# A Post-Keynesian SFC model with Directed Technical Change

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# Existing mainstream debate

- Original economic models with environmental constraints (IAMs, Nordhaus, Stern, Tol) assumed exogenous technical change
  - Emissions feedback on the real economy -> Damage function
  - Social cost of carbon is determined through prices

- Acemoglu (2008, 2012) include endogenous technological change
  - Hypothesis: Innovation is directed toward sectors with
    - Larger size (economies of scale)
    - Higher price (higher profits)
  - Investment can be directed to the right sector given the right incentives

# Gaps in mainstream models

- Mainstream models are supply side driven with minimal or no discussion of state intervention
  - Purely price driven
  - Innovation and implementation is costless and immediately
- The role of finance is missing
  - No discussion on the limits of investment
  - Who invests?
- Focus remains on overall output efficiency
  - Inputs (L, K) can be perfectly substituted
  - Energy as an input is missing: Y=f(K,L,E)

# Our contribution

- We introduce the government as key decision maker
- Banks are introduced and finance is fully tracked
  - Stock-flow consistent
- Three inputs y=f(L,K,E)
- Investment function

$$I_t = I_0 + \gamma_1(K^T - K_{t-1}) - \gamma_2\, r_{l,t-1}$$

- Firms R&D investment
  - $R\&D_t = \mu I_t + R\&D_t^G$
  - Investment decisions across all inputs; labor (L), capital (K), and energy (E) based on price signals -> A portfolio choice problem

# Portfolio choice

- Labor: Growth of wage rate
- Capital: Increase in price of capital
- Energy: Growth of cost of energy

$$\begin{pmatrix} R\&D_t^L \\ R\&D_t^K \\ R\&D_t^R \end{pmatrix} = \left( \begin{pmatrix} \lambda_{10} \\ \lambda_{20} \\ \lambda_{30} \end{pmatrix} + \begin{pmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} \\ \lambda_{21} & \lambda_{22} & \lambda_{23} \\ \lambda_{31} & \lambda_{32} & \lambda_{33} \end{pmatrix} \begin{pmatrix} \omega_t - \widetilde{\omega}_{t-1} \\ r_{lt} - r_{l,t-1} \\ \psi_t - \tilde{\psi}_{t-1} \end{pmatrix} \right) R\&D_t$$

# Innovation

- Investment results in a non-reversible innovation in the relative productivities of each input

$$\epsilon_t^i = \epsilon_{t-1}^i (1 + \phi_t^i) \left(1 + \frac{R\&D_t}{y_t}\right)$$

for $i = L, K, E$

Where $\phi^i = \frac{R\&D_t^i}{R\&D_t}$

- Feedback: higher productivity implies lower input requirement
  - Labor vs capital/energy

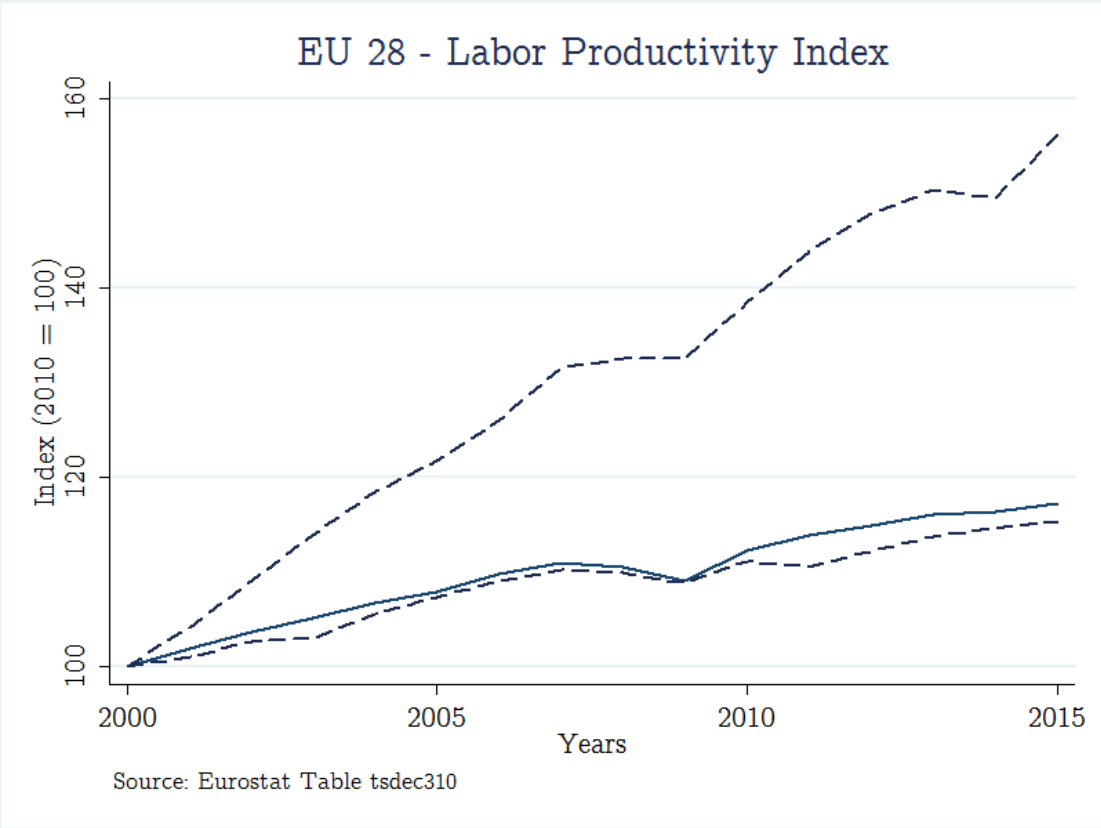
# Balance sheet

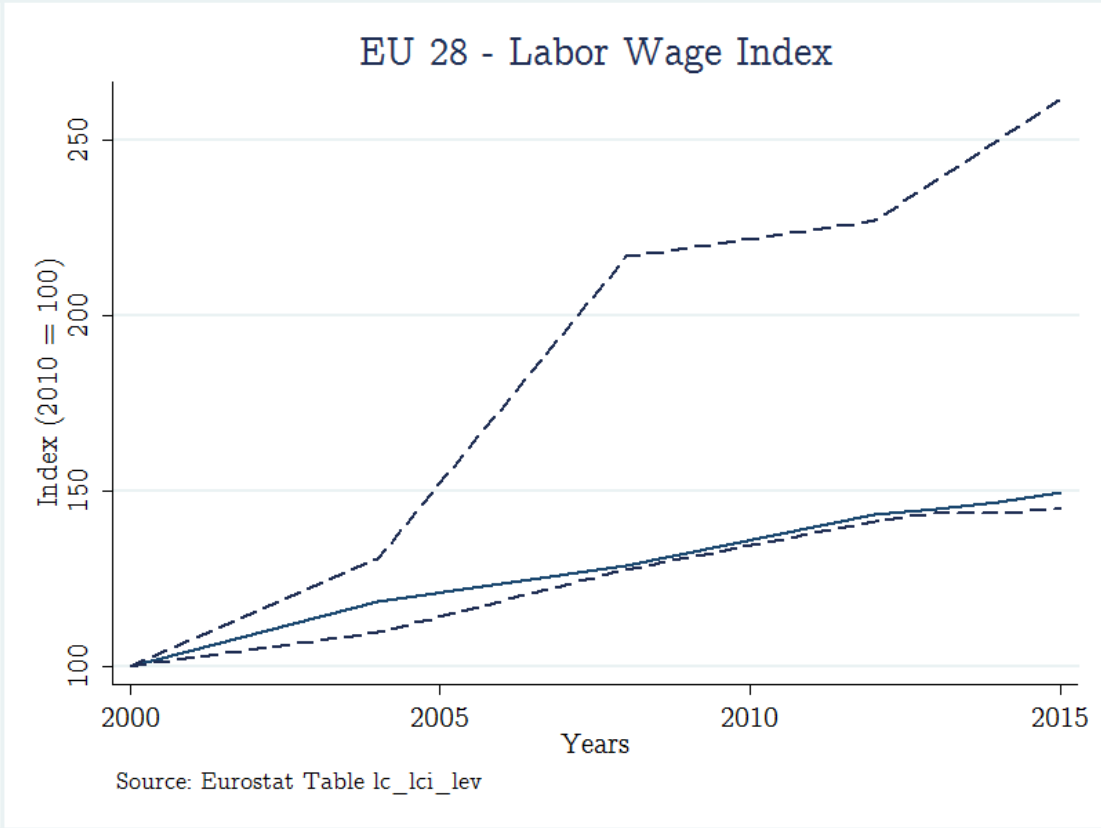
| | Households | Firms | Banks | Government | Net Worth |
|---|---|---|---|---|---|
| **Capital stock** | | $+K$ | | | $+K$ |
| **Deposits** | $+D$ | | $-D$ | | $0$ |
| **Loans** | | $-L$ | $+L$ | | $0$ |
| **Bank Balance** | | | $+Bal$ | $-Bal$ | $0$ |
| **Net Worth** | $+D$ | $0$ | $0$ | $-Bal$ | $+NV$ |

# Transition matrix (FoF account)

| | Households | Firms | | | Banks | Government | Total |
|---|---|---|---|---|---|---|---|
| | | Current | Capital | R&D | | | |
| Consumption | $-C$ | $+Y$ | | | | $+G$ | 0 |
| Investment | | $-I$ | $+I$ | $\mu I + R\&D^G = \begin{cases} RD^L \\ RD^K \\ RD^R \end{cases}$ | | $-R\&D^G$ | 0 |
| Wages | $+WB$ | $-WB$ | | | | | 0 |
| Resource tax | | $-R$ | | | | $+R$ | 0 |
| Income taxes | $-T^H$ | $-T^F$ | | | | $+T$ | 0 |
| i Deposits | $+r_d D_{t-1}$ | | | | $-r_d D_{t-1}$ | | 0 |
| i Loans | | $-r_l L_{t-1}$ | | | $+r_l L_{t-1}$ | | 0 |
| i Bank Balance | | | | | $-r_b B_{t-1}$ | $+r_b B_{t-1}$ | 0 |
| **Δ** Deposits | $-\Delta D$ | | | | $+\Delta D$ | | 0 |
| **Δ** Loans | | | $+\Delta L$ | | $-\Delta L$ | | 0 |
| **Δ** Bank Balance | | | | | $+\Delta B$ | $-\Delta B$ | 0 |
| Total | 0 | 0 | 0 | | 0 | 0 | 0 |

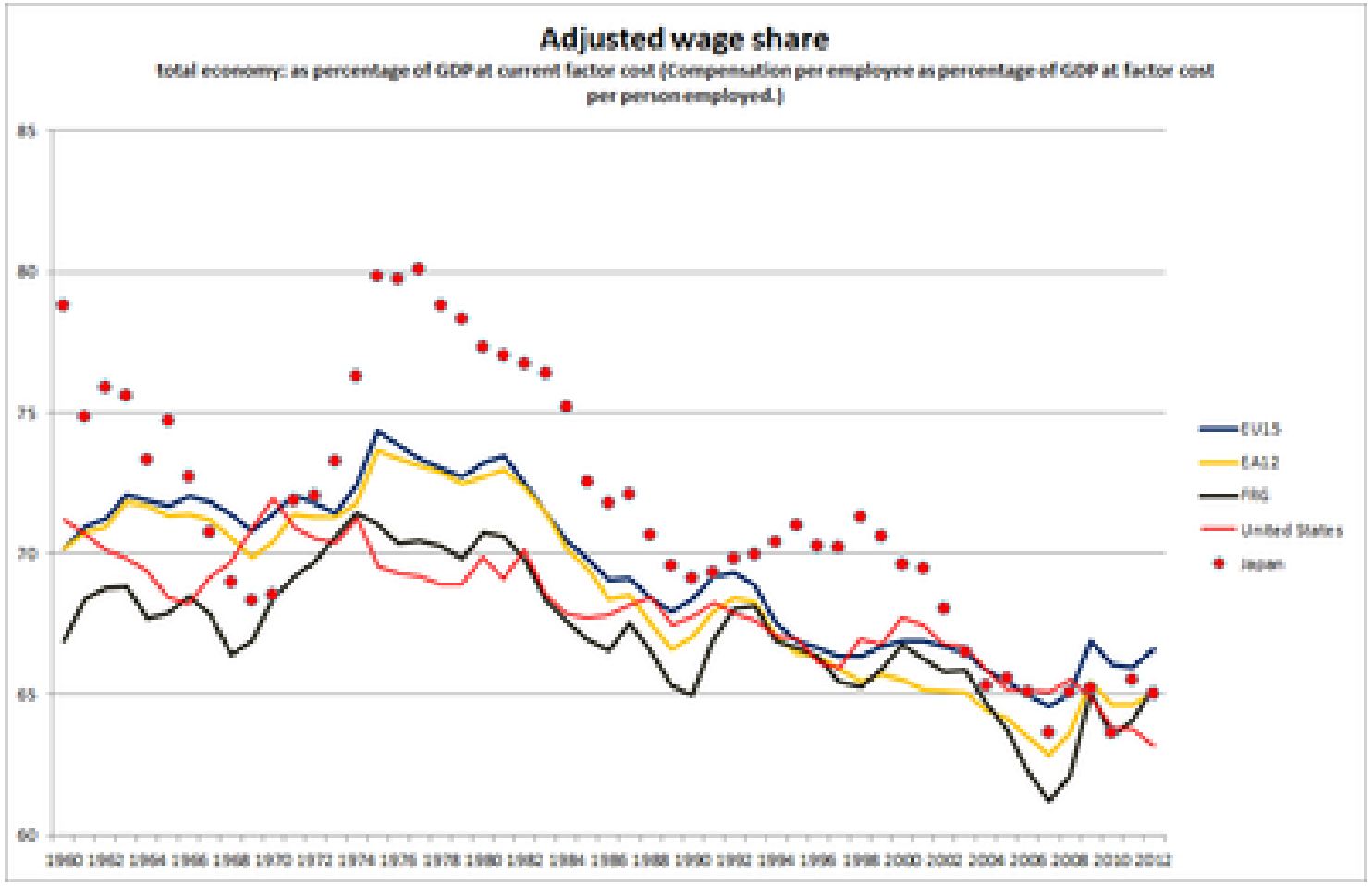
# Stylized facts




Dark line = Median, Dotted lines = 25$^{th}$-75$^{th}$ Percentile

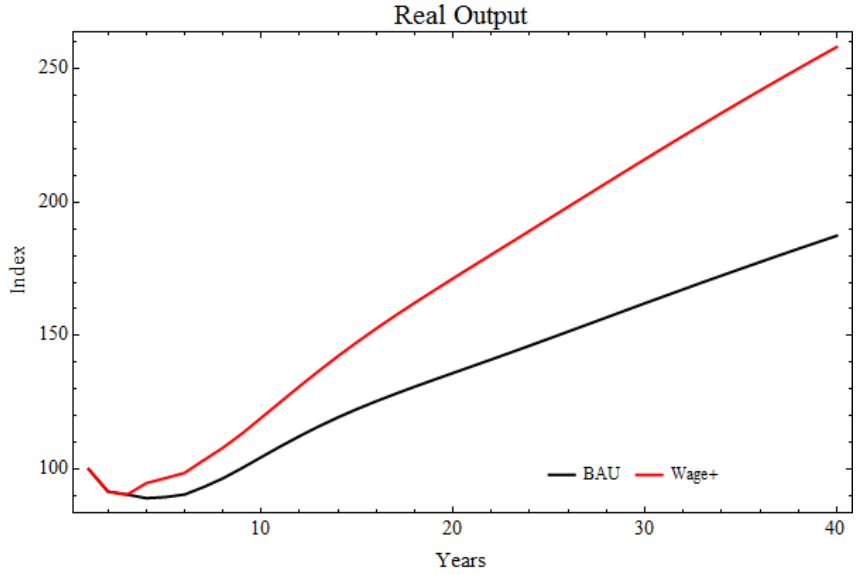
# Wage share


Adjusted wage share
total economy: as percentage of GDP at current factor cost (Compensation per employee as percentage of GDP at factor cost per person employed.)
85
80
75
70
65
60
EU15
EA12
FRG
United States
Japan

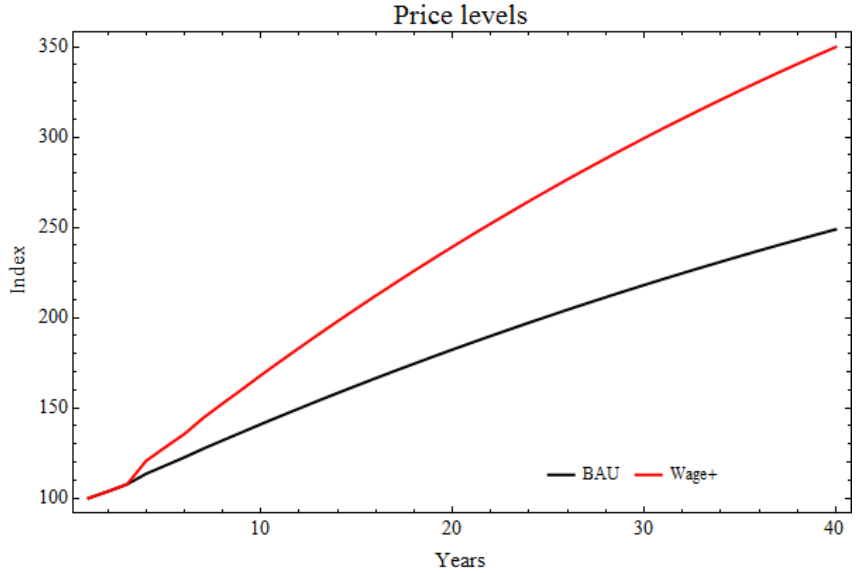
# Experiment 1

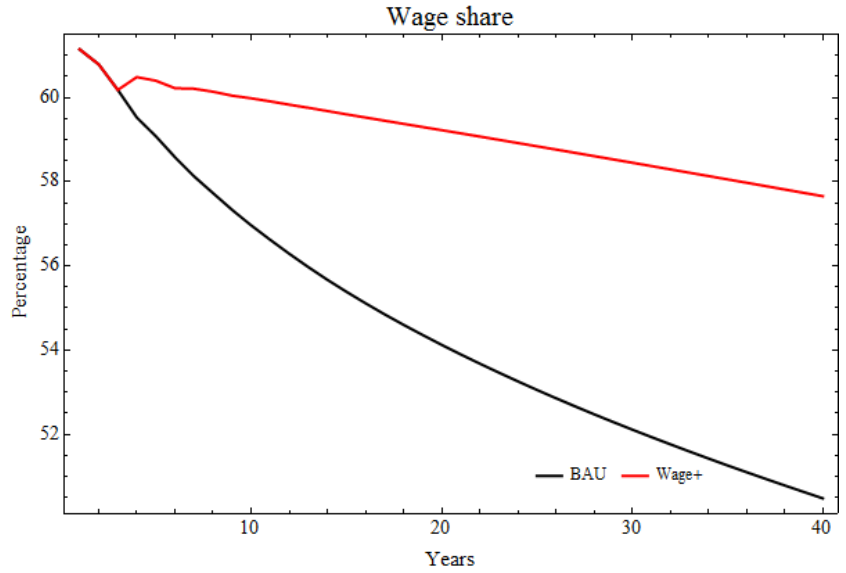
Increase in Minimum wage rate

# Experiment – Min wage rate increase (Wage+)

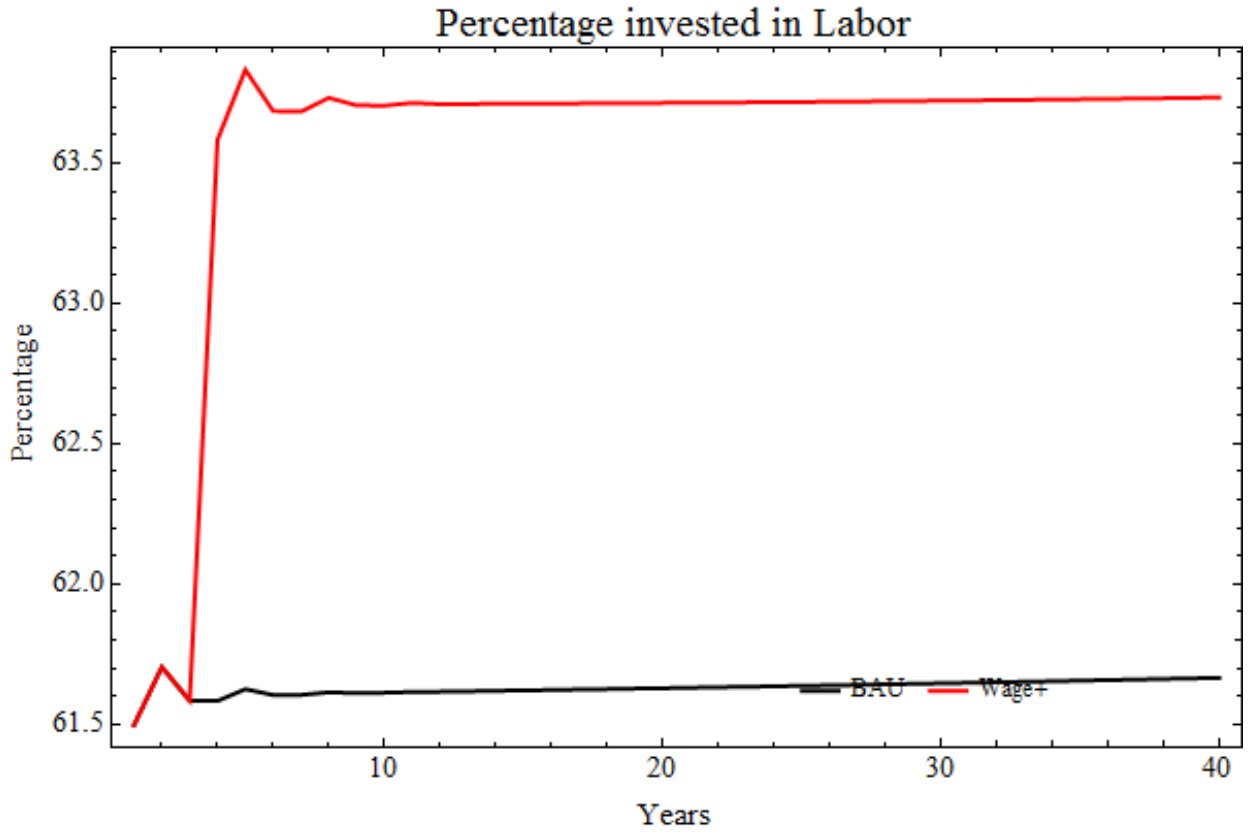


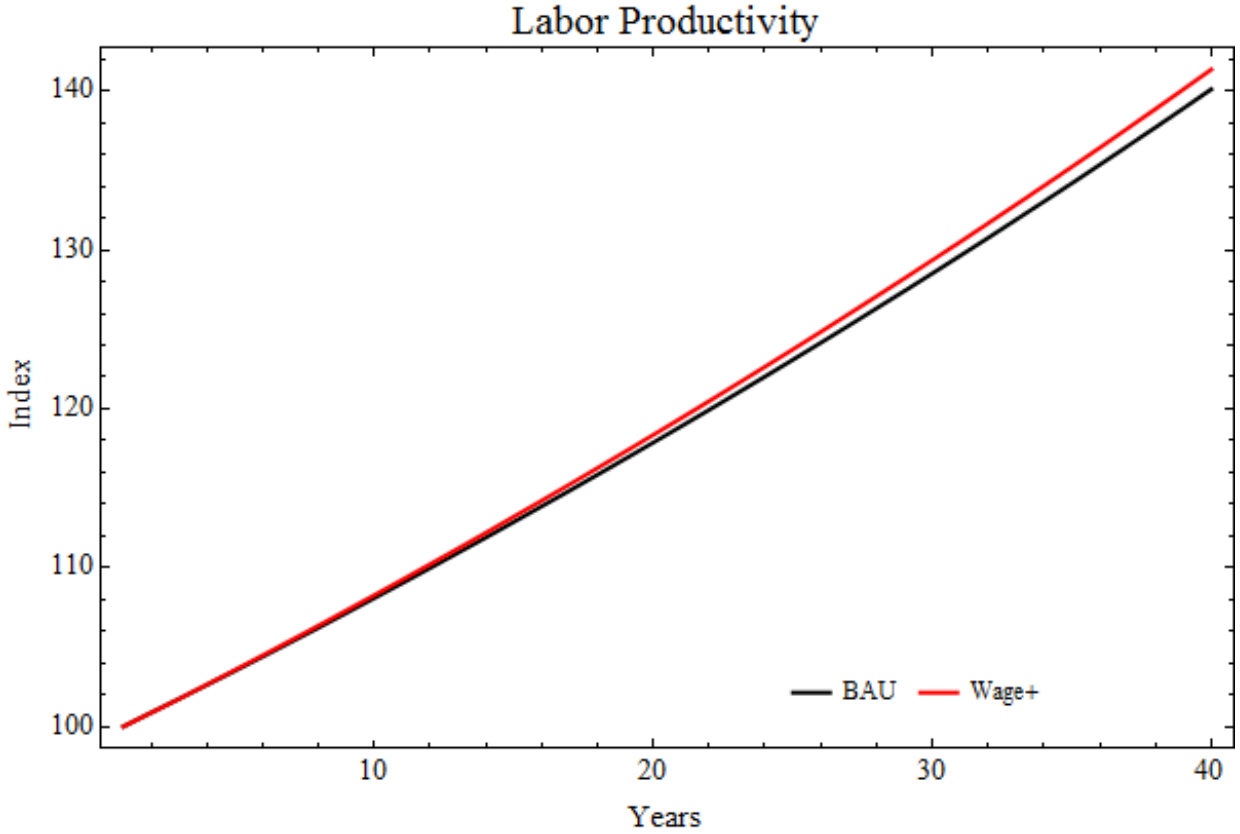




# Experiment – Min wage rate increase (Wage+)



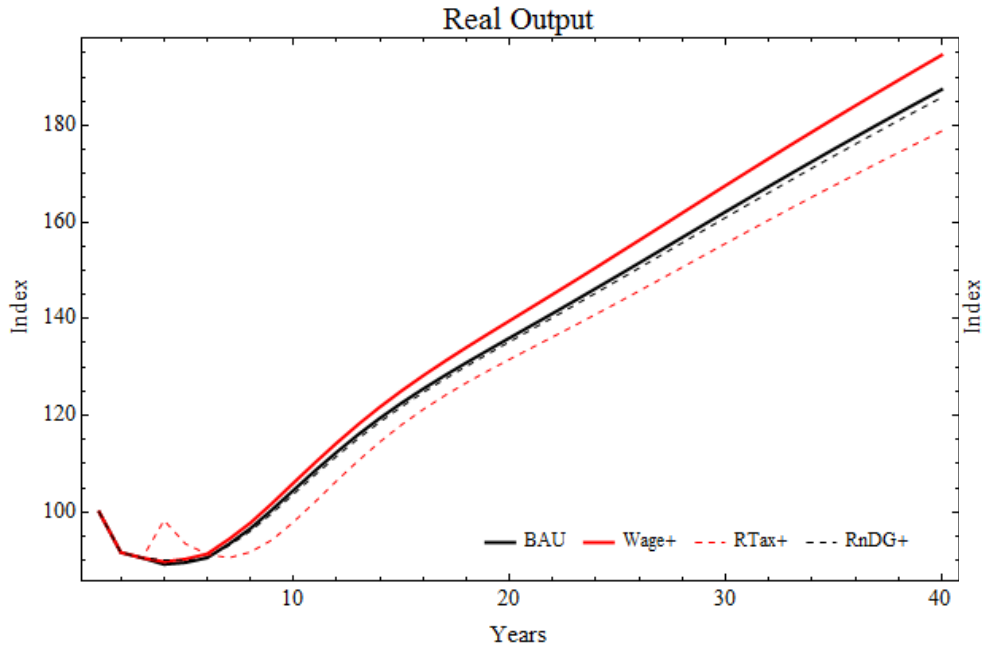



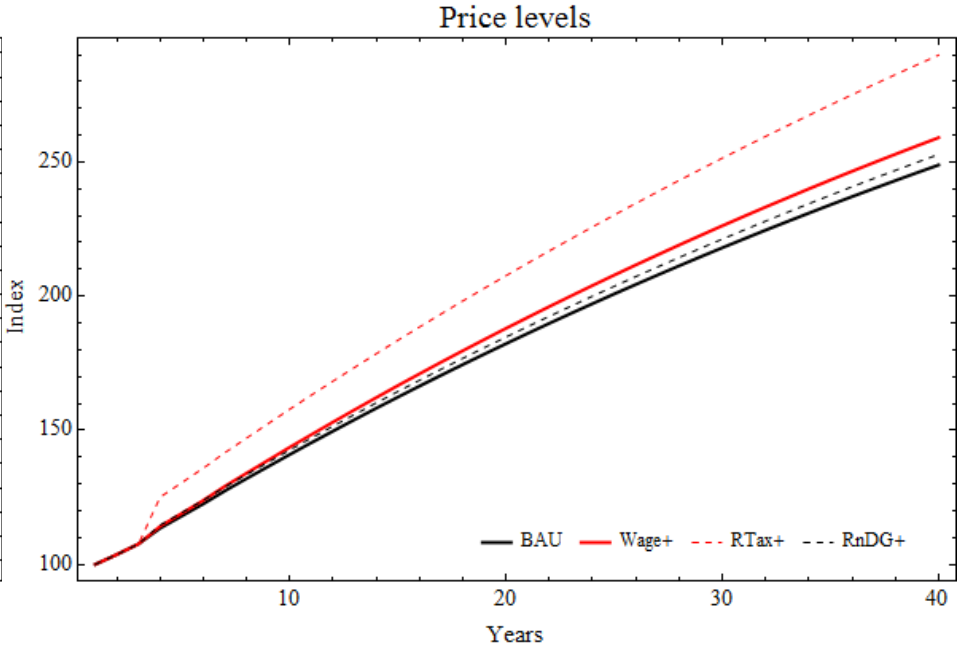
# Experiment 2

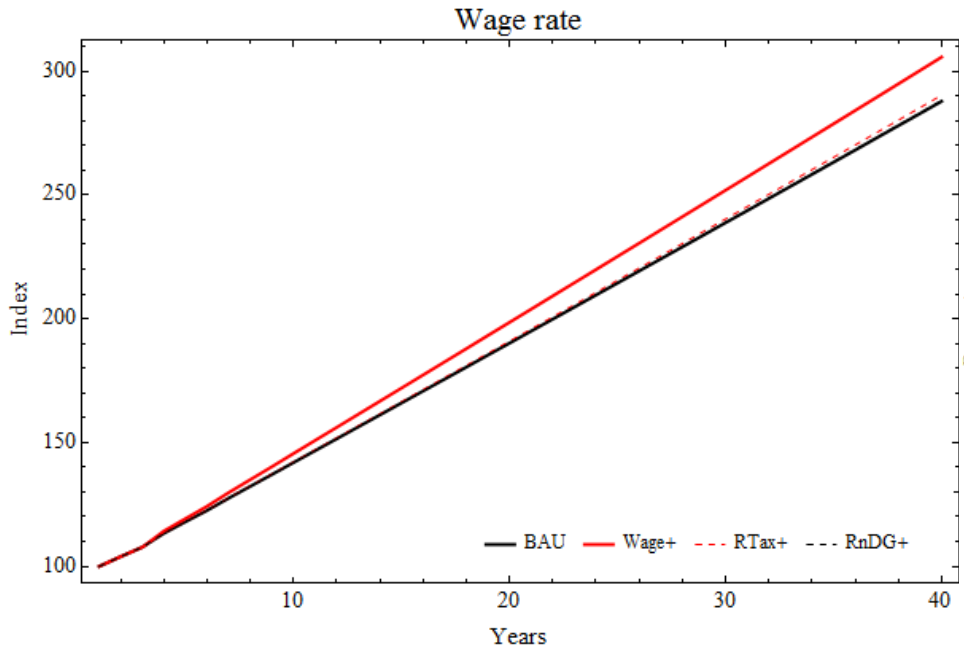
Policy interventions

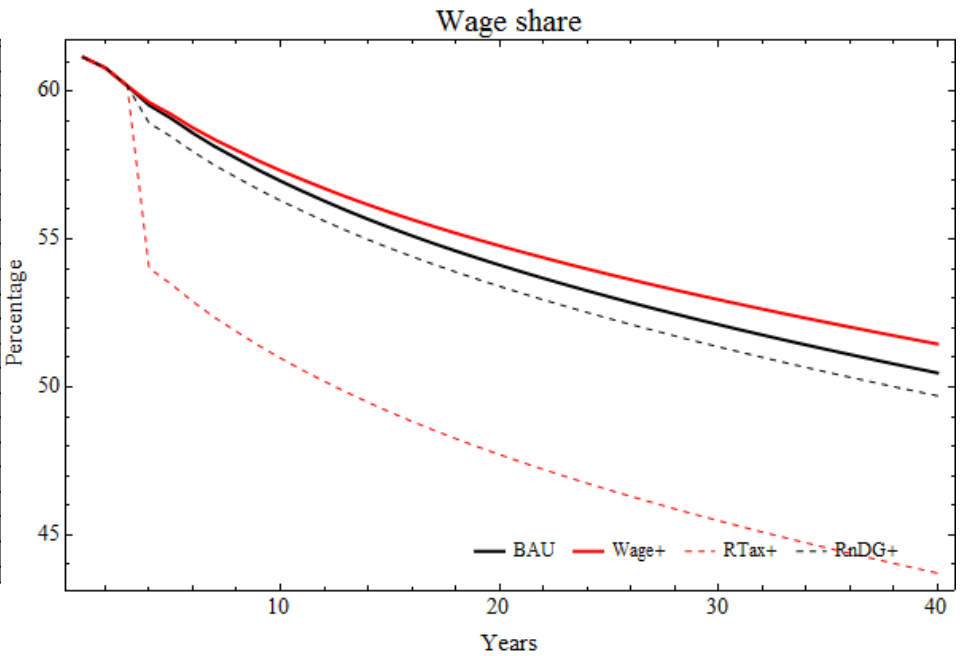
# Policy Interventions

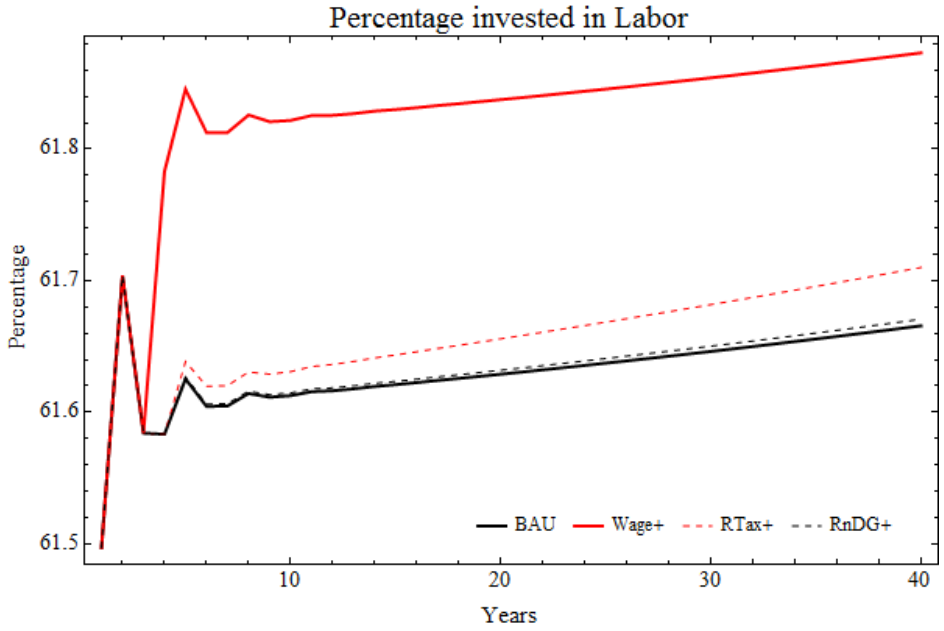
| Experiment | Description | Parameter |
|---|---|---|
| Wage+ | One-off increase in wage rate | 10% increase in $W$ |
| RTax+ | Increase in resource tax | 10% increase in $\tau^R$ |
| RnD+ | Increase in R&D expenditure | 10% increase in $R\&D^G$ |

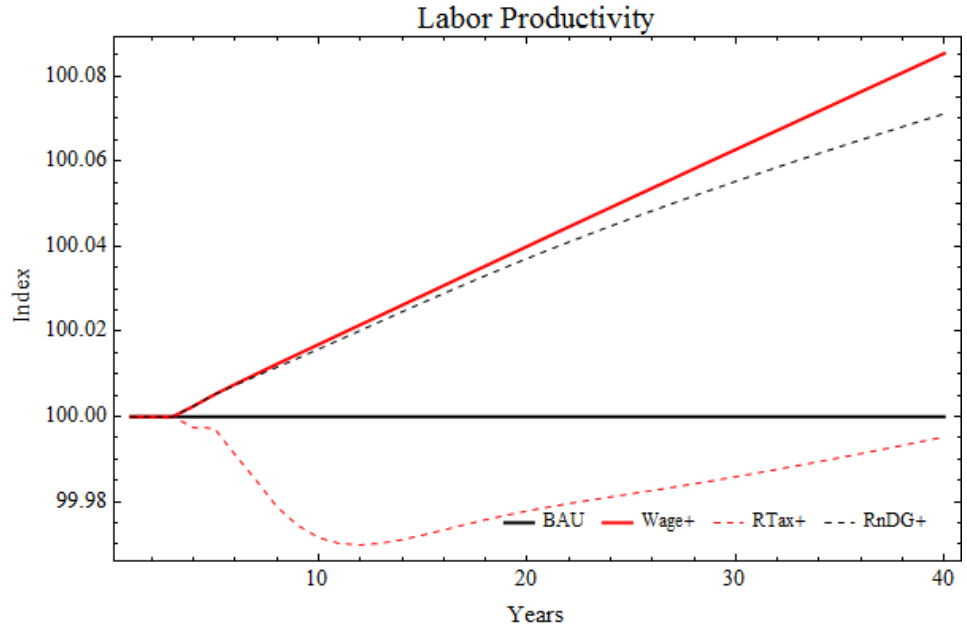

Real Output
Index
Years
BAU
Wage+
RTax+
RnDG+

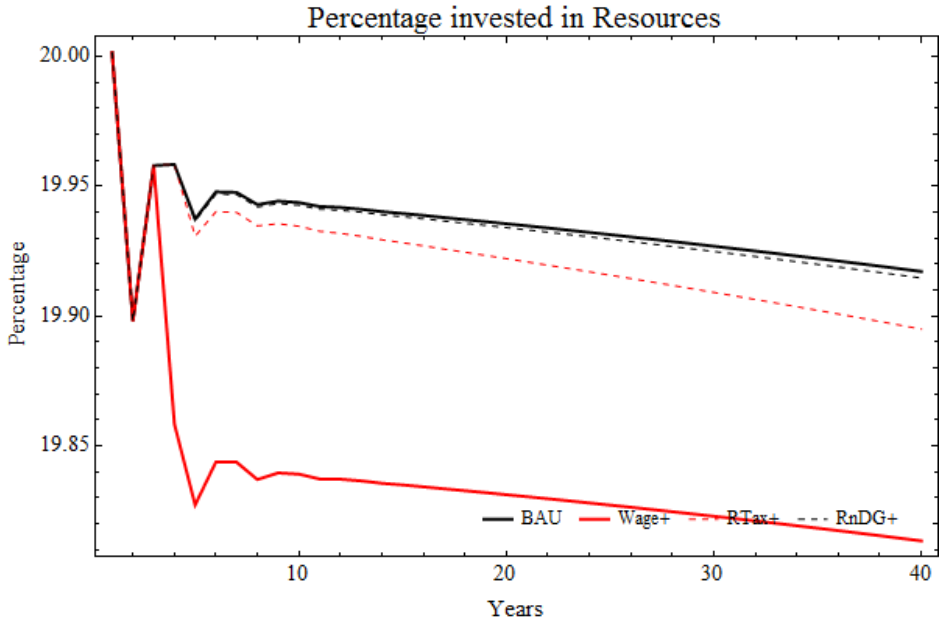

Price levels
Index
Years
BAU
Wage+
RTax+
RnDG+

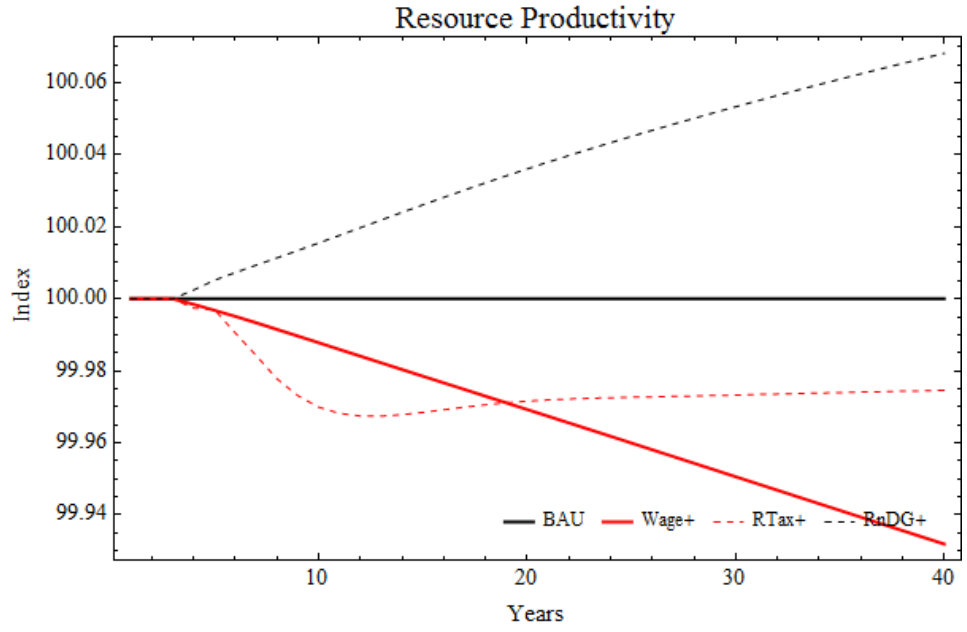

Wage rate
Index
Years
BAU
Wage+
RTax+
RnDG+


Wage share
Percentage
Years
BAU
Wage+
RTax+
RnDG+


Percentage invested in Labor
Percentage
61.8
61.7
61.6
61.5
10
20
30
40
Years
BAU
Wage+
RTax+
RnDG+


Labor Productivity
Index
100.08
100.06
100.04
100.02
100.00
99.98
10
20
30
40
Years
BAU
Wage+
RTax+
RnDG+


Percentage invested in Resources
Percentage
20.00
19.95
19.90
19.85
10
20
30
40
Years
BAU
Wage+
RTax+
RnDG+


Resource Productivity
Index
100.06
100.04
100.02
100.00
99.98
99.96
99.94
10
20
30
40
Years
BAU
Wage+
RTax+
RnDG+

# Summary

- Propose a post-Keynesian Ecological Economic model that has directed technological change and a full financial sector in an SFC framework
- Directed tech change: R&D react to price signals, productivity growth biased towards factors that are rising in prices
- Financial flows modelled SFC, the level of debt effects investment and R&D
- Model used to analyse different economic policy strategies
- Mainstream lit emphasises need to calculate static marginal social costs
- Instead we emphasize the need re-direct tech change by continuous intervention, i.e. a regime of annually increasing environmental taxes that mimic the continuous wage rises that have been feature of capitalist economies for a extended periods