LINCOLN TRADE AND ENVIRONMENT MODEL

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1. Brief overview

The LTEM is an agricultural multi-country, multi-commodity model which uses a partial equilibrium framework to quantify and analyze the price, supply, demand and net trade effects of various domestic agricultural and border policy changes and non-policy induced changes. The commodities included in the model are treated as homogenous with respect to the country of origin and destination and to physical characteristics of the product. Importers and exporters are assumed to be indifferent about their trade partners. Therefore commodities are perfect substitutes in consumption in international markets. Based on this, the model was built as a non-spatial type which emphasizes the net trade of commodities in each region instead of the bilateral trade flows between the countries. However, the supply and demand shares of countries in trade can be traced down. The economic welfare implications of policy changes are also calculated in the LTEM by using the producer and consumer surplus measures.

The interdependencies between primary and processed products and/or between substitutes are reflected by cross-price elasticity measures. In general there are six behavioural equations and one economic identity for each commodity under each country in the LTEM framework. Basically, the model works by simulating the commodity based world market clearing price on the domestic quantities and prices, which may or may not be under the effect of policy changes, in each country. Excess domestic supply or demand in each country spills over onto the world market to determine world prices. The world market-clearing price is determined at the level that equilibrates the total excess demand and supply of each commodity in the world market by using a non-linear optimization algorithm, namely Newton’s global or search algorithm (Fair, 1984; Wooldridge, 2002).

The dairy sector is modeled as five commodities, raw milk is defined as the farm gate product and then is allocated to the liquid milk, butter, cheese, whole milk powder or skim milk powder markets depending upon their relative prices subject to physical constraints. The meat sector is disaggregated into sheep meat, beef and pig meat and the poultry sector (poultry meat and eggs) and wool are also explicitly modeled. There are seven crop products (wheat, sugar, coarse grains, rice, oilseeds, oil meals, oil) in the LTEM.

2. General characteristics

Table 1: General characteristics

Model	*LTEM*
Modeling Approach	Partial equilibrium, price equilibrium
Temporal Properties	Comparative static & can also provide Short term dynamics (via sequential simulation)
Solution Type	Non-spatial, net trade
Solution Algorithm	Newton's global algorithm
Base Year	2000
Parameters	Synthetic
Commodity Coverage	19
Country Coverage	17
Behavioural Equations (per commodity, country)	Domestic supply Domestic demand* (food, feed, processing) Stocks Producer price Consumer price Trade price
Economic Identity	Net trade

*:Type of demand depends on the type of product.

3. Country and commodity coverage

Table 2: Country and commodity coverage

Country	*Commodity*
Argentina	Wheat
Australia	Coarse grains
Canada	Sugar (refined)
Czech Republic	Rice
EU (15)	Oilseeds
Hungary	Oils
Japan	Oil meal
Mexico	Beef and veal
New Independent States	Sheep meat
Norway	Pig meat
New Zealand	Wool
Poland	Poultry

Slovakia Switzerland Turkey USA Rest of World	Eggs Raw milk Liquid milk Butter Cheese Whole milk powder Skim milk powder

4. Behavioural equations

In general there are six behavioral equations and one economic identity for each commodity under each country in the LTEM framework. Therefore, there are seven endogenous variables in the structural-form of the equation set for a commodity under each country[1]. There are four exogenously determined variables but the number of exogenous variables in the structural-form equation set for a commodity varies based on the cross-price, cross-commodity relationships. Behavioral equations are domestic supply, demand, stocks, domestic producer and consumer price functions and trade price equation. The economic identity is the net trade equation which is equal to excess supply or demand in the domestic economy. For some products the number of behavioral equations may change as the total demand is disaggregated into food, feed, processing industry demand, and are determined endogenously. Functional form and variable specification of each equation is explained in the following sections separately at commodity group level.

4.1. Domestic supply

In the LTEM framework a uniform aggregate domestic supply function is used for each commodity and country, which is specified as a function of own- and cross-prices. Colman (1983) refers to this type of agricultural supply response functions, whose theoretical underpinnings are of an *ad hoc* nature, as directly estimated partial supply response models. An agricultural commodity is assumed to be produced in a single farm and therefore agricultural sector is treated as a single multi-product farm producing under perfect competition and producers are assumed price takes in the domestic market. The conditions that allow this exact aggregation are given in Moschini (1989). Cobb-Douglas (CD) constant elasticity functional form is specified at levels of the variables to reflect the domestic supply response with respect to various prices. In the LTEM framework the interdependencies between primary and processed products and/or between substitutes are reflected by cross-price elasticity measures.

Crops

Wheat and coarse grains, oils and oilseeds, sugar and rice

$$qs_{it} = \alpha_0 pp_{it}^{\alpha_1} \prod_j pp_{jt}^{\alpha_j} \;; \qquad \alpha_1 > 0,\ \alpha_j < 0 \qquad 1$$

Livestock Products

Meat: beef and veal, sheep meat, pig meat

$$qs_{it} = \alpha_0 pp_{it}^{\alpha_1} \prod_j \prod_k pp_{jt}^{\alpha_j} pc_{kt}^{\alpha_k} \;; \qquad \alpha_1 > 0,\ \alpha_j < 0, \alpha_k < 0 \qquad 2$$

Dairy: raw milk

$$qs_{it} = \alpha_0 pp_{it}^{\alpha_1} \prod_j \prod_k pp_{jt}^{\alpha_j} pc_{kt}^{\alpha_k} \;; \qquad \alpha_1 > 0,\ \alpha_j < 0, \alpha_k < 0 \qquad 3$$

[1] There are 126 equations for each country and in total there are 2142 equations.

Dairy: liquid milk, butter, cheese, whole milk powder, skim milk powder

$$qs_{it} = \alpha_0 pp_{it}^{\alpha_1} qs_{RMt}^{\alpha_{RM}} \prod_j pp_{jt}^{\alpha_j} \; ; \qquad \alpha_1 > 0, \; \alpha_{RM} > 0, \alpha_j < 0 \qquad 4$$

Poultry: eggs and poultry meat

$$qs_{it} = \alpha_0 pp_{it}^{\alpha_1} \prod_j \prod_k pp_{jt}^{\alpha_j} pc_{kt}^{\alpha_k} \; ; \qquad \alpha_1 > 0, \; \alpha_j < 0, \alpha_k < 0 \qquad 5$$

Variables and parameters:

i: own commodity
j: substitutes
k: feed products
qs: domestic supply
pp: producer price
pc: consumer price

In the LTEM the dairy sector supply and demand response is modeled explicitly as opposed to the two other main approaches used to model this sector[2]. Explicit modeling is essential as the sector is under the effect of various domestic and border policies in the world markets. In addition, full exhaustion of the domestic supply of raw milk into various demand categories is also another challenge of modeling exercises which is overcome by explicit modeling in the LTEM.

4.2. Domestic demand

A uniform CD type aggregate domestic demand function is used in the LTEM framework for each commodity and country. The behavioural relationship is assumed to be derived from consumer's utility maximization problem (at an *ad hoc* nature) acting under perfect competition. Therefore, demand is specified as a function of own- and substitute prices, per capita income and population growth rate. The variables per capita income and population are exogenous to the model. The interdependencies between primary and processed products and/or between substitutes are reflected by cross-price elasticity measures.

Crops

Wheat and coarse grains

$$qd_{i,fot} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop_t^{\beta_3} \prod_j pc_{jt}^{\beta_j} \; ; \qquad \beta_1 < 0, \beta_2 > 0, \beta_3 > 0, \beta_j > 0 \qquad 6$$

$$qd_{i,fet} = \beta_0 pc_{it}^{\beta_1} \prod_j \prod_q pc_{jt}^{\beta_j} qs_{qt}^{\beta_q} \; ; \qquad \beta_1 < 0, \beta_j > 0, \beta_q > 0 \qquad 7$$

Oils and oilseeds

$$qd_{i,fot} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop_t^{\beta_3} \prod_j pc_{jt}^{\beta_j} \; ; \qquad \beta_1 < 0, \beta_2 > 0, \beta_3 > 0, \beta_j > 0 \qquad 8$$

[2] The first and more traditional approach deals with dairy products in terms of raw milk equivalents. Various components of the raw milk produce a variety of dairy products when combined in different proportions. The second approach allocates raw milk to various product categories such as fluid milk, cheese etc. in a hierarchical fashion and the rest and left over is then assumed to be processed for butter and skim milk powder production (Lariviere and Meilke, 1999).

$$qd_{i,fet} = \beta_0 pc_{it}^{\beta_1} \prod_j \prod_q pc_{jt}^{\beta_j} qs_{qt}^{\beta_q}; \qquad \beta_1 < 0, \beta_j > 0, \beta_q > 0 \qquad 9$$

$$qd_{OS,prt} = \beta_0 pc_{OSt}^{\beta_{OS}} \prod_r pp_{rt}^{\beta_r}; \qquad \beta_{OS} < 0, \beta_r > 0 \qquad 10$$

Sugar and rice

$$qd_{i,fot} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop_t^{\beta_3}; \qquad \beta_1 < 0, \beta_2 > 0, \beta_3 > 0 \qquad 11$$

Livestock products

Meat: beef and veal, sheep meat, pig meat

$$qd_{it} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop^{\beta_3} \prod_j pc_{jt}^{\beta_j}; \qquad \beta_1 < 0,\ \beta_2 > 0,\ \beta_3 > 0,\ \beta_j > 0 \qquad 12$$

Dairy: liquid milk, butter, cheese, skim milk powder, whole milk powder

$$qd_{it} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop^{\beta_3} \prod_j pc_{jt}^{\beta_j}; \qquad \beta_1 < 0,\ \beta_2 > 0,\ \beta_3 > 0,\ \beta_j > 0 \qquad 13$$

Poultry: eggs, poultry meat

$$qd_{it} = \beta_0 pc_{it}^{\beta_1} pinc_t^{\beta_2} pop^{\beta_3} \prod_j pc_{jt}^{\beta_j}; \qquad \beta_1 < 0,\ \beta_2 > 0,\ \beta_3 > 0,\ \beta_j > 0 \qquad 14$$

Variables and parameters:

i: own commodity
j: substitutes
pc: consumer price
pinc: per capita income
pop: population
pp_r: producer price of oil meals and oil
qd_{fe}: domestic feed demand
qd_{fo}: domestic food demand
qd_{OS}: domestic processing demand for oilseeds
qs_q: domestic supply of meat, poultry products and raw milk

4.3. Stocks

The stocks are explicitly modeled in the LTEM framework by basing upon the inventory demand theory (FAPRI, 1989a; b). The main determinant of the stock demand is the transaction motive, which responds to quantity of production or consumption, rather than speculative motives.

Crops

Wheat and coarse grains, oils and oilseeds, sugar and rice

Livestock products

Meat, dairy, poultry

$$qe_{it} = \varphi_0 qs_{it}^{\varphi_1}; \qquad \varphi_1 > 0 \qquad 15$$

$$qe_{it} = \varphi_i qd_{it}^{\varphi_1}; \qquad \varphi_1 > 0 \qquad 16$$

Variables and parameters:

i: own commodity

qd: domestic demand (can be food, feed or processing)
qe: stocks
qs: domestic supply

In these equations φ_1 represents the elasticity of stock demand with respect to quantity of supply and demand respectively. There is no stock demand for raw and liquid milk. It is assumed that raw milk is stocked in the form of butter, cheese and/or milk powder.

4.4 Net trade

The net trade function for a commodity and country is defined as an economic identity which accounts for the difference between domestic supply and sum of various demand amounts and stocks. Stocks are incorporated as change from previous year, Δqe_{mi}, therefore it is the difference between ending stocks at time $_{t-1}$ (which is the beginning stocks at time $_t$) and estimated stocks at time $_t$. (which is the ending stocks at time $_t$).

Crops
Wheat and coarse grains, oils and oilseeds, sugar and rice

Livestock products
Meat, dairy, poultry

$$qt_{it} = qs_{it} - (qd_{i,fot} + qd_{i,fet} + qd_{i,prt}) - (\Delta qe_{it}) \qquad 17$$

The produced raw milk is assumed to be totally used for production of other dairy products and not traded.

4.5 Prices

The domestic producer and consumer prices in the LTEM are determined by trade price of the related commodity and country, domestic and border policies that effect domestic prices and transportation costs. Equations 19 and 20 present this price transmission mechanism which consists of protection, tp_i and tc_i, and stabilization $(WDp_i/ex)^{\varepsilon\tau}$ components (Tyers and Anderson, 1986). The trade price of a commodity in a country is determined by the world market price of that commodity, equation 18, in which the variable *ex* is the nominal exchange rate and the parameter ε_τ shows the price transmission elasticity. The price transmission elasticity shows how much a change in world prices is transmitted to the domestic market, which the effect is referred to as stabilization component. If a country for example is applying a fixed-price policy for a certain commodity then ε_τ takes the value of 0, or instead if there is a completely free market policy then ε_τ equals 1. When there are no policy measures that affect domestic prices (protection component is 0) and under the assumptions of no transportation costs and homogenous, perfectly substitutable products then the domestic producer and consumer prices are determined by stabilization component and defined as in equations 19 and 20.

Various producer and consumer support and subsidy measures can also be incorporated to the protection component of the price transmission mechanism through the use of commodity based price wedge variables which differentiate the domestic and trade price of the commodity. These measures include per unit direct payments, inputs subsidies, general services expenditures and other market subsidy payments to the producers and consumer market subsidy, equations 21 and 22. Each of these policy instruments are calculated as per tones of production or consumption, as it was previously introduced with the methodology of producer and consumer subsidy equivalent (PSE and CSE) variables (Cahill and Legg, 1990).

Crops
Wheat and coarse grains, oils and oilseeds, sugar and rice

Livestock products
Meat, dairy, poultry

$$pt_{it} = \left(\frac{WDp_{it}}{ex} \right)^{\varepsilon_{\tau}} \quad 18$$

$$pp_{it} = pt_{it} + tp_{it} + tc_{t} \;; \qquad tc = 0 \quad 19$$

$$pc_{it} = pt_{it} + tc_{it} + tc_{t} \;; \qquad tc = 0 \quad 20$$

$$pp_{it} = (pt_{it} + tp_{it} + sd_{it} + si_{it} + sg_{it} + sm_{it}) \quad 21$$

$$pc_{it} = pt_{it} + tc_{it} + cm_{it} \quad 22$$

Variables and parameters:
i: own commodity
cm: consumer market subsidy
ex: exchanger ate
pc: consumer price
pp: producer price
pt: trade price
sd: direct payments
sg: general services expenditure
si: input subsidy
sm: other producer market subsidy
tc_i: export subsidy
tc: transportation costs
tp_i: import tariffs
WDp: world price

5. Policy instruments

Table 3: Policy variables and parameters

Unilateral Policies	*Bilateral Policies*
Land set-aside Production quota Minimum price Producer market subsidy Producer input subsidies Producer direct payments Producer general services Consumer market subsidy Import tariff Export subsidy	Preferential access Trade quota In-quota tariff Out-quota tariff

6. Policy incorporation

Various unilateral and bilateral agricultural and border policies can be simulated through the LTEM with some modifications to behavioral equations. The unilateral domestic and border policy changes are incorporated to the LTEM via two channels. The first channel is through the supply function which allows the simulation of directly supply related policies such as: production quotas, land set-aside policy and acreage reduction. The second channel is the price formation equations which allow the simulation of various per unit border policies and minimum price policy as well as various per unit producer and consumer support and subsidy measures. In general any policy measure that creates directly per unit wedge between domestic and trade prices can be incorporated through the price functions. Bilateral policies such as preferential excess policy including trade quotas and in- and out-quota tariff rates can also be incorporated to the LTEM through modifications to the supply, price and net trade equations of the related two countries. Policy instruments used in the LTEM framework are listed in Table 3 and are grouped into unilateral and bilateral policy measures.

6.1. Unilateral policies

Land set-aside policy

The changes in for example in the pasture and grazed areas or in sawn area are incorporated to the domestic supply equation by an exogenously determined shift factor that gets the value 1 initially. The variable shf_{qs} proxies the supply side shift factors[3] which is commonly used in partial equilibrium (PE) trade models such as GAP, GLS, SPEL,WATSIM[4]. When a policy that reduces the acreage for example about % 5 is implemented then the value of the shift factor is decreased by the same amount exogenously in order to simulate the downward shift in the supply curve.

$$qs_{it} = \alpha_0 shf_{qs}^{\ 1} pp_{it}^{\ \alpha_1} \prod_j pp_{jt}^{\ \alpha_j} \ ; \qquad \alpha_1 > 0,\ \alpha_j < 0 \qquad shf_{qs} = 1 \text{ initially} \qquad 23$$

$$qs_{it} = \alpha_0 (shf_{qs} - 0{,}05)^1 pp_{it}^{\ \alpha_1} \prod_j pp_{jt}^{\ \alpha_j} \ ; \qquad shf_{qs} = 1 - 0.05 = 0.95 \text{ with policy change} \qquad 24$$

Production quota

Production quotas are incorporated exogenously during the simulation procedure by using MIN function. For example if production of a specific commodity in a country is limited with a maximum production quota amount, pq_{it}, then this quota amount can be introduced as a constraint in finding the equilibrium level of domestic supply during the mathematical solution procedure as in equation 25. With this method the production quota amount becomes binding if the calculated equilibrium qs_{it} is greater than the pq_{it} and the model is pushed to choose pq_{it} as the solution value. If the calculated equilibrium qs_{it} is less than the pq_{it} then the model chooses the calculated qs_{it} as the solution amount.

$$qs_{it} = MIN((\alpha_0 (shf_{qs} - 0{,}05)^1 pp_{it}^{\ \alpha_1} \prod_j pp_{jt}^{\ \alpha_j}), pq_{it}) \qquad 25$$

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[3] In a similar way, in order to analyze the effects of demand side shifters the demand function is re-specified to include an exogenously determined shift factor which gets the value 1 initially. The variable shf_{qd} proxies the demand side shift factors which is commonly used in PE trade models such as GAP, GLS, SPEL,WATSIM.

[4] See Salomon (1998a; b) for GAP, Tyers and Anderson (1986) for GLS, Henrichsmeyer (1990) for SPEL and Lampe (1998) for WATSIM models.

Minimum price

Minimum price policy applied in the domestic market is incorporated again in the solution procedure. The producer price function is re-specified here as in equation 26 by adding a MAX function. With this method the minimum price level (mp_{it}) becomes binding if the calculated equilibrium pp_{it} is less than the mp_{it} and the model is pushed to choose mp_i as the solution value. If the calculated equilibrium pp_{it} is greater than the mp_{it} then the model chooses the calculated pp_{it} as the solution price level.

$$pp_{it} = MAX\left((pt_{it} + tc_i), mp_{it}\right) ; \qquad tc_i = 0 \qquad 26$$

Output and input related subsidies/support expenditures

Various producer and consumer support and subsidy measures are incorporated to the price transmission mechanism through the use of commodity based price wedge variables which differentiate the domestic and trade price of the commodity. These measures include direct payments (sd_{it}), inputs subsidies (si_{it}), general services expenditures (sg_{it}) and other market subsidy payments (sm_{it}) to the producers and consumer market subsidy (cm_{it}). Each of these policy instruments are calculated as per tones of production or consumption, as it was first introduced with the methodology of producer and consumer subsidy equivalent (PSE and CSE) variables (Cahill and Legg, 1990).

$$pp_{it} = MAX\left((pt_{it} + tc_i + sd_{it} + si_{it} + sg_{it} + sm_{it}), mp_{it}\right); \qquad tc_i = 0 \qquad 27$$

$$pc_{it} = pt_{it} + tc_i + cm_{it} ; \qquad tc_i = 0 \qquad 28$$

Border measures: import tariffs and export subsidies

Border policies such as per unit import tariffs and export subsidies are incorporated to the price transmission mechanism through the use of commodity based price wedge variables, tp_{it} and tc_{it}, which differentiate the domestic and trade price of the commodity.

$$pp_{it} = MAX\left((pt_{it} + tc_i + sd_{it} + si_{it} + sg_{it} + sm_{it} + tp_{it}), mp_{it}\right); \qquad tc_i = 0 \qquad 29$$

$$pc_{it} = pt_{it} + tc_i + cm_{it} + tc_{it} ; \qquad tc_i = 0 \qquad 30$$

6.2. Bilateral policies: modeling preferential access policy

Import quotas

The original specification of the LTEM does not allow measuring the impact of any bilateral relationships between two countries therefore, the structure of the model is not proper to measure the impact of preferential access policies. In order to measure the impact of preferential access between any two countries, *d* and *x*, the equation sets of these two countries has to be modified. If for example it is aimed to quantify the impact of import quota applied on the commodity *i* by country *d* on the exporting country *x* then the specification of net trade functions of *d* and *x*, (qt_{dit} and qt_{xit}, equations 31 and 32), and producer price function of *x* (pp_{xit}, equation 33) for *i* has to be re-specified. In addition, a weight (w_{di}) is constructed in order to measure the share of country *d*'s import quota (tq_{dit}) in *x*'s supply (qs_{xit}), equation 34. Accordingly, the tq_{dit} (assuming that *x* fills this quota) is removed from qt_{xit} and it is added to qt_{dit} (equations 31 and 32 respectively). This specification allows measuring the trade impact of policy changes when quota amount is removed from two countries' net trade amount. The producer price (pp_{xit}) impact in country *x* is therefore becomes a weighted-average of *d*'s internal price (pp_{dit}) multiplied by the proportion of quota (w_{di}), since the quota amount administered by *d* is traded at *d*'s internal price, and *x*'s trade/world price (pt_{xit}) multiplied by the proportion of *x*'s exports to world market ($1-w_{di}$), equation 35.

If the importing country has an in-quota tariff rate (tr_{dit}) policy applied on imports then its effect on the exporting country *x* can be measured by subtracting tr_{dit} from pp_{dit} (equation 35).

$$qt_{xit} = qs_{xit} - tq_{dit} - qd_{xit} - \Delta qe_{xit} \quad 31$$

$$qt_{dit} = qs_{dit} + tq_{dit} - qd_{dit} - \Delta qe_{dit} \quad 32$$

$$pp_{xit} = \left[pt_{xit}(1-w_{di}) + pp_{dit}w_{di}\right] \quad 33$$

$$w_{di} = \frac{tq_{dit}}{qs_{xit}} \quad 34$$

$$pp_{xit} = \left[pt_{xit}(1-w_{di}) + (pp_{dit} - tr_{dit})w_{di}\right] \quad 35$$

Export quotas

In this case country *d* is assumed to both subsidize its exports of *i* and at the same time to apply quota on imports of *i* from country *x*. In addition, the country *d* is also allowed to export only certain amount of *i*, therefore export quotas are also in place in *d*. In order to measure the effects of this complex preferential access policy structure the equation set of country *d* has to be modified. Assuming *d* is a net exporter, these net exports (qt_{dit}) becomes a decision variable for the modelling framework between the total exportable (tb_{dit}) and subsidised export amounts, xq_{dit} (export quota). The solution algorithm is pushed to choose the minimum of these two amounts by using the MIN function, equation 36. The tradable amount now includes the *d*'s import quota amount given to *x* (tq_{dit}) as a result of preferential access policy and one year lagged sink stock variable (qes_{dit}), equation 37. The policy applies such that when the solved exportable (tb_{dit}) amount is greater than the export quota (xq_{dit}), the model is pushed to export xq_{dit} amount and the difference between the tb_{dit} and the xq_{dit} goes into the sink stocks (qes_{dit}) which feeds back into next years domestic supply amount through the use of tb_{dit}, equation 38. However, if the solved exportable amount is less than the export quota, then the model carries on with the solved tb_{dit} amount.

$$qt_{dit} = MIN(tb_{dit}, xq_{dit}) \quad 36$$

$$tb_{dit} = qs_{dit} - qd_{dit} + tq_{dit} - \Delta qe_{dit} + qse_{dit-1} \quad 37$$

$$qse_{dit} = IF(tb_{dit} \leq xq_{dit}, 0, tb_{dit} - xq_{dit}) \quad 38$$

In- and out- quota-tariff-rate

The effects of the most favoured nation (MFN) tariff-rate-quota policy, applied by a country such as *d* to an exporter country such as x, are incorporated to the LTEM through the equations re-specified in 39-42. The trade price (pt_{dit}) at the border is now determined as a function of world price (WDp_{dit}) of the commodity and the applied tariff rate, which is based on the country's net trade position and on the difference between the net trade (qt_{dit}) and the *MFN* quota amounts. If the *d* becomes a net importer and if net imports (qt_{dit}) happen to be larger than or equal to the *MFN* amount after a policy shock, then the applied tariff rate becomes a function of in- (itr_{dit}) and out-quota-tariff-rates (otr_{dit}), equation 39. The weights attributed to these different tariff rates are shown by equations 41 and 42. The share of the difference ($|qt_{dit}|-MFN$) in $|qt_{dit}|$ is reflected as the weight (w_1) and multiplied by the out-quota-tariff-rate, otr_{dit}, if ($|qt_{dit}|-MFN$) is larger than *0*. The share of the rest of the trade is reflected by the w_2 and multiplied by the in-quota-tariff-rate, itr_{dit}, (in the case of $|qt_{dit}|=MFN$ the applied tariff becomes $itr*w_2$ as w_1 goes to 0, equation 39). If the *d*'s net imports are smaller than the *MFN* then the applied tariff becomes itr_{dit}, equation 39. Therefore if the *d* is a net importer, whether qt_{dit} is larger than or smaller than *MFN* amount, the model calculates a new trade price, npt_{dit}, based on the applied tariff rate. However, during the simulations if the *d* is a net exporter, then trade price is calculated by using in-quota-tariff-rate, itr_{dit}, as given in equation 40.

$$npt_{dit} = WDp_{dit} + IF(|qt_{dit}| - MFN \geq 0, (w_1 * otr_{dit} + w_2 * itr_{dit}), itr_{dit}) \quad (39)$$

$$pt_{dit} = WDp_i + IF(qt_{dit} > 0, itr_{dit}, npt_{it}) \quad (40)$$

$$w_1 = \frac{(|qt_{dit}| - MFN)}{|qt_{dit}|} \quad (41)$$

$$w_2 = 1 - w_1 \quad (42)$$

Variables and parameters:

i:	own commodity
j:	substitutes and complements
t:	time period
d:	domestic market
x:	international market
α_1:	own-price elasticity of supply
α_j:	cross-price elasticity of supply
cm:	other market subsidies to consumers
itr_{dit}:	in-quota-tariff rate
mp:	minimum price
npt:	new trade price
otr_{dit}:	out-quota-tariff rate
pc:	consumer price
pp:	producer price
pq:	production quota
pt:	trade price
qd:	domestic demand
qe:	stocks
qs:	domestic supply
qse:	sink stocks
qt:	net trade
sd:	direct payments
sg:	general services expenditures
shf_{qs}:	supply shifter
si:	input subsidies
sm:	other market subsidies to producers
tb:	tradable amount
tc:	transportation cost
tc_{it}:	export subsidies
tp_{it}:	import tariffs
tq:	import quotas
tr_{dit}:	in-quota-tariff rate in *d*
w_{di}:	ratio of import quotas in *d* over domestic supply in *x*
w_1:	share of difference of net trade and MFN in net trade
xq:	export quotas

7. Behavioral parameters

Table 4: Supply side parameters: own- and cross-price elasticity measures

Table 5: Demand side parameters: own-, cross-price and income elasticity measures

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