Appendix B: Summary of the numerical CGE model

Indices and sets:

Set of regions	R	EU, BRA, IDN, ROW
Set of goods	g	q, x, y, z
r (alias j)		Index for regions

Variables:

S^{gr}	Production of good g in r
S^{r}_{FE}	Production of FE in r
D^{gr}	Aggregated consumer demand of good g in r
KL^{gr}	Value-added composite for g in r
KLF^{r}	Value-added composite for FE in r
A^{gr}	Armington aggregate of g in r
IM^{gr}	Import aggregate of g in r
W^{r}	Consumption composite in r
$CO2^{qr}$	Land use related CO_2 emission in region r
p^{gr}	Price of g in r
p^{r}_{FE}	Price of Primary fossil FE in r
p^{gr}_{KL}	Price of value added for g in r
p^{r}_{KLF}	Price of value added for FE in r
p^{r}_{L}	Price of labor (wage rate) in r
p^{r}_{K}	Price of capital (rental rate) in r
p^{r}_{O}	Rent for primary energy resource in r
p^{gr}_{A}	Price of Armington aggregate of g in r
p^{gr}_{IM}	Price of aggregate imports of g in r
p^{gr}_{CO2}	Price of CO2 emission in r

p_{REDD}^{gr} Price of REDD credits in *r*

p_W^r Price of consumption composite in *r*

LA^{gr} Land use endowment in sector g in region r

Parameters:

α^r Offset share allowance in region *r* through REDD credits from BRA

σ_{KLE}^{gr} Substitution between value-added and energy/land g in *r*

σ_{KL}^r Substitution between value-added g in *r*

σ_Q^r Substitution between value-added and natural resource in *FE* in *r*

σ_{LN}^r Substitution between value-added in *FE* in *r*

σ_A^{gr} Substitution between import and domestic g in *r*

σ_{IM}^{gr} Substitution between imports from different g in *r*

σ_W^r Substitution between goods to consumption

θ_{FE}^{gr} Cost Share of FE in production of g in *r*

θ_{KL}^{gr} Cost Share of labor in production of g in *r*

θ_O^r Cost Share of natural resource in production of *FE* in *r*

θ_{LN}^r Cost Share of labor in production of *FE* in *r*

θ_A^{gr} Cost Share of domestic goods g in consumption in *r*

θ_{IM}^{gr} Cost Share of different imports goods g in consumption in *r*

p_{LA}^r Price of land (rental rate) in *r*

L_0^{gr} Labor endowment in sector g in region r

$L_{0,FE}^r$ Labor endowment in *FE* in region r

K_0^{gr} Capital endowment in sector g in region r

$K_{0,FE}^r$ Capital endowment in *FE* in region r

O_0^r Resource endowment of primary fossil energy in region r

$CO2_{MAX}^r$ Fossil related CO_2 emission allowance in region r

$CO2_0^{gr}$ Land use related CO_2 emission for good g in region r

γ_{CO2}^{r} Coefficient for land use CO_2 emission in region r

κ_{CO2}^{r} Coefficient for primary fossil energy of CO_2 emission in region r

Zero Profit Conditions

Production of goods except fossil primary energy:

$$\pi_S^{gr} = \left(\theta_{FE}^{gr}\left(p_{FE}^{r} + \kappa_{CO2}^{r} p_{CO2}^{gr}\right)^{\left(1-\sigma_{KLE}^{gr}\right)} + \theta_{LA}^{gr}\left(p_{LA}^{r}\right)^{\left(1-\sigma_{KLE}^{gr}\right)} + \left(1-\theta_{FE}^{gr}-\theta_{LA}^{gr}\right)p_{KL}^{gr\left(1-\sigma_{KLE}^{gr}\right)}\right)^{\left(\frac{1}{1-\sigma_{KLE}^{gr}}\right)} \geq p^{gr} \quad \perp S^{gr}$$

Sector specific value-added aggregate for *q*, *x*, *y* and *z*:

$$\pi_{KL}^{gr} = \left(\theta_{KL}^{gr} p_L^{r\left(1-\sigma_{KL}^{gr}\right)} + \left(1-\theta_{KL}^{gr}\right)p_K^{r\left(1-\sigma_{KL}^{gr}\right)}\right)^{\left(\frac{1}{1-\sigma_{KL}^{gr}}\right)} \geq p_{KL}^{gr} \quad \perp KL^{gr}$$

Production of fossil primary energy:

$$\pi_{FE}^{r} = \left(\theta_O^{r} p_O^{r\left(1-\sigma_O^{r}\right)} + \left(1-\theta_Q^{r}\right)p_{KLF}^{r\left(1-\sigma_O^{r}\right)}\right)^{\left(\frac{1}{1-\sigma_O^{r}}\right)} \geq p_{FE}^{r} \quad \perp S_{FE}^{r}$$

Sector specific value-added aggregate for *FE*:

$$\pi_{KLF}^{r} = \left(\theta_{LN}^{r} p_L^{r\left(1-\sigma_{LN}^{r}\right)} + \left(1-\theta_{LN}^{r}\right)p_K^{r\left(1-\sigma_{LN}^{r}\right)}\right)^{\left(\frac{1}{1-\sigma_{LN}^{r}}\right)} \geq p_{KLF}^{r} \quad \perp KLF^{r}$$

Armington aggregate except for *FE*:

$$\pi_A^{gr} = \left(\theta_A^{gr}\left(p^{gr}\right)^{\left(1-\sigma_A^{gr}\right)} + \left(1-\theta_A^{gr}\right)p_{IM}^{gr\left(1-\sigma_A^{gr}\right)}\right)^{\left(\frac{1}{1-\sigma_A^{gr}}\right)} \geq p_A^{gr} \quad \perp A^{gr}$$

Import Composite except for *FE*:

$$\pi_{IM}^{gr} = \left(\sum_{j\neq r}\theta_{IM}^{gjr}\left(p^{gj}\right)^{\left(1-\sigma_{IM}^{gr}\right)}\right)^{\left(\frac{1}{1-\sigma_{IM}^{gr}}\right)} \geq p_{IM}^{gr} \quad \perp IM^{gr}$$

Consumption composite:

$$\pi_W^{r} = \left(\theta_W^{qr} p_A^{qr\left(1-\sigma_W^{r}\right)} + \theta_W^{xr} p_A^{xr\left(1-\sigma_W^{r}\right)} + \theta_W^{yr} p_A^{yr\left(1-\sigma_W^{r}\right)} + \theta_W^{zr} p_A^{zr\left(1-\sigma_W^{r}\right)}\right)^{\left(\frac{1}{1-\sigma_W^{r}}\right)} \geq p_W^{r} \quad \perp W^{r}$$

Market Clearing Conditions

Labor:

$$\sum_{g} L_0^{gr} + L_{0,FE}^{r} \geq \sum_{g} KL^{gr} \frac{\partial \pi_{KL}^{gr}}{\partial {p_L}^r} + KLF^r \frac{\partial \pi_{KLF}^{r}}{\partial {p_L}^r} \qquad \perp {p_L}^r$$

Capital:

$$\sum_{g} K_0^{gr} + K_{0,FE}^{r} \geq \sum_{g} KL^{gr} \frac{\partial \pi_{KL}^{gr}}{\partial {p_K}^r} + KLF^r \frac{\partial \pi_{KLF}^{r}}{\partial {p_K}^r} \qquad \perp {p_K}^r$$

Primary fossil energy resource:

$$O_0^r \geq S_{FE}^r \frac{\partial \pi_{FE}^r}{\partial p_O^r} \qquad \perp {p_O}^r$$

Land use resource:

$$LA^{gr} \geq S^{gr} \frac{\partial \pi_S^{gr}}{\partial P^{gr}} \qquad \perp {p_{LA}}^r$$

Value-added except *FE*:

$$KL^{gr} \geq S^{gr} \frac{\partial \pi_S^{gr}}{\partial p_{KL}^{gr}} \qquad \perp p_{KL}^{gr}$$

Value-added *FE*:

$$KLF^r \geq S_{FE}^r \frac{\partial \pi_{FE}^r}{\partial p_{KLF}^r} \qquad \perp p_{KLF}^r$$

Armington Aggregate:

$$A^{gr} \geq W^r \frac{\partial \pi_W^r}{\partial p_A^{gr}} \qquad \perp p_A^{gr}$$

Import Aggregate:

$$IM^{gr} \geq A^{gr} \frac{\partial \pi_A^{gr}}{\partial p_{IM}^{gr}} \qquad \perp p_{IM}^{gr}$$

Supply-demand balance of goods, except *FE*:

$$S^{gr} \geq A^{gr}\frac{\partial \pi_A^{gr}}{\partial p^{gr}} + \sum_{j \neq r} IM^{gj}\frac{\partial \pi_{IM}^{gj}}{\partial p^{gj}} \qquad \perp p^{gr}$$

Supply-demand balance of *FE*:

$$S_{FE}^{r} \geq \sum_{g} S^{gr}\frac{\partial \pi_S^{gr}}{\partial\left(p_{FE}^{r} + \kappa_{CO2}^{r} p_{CO2}^{gr}\right)} \qquad \perp p_{FE}^{r}$$

Demand of goods:

$$D^{gr} \geq A^{gr}\frac{\partial \pi_A^{gr}}{\partial p^{gr}} + IM^{gr}\frac{\partial \pi_{IM}^{gr}}{\partial p^{gr}} \qquad \perp D^{gr}$$

Allowed CO_2 emission in region, with offset from region BRA:

$$CO2_{MAX}^{r} \geq \kappa_{CO2}^{r} S_{FE}^{r} - \alpha^{r}\left(CO2_0^{qBRA} - CO2^{qBRA}\right) \qquad \perp p_{CO2}^{r}$$

Land use related CO_2 emission in region by q:

$$CO2^{qr} \geq \gamma_{CO2}^{r} LA^{qr} \qquad \perp CO2^{qr}$$

Fossil fuel related CO_2 emission in region by g:

$$CO2^{qr} \geq \kappa_{CO2}^{r} S_{FE}^{r} \qquad \perp CO2^{gr}$$

CO_2 emission offset through REDD credits in region:

$$\alpha^{r} p_{CO2}^{r} \geq p_{REDD}^{BRA} \qquad \perp p_{REDD}^{BRA}$$

Consumption by consumers

$$p_W^{r} W^{r} \geq p_L^{r}\left(\sum_{g} L_0^{gr} + L_{0,FE}^{r}\right) + p_K^{r}\left(\sum_{g} K_0^{gr} + K_{0,FE}^{r}\right) + p_O{}^{r} O_0^{r} + P_{LA}^{r} LA^{qr} + p_{CO2}^{r} CO2_{MAX}^{r}$$
$$- p_{REDD}^{BRA}\left(CO2_0^{qBRA} - CO2^{qBRA}\right) \qquad \perp p_W^{r}$$

Elasticities: $\sigma_{KLE}^{x}, \sigma_{KLE}^{y}, \sigma_{KLE}^{z} = 0.5 \quad \sigma_{KL} = 1$

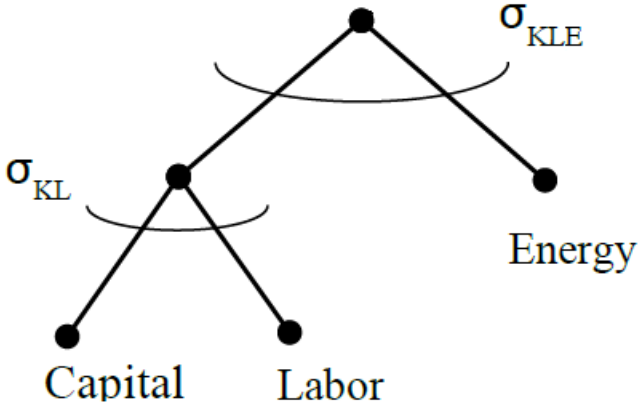

Figure B1: Nesting in production of *x*, *y* and *z*

Elasticities: $\sigma_{KLE}^{q} = 0.1 \qquad \sigma_{KL} = 1$

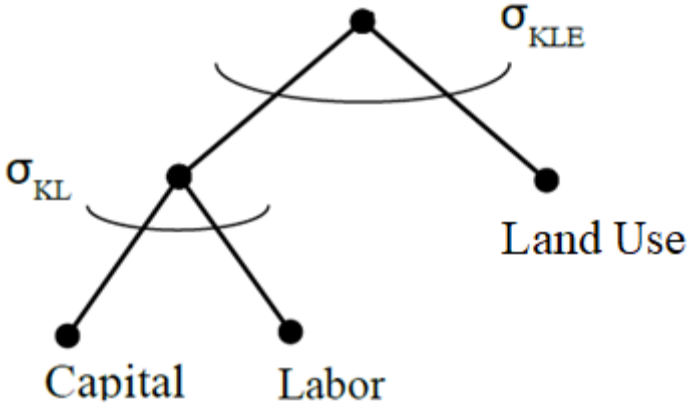

Figure B2: Nesting in production of agriculture and forestry good

Elasticities: $\sigma_O = 0.9 \quad \sigma_{KL} = 1$

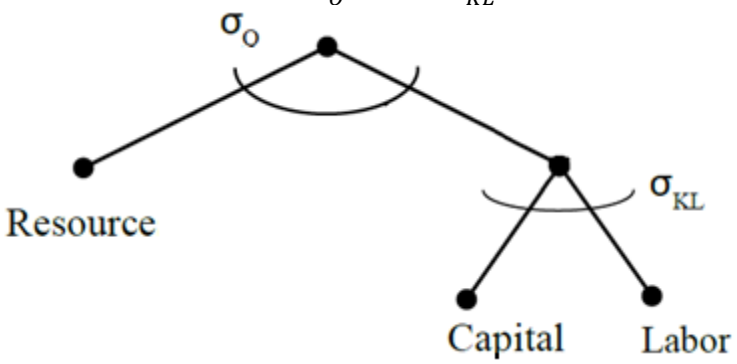

Figure B3: Nesting in production of fossil fuel energy

Elasticity: $\sigma_W = 0.5$

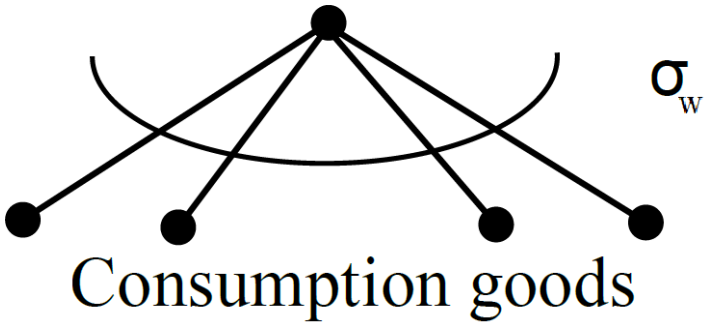

Figure B4: Nesting in final consumption