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 $r$
$S_{FE}^r$: Production of FE in $r$
$D_{gr}$: Aggregated consumer demand of good $g$ in $r$
$KL_{gr}$: Value-added composite for $g$ in $r$
$KLF_{gr}$: 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 $r$
$CO2_{gr}$: Land use related CO2 emission in region $r$

$p_{gr}$: Price of $g$ in $r$
$p_{FE}^r$: Price of Primary fossil FE in $r$
$p_{KL}^{gr}$: Price of value added for $g$ in $r$
$p_{KLF}^r$: Price of value added for FE in $r$
$p_L^r$: Price of labor (wage rate) in $r$
$p_K^r$: Price of capital (rental rate) in $r$
$p_O^r$: Rent for primary energy resource in $r$
$p_A^{gr}$: Price of Armington aggregate of $g$ in $r$
$p_{IM}^{gr}$: Price of aggregate imports of $g$ in $r$
$p_{CO2}^{gr}$: Price of CO2 emission in $r$
$p_{\text{REDD}}^{gr}$ Price of REDD credits in $r$

$p_{W}^{r}$ Price of consumption composite in $r$

$L_{A}^{gr}$ Land use endowment in sector $g$ in region $r$

Parameters:

$\alpha^{r}$ Offset share allowance in region $r$ through REDD credits from BRA

$\sigma_{KLE}^{gr}$ Substitution between value-added and energy/land $g$ in $r$

$\sigma_{KL}^{r}$ Substitution between value-added $g$ in $r$

$\sigma_{Q}^{r}$ Substitution between value-added and natural resource in $FE$ in $r$

$\sigma_{LN}^{r}$ Substitution between value-added in $FE$ in $r$

$\sigma_{A}^{gr}$ Substitution between import and domestic $g$ in $r$

$\sigma_{IM}^{gr}$ Substitution between imports from different $g$ in $r$

$\sigma_{W}^{r}$ Substitution between goods to consumption

$\theta_{FE}^{gr}$ Cost Share of $FE$ in production of $g$ in $r$

$\theta_{KL}^{gr}$ Cost Share of labor in production of $g$ in $r$

$\theta_{O}^{r}$ Cost Share of natural resource in production of $FE$ in $r$

$\theta_{LN}^{r}$ Cost Share of labor in production of $FE$ in $r$

$\theta_{A}^{gr}$ Cost Share of domestic goods $g$ in consumption in $r$

$\theta_{IM}^{gr}$ 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 $r$

$CO_{2}^{r}$ Fossil related CO$_2$ emission allowance in region $r$
$CO_2_{gr}^r$  Land use related CO$_2$ emission for good g in region r

$\gamma_{CO_2}^r$  Coefficient for land use CO$_2$ emission in region r

$\kappa_{CO_2}^r$  Coefficient for primary fossil energy of CO$_2$ emission in region r

**Zero Profit Conditions**

Production of goods except fossil primary energy:

$$\pi_{S}^{gr} = (\theta_{FE}^{gr} p_{FE}^r + \kappa_{CO_2 P_{CO_2}}^{gr} (1-\sigma_{KLE}^r) + \theta_{LA}^{gr} p_{LA}^r (1-\sigma_{KLE}^r) + (1 - \theta_{FE}^{gr} - \theta_{LA}^{gr}) p_{KL}^{gr} (1-\sigma_{KLE}^r) \left( \frac{1}{1-\sigma_{KLE}^r} \right)) \geq p^{gr} \perp S^{gr}$$

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

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

Production of fossil primary energy:

$$\pi_{FE}^r = \left( \theta_{0}^{gr} p_{O}^r (1-\sigma_{O}^r) + (1 - \theta_{Q}^{gr}) p_{K}^{gr} (1-\sigma_{O}^r) \right) \left( \frac{1}{1-\sigma_{O}^r} \right) \geq p_{FE}^r \perp S_{FE}^r$$

Sector specific value-added aggregate for FE:

$$\pi_{KLF}^{r} = \left( \theta_{LN}^{gr} p_{LN}^r (1-\sigma_{LN}^r) + (1 - \theta_{LN}^{gr}) p_{K}^{gr} (1-\sigma_{LN}^r) \right) \left( \frac{1}{1-\sigma_{LN}^r} \right) \geq p_{KLF}^{r} \perp KL^{r}$$

Armington aggregate except for FE:

$$\pi_{A}^{gr} = \left( \theta_{A}^{gr} p^{gr} (1-\sigma_{A}^r) + (1 - \theta_{A}^{gr}) p_{I}^{gr} (1-\sigma_{A}^r) \right) \left( \frac{1}{1-\sigma_{A}^r} \right) \geq p_{A}^{gr} \perp A^{gr}$$

Import Composite except for FE:

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

Consumption composite:

$$\pi_{W}^{r} = \left( \theta_{w}^{gr} p_{A}^{gr} (1-\sigma_{W}^r) + \theta_{w}^{gr} p_{A}^{gr} (1-\sigma_{W}^r) + \theta_{w}^{gr} p_{A}^{gr} (1-\sigma_{W}^r) + \theta_{w}^{gr} p_{A}^{gr} (1-\sigma_{W}^r) \right) \left( \frac{1}{1-\sigma_{W}^r} \right) \geq p_{W}^{r} \perp W^{r}$$
Market Clearing Conditions

Labor:
\[ \sum_g L_0^{gr} + L_{0,FE}^{gr} \geq \sum_g K^{gr}_L \frac{\partial \pi^{KL}}{\partial p_L^r} + K^{KL} \frac{\partial \pi^{KL_foot}}{\partial p_L^r} \perp p_L^r \]

Capital:
\[ \sum_g K_0^{gr} + K_{0,FE}^{gr} \geq \sum_g K^{gr}_L \frac{\partial \pi^{KL}}{\partial p_K^r} + K^{KL} \frac{\partial \pi^{KL_foot}}{\partial p_K^r} \perp p_K^r \]

Primary fossil energy resource:
\[ O_0^{gr} \geq S^{FE}_{FE} \frac{\partial \pi^{FE}}{\partial p_{O_0}^r} \perp p_{O_0}^r \]

Land use resource:
\[ L_A^{gr} \geq S^{gr}_L \frac{\partial \pi^{gr}}{\partial p_{gr}} \perp p_{L_A}^r \]

Value-added except FE:
\[ K^{gr}_L \geq S^{gr}_L \frac{\partial \pi^{gr}}{\partial p_{K_L}^r} \perp p_{K_L}^{gr} \]

Value-added FE:
\[ K^{KL}_{FE} \geq S^{FE}_{FE} \frac{\partial \pi^{FE}}{\partial p_{K_L}^{KL}} \perp p_{K_{KL}}^{FE} \]

Armington Aggregate:
\[ A^{gr} \geq W^{gr} \frac{\partial \pi^{gr}}{\partial p_A^r} \perp p_A^{gr} \]

Import Aggregate:
\[ I^{gr}_M \geq A^{gr} \frac{\partial \pi^{gr}_A}{\partial p_{I_M}^{gr}} \perp p_{I_M}^{gr} \]
Supply-demand balance of goods, except $FE$:

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

Supply-demand balance of $FE$:

$$S^{r}_{FE} \geq \sum_g S^{gr} \frac{\partial \pi_S^{gr}}{\partial (p^{FE}r + k^{r}_{CO2}p^{gr})} \perp p^{r}_{FE}$$

Demand of goods:

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

Allowed CO$_2$ emission in region, with offset from region BRA:

$$CO2^{r}_{MAX} \geq k^{r}_{CO2}S^{r}_{FE} - \alpha^{r} (CO2^{q}_{0BRA} - CO2^{qBRA}) \perp p^{r}_{CO2}$$

Land use related CO$_2$ emission in region by $q$:

$$CO2^{q}_{qr} \geq \gamma^{r}_{CO2}LA^{qr} \perp CO2^{qr}$$

Fossil fuel related CO$_2$ emission in region by $g$:

$$CO2^{q}_{qr} \geq k^{r}_{CO2}S^{r}_{FE} \perp CO2^{qr}$$

CO$_2$ emission offset through REDD credits in region:

$$\alpha^{r}p^{r}_{CO2} \geq p^{BRA}_{REDD} \perp p^{BRA}_{REDD}$$

Consumption by consumers

$$p^{r}_{W^r}W^r \geq p^{r}_L \left( \sum_g L^{gr}_0 + L^{r}_{0,FE} \right) + p^{r}_K \left( \sum_g K_0^{gr} + K^{r}_{0,FE} \right) + p^{r}_0O^{r}_0 + p^{r}_LA^{qr} + p^{r}_{CO2}CO2^{r}_{MAX} - p^{BRA}_{REDD} (CO2^{q}_{0BRA} - CO2^{qBRA}) \perp p^{r}_{W}$$
Elasticities: $\sigma_{KLE}^x, \sigma_{KLE}^y, \sigma_{KLE}^z = 0.5$  $\sigma_{KL} = 1$

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

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

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