotalLand_{r,t} \equiv CET_i^{\sigma^{Land}}\left[\left(w_{i,r,t}^{Land}, Land_{i,r,t}\right)\right] \tag{29}$$

$$TotalLand_{r,t} = TotalLand_r^0\left(\frac{w_{r,t}^{TotalLand}}{P_{r,t}^{U}}\right)^{\sigma^{TotalLand}} \tag{30}$$

$$TotalLand_{r,t} = \sum_j Land_{j,r,t} \tag{31}$$

$$w_{j,r,t}^{Land} = w_{r,t}^{TotalLand} \tag{32}$$

Capital Stock and investment

$$K_{i,r,s,t} = K_{i,r,s,t-1}\left(1 - \delta_r\right) + INV_{i,r,s,t} \tag{33}$$

$$Capital_{i,s,t} = \sum_r K_{i,r,s,t} \tag{34}$$

$$TotalCapital_{r,t} = \sum_j Capital_{j,r,t} \tag{35}$$

Factor-based subsidies

$$P^{Land}_{i,r,t} = w^{Land}_{i,r,t} - P^{U}_{r,t} subf^{Land}_{i,r,t} \tag{36}$$

$$P^{UnSkL}_{i,r,t} = w^{UnSkL}_{r,t} - P^{U}_{r,t} subf^{UnSkL}_{i,r,t} \tag{37}$$

$$P^{SkL}_{i,r,t} = w^{SkL}_{r,t} - P^{U}_{r,t} subf^{SkL}_{i,r,t} \tag{38}$$

$$P^{Capital}_{i,r,t} = w^{Capital}_{i,r,t} - P^{U}_{r,t} subf^{Capital}_{i,r,t} \tag{39}$$

4.4 Energy and CO_2 emissions

Energy in Mtoe

Production

$$EVoleY_{e,r,t} = \varepsilon^{Y}_{e,r} \,.\, Y_{e,r,t} \tag{40}$$

Consumption

$$EVoleC_{e,r,t} = AgCons_{e,r,t} \,.\, \varepsilon^{C}_{e,r} \,.\, C_{e,r,t} \tag{41}$$

$$EVoleIC_{e,j,r,t} = AgCons_{e,r,t} \,.\, \varepsilon^{IC}_{e,j,r} \,.\, IC_{e,j,r,t} \tag{42}$$

$$EVoleCons_{e,r,t} = EVoleC_{e,r,t} + \sum_{j} EVoleIC_{e,j,r,t} \tag{43}$$

Demand

$$EVoleD_{e,r,t} = AgDem_{e,r,t} \,.\, \varepsilon^{D}_{e,r} \,.\, D_{e,r,t} \tag{44}$$

$$EVoleDEM_{e,r,s,t} = AgDem_{e,r,t} \,.\, \varepsilon^{DEM}_{e,r,s} \,.\, DEM_{e,r,s,t} \tag{45}$$

$$EVoleDEMTOT_{e,s,t} = EVoleD_{e,s,t} + \sum_{r} EVoleDEM_{e,r,s,t} \tag{46}$$

$$EVoleDEMfromReg_{e,r,t} = EVoleD_{e,r,t} + \sum_{s} EVoleDEM_{e,r,s,t} \tag{47}$$

Quantity accounting

$$EVoleY_{e,r,t} = EVoleDEMfromReg_{e,r,t} \tag{48}$$

$$EVoleCons_{e,r,t} = EVoleDEMTOT_{e,r,t} \tag{49}$$

CO_2 emissions

$$EmCO_2IC_{e,j,r,t} = AgCons_{e,r,t} \,.\, \kappa^{IC}_{e,j,r} \,.\, IC_{e,j,r,t} \tag{50}$$

$$EmCO_2H_{e,r,t} = AgCons_{e,r,t} \,.\, \kappa^{H}_{e,r} \,.\, C_{e,r,t} \tag{51}$$

4.5 Revenues and macroeconomic closure

Revenues

Production tax

$$ProdTaxREV_{i,r,t} = tax^{P}_{i,r,t} \,.\, P^{Y}_{i,r,t} \,.\, Y_{i,r,t} \tag{52}$$

Export tax

$$ExpTaxREV_{i,r,t} = \sum_{s} \left[\left(tax^{EXP}_{i,r,s,t} + tax^{AMF}_{i,r,s,t} \right) \,.\, \left(1 + tax^{P}_{i,r,t} \right) \left(1 + tCost_{i,r,s,t} \right) P^{Y}_{i,r,t} \,.\, TRADE_{i,r,s,t} \right] \tag{53}$$

Tariff

$$TariffREV_{i,s,t} = \sum_{r} Tariff_{i,r,s,t} \,.\, P^{CIF}_{i,r,s,t} \,.\, TRADE_{i,r,s,t} \tag{54}$$

Consumption tax

$$\begin{aligned} ConsTaxREV_{i,s,t} = & \, tax^{C}_{i,s,t} \, . \, P^{DEMTOT}_{i,s,t} \, . \, C_{i,s,t} \\ & + tax^{KGC}_{i,s,t} \, . \, P^{DEMTOT}_{i,s,t} \, . \, KG_{i,s,t} \\ & + \sum_{j} tax^{IC}_{i,j,s,t} \, . \, P^{DEMTOT}_{i,s,t} \, . \, IC_{i,j,s,t} \end{aligned} \tag{55}$$

Total revenue

$$TaxREV_{s,t} = \sum_{i} ProdTaxREV_{i,s,t} + ExpTaxREV_{i,s,t} + TariffREV_{i,s,t} + ConsTaxREV_{i,s,t} \tag{56}$$

$$\begin{aligned} REV_{r,t} = & \sum_{i} [P^{NatRes}_{i,r,t} NatRes_{i,r,t} + P^{Land}_{i,s,t} Land_{i,s,t} + P^{SkL}_{i,s,t} SkL_{i,s,t} \\ & + P^{UnSkL}_{i,s,t} UnSkL_{i,s,t} + \sum_{s} PCapital_{i,s,t} K_{i,r,s,t}] \\ & + TaxREV_{r,t} \end{aligned} \tag{57}$$

$$BUDC_{r,t} = (1 - Sav_{r,t}) \, REV_{r,t} \tag{58}$$

Closure

$$INV_{i,r,s,t} = B_{r,t} a_{i,r,s} Capital_{i,s,t} \exp\left[\alpha \left(\frac{w^{Capital}_{i,s,t}}{P^{INVTOT}_{s,r}} - \delta_r\right)\right] \tag{59}$$

$$INVTOT_{s,t} = \sum_{i,r} INV_{i,r,s,t} \tag{60}$$

$$Sav_{r,t} REV_{r,t} = \sum_{i,s} P^{INVTOT}_{s,t} INV_{i,r,s,t} + WGDPVAL_t \, . \, CABal_{r,t} \tag{61}$$

GDP and numeraire

National Accounts

$$\left(P^{D^{NA}}_{i,r,t}, D^{NA}_{i,r,t}\right) = \left(P^{D}_{i,r,t}, D_{i,r,t}\right) \tag{62}$$

$$P^{DEM^{NA}}_{i,r,s,t} = P^{DEM}_{i,r,s,t} \tag{63}$$

$$DEMTOT^{NA}_{i,s,t} = P^{D^{NA}}_{i,s,t} D^{NA}_{i,s,t} + \sum_{r} P^{DEM^{NA}}_{i,r,s,t} TRADE_{i,r,s,t} \tag{64}$$

$$P^{DEMTOT^{NA}}_{i,s,t} = \frac{DEMTOT^{NA}_{i,s,t}}{DEMTOT^{NA^{\star}}_{i,s,t}} \tag{65}$$

$$\left(P^{KG^{NA}}_{i,r,t}, KG^{NA}_{i,r,t}\right) = \left(P^{DEMTOT^{NA}}_{i,s,t} \left(1 + tax^{KG}_{i,r,t}\right), \frac{P^{KG}_{i,r,t}}{P^{KG^{NA}}_{i,r,t}} KG_{i,r,t}\right) \tag{66}$$

$$\left(P^{C^{NA}}_{i,r,t}, C^{NA}_{i,r,t}\right) = \left(P^{DEMTOT^{NA}}_{i,s,t} \left(1 + tax^{C}_{i,r,t}\right), \frac{P^{C}_{i,r,t}}{P^{C^{NA}}_{i,r,t}} C_{i,r,t}\right) \tag{67}$$

$$\begin{aligned} GDP_{r,t} = & \sum_{i} P^{C^{NA}}_{i,r,t} C^{NA}_{i,r,t} + P^{KG^{NA}}_{i,r,t} KG^{NA}_{i,r,t} \\ & + \sum_{i \in TrT(i)} P^{Y}_{i,r,t} \left(1 + tax^{P}_{i,r,t}\right) TrSupply_{i,r,t} \\ & + \sum_{i,s} \left(P^{FOB}_{i,r,s,t} TRADE_{i,r,s,t} - P^{CIF}_{i,s,r,t} TRADE_{i,s,r,t}\right) \end{aligned} \tag{68}$$

Numeraire

$$WGDPVAL_t = \sum_r GDP_{r,t} \tag{69}$$

$$\sum_r GDP^{\star}_{r,t} = WGDPVAL_t \tag{70}$$

4.6 Dynamics

Exogenous variables

$$TotalUnSkL_{r,t} = \left(1 + g^{L}_{r,t}\right) TotalUnSkL_{r,t-1} \tag{71}$$

$$TotalSkL_{r,t} = \left(1 + g^{H}_{r,t}\right) TotalSkL_{r,t-1} \tag{72}$$

$$Sav_{r,t} = Sav_{r,t-1} + \Delta Savings_{r,t} \tag{73}$$

Baseline

$$GDP^{\star}_{r,t,ref} = \left(1 + g^{GDP}_{r,t}\right) GDP^{\star}_{r,t-1,ref} \tag{74}$$

$$TFPJ_{j,r,t,ref} \; . \; TFP_{r,t,ref} = \begin{cases} TFPAgri_{j,r,t} & \text{if } j \in Agri \\ \left(1 + \Delta g^{TFP}_{j}\right) TFPJ_{j,r,t-1,ref} \; . \; TFP_{r,t,ref} & \text{if } j \notin Agri \end{cases} \tag{75}$$

$$CABal_{r,t,ref} = CABal_{r,t-1,ref} + \Delta CABal_{r,t} \tag{76}$$

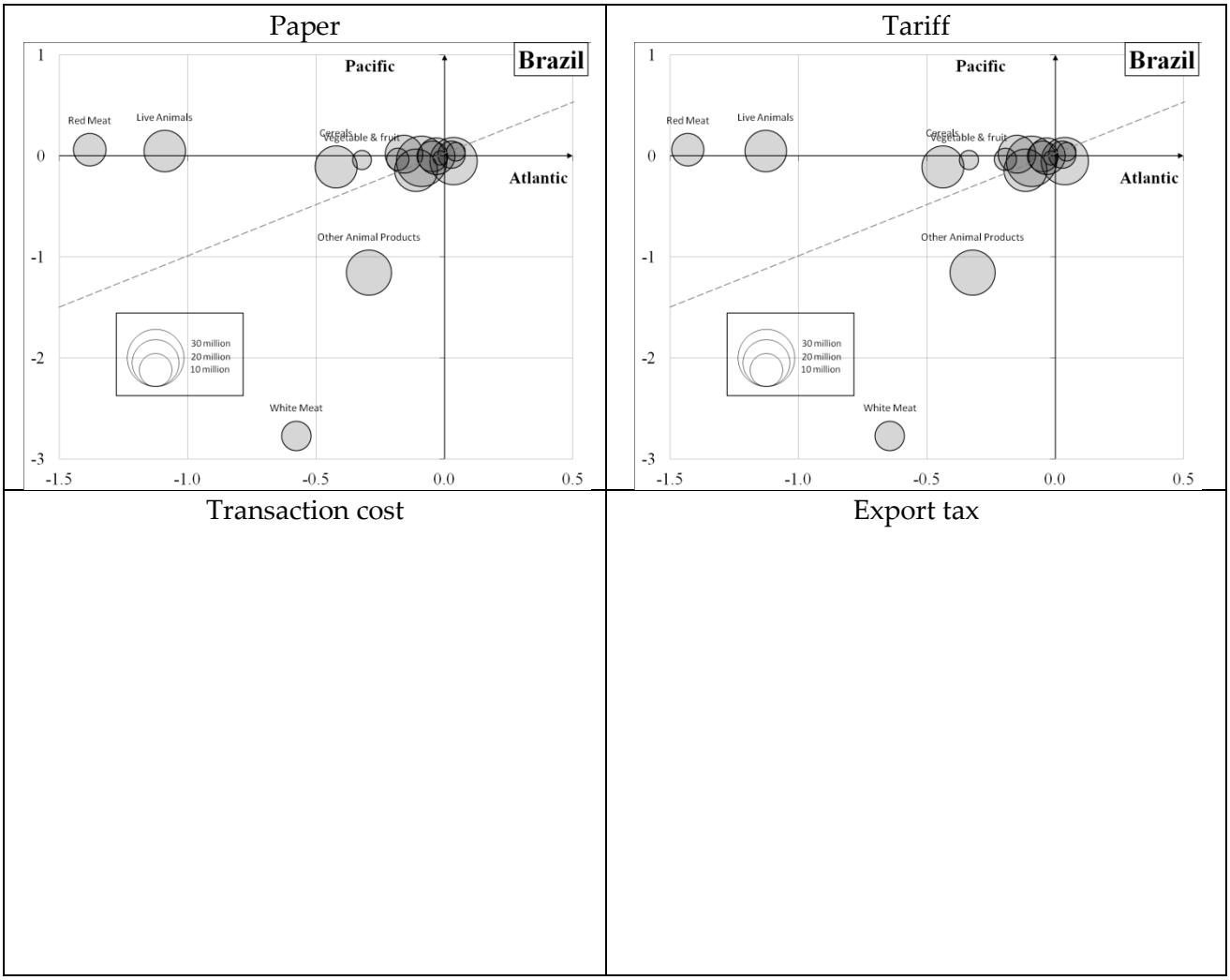
Simulation

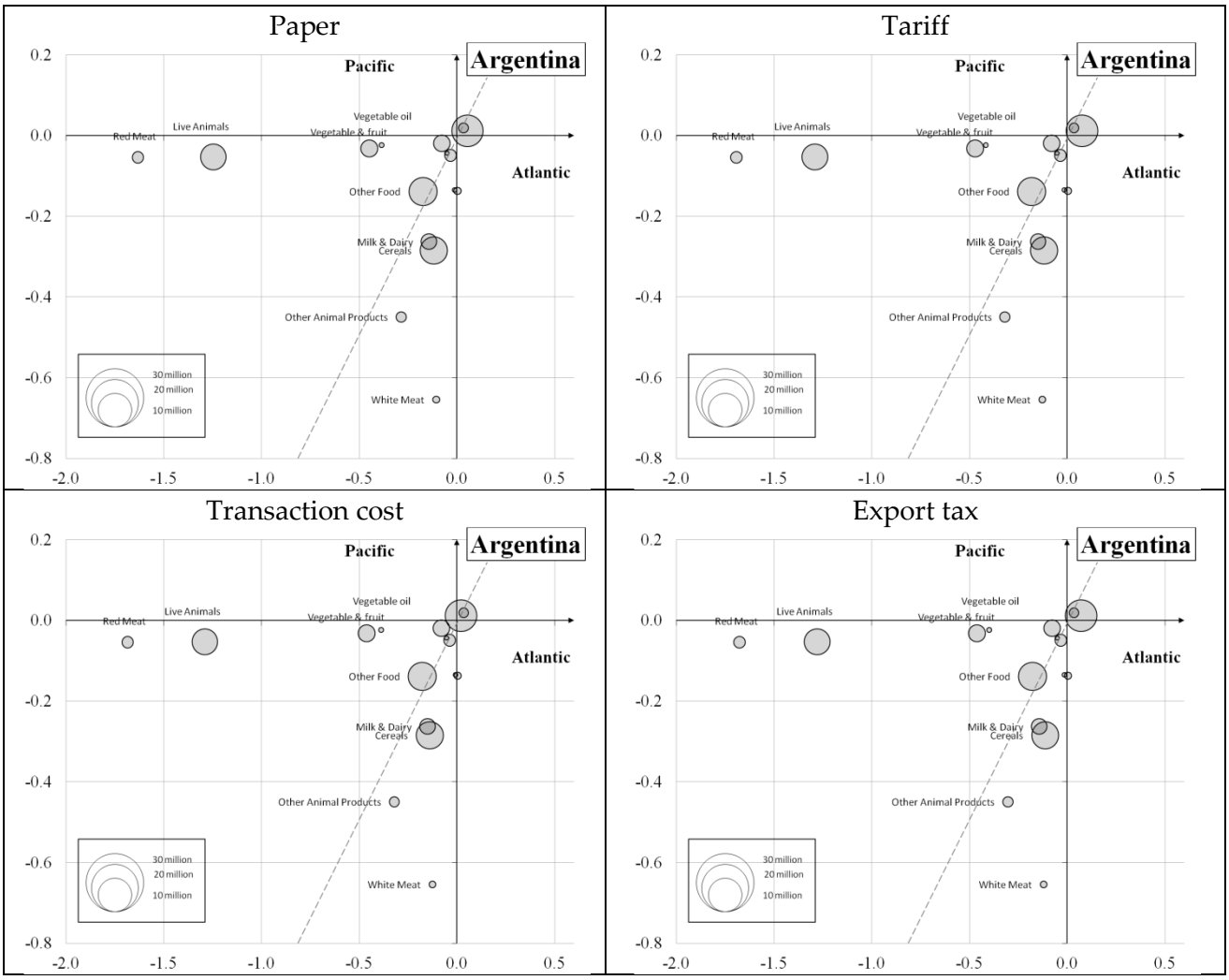
$$TFPJ_{j,r,t,sim} = TFPJ_{j,r,t,ref} \tag{77}$$

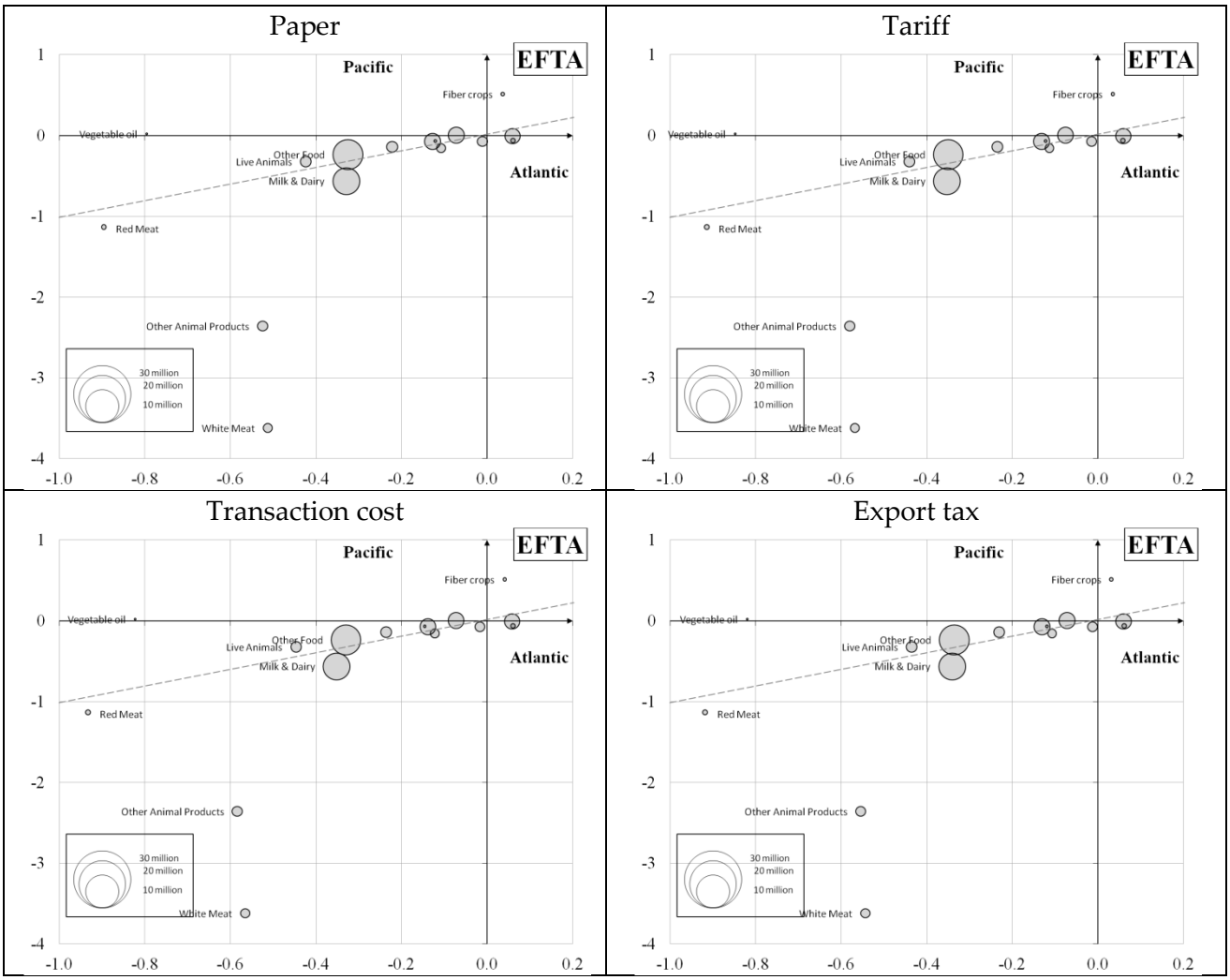
$$TFP_{r,t,sim} = TFP_{r,t,ref} \tag{78}$$

$$CABal_{r,t,sim} = CABal_{r,t,ref} \tag{79}$$

Figure 2 Comparative variation in agri -food output (pct. variation) and initial agri -food value added (million 2007 USD) for third countries, 2025




Paper
Tariff
Transaction cost
Export tax
Argentina
Pacific
Atlantic
Red Meat
Live Animals
Vegetable & fruit
Vegetable oil
Other Food
Milk & Dairy
Cereals
Other Animal Products
White Meat
30 million
20 million
10 million
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-2.0
-1.5
-1.0
-0.5
0.0
0.5


Paper
Tariff
Transaction cost
Export tax
EFTA
Pacific
Atlantic
Fiber crops
Vegetable oil
Other Food
Live Animals
Milk & Dairy
Red Meat
Other Animal Products
White Meat
30 million
20 million
10 million
1
0
-1
-2
-3
-4
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2