The Idaho-Washington CGE model is an adaptation of the CGE model developed by Hans Lofgren. That model has been redesigned for regional economic analysis. The source of data for the model is IMPLAN which is used to produce a regional SAM for either Idaho or Washington using an adaptation of the aggregation algorithm developed by Rutherford and adjusted to fit the Lofgren model. Based on information available in IMPLAN, the major changes to Lofgren’s model are:

1. Institutional make data are included.
2. Indirect business taxes are included.
3. Transfers between institutions are more extensive than the transfers included in Lofgren’s model.
4. Imports of factors of production and of institutional products are included.
5. Exports of factors of production and of institutional products are included.
6. There are two sources of imports: rest of the world and rest of the US.
7. There are two destinations for exports: rest of the world and rest of the US.
8. Government and investment as well as households receive payments from the primary factors of production.

Model Documentation:

Index sets used in the model:

- **A** – activities
- **C** – commodities
- **CM\(\subset\)C** – commodities which have at least one source of imports (from ROW or from RUS or from both)
- **CE\(\subset\)C** – commodities which have at least one destination for exports (to ROW or to RUS or to both)
- **CNM\(\subset\)C** – commodities which are not imported
- **CNE\(\subset\)C** – commodities which are not exported
- **CM1\(\subset\)C** – commodities which have exactly one import source
- **CE1\(\subset\)C** – commodities which have exactly one export destination
- **CM2\(\subset\)C** – commodities which are imported from both sources
- **CE2\(\subset\)C** – commodities which are exported to both destinations
- **F** – factors of production and indirect business taxes
- **FF\(\subset\)F** – factors of production
- **I** – institutions
- **H\(\subset\)I** – households
- **G\(\subset\)I** – government units
- **HG\(\subset\)I** – households and government units
- **FG\(\subset\)G** – federal government units
- **SG\(\subset\)G** – state government units
- **T** – trading regions (FT: rest of world, DT: rest of US)
Aliases:

FF – FFF
C – CC
H – HH
G – GG
FG – FGG
SG – SGG

Base Parameters:

Prices (set by user):

\[
\begin{align*}
X_{RO_T} & \quad \text{Initial exchange rate} \\
PM_{ROTO,C} & \quad \text{Initial regional import price in regional currency} \\
P_{WEOT,C} & \quad \text{Initial world export price in foreign currency} \\
PER_{T,C} & \quad \text{Initial regional export price in regional currency} \\
PM_{OC} & \quad \text{Initial composite import price in regional currency} \\
PE_{OC} & \quad \text{Initial composite export price in regional currency} \\
PQ_{OC} & \quad \text{Initial composite commodity price} \\
P_{DOC} & \quad \text{Initial regional price of regional output} \\
P_{XOC} & \quad \text{Initial producer price} \\
PA_{OA} & \quad \text{Initial activity price} \\
P_{VAOA} & \quad \text{Initial value added price} \\
W_{FOFF} & \quad \text{Initial average wage or rental rate for factor FF} \\
p_{wmT,C} & \quad \text{World import price in foreign currency (exogenous)}
\end{align*}
\]

Quantities (calculated from initial data):

\[
\begin{align*}
QM_{ROTO,C} & \quad \text{Initial regional imports} \\
QERO_{T,C} & \quad \text{Initial regional exports} \\
QMO_{C} & \quad \text{Initial composite import quantity} \\
QEO_{C} & \quad \text{Initial composite export quantity} \\
QQ_{OC} & \quad \text{Initial composite quantity supplied to regional demanders} \\
QDOC & \quad \text{Initial quantity of regional output supplied to regional demanders} \\
QXOC & \quad \text{Initial quantity of regional output} \\
QAOA & \quad \text{Initial activity level} \\
QINTOC,A & \quad \text{Initial quantity of intermediate use of commodity C by activity A} \\
IMAKEQO_{T,C} & \quad \text{Initial institutional make matrix (quantity)} \\
QFO_{FF,A} & \quad \text{Initial quantity of factor FF demanded by activity A} \\
QHO_{C,H} & \quad \text{Initial household consumption} \\
QINVOC & \quad \text{Initial investment demand} \\
QINVOI & \quad \text{Initial institutional investment demand} \\
QFSO_{FF} & \quad \text{Initial factor supply} \\
INDTOG & \quad \text{Initial indirect business taxes receipts for each government unit} \\
EMPLOY_A & \quad \text{Employment data (actual number of jobs in each sector)}
\end{align*}
\]
Accounting variables (calculated from initial data):

- YFOI,FF – Initial transfer of income to institution I from factor FF
- YHOH – Initial gross household income
- NYHOH – Initial net household income
- YFGO – Initial federal government income
- EFGO – Initial federal government spending
- YSGO – Initial state government income
- ESGO – Initial state government spending
- FSAVXO – Initial foreign savings (export column)
- FSAVMO – Initial foreign savings (import row)
- DSAVXO – Initial savings for RUS (export column)
- DSAVMO – Initial savings for RUS (import row)
- CPIO – Initial consumer price index

Factors:

- WFDISTO_{FF,A} – Initial factor price distortion factor
- IADJO – Initial investment adjustment factor
- SADJO – Initial savings adjustment factor
- SGADJO – Initial state government spending adjustment factor
- SHIFTFFOF – Initial shift variable for factor supply equation

Parameters set by user:

- frischC – Frisch parameter for Stone-Geary utility function
- ineC,H – Income elasticity
- xedC,T – Elasticity of demand for world export demand function
- esubpA – Elasticity of substitution for production function
- esubdC – Elasticity of substitution between regional output and imports
- esubsC – Elasticity of transformation between regional output and exports
- esubec – Elasticity of transformation between foreign and regional exports
- esubmC – Elasticity of substitution between foreign and regional imports
- tqC – Sales tax rate
- tcC – Consumption tax rate (paid only by households)
- tqSC – Sales tax rate on services not previously taxed
- tmT,C – Import tax rate
- teC,T – Export tax rate
- efacFF – Demand elasticity for factors of production

Parameters calculated from initial data:

- theta_{A,C} – Yield of output C per unit of activity A
- ica_{C,A} – Quantity of C as intermediate input per unit of activity A
- tbA – Indirect business tax rate
ty_{G,H} \quad \text{Household income tax rate}
\%
tr_{H,HH} \quad \text{Inter-household transfers}
m_{PSH} \quad \text{Marginal propensity to save}
c_{wtsC} \quad \text{Weight of commodity C in the consumer price index}
w_{fa_{FF,A}} \quad \text{Price for factor FF in activity A}
x_{shift_{C,T}} \quad \text{Shift parameter for world export demand function}
lamda_{ac_{C,H}} \quad \text{Subsistence level parameter for Stone-Geary utility function}
\beta_{ac_{C,H}} \quad \text{Marginal budget share parameter for Stone-Geary utility function}
engelwth \quad \text{Engel aggregation weight}
q_{gC,G} \quad \text{Government consumption}
shry_{Y,FF} \quad \text{Institutional share of factor income}
tbshrG \quad \text{Government unit share of indirect business taxes}
sgovbal \quad \text{Initial state government budget balance}
ad_{A} \quad \text{Shift parameter for production function}
del_{F,A} \quad \text{Share parameter for production function}
rho_{A} \quad \text{Exponent for production function}
aq_{c} \quad \text{Shift parameter for armington demand function}
adel_{C} \quad \text{Share parameter for armington demand function}
arho_{C} \quad \text{Exponent for armington demand function}
as_{C} \quad \text{Shift parameter for supply transformation function}
sdel_{C} \quad \text{Share parameter for supply transformation function}
srho_{C} \quad \text{Exponent for supply transformation function}
ae_{C} \quad \text{Shift parameter for export transformation function}
edel_{C} \quad \text{Share parameter for export transformation function}
erho_{C} \quad \text{Exponent for export transformation function}
am_{C} \quad \text{Shift parameter for armington import function}
mdel_{C} \quad \text{Share parameter for armington import function}
mrho_{C} \quad \text{Exponent parameter for armington import function}

Calculation of base values (SAM is the adjusted data from IMPLAN):

\[
PMRO_{T,C} = pwm_{T,C}*(1+tm_{T,C})*XRO_{T}
\]

\[
PERO_{C,T} = PWEO_{C,T}*(1-te_{C,T})*XRO_{T}
\]

\[
PVAO_{A} = \frac{\sum_{FF} SAM_{FF,A}}{SAM_{TOTAL,A}*PAO_{A}}
\]

\[
QMRO_{T,C} = \frac{SAM_{T,C}}{PMRO_{T,C}}
\]

\[
QERO_{C,T} = \frac{SAM_{C,T}}{PMRO_{C,T}}
\]

\[
QMO_{C} = \frac{\sum_{T} SAM_{T,C}}{PMO_{C}}
\]
\[ \text{QEO}_C = \frac{\sum \text{SAM}_{c,t}}{\text{PEO}_C} \]

\[ \text{QQO}_C = \frac{\text{SAM}_{\text{TOTAL},c} - \sum \text{SAM}_{c,t}}{\text{PQO}_C} \]

\[ \text{QDO}_C = \frac{\sum \text{SAM}_{A,c} + \sum \text{SAM}_{l,c} - \sum \text{SAM}_{c,t}}{\text{PDO}_C} \]

\[ \text{QBO}_C = \frac{\sum \text{SAM}_{A,c} + \sum \text{SAM}_{l,c}}{\text{PXO}_C} \]

\[ \text{QAO}_A = \frac{\text{SAM}_{\text{TOTAL},A}}{\text{PAO}_A} \]

\[ \text{QINTO}_{C,A} = \frac{\text{SAM}_{A,c}}{\text{PQO}_C} \]

\[ \text{IMAKEQO}_{L,c} = \frac{\text{SAM}_{l,c}}{\text{PXO}_C} \]

\[ \text{QFO}_{\text{CAP},A} = \text{SAM}_{\text{CAP},A} \]

IF LBR = NO: \[ \text{QFO}_{\text{LAB},A} = \text{SAM}_{\text{LAB},A} \]

ELSE: \[ \text{QFO}_{\text{LAB},A} = \text{EMPLOY}_A \]

\[ \text{WFO}_{FF} = \frac{\sum \text{SAM}_{FF,A}}{\sum \text{QFO}_{FF,A}} \]

\[ \text{QHO}_{C,H} = \frac{\text{SAM}_{C,H}}{(1 + \text{tec}) \times \text{PQO}_C} \]

\[ \text{QINV}_{O,C} = \frac{\text{SAM}_{C,INV}}{\text{PQO}_C} \]

\[ \text{QINV}_{O,HG} = \text{SAM}_{HG,INV'} \]

\[ \text{QFSO}_{FF} = \frac{\sum \text{SAM}_{FF,A}}{\text{WFO}_{FF,A}} \]

\[ \text{INDT}_{O,G} = \text{SAM}_{G,INDT} \]

\[ \text{YFO}_{I,FF} = \text{SAM}_{I,FF} \]

\[ \text{YHO}_{H} = \sum_{FF} \text{SAM}_{I,FF} + \sum_{I} \text{SAM}_{H,1} + \sum_{T} \text{SAM}_{H,T} + \sum_{C} \text{PX}_C \times \text{SAM}_{H,C} \]
NYHO_{H} = \sum_{C} SAM_{C, H} \\
\text{YFGO} = \sum_{FG} SAM_{FG, \text{TOTAL}} \\
\text{EFGO} = \sum_{FG} SAM_{\text{TOTAL}, FG} - \sum_{FG} SAM_{\text{INV'}, FG} \\
\text{YSGO} = \sum_{SG} SAM_{SG, \text{TOTAL}} \\
\text{ESGO} = \sum_{SG} SAM_{\text{TOTAL}, SG} - \sum_{SG} SAM_{\text{INV'}, SG} \\
\text{FSAVXO} = \frac{SAM_{\text{INV'}, FT'}}{XRO_{FT'}} \\
\text{DSAVXO} = \frac{SAM_{\text{INV'}, DT'}}{XRO_{DT'}} \\
\text{FSAVMO} = \frac{SAM_{FT', \text{INV'}}}{XRO_{FT'}} \\
\text{DSAVMO} = \frac{SAM_{DT', \text{INV'}}}{XRO_{DT'}} \\
wfa_{FF,A} = \frac{SAM_{FF,A}}{QFO_{FF,A}} \\
\text{WFDISTOFF}_{FF,A} = \frac{wfa_{FF,A}}{WFO_{FF}} \\
\text{SHIFTFF}_{FF} = \frac{QFSO_{FF}}{WFO_{FF}^{\text{fac}}}} \\
\text{CPIO} = \sum_{C} cwt sc \ast PDOc \\
\text{Calibration of parameters:} \\
\theta_{A,C} = \frac{SAM_{A,C}}{PXO_{C} \ast QAO_{A}} \\
ica_{C,A} = \frac{QINTO_{C,A}}{QAO_{A}} \\
tb_{A} = \frac{SAM_{\text{INDT}, A}}{SAM_{\text{TOTAL}, A}} \\
ty_{G,H} = \frac{SAM_{G, H}}{SAM_{\text{TOTAL}, H}}
\[ \text{trh}_{H,HH} = \frac{\text{SAM}_{H,HH}}{(1 - \sum_g \text{ty}_{G,HH})\text{SAM}_{\text{TOTAL},H}} \]

\[ \text{mps}_H = \frac{\text{SAM}_{\text{INV},H}}{(1 - \sum_g \text{ty}_{G,H})\text{SAM}_{\text{TOTAL},H}} \]

\[ \text{cwts}_C = \sum_H \sum_{C' C''} \text{SAM}_{C, H} \]

\[ \text{xshift}_{C,T} = \frac{\text{QERO}_{C, T}}{\text{PWEO}_{C, T \text{,xed},T}} \]

\[ \text{engelwtx}_{H} = \frac{1}{\sum_C \text{QHO}_{C, H} \cdot \text{PQO}_C \cdot \text{ine}_{C, H}} \]

\[ \text{ine}_{C, H} = \text{engelwtx}_{H} \cdot \text{ine}_{C, H} \]

\[ \text{beta}_{C, H} = \frac{\text{QHO}_{C, H} \cdot \text{PQO}_C \cdot \text{ine}_{C, H}}{\text{NYHO}_H} \]

\[ \text{lambda}_{C, H} = \frac{\text{QHO}_{C, H} \cdot \text{PQO}_C + \beta_{C, H} \cdot \text{NYHO}_H}{\text{PQO}_C} \]

\[ \text{qg}_{C,G} = \frac{\text{SAM}_{C, G}}{\text{PQO}_C} \]

\[ \text{shry}_{I,FF} = \frac{\text{SAM}_{I, FF}}{\text{SAM}_{\text{TOTAL}, FF} = \sum_T \text{SAM}_{T, FF}} \]

\[ \text{tbshr}_{G} = \frac{\text{SAM}_{G', \text{INDT}'}}{\sum_{GG'} \text{SAM}_{GG', \text{INDT}'}} \]

\[ \text{sgovbal} = \sum_{SG} \text{SAM}_{\text{INV}', SG} \]

\[ \text{rho}_A = \frac{1}{\text{esubp}_A} - 1 \]

\[ \text{del}_{FF,A} = \frac{\sum_{FFF} \text{WFDIST}_{FFF, A} \cdot \text{WFO}_{FFF} \cdot \text{QFO}_{FFF, A}^{\rho_{A}+1}}{\sum_{FFF} \text{WFDIST}_{FFF, A} \cdot \text{WFO}_{FFF} \cdot \text{QFO}_{FFF, A}^{\rho_{A}+1}} \]
\[ \text{Endogenous variables:} \]

\[ \text{ad}_A = \frac{\text{QAO}_A (1 - \text{tb}_A - \sum_{i} \text{icac}_A)}{\left( \sum_{\text{FF}} \text{del}_{\text{FF}, A} * \text{QFO}_{\text{FF}, A} \right)^{-1}} \]

\[ \text{arho}_{\text{CM}} = \frac{1}{\text{esubd}_{\text{CM}}} - 1 \]

\[ \text{adel}_{\text{CM}} = \frac{\text{PMO}_{\text{CM}} * \text{QMO}_{\text{CM}}}{\frac{1}{1 + \text{arho}_{\text{CM}}} \text{PMO}_{\text{CM}} * \text{QMO}_{\text{CM}} + \text{PDO}_{\text{CM}} * \text{QDO}_{\text{CM}}} \]

\[ \text{aq}_{\text{CM}} = \frac{\frac{1}{\text{arho}_{\text{CM}}} \text{QDO}_{\text{CM}}}{\left( \text{adel}_{\text{CM}} * \text{QMO}_{\text{CM}} + (1 - \text{adel}_{\text{CM}}) * \text{QDO}_{\text{CM}} \right)^{-1}} \]

\[ \text{srho}_{\text{CE}} = \frac{1}{\text{esubs}_{\text{CE}}} + 1 \]

\[ \text{sdel}_{\text{CE}} = \frac{\text{PEO}_{\text{CE}} * \text{QEO}_{\text{CE}}}{\frac{1}{1 - \text{srho}_{\text{CE}}} \text{PEO}_{\text{CE}} * \text{QEO}_{\text{CE}} + \text{PDO}_{\text{CE}} * \text{QDO}_{\text{CE}}} \]

\[ \text{as}_{\text{CE}} = \frac{\frac{1}{\text{srho}_{\text{CE}}} \text{QDO}_{\text{CE}}}{\left( \text{sdel}_{\text{CE}} * \text{QEO}_{\text{CE}} + (1 - \text{sdel}_{\text{CE}}) * \text{QDO}_{\text{CE}} \right)^{1 - \text{srho}_{\text{CE}}}} \]

\[ \text{erho}_{\text{CE2}} = \frac{1}{\text{esube}_{\text{CE2}}} + 1 \]

\[ \text{edel}_{\text{CE2}} = \frac{\text{PERO}_{\text{CE2, FT}} * \text{QERO}_{\text{CE2, FT}}}{\frac{1}{1 - \text{erho}_{\text{CE2}}} \text{PERO}_{\text{CE2, FT}} * \text{QERO}_{\text{CE2, FT}} + \text{PERO}_{\text{CE2, DT}} * \text{QERO}_{\text{CE2, DT}}} \]

\[ \text{ae}_{\text{CE2}} = \frac{\frac{1}{\text{erho}_{\text{CE2}}} \text{QDO}_{\text{CE2}}}{\left( \text{edel}_{\text{CE2}} * \text{QERO}_{\text{CE2, FT}} + (1 - \text{edel}_{\text{CE2}}) * \text{QDO}_{\text{CE2, DT}} \right)^{1 - \text{erho}_{\text{CE2}}}} \]

\[ \text{mrho}_{\text{CM2}} = \frac{1}{\text{esubm}_{\text{CM2}}} - 1 \]

\[ \text{mdel}_{\text{CM2}} = \frac{\text{PMRO}_{\text{FT, CM2}} * \text{QMRO}_{\text{FT, CM2}}}{\frac{1}{1 + \text{mrho}_{\text{CM2}}} \text{PMRO}_{\text{FT, CM2}} * \text{QMRO}_{\text{FT, CM2}} + \text{PMRO}_{\text{DT, CM2}} * \text{QMRO}_{\text{DT, CM2}}} \]

\[ \text{am}_{\text{CM2}} = \frac{\frac{1}{\text{mrho}_{\text{CM2}}} \text{QMO}_{\text{CM2}}}{\left( \text{mdel}_{\text{CM2}} * \text{QMRO}_{\text{FT, CM2}} + (1 - \text{mdel}_{\text{CM2}}) * \text{QMRO}_{\text{DT, CM2}} \right)^{-1}} \]
Prices:

- $X_{RT}$ – Exchange rate
- CPI – Consumer price index
- $PM_{RT,C}$ – Regional import price in regional currency
- $PWE_{C,T}$ – World export price in foreign currency
- $PER_{C,T}$ – Regional export price in regional currency
- $PM_{C}$ – Composite import price in regional currency
- $PEC$ – Composite export price in regional currency
- $PQ_{C}$ – Composite commodity price
- $PD_{C}$ – Regional price of regional output
- $PX_{C}$ – Producer price
- $PA_{A}$ – Activity price
- $PVA_{A}$ – Value added price
- $WF_{FF}$ – Average wage or rental rate for factor FF

Quantities:

- $QM_{RT,C}$ – Regional imports
- $QER_{C,T}$ – Regional exports
- $QM_{C}$ – Composite import quantity
- $QE_{C}$ – Composite export quantity
- $QQ_{C}$ – Composite quantity supplied to regional demanders
- $QD_{C}$ – Quantity of regional output supplied to regional demanders
- $QX_{C}$ – Quantity of regional output
- $QA_{A}$ – Activity level
- $QINT_{C,A}$ – Quantity of intermediate use of commodity C by activity A
- $IMAKEQ_{I,C}$ – Institutional make matrix (quantity)
- $Q_{FF,A}$ – Quantity of factor FF demanded by activity A
- $QH_{CH}$ – Household consumption
- $QINV_{C}$ – Investment demand
- $QINV_{I}$ – Investment demand by institutions
- $QFS_{FF}$ – Factor supply
- $INDT(G)$ – Indirect business taxes receipts for each government unit

Accounting variables

- $Y_{I,FF}$ – Transfer of income to institution I from factor FF
- $YH_{H}$ – Gross household income
- $NYH_{H}$ – Net household income
- $YFG$ – Federal government income
- $EFG$ – Federal government expenditure
- $YSG$ – State government revenue
- $ESG$ – State government expenditure
- $FSAVX$ – Foreign savings (export column)
- $FSAVM$ – Foreign savings (import row)
- $DSAVX$ – RUS savings (export column)
DSAVM – RUS savings (import row)

Factors:
- WFDISTFF,A – Factor price distortion factor
- IADJ – Investment adjustment factor
- SADJ – Savings adjustment factor
- SGADJ – State government spending adjustment factor
- SHIFTFF – Factor supply equation shift variable
- WALRAS – WALRAS dummy variable (should be 0)

Equations:

Regional foreign import price equation:
\[ \text{PMR}_{FT,CM} = \text{pwm}_{FT,CM} \times (1 + \text{tm}_{FT,CM}) \times \text{XR}_{FT} \]

Regional foreign export price equation:
\[ \text{PER}_{CE,FT} = \text{PWE}_{CE,FT} \times \text{XR}_{FT} \times (1 - \text{te}_{CE,FT}) \text{ if } \text{QERO}_{CE,FT} \neq 0 \]

Regional RUS import price equation:
\[ \text{PMR}_{DT,CM} = \text{CPI} \times \text{pwm}_{DT,CM} \times (1 + \text{tm}_{DT,CM}) \times \text{XR}_{DT} \]

Regional RUS export price equation:
\[ \text{PER}_{CE,DT} = \text{CPI} \times \text{PWE}_{CE,DT} \times \text{XR}_{DT} \times (1 - \text{te}_{CE,DT}) \text{ if } \text{QERO}_{CE,DT} \neq 0 \]

World export demand function:
\[ \text{QER}_{CE,T} = \text{PWE} \times \text{shift} \text{ if } \text{QERO}_{CE,T} \neq 0 \]

Armington import composite equation:
\[ \text{QM}_{CM2} = \text{am}_{CM2} \times \left( \text{mde}_{CM2} \times \text{QMR}_{FT,CM2} \times \text{mho}_{CM2} + (1 - \text{mde}_{CM2}) \times \text{QMR}_{DT,CM2} \times \text{mho}_{CM2} \right)^{-1} \]

ROW-RUS import ratio:
\[ \frac{\text{QMR}_{FT,CM2}}{\text{QMR}_{DT,CM2}} = \left( \frac{\text{PMR}_{DT,CM2} \times \text{mde}_{CM2}}{\text{PMR}_{FT,CM2} \times (1 - \text{mde}_{CM2})} \right)^{\frac{1}{\text{mho}_{CM2}}} \]

Import quantity for imports from exactly one source:
\[ \text{QM}_{CM1} = \text{QMR}_{DT,CM1} \text{ if } \text{QMRO}_{DT,CM1} \neq 0 + \text{QMR}_{FT,CM1} \text{ if } \text{QMRO}_{FT,CM1} \neq 0 \]

Import price for imports from exactly one source:
\[ \text{PM}_{CM1} = \text{PMR}_{DT,CM1} \text{ if } \text{QMRO}_{DT,CM1} \neq 0 + \text{PMR}_{FT,CM1} \text{ if } \text{QMRO}_{FT,CM1} \neq 0 \]
Value of imports:
\[ PM_{CM2} \cdot QM_{CM2} = \sum_T PMR_{T, CM2} \cdot QMR_{T, CM2} \]

Export composite transformation equation:
\[ QE_{CE2} = ae_{CE2} \left( edel_{CE2} \cdot QER_{CE2, FT}^{\epsilon rho_{CE2}} + (1 - edel_{CE2}) \cdot QER_{CE2, DT}^{\epsilon rho_{CE2}} \right)^{-1/\epsilon rho_{CE2}} \]

ROW-RUS export ratio:
\[ \frac{QER_{CE2, DT}}{QER_{CE2, FT}} = \left( \frac{PER_{CE2, DT}}{PER_{CE2, FT}} \cdot \frac{edel_{CE2}}{1 - edel_{CE2}} \right)^{1/\epsilon rho_{CE2}} \]

Export quantity for exports to exactly one destination:
\[ QE_{CE1} = QER_{CE1, DT} \text{ (if } QERO_{CM1,DT} \neq 0) + QER_{CM1,FT} \text{ (if } QERO_{CM1,FT} \neq 0) \]

Export price for exports to exactly one destination:
\[ PE_{CE1} = PER_{CM1,DT} \text{ (if } QERO_{CM1,DT} \neq 0) + PER_{CM1,FT} \text{ (if } QERO_{CM1,FT} \neq 0) \]

Value of exports:
\[ PE_{CE2} \cdot QE_{CE2} = \sum_T PER_{CE2, T} \cdot QER_{CE2, T} \]

Absorption equation:
\[ PQC \cdot QQC = (1+tqC) \cdot PMC \cdot QMC \text{ (if } C \subset CM) + (1+tqC+tqSC) \cdot PD_{C} \cdot QD_{C} \]

Value of regional output:
\[ PX_{C} \cdot QX_{C} = PD_{C} \cdot QD_{C} + PE_{C} \cdot QE_{C} \text{ (if } C \subset CE) \]

Activity price equation:
\[ PA_{A} = \sum_C PX_{C} \cdot theta_{A, C} \]

Value added price equation:
\[ PVA_{A} = PA_{A} \cdot (1 - tb_{A}) - \sum_C PQ_{C} \cdot ic_{A, C} \]

Leontief-CES production function:
\[ QA_{A} = \frac{ad_{A}}{1 - tb_{A} - \sum_C ic_{A, C}} \cdot \left( \sum_{FF} del_{FF, A} \cdot QF_{FF, A}^{-\rho_{hoa}} \right)^{-1/\rho_{hoa}} \]

Factor demand equation:
\[ WF_{DIST, FF, A} \cdot WF_{FF} = \frac{PVA_{A} \cdot ad_{A}}{1 - tb_{A} - \sum_C ic_{A, C}} \cdot \left( \sum_{FFF} del_{FFF, A} \cdot QF_{FFF, A}^{-\rho_{hoa}} \right)^{-1/\rho_{hoa} - 1} \cdot del_{FF, A} \cdot QF_{FF, A}^{-\rho_{hoa} - 1} \]
Intermediate input demand equation:

\[ Q_{\text{INT},A} = \text{ica}_{C,A} \cdot Q_{A,A} \]

Output function:

\[ Q_{X,C} = \sum_A \text{theta}_{A,C} \cdot Q_{A,A} + \sum_I \text{IMAKEQ}_I.C \]

Arntington commodity composite equation:

\[ Q_{Q,C,M} = \text{aq}_{C,M} \left[ (\text{adel}_{C,M} \cdot Q_{M,C} - \text{arho}_{C,M} - 1 + \text{adel}_{C,M} \cdot Q_{D,M} - \text{arho}_{C,M} - 1) \right]^{-1/\text{arho}_{C,M}} \]

Import regional demand ratio:

\[ \frac{Q_{M,C,M}}{Q_{D,C,M}} = \left( \frac{\text{PD}_{C,M} \cdot \text{adel}_{C,M}}{\text{PM}_{C,M} \cdot (1 - \text{adel}_{C,M})} \right)^{1/\text{arho}_{C,M}} \]

Composite supply for non-imported commodities:

\[ Q_{Q,C,NM} = Q_{D,C,NM} \]

Output transformation equation:

\[ Q_{X,C,E} = \text{as}_{C,E} \left[ (\text{sdel}_{C,E} \cdot Q_{E,C} - \text{srho}_{C,E} - 1 + \text{sdel}_{C,E} \cdot Q_{D,E} - \text{srho}_{C,E} - 1) \right]^{-1/\text{srho}_{C,E}} \]

Export regional supply ratio:

\[ \frac{Q_{E,C,E}}{Q_{D,C,E}} = \left( \frac{\text{PE}_{C,E} \cdot (1 - \text{sdel}_{C,E})}{\text{PD}_{C,E} \cdot \text{sdel}_{C,E}} \right)^{1/\text{srho}_{C,E} - 1} \]

Output transformation for non-exported commodities:

\[ Q_{X,C,NE} = Q_{D,C,NE} \]

Factor income equation:

\[ Y_{F,L,F} = \text{shry}_{L,F}(\sum_A \text{WFDIST}_{F,F,A} \cdot Q_{F,F,A} \cdot \text{WF}_{F,F,A} - \text{CPI} \cdot \sum_T \text{SAM}_{T,F,F}) \]

Household income equation:

\[ Y_{H, H} = \sum_{F,F} Y_{F,H,F} + \sum_C \text{PX}_C \cdot \text{IMAKEQ}_{H,C} + \text{cpi} \cdot \sum_T \text{SAM}_{H,T} \]

\[ + Q_{IINV}_H + \text{CPI} \cdot \sum_G \text{SAM}_{H,G} + \sum_{H,H} (\text{trh}_{H,H} \cdot (1 - \sum_G \text{ty}_{G,H} \cdot Y_{H,H})) \]

Net household income equation:

\[ N_{Y,H} = Y_{H,H} - \sum_{H,H} \text{trh}_{H,H} \cdot (1 - \sum_G \text{ty}_{G,H} \cdot Y_{H,H}) - \text{cpi} \cdot \sum_T \text{SAM}_{T,H} \]

\[ - \text{SADJ} \cdot \text{mps}_{H} \cdot (1 - \sum_G \text{ty}_{G,H}) \cdot Y_{H,H} - Y_{H,H} \cdot \sum_G \text{ty}_{G,H} \]
Household consumption demand:

\[ QH_{C,H} = \lambda C_{H} + \beta C_{H} \left( NYH - \sum_{CC} \lambda C_{H} \right) * (1 + tc_{CC}) * P_{QCC} / ((1 + tc_{C}) * P_{C}) \]

Investment demand equation:

\[ QINV_{C} = IADJ * QINVO_{C} \]

Institutional investment demand equation:

\[ QIINV_{HG} = QIINVO_{HG} \]

Federal government revenue:

\[ YFG = \sum_{H} \sum_{FG} ty_{H,F} * YH + \sum_{T} \sum_{FG} SAM_{FG,T} + \sum_{C} \sum_{FG} PX_{C} * IMAKEQ_{FG,C} + \sum_{FG} \sum_{FF} YF_{FG,FF} \]

\[ + \sum_{FG} QIINV_{FG} + \sum_{FG} \sum_{FF} SAM_{FG,FF} + \sum_{FG} INDT_{FG} \]

Federal government expenditures:

\[ EFG = \sum_{F} \sum_{I} \sum_{FG} SAM_{I,F} + \sum_{F} \sum_{T} \sum_{FG} SAM_{T,F} + \sum_{F} \sum_{C} \sum_{FG} PQ_{C} = \sum_{FG} \sum_{C} \sum_{SAM} CPI_{SAM} + \sum_{FG} YF_{FG,FF} \]

State government revenue:

\[ YSG = \sum_{H} \sum_{SG} ty_{H,S} * YH + \sum_{T} \sum_{SG} SAM_{SG,T} + \sum_{C} \sum_{SG} PX_{C} * IMAKEQ_{SG,C} + \sum_{SG} \sum_{FF} YF_{SG,FF} \]

\[ + \sum_{SG} QIINV_{SG} + \sum_{SG} \sum_{SGG} SAM_{SG,SGG} + \sum_{SG} INDT_{SG} \]

\[ + CPI \sum_{FG} \sum_{SG} SAM_{SG,FG} \]

\[ + \sum_{C} t_{c} * (PM_{C} * QM_{C} (if(C \subset CM)) + PD_{C} * QD_{C}) \]

\[ + \sum_{C} t_{Q_{S_{C}}} * PD_{C} * QD_{C} \]

\[ + \sum_{H} \sum_{C} t_{C} * PQ_{C} * QH_{C,H} \]

State government expenditures:

\[ ESG = \]

\[ \sum_{SG} \sum_{I} \sum_{SG} \sum_{I} \sum_{T} \sum_{SG} SAM_{I,SG} + \sum_{SG} \sum_{T} \sum_{SG} SAM_{T,SG} \]

\[ + \sum_{SG} \sum_{C} \sum_{C} \sum_{C} \sum_{Q_{C}} \sum_{C} \sum_{Q_{C}} Sam_{IN_{C},SG} + \sum_{SG} \sum_{C} CPI_{sgovbal} \]
State government budget balanced:
\[ \text{YSG} = \text{ESG} + \text{CPI} \times \text{sgovbal} \]

Factor market equation:
\[ Q_{FS,FF} = \sum_{A} Q_{FF, A} \]

Composite commodity market equation:
\[ Q_{QC} = \sum_{A} Q_{\text{INT}, A} + \sum_{H} Q_{\text{H}, H} + \sum_{\text{FG}} q_{\text{G}, \text{FG}} + \text{SGADJ} \times \sum_{\text{SG}} q_{\text{G}, \text{SG}} + Q_{\text{INV}, C} \]

ROW current account balance:
\[ \sum_{\text{CE}} \text{PER}_{CE, FT} \times \text{QER}_{CE, FT} + \text{cpi} \times \sum_{H} \text{SAM}_{H, FT} + \text{cpi} \times \sum_{G} \text{SAM}_{G, FT} + \text{XR}_{FT} \times \text{FSAVX} \]
\[ = \sum_{\text{CM}} \text{PMR}_{CT, CM} \times \text{QMR}_{CT, CM} + \text{cpi} \times \sum_{\text{FF}} \text{SAM}_{FT, FF} + \text{cpi} \times \sum_{\text{HG}} \text{SAM}_{FT, HG} + \text{XR}_{FT} \times \text{FSAVM} \]

RUS current account balance:
\[ \sum_{\text{CE}} \text{PER}_{CE, DT} \times \text{QER}_{CE, DT} + \text{cpi} \times \sum_{H} \text{SAM}_{H, DT} + \text{cpi} \times \sum_{G} \text{SAM}_{G, DT} + \text{cpi} \times \text{XR}_{DT} \times \text{DSAVX} \]
\[ = \sum_{\text{CM}} \text{PMR}_{CT, CM} \times \text{QMR}_{CT, CM} + \text{cpi} \times \sum_{\text{FF}} \text{SAM}_{DT, FF} + \text{cpi} \times \sum_{\text{HG}} \text{SAM}_{DT, HG} + \text{cpi} \times \text{XR}_{DT} \times \text{DSAVM} \]

Savings investment balance:
\[ \sum_{C} \text{PX}_{C} \times \text{MAKEQ}_{INV, C} + \text{SADJ} \times \sum_{H} \text{tys}_{H} \times (1 - \sum_{G} \text{ty}_{G, H}) \times \text{Y}_{H} + \sum_{\text{FF}} \text{Y}_{F} \times \text{INV, FF} \]
\[ + (\text{YFG} - \text{EFG}) + \text{XR}_{FT} \times \text{FSAVX} + \text{CPI} \times \text{XR}_{DT} \times \text{DSAVX} + \text{CPI} \times \text{sgovbal} \]
\[ = \sum_{C} \text{PQ}_{C} \times \text{QINV}_{C} + \sum_{\text{HG}} \text{QINV}_{H} + \text{XR}_{FT} \times \text{FSAVM} + \text{CPI} \times \text{XR}_{DT} \times \text{DSAVM} + \text{WALRAS} \]

Price normalization equation
\[ \sum_{C} (1 + \text{tc}_{C}) \times \text{PQ}_{C} \times \text{cwts}_{C} = \text{CPI} \]
Indirect taxes calculation:

\[ \text{INDT}_G = \text{tbshr}_G \times \sum_A \text{tb}_A \times \text{PA}_A \times \text{QA}_A \]

Factor supply equation:

\[ \text{QFS}_{FF} = \text{SHIFTFF}_{FF} \times \text{WF}_{FF} \]

**Using the employment data provided by IMPLAN:**

The global variable LBR controls whether or not the employment data provided by IMPLAN is used by the model. If LBR is set to YES, the aggregated employment data extracted from IMPLAN is loaded into the initial values for QF (‘LAB’). These numbers are used to calculate a real initial wage. In this case, QF (‘LAB’) and QFS (‘LAB’) represent actual number of jobs. WF (‘LAB’) represents a real wage.

If LBR is set to NO, the initial numbers in the SAM representing the total value of labor are loaded into the initial values for QF (‘LAB’). The initial values of WF are set to 1. In this case, QF (‘LAB’) and QFS (‘LAB’) represent values of labor and WF (‘LAB’) represents nominal wages.

**Closure:**

The following closure options are available:

1. Capital closure (determined by setting the scalar CAPCLOS)
   - CAPCLOS = 1. Capital is mobile and supply is fixed.
   - CAPCLOS = 2. Capital is mobile and supply is variable.
   - CAPCLOS = 3. Capital is activity specific and fixed.

2. Labor closure (determined by setting the scalar LABCLOS)
   - LABCLOS = 1. Labor is mobile and supply is fixed.
   - LABCLOS = 2. Labor is mobile and supply is variable.
   - LABCLOS = 3. Labor is mobile. Unemployment is possible.

3. Savings and investment closure (determined by setting the scalar SICLOS)
   - SICLOS = 1. Savings is investment driven.
   - SICLOS = 2. Investment is savings driven.
   - SICLOS = 3. CPI varies allowing prices to adjust to achieve equilibrium.

4. ROW current account closure (determined by setting the scalar ROWCLOS)
   - ROWCLOS = 1. Foreign exchange rate is variable.
   - ROWCLOS = 2. Foreign savings (export - FSAVX) is variable.
   - ROWCLOS = 3. Foreign savings (import - FSAVM) is variable.

5. RUS current account closure (determined by setting the scalar RUSCLOS)
   - RUSCLOS = 1. RUS exchange rate is variable.
   - RUSCLOS = 2. RUS savings (export - DSAVX) is variable.
   - RUSCLOS = 3. RUS savings (import - DSAVM) is variable.
Homogeneity:

This model is homogeneous of degree 0 when foreign savings is fixed and the exchange rate for foreign trade is allowed to vary. The exchange rate for regional trade is fixed and the value of imports from and exports to the rest of the US is indexed to the cpi. The model may not be homogeneous of degree 0 under other closure rules that may or may not index fixed flows such as transfers and government expenditures to the cpi.

GAMS programming documentation:

Input data for the model comes from the IMPLAN data base. A state model is constructed with the IMPLAN program using the social accounts option. A report can then be generated which will create the 26 CGE files that are used as input into the GAMS programs. The 26 text files created by IMPLAN are:

1x2.dat
1x5.dat
1x6.dat
1x7.dat
1x8.dat
2x1.dat
2x4.dat
3x1.dat
4x2.dat
4x3.dat
4x4.dat
4x5.dat
4x6.dat
4x7.dat
4x8.dat
5x1.dat
5x3.dat
5x4.dat
5x5.dat
6x1.dat
6x3.dat
6x4.dat
7x1.dat
7x4.dat
8x1.dat
8x4.dat

The GAMS files required to run the model are:

1. check.gms
2. aggreg.gms
3. map.gms
4. model.gms
5. report.gms
6. gms2xcl.gms
In addition to these 6 program files, additional files are created by these programs:

1. SAM.gms
2. fn.txt
3. SAM.gdx
4. SAM.xls

These programs have been tested using version 21.3 of GAMS. Versions before 21.3 should work except for the gms2xcl.gms program. The GAMS gdx facility (described below) apparently will not work with earlier versions.

While the names and locations of these files can and will be changed for various runs, it is important to insure that the correct names and paths are inserted into the INCLUDE and BATINCLUDE instructions within each of the programs. This will be explained further in the documentation for each program.

check.gms – This file is Rutherford’s program with minor changes by Leroy Stodick which sets up the SAM accounts as required to read the data in the 26 IMPLAN output files. Check.gms reads the IMPLAN data by using the include command to insert the data into the GMS program. It is important to insure that the include commands in check.gms correctly point to the location of IMPLAN data. After setting the social accounts and reading in the data, check.gms calls the aggreg.gms file by using the include command. It is important that the user sets the correct path for the aggreg.gms file in the include line in check.gms. The folder where the aggreg.gms file is located can be set using the global variable PROGPATH. This will also be the folder where the map.gms file is located and where the output file named SAM.gms will be placed. The prefix for all the name of these data files can be set using the DATANAM global variable. The 27 include instructions which must contain the correct paths are:

```
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\2x1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\3x1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\5x1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\1x2.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x2.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x3.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\5x3.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\2x4.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x4.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\5x4.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\1x5.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x5.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\5x5.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4X6.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\6X1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\6X3.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\6X4.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\1X6.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\1x7.dat"
```
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x7.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\1x8.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\4x8.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\7x1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\7x4.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\8x1.dat"
$INCLUDE "C:\CGE\%DATAPATH%DATANAM\8x4.dat"

$INCLUDE "%PROGPATH%aggreg.gms"

Notice that the DATAPATH and DATANAME global variables can be used to facilitate changing the path or names from one set of data to another.

Aggreg.gms aggregates the SAM accounts according to the aggregation scheme defined in MAP.gms. This file is included in aggreg.gms with the following include instruction:

$INCLUDE "%PROGPATH%Map.gms"

It is important that the path to Map.gms is correct.

In additional to aggregating the data, aggreg.gms also adjusts the SAM to fit Lofgren’s implementation of CGE. It incorporates the imports of activities into the USE and IUSE matrices and inserts the imports of commodities into the commodities columns. It also incorporates the exports of activities into the MAKE matrix and inserts the exports of commodities into the commodity rows. When the aggregated and adjusted SAM has been calculated, aggreg.gms writes the SAM to a file which has been opened using the following command:

    FILE KDATA / "%PROGPATH%SAM.gms" /;

This is the file which will be included in the model file and in the gms2xcl.gms program. The path and name used here must also be used in these two files.

Map.gms is the name of the GAMS program in which the user defines the aggregation scheme.

To run the set of these three programs, the user should run check.gms. Check.gms will call aggreg.gms which in turn will call map.gms. If no errors are encountered, the output of these programs is a file called SAM.gms (or another name given by the user) which contains the aggregated and adjusted SAM.

The easiest way to visualize the SAM is to import it into an Excel worksheet. This can be done using the gms2xcl.gms program (GAMS version 20.6 and higher).

$INCLUDE "C:\CGE\SEPT2003\IDSam.gms"

EXECUTE_UNLOAD "C:\CGE\SEPT2003\IDSAM.gdx",SAM;
EXECUTE "GDXXRW.EXE I = C:\CGE\SEPT2003\IDSAM.gdx O = C:\CGE\SEPT2003\IDSAM.xls PAR=SAM";

The first line must have the path and name of the file created by the aggreg.gms program. The second line must have the path and name of a new file to be created. This is a temporary intermediate file which must have the file extension .gdx. gdx stands for
GAMS Data Exchange and is one way GAMS programs communicate with other programs. The third line must have the path and name of the gdx file just created in the previous line and the path and name of the Excel file to be created. It must have a .xls file extension.

Once the file containing the aggregated and adjusted SAM has been created, there is no need to create it again unless the aggregation scheme is changed. Multiple runs of the model can be executed using various counter-factual simulations with the same data input file.

Model.gms is the name of the GAMS program which uses the input data to find economic equilibrium. The following line must be set to reflect the path and name of the file containing the SAM created by aggreg.gms. The global variable PROGPATH where the SAM file is located must be initialized prior to this include statement.

$INCLUDE "%PROGPATH%SAM.gms"

Initial prices and parameter values should be set by the user before running the program. The program has been tested using the PATH solver but there is no reason why other solvers cannot be used. Output is reported by calling a report generator using the following command:

$BATINCLUDE "%PROGPATH%Report.GMS" file_name

As in all include and batinclude commands, the path and name of the file to be included (Report.gms) must be updated in this line. The parameter to the batinclude command is the name of the file the report generator will create. It will automatically be given a .txt extension.

Report.gms is the report generator. It will create a text file using the following command:

FILE KDATA / "%PROGPATH%1.txt" ;

This line contains the path where the output file will be stored and should be set by the user.

The $BATINCLUDE instruction can be changed to:

$BATINCLUDE "%PROGPATH%Report.GMS" file_name P

The report generated will include all the calculated parameters as well as the normal output.
Instructions for extracting data from IMPLAN for use with check.gms:

If a state model has not been created in IMPLAN:

Run IMPLAN.

1. Select ‘File’.
2. Select ‘New Model’.
3. Name the model and select ‘Save’.
4. Select the desired region from the ‘Available IMPLAN Data Files’ table by double clicking on the region name. If the desired region is not shown in the table, you will have to purchase the data files from IMPLAN and install them.
5. Select ‘Continue’.
6. IMPLAN will show a window stating that the study area has been built. Select OK.
7. Select ‘Construct Model’.
8. Select ‘Social Accounts’ and click on ‘Continue’.
9. IMPLAN will state that the model construction is complete. Select ‘OK’.
10. Select ‘Reports’.
12. Select ‘26 File CGE Format Files’ and click on ‘Continue’.
13. Type in the name and location of the files to be saved and click on ‘Save’.
15. Exit from IMPLAN. The 26 CGE files have been created and saved.

If a state model has already been created in IMPLAN:

1. Select ‘File’.
2. Select ‘Open an Existing Model’.
3. Select the file and click on ‘Open’.
4. Select ‘Reports’.
5. Select the ‘3: SAM’ tab.
6. Select ‘26 File CGE Format Files’ and click on ‘Continue’.
7. Type in the name and location of the files to be saved and click on ‘Save’.
8. Close the ‘Print Reports’ window.
9. Exit from IMPLAN. The 26 CGE files have been created and saved.
References:


