Stock-Flow Consistent Input-Output Models

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Goal

- merging different strands of economic theory

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- synthesizing Stock-Flow Consistent (SFC) models, Input-Output (IO) models, and Ecological macroeconomics
- flows of money, goods and products and physical materials in the economy and the natural environment

Ecological and Post-Keynesian Economics

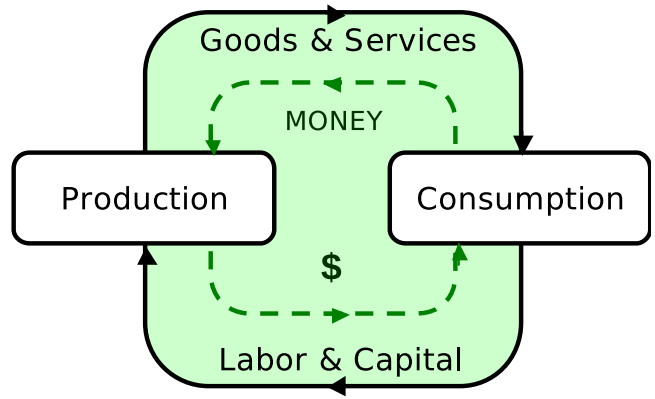
Similarities:

- consumption & production theory
- irreversibility of historical time, path dependency
- fundamental uncertainty (not only risk)

Differences

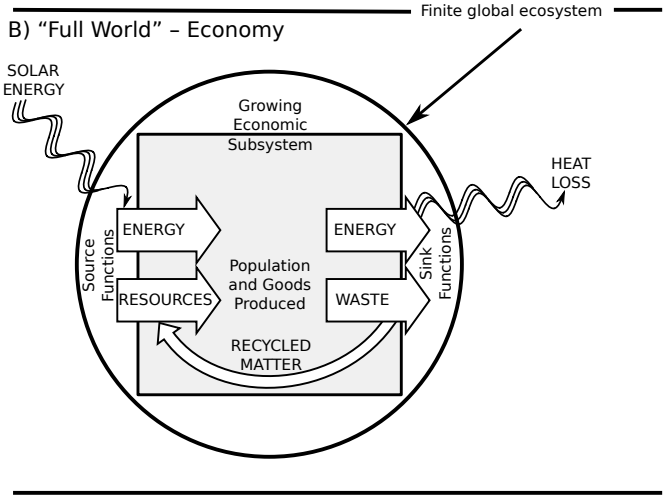
Post-Keynesian:

- macroeconomic theory, focus on finance, endogenous money
- emphasis on pushing demand



Ecological Economics:

- economy as subsystem of ecological system
- growth driven by energy and material use



A finite global ecosystem relative to the growing economic subsystem (after Daly, 1990; Goodland and Daly, 1990)

Stock-Flow Consistent models

- model money flowing through monetary economy
- stocks generate flows, flows change stocks of money
- endogeneous money creation via loan origination

[Lavoie/Godley 2007]

Industry interlinkages: Input-Output (IO)

- flows of goods and services through sectors of real economy

INDUSTRY INTERLINKAGES: INPUT-OUTPUT (IO)

- flows of goods and services through sectors of real economy
- $a_{ij} \geq 0$: flow of inputs from sector i to sector j

		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

source: Miller/Blair 2009

Industry interlinkages: Input-Output (IO)

- flows of goods and services through sectors of real economy
- $a_{ij} \geq 0$: flow of inputs from sector i to sector j
- vectors: $\boldsymbol{x}$: gross output. $\boldsymbol{d}$: net output (GDP)

$$\boldsymbol{x} = \mathbf{a}\boldsymbol{x} + \boldsymbol{d} \tag{1}$$

$$\boldsymbol{x} = (\mathbf{1} - \mathbf{a})^{-1} \boldsymbol{d} \tag{2}$$

including prices P_i:

$$A_{ij} = a_{ij} P_i. \tag{3}$$

Ripe for a synthesis

- analyze the interplay of economic decisions, money policy and ecological impact
- important for macroeconomic management
- luckily: no theoretical impediments [Gowdy 1991, Kronenberg 2010]

Stock-Flow Consistent Input-Output model

ACCOUNTING IDENTITIES – BALANCE SHEET MATRIX

Households	
Money: M_h	Net Worth: V_h

Production Indus.	
invent.: Ψ_p	Loans: L_p

Energy Indus.	
invent.: Ψ_e	Loans: L_e

Gov./Banks	
Loans: L_g	Money: M_g Net Worth: V_g

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	Net Worth:
	V_g

Energy Indus.

invent.:	Loans:
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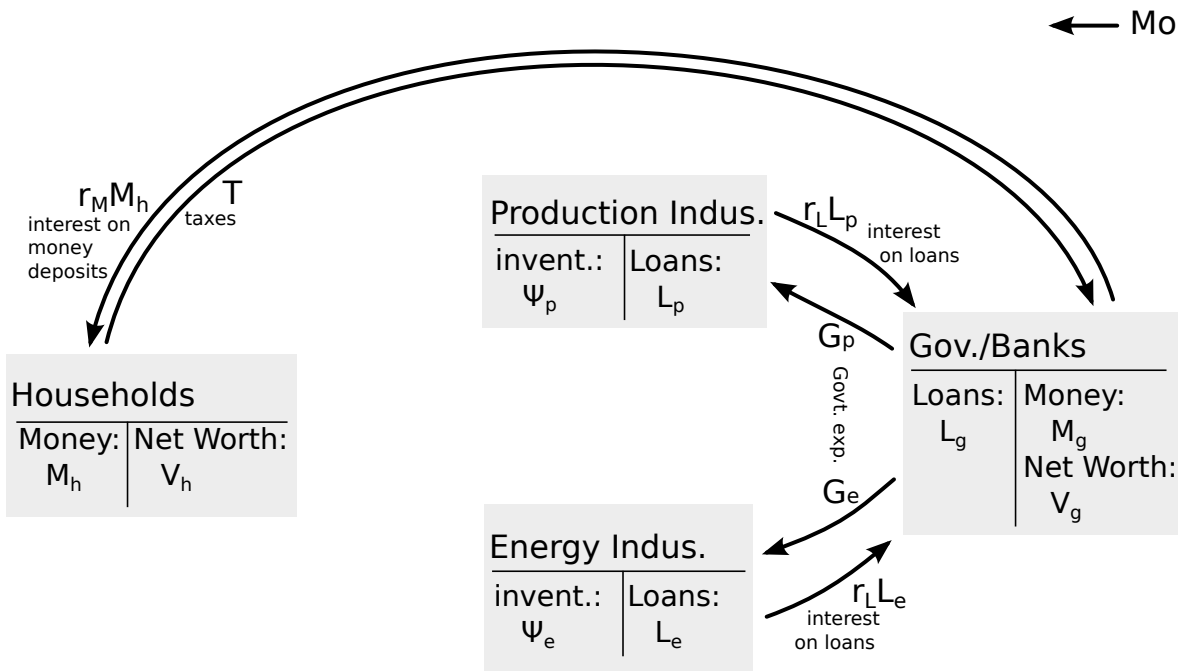
	Households	**Industry $i \in \{1, \ldots, n\}$**	**Government**	$\sum$
Money Deposits	$+M_h$		$-M_g$	0
Loans		$-L_i$	$+L_g$	0
Inventories		$+\Psi_i$		$+\sum_i \Psi_i$
Net Worth	$-V_h$	0	$-V_g$	$-V_h - V_g$
$\sum$	0	0	0	0

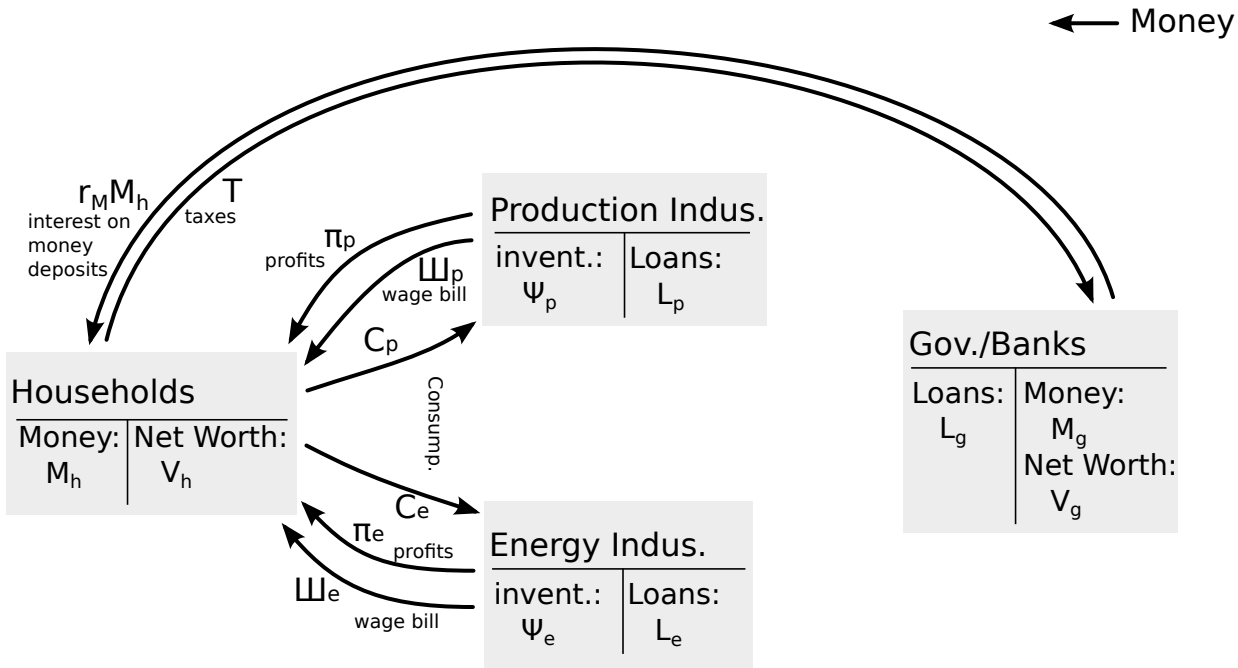
Government / Banking sector



Pays interest on deposits, receives money on loans and taxes.
Expenditures $g_p = G_p/P_p$, $g_e = G_e/P_e$ exogeneously given.

$$M_{g(t)} = (1 + r_M)M_{g(t-1)} + \sum_i G_i + \sum_i \Delta L_i - r_L \sum_i L_i - T. \quad (4)$$

HOUSEHOLDS

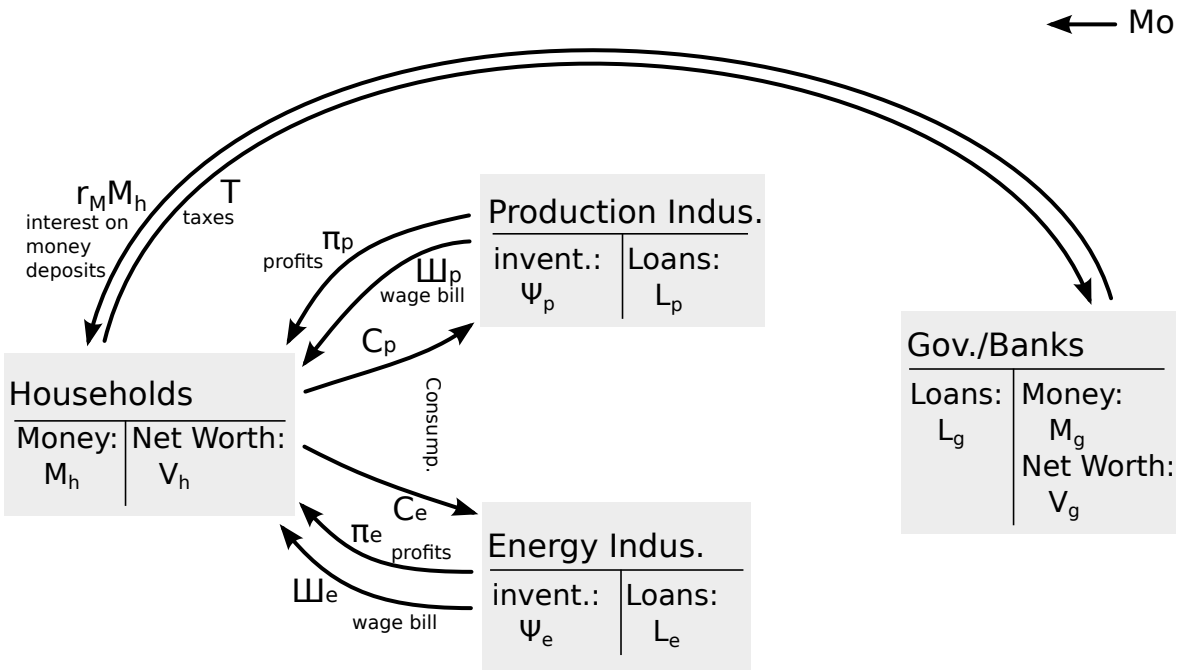


nominal and physical consumption, with P_i prices for different goods:

$$C = \alpha_1(1-\theta)\sum_j \amalg_j + \alpha_2 M_{h(t-1)}, \tag{5}$$

$$c_i = CC_i^0/P_i \qquad \text{with} \sum_j C_j^0 = 1. \tag{6}$$

HOUSEHOLDS

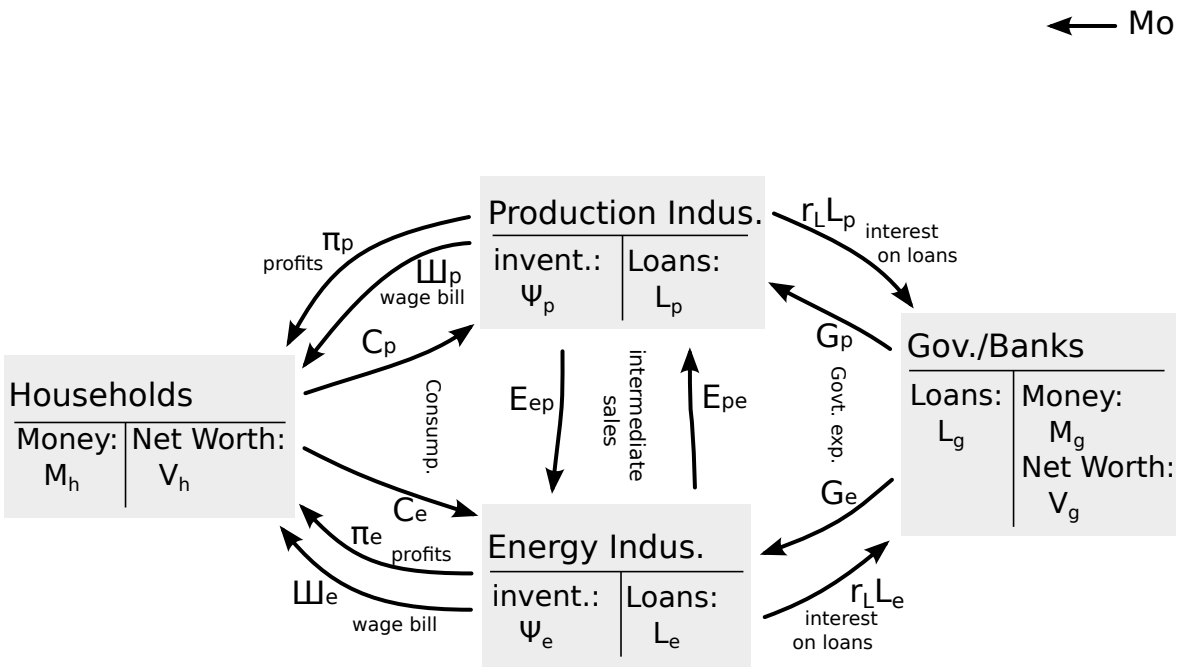


disposable income Y, taxes T and update of money stock $M_{h(t)}$,

$$Y = \sum_i \amalg_i + \sum_i \Pi_i + r_M M_{h(t-1)}, \qquad T = \theta \cdot Y, \tag{7}$$

$$M_{h(t)} = M_{h(t-1)} + \sum_i \amalg_i + \sum_i \Pi_i - \sum_i C_i - T + r_M M_{h(t-1)}. \tag{8}$$

INDUSTRY SECTORS – FOR $n = 2$



Determination of produced goods

$s_{(t)}$: sales. $s^X_{(t)}$: expected sales. $\psi^\top$ ($\Delta\psi^\top$): targeted inventory (change). $\beta, \gamma < 1$: partial adjustment accelerators

$$s^X_{(t)} = \beta s_{(t-1)} + (1-\beta) s^X_{(t-1)}. \tag{9}$$

$$\psi^\top = \sigma^\top s^X_{(t)}, \tag{10}$$

$$\Delta\psi^\top = \gamma \left[\psi^\top - \psi_{(t-1)}\right]. \tag{11}$$

$$\Rightarrow x = s^X_{(t)} + \Delta\psi^\top_{(t)}. \tag{12}$$

x: realized total production.

Pricing and wages

wages:

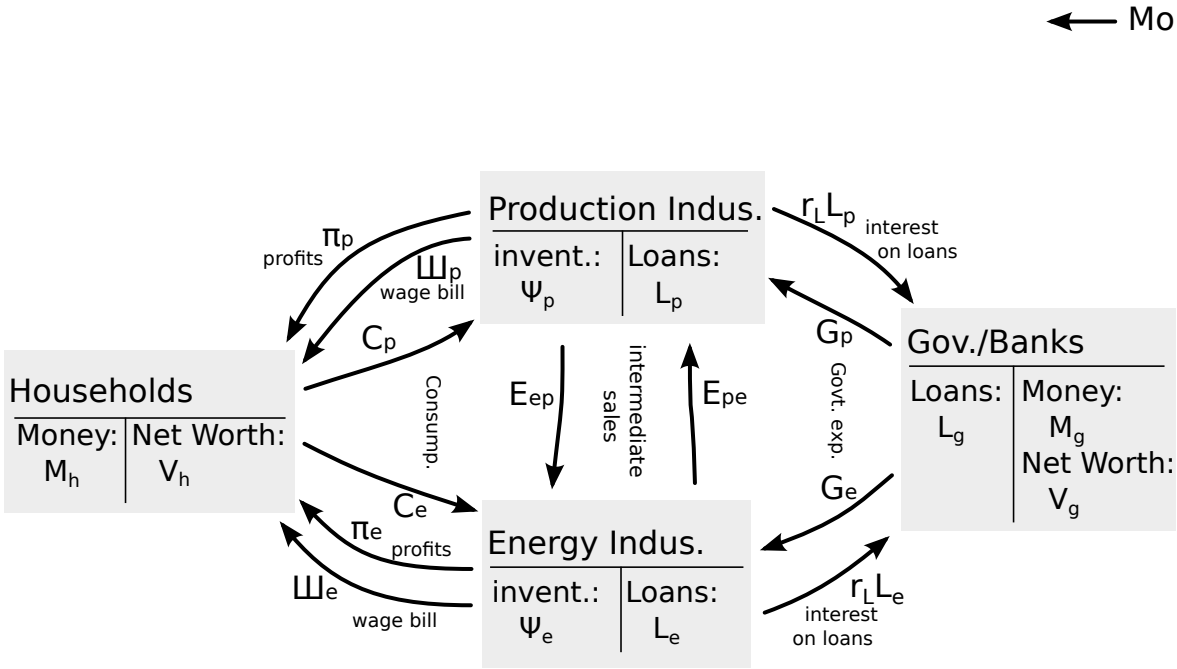
$$l_i = \lambda_i x_i, \tag{13}$$

$$W = \sum_i \text{III}_i = \sum_i \omega_i \lambda_i x_i. \tag{14}$$

pricing based on expected costs with markup $\phi_{i(t)}$:

$$P_{i(t)} = (1 + \phi_{i(t)}) \left[\omega_{i(t-1)} \lambda_{i(t-1)} + \sum_k P_{k(t-1)} a_{ki(t-1)} \right]. \tag{15}$$

DETERMINATION OF REALIZED SALES AND INVENTORIES



ξ: intermediate purchases. E_{ij}: money payments between sectors.

$$\xi = \mathbf{a} \cdot x. \tag{16}$$

$$E_{ij} = a_{ij} P_i x_j. \tag{17}$$

DETERMINATION OF NEW STOCKS

realized sales:

$$s_{(t)} = c + \xi + g. \tag{18}$$

realized inventory stock and loans to finance them:

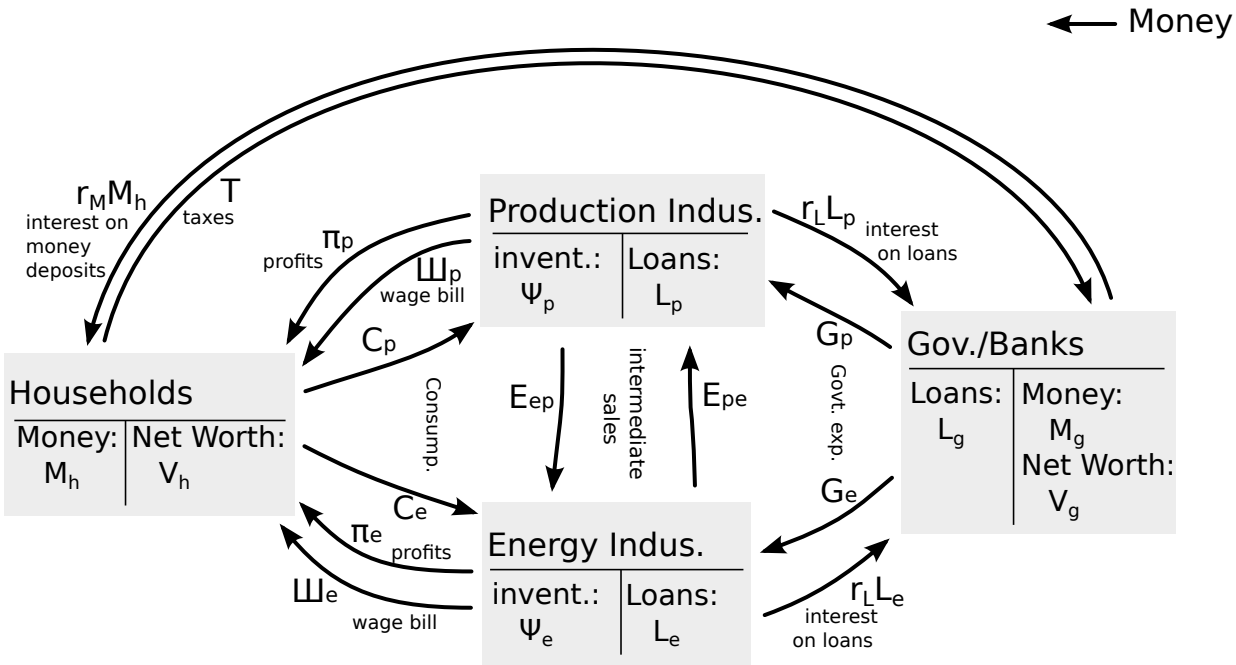
$$\psi_{(t)} = \psi_{(t-1)} + x_{(t)} - s_{(t)}, \tag{19}$$

$$L_{i(t)} = \Psi_{i(t)} = \psi_{i(t)} \left[\omega_{i(t-1)} \lambda_{i(t-1)} + \sum_k P_{k(t-1)} a_{ki(t-1)} \right]. \tag{20}$$

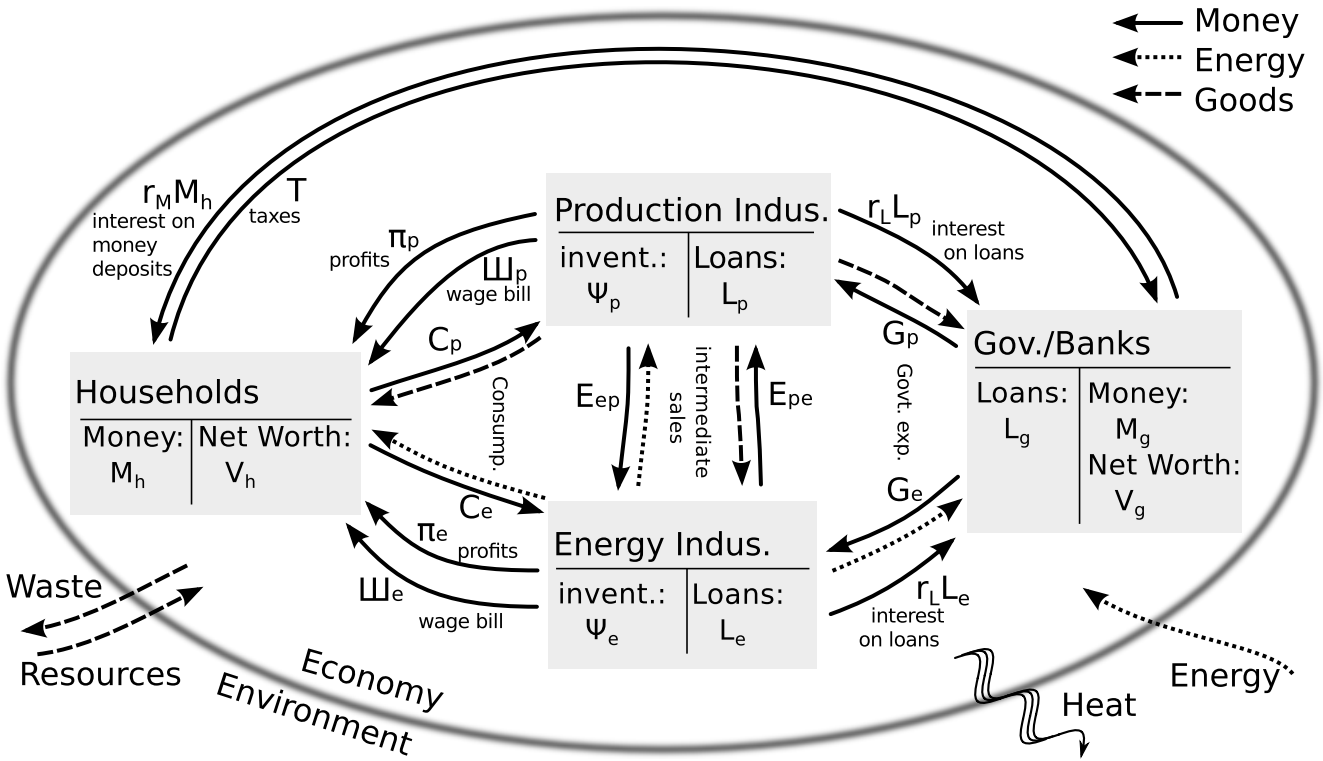
profits distributed to households:

$$\Pi_i = C_i + G_i - \text{III}_i + \sum_j E_{ij} - \sum_j E_{ji} - r_L L_{i(t-1)} + \Delta\Psi_i. \tag{21}$$

All monetary flows



FLOWS OF MATTER AND ENERGY IN THE ECOSYSTEM



Transaction matrix

	Households	Industry i		Government	$\sum$
		Current Account	Capital Acc.		
Govt. Spending		$+G_i$		$-\sum_i G_i$	0
Taxes	$-T$			$+T$	0
Consumption	$-\sum_i C_i$	$+C_i$			0
Wage Bill	$+\sum_i \text{Ш}_i$	$-\text{Ш}_i$			0
Intermediate Purchases		$\sum_i E_{ij} - \sum_j E_{ij}$			0
Profits	$+\sum_i \Pi_i$	$-\Pi_i$			0
Interest on Money Deposits	$+r_M M_{h(t-1)}$			$-r_M M_{g(t-1)}$	0
Interest on Loans		$-r_L L_{i(t-1)}$		$+\sum_i r_L L_{i(t-1)}$	0
Δ Money Deposits	$-\Delta M_h$			$+\Delta M_g$	0
Δ Loans			$+\Delta L_i$	$-\sum_i \Delta L_i$	0
Δ Inventory Value		$+\Delta\Psi_i$	$-\Delta\Psi_i$		0
$\sum$	0	0	0	0	0

Overview parameters

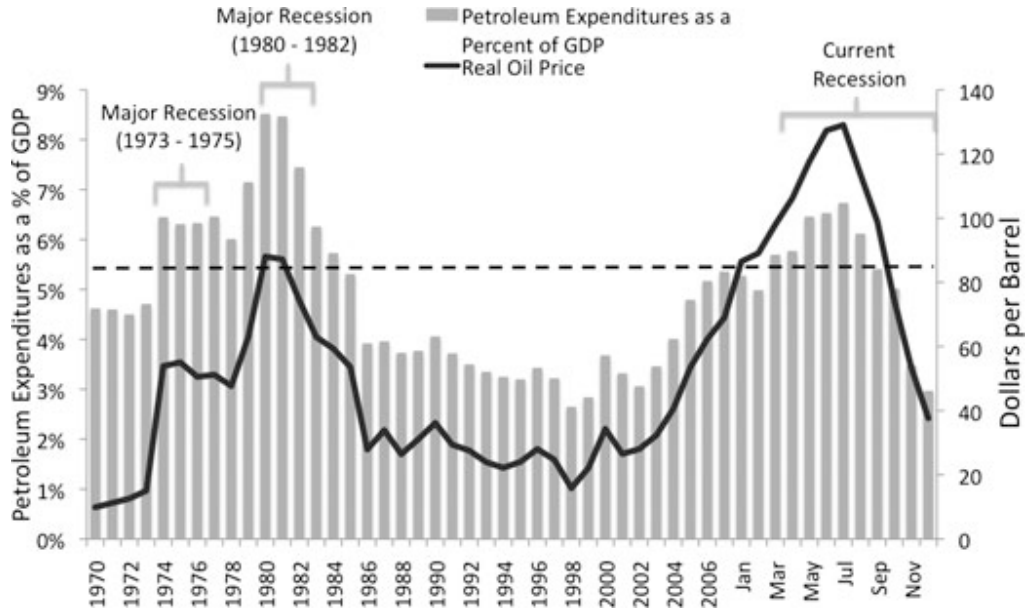
parameter name	general model	model presented
Household consumption parameters	α_1, α_2	$\alpha_1 = 0.8, \alpha_2 = 0.2$
Input-Output matrix	$\mathbf{a} = \left(a_{ij}\right)$	$\mathbf{a} = \begin{bmatrix} 0.48 & 0.60 \\ 0.02 & 0.15 \end{bmatrix}$
Price matrix	$\mathbf{P} = \mathbf{diag}(P_i)$	$\mathbf{P} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$
Partial adjustment accelerators	β, γ	$\beta = 0.75, \gamma = 0.5$
Government spending	$\boldsymbol{G}$	$G_p = 46.6, G_e = 0$
Consumption	$\boldsymbol{C^0}$	$C_p^0 = 0.961, C_e^0 = 0.039$
Individual markups	$\boldsymbol{\phi}$	$\phi_p = 0.3333, \phi_e = 0.1364$
Interest rates	r_M, r_L	$r_M = 0.04, r_L = 0.05$
Tax rate	θ	$\theta = 0.48$
Inventory to sales ratio	$\sigma^\top$	$\sigma^\top = 0.5$
Labor demand per output unit	$\boldsymbol{\lambda}$	$\omega_p \lambda_p = 0.25; \omega_e \lambda_e = 0.13$
Wages per labor unit	$\boldsymbol{\omega}$	

Study energy price shocks

Study energy price shocks

Motivation:

- historically, recessions were correlated with high energy prices



source: Murphy/Hall 2011

Impact of an increase in Energy markup ϕ_e

- increase markup ϕ_e on Energy ($0.1364 \rightarrow 0.4$).
- low price elasticity $\rightarrow$ increase C_e^0,

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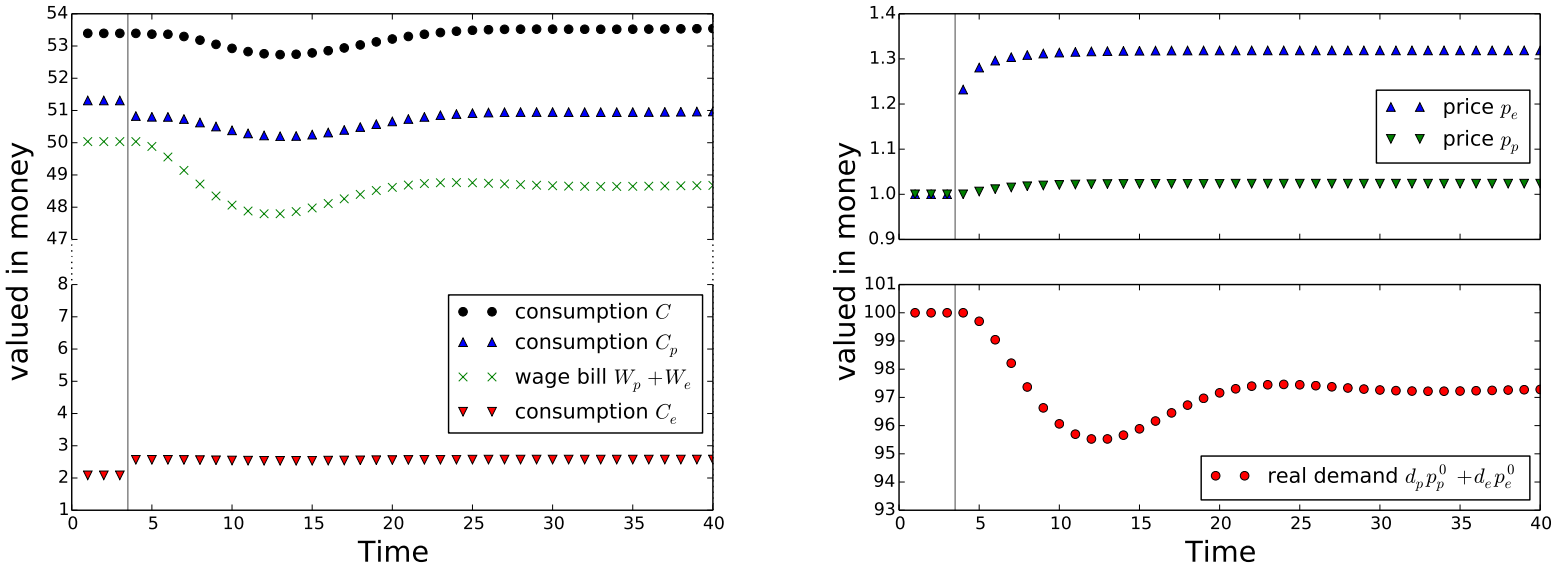
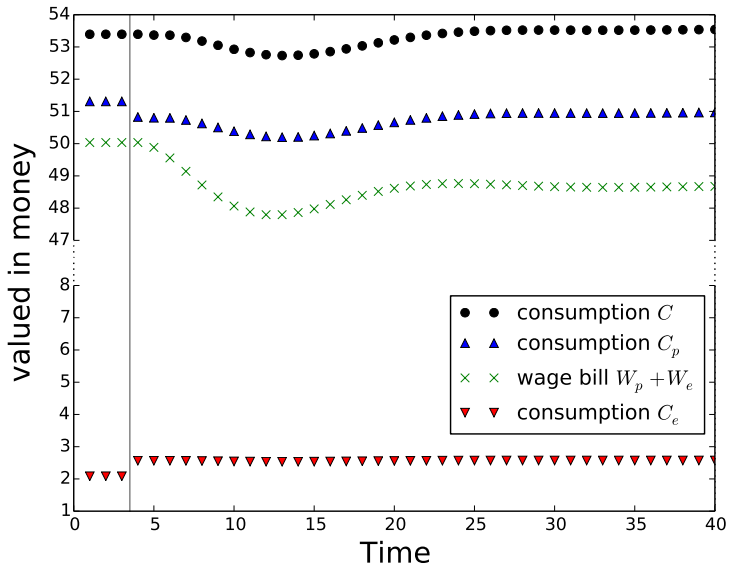
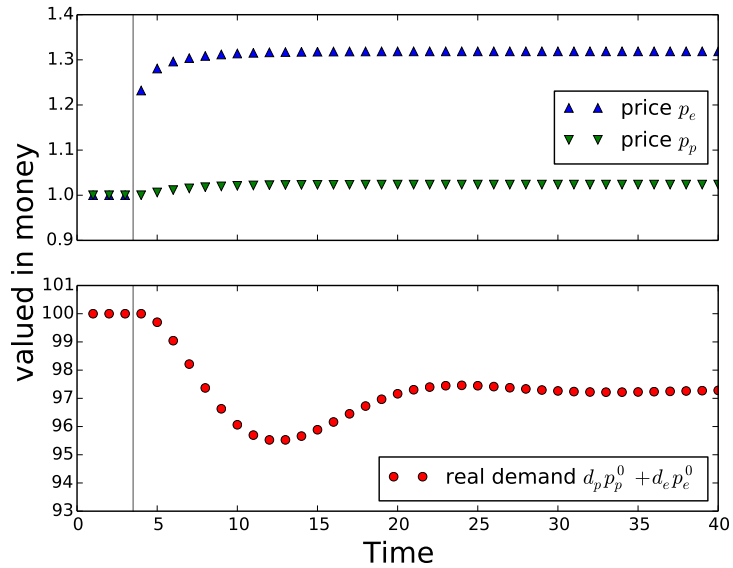


- Left: change of consumption pattern.
- Right: increase in prices, drop in real demand.

Explanation for energy price shocks





- increased prices reduce real demand
- wage income drops $\rightarrow$ nominal demand decreases
- Keynesian multiplier effect

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