

# Stock-flow Consistent Macroeconomics in the Face of the Climate Crisis

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## Outline

- Stock-flow consistent macro modeling as an alternative
    - The sectoral balances approach
    - Basics of quadruple-book accounting
    - Coding a simple example
  - Ecological Input-Output SFC
    - Input-Output Structure
    - Main Insights and Challenges
  - Philippines 2046

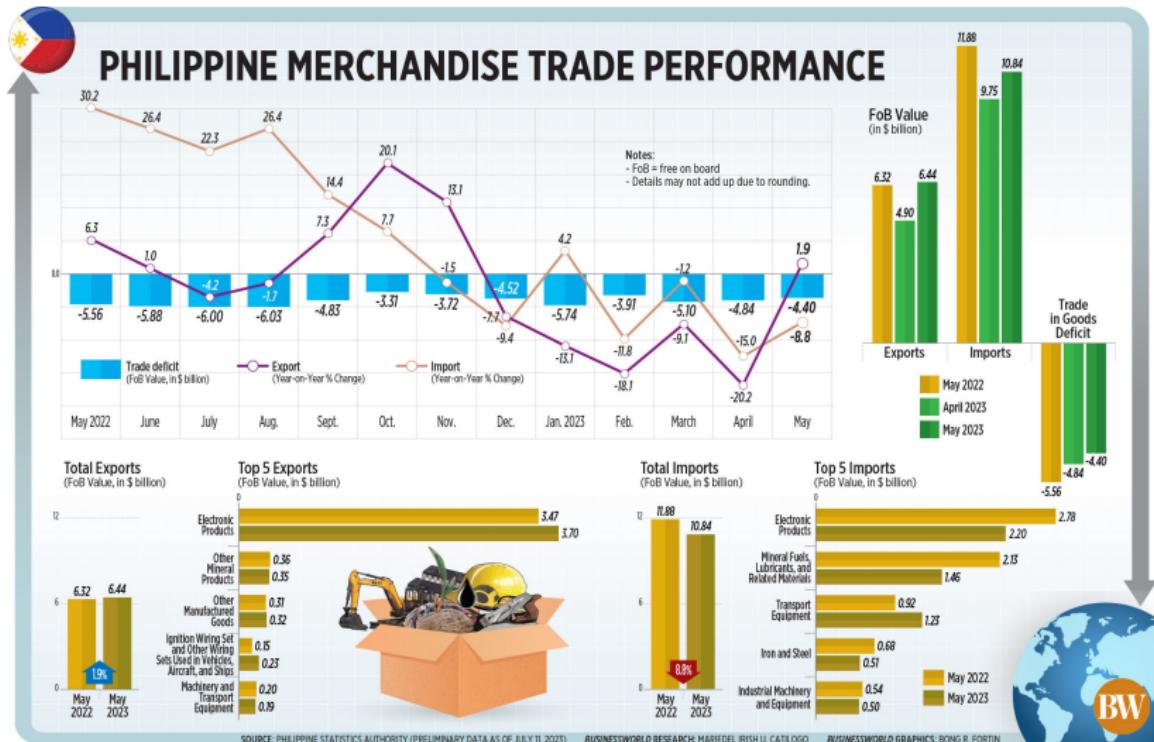
## Focus on Philippines

The Philippines faces significant economic challenges a decade before the 100th anniversary of its independence from the US in 2046. Despite the country's commendable economic performance in recent years,

- persistent high poverty,
- social and regional inequality,
- unemployment and underemployment,
- fragile sustained growth,
- technological value-chain upgrading,
- and regional and global economic integration

remain as key issues for the emerging economy, as mounting exposure to the climate crisis and the question of the sustainable energy transition in the context of a circular economy loom.

# Trade Profile



# Many Tools in Macroeconomic Modeling

- **Dynamic Stochastic General Equilibrium (DSGE)**  
micro-founded, optimization, equilibrium, subject to random shocks, representative agent
  - Real Business Cycle: neutrality of fiscal policy, Ricardian equivalence
  - New Keynesian incorporates non-instantaneous market clearing, price-setting, price adjustment frictions
- **Computable General Equilibrium (CGE)** social accounting matrix + elasticities capturing behavioral response, disaggregated, money neutrality, supply-led
  - Lance Taylor's *Structuralist* approach incorporates Keynesian behavioral principles

# Many Tools in Macroeconomic Modeling

- **Stock-Flow Consistent (SFC)** post-Keynesian tradition, non-equilibrium, demand-led, endogenous money, loans create deposits
  - integrate real and financial sides of the economy through careful accounting
  - comprehensive description of the institutional structure of an economy

# Wynne Godley, 'Doctor Doom'



Figure: British Economist (1926 - 2010), Founder of the Stock-Flow Consistent Approach

## Selected Works

- Godley, W., & Lavoie, M. (2006). *Monetary economics: an integrated approach to credit, money, income, production and wealth*. Springer.
- Godley, W. (2012). Maastricht and all that. In *The Stock-Flow Consistent Approach: Selected Writings of Wynne Godley* (pp. 189-193). London: Palgrave Macmillan UK.  
[published in 1992]
- Godley, W. (2012). Seven unsustainable processes: medium-term prospects and policies for the United States and the world. In *The stock-flow consistent approach: Selected writings of Wynne Godley* (pp. 216-254). London: Palgrave Macmillan UK. [published in 1999]

## Seven Unsustainable Processes

"Current growth is associated with seven unsustainable processes in the United States:"

- 1 the fall in private saving into ever deeper negative territory,
- 2 the rise in the flow of net lending to the private sector,
- 3 the rise in the growth rate of the real money stock,
- 4 the rise in asset prices at a rate that far exceeds the growth of profits (or of GDP),
- 5 the rise in the budget surplus,
- 6 the rise in the current account deficit,
- 7 the increase in the United States's net foreign indebtedness relative to GDP.

# Maastricht and All That

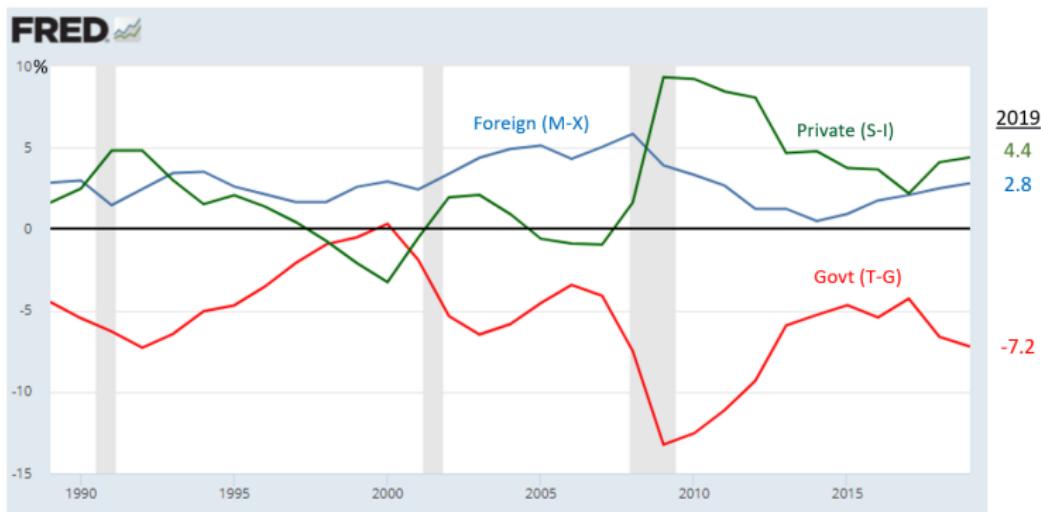
*Central idea of Maastricht is that EC countries should move towards an economic and monetary union, with a single currency managed by an independent central bank. But how is the rest of economic policy to be run?*

*Such a view - that economies are self-adjusting organisms which never under any circumstances need management at all - underlies the way in which the Maastricht Treaty was framed. All that can legitimately be done is to control the money supply and balance the budget.*

*The power to issue its own money is the main thing which defines national independence. If a country loses this power, it acquires the status of a local authority or colony. Local authorities obviously cannot devalue or finance deficits through money creation.*

# One's Surplus is Another's Deficit

## U.S. Sectoral Balances 1990 – 2019 (% GDP)

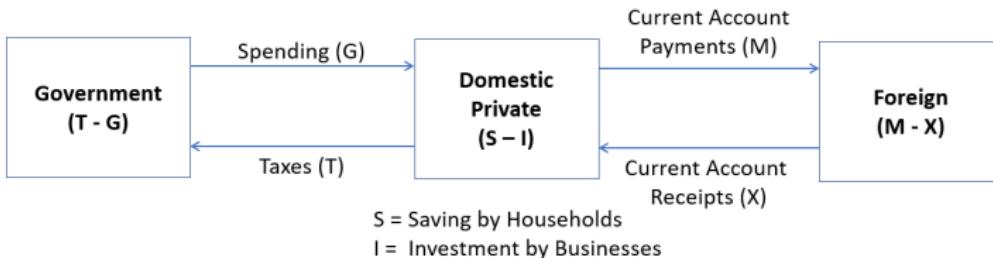


Source Data: FRED / BEA Integrated Macroeconomic Accounts – Table S.2.a

**Figure:** The government budget is not like a household.  
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# The Sectoral Balances Approach

## Sectoral Balances



**Identity: Must hold true by definition**

$$(T - G) + (S - I) + (M - X) = 0$$

Source: Wynne Godley – Levy Institute – “Some Unpleasant American Arithmetic” (June 2005)

**Figure:** Derived from the standard Keynesian macro identity:  
 $Y = C + I + G$  knowing that  $S = Y - C - T$

# Literature Overview

- **Surveys** Caverzasi and Godin 2014, Nikiforos and Zizza 2017
- **Simplified Post-Keynesian Benchmark** dos Santos and Zizza 2008
- **Financial Instability** Kinsella 2011; Passarella 2012; Caverzasi and Godin 2015
- **Reforming International Monetary System** Valdecantos and Zizza 2015; Mazier and Valdecantos 2015
- **Agent-based SFC** Caiani et al 2016
- **Personal and Functional Income Distribution** Dafermos and Papatheodorou 2015
- **Empirical Regional SFC** Zizza and Zizza 2022
- **ECO-IO-SFC** Berg, Hartley, and Richters 2015; Naqvi 2015, 2018; Jackson and Jackson 2021
- **Climate Financial Risks** Bovari and Giraud 2020

## The Basic Principle

*Our method is rooted in the fact that every transaction by one sector implies an equivalent transaction by another sector (every purchase implies a sale), while every financial balance (the difference between a sector's income and its outlays) must give rise to an equivalent change in the sum of its balance-sheet (or stock) variables, with every financial asset owned by one sector having a counterpart liability owed by some other.* (p.xxiv, 2006)

## SFC: Key Aspects

- Transaction Flow Matrix
    - Social Accounting Matrix (Stone and Brown 1962)
    - Flow-of-funds Matrix (Copeland 1949)
  - Balance Sheet
  - Reevaluation (due to change of prices in financial markets)
  - Stocks-to-flows links (should be stable)
  - (Behavioral) Closure

# Simplified National Income Matrix (p.5)

	Business				
	Households	Current	Capital	Government	$\Sigma$
Consumption	$-C$	$+C$			0
Govt. expenditure		$+G$		$-G$	0
Investment		$+I$	$-I$		0
[GDP (memo)]		$[Y]$			
Wages	$+WB$	$-WB$			0
Profits	$+F$	$-F$			0
Tax net of transfers	$-T$			$+T$	0
$\Sigma$	$SAVING$	0	$INVESTMENT (-)$	$GOVT SURPLUS$	0

# Complete Transaction Flow Matrix (p.7)

Table 1.2 Transactions flow matrix

	Production firms		Banks	Government	$\Sigma$		
	Households	(1)	Current (2)	Capital (3)	(4)	(5)	
Consumption		$-C$	$+C$			0	
Investment			$+I$	$-I$		0	
Govt. expenditures			$+G$		$-G$	0	
Wages		$+WB$	$-WB$			0	
Profits		$+FD_f$	$-F_f$	$+FU_f$		0	
Taxes-transfers		$-T$			$+T$	0	
Change in loans				$+ΔL_f$	$-ΔL$	0	
Change in cash		$-ΔH_h$			$-ΔH_b$	$-ΔH$	0
Change in deposits		$-ΔM$			$+ΔM$	0	
Change in bills		$-ΔB_h$			$-ΔB_b$	$+ΔB$	0
Change in equities		$-Δe \cdot p_e$		$+Δe \cdot p_e$		0	
$\Sigma$		0	0	0	0	0	

# Full Transaction Flow Matrix (p.39)

Table 2.6 Transactions flow matrix

	Households (1)	Production firms		Banks		(6)	Central Bank		$\Sigma$
		Current (2)	Capital (3)	Current (4)	Capital (5)		Current (7)	Capital (8)	
Consumption	$-C$	$+C$							0
Investment	$-I_h$	$+I$	$-I_f$						0
Govt. exp.		$+G$				$-G$			0
Wages	$+WB$	$-WB$							0
Profits, firms	$+FD_f$	$-F_f$	$+FU_f$						0
Profits, banks	$+FD_b$			$-F_b$	$+FU_b$		$+F_{cb}$	$-F_{cb}$	0
Profit, central Bk						$+F_{cb}$			0
Loan interests	$-r_{l(-1)} \cdot L_{h(-1)}$	$-r_{l(-1)} \cdot L_{f(-1)}$		$+r_{l(-1)} \cdot L_{(-1)}$					0
Deposit interests	$+r_{m(-1)} \cdot M_{h(-1)}$			$-r_{m(-1)} \cdot M_{(-1)}$					0
Bill interests	$+r_{b(-1)} \cdot B_{h(-1)}$			$+r_{b(-1)} \cdot B_{b(-1)}$			$-r_{b(-1)} \cdot B_{(-1)}$	$+r_{b(-1)} \cdot B_{cb(-1)}$	0
Taxes - transfers	$-T_h$	$-T_f$		$-T_b$			$+T$		0
Change in loans	$+ΔL_h$		$+ΔL_f$			$-ΔL$			0
Change in cash	$-ΔH_h$				$-ΔH_b$			$+ΔH$	0
Change, deposits	$-ΔM_h$				$+ΔM$				0
Change in bills	$-ΔB_h$				$-ΔB_b$	$+ΔB$		$-ΔB_{cb}$	0
Change, equities	$-(Δe_f \cdot p_{ef} + Δe_b \cdot p_{eb})$		$+Δe_f \cdot p_{ef}$		$+Δe_b \cdot p_{eb}$				0
$\Sigma$	0	0	0	0	0	0	0	0	0

## Balance Sheet (p.32)

*Table 2.4* A simplified sectoral balance sheet matrix

	Households	Production firms	Banks	Government	Central bank	$\Sigma$
Tangible capital	$+K_h$	$+K_f$				$+K$
Bills	$+B_h$		$+B_b$	$-B$	$+B_{cb}$	0
Cash	$+H_h$		$+H_b$		$-H$	0
Deposits	$+M_h$		$-M$			0
Loans	$-L_h$	$-L_f$	$+L$			0
Equities	$+E_f$	$-E_f$				0
Equities	$+E_b$		$-E_b$			0
Net worth	$-NW_h$	$-NW_f$	$-NW_b$	$-NW_g$	0	$-K$
$\Sigma$	0	0	0	0	0	0

# Simplest Model with Government Money (ch.3)

- Closed economy without imports, exports, or foreign capital flows
- Monetary economy where businesses sell services and pay wages, households receive income and accumulate assets
- Production consists of service provision: no capital equipment, no production costs, no inventories
- No finance for inventory accumulation
- Pure labour economy: no private banks, no firms, and no profits

# Balance Sheet

Table 3.1 Balance sheet of Model SIM

	1. Households	2. Production	3. Government	$\Sigma$
Money stock	$+H$	0	$-H$	0

# Transaction Flow Matrix

Table 3.3 Behavioural (transactions) matrix for Model SIM

	1. Households	2. Production	3. Government	$\Sigma$
1. Consumption	$-C_d$	$+C_s$		0
2. Govt. expenditures		$+G_s$	$-G_d$	0
3. [Output]		[Y]		
4. Factor income (wages)	$+W \cdot N_s$	$-W \cdot N_d$		0
5. Taxes	$-T_s$		$+T_d$	0
6. Change in the stock of money	$-\Delta H_h$		$+\Delta H_s$	0
$\Sigma$	0	0	0	0

# Horizontal Consistency (rows 1, 2, 4, 5)

$$C_s = C_d \quad (1)$$

$$G_s = G_d \quad (2)$$

$$T_s = T_d \quad (3)$$

$$N_s = N_d \quad (4)$$

# Other Equations

## ■ Disposable Income

$$Y_D = WN_s - T_s \quad (5)$$

## ■ Behavioral Equations

$$T_d = \theta WN_s, \quad \theta < 1 \quad (6)$$

$$C_d = \alpha_1 Y_D + \alpha_2 H_{h-1}, \quad 0 < \alpha_2 < \alpha_1 < 1 \quad (7)$$

## Vertical Consistency (columns)

- Budget Constraint of Government (from the TFM)

$$\Delta H_s = H_s - H_{s-1} = G_d - T_d \quad (8)$$

- Budget Constraint of Households (from the TFM)

$$\Delta H_h = H_h - H_{h-1} = Y_D - C_d \quad (9)$$

- Determination of Income

$$Y = C_s + G_s \quad (10)$$

- Determination of Employment

$$N_d = W/Y \quad (11)$$

# Computation

## Equations

The first step is to write down the equations, exogenous variables, and parameters:

```
sim_eqs <- sfcr_set(
  TXs ~ TXd,
  YD ~ W * Ns - TXs,
  Cd ~ alpha1 * YD + alpha2 * Hh[-1],
  Hh ~ YD - Cd + Hh[-1],
  Ns ~ Nd,
  Nd ~ Y / W,
  Cs ~ Cd,
  Gs ~ Gd,
  Y ~ Cs + Gs,
  TXd ~ theta * W * Ns,
  Hs ~ Gd - TXd + Hs[-1]
)

sim_ext <- sfcr_set(
  Gd ~ 20,
  W ~ 1,
  alpha1 ~ 0.6,
  alpha2 ~ 0.4,
  theta ~ 0.2
)
```

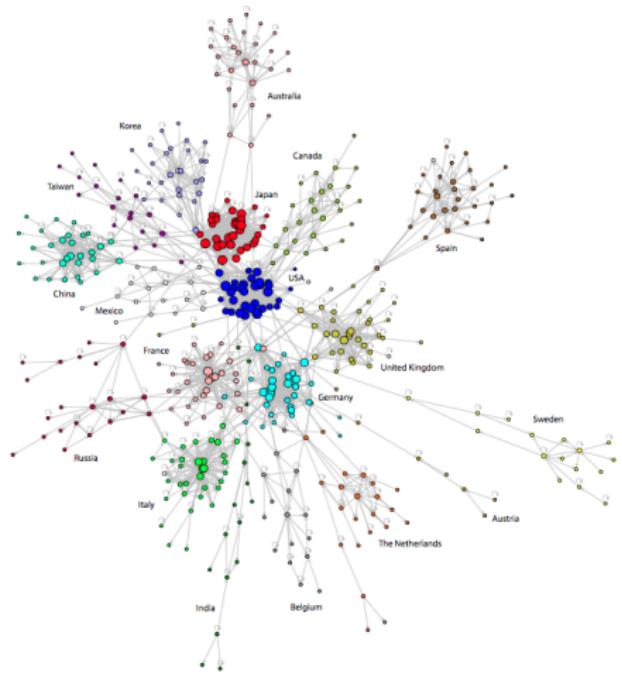
# Input-Output Matrix

		PRODUCERS AS CONSUMERS								FINAL DEMAND					
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchases of Goods & Services	Net Exports of Goods & Services		
PRODUCERS	Agriculture														
	Mining														
	Construction														
	Manufacturing														
	Trade														
	Transportation														
	Services														
	Other Industry														
VALUE ADDED	Employees	Employee compensation								GROSS DOMESTIC PRODUCT					
	Business Owners and Capital	Profit-type income and capital consumption allowances													
	Government	Indirect business taxes													

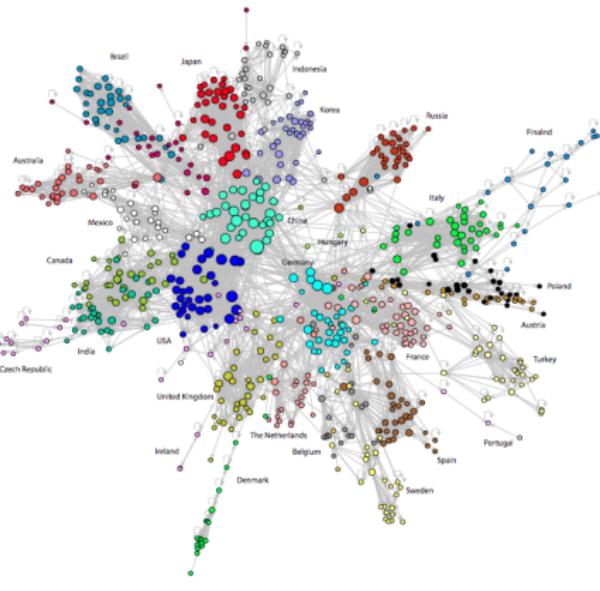
Figure 1.1 Input–Output Transactions Table

Figure: Miller and Blair, Input-Output Analysis, 2009, p.3

# Evolution of Globalization

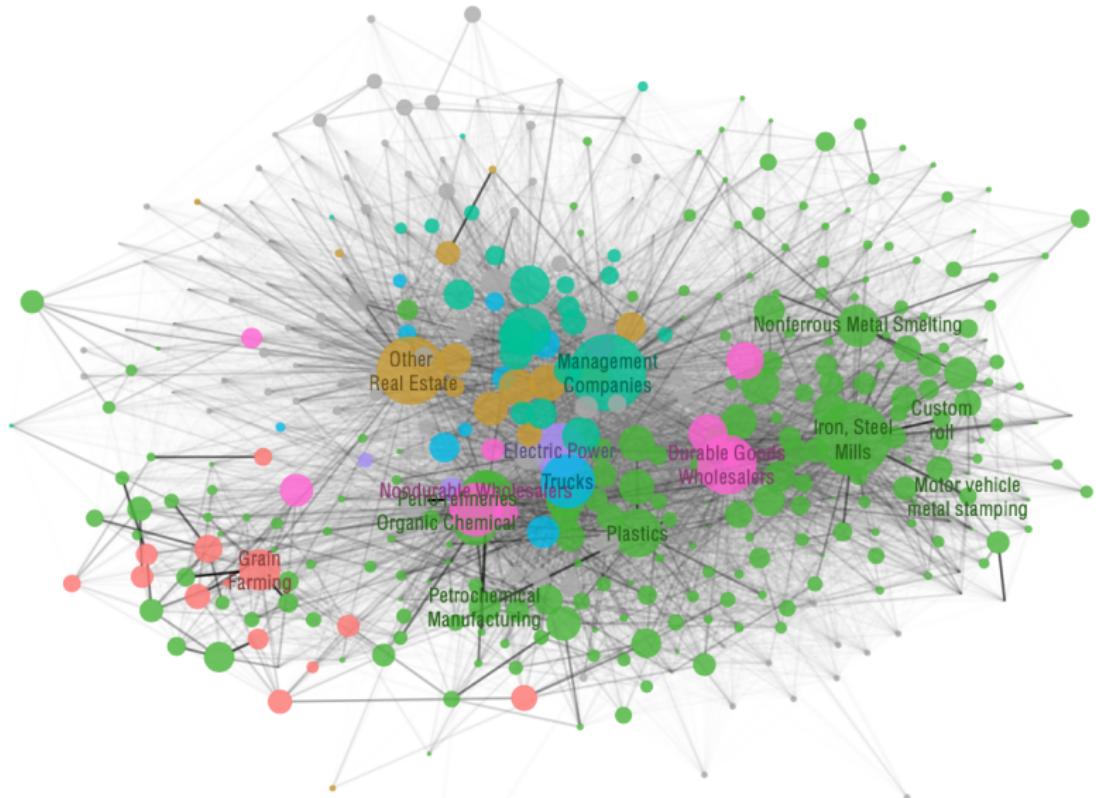


(a) 1995

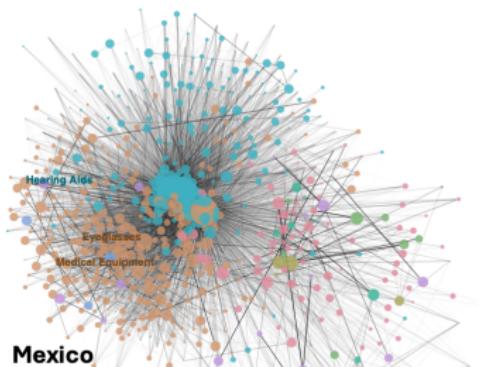


(b) 2011

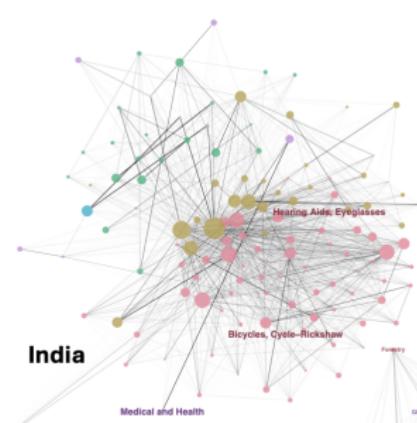
## US Input-Output Network (BEA, 400 sectors)



# Four Input-Output Networks of Middle-Income Economies



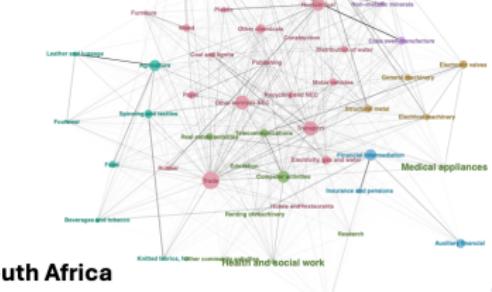
Mexico



India



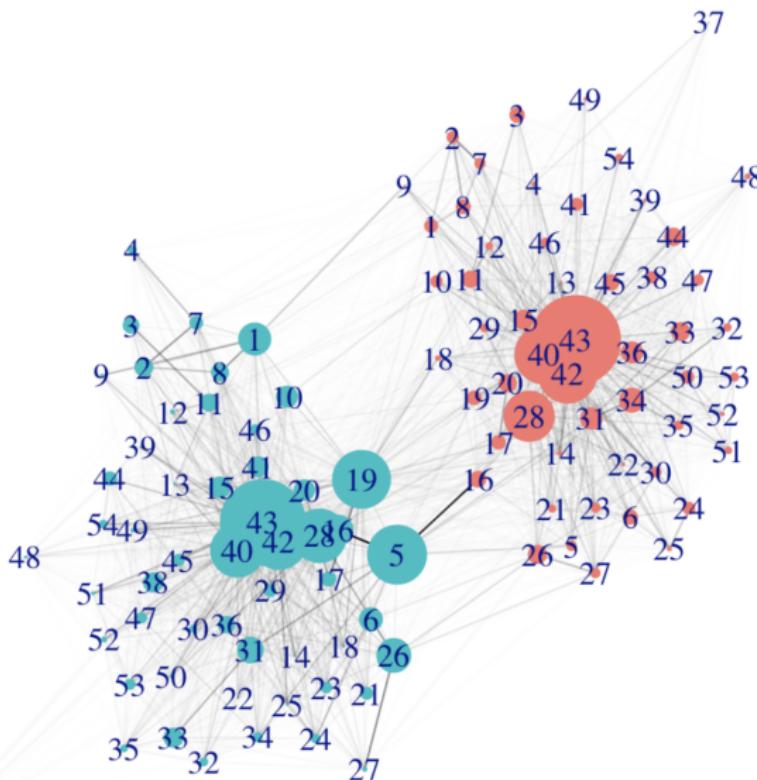
Iran



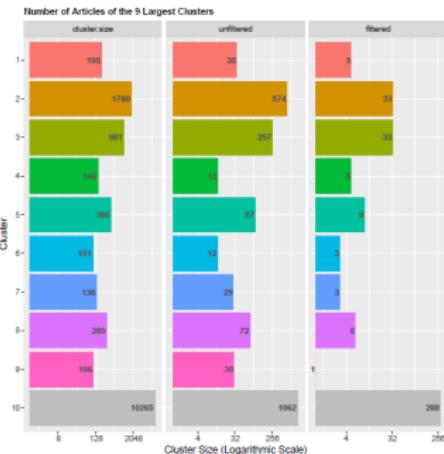
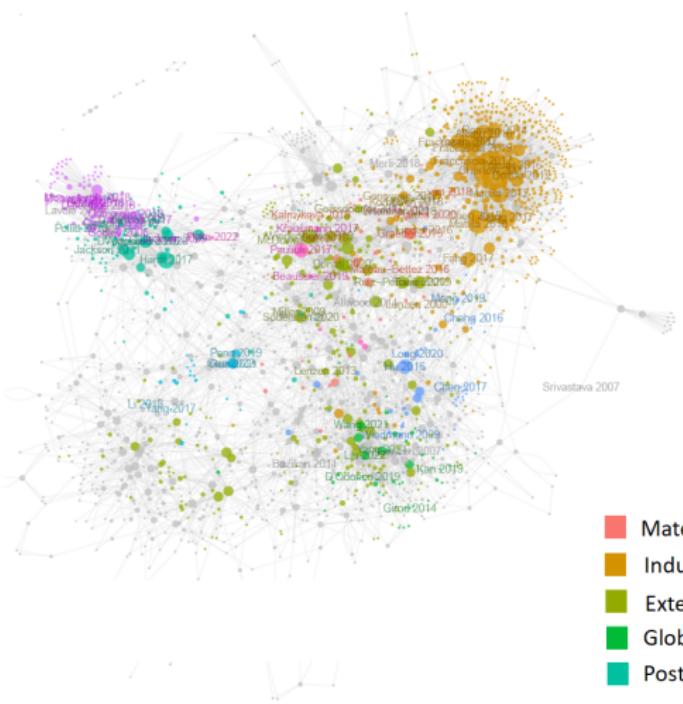
## **South Africa**



# Two-Country World Network



# Citation Network of Ecological Macroeconomics



- Material flow analysis
- CGE (electric vehicles)
- Industrial symbiosis
- Carbon footprint analysis
- Extended IO
- Post-Keynesian SFC
- Global value chain
- Post-growth SFC
- IAMs

# ECO-IO-SFC Model

- a) Two-country macro frame taken from standard SFC models *Godley and Lavoie 2007, ch.12*:
  - **Six Sectors** households, production firms, government, commercial banks, central bank
  - **Four Assets** cash, bank deposits, shares, and government bills (+ advances)
  - Only **loans to firms** (no personal loans)
  - **Fixed capital**, but no inventories
- b) Flexible IO structure: **5 or 54 industries**
- c) Parameter Identification: literature, empirical databases, **calibration** to target final demand components
- d) Solution: numerical simulations (*R* code), 100 periods, 100 iterations

## Selected equations: firms (capital)

- The target stock of fixed capital depends on industry-specific target capital to output ratios:

$$k^* = \frac{\mathbf{p}_{-1}^T \cdot (\mathbf{h} \odot \mathbf{x}_{-1})}{p_{I,-1}} \quad (12)$$

The real gross investment is:

$$i_d = \gamma \cdot (k^* - k_{-1}) + \delta \cdot k_{-1} \quad (13)$$

- The end-of-period stock of bank loans is defined residually:

$$L_f = L_{f,-1} + i_d \cdot p_1 - AF, \quad \text{with : } AF = \delta \cdot k_{-1} \cdot p_1 \quad (14)$$

## Selected equations: waste and emissions

- The quantity of waste generated by each (domestic) industry is:

$$WA_j = WA_{j,-1} + (x_j - x_{j,fo}) \cdot (\zeta_j - a_{j,4}) \quad (15)$$

- $CO_2$  emissions generated by each (domestic) industry are:

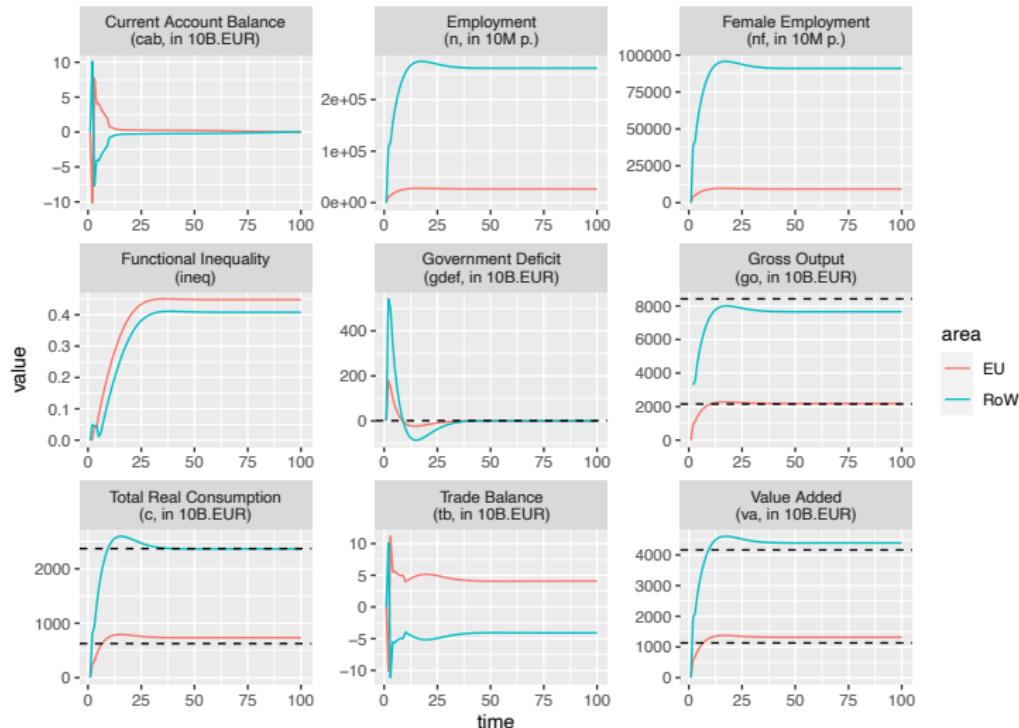
$$EM_j = (x_j - x_{j,fo}) \cdot \varepsilon_j \cdot \beta_e \quad (16)$$

where  $\varepsilon_j = Ej_j/x_j$  = industry-specific energy intensity coefficient,  
and  $\beta_e = Gt/Ej$  = common  $CO_2$  intensity coefficient.

- Atmospheric  $CO_2$  concentration is then calculated using carbon cycle equations.

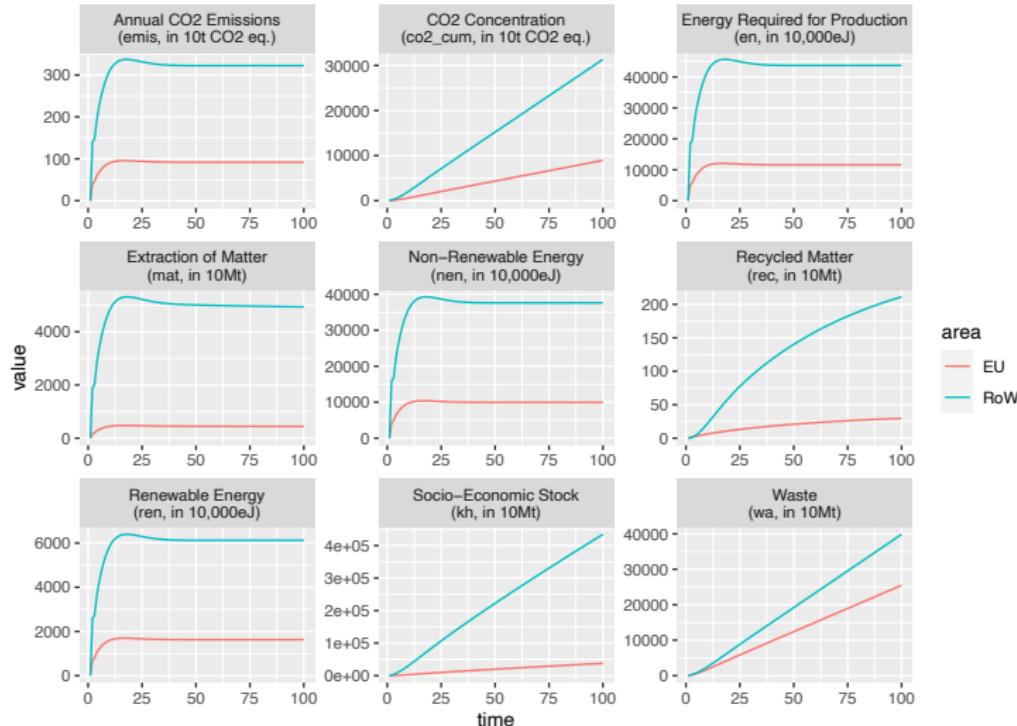
# 5-Sector Baseline, Macroeconomic

Selected Aggregate Macroeconomic Indicators

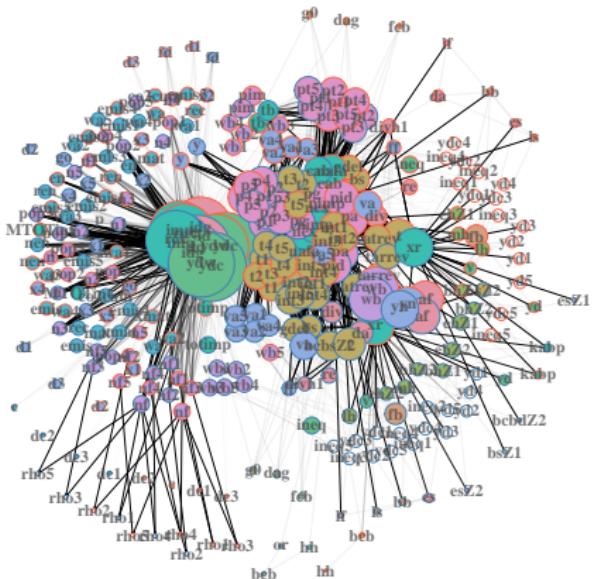


# 5-Sector Baseline, Ecological

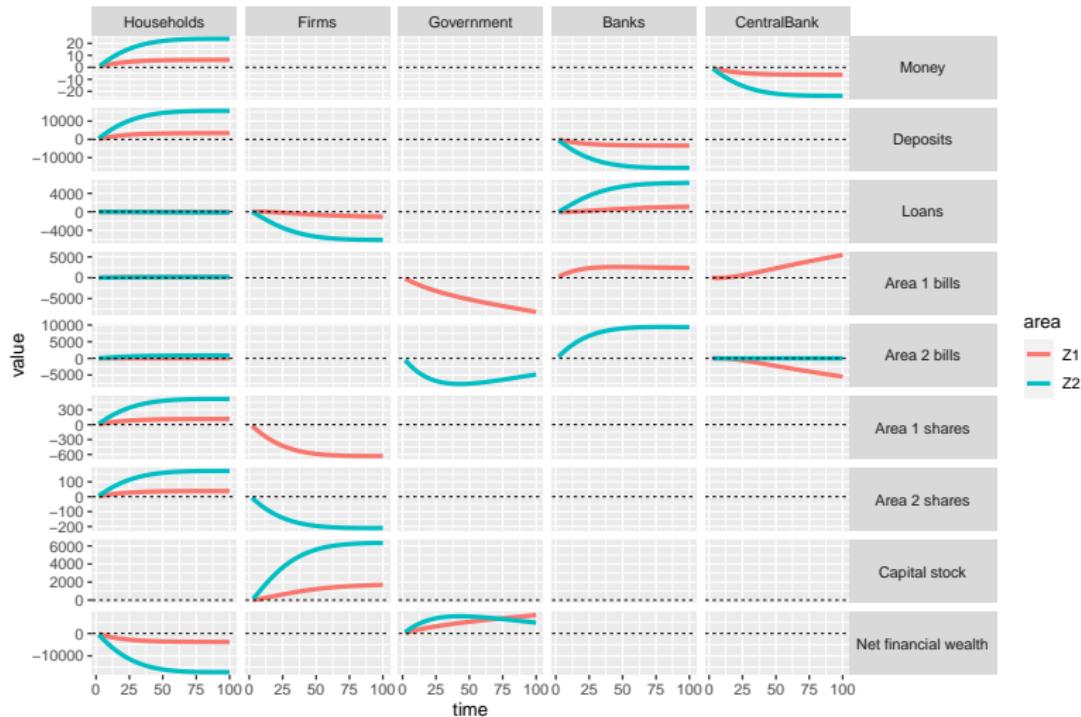
Aggregate Ecological Indicators



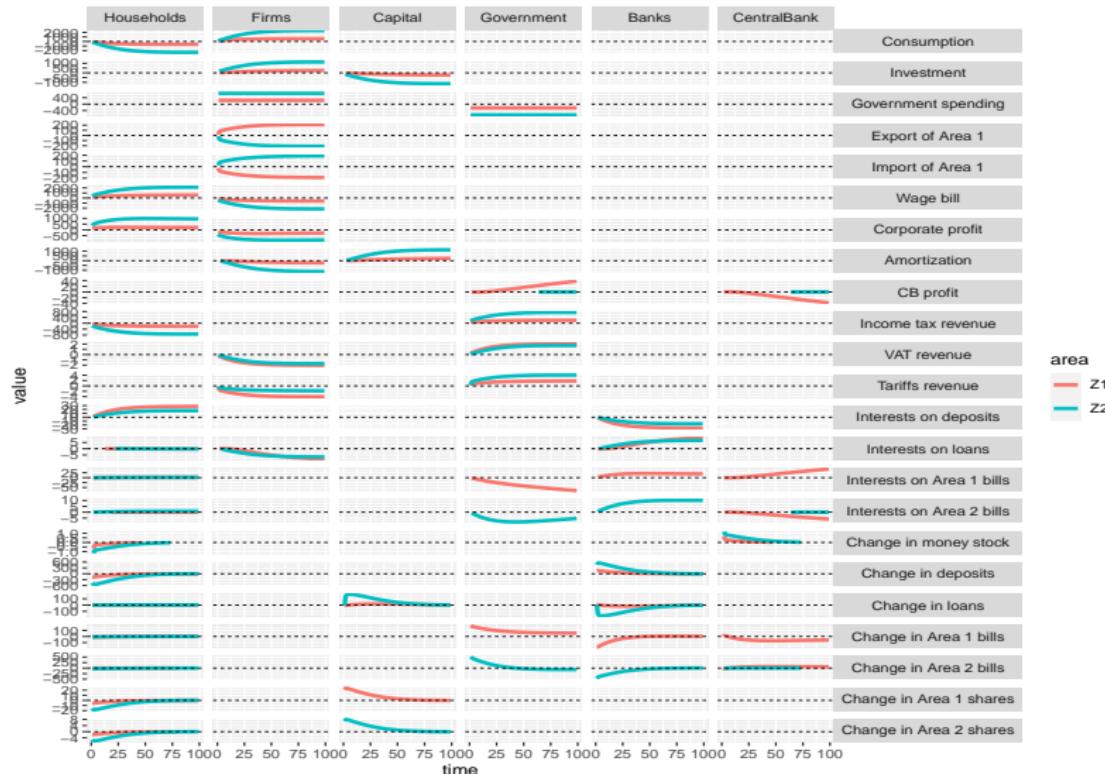
## 5-Sector Dynamical Structure



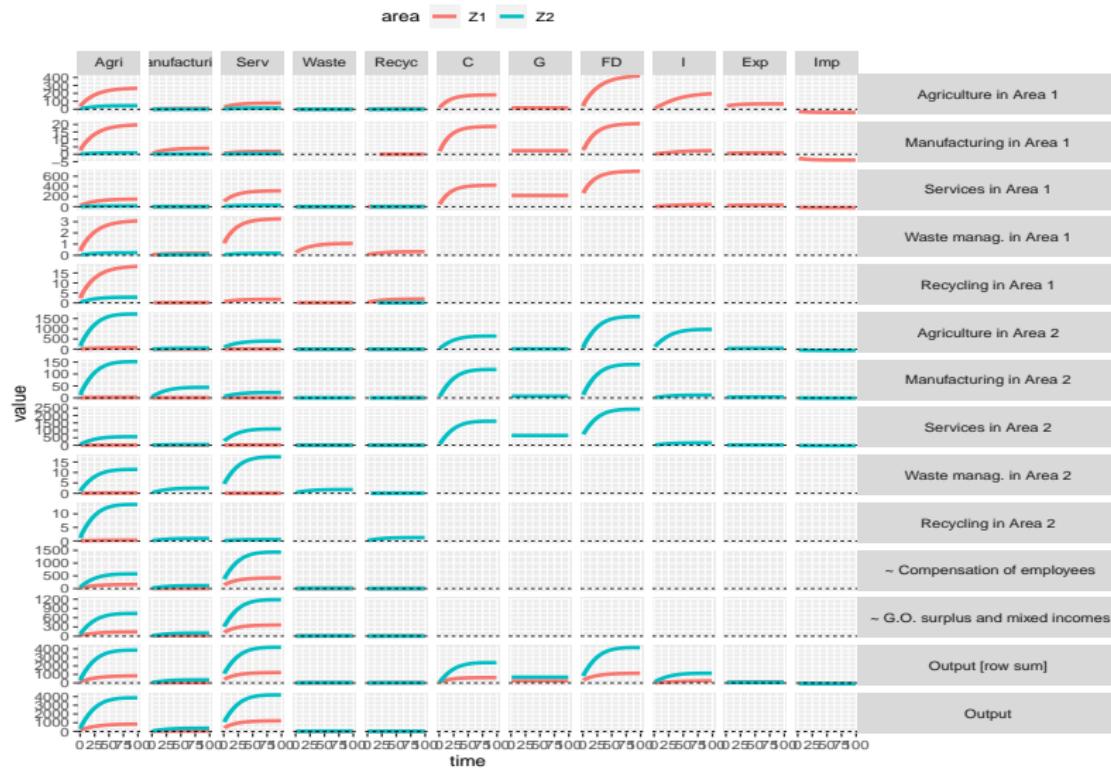
# Balance Sheet



# Transaction-Flow Matrix



## Multi-Region Input-Output



# Shocks

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## Shock

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Reduction in Consumption Level

Change in Consumption Composition towards Services

Product Life Time Extension

Higher Recycling Rate

Higher Propensity to Consume Green

Lower Extraction (or Conversion) Rate of Matter

Lower Discarding Rate of Socio-Economic Stock

Higher Renewable Energy Share

Higher Govt Spending towards Efficiency

More Selective Govt Spending towards Recycling Efficiency

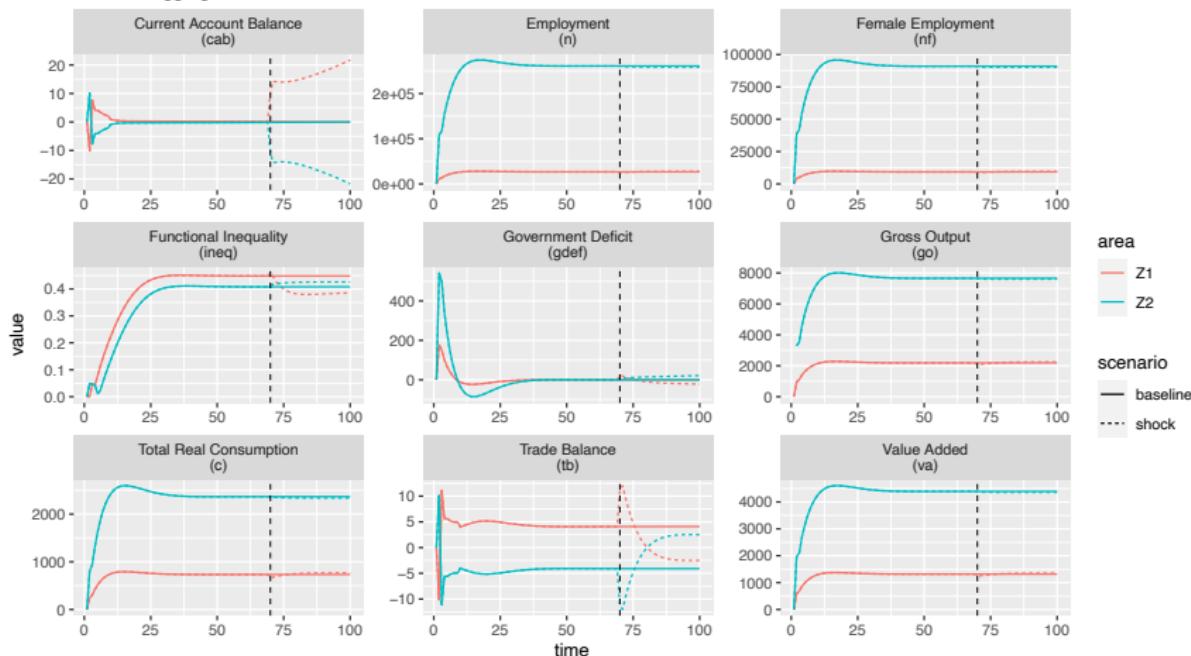
More Progressive Taxation

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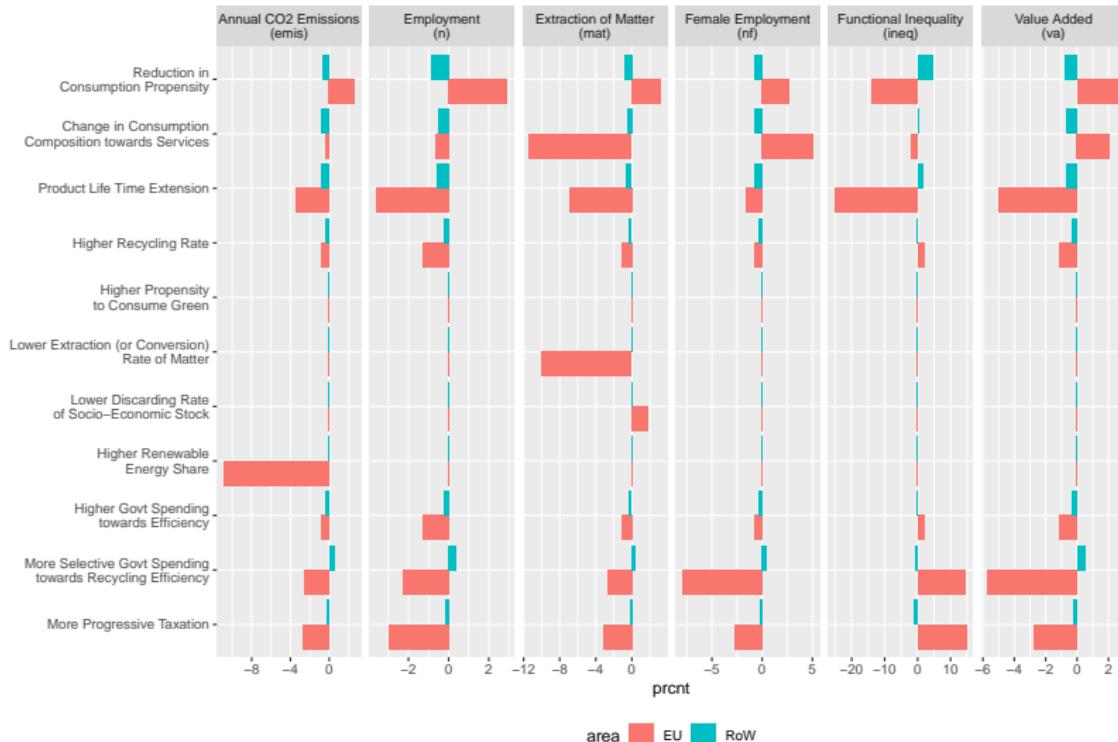
### Scenario: Reduction in Consumption Propensity

### Shock 1: Reduction in Consumption Level

**Selected Aggregate Macroeconomic Indicators.** Vertical dashed line indicates shock time



# Scenario Analysis



# Complex Product Lifetime Extension



## Main Challenges

- Methodological
    - High Sensitivity to Initial Conditions: Calibration
    - Flexible Exchange Rate requires more sophisticated numerical solvers
  - Policy Implications: Climate policies exclusively focused on the Global North threaten severe impacts on economic growth, employment, and financial stability in the Global South

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## Focus on Philippines

The Philippines faces significant economic challenges a decade before the 100th anniversary of its independence from the US in 2046. Despite the country's commendable economic performance in recent years,

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# Thank you!

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