Wage formation, Investment Behavior and Growth Regimes: An Agent-Based Analysis

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The Great Recession and Macroeconomic Theory...

The Economic Crisis is a Crisis for Economic Theory?

- YES!, Kirman (2010); Colander et al. (2009); Caballero (2010); Stiglitz (2011); Kay (2011); Dosi (2011); Delong (2011); Krugman (2011)

Some key ingredients needed to understand economic crises (Stiglitz, 2011)

- distributions (including income distributions) matter
- credit and asymmetric information problems among heterogeneous agents
- markets that do not clear
- departure from rational expectations and perfect rationality
...and the Increasing Interest for Agent-Based Models

**Trichet (18/11/2010):** “The atomistic, optimising agents underlying existing models do not capture behaviour during a crisis period. We need to deal better with heterogeneity across agents and the interaction among those heterogeneous agents. Agent-based modelling dispenses with the optimisation assumption and allows for more complex interactions between agents.”

- ABMs allow for all the above ingredients, because they model economies as complex dynamical systems of heterogeneous and boundedly rational agents, interacting out of equilibrium
- ABMs possible alternative to DSGE to provide microfounded macroeconomic models accounting for economic crises
Wages determination and Macroeconomic Dynamics

- Long debate in macroeconomics about the role of wages in the determination of the level of unemployment
- Neo-Classical (including DSGE view, e.g. Smets, Wouters and Galì, 2011): real wage rigidity is the main source of unemployment in labor markets because it impedes the adjustment in labor market after an adverse shock
- Keynes’ view: aggregate demand deficiency is the main source of unemployment. Reductions in nominal wages adversely affect consumption demand and, via expectations, investment thereby causing unemployment.
Institutional Complementarities, Business Cycles and Growth

- A good deal of literature highlights that “Growth regimes” (and crises) are generated by the matching or the mismatching between, on one hand processes of technical change and, on the other hand, the *institutional complementarities* between firms’ behavior and the division of income in the economy.

- “Theorie de la Régulation”: “Classical” vs. “Fordist” Growth regimes (e.g. Boyer, 1988)

- Varieties of Capitalism: Coordinated vs. Liberal Market Economies (Hall and Soskice, 2001)
Goal

- Extend the Keynes+Schumpeter agent-based model (Dosi, Fagiolo and Roventini, 2010, 2012) to

- Analyze the effect of income distribution between profits and wages in two different firm investment scenarios
  - Profit-led investment scenario: desired expansionary investment is determined by past profits
  - Demand-led investment scenario: desired expansionary investment is determined by expectations about future consumption demand

- Analyze the short- and long-run impact of nominal wage flexibility on unemployment, business cycles and growth
Related Literature

• **Schumpeterian and Evolutionary-Growth Models**

• **French Theory of Régulation and Varieties of Capitalism**
  - Aglietta (1979), Boyer (1988), Hall and Soskice (2001)

• **Agent-Based Computational Economics**
  - Tesfatsion; Gintis; Howitt; Dawid, Neugart, Cincotti et al. (EURACE); Delli Gatti, Gallegati and co-authors; and many many others!

• **Post-Keynesian and Good New-Keynesian Literature on Wages and Unemployment**
Structure of the Keynes+Schumpeter Model
Close antecedents: Dosi, Fagiolo, Roventini, JEDC 2010

- Capital-good Industry
  - j=1,...,F1 firms
    - Perform R&D
    - Produce heterogeneous machines
    - Use labor only to produce
    - Each firm produces only a machine

- Consumption-Good Industry
  - i=1,...,F2 firms
    - Buy machines from MT industry
    - Use machine and labor to produce
    - Finance their production and investment using internal and external funds
    - Sell products to consumers

- Consumers/Workers
  - n=1,...,N individuals
    - Inelastically sell labor to firms
    - Fully consume their income

- Public Sector
  - Levies taxes on firms’ profits
  - Gives unemployment benefits

Discrete-Time: t=0,1,2,...
The Sequence of Microeconomic Decisions

- **Model Dynamics:**
  1) capital-good firms perform R&D
  2) capital-good firms advertise their machines sending “brochures” to consumption-good firms
  3) consumption-good firms decide how much to produce, choose their supplier for next period machines and order machines
  4) firms hire workers (wages are anticipated), and pay machines using internal funds and credit provided by an unmodelled credit sector
  5) production in both sectors begins
  6) consumption-good market opens
  7) entry and exit take place
  8) consumption-good firms receive the machines they ordered
Technical Change I

- Capital-good firms search for better machines and for more efficient production techniques
  - $A_i(t)$: productivity of machine manufactured by firm $i$
  - $B_i(t)$: productivity of production technique of firm $i$
  - $A_i(t)$ and $B_i(t)$ determine the technology of firm $i$ at time $t$

- R&D:
  - R&D investment ($RD$) is a fraction of firm sales ($S$):
    \[ RD_i(t) = \nu S_i(t - 1) \quad \nu > 0 \]
  - capital-good firms allocate R&D funds between innovation ($IN$) and imitation ($IM$):
    \[ IN_i(t) = \xi RD_i(t) \quad IM_i(t) = (1 - \xi) RD_i(t) \quad \xi \in [0, 1] \]
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Technical Change II

- **Innovation and imitation: two steps procedure**

  - **Innovation:**
    1) firm successfully innovates or not through a draw from a Bernoulli($\theta_1(t)$), where $\theta_1(t)$ depends on $IN_i(t)$:
       $$\theta_1(t) = 1 - e^{-\sigma_1 IN_i(t)} \quad \sigma_1 > 0$$
    2) search space: the new technology is obtained multiplying the current technology by $(1 + x_i(t))$, where $x_i(t) \sim Beta$ over the support $(x_0, x_1)$ with $x_0 < 0, x_1 > 0$

  - **Imitation**
    1) firm successfully imitates or not through a draw from a Bernoulli($\theta_2(t)$), where $\theta_2(t)$ depends on $IM_i(t)$:
       $$\theta_2(t) = 1 - e^{-\sigma_2 IM_i(t)} \quad \sigma_2 > 0$$
    2) firms are more likely to imitate competitors with similar technologies (Euclidean distance)
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  2) firms are more likely to imitate competitors with similar technologies (Euclidean distance)
Beta Distribution
Capital-Good Market

**Capital-good firms:**
- if they successfully innovate and/or imitate, they choose to manufacture the machine with the lowest \( p_i + c_i b \)
  - \( p_i \): machine price;
  - \( c_i \): unit labor cost of production entailed by machine in consumption-good sector;
  - \( b \): payback period parameter
- fix prices applying a mark-up on unit cost of production
- send a “brochure” with the price and the productivity of their machines to both their historical and some potential new customers

**Consumption-good firms:**
- choose as supplier the capital-good firm producing the machine with the lowest \( p_i + c_i b \) according to the information contained in the “brochures”
- send their orders to their supplier according to their investment decisions
Capital-Good Market

- **Capital-good firms:**
  - if they successfully innovate and/or imitate, they choose to manufacture the machine with the lowest $p_i + c_i^1 b$
    - $p_i$: machine price;
    - $c_i^1$: unit labor cost of production entailed by machine in consumption-good sector;
    - $b$: payback period parameter
  - fix prices applying a mark-up on unit cost of production
  - send a “brochure” with the price and the productivity of their machines to both their historical and some potential new customers

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  - send their orders to their supplier according to their investment decisions
Replacement Investment

- payback period routine:
  - an incumbent machine is scrapped if
    \[ \frac{p^*}{c(\tau) - c^*} \leq b, \quad b > 0 \]
  - \( c(\tau) \) unit labor cost of an incumbent machine;
  - \( p^*, c^* \) price and unit labor cost of new machines
- also machine older than \( \Lambda \) periods are replaced
Expansion Investment

- **Profit-led Investment Scenario**
  - Desired production \( Q^d_j \) and capital stock \( K^d \) is determined by the level of firm net-worth \( NW_j(t-1) \) (see e.g. Greenwald and Stiglitz, 1993, Delli Gatti et al., 2005)

\[
Q^d_j(t) = \sigma NW_j(t-1), \quad \sigma > 0
\]

- **Demand-led Investment Scenario**
  - Demand expectations \( D^e_j \) determine the desired level of production \( Q^d_j \) and the desired capital stock \( K^d_j \)

\[
D^e_j(t) = f(D_j(t-1), D_j(t-2), \ldots, D_j(t-h))
\]

- In both scenarios firm invests \( EI \) if the desired capital stock is higher than the current capital stock \( K \):

\[
EI = K^d - K
\]
Financial Structure

- Production and investment decisions of consumption-good firms can be constrained by their financial balances
  - consumption-good firms first rely on their stock of liquid assets and then on more expensive external funds provided by the banking sector
  - credit ceiling: the stock of debt ($Deb$) of consumption-good firms is limited by their gross cash flows ($= sales S$):

$$Deb_j(t) \leq \kappa S_j(t - 1), \quad \kappa \geq 1$$
Consumption-Good Markets

- **Supply:**
  - imperfect competition: prices \((p_j)\) ⇒ variable mark-up \((m_i_j)\)
  - on unit cost of production \((c_j)\)

\[
p_j(t) = (1 + m_i_j(t))c_j(t);
\]

\[
m_i_j(t) = m_i_j(t - 1) \left(1 + \alpha \frac{f_j(t - 1) - f_j(t - 2)}{f_j(t - 2)}\right);
\]

\(\alpha > 0; \quad f_j: \) market share of firm \(j\)

- firms first produce and then try to sell their production (inventories)
Consumption-Good Markets

**Market dynamics:**

- market shares evolve according to a “quasi” replicator dynamics:

\[
f_j(t) = f_j(t - 1) \left(1 + \chi \frac{E_j(t) - \overline{E}(t)}{\overline{E}(t)} \right); \quad \chi \geq 0
\]

- \( E_j \): competitiveness of firm \( j \);
- \( \overline{E} \): avg. competitiveness of consumption-good industry;

- firm competitiveness depends on price and unfilled demand \( (l_j) \):

\[
E_j(t) = -\omega_1 p_j(t) - \omega_2 l_j(t), \quad \omega_{1,2} > 0
\]
Exit and Entry

- **Exit:**
  - (near) zero market share or negative net worth

- **Entry:**
  - each entrant replaces a dead firm
  - entrant random copies of incumbents firm
Macro Level

- **Public sector**
  - levies taxes on firms’ profits and workers’ wages or on profits only
  - gives a fraction of the market wage to unemployed workers
  - However, in all simulation experiments we set both the tax and the unemployment subsidy rate to zero

- **Labor Market**
  - exogenous labor supply
  - wage dynamics determined by avg. productivity, inflation and unemployment
  - involuntary unemployment + possibility of labor rationing

- Employment, consumption, investment, inventories and GDP are obtained by aggregating micro quantities
## Simulation Strategy

1. Choose initial conditions and systems parameters
2. Generate a simulation run for \( t = 1, \ldots, T \)
3. Analyze qualitative and quantitative results
4. Redo Steps 1-3 performing a Monte Carlo exercise to
   - Wash away across-simulations variability introduced by stochastic components
     - Negligible across-simulations stochastic variability
     - Limited number of replications as robust proxy for time-series behavior
   - Study how different initial conditions and system parameters affect the statistics of interest
     - Initial conditions do not dramatically affect results
     - Focus on sensitivity analysis of system parameters
5. Replication of stylized facts (output validation) as a pre-requisite for policy analysis (“what happens if”)
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Validating the K+S Model

- ABMs are much more complex than standard, e.g. RBC, macroeconomic models.

- The model should then be able at least to match the same macroeconomic stylized facts of standard models.

- The model should also be able to match the largest possible number of microeconomic stylized facts.

- This is relevant because standard macroeconomic models are not usually able to match any microeconomic stylized fact.
Empirical Validation I

The model is able to account for a rich ensemble of macro stylized facts

(1) Self-sustained, endogenous growth...
Bandpass-filtered GDP, Consumption, and Investment

...with endogenous business cycles
(2) Investment more volatile than GDP; consumption less volatile than GDP

<table>
<thead>
<tr>
<th></th>
<th>Output</th>
<th>Consumption</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. growth rate</td>
<td>0.0254</td>
<td>0.0252</td>
<td>0.0275</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td>(0.0004)</td>
</tr>
<tr>
<td>Dickey-Fuller test (logs)</td>
<td>6.7714</td>
<td>9.4807</td>
<td>0.2106</td>
</tr>
<tr>
<td>Dickey-Fuller test (Bpf)</td>
<td>−6.2564*</td>
<td>−5.8910*</td>
<td>−6.8640*</td>
</tr>
<tr>
<td>Std. Dev. (Bpf)</td>
<td>0.0809</td>
<td>0.0679</td>
<td>0.4685</td>
</tr>
<tr>
<td></td>
<td>(0.0007)</td>
<td>(0.0005)</td>
<td>(0.0266)</td>
</tr>
<tr>
<td>Rel. Std. Dev. (output)</td>
<td>1</td>
<td>0.8389</td>
<td>5.7880</td>
</tr>
</tbody>
</table>

Table: Monte Carlo simulation standard errors in parentheses. Asterisks (*): Significant at 95% level
(3) Consumption, net investment and change in inventories procyclical and coincident variables
(4) Countercyclical unemployment
(5) Procyclical productivity
(6) Countercyclical prices; procyclical inflation
(7) Countercyclical mark-ups
Output Growth-Rate Distributions

(10) Quasi-Laplace fat-tailed distributions (see Fagiolo, Napoletano and Roventini, 2008, JAE and Castaldi and Dosi, 2009, EmpEcon)
Empirical Validation II

The model is able to account for a rich ensemble of micro (firm-level) stylized facts (Dosi, 2007)

1. Productivity dispersion among firms is large

Figure: 1st panel: capital-good firms; 2nd panel: consumption-good firms
**Persistence of Productivity Differentials**

(2) Inter-firm productivity differentials are persistent over time

<table>
<thead>
<tr>
<th>Industry</th>
<th>t-1</th>
<th>t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital-good</td>
<td>0.5433</td>
<td>0.3700</td>
</tr>
<tr>
<td></td>
<td>(0.1821)</td>
<td>(0.2140)</td>
</tr>
<tr>
<td>Consumption-good</td>
<td>0.5974</td>
<td>0.3465</td>
</tr>
<tr>
<td></td>
<td>(0.2407)</td>
<td>(0.2535)</td>
</tr>
</tbody>
</table>

Table: *Standard deviations in parentheses*
(3) Firm size distributions are more right-skewed than log-normal distributions

<table>
<thead>
<tr>
<th>Industry</th>
<th>Jarque-Bera stat.</th>
<th>p-value</th>
<th>Lilliefors stat.</th>
<th>p-value</th>
<th>Anderson-Darling stat.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital-good</td>
<td>20.7982</td>
<td>0</td>
<td>0.0464</td>
<td>0</td>
<td>4.4282</td>
<td>0</td>
</tr>
<tr>
<td>Consumption-good</td>
<td>3129.7817</td>
<td>0</td>
<td>0.0670</td>
<td>0</td>
<td>191.0805</td>
<td>0</td>
</tr>
</tbody>
</table>
Growth-Rate Distributions: Subbotin Estimation

(4) Firms growth rates are proxied by fat-tailed, tent-shaped densities

<table>
<thead>
<tr>
<th>Series</th>
<th>$b$</th>
<th>std. dev.</th>
<th>$a$</th>
<th>std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital-good firms</td>
<td>0.5285</td>
<td>0.0024</td>
<td>0.4410</td>
<td>0.0189</td>
</tr>
<tr>
<td>Consumption-good firms</td>
<td>0.4249</td>
<td>0.0051</td>
<td>0.0289</td>
<td>0.0037</td>
</tr>
</tbody>
</table>
Investment Lumpiness

(5) Coexistence of firms investing a lot and investing almost-zero (see Gourio & Kayshap, J. Mon. Econ., 2007)

Figure: 1st panel: share of firms with (near) zero investment; 2nd panel: share of firms with investment spikes
Keynesian Demand Policies: Eliminate Public Sector

**Description of the experiment:**
- we begin eschewing the public sector from our model
- we then “drug up” the economy with Schumpeterian policies (high opportunities and high search capabilities)

**Results**
- Evidence of multiple growth paths: Keynesian policies are necessary to support sustained long-run economic growth
- Schumpeterian policies are not enough to push the economy away from low growth trajectories

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>benchmark scenario</td>
<td>0.0252</td>
<td>0.0809</td>
<td>0.1072</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0007)</td>
<td>(0.0050)</td>
</tr>
<tr>
<td>no fiscal policy</td>
<td>0.0035</td>
<td>1.5865</td>
<td>0.8868</td>
</tr>
<tr>
<td></td>
<td>(0.0012)</td>
<td>(0.0319)</td>
<td>(0.0201)</td>
</tr>
<tr>
<td>Schumpeter drugged-up</td>
<td>0.0110</td>
<td>1.5511</td>
<td>0.7855</td>
</tr>
<tr>
<td>(no fiscal policy)</td>
<td>(0.0018)</td>
<td>(0.0427)</td>
<td>(0.0274)</td>
</tr>
</tbody>
</table>
Keynesian Demand Policies: Changing Taxes and Unemployment Benefits

**Description of the experiment**

- we increase both taxes and unemployment benefits by the same amounts in the otherwise “canonic” parametrization

**Results:**

- tuning up fiscal demand management does delock the economy from the low growth trajectory and brings it to the high growth one
- avg. GDP growth almost the same, but Keynesian policies have countercyclical effects dampening fluctuations and reducing unemployment
- More generally, strong complementarity between “Keynesian” policies affecting demand, and “Schumpeterian” policies affecting innovation.
Keynesian Demand Macro Management Policies

Figure: Results are obtained under balanced budget ratios of expenditures (taxes) to GDP.
Macroeconomic Dynamics under Different Income Distributions and Firm Investment Behaviors

**Description of the experiment**

- we assume that nominal wage growth is determined only by productivity growth
- we tune the (initial) mark-up rate in the otherwise “canonic” parametrization
- we repeat the experiment both in the “profit-led” and in the “demand-led” scenarios
- goal: understanding the effect on aggregate dynamics of the interplay between income distribution and firm investment behavior. regimes
- notice that the mark-up rate determines:
  - real wages and the distribution of income between profits and wages (distributive effect)
  - the flow of internal funds of firms (financial dependence effect)
Income Distribution and Investment Behavior
Long-run Growth

- In the profit-led scenario long-run growth is positively affected by the mark-up rate (and thus inversely related to real wages)
- In the demand-led scenario the relation is non-linear: both low and high mark-up rates result into low average growth rates
Changing Income Distribution

Unemployment

- In the profit-led scenario unemployment is inversely related to the mark-up rate (and thus directly related to real wages).
- In the demand-led scenario the relation is non-monotonic: existence of a threshold above which unemployment increases with the mark-up rate (and thus increases with lower levels of real wages).
Changing Income Distribution
Volatility and Crises

- U-shaped relation between mark-ups and crises in the profit-led scenario
- Similar relation in the demand-led scenario. However, high mark-up rates implies much higher crises incidence in this scenario
Description of the experiment

- we assume that nominal wages growth is determined both by productivity growth and by changes in unemployment
- we select different mark-up rates corresponding to different growth regimes
- we repeat the experiment both in the “profit-led” and in the “demand-led” scenarios
- goal: understanding the ability of nominal wage flexibility to increase growth and to reduce unemployment and volatility under different institutional scenarios
Wage-Flexibility, Growth and Unemployment

**Results**

- **Profit-led investment scenario.** Nominal wage-flexibility curbs unemployment (and the probability of crises in some cases. However, it also lowers the average growth rate of the economy.

<table>
<thead>
<tr>
<th>Mark-Up Rate 0.05</th>
<th>Avg.GDP growth rate</th>
<th>Avg.unempl. rate</th>
<th>Avg.likel. GDP crises</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_3 = 0$</td>
<td>0.0270</td>
<td>0.1463</td>
<td>0.0582</td>
</tr>
<tr>
<td>$\psi_3 = 0.2$</td>
<td>0.0266</td>
<td>0.1098</td>
<td>0.0733</td>
</tr>
<tr>
<td>$\psi_3 = 0.4$</td>
<td>0.0247</td>
<td>0.0694</td>
<td>0.0770</td>
</tr>
<tr>
<td>$\psi_3 = 0.6$</td>
<td>0.0198</td>
<td>0.0576</td>
<td>0.0752</td>
</tr>
<tr>
<td>$\psi_3 = 0.8$</td>
<td>0.0177</td>
<td>0.0391</td>
<td>0.0714</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mark-Up Rate 0.30</th>
<th>Avg.GDP growth rate</th>
<th>Avg.unempl. rate</th>
<th>Avg.likel. GDP crises</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_3 = 0$</td>
<td>0.0295</td>
<td>0.1318</td>
<td>0.1596</td>
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<td>$\psi_3 = 0.2$</td>
<td>0.0307</td>
<td>0.0712</td>
<td>0.1311</td>
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<tr>
<td>$\psi_3 = 0.4$</td>
<td>0.0263</td>
<td>0.0532</td>
<td>0.1431</td>
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<tr>
<td>$\psi_3 = 0.6$</td>
<td>0.0222</td>
<td>0.0521</td>
<td>0.1352</td>
</tr>
<tr>
<td>$\psi_3 = 0.8$</td>
<td>0.0173</td>
<td>0.0519</td>
<td>0.1168</td>
</tr>
</tbody>
</table>

*Note: higher values of $\psi_3$ capture higher degrees of nominal wage flexibility to unemployment variations*
Wage-Flexibility, Growth and Unemployment

Results

- **Demand-led investment scenario.** Nominal wage flexibility has no effect (or possibly some negative effect under low mark-up) on growth, unemployment and the likelihood of crises.

<table>
<thead>
<tr>
<th>Mark-Up Rate</th>
<th>Avg.GDP growth rate</th>
<th>Avg.unempl. rate</th>
<th>Avg.likel. GDP crises</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\psi_3 = 0$</td>
<td>0.0334</td>
<td>0.0307</td>
<td>0.0080</td>
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<td>$\psi_3 = 0.2$</td>
<td>0.0333</td>
<td>0.0318</td>
<td>0.0092</td>
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<tr>
<td>$\psi_3 = 0.4$</td>
<td>0.0330</td>
<td>0.0509</td>
<td>0.0169</td>
</tr>
<tr>
<td>$\psi_3 = 0.6$</td>
<td>0.0335</td>
<td>0.0285</td>
<td>0.0080</td>
</tr>
<tr>
<td>$\psi_3 = 0.8$</td>
<td>0.0331</td>
<td>0.0540</td>
<td>0.0151</td>
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<tr>
<td>0.30</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\psi_3 = 0$</td>
<td>0.0128</td>
<td>0.7733</td>
<td>0.3388</td>
</tr>
<tr>
<td>$\psi_3 = 0.2$</td>
<td>0.0128</td>
<td>0.8144</td>
<td>0.3416</td>
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<tr>
<td>$\psi_3 = 0.4$</td>
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<td>0.7836</td>
<td>0.3390</td>
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<tr>
<td>$\psi_3 = 0.6$</td>
<td>0.0125</td>
<td>0.8259</td>
<td>0.3401</td>
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<tr>
<td>$\psi_3 = 0.8$</td>
<td>0.0136</td>
<td>0.8018</td>
<td>0.3384</td>
</tr>
</tbody>
</table>

*Note:* higher values of $\psi_3$ capture higher degrees of nominal wage flexibility to unemployment variations.
Concluding Remarks

- Developing an ABM of endogenous growth and business cycles to analyze the institutional complementarities between technical change, income distribution and investment behavior

1) Schumpeterian dynamics: generation of innovations, expensive search and endogenously-determined technological heterogeneity
2) Keynesian dynamics: investment decisions and consumption

Results

- Independently from firm investment behavior, the emergence of long-run growth associated with low rates of unemployment and short-run volatility always requires a balance in the distribution between profits and wages.
- Otherwise, the economy gets locked either in stagnation (low growth and high unemployment), or in trajectories with high but volatile growth
- If investment is profit-led growth and unemployment are inversely related to the level of real wages. In contrast, if investment is demand-led the relation is non linear, and unemployment may increase if real wages decrease
- Nominal-wage flexibility decreases unemployment in the profit-led scenario but not in the demand-led one.
The Way Ahead

1. Explore a wider spectrum of scenarios and parameterizations
   1. open vs. closed economy scenario.

2. Full-fledged analysis of the labor market and of wage-price dynamics
### Benchmark Parametrization

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms in capital-good industry</td>
<td>$F_1$</td>
<td>50</td>
</tr>
<tr>
<td>Number of firms in consumption-good industry</td>
<td>$F_2$</td>
<td>200</td>
</tr>
<tr>
<td>R&amp;D investment propensity</td>
<td>$\nu$</td>
<td>0.04</td>
</tr>
<tr>
<td>R&amp;D allocation to innovative search</td>
<td>$\xi$</td>
<td>0.50</td>
</tr>
<tr>
<td>Firm search capabilities parameters</td>
<td>$\zeta_{1,2}$</td>
<td>0.30</td>
</tr>
<tr>
<td>Beta distribution parameters (innovation process)</td>
<td>$(\alpha_1, \beta_1)$</td>
<td>(3,3)</td>
</tr>
<tr>
<td>Beta distribution support (innovation process)</td>
<td>$[x_1, \bar{x}_1]$</td>
<td>$[-0.15, 0.15]$</td>
</tr>
<tr>
<td>Payback period</td>
<td>$b$</td>
<td>3</td>
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<tr>
<td>“Physical” scrapping age</td>
<td>$\eta$</td>
<td>20</td>
</tr>
<tr>
<td>Wage setting $\Delta \overline{AB}$ weight</td>
<td>$\psi_1$</td>
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<tr>
<td>Wage setting $\Delta cpi$ weight</td>
<td>$\psi_2$</td>
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<tr>
<td>Wage setting $\Delta U$ weight</td>
<td>$\psi_3$</td>
<td>0</td>
</tr>
<tr>
<td>Capital-good firm mark-up rate</td>
<td>$\mu_1$</td>
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<tr>
<td>Consumer-good firm mark-up rate</td>
<td>$\nu$</td>
<td>0.20</td>
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<tr>
<td>Tax rate</td>
<td>$tr$</td>
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<tr>
<td>Unemployment subsidy rate</td>
<td>$\varphi$</td>
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<tr>
<td>Loan-to-value ratio</td>
<td>$\Lambda$</td>
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<tr>
<td>Baseline Interest Rate</td>
<td>$r$</td>
<td>0.025</td>
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</table>

**Table:** Benchmark Parameters