

## Appendix A: Mathematical Summary Statement for the Standard Static CGE Model

<b>Sets</b>	$a \in A$ $a \in ACES (\subset A)$ $a \in ALEO (\subset A)$ $a \in ACCES (\subset A)$ $c \in C$ $c \in CD (\subset C)$ $c \in CDN (\subset C)$ $c \in CE (\subset C)$ $c \in CEN (\subset C)$ $c \in CM (\subset C)$ $c \in CMN (\subset C)$ $c \in CT (\subset C)$ $c \in CX (\subset C)$ $f \in F$ $i \in INS$ $i \in INSD (\subset INS)$ $i \in INSDNG (\subset INSD)$ $h \in H (\subset INSDNG)$	activities activities with a CES function at the top of the technology nest activities with a Leontief function at the top of the technology nest activities with CES domestic activity aggregation function commodities commodities with domestic sales of domestic output commodities not in $CD$ exported commodities commodities not in $CE$ imported commodities commodities not in $CM$ transactions services commodities commodities with domestic production factors institutions (domestic and rest of the world) domestic institutions domestic non-government institutions households
<b>Parameters</b>		
Latin letters	$cwts_c$ $dwts_c$ $ica_{c'a}$ $icd_{c'c}$ $ice_{c'c'}$ $icm_{c'c'}$ $inta_a$ $iva_a$ $mps01_i$ $\overline{mps}_i$ $pop_h$ $pwe_c$ $pwm_c$ $\overline{qg}_c$ $qdst_c$ $\overline{qinv}_c$ $shif_{i'f}$ $shii_{i'i'}$ $ta01_a$ $\overline{ta}_a$ $te01_c$ $\overline{te}_c$ $tf01_f$ $\overline{tf}_c$ $ti01_i$ $\overline{ti}_i$ $tm01_c$ $\overline{tm}_c$	weight of commodity c in the CPI weight of commodity c in the producer price index quantity of c as intermediate input per unit of activity a quantity of commodity c as trade input per unit of c produced and sold domestically quantity of commodity c as trade input per exported unit of c' quantity of commodity c as trade input per imported unit of c' quantity of aggregate intermediate input per activity unit quantity of value-added per activity unit 0-1 parameter for institutions without/with flexible savings rates base savings rate for domestic institution i population of representative household h export price (foreign currency) import price (foreign currency) base-year quantity of government demand quantity of stock change base-year quantity of private investment demand share for domestic institution i in income of factor f share of net income of institution i' to institution i 0-1 parameter for activities without/with flexible activity tax rates exogenous activity tax rate for activity a 0-1 parameter for commodities without/with flexible export tax rates exogenous export tax rate for commodity c 0-1 parameter for factors without/with flexible factor tax rates exogenous factor tax rate for factor f 0-1 parameter for institutions without/with flexible direct tax rates exogenous direct tax rate for domestic institution i 0-1 parameter for commodities without/with flexible import tariff rates exogenous import tariff rate for commodity c

	$trnsf_i$	exogenous transfer from institution i to factor f
	$trnsi_{i'}$	exogenous transfer from institution i' to institution i
	$tq01_c$	0-1 parameter for commodities without/with flexible sales tax rates
	$\bar{t}q_c$	exogenous sales tax rate for commodity c
	$tv01_a$	0-1 parameter for activities without/with flexible value-added tax rates
	$\bar{t}v_a$	exogenous value-added tax rate for activity a
Greek letters	$\alpha_a^a$	efficiency parameter in the CES activity function
	$\alpha_c^{ac}$	shift parameter for domestic commodity aggregation function
	$\alpha_a^{ca}$	shift parameter for domestic activity aggregation function
	$\alpha_{fa}^f$	factor efficiency parameter in the CES activity function
	$\alpha_c^q$	Armington function shift parameter
	$\alpha_c^t$	CET function shift parameter
	$\alpha_a^{va}$	efficiency parameter in the CES value-added function
	$\beta_{ah}^h$	marginal home consumption spending share for activity output a for household h
	$\beta_{ch}^m$	marginal market consumption spending share for commodity c for household h
	$\delta_a^a$	CES activity function share parameter
	$\delta_{ac}^{ac}$	share parameter for domestic commodity aggregation function
	$\delta_{ac}^{ca}$	share parameter for domestic activity aggregation function
	$\delta_c^q$	Armington function share parameter
	$\delta_c^t$	CET function share parameter
	$\delta_{fa}^{va}$	CES value-added function share parameter for factor f in activity a
	$\gamma_{ah}^h$	subsistence home consumption of activity output a by household h
	$\gamma_{ch}^m$	subsistence market consumption of commodity c by household h
	$\rho_a^a$	CES production function exponent
	$\rho_c^{ac}$	domestic commodity aggregation function exponent
	$\rho_a^{ca}$	domestic activity aggregation function exponent
	$\rho_c^q$	Armington function exponent
	$\rho_c^t$	CET function exponent
	$\rho_a^{va}$	CES value-added function exponent
	$\theta_{ac}$	yield of output c per unit of activity a

<b>Variables</b>	<i>CPI</i>	consumer price index
(* indicates exogenous in base model)	<i>DMPS</i>	* change in domestic institution savings rates (0 in base)
	<i>DPI</i>	producer price index for domestically marketed output
	<i>DTA</i>	* change in activity tax rates (0 in base)
	<i>DTE</i>	* change in export tax rates (0 in base)
	<i>DTF</i>	* change in factor tax rates (0 in base)
	<i>DTI</i>	* change in direct institution tax rates (0 in base)
	<i>DTM</i>	* change in import tariff rates (0 in base)
	<i>DTQ</i>	* change in sales tax rates (0 in base)
	<i>DTV</i>	* change in value-added tax rates (0 in base)
	<i>EG</i>	government expenditures
	<i>EH_h</i>	total household consumption spending
	<i>EXR</i>	exchange rate (LCU per unit of FCU)
	<i>FSAV</i>	* foreign savings (FCU)
	<i>GADJ</i>	* government consumption adjustment factor

<i>GOVSHR</i>	government consumption share in nominal absorption
<i>GSAV</i>	government savings
<i>IADJ</i>	investment adjustment factor
<i>INVSHR</i>	investment share in nominal absorption
<i>MPS<sub>i</sub></i>	marginal propensity to save for domestic non-government institution
<i>MPSADJ</i>	*
<i>PA<sub>a</sub></i>	savings rate scaling factor (0 in base)
<i>PDD<sub>c</sub></i>	activity price (unit gross revenue)
<i>PDS<sub>c</sub></i>	demand price for commodity produced and sold domestically
<i>PE<sub>c</sub></i>	supply price for commodity produced and sold domestically
<i>PINTA<sub>a</sub></i>	export price (domestic currency)
<i>PM<sub>c</sub></i>	aggregate intermediate input price for activity a
<i>PQ<sub>c</sub></i>	import price (domestic currency)
<i>FSAV</i>	composite commodity price
<i>PVA<sub>a</sub></i>	*
<i>PX<sub>c</sub></i>	foreign savings (FCU)
<i>PXAC<sub>a c</sub></i>	value-added price (factor income per unit of activity)
<i>QA<sub>a</sub></i>	aggregate producer price for commodity
<i>QD<sub>c</sub></i>	producer price of commodity c for activity a
<i>QE<sub>c</sub></i>	quantity (level) of activity
<i>QF<sub>f a</sub></i>	quantity sold domestically of domestic output
<i>QFS<sub>f</sub></i>	quantity of exports
<i>QG<sub>c</sub></i>	quantity demanded of factor f from activity a
<i>QH<sub>c h</sub></i>	*
<i>QHA<sub>a h</sub></i>	quantity supplied of factor
<i>QINT<sub>c a</sub></i>	government consumption demand for commodity
<i>QINTA<sub>a</sub></i>	quantity consumed of commodity c by household h
<i>QINV<sub>c</sub></i>	quantity of household home consumption of activity output a by household h
<i>QM<sub>c</sub></i>	quantity of commodity c as intermediate input to activity a
<i>QQ<sub>c</sub></i>	quantity of aggregate intermediate input
<i>QT<sub>c</sub></i>	quantity of investment demand for commodity
<i>QVA<sub>a</sub></i>	quantity of imports of commodity
<i>QX<sub>c</sub></i>	quantity of goods supplied to domestic market (composite supply)
<i>QXAC<sub>a c</sub></i>	quantity of commodity demanded as trade input
<i>TA<sub>a</sub></i>	quantity of (aggregate) value-added
<i>TAADJ</i>	aggregated marketed quantity of domestic output of commodity
<i>TABS</i>	quantity of marketed output of commodity c from activity a
<i>TE<sub>c</sub></i>	activity tax rate for activity a
<i>TEADJ</i>	*
<i>TF<sub>f</sub></i>	activity tax rate scaling factor (0 in base)
<i>TFADJ</i>	total nominal absorption
<i>TI<sub>i</sub></i>	export tax rate for commodity c
<i>TIADJ</i>	*
<i>TM<sub>c</sub></i>	export tax rate scaling factor (0 in base)
<i>TMADJ</i>	factor tax rate for factor f
<i>TRII<sub>i i'</sub></i>	*
<i>TQ<sub>c</sub></i>	factor tax rate scaling factor (0 in base)
<i>TQADJ</i>	direct institution tax rate for institution i
<i>TV<sub>a</sub></i>	*
<i>TVADJ</i>	direct institution tax rate scaling factor (0 in base)
	import tariff rate for commodity c
	*
	import tariff rate scaling factor (0 in base)
	transfers from institution i' to i
	*
	sales tax rate for commodity c
	*
	sales tax rate scaling factor (0 in base)
	value-added tax rate for activity a
	*
	value-added tax rate scaling factor (0 in base)

$WF_f$	average price of factor f
$WFDIST_{f\alpha}$	wage distortion factor for factor f in activity a
$YF_f$	income of factor f
$YG$	government revenue
$YI_i$	income of domestic nongovernment institution
$YIF_{if}$	income to domestic institution i from factor f

## Static Model Equations

### Price Block

Import price

$$PM_c = pwm_c \cdot (1 + TM_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \quad c \in CM \quad (1)$$

$$\begin{bmatrix} import \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} import \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} tariff \\ adjustment \end{bmatrix} \cdot \begin{bmatrix} exchange rate \\ (LCU per \\ FCU) \end{bmatrix} + \begin{bmatrix} cost of trade \\ inputs per \\ import unit \end{bmatrix}$$

Export price

$$PE_c = pwe_c \cdot (1 - TE_c) \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c} \quad c \in CE \quad (2)$$

$$\begin{bmatrix} export \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} export \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} tax \\ adjustment \end{bmatrix} \cdot \begin{bmatrix} exchange rate \\ (LCU per \\ FCU) \end{bmatrix} - \begin{bmatrix} cost of trade \\ inputs per \\ export unit \end{bmatrix}$$

Demand price  
of domestic  
nontraded goods

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \quad c \in CD \quad (3)$$

$$\begin{bmatrix} domestic \\ demand \\ price \end{bmatrix} = \begin{bmatrix} domestic \\ supply \\ price \end{bmatrix} + \begin{bmatrix} cost of trade \\ inputs per unit of \\ domestic sales \end{bmatrix}$$

Absorption

$$PQ_c \cdot (1 - TQ_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \quad c \in (CD \cup CM) \quad (4)$$

$$\begin{bmatrix} absorption \\ (at demand prices) \\ net of sales tax \end{bmatrix} = \begin{bmatrix} domestic demand price \\ times domestic sales \\ quantity \end{bmatrix} + \begin{bmatrix} import price \\ times import \\ quantity \end{bmatrix}$$

Marketed  
output value

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c \quad c \in CX \quad (5)$$

$$\begin{bmatrix} producer price \\ times marketed \\ output quantity \end{bmatrix} = \begin{bmatrix} domestic supply price \\ time domestic sales \\ quantity \end{bmatrix} + \begin{bmatrix} import price \\ times import \\ quantity \end{bmatrix}$$

Activity output  
price

$$PA_a = \sum_{c \in C} P X A C_{a c} \cdot \theta_{a c} \quad a \in A \quad (6)$$

$$\begin{bmatrix} \text{activity} \\ \text{price} \end{bmatrix} = \begin{bmatrix} \text{producer prices} \\ \text{times yields} \end{bmatrix}$$

Aggregate  
intermediate  
input price

$$PINTA_a = \sum_{c \in C} P Q_{a c} \cdot \theta_{a c} \quad a \in A \quad (7)$$

$$\begin{bmatrix} \text{aggregate} \\ \text{intermediate} \\ \text{input price} \end{bmatrix} = \begin{bmatrix} \text{intermediate input cost} \\ \text{per unit of aggregate} \\ \text{intermediate input} \end{bmatrix}$$

Value-added price

$$PVA_a \cdot QVA_a = PA_a \cdot (1 - TA_a) \cdot QA_a - PINTA_a \cdot QINTA_a \quad a \in A \quad (8)$$

$$\begin{bmatrix} \text{value-added} \\ \text{price times} \\ \text{quantity} \end{bmatrix} = \begin{bmatrix} \text{activity price} \\ (\text{net of taxes}) \\ \text{times activity level} \end{bmatrix} \begin{bmatrix} \text{aggregate} \\ \text{intermediate input} \\ \text{price times quantity} \end{bmatrix}$$

Consumer price index

$$CPI = \sum_{c \in C} P Q_c \cdot cwts_c \quad (9)$$

$$\begin{bmatrix} \text{consumer} \\ \text{price index} \end{bmatrix} = \begin{bmatrix} \text{prices times} \\ \text{weights} \end{bmatrix}$$

Producer price index  
for nontraded  
market output

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \quad (10)$$

$$\begin{bmatrix} \text{domestic price} \\ \text{price index} \end{bmatrix} = \begin{bmatrix} \text{prices times} \\ \text{weights} \end{bmatrix}$$

## Production and Trade Block

Activity production function  
(CES technology)

$$QA_a = \alpha_a^a \cdot \left( \delta_a^a \cdot QVA_a^{-\rho_a^a} + (1 - \delta_a^a) \cdot QINTA_a^{-\rho_a^a} \right)^{-\frac{1}{\rho_a^a}} \quad a \in ACES \quad (11)$$

$$\begin{bmatrix} \text{activity level} \\ \text{quantity of aggregate value added,} \\ \text{quantity of aggregate intermediate input} \end{bmatrix} = CES \begin{bmatrix} \text{activity level} \\ \text{quantity of aggregate value added,} \\ \text{quantity of aggregate intermediate input} \end{bmatrix}$$

Value-added intermediate-input quantity ratio  
(CES technology)

$$\frac{QVA_a}{QINTA_a} = \left( \frac{PINTA_a}{PVA_a} \cdot \frac{\delta_a^a}{1 - \delta_a^a} \right)^{\frac{1}{1+\rho_a^a}} \quad a \in ACES \quad (12)$$

$$\begin{bmatrix} \text{value-added :} \\ \text{intermediate input} \\ \text{quantity ratio} \end{bmatrix} = f \begin{bmatrix} \text{intermediate input :} \\ \text{value-added} \\ \text{price ratio} \end{bmatrix}$$

Activity production function  
(Leontief technology)

$$QVA_a = iv_a \cdot QA_a \quad a \in ALEO \quad (13)$$

$$\begin{bmatrix} \text{demand for aggregate intermediate input} \\ \text{activity level} \end{bmatrix} = f \begin{bmatrix} \text{activity level} \end{bmatrix}$$

Value-added intermediate-input quantity ratio  
(Leontief technology)

$$QINTA_a = int_a \cdot QA_a \quad a \in ALEO \quad (14)$$

$$\begin{bmatrix} \text{demand for aggregate intermediate input} \\ \text{activity level} \end{bmatrix} = f \begin{bmatrix} \text{activity level} \end{bmatrix}$$

Value-added and factor demands

$$QVA_a = \alpha_a^{va} \cdot \left( \sum_{f \in F} \delta_{fa}^{va} \cdot (\alpha_{fa}^f \cdot QF_{fa})^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad a \in A \quad (15)$$

$$\begin{bmatrix} \text{quantity of aggregate value added} \\ \text{factor inputs} \end{bmatrix} = CES \begin{bmatrix} \text{quantity of aggregate value added} \\ \text{factor inputs} \end{bmatrix}$$

Factor demand

$$WF_f \cdot WFDIST_{f,a} = PVA_a \cdot (1 - TV_a) \cdot QVA_a \cdot \left( \sum_{f' \in F} \delta_{f'}^{va} \cdot (\alpha_{f'}^f \cdot QF_{f'}^a)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_f^{va} \cdot QF_f^{-\rho_a^{va}-1} \quad \begin{matrix} a \in A \\ f \in F \end{matrix} \quad (16)$$

$$\begin{bmatrix} \text{marginal cost of} \\ \text{factor } f \text{ in activity } a \end{bmatrix} = \begin{bmatrix} \text{marginal revenue product} \\ \text{of factor } f \text{ in activity } a \end{bmatrix}$$

Disaggregated intermediate input demand

$$QINT_{c,a} = ica_{c,a} \cdot QINTA_a \quad \begin{matrix} a \in A \\ c \in C \end{matrix} \quad (17)$$

$$\begin{bmatrix} \text{intermediate demand} \\ \text{for commodity } c \\ \text{from activity } a \end{bmatrix} = f \begin{bmatrix} \text{aggregate intermediate} \\ \text{input quantity} \\ \text{for activity } a \end{bmatrix}$$

Commodity production (Leontief)

$$QXAC_{a,c} = \theta_{a,c} \cdot QA_a - \sum_{h \in H} QHA_{a,h} \quad \begin{matrix} a \notin ACSES \\ c \in CX \end{matrix} \quad (18)$$

$$\begin{bmatrix} \text{marketed quantity} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix} = \begin{bmatrix} \text{production} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix} - \begin{bmatrix} \text{household home} \\ \text{consumption of commodity } c \\ \text{from activity } a \end{bmatrix}$$

Commodity production (CET)

$$QXAC_{a,c} = \left( QA_a - \sum_{h \in H} QHA_{a,h} \right) \cdot \left( \frac{PXAC_{a,c}}{PA_a \cdot \delta_{a,c}^{ca} \cdot (\alpha_a^{ca})^{\rho_a^{ca}}} \right)^{\frac{1}{\rho_a^{ca}-1}} \quad \begin{matrix} a \in ACSES \\ c \in CX \end{matrix} \quad (19)$$

$$\begin{bmatrix} \text{marketed quantity} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix} = \begin{bmatrix} \text{production of commodity } c \text{ from} \\ \text{activity } a \text{ less home consumption} \\ \text{of commodity } c \text{ from activity } a \end{bmatrix} - \begin{bmatrix} \text{household home} \\ \text{consumption of commodity } c \\ \text{from activity } a \end{bmatrix}$$

Output aggregation function

$$QX_c = \alpha_c^{ac} \cdot \left( \sum_{a \in A} \delta_{a,c}^{ac} \cdot QXAC_{a,c}^{-\rho_a^{ac}} \right)^{-\frac{1}{\rho_c^{ac}}} \quad c \in CX \quad (20)$$

$$\begin{bmatrix} \text{aggregate marketed} \\ \text{production of} \\ \text{commodity } c \end{bmatrix} = CES \begin{bmatrix} \text{activity-specific} \\ \text{marketed production} \\ \text{of commodity } c \end{bmatrix}$$

First-order condition  
for output aggregation  
function

$$PXAC_{ac} = PX_c \cdot QX_c \cdot \left( \sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1}$$

$$\begin{bmatrix} \text{marginal cost of commodity } c \\ \text{from activity } a \end{bmatrix} = \begin{bmatrix} \text{marginal revenue product} \\ \text{of commodity } c \text{ from activity } a \end{bmatrix}$$
 $a \in A$   
 $c \in CX$  (21)

Output transformation  
(CET) function

$$QX_c = \alpha_c^t \cdot \left( \delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$$

$$\begin{bmatrix} \text{aggregate marketed} \\ \text{domestic output} \end{bmatrix} = CET \begin{bmatrix} \text{export quantity, domestic} \\ \text{sales of domestic output} \end{bmatrix}$$
 $c \in$   
 $(CE \cap CD)$  (22)

Export-domestic  
supply ratio

$$\frac{QE_c}{QD_c} = \left( \frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t-1}}$$

$$\begin{bmatrix} \text{export-domestic} \\ \text{supply ratio} \end{bmatrix} = f \begin{bmatrix} \text{export-domestic} \\ \text{price ratio} \end{bmatrix}$$
 $c \in$   
 $(CE \cap CD)$  (23)

Output transformation  
for non-exported  
commodities

$$QX_c = QD_c + QE_c$$

$$\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{domestic output} \end{bmatrix} = \begin{bmatrix} \text{domestic market} \\ \text{sales of domestic output} \\ [\text{for } c \in (CD \cap CEN)] \end{bmatrix} - \begin{bmatrix} \text{exports} \\ [\text{for } c \in (CE \cap CDN)] \end{bmatrix}$$
 $c \in$   
 $(CD \cap CEN)$   
 $\cup$   
 $(CE \cap CDN)$  (24)

Composite supply  
(Armington) function

$$QQ_c = \alpha_c^q \cdot \left( \delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$$

$$\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = CES \begin{bmatrix} \text{import quantity, domestic} \\ \text{use of domestic output} \end{bmatrix}$$
 $c \in$   
 $(CM \cap CD)$  (25)

Import-domestic demand ratio

$$\frac{QM_c}{QD_c} = \left( \frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1 + \rho_c^q}} \quad c \in (CM \cap CD) \quad (26)$$

$$\begin{bmatrix} \text{import-domestic} \\ \text{demand ratio} \end{bmatrix} = f \begin{bmatrix} \text{domestic-import} \\ \text{price ratio} \end{bmatrix}$$

Composite supply for non-imported outputs and non-produced imports

$$QQ_c = QD_c + QM_c \quad c \in (CD \cap CMN) \cup (CM \cap CDN) \quad (27)$$

$$\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = \begin{bmatrix} \text{domestic use of} \\ \text{marketed domestic output} \\ [\text{for } c \in (CD \cap CMN)] \end{bmatrix} - \begin{bmatrix} \text{imports} \\ [\text{for } c \in (CM \cap CDN)] \end{bmatrix}$$

Demand for transaction services

$$QT_c = \sum_{c' \in C} (icm_{c'c} \cdot QM_{c'} + ice_{c'c} \cdot QE_{c'} + icd_{c'c} \cdot QD_{c'}) \quad c \in CT \quad (28)$$

$$\begin{bmatrix} \text{demand for} \\ \text{transaction services} \end{bmatrix} = \begin{bmatrix} \text{sum of demands for imports,} \\ \text{exports, and domestic sales} \end{bmatrix}$$

## Institution Block

Factor income

$$YF_f = \sum_{a \in A} WF_f \cdot WFDIST_{fa} \cdot QFa + trnsfr_{fgv} \cdot CPI + trnsfr_{frw} \cdot EXR \quad f \in F \quad (29)$$

$$\begin{bmatrix} \text{income of} \\ \text{factor } f \end{bmatrix} = \begin{bmatrix} \text{sum of activity payments (activity-} \\ \text{specific wages times employment levels} \end{bmatrix} + \begin{bmatrix} \text{income of factor } f \\ \text{from government} \end{bmatrix} + \begin{bmatrix} \text{income of factor } f \\ \text{from rest of world} \end{bmatrix}$$

Institutional factor incomes

$$YIF_{if} = shif_{if} \cdot YF_f \cdot (1 - TF_f) \quad i \in INS \quad f \in F \quad (30)$$

$$\begin{bmatrix} \text{income of} \\ \text{institution } i \\ \text{from factor } f \end{bmatrix} = \begin{bmatrix} \text{share of income} \\ \text{of factor } f \text{ to} \\ \text{institution } i \end{bmatrix} \cdot \begin{bmatrix} \text{income of} \\ \text{factor } f \\ (\text{net of taxes}) \end{bmatrix}$$

Income of domestic, non-government institutions

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG} TRII_{i'i'} + trnsfr_{igv} \cdot CPI + trnsfr_{irw} \cdot EXR \quad i \in INSDNG \quad (31)$$

$$\begin{bmatrix} \text{income of institution } i \\ \text{factor income} \end{bmatrix} = \begin{bmatrix} \text{transfers from other domestic non-government institutions} \\ \text{institution } i \text{ from government} \end{bmatrix} + \begin{bmatrix} \text{transfer income for institution } i \text{ from government} \\ \text{institution } i \text{ from rest of world} \end{bmatrix}$$

Intra-institutional transfers

$$TRII_{i'i'} = shii_{i'i'} \cdot YI_{i'} \cdot (1 - MPS_{i'}) \cdot (1 - TI_{i'}) \quad i \in INS \quad i' \in INSDNG \quad (32)$$

$$\begin{bmatrix} \text{transfer from institution } i \text{ to institution } i' \\ \text{share of net income of institution } i' \text{ transferred to } i \end{bmatrix} = \begin{bmatrix} \text{income of institution } i' \\ (\text{net of savings and direct taxes}) \end{bmatrix}$$

Household consumption expenditure

$$EH_h = \left( 1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot YI_h \cdot (1 - MPS_h) \cdot (1 - TI_h) \quad h \in H \quad (33)$$

$$\begin{bmatrix} \text{household income disposable for consumption} \\ \text{household income (net of savings, direct taxes, and transfers to other non-government institutions)} \end{bmatrix}$$

Household consumption demand for marketed commodities

$$PQ_c \cdot QH_{ch} = pop_h \cdot \left( PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left( \frac{EH_h}{pop_h} - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} PA_a \cdot \gamma_{ah}^h \right) \right) \quad c \in C \quad h \in H \quad (34)$$

$$\begin{bmatrix} \text{household consumption spending on market commodity } c \\ \text{population of household } h \end{bmatrix} = \begin{bmatrix} \text{per capita household consumption spending, market price of } c, \text{ and other commodity prices (market and home)} \end{bmatrix}$$

Household consumption demand for home commodities

$$PA_a \cdot QHA_{ah} = pop_h \cdot \left( PA_a \cdot \gamma_{ah}^h + \beta_{ah}^h \cdot \left( \frac{EH_h}{pop_h} - \sum_{c \in C} PQ_c \cdot \gamma_{ch}^m - \sum_{a' \in A} PA_{a'} \cdot \gamma_{a'h}^h \right) \right) \quad a \in A \quad h \in H \quad (35)$$

$$\begin{bmatrix} \text{household consumption spending on home output from activity } a \\ \text{population of household } h \end{bmatrix} = \begin{bmatrix} \text{per capita household consumption spending, producer price of } a, \text{ and other commodity prices (market and home)} \end{bmatrix}$$

Investment demand

$$QINV_c = IADJ \cdot qinv_c$$

$c \in C$  (36)

$$\begin{bmatrix} \text{fixed investment demand} \\ \text{for commodity } c \end{bmatrix} = \begin{bmatrix} \text{adjustment factor times} \\ \text{base-year fixed investment} \end{bmatrix}$$

Government consumption demand

$$QG_c = GADJ \cdot qg_c$$

$c \in C$  (37)

$$\begin{bmatrix} \text{fixed investment demand} \\ \text{for commodity } c \end{bmatrix} = \begin{bmatrix} \text{adjustment factor times} \\ \text{base-year fixed investment} \end{bmatrix}$$

Government revenue

$$\begin{aligned} YG = & \sum_{a \in A} TA_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} TM_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in CE} TE_c \cdot pwe_c \cdot QE_c \cdot EXR \\ & + \sum_{c \in C} TQ_c \cdot PQ_c \cdot QQ_c + \sum_{a \in A} TV_a \cdot PVA_a \cdot QVA_a + \sum_{f \in F} TF_f \cdot YF_f \cdot gv \\ & + \sum_{i \in INSDNG} TI_i \cdot YI_i + \sum_{i \in INSDNG} TRII_{gv}{}_i + trsnfr_{gv}{}_{rw} \cdot EXR \end{aligned} \quad (38)$$

$$\begin{aligned} \begin{bmatrix} \text{government revenue} \end{bmatrix} = & \begin{bmatrix} \text{activity taxes} \end{bmatrix} + \begin{bmatrix} \text{import tariffs} \end{bmatrix} + \begin{bmatrix} \text{export taxes} \end{bmatrix} + \begin{bmatrix} \text{sales taxes} \end{bmatrix} + \begin{bmatrix} \text{value-added taxes} \end{bmatrix} + \begin{bmatrix} \text{direct taxes from factors} \end{bmatrix} \\ & + \begin{bmatrix} \text{direct taxes from institutions} \end{bmatrix} + \begin{bmatrix} \text{transfers from institutions} \end{bmatrix} + \begin{bmatrix} \text{transfers from rest of world} \end{bmatrix} \end{aligned}$$

Government expenditures

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i}{}_{gv} \cdot CPI + trnsfr_{rw}{}_{gv} \cdot EXR$$

(39)

$$\begin{bmatrix} \text{government spending} \end{bmatrix} = \begin{bmatrix} \text{government consumption} \end{bmatrix} + \begin{bmatrix} \text{transfers to domestic non-government institutions} \end{bmatrix} + \begin{bmatrix} \text{transfers to rest of world} \end{bmatrix}$$

## System Constraint Block

Factor market

$$QFS_f = \sum_{a \in A} QF_{fa} \quad f \in F \quad (40)$$

$$\begin{bmatrix} \text{supply of} \\ \text{factor } f \end{bmatrix} = \begin{bmatrix} \text{demand for} \\ \text{factor } f \end{bmatrix}$$

Composite commodity market

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \quad c \in C \quad (41)$$

$$\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = \begin{bmatrix} \text{intermediate} \\ \text{use} \end{bmatrix} + \begin{bmatrix} \text{household} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix} + \begin{bmatrix} \text{trade} \\ \text{input use} \end{bmatrix}$$

Current account balance for rest of the world (in foreign currency)

$$\begin{aligned} & \sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} YIF_{rw\,f}/EXR + \sum_{i \in INSDNG} TRII_{rw\,i}/EXR + trnsfr_{rw\,gv} \\ &= \sum_{c \in CM} pwe_c \cdot QE_c + \sum_{f \in F} trnsfr_{f\,rw} + \sum_{i \in INSD} trnsfr_{i\,rw} + FSAV \end{aligned} \quad (42)$$

$$\begin{aligned} \begin{bmatrix} \text{import} \\ \text{spending} \end{bmatrix} &= \begin{bmatrix} \text{factor transfers} \\ \text{to rest of world} \end{bmatrix} + \begin{bmatrix} \text{institution transfers} \\ \text{to rest of world} \end{bmatrix} + \begin{bmatrix} \text{government transfers} \\ \text{to rest of world} \end{bmatrix} \\ &= \begin{bmatrix} \text{export} \\ \text{revenue} \end{bmatrix} + \begin{bmatrix} \text{factor transfers} \\ \text{from rest of world} \end{bmatrix} + \begin{bmatrix} \text{institution transfers} \\ \text{from rest of world} \end{bmatrix} + \begin{bmatrix} \text{foreign} \\ \text{savings} \end{bmatrix} \end{aligned}$$

Government balance

$$YG = EG + GSAV \quad (43)$$

$$\begin{bmatrix} \text{government} \\ \text{revenue} \end{bmatrix} = \begin{bmatrix} \text{government} \\ \text{expenditures} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{savings} \end{bmatrix}$$

Private savings

$$PSAV = \sum_{i \in INSDNG} MPS_i \cdot (1 - TI_i) \cdot YI_i \quad (44)$$

$$\begin{bmatrix} \text{total private} \\ \text{savings} \end{bmatrix} = \begin{bmatrix} \text{savings rate times institution} \\ \text{income (net of taxes)} \end{bmatrix}$$

Savings-investment balance

$$PSAV + GSAV + FSAV \cdot EXR = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c + WALRAS \quad (45)$$

$$\begin{bmatrix} \text{total private} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{foreign} \\ \text{savings} \end{bmatrix} = \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$

Total absorption

$$\begin{aligned} TABS = & \sum_{c \in C} \sum_{h \in H} PQ_c \cdot QH_{ch} + \sum_{a \in A} \sum_{h \in H} PA_a \cdot QHA_{ah} \\ & + \sum_{c \in C} PQ_c \cdot QG_c + \sum_{c \in C} PQ_c \cdot QINV_c \sum_{c \in C} PQ_c \cdot qdst_c \end{aligned} \quad (46)$$

$$\begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{household market} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{household home} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$

Ratio of investment to absorption

$$INVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QINV_c \sum_{c \in C} PQ_c \cdot qdst_c \quad (47)$$

$$\begin{bmatrix} \text{investment} \\ \text{absorption ratio} \end{bmatrix} \cdot \begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$

Ratio of government consumption to absorption

$$GOVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QG_c \quad (48)$$

$$\begin{bmatrix} \text{government consumption} \\ \text{absorption ratio} \end{bmatrix} \cdot \begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{government} \\ \text{consumption} \end{bmatrix}$$

## Savings and Tax Rates Block

Institutional  
savings rates

$$MPS_i = \bar{mps}_i \cdot (1 + MPSADJ \cdot mps01_i) + DMPS \cdot mps01_i \quad i \in INSDNG \quad (49)$$

$$\begin{bmatrix} \text{savings rate} \\ \text{for institution } i \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected institutions} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected institutions} \end{bmatrix}$$

Activity tax rates

$$TA_a = \bar{ta}_a \cdot (1 + TAADJ \cdot ta01_a) + DTA \cdot ta01_a \quad a \in A \quad (50)$$

$$\begin{bmatrix} \text{activity tax rate} \\ \text{for activity } a \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected activities} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected activities} \end{bmatrix}$$

Export tax rates

$$TE_c = \bar{te}_c \cdot (1 + TEADJ \cdot te01_c) + DTE \cdot te01_c \quad c \in CE \quad (51)$$

$$\begin{bmatrix} \text{export tax rate} \\ \text{for commodity } c \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected commodities} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected commodities} \end{bmatrix}$$

Direct factor tax rates

$$TF_f = \bar{tf}_f \cdot (1 + TFADJ \cdot tf01_f) + DTF \cdot tf01_f \quad f \in F \quad (52)$$

$$\begin{bmatrix} \text{direct factor tax} \\ \text{rate for factor } f \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected factors} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected factors} \end{bmatrix}$$

Direct institutional  
tax rates

$$TI_i = \bar{ti}_i \cdot (1 + TIADJ \cdot ti01_i) + DTI \cdot ti01_i \quad i \in INSDNG \quad (53)$$

$$\begin{bmatrix} \text{direct tax rate} \\ \text{for institution } i \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected institutions} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected institutions} \end{bmatrix}$$

$$\text{Import tariff rates} \quad TM_c = \bar{tm}_c \cdot (1 + TMADJ \cdot tm01_c) + DTM \cdot tm01_c \quad c \in CM \quad (54)$$

$$\begin{bmatrix} \text{import tariff rate} \\ \text{for commodity } c \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected commodities} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected commodities} \end{bmatrix}$$

$$\text{Sales tax rates} \quad TQ_c = \bar{tq}_c \cdot (1 + TQADJ \cdot tq01_c) + DTQ \cdot tq01_c \quad c \in C \quad (55)$$

$$\begin{bmatrix} \text{sales tax rate} \\ \text{for commodity } c \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected commodities} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected commodities} \end{bmatrix}$$

$$\text{Value-added tax rates} \quad TV_a = \bar{tv}_a \cdot (1 + TVADJ \cdot tv01_a) + DTV \cdot tv01_a \quad a \in A \quad (56)$$

$$\begin{bmatrix} \text{value-added rate} \\ \text{for activity } a \end{bmatrix} = \begin{bmatrix} \text{base rate adjusted for scaling} \\ \text{for selected activities} \end{bmatrix} + \begin{bmatrix} \text{point change for} \\ \text{selected activities} \end{bmatrix}$$