

# Post Keynesianism and Monetarist Models of Computational Agents in Stock-Flow Consistent Framework

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# Overview

- Preliminary discussion and the introduction to the method
- A simple toy model
- Agent Based Model and SFC
- Agent Based Model and SFC II

# The Basic course in Macroeconomic

- The standard macroeconomic concept (accounts?) of national income identity

$$\underbrace{C + I + G}_{\text{Expenditure}} = Y = \underbrace{WB + F}_{\text{Income}}$$

- Related to consumption, the disposable income of households is

$$YD = Y - T$$

- What happened with Firms profits  $F$ ?
- Basic components: salaries, work, capital, interest rate, money stock
- Equilibrium markets, and different IS / LM derivations (money, production and employment), these are the basic of the neoclassical synthesis

# Looking at the transactions...

$$C + I + G = Y = WB + F$$

	Business				
	Households	Current	Capital	Government	Σ
Consumption	−C	+C			0

Each account is a transaction between two sectors

Sources of funds have **positive signs**, and uses have **negative signs**

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$$C + I + G = Y = WB + F$$

	Business				
	Households	Current	Capital	Government	Σ
Consumption	−C	+C			0
Govt. expenditure		+G		−G	0

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	Business				
	Households	Current	Capital	Government	Σ
Consumption	$-C$	$+C$			0
Govt. expenditure		$+G$		$-G$	0
Investment		$+I$	$-I$		0

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$$C + I + G = Y = WB + F$$

	Business				
	Households	Current	Capital	Government	Σ
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
Σ	<i>SAVING</i>	0	<i>INVESTMENT</i> (-)	<i>GOVT SURPLUS</i>	0

Each account is a transaction between two sectors

Sources of funds have **positive signs**, and uses have **negative signs**

# An incomplete story...

		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
$\Sigma$	<i>SAVING</i>	0	<i>INVESTMENT (-)</i>	<i>GOVT SURPLUS</i>	0

- What happens with households saving?
- What happens in general with the excesses of the sectors?
- Where does the finance for investment come from?
- How is the government deficit financed?

# Here are all the hidden transactions

	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$-\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

- Principle: Everything has to have a counterpart!!!

# The transactions

- Profit from firms does not go to Households anymore

	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$-\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

# Transactions

- How savings are applied

	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$-\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

# Transactions

- Government uses bills and money to fund its deficit

	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$+\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

# All the transactions

- Notice that if we are going to explain the origin and destination of funds, we need to add a banking system

	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$-\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

# Flows

- Notice that all these transactions are flows!!!!
  - Where do they go?

	Households	Production firms		Banks	Government	$\Sigma$
	(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
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Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

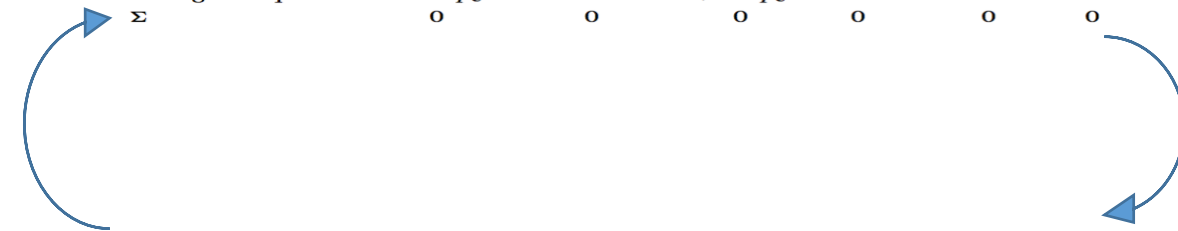
# Stocks of the Economy: Balance-Sheet matrix

- Here is where the dynamic of the economy is captured
- All the assets and liabilities of households are described
  - Assets are positives and liabilities negative

	Households	Production firms	Banks	Government	$\Sigma$
Loans		$-L$	$+L$		0
Cash	$+H_h$		$+H_b$	$-H$	0
Deposits	$+M$		$-M$		0
Bills	$+B_h$		$+B_b$	$-B$	0
Equities	$+e \cdot p_e$	$-e_f \cdot p_e$	$-e_b \cdot p_e$		0
Tangible capital	$+K_h$	$+K_f$			$+K$
Sum (net worth)	$NW_h$	$NW_f$	$NW_b$	$NW_g$	$K$

# Dynamical System

$F(.)$



$S_t =$

- **Flows:** changes in the system
  - The behavior of the agents have to be specified

- **Stocks Variables:** represents the state of the system

$$S_t = F(S_{t-1}, \theta)$$

	Households	Production firms		Banks	Government	$\Sigma$
	(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
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Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

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Loans		$-L$	$+L$		0
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Deposits	$+M$		$-M$		0
Bills	$+B_h$		$+B_b$	$-B$	0
Equities	$+e \cdot p_e$	$-e_f \cdot p_e$	$-e_b \cdot p_e$		0
Tangible capital	$+K_h$	$+K_f$			$+K$
Sum (net worth)	$NW_h$	$NW_f$	$NW_b$	$NW_g$	$K$

# Dynamical System and the behavioral assumptions

	Households	Production firms		Banks	Government	$\Sigma$
	(1)	Current (2)	Capital (3)	(4)	(5)	
Consumption	$-C$	$+C$				0
Investment		$+I$	$-I$			0
Govt. expenditures		$+G$			$-G$	0
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Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

Behavior 1



	Households	Production firms		Banks	Government	$\Sigma$
	(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			$+\Delta L_f$	$-\Delta L$		0
Change in cash	$-\Delta H_h$			$-\Delta H_b$	$-\Delta H$	0
Change in deposits	$-\Delta M$			$+\Delta M$		0
Change in bills	$-\Delta B_h$			$-\Delta B_b$	$+\Delta B$	0
Change in equities	$-\Delta e \cdot p_e$		$+\Delta e \cdot p_e$			0
$\Sigma$	0	0	0	0	0	0

Behavior 2



	Households	Production firms	Banks	Government	$\Sigma$
Loans		$-L$	$+L$		0
Cash	$+H_h$		$+H_b$	$-H$	0
Deposits	$+M$		$-M$		0
Bills	$+B_h$		$+B_b$	$-B$	0
Equities	$+e \cdot p_e$	$-e_f \cdot p_e$	$-e_b \cdot p_e$		0
Tangible capital	$+K_h$	$+K_f$			$+K$
Sum (net worth)	$NW_h$	$NW_f$	$NW_b$	$NW_g$	$K$

# Leaving in a Complex System (and dealing with it in a rational bounded world)

- Reality is multidimensional and nonlinear system.
- How do we deal with a system that is far more complex than our capacities?
- Theories and Methods are two good bounded rational answers

# Economic Theory

- Theory plays a double role: it is both a lens and a blinder (Minsky, chapter 5)
  - In a sense theory capture "The Architecture of Complexity" (subsystems, relationship between them, dynamics, and relation between complex system and their description)
  - A theory becomes useless when questions which are meaningful in the world are often nonsense in theory
- Dani Rodrick's Economics Rules
  - Economist do it with models, but we are not really good at capturing the context of the models

# Methods (and techniques) in Science and E. Science

- An infinitum discussion between deductive vs inductive; causal vs stochastic; static vs dynamic; symbolic (formal) vs language; quantitative vs qualitative; statistical techniques, etc...
- Galileo's telescope, Newton's prisma, cloud chamber, leaser interferometer gravitational-wave observatory (LIGO)
- But, methods and techniques are not innocent. They come with artifacts
- *Nicholas Georgescu-Roegen(1979) Methods in Economic Science Journal of Economic Issues, Vol. 13, No. 2 (Jun., 1979), pp. 317-328*
- *Marshall J. (1941) A Discussion on Methods in Economics, Journal of Political Economy, Vol 49, Nº 3, pp 441-448*

# Keynes, and the foundation of Macroeconomics

- In 1906, he worked at the Indian Office,
- and in 1913 he wrote "Currency and Finance in India"
- 1909 works in the chair of probability of the U. Of Cambridge.
- Work with Pigou 1916 is appointed advisor to the British Ministry of Finance
- 1919 is part of the Paris Peace Conference after the WWI resigning for not agreeing with what was imposed on Germany.
- 1929 The Great Depression was experienced. Crisis in economic science
- 1936 ends "General Theory of Employment, Interest and Money", points out the importance of effective demand

# Two paradigms of theory, after Keynes

## Neoclassics

- Economic activities are exclusively motivated by the aspirations of individuals
- Markets are not perfect because prices adjust slowly
- Production is instantaneous, so a credit system is not necessary
- Money is important as an asset (which has no counterpart)
- Macroeconomic Theory is deductive

## Post-Keynesian

- Joan Robinson, Michal Kalecki, Kaldor
- The stylized facts are what count
- There are multiple institutions and many regularities that can be tested
- There are multiple incentives
- There is no Neoclassical Production Function
- Companies have to decide many things all the time ... investments, employment, prices, production
- As people are wrong ... there is a permanent need for adjustment mechanism ... or credit system

# Neoclassical Synthesis: Prices as Parameter

- The basic price-theoretic core of the neoclassical synthesis is to show that prices are coherent results of everyone optimizing
- This is valid, in the domain of markets in which the ability to spend is governed by some predetermined budget
  - Market involving finance and investments can achieve prices, quantities and payments commitments that may not be sustained by future demand or profits
- In the neoclassical view, speculation, financing conditions, inherited financial obligations and the fluctuating behavior of aggregate demand have nothing whatsoever to do with savings, investment, and interest rate determination

# The almost end of one story

- After WWII, there was a development of Structural Economic Models (SEMs) and single equation models with estimation of parameters
  - The single equation becomes single building block of the SEMs
- In the 70's, there was problem to explain the effects of inflation
- A Fork: Lucas Critique (1976) and the born of DSGE and RBC Development

# A Basic New Keynesian Model

## Household

$$\text{Max, } E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

$$\text{Subject to, } p_t C_t + Q_t B_t \leq B_{t-1} + W_t N_t + T_t$$

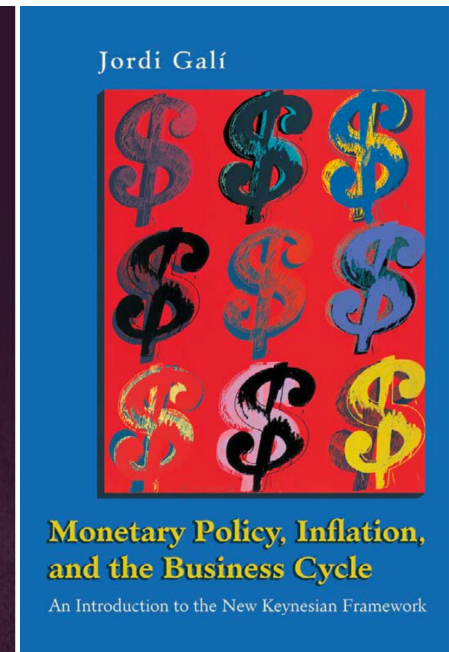
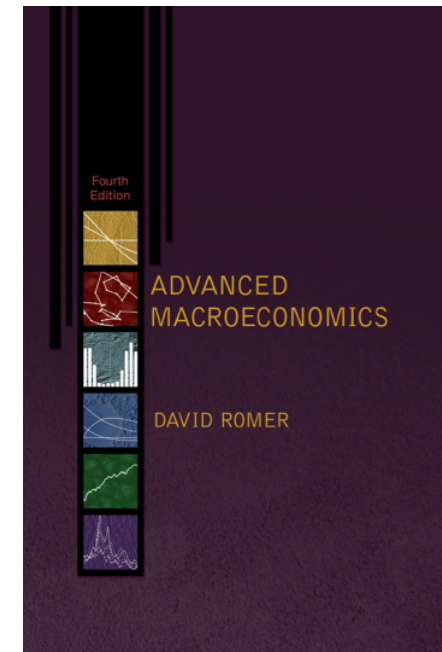
$$\text{Euler Equation } c_t = E_t c_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{(t+1)} - \rho)$$

## Firms

$$Y_t = A_t N_t^{1-\alpha}$$

$$\text{Max, using } p_t, \sum_{k=0}^{\infty} \theta^k E_t \{p_t Y_{t+k} - c(Y_{t+k})\}$$

- Equilibrium,  $C_t = Y_t$ ,
  - Euler Equation becomes  $y_t = E_t y_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{(t+1)} - \rho)$
- Effects under Monetary Policy Rules
  - $i_t = \rho + \phi_{\pi} \pi_t + \phi_y \tilde{y}_t + v_t$

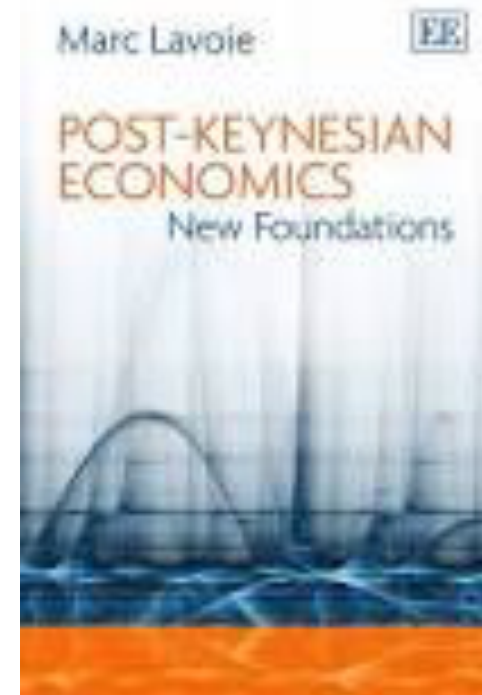
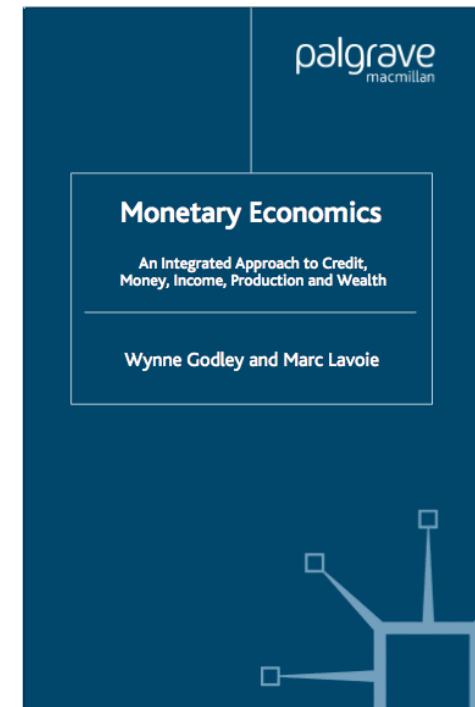


# Moreover, on the methodological side...

- Models are analyzed in stationary state, and deviations using log-linearizations. This introduces problem to analyze out of equilibrium behaviors, and the unique way to analyze the system is through shocks
- Most of these models either assume that banks are totally absent and all lending is direct, or adopt the loanable funds approach which reduces the role of financial institutions to mere intermediaries, accepting deposits of pre-existing real resources from savers and lending them to borrowers (i.e saving before lending)
- Even for exogenous money creation, the mechanism described are very poor (lump sum with seigniorage)

# Monetary Economics from the Post-Keynesianism

- Reference: Godley Wynne y Marc Lavoie (2007), Monetary Economics: an integrated approach to credit, money, income, production and Wealth. *Palgrave MacMillan*.
- This approach starts with the assumption that every modern industrial economy is composed of a complex institutional fabric, which has homes, businesses, banks and government: it is necessary to understand this system as a whole
- A distinctive element of the approach is that the transactions that are generated in the network, generates debit on one side and credits on the other (Everything comes from somewhere and goes somewhere)
- Additionally, all the time we try to model the complete system



# An Stock and Flow Consistent Model

- Assume a simple and closed economy
- Assume that are four sectors: household, firms, financial sector (banks) and government (gov. and central bank)
- Let's have a look to their balance sheets

# Households

- Households have tangible assets
- They usually have positive Net Worth
- Note, however, that if equity prices (or housing prices) were to fall below the value at which they were purchased with the help of loans taken for pure speculative purposes – as would happen during a stock market crash that would have followed a stock market boom – the net worth of households taken overall could become negative
- In a one column matrix, all the elements on the asset side will be entered with a plus sign, and the elements of the liability side will be entered with a negative sign.

Assets	64,000	Liabilities	64,000
Tangible capital $K_h$	25,500	Loans $L_h$	11,900
Equities $e \cdot p_e$		Net Worth $NW_h$	52,100
Bills $B_h$			
Money deposits $M_h$	5,900		
Cash $H_h$			

Tangible capital $K_h$	25,500
Equities	15,000
Bills	17,600
Money Deposits	5,900
Cash	
Loans	-11,900
Net Worth	-52,100
Total	0

# Firms

Assets	2001	2005	Liabilities	2001	2005
Total	17,500	22,725	Total	17,500	22,725
Tangible capital $K_f$	9,200	11,750	Loans $L_f$	9,100	10,125
Financial assets $M_f$	8,300	11,975	Equities issued $e_f \cdot p_{ef}$	10,900	10,925
			Net Worth $NW_f$	-2,500	+1,675

- The balance sheet of firms has the complication arising from the existence of corporate equities
- All the components of the balance sheets are evaluated to market price
- What happen when the net financial value of a firm is larger than replacement value of its tangible capital? (q-ratio larger than one)

# Balance Sheet of the Economy

	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

- Government issues short-term securities  $B$  (Treasury bills)
- Production firms and financial firms (banks) issue equities (shares), bought by households
- Loans are taken by households and firms

Note: the elements on the asset side will be entered with a plus sign, and the elements of the liability side will be entered with a negative sign.

# Transactions flow matrix

[illegible]

# Full integration of flows and balances

		Households	Production firms	Banks	Government	Central bank	
		(1)	(2)	(3)	(4)	(5)	$\Sigma$
	Net worth, end of previous period	$NW_{h-1}$	$NW_{f-1}$	$NW_{b-1}$	$NW_{g-1}$	0	$K_{-1}$
Change in net assets arising from transactions	Change in loans	$-\Delta L_h$	$-\Delta L_f$	$+\Delta L$			0
	Change in cash	$+\Delta H_h$		$+\Delta H_b$		$-\Delta H$	0
	Change in deposits	$+\Delta M_h$		$-\Delta M$			0
	Change in bills	$+\Delta B_h$		$+\Delta B_b$	$-\Delta B$	$+\Delta B_{cb}$	0
	Change in equities	$+\Delta e_f \cdot p_{ef} + \Delta e_b \cdot p_{eb}$	$-\Delta e_f \cdot p_{ef}$	$-\Delta e_b \cdot p_{eb}$			0
	Change in tangible capital	$+\Delta k_h \cdot pk$	$+\Delta k_f \cdot pk$				$+\Delta k \cdot pk$
Change in net assets arising from revaluations	Capital gains in equities	$+\Delta p_{ef} \cdot e_{f-1}$ $+\Delta p_{eb} \cdot e_{b-1}$	$-\Delta p_{ef} \cdot e_{f-1}$	$-\Delta p_{eb} \cdot e_{b-1}$			0
	Capital gains in tangible capital	$+\Delta pk \cdot k_{h-1}$	$+\Delta pk \cdot k_{f-1}$				$\Delta pk \cdot (k_{h-1} + k_{f-1})$
	Net worth, end of period	$NW_h$	$NW_f$	$NW_b$	$NW_g$	0	$K$

# The dynamic of the system

	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

Behavioural Rules

	Households (1)	Production firms		Banks		Government	Central Bank		$\Sigma$
		Current (2)	Capital (3)	Current (4)	Capital (5)	(6)	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	$+FD_b$			$-F_b$	$+FU_b$				0
Profit, central Bk						$+F_{cb}$	$-F_{cb}$		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	$+\Delta L_h$		$+\Delta L_f$		$-\Delta L$				0
Change in cash	$-\Delta H_h$				$-\Delta H_b$			$+\Delta H$	0
Change, deposits	$-\Delta M_h$				$+\Delta M$				0
Change in bills	$-\Delta B_h$				$-\Delta B_b$	$+\Delta B$		$-\Delta B_{cb}$	0
Change, equities	$-(\Delta e_f \cdot p_{ef} + \Delta e_b \cdot p_{eb})$		$+\Delta e_f \cdot p_{ef}$		$+\Delta e_b \cdot p_{eb}$				0
$\Sigma$	0	0	0	0	0	0	0	0	0

Accounting

		Households (1)	Production firms (2)	Banks (3)	Government (4)	Central bank (5)	$\Sigma$
	Net worth, end of previous period	$NW_{h-1}$	$NW_{f-1}$	$NW_{b-1}$	$NW_{g-1}$	0	$K_{-1}$
Change in net assets arising from transactions	Change in loans	$-\Delta L_h$	$-\Delta L_f$	$+\Delta L$		$-\Delta H$	0
	Change in cash	$+\Delta H_h$		$+\Delta H_b$			0
	Change in deposits	$+\Delta M_h$		$-\Delta M$			0
	Change in bills	$+\Delta B_h$		$+\Delta B_b$	$-\Delta B$	$+\Delta B_{cb}$	0
	Change in equities	$+\Delta e_f \cdot p_{ef} + \Delta e_b \cdot p_{eb}$	$-\Delta e_f \cdot p_{ef}$	$-\Delta e_b \cdot p_{eb}$			0
	Change in tangible capital	$+\Delta k_h \cdot pk$	$+\Delta k_f \cdot pk$				$+\Delta k \cdot pk$
Change in net assets arising from revaluations	Capital gains in equities	$+\Delta p_{ef} \cdot e_{f-1}$	$-\Delta p_{ef} \cdot e_{f-1}$	$-\Delta p_{eb} \cdot e_{b-1}$			0
	Capital gains in tangible capital	$+\Delta p_k \cdot k_{h-1}$	$+\Delta p_k \cdot k_{f-1}$				$\Delta p_k \cdot (k_{h-1} + k_{f-1})$
	Net worth, end of period	$NW_h$	$NW_f$	$NW_b$	$NW_g$	0	$K$

Accounting

# A Full Stock-Flow Model

Government Money

# Money Creation

- There is *outside* money, which is created whenever a government pays for something by making a draft on its central bank or by paying for something with banknotes, and which is extinguished when a payment is made by a member of the public to the government, typically in the form of taxes. This kind of money we may call *government* money, since it is issued by public institutions, namely the central bank or the Treasury department of central government. Government money is usually called *central bank* money or *high-powered* money in the literature.
- There is *inside* money, which is created by commercial banks when they make loans, and which ceases to exist when loans are repaid. This second kind of money will be called *private* money, since it is issued by private institutions, namely private banks.

# A Model with Outside Money

- The economy is closed to the outside world: there are neither exports nor imports, nor foreign capital flows
- Suppose that this is a monetary economy where besides gov there are firms selling services and paying wages and housing receiving income, consuming and accumulating assets. This is a pure labour economy.
- The government buys services and pays for them with money, which consists of pieces of paper which it prints. It collect taxes too
- Firms have not benefits, and there are no banks
- There is no labor constraints, and wage is established by government
- The economy is demand-driven, so supply adjust

# Basic elements of the model

- Balance Sheets (or Matrix)
- Transaction Matrix
- Behavioral Specifications (described into the Transactional Matrix)

# Balance Sheets

- There is only one item – money ( $H$ ) – which is a liability of the government and an asset of households
  - Assets positivs, liabilities negatives

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

- Firms do not have money

# Transaction Matrix

- Sources of funds have **positive signs**, and uses of funds with **negatives signs**

	1. Households	2. Production	3. Government	$\Sigma$
1. Consumption	$-C$	$+C$		0
2. Govt. expenditures		$+G$	$-G$	0
3. [Output]		$[Y]$		
4. Factor income (wages)	$+WB$	$-WB$		0
5. Taxes	$-T$		$+T$	
6. Change in the stock of money	$-\Delta H$		$+\Delta H$	0
$\Sigma$	0	0	0	0

¿Why  $\Delta H = H - H_{-1}$  is negative for households?

- The Household budget constraint should be written as

$$WB - C - T - \Delta H = 0$$

With  $\Delta H = H - H_{-1}$ . This is,

$$H = H_{-1} + WB - C - T$$

Which is what we observe in the matrix 

	1. Households	2. Production	3. Government	$\Sigma$
1. Consumption	$-C$	$+C$		0
2. Govt. expenditures		$+G$	$-G$	0
3. [Output] [Y]				
4. Factor income (wages)	$+WB$	$-WB$		0
5. Taxes	$-T$		$+T$	
6. Change in the stock of money	$-\Delta H$		$+\Delta H$	0
$\Sigma$	0	0	0	0

# About the behaviour

- The rules of behaviour determines the dynamics

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

	1. Households	2. Production	3. Government	$\Sigma$
1. Consumption	-C	+C		0
2. Govt. expenditures		+G	-G	0
3. [Output]		[Y]		
4. Factor income (wages)	+WB	-WB		0
5. Taxes	-T		+T	
6. Change in the stock of money	$-\Delta H$		$+\Delta H$	0
$\Sigma$	0	0	0	0

# Behaviours

- Let's agree with this notation:
  - $s$ , supply,  $d$  demand y  $h$  money on households hands
  - Sources of funds have **positive signs**, and uses of funds with **negatives signs**

	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

# What the transaction matrix represents?

- The observed behavior of the agents. This is ex-post behavior.
- It does not represent what agents expect to occur

	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

# Equilibria and its mechanisms

- Identities in the model,
- $C_s = C_d$
- $G_s = G_d$ 
  - Suppliers produce what it is demanded
- $T_s = T_d$ 
  - Taxes
- $N_s = N_d$ 
  - Labor Market, with wage exogenously given (there is a buffer of workers Levis 1954)

## • Transactional Matrix

	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

# Assumptions on Market equilibrium

- How the first two rows are equal zero?
- Fourth possible mechanisms

	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

- Price adjustments, so that Demand = Supply
- Rationing Theory: there are some price rigidities, and market always adjust for the short side
- Inventory management, or disequilibrium approach
- *Keynesian Mechanism: suppliers produce exactly what is demanded*
  - *Firms sell whatever is demanded. There is no rationing*
  - *There is no inventory*

# Consumption Behaviour

	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

Main Equation

- Disposable Income

$$YD = W N_s - T_s$$

- Taxes

$$T_d = \theta W N_s \text{ con } \theta < 1$$

- Consumption

$$C_d = \alpha_1 YD + \alpha_2 H_{h,-1}$$

With  $0 < \alpha_2 < \alpha_1 < 1$

# More Behaviour

- Why the Government prints Money?

$$\Delta H_s = H_s - H_{s-1} = G_d - T_d$$

- What Household do with Savings?

$$\Delta H_h = H_h - H_{h-1} = YD - C_d$$

	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

# Labor Market

- Production is

$$Y = C_s + G_s = W N_d$$

- Therefore

$$N_d = \frac{Y}{W}$$

	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

# Putting all together: Structural Form

1.  $C_s = C_d$
2.  $G_s = G_d$
3.  $T_s = T_d$
4.  $N_s = N_d$
5.  $YD = W N_s - T_s$
6.  $T_d = \theta W N_s$
7.  $C_d = \alpha_1 YD + \alpha_2 H_{h,-1}$
8.  $\Delta H_s = H_s - H_{s-1} = G_d - T_d$
9.  $\Delta H_h = H_h - H_{h-1} = YD - C_d$
10.  $Y = C_s + G_s$
11.  $N_d = \frac{Y}{W}$
- Redundant Equation
1.  $\Delta H_s = \Delta H_h$

	1. Households	2. Production	3. Government	Σ
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
Σ	0	0	0	0

Eleven  
Variables

	1. Households	2. Production	3. Government	Σ
Money Stock	+H	0	-H	0

# A numeric example

- Let's suppose that  $\theta = 0,2$  ,  $\alpha_1=0,6$  and  $\alpha_2 = 0,4$ 
  - $C_d = \alpha_1 YD + \alpha_2 H_{h,-1}$ ;  $T_d = \theta W N_s$
- Suppose we start from an economy without activity
- Let's assume that gov expenditure is 20 monetary units in each period
- What should happens to the economy?
- Look at the model in R

# Analysis

- In every period, the keynesian multipliers is at work

Period	1	2	3	$\infty$
$G$	0	20	20	20
$Y = G + C$	0	38.5	47.9	100
$T = \theta \cdot Y$	0	7.7	9.6	20
$YD = Y - T$	0	30.8	38.3	80
$C = \alpha_1 \cdot YD + \alpha_2 \cdot H_{-1}$	0	18.5	27.9	80
$\Delta H_s = G - T$	0	12.3	10.4	0
$\Delta H_h = YD - C$	0	12.3	10.4	0
$H = \Delta H + H_{-1}$	0	12.3	22.7	80

# Impact Analysis: Multiplier

- In the first period...,

$$C = \alpha_1 YD$$

$$Y = C + G = \alpha_1 ((1 - \theta)Y + G$$

- With perfect foresight these two terms should be equal,

$$Y^* = \frac{G}{1 - \alpha_1(1 - \theta)}$$

- Substituting...

$$Y^* = \frac{20}{1 - 0.6(1 - 0.2)} = 38.5$$

- Standard results in the IS/LM model
  - What is additional in this framework?

Period	1	2	3	$\infty$
$G$	0	20	20	20
$Y = G + C$	0	38.5	47.9	100
$T = \theta \cdot Y$	0	7.7	9.6	20
$YD = Y - T$	0	30.8	38.3	80
$C = \alpha_1 \cdot YD + \alpha_2 \cdot H_{-1}$	0	18.5	27.9	80
$\Delta H_s = G - T$	0	12.3	10.4	0
$\Delta H_h = YD - C$	0	12.3	10.4	0
$H = \Delta H + H_{-1}$	0	12.3	22.7	80

# Problems with the simple Keynesian Multiplier

- If the short-term equilibrium were the final result, the government would incur a deficit in each period, which would lead to an infinite debt
- Standard models work with flows, and with very few stocks.
- This is a problem of dynamics. Generates poor description of the stationary states. In the model, it is necessary to take into account that households generate wealth

# Stationary State Solution

- Stationary state: the state of the system where the relations between variables remain constant
  - Diferencia entre steady state y stationary state (con y sin crecimiento)
- In Stationary State, government spending is equal to government taxes.
  - Notar que es la condición de que el stock de dinero no cambie

# SS Solution

- Formally

$$G = T^* = \theta W N^* = \theta Y^*$$

- Thus,

$$Y^* = \frac{G}{\theta}$$

- This is known as the fiscal stance:
  - Expected and desired impact on the future economy due to taxation and government spending. <http://www.businessdictionary.com/definition/fiscal-stance.html>

# In SS...

- Consumption is equal to disposable income

$$\Delta H_h^* = YD^* - C^* = 0$$

$$YD^* - C^* = \frac{G(1 - \theta)}{\theta}$$

	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

# SS for household's wealth

- From the Consumption equation in SS

$$C_d = \alpha_1 YD + \alpha_2 H_{h,-1}$$

$$C^* = \alpha_1 YD^* + \alpha_2 H_h^*$$

$$H_h^* = \frac{(1 - \alpha_1)}{\alpha_2} G \frac{1 - \theta}{\theta}$$

# Description of the norm of flow

- The consumption function is defined in terms of flows and stock
- It can be expressed in terms of the accumulation of wealth

$$C = YD - \Delta H_h$$
$$C = YD - \Delta H_h = \alpha_1 YD + \alpha_2 H_{h-1}$$

or

$$\Delta H_h = (1 - \alpha_1) YD - \alpha_2 H_{h-1}$$

$$\Delta H_h = \alpha_2 \left( \frac{1 - \alpha_1}{\alpha_2} YD - H_{h-1} \right)$$

$$\alpha_3 = \frac{1 - \alpha_1}{\alpha_2}$$

# La función de Consumo con la norma de flujo y stock

- $\alpha_3$  is the objective proportion of disposable income that is desired as wealth
- It is known as the standard flow-stock of households
- Households save if the target is below, and spend more if it is above

# Expectations and its mistakes

- Agents have to create **expectations**, when uncertainty is introduced into the model,
  - Agents might have not trustable knowledge (ontologic uncertainty)
  - Agents have bounded computational capacities to process information (epistemologic uncertainty)
- Back into the model
- Let's suppose that households are not secure about their income, therefore now they have an **expected income**.

# Expectations

- There are two issues that we have to describe when expectations are modeled
  - How the expectations are formed?
  - What happens when agents' expectations are wrong?

# Introduction of Expectations

- Change into the consumption function

$$C_d = \alpha_1 YD^e + \alpha_2 H_{h-1}$$

- How  $YD^e$  is computed?
  - $YD^e = YD_{-1}$

# Error Correction

- Household stock of money will be the desire one, when their expectations about income turn to be true
- At the beginning of a period, households decide the additional amount of money they want to have, given their expectations. This desire, is their *demand for money*.  $H_d$

$$\Delta H_d = H_d - H_{h-1} = YD^e - C_d$$

- At the end of the period, it might exist differences

$$H_h - H_d = YD - YD^e$$

- Notice that money behave as buffer

# Transaction Matrix

	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)	$+W \cdot N_s^e$	$-W \cdot N_d$		$W \cdot N_s^e - W \cdot N_d$
5. Taxes	$-T_s^e$		$+T_d$	$T_d - T_s^e$
6. Change in the stock of money	$-\Delta H_d$		$+\Delta H_s$	$\Delta H_s - \Delta H_d$
$\Sigma$	0	0	0	0

# Equations

$$C_s = C_d \quad (3.1)$$

$$G_s = G_d \quad (3.2)$$

$$T_s = T_d \quad (3.3)$$

$$N_s = N_d \quad (3.4)$$

$$YD = W \cdot N_s - T_s \quad (3.5)$$

$$T_d = \theta \cdot W \cdot N_s \quad \theta < 1 \quad (3.6)$$

$$C_d = \alpha_1 \cdot YD^e + \alpha_2 \cdot H_{h-1} \quad 0 < \alpha_2 < \alpha_1 < 1 \quad 3.7E$$

$$\Delta H_s = H_s - H_{s-1} = G_d - T_d \quad (3.8)$$

$$\Delta H_h = H_h - H_{h-1} = YD - C_d \quad (3.9)$$

$$Y = C_s + G_s \quad (3.10)$$

$$N_d = \frac{Y}{W} \quad (3.11)$$

$$\Delta H_d = H_d - H_{h-1} = YD^e - C_d \quad 3.18$$

$$YD^e = YD_{-1} \quad 3.20$$

Redundant Equation

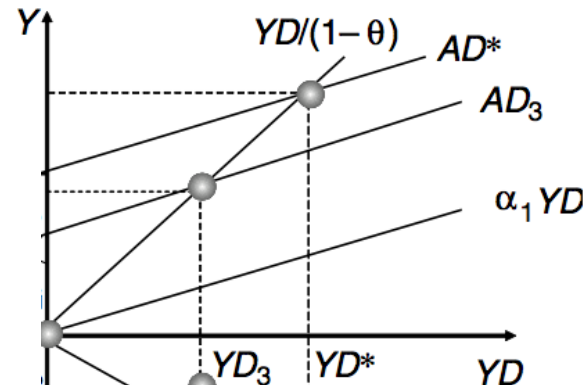
$$1. \quad \Delta H_s = \Delta H_h$$

# Numerical Exercise

Period	1	2	3	$\infty$
$G$	0	20	20	20
$Y = C + G$	0	29.6	39.9	100
$T = \theta \cdot Y$	0	5.9	8.0	20
$YD = Y - T$	0	23.7	31.9	80
$YD^e = YD_{-1}$	0	16.0	23.7	80
$C = \alpha_1 \cdot YD^e + \alpha_2 \cdot H_{-1}$	0	9.6	19.9	80
$\Delta H_s = G - T$	0	14.1	12.0	0
$\Delta H_h = YD - C$	0	14.1	12.0	0
$H = H_s = H_h = \Delta H + H_{-1}$	0	14.1	26.1	80
$\Delta H_d = YD^e - C$	0	6.4	3.8	0
$H_d = \Delta H_d + H_{-1}$	0	6.4	17.9	80

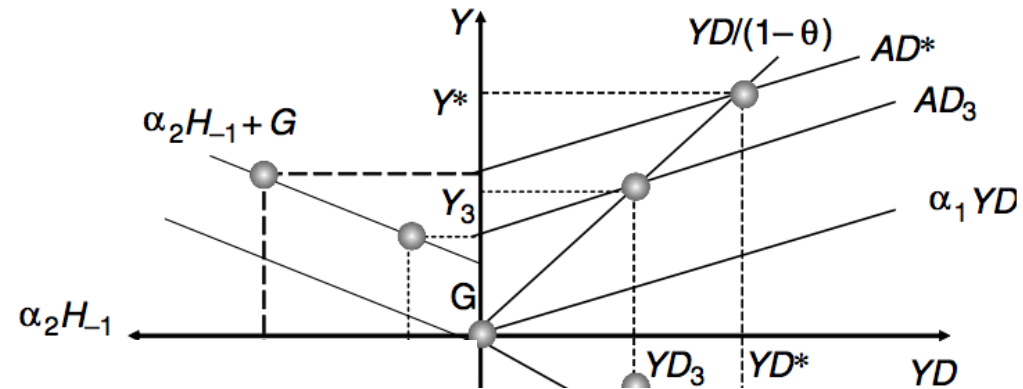
# Representación Gráfica

- Mirando las decisiones de producción ¿Cuál es el nivel de producción compatible con la demanda agregada?
- Hay una solución de corto plazo y otra de largo plazo. ¿Que representa  $AD^3$ ?



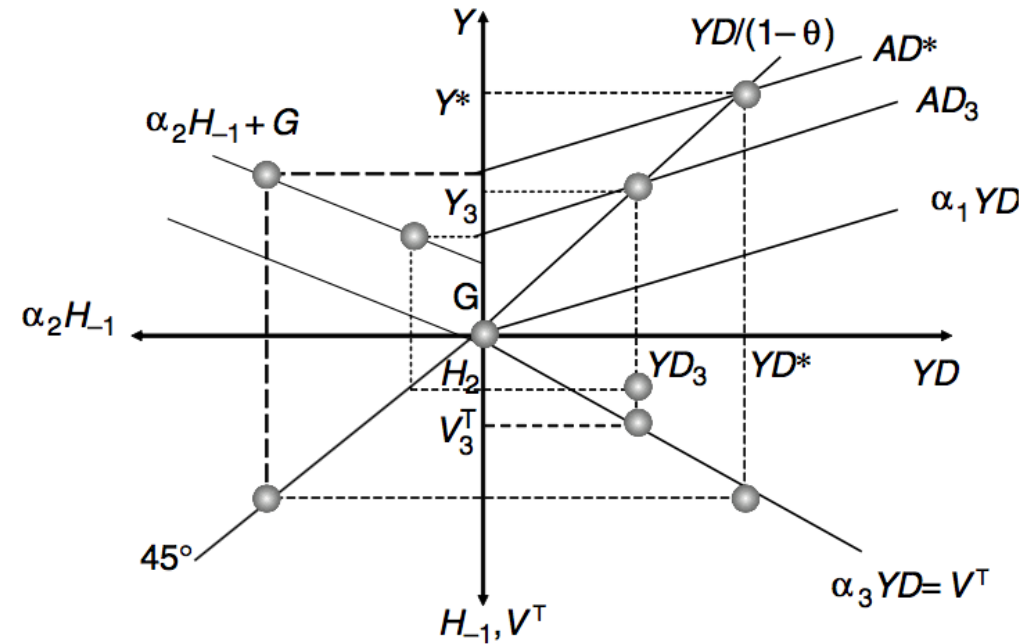
# Representación Gráfica

- El consumo desde La Riqueza
- $\alpha_2 H_{-1}$  es el consumo desde la riqueza
- Los desplazamientos verticales representa los efectos del consumo autónomo



# Representación Gráfica

- La Riqueza deseada se representa sobre el eje vertical parámetro  $\alpha_3$
- El cuarto cuadrante representa un mapa de la riqueza deseada con la obtenida



# Sistema: forma reducida

1.  $C = \alpha_1(1 - \theta)(C + G) + \alpha_2 H_{h,-1}$
2.  $H_s = H_{s-1} + G - \theta(C + G)$
3.  $H_h = H_{h-1} + (1 - \theta)(C + G) - C$

- Ecuación redundante

1.  $\Delta H_s = \Delta H_d$

# Forma reducida

$$1. \quad C = \frac{\alpha_1(1-\theta)G + \alpha_2 H_{h,-1}}{1 - \alpha_1 + \theta \alpha_1}$$

$$2. \quad H_s = H_{s-1} + (1 - \theta)G - \theta C$$

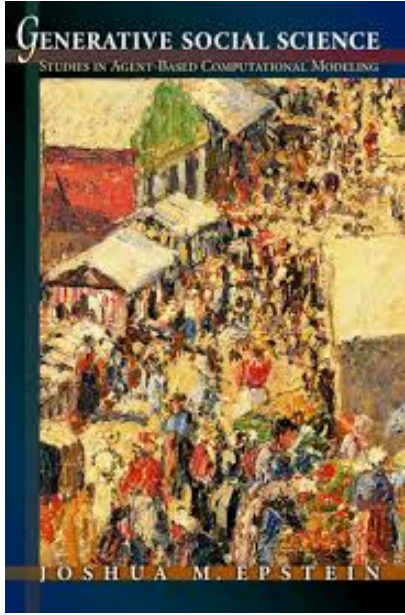
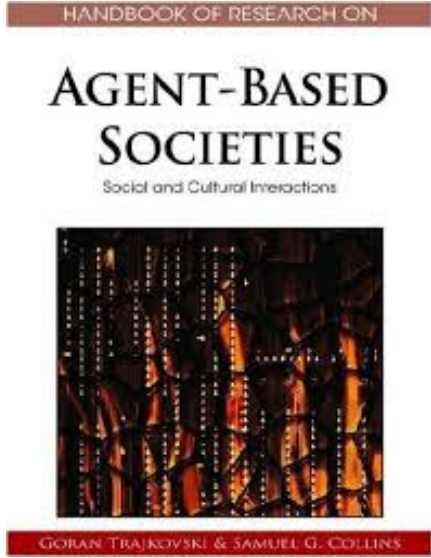
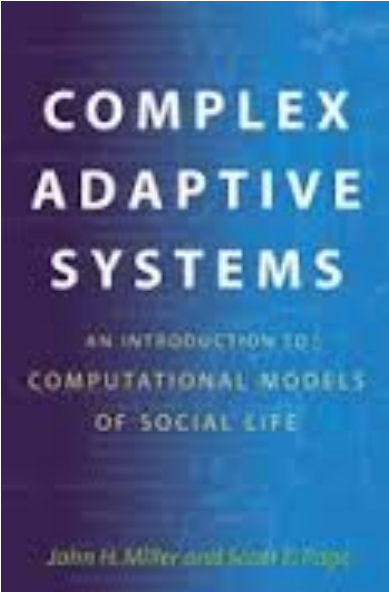
$$3. \quad H_h = H_{h-1} + (1 - \theta)G - \theta C$$

- Comprobación de que

$$1. \quad \Delta H_s = \Delta H_h$$

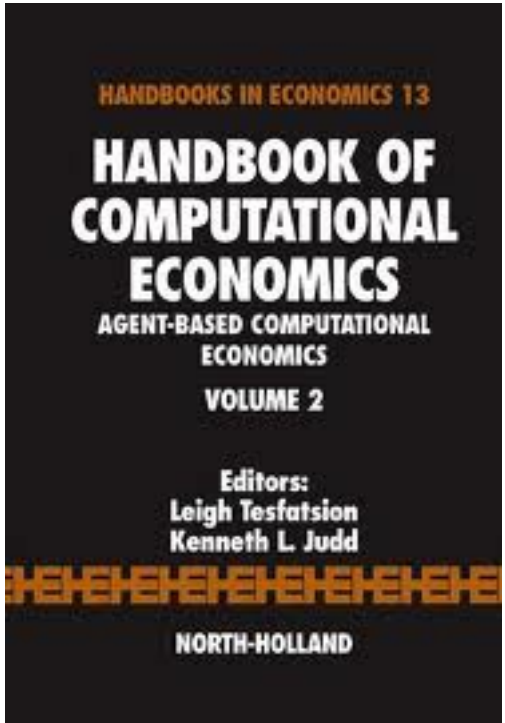
# Caveats of Stock-Flow Consistent Model

- Traditional SFC models are highly aggregated, dividing the economy in major institutional sectors, typically households, banks, firms, and the public sector
- This limit definitively hinders, and in some cases impedes, the possibility of studying phenomena which are deeply connected to agents' heterogeneity and agents' disperse interaction, such as selection and self-organization processes within markets or industries, the generation of financial bubbles, and the propagation of shocks through network-based balance sheet relationships



# Computational Agents

A methodological innovation



## Agent based-stock flow consistent macroeconomics: Towards a benchmark model



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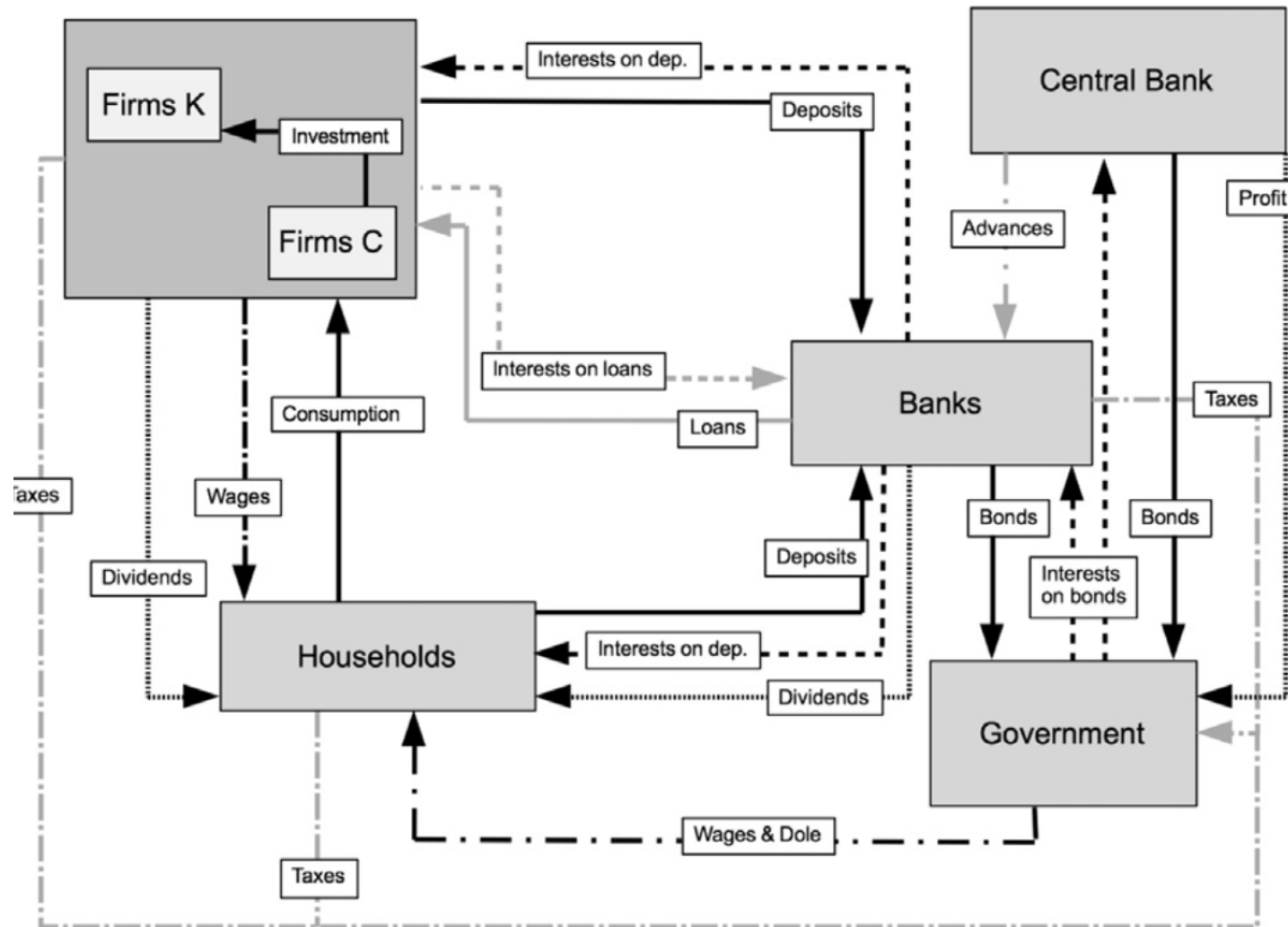
### ABSTRACT

The paper moves from a discussion of the challenges posed by the crisis to standard macroeconomics and the solutions adopted within the DSGE community. Although several recent improvements have enhanced the realism of standard models, we argue that major drawbacks still undermine their reliability. In particular, DSGE models still fail to recognize the complex adaptive nature of economic systems, and the implications of money endogeneity. The paper argues that a coherent and exhaustive representation of the inter-linkages between the real and financial sides of the economy should be a pivotal feature of every macroeconomic model and proposes a macroeconomic framework based on the combination of the Agent Based and Stock Flow Consistent approaches. The paper aims at contributing to the nascent AB-SFC literature under two fundamental respects: first, we develop a fully decentralized AB-SFC model with several innovative features, and we thoroughly validate it in order to check whether the model is a good candidate for policy analysis applications. Results suggest that the properties of the model match many empirical regularities, ranking among the best performers in the related literature, and that these properties are robust across different parameterizations. Second, the paper has also a methodological purpose in that we try to provide a set of rules and tools to build, calibrate, validate, and display AB-SFC models.

# Methodological Proposal

- Real modeling of the balances of the organizational sectors, institutions and individuals (according to the level of disaggregation)
- Consistent monitoring of the financial transactions carried out by the agents and the flow of the financial assets they have
- Computer Agents Consistent Flow and Stock Framework

# Sectores Económicos y las transacciones



# Modelling Agents Balance Sheet within SF

Firm A

Cash	100	
Inventory	50	
		Net-Wealth 150

Worker 1

Deposits	50	
		Net-Wealth 50

Worker 2

Deposits	50	
		Net-Wealth 50

Bank

Cash	200	Deposits 100
Loans	0	
		Net-Wealth 100

Firm A

Cash	0	Liabilities 100
Inventory	50	
		Net-Wealth -50

Worker 1

Deposit	150	
		Net-Wealth 150

Worker 2

Deposit	150	
		Net-Wealth 150

Bank

Cash	300	Liabilities 300
Loans	100	
		Net-Wealth 100

Suppose firm pay wages of 100\$ to each worker

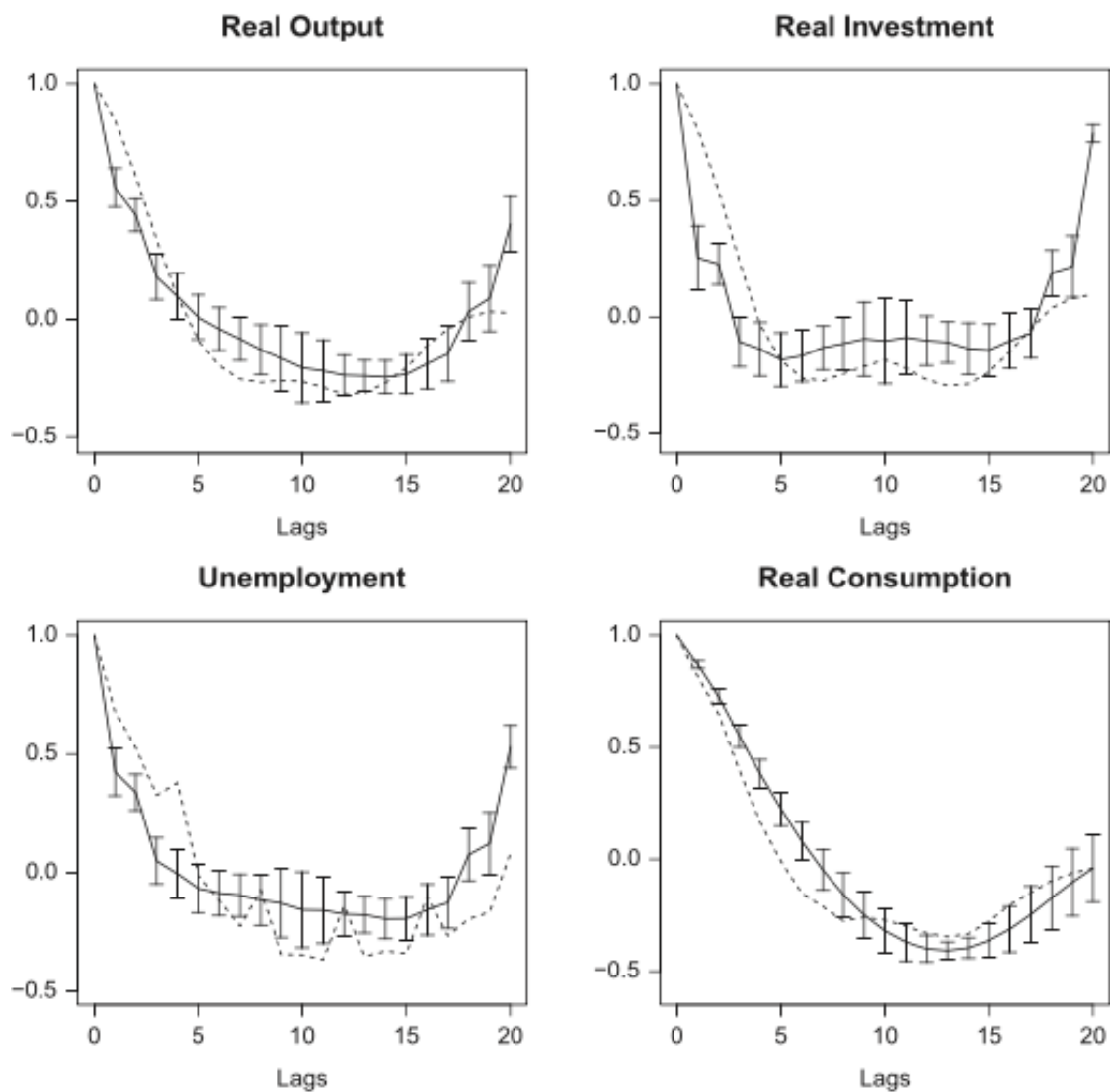
- ABMs are conceived to analyze **out-of-equilibrium dynamics and adaptation processes from heterogeneous and interacting entities** ...

On a more specific note, we use a stock-flow consistent (hereafter, SFC) framework ... there has been a multiplicity of macroeconomic models that combine two important features: **the principle of decentralization/disaggregation which is found in ABM and the principle of stock-flow consistency** ... In an ABM, macroeconomic variables are the result of a simple process of aggregation of individual data, as in the real word [sic] ..., so that the accounting accuracy provided by the SFC ensures the relevance of the aggregation process ..., as well as the interconnected nature of the balance sheets of all agents. Symmetrically, AB principles could provide micro-foundations to SFC macroeconomics, that is, a way to logically articulate and rigorously organize the interactions between the micro and the macro levels.

- Pascal Seppecher, Isabelle Salle, Marc Lavoie. What drives markups? Evolutionary pricing in an agent-based stock-flow consistent macroeconomic model. 2018.

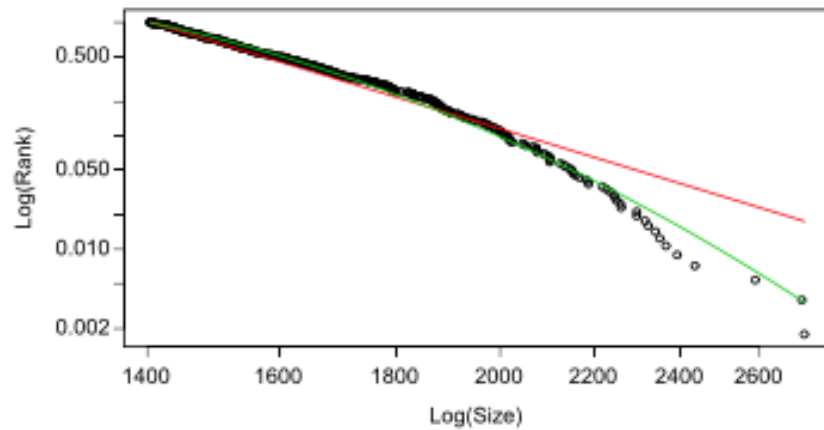
# Calibración y Validación

Auto-correlations

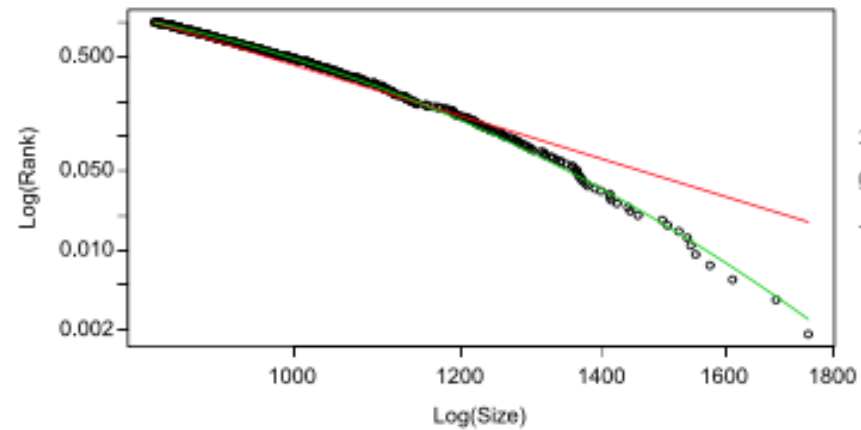


# Distribuciones de tamaños

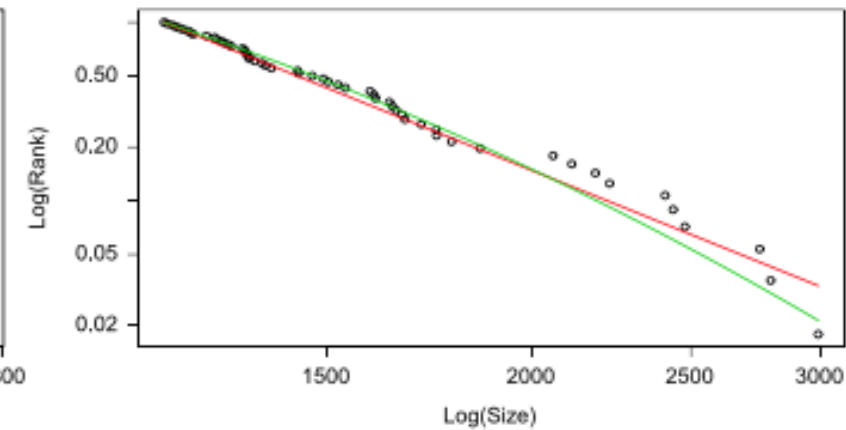
Consumption Firm Size Distribution (Capacity)



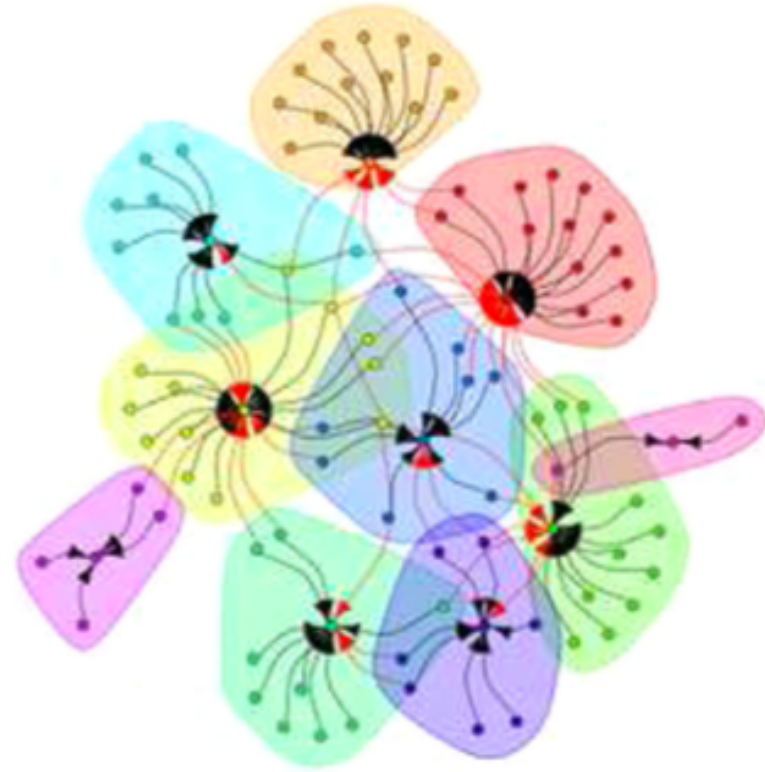
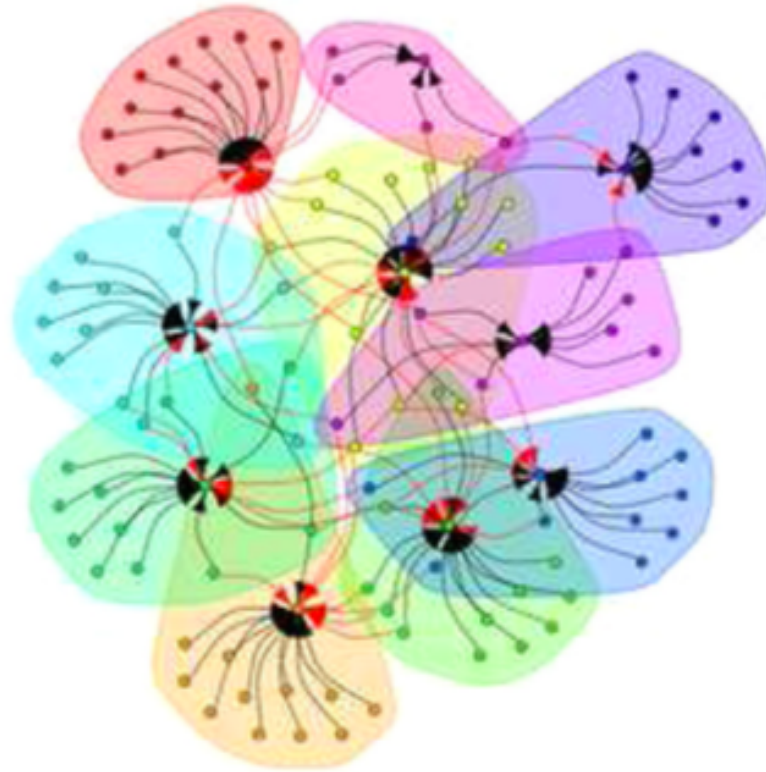
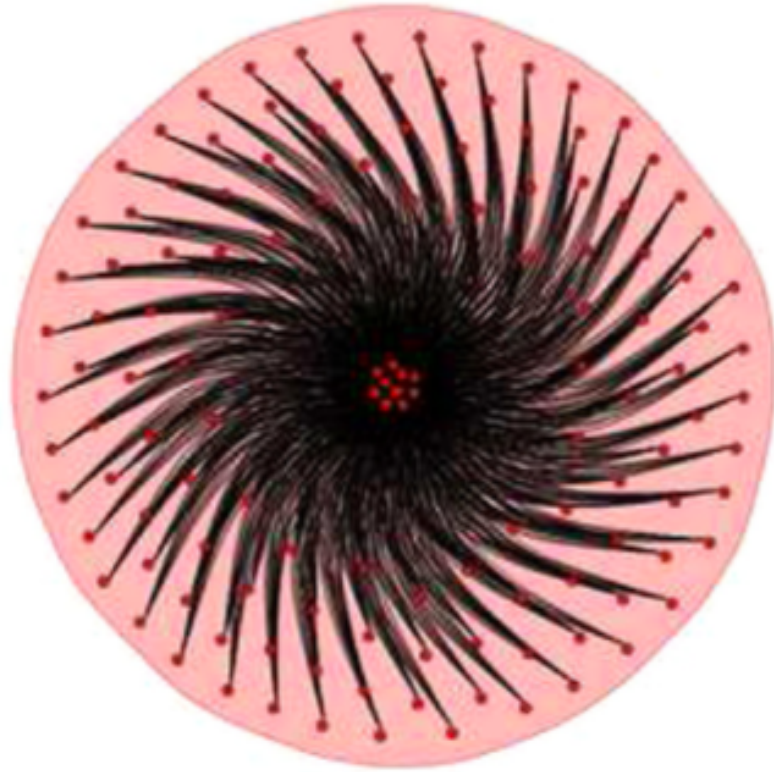
Consumption Firm Size Distribution (Sales)



Capital Firm Size Distribution (Sales)



# Redes de Créditos



# Some thoughts

- General model, with the possibility of characterizing a steady state of the dynamic system
- Model with organizational heterogeneities and intraorganizations
- Integrated treatment of the monetary system and the productive system allows analysis of the banking system
- Calibration and External Validation
- Internal Verification & Validation of the models insured by SFC

# An exploration of the Bertrand-Edgeworth price-setting behavior within a Macroeconomic Stock-Flow Consistent model

Nicolás Garrido

Universidad Diego Portales

Winter School CEPAL 2018

# Overview

- Motivation
- A frame
- The Method of the paper and its models
- p-Results
- Conclusions and More Work

# Motivation

- The economic fluctuations have origin in capacity constraints of the firms, and the behavior of the firms to deal with these restrictions
- Algorithm specification of models as the language to explore the consequence of their interaction

# Economic Fluctuations

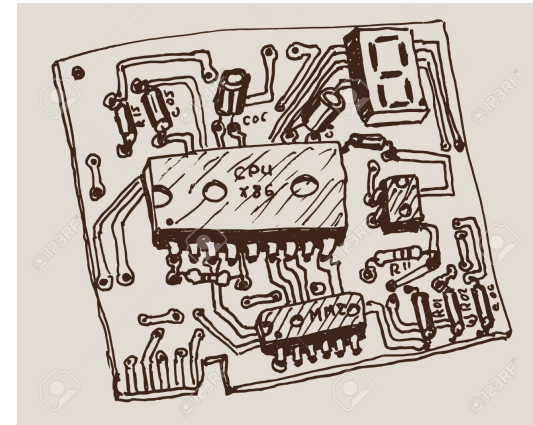
- Pre Keynesian explanations of business cycle
- Lucas & Prescott (1971) to Kydland and Prescott (1982)
- Sources of fluctuations
  - Technological Change, Kydland and Prescott (1982)
  - Technological Change in big Firms, Gabaix (2011) Granular Hipotesis
  - Nonlinear interaction between firms, Durlauf (1993)
  - Fluctuations arise from (s,S) rules at firm level, Nirei (2006)
  - The network origins of aggregate fluctuations (2012)

# A frame for the method

- Axel Leijonhufvud (1973) "Life among the Econ". Econ tribe and its obsession with "modls"
  - Economics Rules (2016): "Training in economic consists essentially of learning a sequence of models"
- Solow (2008), "My general preference is for small, transparent, tailored models, often partial equilibrium, usually aimed at understanding some little piece of the (macro-)economic mechanism"
  - Blanchard (2009) "the rehabilitation of partial equilibrium modeling in macroeconomics"
  - The role of ceteris paribus
- A Complexity Science would like models interacting

# The Method

- Partial equilibrium analysis to identify a potential source of fluctuations
  - D. Heymann, E. Kawamura, R. Perazzo and M. G. Zimmermann (2014) (HKPZ)
- Construction of Macro (Agent Based) Model
  - Instead of equilibriums, budget constrains as the mechanism of validate the interaction
- To integrate the partial equilibrium model, into the MABM to explore the consequences of the interaction



# Bertrand-Edgeworth price-setting game

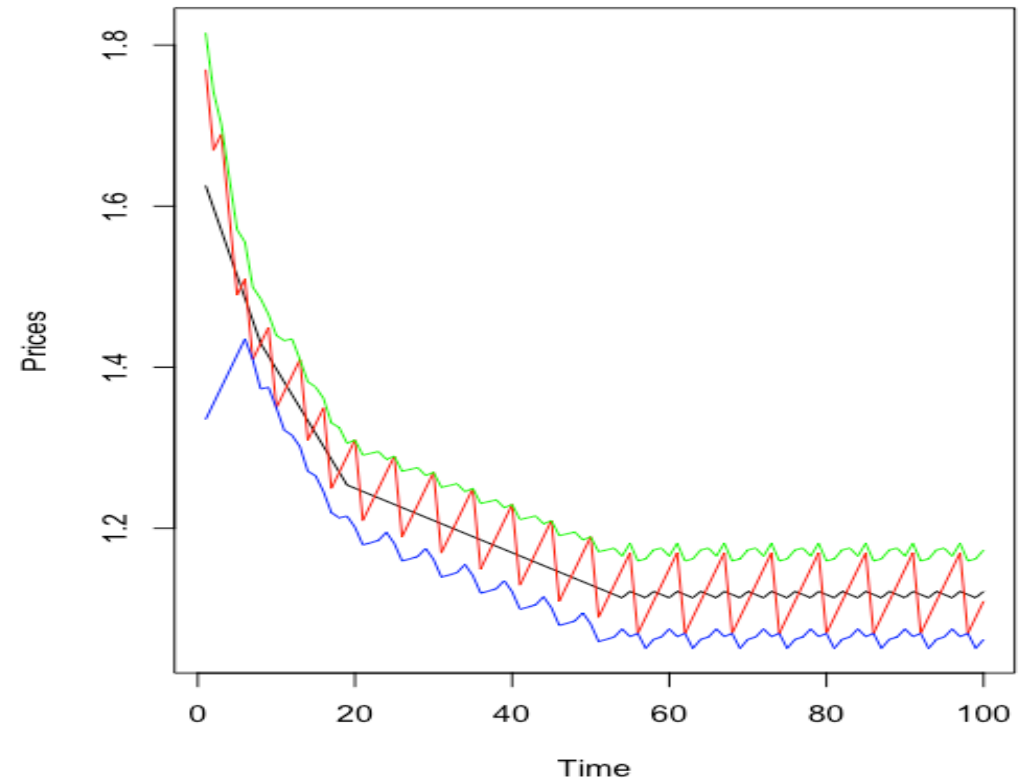
- The market is populated by  $N$  firms, selling a single, homogeneous, non-storable good
- Each firm can produce up to a maximum quantity  $q^*$  with a unit cost of constant  $c$
- All firms post a selling price  $p_i$ ;  $i = 1 \dots N$  ( $p_i > c$ ), simultaneously
- Firms supply the good at that price, up to the limit determined by the capacity
- There is no search or mobility cost for the consumers, and they plan to purchase  $M$  every day, with  $M > Ncq^*$
- Competitive price  $p^* = \frac{M}{Ncq^*}$

# Analysis from HKPZ

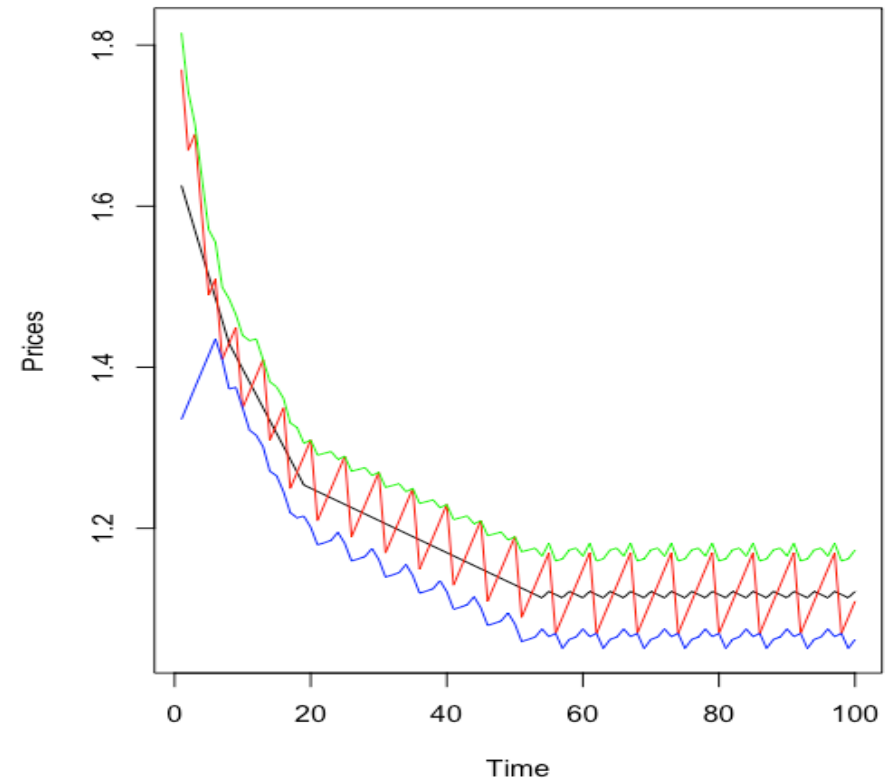
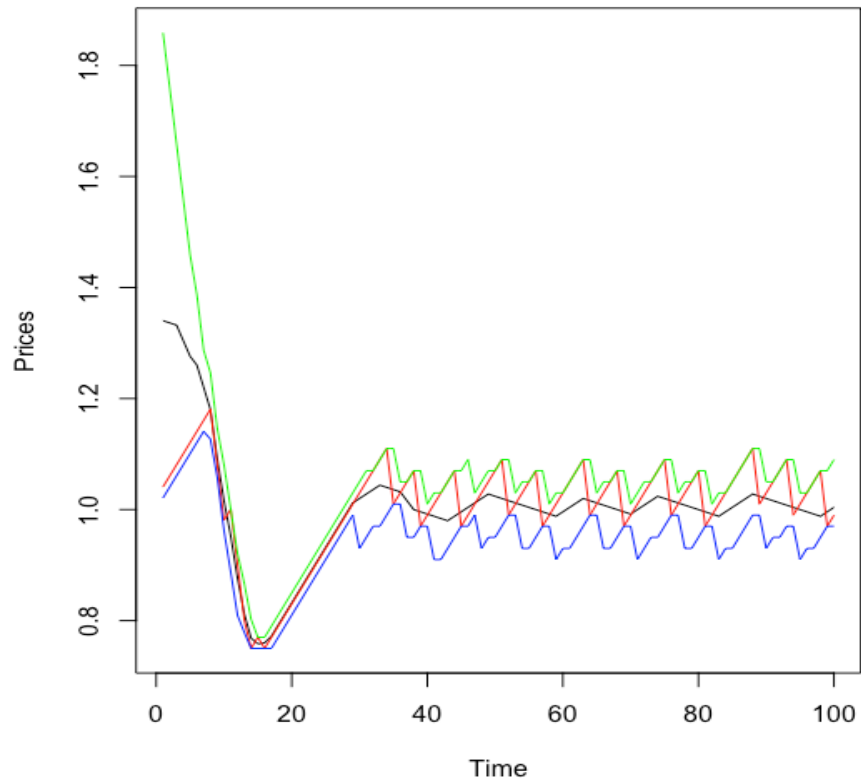
- Claim 1: The competitive outcome is not a pure strategy Nash equilibrium
- Claim 2: no price  $p'$  set by all firms  $p_i = p'; \forall i$  can be a pure-strategy, symmetric Nash equilibrium
- Modelo de comportamiento de HKPZ
  - Las Firms intentan vender todo lo que pueden producir
  - Las Firms al final de cada período, actualizan sus precios según la demanda que tuvieron
  - $$p_i(t + 1) = p_i(t) + \begin{cases} \gamma^+ & \text{si } q = q^* \\ \gamma^- & \text{si } q < q^* \end{cases}$$

# An Agent Based Model

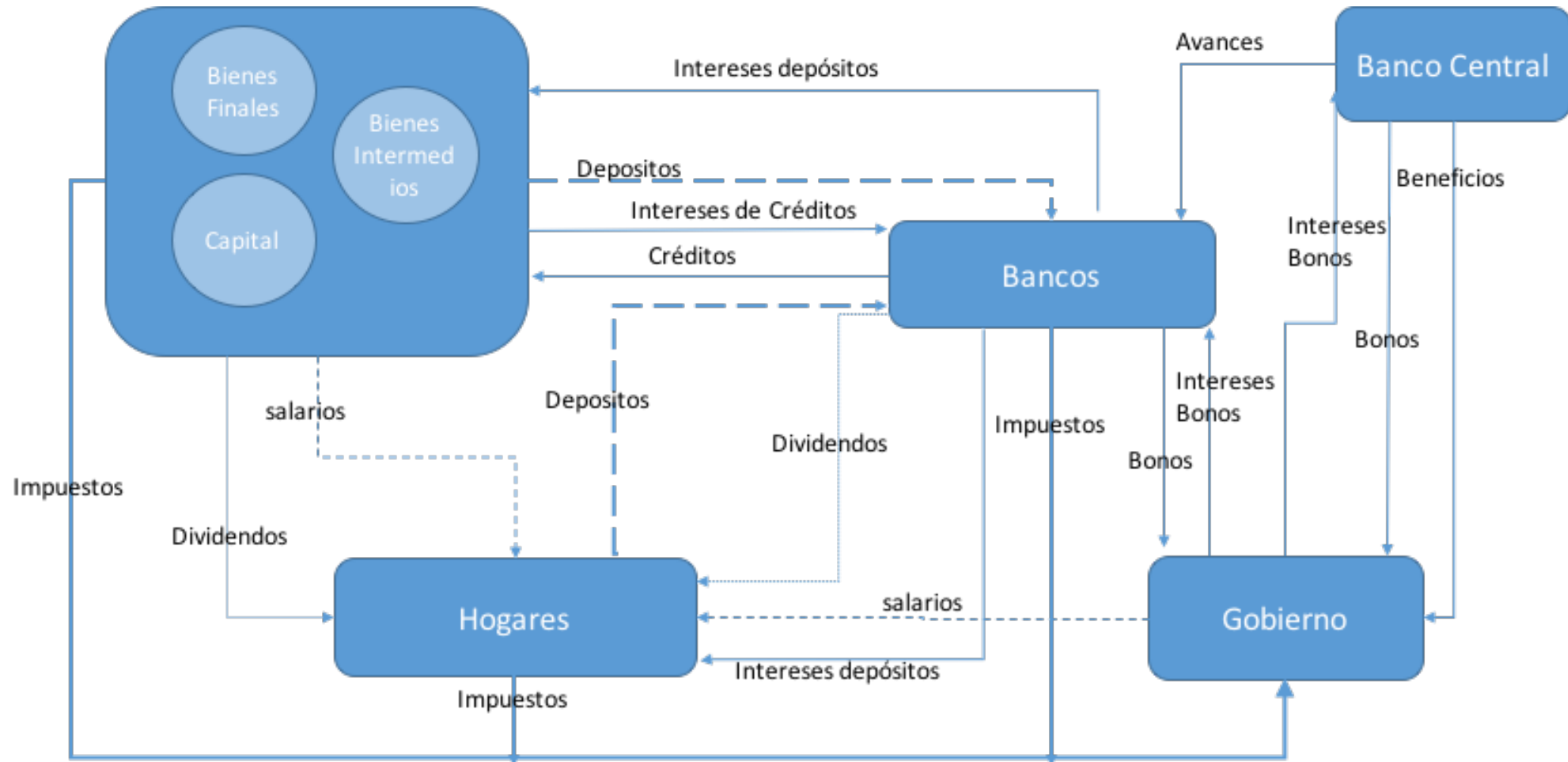
- $N = 10$ ,
- $c=0.75$ ,
- $\gamma^+ = 0.02, \gamma^- = 0.1$



# An Agent Based Model, with inventory



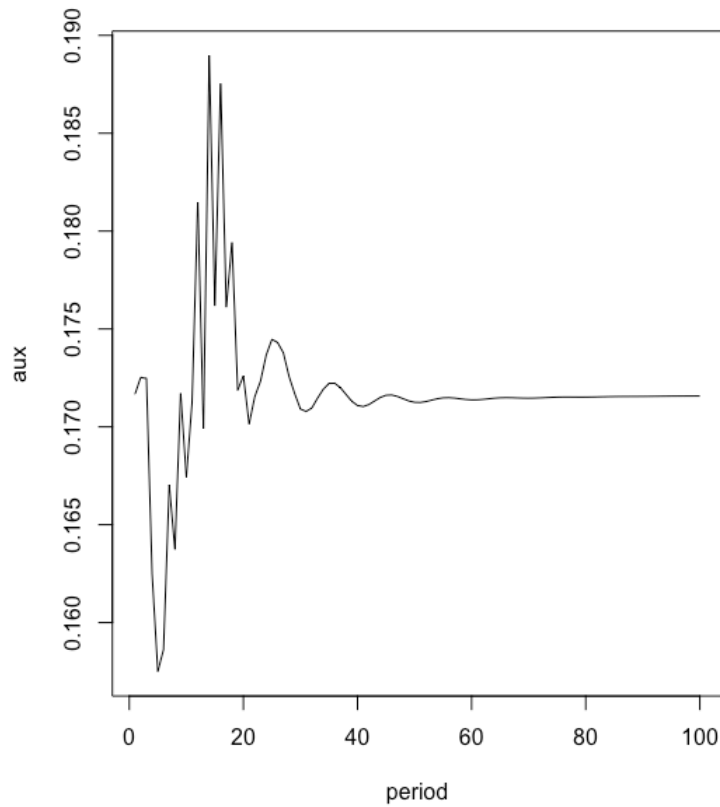
# Macro Model



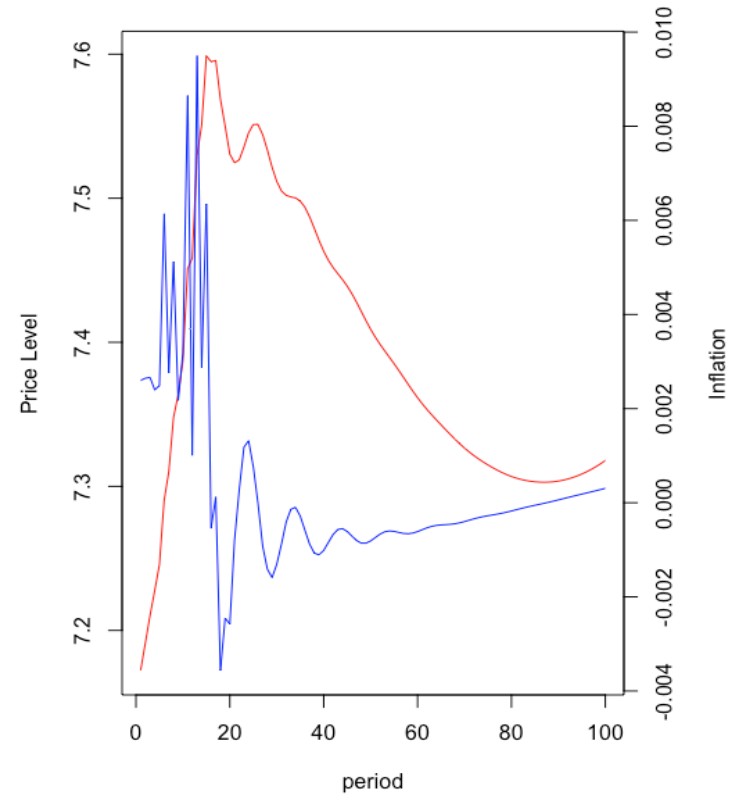
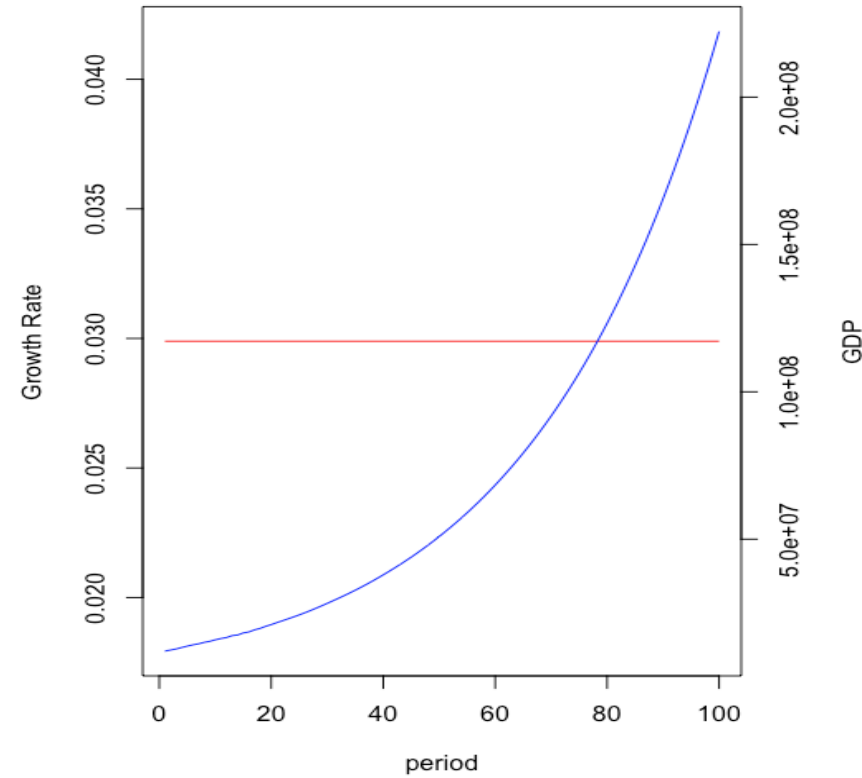
# General Macro Model Setting

- General Agent and Organization Behavior (Lavoie (2014))
  - Agents follow targets, which are the results of norms, conventions or rules. They try to adapt their reality to those targets. The adaptation process takes time, and it is never instantaneous
  - The organizations that solve the interaction between agents, or among agents does not clear, in the sense of market equilibrium. The organizations allocate, and they rationate their excess of demand and they allocate in buffers the excess of supply
- The interaction between agents are stock-flow consistent, Godley and Lavoie (2006)
- Structural Estimation in the Cowes Commission style. Fair, Ray (2012)
  - Difference as compared to Caiani, Godin, Caverszasi, Gallegati, Kinsella y Stiglitz (2016)
- Initial Conditions given by SAM
  - “[...] in many nations’ compilations of national statistics, no framework exists to ensure consistency across statistics from various sources [...]. Both goals can be accomplished by means of a so-called Social Accounting Matrix (SAM)” Miller & Blair (2009)

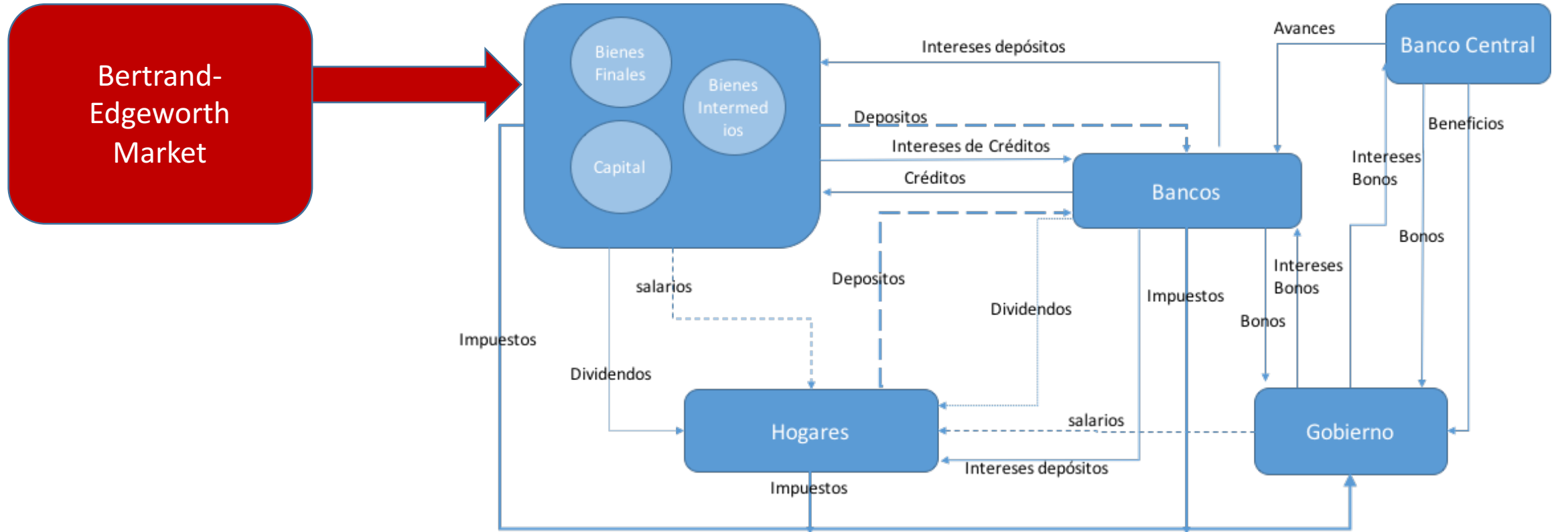
# Properties of the Model



Inventory/sale



# Integration



# Macro Model, firm behavior

- There are N symmetric firms with production function  $y_t = A_t N_t$
- Sell expectations on productivity growth:  $s_t^e = s_{t-1} * (1 + \gamma_A)$
- Production:  $y_t = s_t^e + (in_t^e - in_{t-1})$
- Inventory need to be financed:
  - $NHC_t = (1 - \sigma^N) \frac{W_t}{A_t} + \sigma^N (1 + r_{l,t-1}) \frac{W_{t-1}}{A_{t-1}}$
- Target markup to cover Investment and Dividends
  - $m_t = m_{t-1} + \alpha(m_t^T - m_{t-1})$
  - $p_t = (1 + m_t) NHC_t$
- Sales:  $s_t = c_t + g_t + i_t$

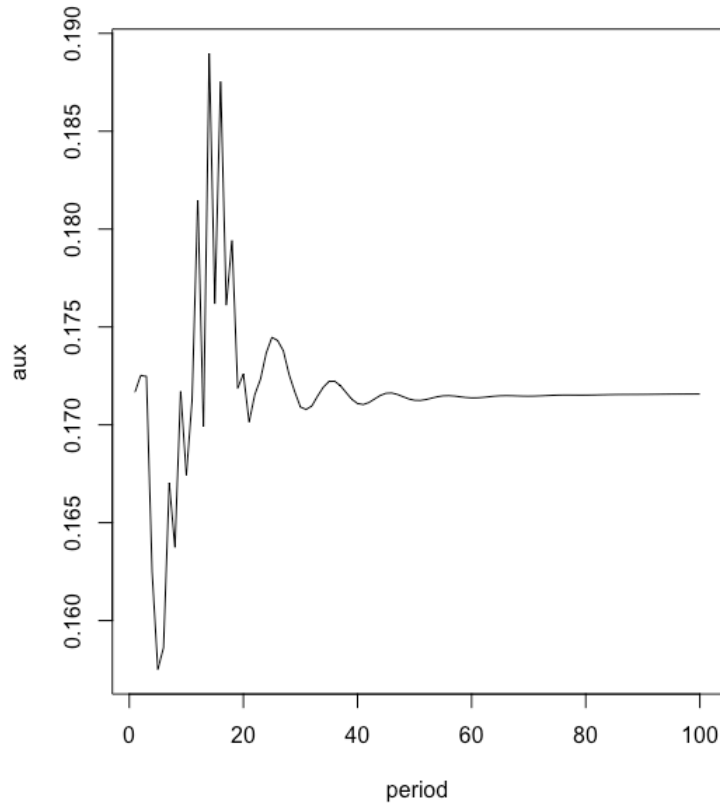
# Integration: Macro Model

- There are  $N$  symmetric firms with production function  $y_t = A_t N_t$
- Sell expectations on productivity growth:  $s_t^e = s_{t-1} * (1 + \gamma_A)$
- Production:  $y_t = s_t^e + (in_t^e - in_{t-1})$
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  - $NHC_t = (1 - \sigma^N) \frac{W_t}{A_t} + \sigma^N (1 + r_{l,t-1}) \frac{W_{t-1}}{A_{t-1}}$
- Target markup to cover Investment and Dividends
  - $m_t = m_{t-1} + \alpha(m_t^T - m_{t-1})$
  - $p_t = (1 + m_t) NHC_t$ ;  $p_{i,t} = p_{i,t} + \begin{cases} 0.1^+ & \text{if } in_{t-1} \leq in_t^e \\ 0.1^- & \text{if otherwise} \end{cases}$
- Sales:  $s_t = c_t + g_t + i_t$ ; **the total expenditure is made in ascending order**

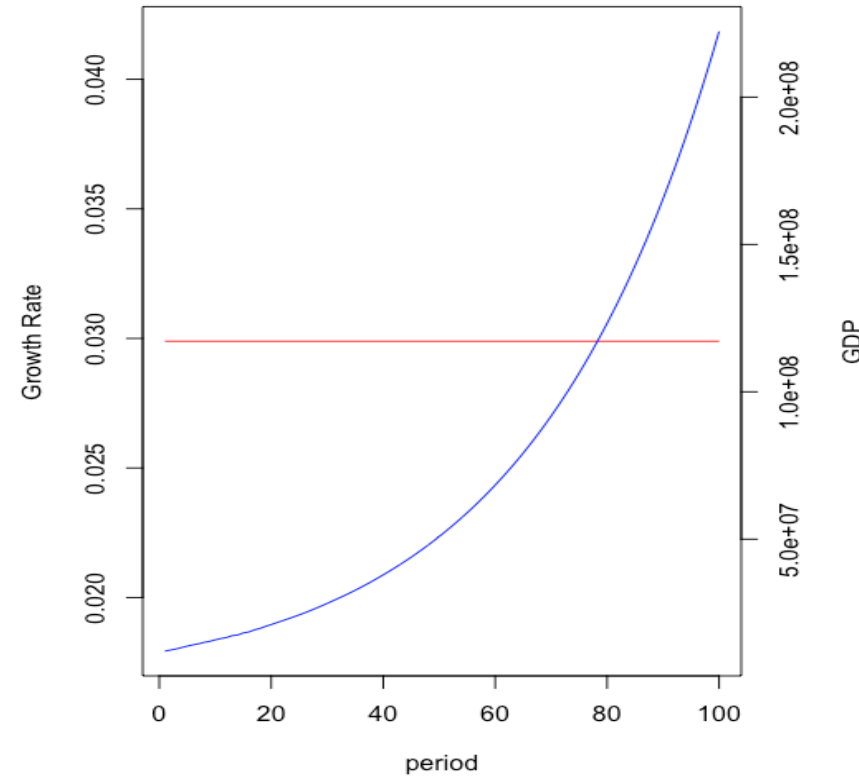
# Caveats of the integration

- Bertrand-Edgeworth model is a short-run model, therefore in order to be integrated the parameter of the MM were adjusted to work every 4 periods
- There is no guarantee that in every period  $M_t > N_t c_t q_t$ 
  - If it is the case that  $M_t > N_t c_t q_t$ , the demand is rationade

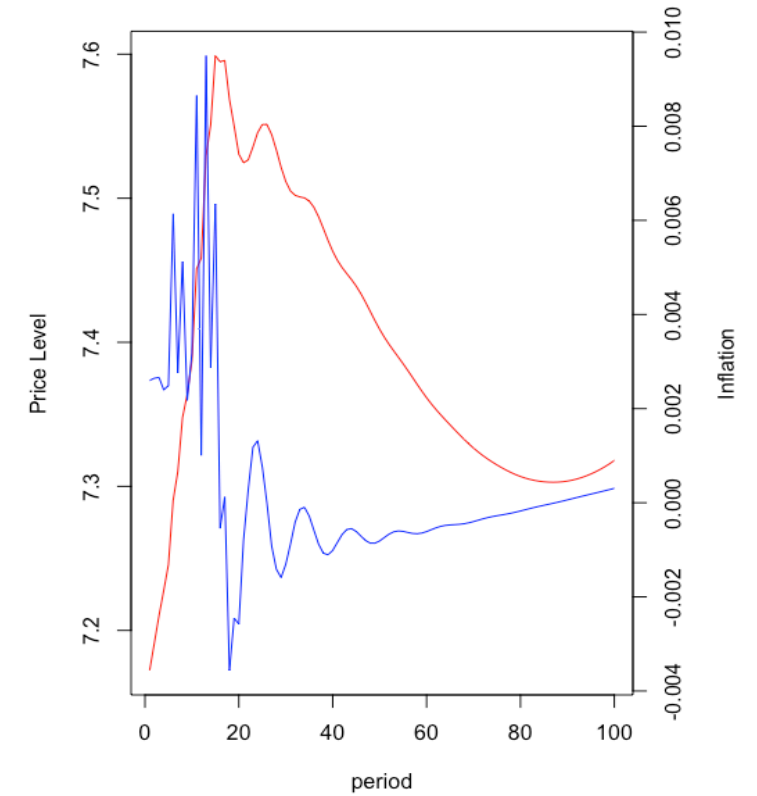
# Properties of the original Model



Inventory/sale

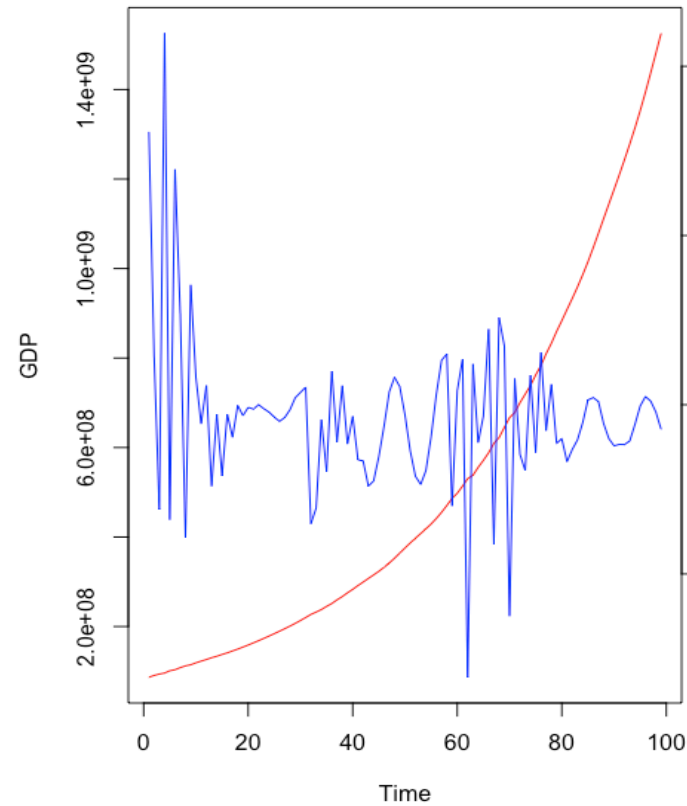
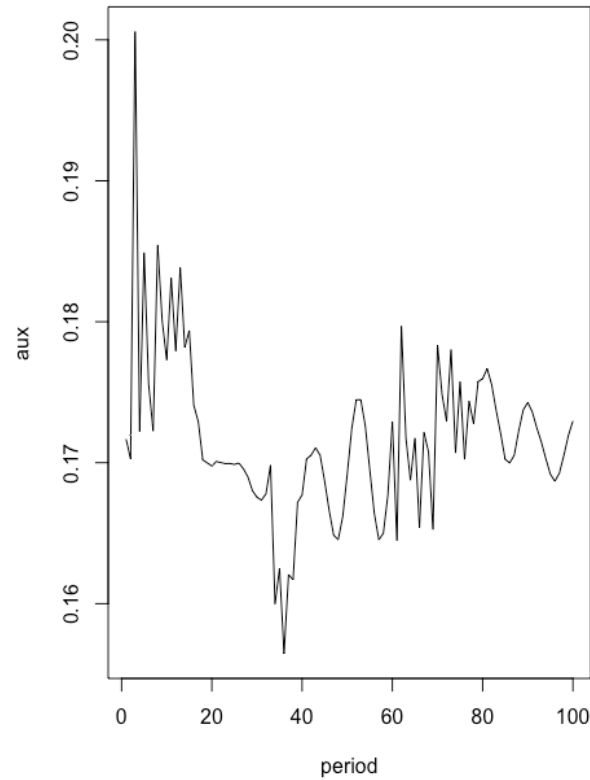


GDP  
growth

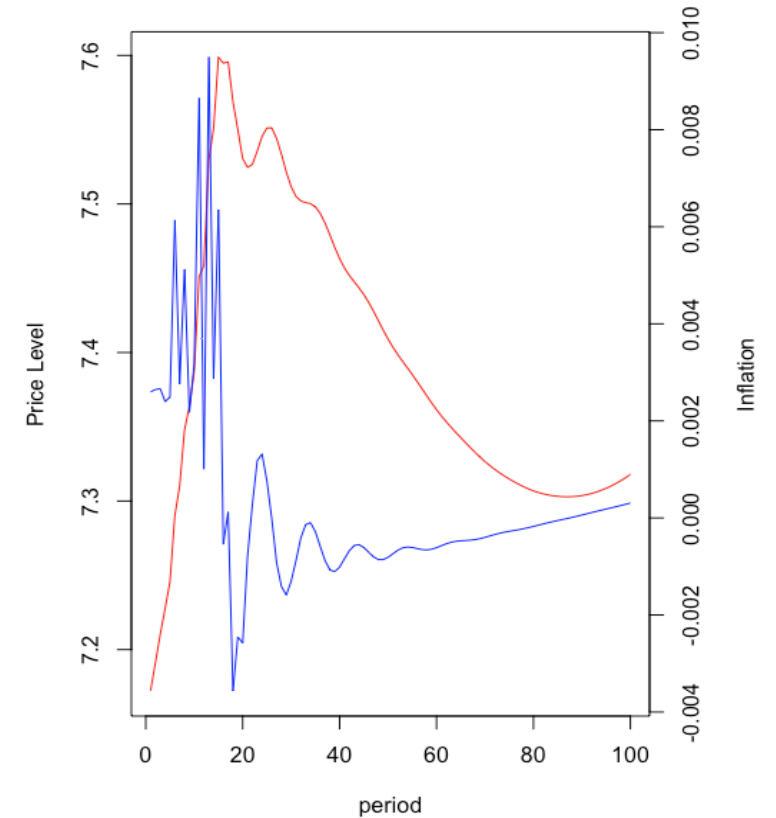


Inflation  
Price Level

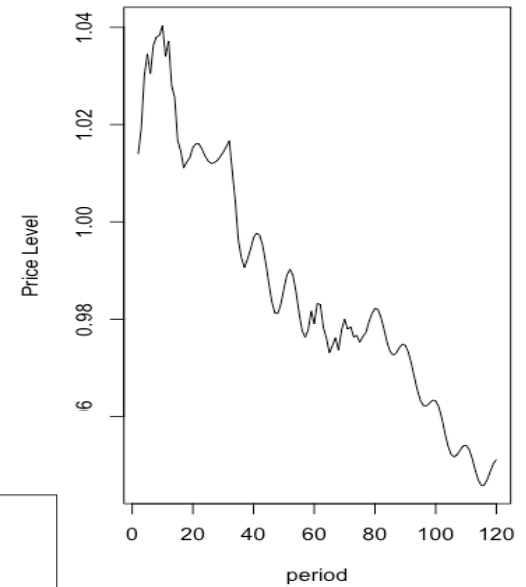
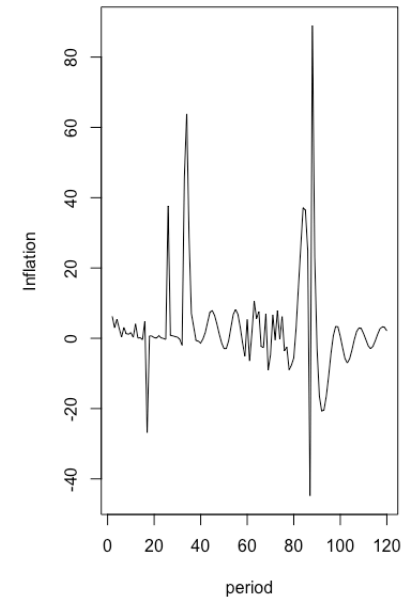
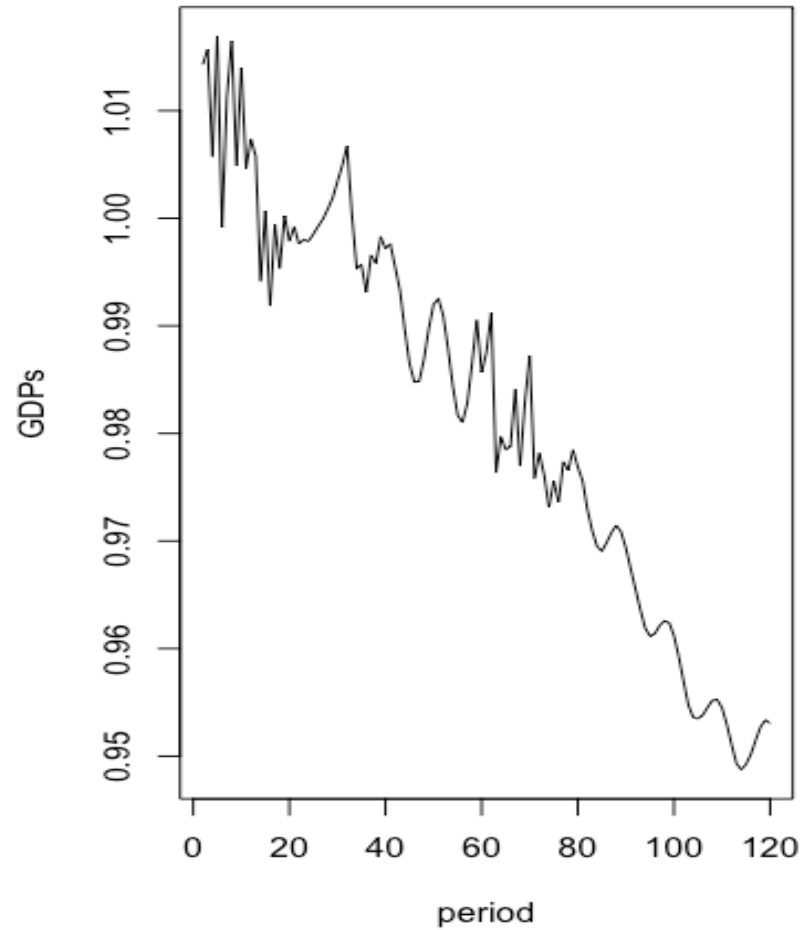
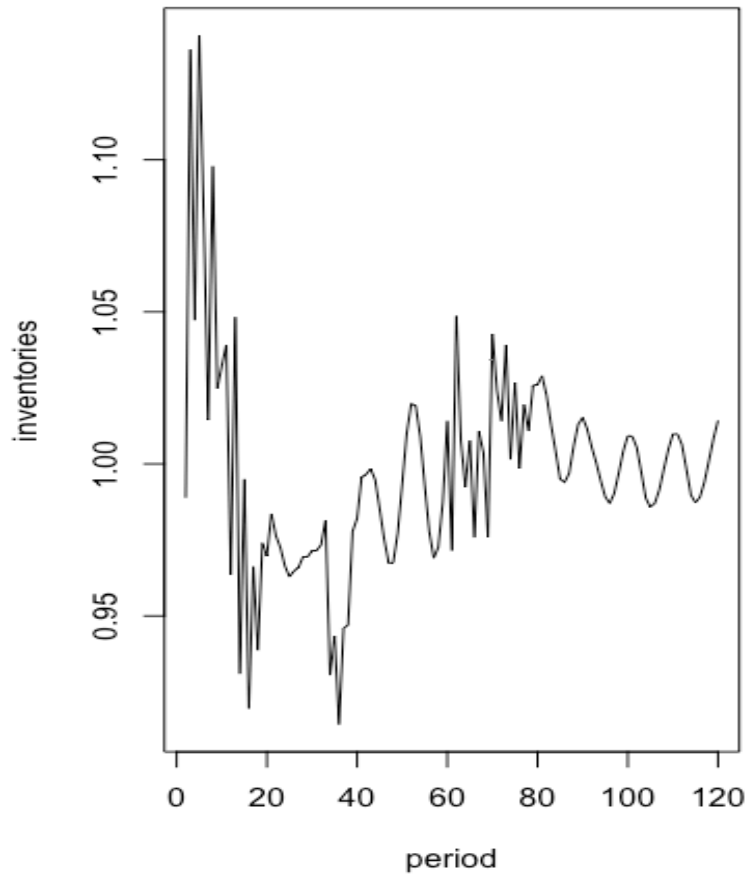
# Properties of the integrated model



growth  
GDP



# Compared results, integrated/benchmark



# Conclusions and More Work

- Deepen the analysis of the results
  - Explore more variations
- One step moving toward the integration of data sources in a consistent framework
- Calibrate the Macro Model using data from a country and replicate aggregate properties of fluctuations

# Gracias

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Winter School 2018 - CEPAL