A Macro CGE Model for the Colombian Economy

Banco de la República's Internal Seminar

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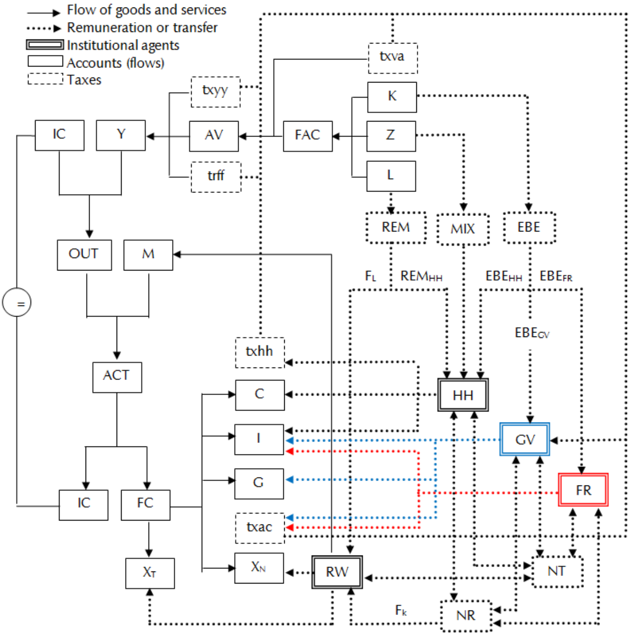
Outline

Motivation

- Macro CGE models acknowledge the **links** between National Accounts and *Balance of Payments* and *Fiscal Accounts*.
- Allow for Taxation and Sectoral analyses.
- CGEM are NOT intended for Policy Recommendations but are mostly used to present the economy's outcomes after assessing different *alternative* scenarios.

The Economy I



Social Accounting Matrix:

			Factors			Production and products							Distribution												Agents				Rents taxes and transfers										Bal.	TOT.
			F			P							D												A				T										B	
			L	K	Z	FAC	AV	Y	ICD	OUT	M	ACT	ICS	FC	C	I	Ihh	Ifr	Igv	Ipr	G	X	Xt	Xn	HH	FR	GV	RW	R	TXv	TXyy	TRf	Thh	Tac	SC	SB	CT	PT	SI	
	LABOUR	L				196																																		196
F	CAPITAL	K				223																																		223
	MIXED	Z				135																																		135
	PRODUCTION	FAC					554																																	554
	ADDED VALUE	AV						567																																567
	GROSS DOMESTIC PRODUCT	Y								622																														622
P	DEMAND OF INT. CONSUMP.	ICD								479																														479
	OUTPUT	OUT										1100																												1100
	IMPORTS	M										123																												123
	ACTIVITY	ACT											479	745																										1223
	SUPPLY OF INT. CONSUMP.	ICS							479																															479
	FINAL CONSUMPTION	FC													423	148					56		81	37																745
	PRIVATE CONSUMPTION	C																							423															423
	INVESTMENT	I															35	92	21																					148
	HOUSEHOLDS INVESTMENT	Ihh																		35																				35
D	FIRMS INVESTMENT	Ifr																		92																				92
	GOVERNMENT INVESTMENT	Igv																																					21	21
	PRIVATE INVESTMENT	Ipr																																					126	126
	GOVERNMENT EXPENDITURE	G																									56													56
	EXPORTS	X																										118												118
	TRADITIONAL EXPORTS	Xt																				81																		81
	NON-TRADITIONAL EXPORTS	Xn																				37																		37
	HOUSEHOLDS	HH	198	26	135																								59							51	25	43		538
A	FIRMS	FR		191																									46						18					254
	GOVERNMENT	GV		6																									25	13	49	5	7	31	36		3			176
	REST OF THE WORLD	RW	-2								123																		27											148
	RENTS	R																							11	130	16													157
	PRODUCTION TAXES	TXva					13																																	13
	PRODUCT TAXES	TXyy						49																																49
	IMPORT TARIFFS	TRff						5																																5
T	DIRECT TAXES TO HH	Thh																							7															7
	DIR TAXES TO FR & GV	Tac																								31	0													31
	SOCIAL CONTRIBUTIONS	SC																							53															53
	SOCIAL BENEFITS	SB																								5	46													51
	CURRENT TRANSFERS	CT																								18		11												28
	PRODUCT TRANSFERS	PT																									43													43
B	SAVINGS-INVESTMENT BAL.	SI																							43	70	15	20												148
	TOTAL		196	223	135	554	567	622	479	1100	123	1223	479	745	423	148	35	92	21	126	56	118	81	37	538	254	176	148	157	13	49	5	7	31	53	51	28	43	148	

The Model: Supply Side

Production factors, Indirect taxes, Intermediate consumption and Imports are combined to create total supply of the representative good (Activity).

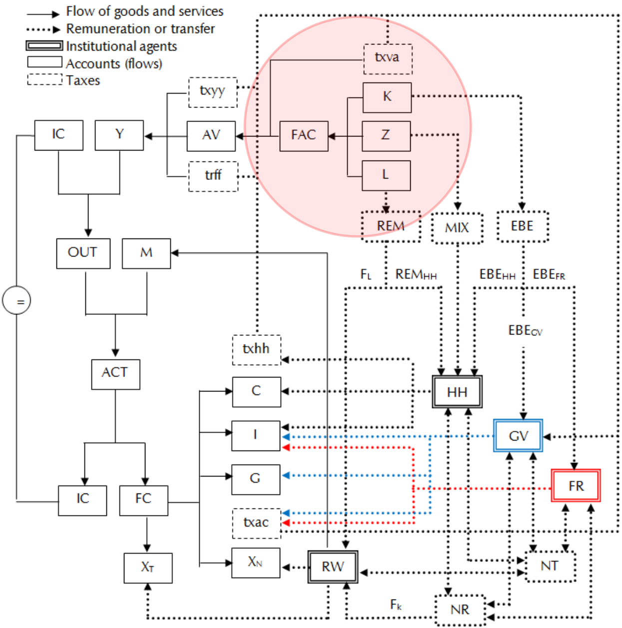
This process involves solving three different cost minimization problems:

- Factor Demand Problem.
- GDP - Intermediate Consumption Problem.
- Output - Imports Problem.

Firm also maximizes its revenue by optimally solving:

- FC and IC Distribution Problem.
- FC components Distribution Problem (link to demand side).

Factor Demand Block



The Model: Factor Demand Problem I

- Three factors combined + Production Taxes = Value Added.
- Firms solve the Factors Demand Problem (minimizes expenditure subject to production):

$$\min_{\{L,K,Z\}} p_L L + p_K K + p_Z Z,$$

s.t.

$$FAC = \theta_F \left(\pi_L L^{\frac{\sigma_F - 1}{\sigma_F}} + \pi_K K^{\frac{\sigma_F - 1}{\sigma_F}} + \pi_Z Z^{\frac{\sigma_F - 1}{\sigma_F}} \right)^{\frac{\sigma_F}{\sigma_F - 1}}$$

- Elasticity of substitution among factors satisfies $\sigma_F > 0$.

The Model: Factor Demand Problem II

From the FOCs we derive the optimal demand of factors:

$$L = \left(\theta_F \pi_L \frac{p_F}{p_L}\right)^{\sigma_F} \frac{FAC}{\theta_F} \ , \ K = \left(\theta_F \pi_K \frac{p_F}{p_K}\right)^{\sigma_F} \frac{FAC}{\theta_F} \ ,$$

$$Z = \left(\theta_F \pi_Z \frac{p_F}{p_Z}\right)^{\sigma_F} \frac{FAC}{\theta_F} \ ,$$

where the aggregated price of factors p_F is expressed as

$$p_F = \frac{1}{\theta_F} \left(\pi_L^{\sigma_F} p_L^{1-\sigma_F} + \pi_K^{\sigma_F} p_K^{1-\sigma_F} + \pi_Z^{\sigma_F} p_Z^{1-\sigma_F}\right)^{\frac{1}{1-\sigma_F}}$$

The Model: Indirect taxes and GDP

- Added value, AV, is completed once indirect production taxes are acknowledged (nominal terms):

$$p_{AV}AV = p_F FAC + TX_{va} \ ,$$

where tax revenue in production (TX_{va}) is given by

$$TX_{va} = tx_{va} p_F FAC.$$

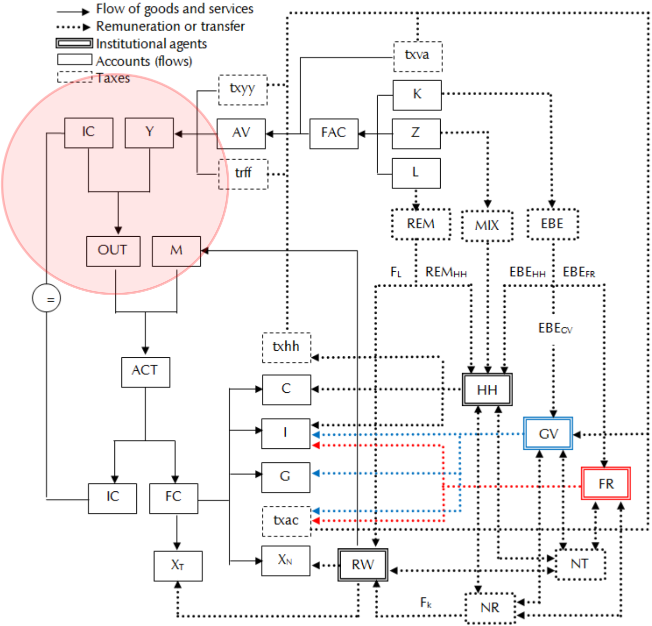
- GDP (Y) supply is obtained by adding up AV, indirect (net) taxes over products (TX_{yy}) and import tariffs (TR_{ff}):

$$p_Y Y = p_{AV}AV + TX_{yy} + TR_{ff} \ ,$$

where indirect product taxes and tariffs are given by

$$TX_{yy} = tx_{yy} p_{AV} AV, \text{ and } TR_{ff} = tr_{ff} p_M M$$

Domestic Supply Block



The Model: Domestic Output Problem I

- GDP and IC combined yield total domestic supply of the representative good.
- The firm solves for optimal combination of Y and IC in the domestic output's second-level cost minimization problem:

$$\min_{\{Y,IC\}} p_Y Y + p_{IC} ICD$$

s.t.

$$OUT = \theta_O \left(\pi_Y Y^{\frac{\sigma_O - 1}{\sigma_O}} + \pi_{ICD} ICD^{\frac{\sigma_O - 1}{\sigma_O}} \right)^{\frac{\sigma_O}{\sigma_O - 1}}$$

- Again, elasticity of substitution between Y and IC satisfy $\sigma_O > 0$, however, these goods are more complementary than substitutes ($0 < \sigma_O < 1$).

The Model: Domestic Output Problem II

- From FOCs, optimal GDP and Intermediate Consumption demands are

$$Y = \left(\theta_O \pi_Y \frac{p_O}{p_Y}\right)^{\sigma_o} \frac{OUT}{\theta_O}\text{ , and } ICD = \left(\theta_O \pi_{ICD} \frac{p_O}{p_{IC}}\right)^{\sigma_O} \frac{OUT}{\theta_O},$$

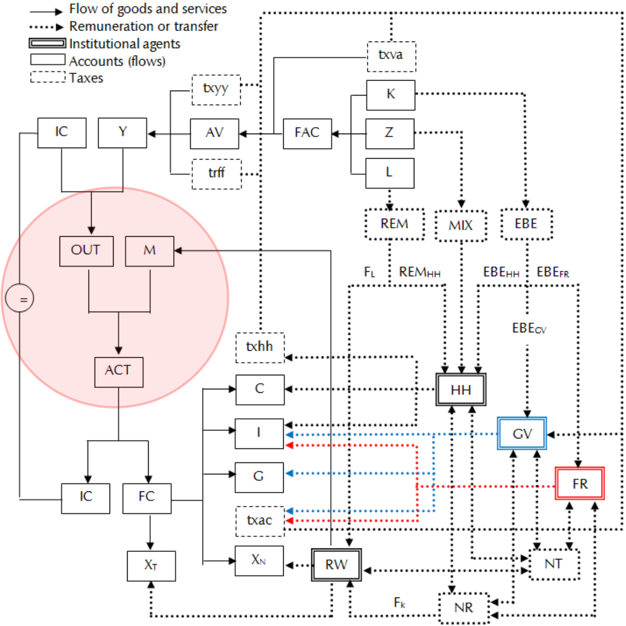
where the aggregated price of domestic output p_O is

$$p_O = \frac{1}{\theta_O}\left(\pi_Y^{\sigma_O} p_Y^{1-\sigma_O} + \pi_{ICD}^{\sigma_O} p_{IC}^{1-\sigma_O}\right)^{\frac{1}{1-\sigma_O}}$$

- With Y's Demand and Supply equations, one can solve for the price of GDP, p_Y:

$$p_Y = \left[\frac{p_{AV} AV + TX_{yy} + TR_{ff}}{(\theta_O \pi_Y p_O)^{\sigma_O} \frac{OUT}{\theta_O}}\right]^{\frac{1}{1-\sigma_O}}$$

Total Supply Block



The Model: Activity (total supply) I

- When The firm when it solves the first-level cost minimization problem given by:

$$\min_{\{OUT,M\}} p_O OUT + p_M M$$

s.t.

$$ACT = \theta_A \left(\pi_O OUT^{\frac{\sigma_A - 1}{\sigma_A}} + \pi_M M^{\frac{\sigma_A - 1}{\sigma_A}} \right)^{\frac{\sigma_A}{\sigma_A - 1}},$$

- Elasticity of substitution between OUT and M is $\sigma_A > 0$.

The Model: Activity (total supply) II

- From FOCs, optimal domestic output and imports demands are, respectively

$$OUT = \left(\theta_A \pi_O \frac{p_A}{p_O}\right)^{\sigma_A} \frac{ACT}{\theta_A}, \text{ and } M = \left(\theta_A \pi_M \frac{p_A}{p_M}\right)^{\sigma_A} \frac{ACT}{\theta_A}$$

  with aggregated price of ACT, p_A given by

$$p_A = \frac{1}{\theta_A}\left(\pi_O^{\sigma_A} p_O^{1-\sigma_A} + \pi_M^{\sigma_A} p_M^{1-\sigma_A}\right)^{\frac{1}{1-\sigma_A}}$$

- OUT demand and supply equations are solved for price of OUT, p_O:

$$p_O = \theta_A \pi_O \left[\frac{\frac{ACT}{\theta_A}}{\theta_O\left(\pi_Y Y^{\frac{\sigma_O - 1}{\sigma_O}} + \pi_{ICD} ICD^{\frac{\sigma_O - 1}{\sigma_O}}\right)^{\frac{\sigma_O}{\sigma_O - 1}}}\right]^{\frac{1}{\sigma_A}} p_A$$

The Model: Activity (total supply) III

Additional considerations on ACT formation:

- The clearing market condition assures that

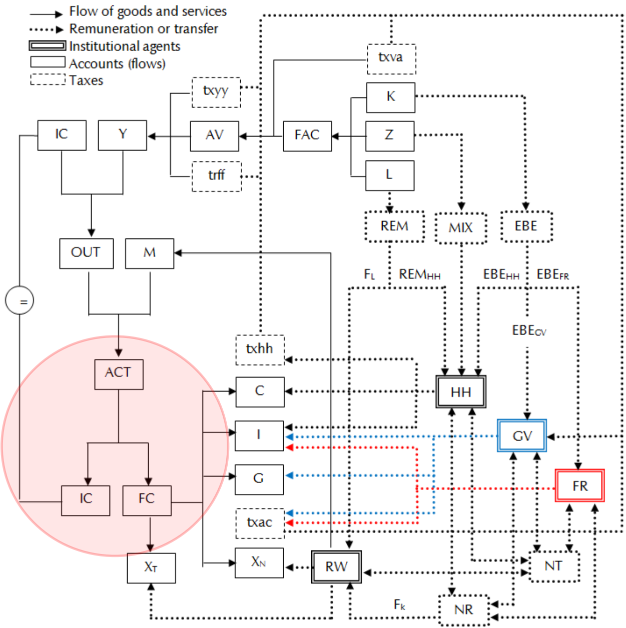
$$p_A ACT = p_O OUT + p_M M.$$

- RW provides all demand for imports inelastically at the international price p_M^*, and therefore

$$p_M = e p_M^*$$

where $\bar{e}$ is the nominal exchange rate.

Supply Distribution Block



The Model: Supply Distribution I

Total supply, ACT, is distributed between intermediate and final consumption.

- The firm determines distribution of ACT between intermediate (IC) and final consumption (FC) by maximizing revenue from sales:

$$\max_{\{IC,FC\}} p_{IC} ICS + p_{FC} FC$$

  s.t. a CET technology of distribution

$$ACT = \theta_{AD} \left(\pi_{ICS} ICS^{\frac{\tau_A - 1}{\tau_A}} + \pi_{FC} FC^{\frac{\tau_A - 1}{\tau_A}} \right)^{\frac{\tau_A}{\tau_A - 1}}$$

- The elasticity of transformation between intermediate and final consumption is $\tau_A < 0$.

The Model: Supply Distribution II

- From the FOCs, optimal FC and IC supplies are

$$ICS = \left(\theta_{AD}\pi_{ICS}\frac{p_A}{p_{IC}}\right)^{\tau_A}\frac{ACT}{\theta_{AD}}, \text{ and } FC = \left(\theta_{AD}\pi_{FC}\frac{p_A}{p_{FC}}\right)^{\tau_A}\frac{ACT}{\theta_{AD}}$$

with aggregated price of activity, p_A, given by

$$p_A = \frac{1}{\theta_{AD}}\left(\pi_{ICS}^{\tau_A}p_{IC}^{1-\tau_A} + \pi_{FC}^{\tau_A}p_{FC}^{1-\tau_A}\right)^{\frac{1}{1-\tau_A}}$$

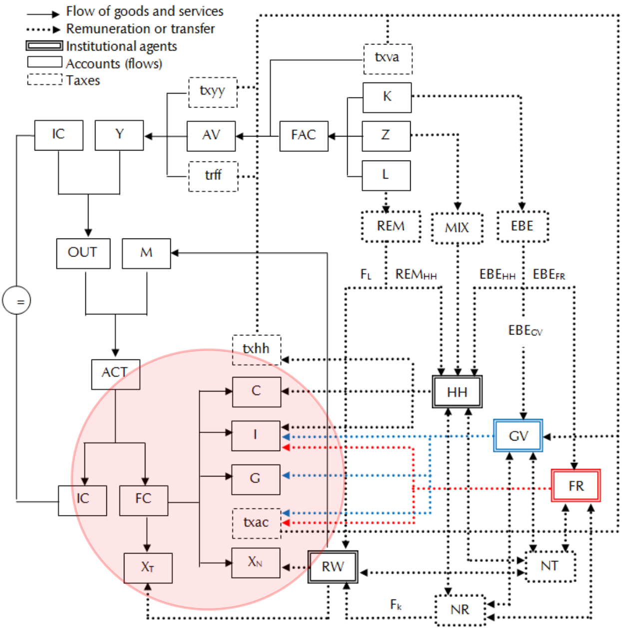
- However, p_A is determined through the market clearing condition:

$$p_A ACT = p_{IC}ICS + p_{FC}FC$$

- With IC supply and demand equations, we have

$$p_{IC} = \left[\frac{(\theta_O\pi_{ICD}p_O)^{\sigma_o}\frac{OUT}{\theta_O}}{(\theta_{AD}\pi_{ICS}p_A)^{\tau_A}\frac{ACT}{\theta_{AD}}}\right]^{\frac{1}{\sigma_O-\tau_A}}$$

FC Distribution Block



The Model: Final Consumption Distribution I

- The firm determines distribution of FC supply between Consumption (C), Investment (I), Government Expenditure (G) and Exports (X). X are classified between traditional, $\bar{X}_T$ (which are assumed as exogenous); and non-traditional, X_N.
- Firm maximizes its revenue from selling final consumption:

$$\max_{\{C,I,G,X_N\}} p_C C + p_I I + p_G G + p_{X_T} \bar{X}_T + p_{X_N} X_N$$

s.t.

$$FC = \bar{X}_T + \theta_{FC} \left(\pi_C C^{\frac{\tau_{FC}-1}{\tau_{FC}}} + \pi_I I^{\frac{\tau_{FC}-1}{\tau_{FC}}} + \pi_G G^{\frac{\tau_{FC}-1}{\tau_{FC}}} + \pi_{XN} X_N^{\frac{\tau_{FC}-1}{\tau_{FC}}} \right)^{\frac{\tau_{FC}}{\tau_{FC}-1}}$$

- Elasticity of transformation between types of final consumption satisfies $\tau_{FC} < 0$.

The Model: Final Consumption Distribution II

- From FOCs we derive the optimal supply of each of the FC components:

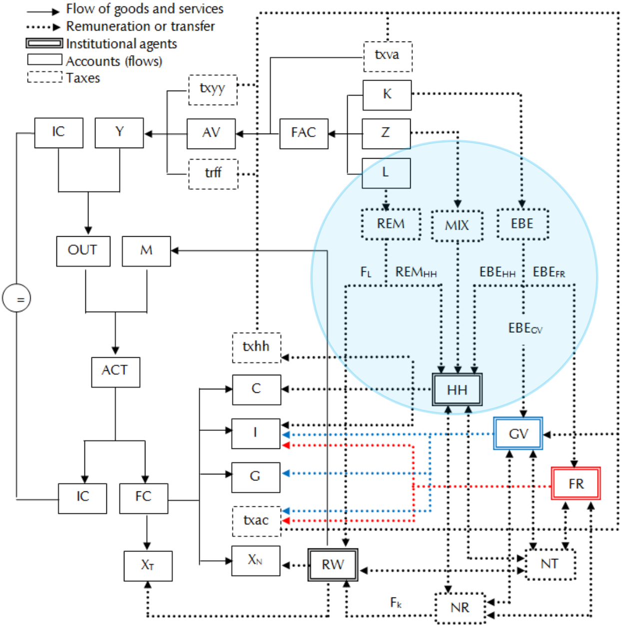
$$Z = \left[\theta_{FC} \pi_Z \frac{p_{FC} FC - p_{XT} \bar{X}_T}{p_Z \left(FC - \bar{X}_T \right)} \right]^{\tau_{FC}} \frac{FC - \bar{X}_T}{\theta_{FC}} \text{, with } Z \in \{C, G, I, X_N\}$$

With p_{FC} given by

$$p_{FC} FC = \frac{1}{\theta_{FC}} \left(\sum \pi_Z^{\tau_{FC}} p_Z^{1-\tau_{FC}} \right)^{\frac{1}{1-\tau_{FC}}} \left(FC - \bar{X}_T \right) + p_{XT} \bar{X}_T$$

- FC supply or FC demand equations can be placed in the latter expression in order to solve for p_{FC}.

Factor Remuneration Block



The Model: Income Distribution I

- Factor supply is assumed to be exogenous (completely inelastic): $\bar{L}$, $\bar{K}$, and $\bar{Z}$.
- Then it holds:

$$\begin{aligned} p_L \bar{L} &= REM = REM_{HH} + F_L \\ p_K \bar{K} &= EBE = EBE_{HH} + EBE_{FR} + EBE_{GV} \\ p_Z \bar{Z} &= MIX = MIX_{HH} \end{aligned}$$

- Given the supplies of factors, and the demands (AV production), we derive the factor prices:

$$p_W = \theta_F \pi_W \left(\frac{FAC}{\theta_F \bar{W}} \right)^{\frac{1}{\sigma_F}} p_F \quad \text{, for } W \in \{L, K, Z\}.$$

The Model: Income Distribution II

Distribution of factor remunerations and rents in the model are paid according to fixed coefficients:

- Factor remunerations:
  - $REM_{HH} = \pi_{HH}^{REM} REM$ and $F_L = \pi_{RW}^{REM} REM$.
  - $EBE_{HH} = \pi_{HH}^{EBE} EBE$, $EBE_{FR} = \pi_{FR}^{EBE} EBE$ and $EBE_{GV} = \pi_{GV}^{EBE} EBE$.
  - $MIX = MIX_{HH}$.
- Rents:
  - *Payments:* $R^{HH} = \pi_R^{HH} EBE_{HH}$, $R^{FR} = \pi_R^{FR} EBE_{FR}$ and $R^{GV} = \pi_R^{GV} EBE_{GV}$.
  - $R = R^{HH} + R^{FR} + R^{GV} = R_{HH} + R_{FR} + R_{GV} + F_K$.
  - *Recipients:* $R_{HH} = \pi_{HH}^{R} R$, $R_{FR} = \pi_{FR}^{R} R$, $R_{GV} = \pi_{GV}^{R} R$, and $F_K = \pi_{RW}^{R} R$.

The Model: Direct Taxes

- Households' income:
  $Y_{HH} = REM_{HH} + EBE_{HH} + MIX_{HH} + \left(R_{HH} - R^{HH}\right).$
- Firm's income: $Y_{FR} = EBE_{FR} + \left(R_{FR} - R^{FR}\right).$
- Government's income: $Y_{GV} = EBE_{GV} + \left(R_{GV} - R^{GV}\right).$

Assuming no tax evasion and perfect fiscal compliance, institutional agents pay direct taxes as a constant fraction of their income:

$$TXhh = txhh Y_{HH}, \ \ TXac_{FR} = txac_{FR} Y_{FR},$$

$$\text{and } \ TXac_{GV} = txac_{GV} Y_{GV}.$$

Total direct taxes are given by

$$T = TXhh + TXac_{HH} + TXac_{GV}.$$

The Model: Transfers I

There are four types of transfers: social contributions (SC), social benefits (SB), current transfers (CT), and product transfers (PT).

- We assume exogenous payments of social contributions $\overline{SC}^{HH}$ by HH, which is distributed FR and GV:

$$SC_{FR}^{HH} = \pi_{FR}^{SC}\overline{SC}^{HH}, \text{ and } SC_{GV}^{HH} = \pi_{GV}^{SC}\overline{SC}^{HH}.$$

- HH receive exogenously assumed social benefits, $SB = \overline{SB}_{HH}$, from FR and GV:

$$SB_{HH}^{FR} = \pi_{FR}^{SB}\overline{SB}_{HH}, \text{ and } SB_{HH}^{GV} = \pi_{GV}^{SB}\overline{SB}_{HH}.$$

- FR and RW pay CT exogenously, $\overline{CT}^{RW} + \overline{CT}^{FR} = CT$, which is distributed to HH and GV as:

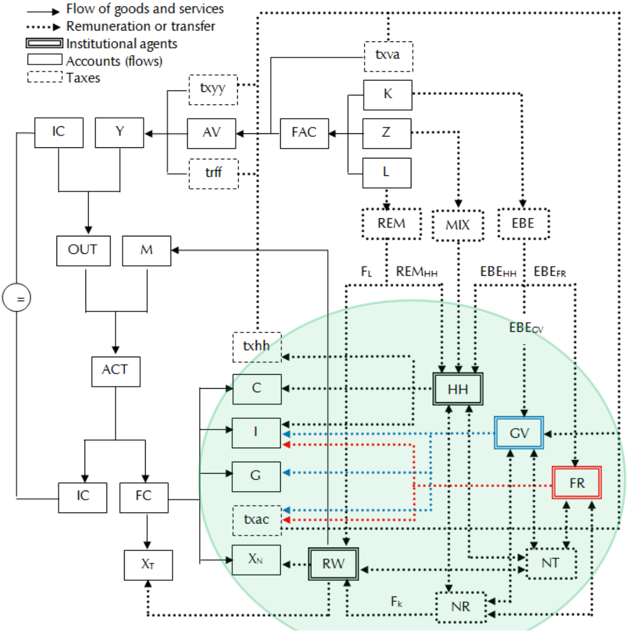
$$CT_{HH} = \pi_{HH}^{CT}CT, \text{ and } CT_{GV} = \pi_{GV}^{CT}CT.$$

The Model: Transfers II

- We also assume exogenous product transfers from the Government to households, $\overline{PT}_{HH}$.
- Net transfers are then represented by the following equations:

$$NT_{HH} = -\overline{SC}^{HH} + \overline{SB}_{HH} + CT_{HH} + \overline{PT}_{HH}^{GV}$$
$$NT_{FR} = SC_{FR}^{HH} - SB_{HH}^{FR} - \overline{CT}^{FR}$$
$$NT_{GV} = SC_{GV}^{HH} - SB_{HH}^{GV} + CT_{GV} - \overline{PT}_{HH}^{GV}$$
$$NT_{RW} = -\overline{CT}^{RW}$$

Demand Block



The Model: Domestic Demand I

- HH have standard well-behaved preferences (e.g. Cobb-Douglas with savings in utility), which yield final consumption demand and savings as:

$$C = \alpha \frac{DY_{HH}}{p_C}, \text{ and } S_{HH} = DY_{HH} - p_C C$$

  with $DY_{HH} = Y_{HH} + NT_{HH} - TXhh$. HH's marginal propensity to consume (MPC) satisfies $0 < \alpha < 1$.
- HH and FR investment form private investment, I_{PR}, as

$$\begin{aligned} I_{HH} &= \beta I_{PR} \\ I_{FR} &= (1 - \beta) I_{PR} \\ I_{PR} &= I_{HH} + I_{FR} \end{aligned}$$

  with $0 < \beta < 1$.

The Model: Domestic Demand II

- Accordingly, we have FR savings given by

$$S_{FR} = Y_{FR} + NT_{FR} - TXac_{FR}.$$

- Total demand for investment, I, is

$$I = I_{PR} + I_{GV}$$

which along with investment supply yields the price of investment equation, p_I

$$p_I = \theta_{FC}\pi_I \frac{p_{FC}FC - p_{XT}\bar{X}_T}{\left(FC - \bar{X}_T\right)} \left[\frac{FC - \bar{X}_T}{\theta_{FC}\left(I_{PR} + \bar{I}_{GV}\right)}\right]^{\frac{1}{\tau_{FC}}}$$

The Model: Domestic Demand III

- We assume GV's expenditure, G, and investment, I_{GV}, to be exogenous:

$$G = \bar{G}, \text{ and } I_{GV} = \bar{I}_{GV}$$

- GV expenditure price is jointly determined by its supply and demand functions

$$p_G = \theta_{FC} \pi_G \frac{p_{FC} FC - p_{XT} \bar{X}_T}{(FC - \bar{X}_T)} \left(\frac{FC - \bar{X}_T}{\theta_{FC} \bar{G}} \right)^{\frac{1}{\tau_{FC}}}$$

- Accordingly, GV savings are given by

$$S_{GV} = Y_{GV} + NT_{GV} + Tx + T - TXac_{GV} - p_G \bar{G}$$

with indirect taxes $Tx = TX_{va} + TX_{yy} + TR_{ff}$.

The Model: External Demand I

- RW demand for X_{NT} is defined according to:

$$X_N = \left(\theta_{M^*} \pi_{COL} \frac{e \bar{p}^*_{M^*}}{p_{XN}} \right)^{\sigma^*_p} \frac{\bar{M}^*}{\theta_{M^*}}$$

  where θ_{M^*} and π_{COL} are scale and Colombian share parameter in the aggregation of RW imports, $\bar{M}^*$ which are assumed to be exogenous, such as their price, $\bar{p}^*_{M^*}$.
- Total exports quantities must satisfy $X = X_N + \bar{X}_T$, and their price is determined by

$$p_X = \frac{p_{X_T} \bar{X}_T + p_{X_N} X_N}{X}$$

The Model: External Demand II

- Price of X_N, p_{X_N}, is determined by its supply and demand equilibrium:

$$p_{X_N} = \left\{ \frac{\left(\theta_{M^*}\pi_{COL} e \bar{p}^*_{M^*}\right)^{\sigma^*_M} \frac{\bar{M}^*}{\theta_{M^*}}}{\left[\theta_{FC}\pi_{XN}\frac{p_{FC}FC - p_{XT}\bar{X}_T}{\left(FC - \bar{X}_T\right)}\right]^{\tau_{FC}} \frac{FC - \bar{X}_T}{\theta_{FC}}} \right\}^{\frac{1}{\sigma^*_M - \tau_{FC}}}$$

- RW demands X_T at the international price $p^*_{X_T}$, which means that the internal price of X_T is given by

$$p_{X_T} = e p^*_{X_T}$$

The Model: Closure Equations I

We set $Y_{RW} = F_L + F_K - \overline{CT}^{RW}$.

Private Investment Closure

- Exogenous exchange rate: $e = \bar{e}$.
- Exogenous I_{PR}: $I_{PR} = \bar{I}_{PR}$.
- Endogenous S_{RW}:

$$-CC = S_{RW} = Y_{RW} + p_M M - p_X X$$

- S-I balance depends on Endogenous p_C (replacing S_{HH}):

$$p_I \bar{I} = S_{HH} + S_{FR} + S_{GV} + S_{RW}$$
$$p_C = \frac{DY_{HH} + S_{FR} + S_{GV} + S_{RW} - p_I \bar{I}}{C}$$

The Model: Closure Equations II

RW Savings Closure

- Exogenous consumption price: $p_C = \bar{p}_C$.
- Exogenous External Savings: $S_{RW} = \bar{S}_{RW}$.
- Endogenous exchange rate, e (derived from the following equation):

$$\bar{S}_{RW} = Y_{RW} + p_M(e)M(e) - p_X(e)X(e)$$

- I_{PR} is determined by the S-I balance:

$$I_{PR} = \frac{S_{HH} + S_{FR} + S_{GV} + \bar{S}_{RW}}{p_I} - \bar{I}_{GV}$$

Parameter Calibration: An example (I)

Using information from the Macro-SAM constructed for the model, we show an example of how share and scale parameters are calibrated. All parameters can be calibrated following the same steps.

- Share parameters: We have that

$$\pi_K = \pi_L \frac{p_K}{p_L} \left(\frac{K}{L} \right)^{\frac{1}{\sigma_F}}, \ \pi_Z = \pi_L \frac{p_Z}{p_L} \left(\frac{Z}{L} \right)^{\frac{1}{\sigma_F}} \quad \text{and}$$

$$\pi_L + \pi_K + \pi_Z = 1,$$

which yields

$$\pi_L = \frac{p_L L^{\frac{1}{\sigma_F}}}{p_L L^{\frac{1}{\sigma_F}} + p_K K^{\frac{1}{\sigma_F}} + p_Z Z^{\frac{1}{\sigma_F}}}$$

all other parameters can be calibrated analogously.

Parameter Calibration: An example (II)

- Scale parameters: Using the share parameters and FAC, we have

$$\theta_F = FAC\left(\frac{p_L L^{\frac{1}{\sigma_F}} + p_K K^{\frac{1}{\sigma_F}} + p_Z Z^{\frac{1}{\sigma_F}}}{p_L L + p_K K + p_Z Z}\right)^{\frac{\sigma_F}{\sigma_F - 1}}$$

Model Summary

A grand total of 99 variables:

- 73 endogenous variables.
- 22 exogenous variables.
- 4 closure variables:
  - 2 endogenous variables (depending on which closure we choose).
  - 2 exogenous remaining variables: i) A *nominal anchor*, and ii) a real quantity.

Endogenous Variables

Endogenous Variables List (73)

FAC	p_F	AV	TX_{va}	p_{AV}	TX_{yy}	TR_{ff}	Y
IC_D	p_Y	OUT	M	p_O	ACT	p_M	IC_S
FC	p_A	p_{IC}	I	X_N	p_{FC}	REM	EBE
MIX	p_L	p_K	p_Z	REM_{HH}	F_L	EBE_{HH}	EBE_{FR}
EBE_{GV}	R^{HH}	R^{FR}	R^{GV}	R_{HH}	R_{FR}	R_{GV}	F_K
R	Y_{HH}	Y_{FR}	Y_{GV}	$TXhh$	$TXac_{FR}$	$TXac_{GV}$	T
SC^{HH}_{FR}	SC^{HH}_{GV}	SB^{FR}_{HH}	SB^{GV}_{HH}	CT	CT_{HH}	CT_{GV}	NT_{HH}
NT_{FR}	NT_{GV}	C	S_{HH}	DY_{HH}	I_{HH}	I_{FR}	S_{FR}
p_I	S_{GV}	Tx	p_G	X	p_X	p_{X_N}	p_{X_T}
Y_{RW}.							

Exogenous Variables: A list (I)

- Factors: $\bar{L}$, $\bar{K}$, $\bar{Z}$ $\longrightarrow$ DPI-BR
- Total Factor Productivity: θ_F $\longrightarrow$ DPI-BR
- Indirect Taxes Rates: tx_{va}, tx_{yy}, tr_{ff} $\longrightarrow$ Calibrated (ftc)
- International Price of Imports: p_M^* $\longrightarrow$ BoP / ToT (Imports Index)
- Traditional Export Quantities: $\bar{X}_T$ $\longrightarrow$ BOP
- Direct Taxes Rates: $txhh$, $txac_{FR}$, $txac_{GV}$ $\longrightarrow$ Calibrated (ftc)

Exogenous Variables: A list (II)

- HH payments to SC: $\overline{SC}^{HH} \longrightarrow$ Pension Funds Financial Statements.
- SB payments to HH: $\overline{SB}_{HH}$
- FR payments to CT: $\overline{CT}^{FR}$
- RW payments to CT: $\overline{CT}^{RW} \longrightarrow$ BOP
- GV payments to PT: $\overline{PT}_{HH}^{GV}$

Exogenous Variables: A list (III)

- GV Investment: $\bar{I}_{GV} \longrightarrow$ DPI-BR
- GV Spending: $\bar{G} \longrightarrow$ DPI-BR
- Price of RW Imports: $\bar{p}^{*}_{M^{*}} \longrightarrow$ WEO (External Inflation)
- RW Imports Quantities: $\bar{M}^{*} \longrightarrow$ BOP
- Traditional Exports Prices: $p_{X_T} \longrightarrow$ BoP / ToT (Exports Index)

Closure Variables

Investment Closure

- Nominal Exchange Rate: $\bar{e} \longrightarrow$ BOP
- Private Investment: $\bar{I}_{PR}$ $\rightarrow$DPI-BR

Savings Closure

- Consumption Good Price: $\bar{p}_C \longrightarrow$ DPI-BR
- External Savings: $\bar{S}_{RW} \longrightarrow$ BOP

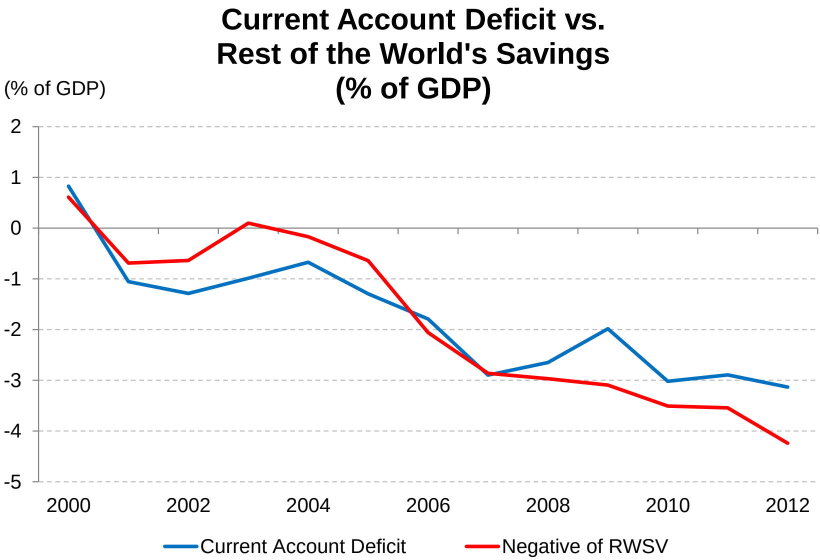
Macro CGEM usage: An example

- Using observed information from BOP, National Accounts and other relevant variables, we replicate 2012 economy taking as a starting point 2011 SAM and our model.

Main Results - 2012

Variable	Observed	CGEM		
		Average	Investment	Savings
GDP	4.0	4.1	4.2	4.1
C	4.4	4.0	4.5	3.5
G	5.7	5.7	5.7	5.7
I	4.6	4.5	5.0	4.0
I_{PR}	4.9	4.4	4.9	3.8
I_{GV}	5.3	5.3	5.3	5.3
X	6.1	5.0	4.6	5.3
M	8.9	5.4	7.2	3.5
CAD (%GDP)	3.1	3.6	4.0	3.1

Consistency of the model



What's Next?

This model can be further extended along the following lines:

- Demand driven economy.
- Assuring BoP matching with the model.
- Multi-sector CGE model.
- Extension of Fiscal Block.
- Money in CGEM (anchor to Monetary accounts).

THE END

Thank You.