Growth, Distributions, and the Environment:

A Modeling Framework for Policy Analysis

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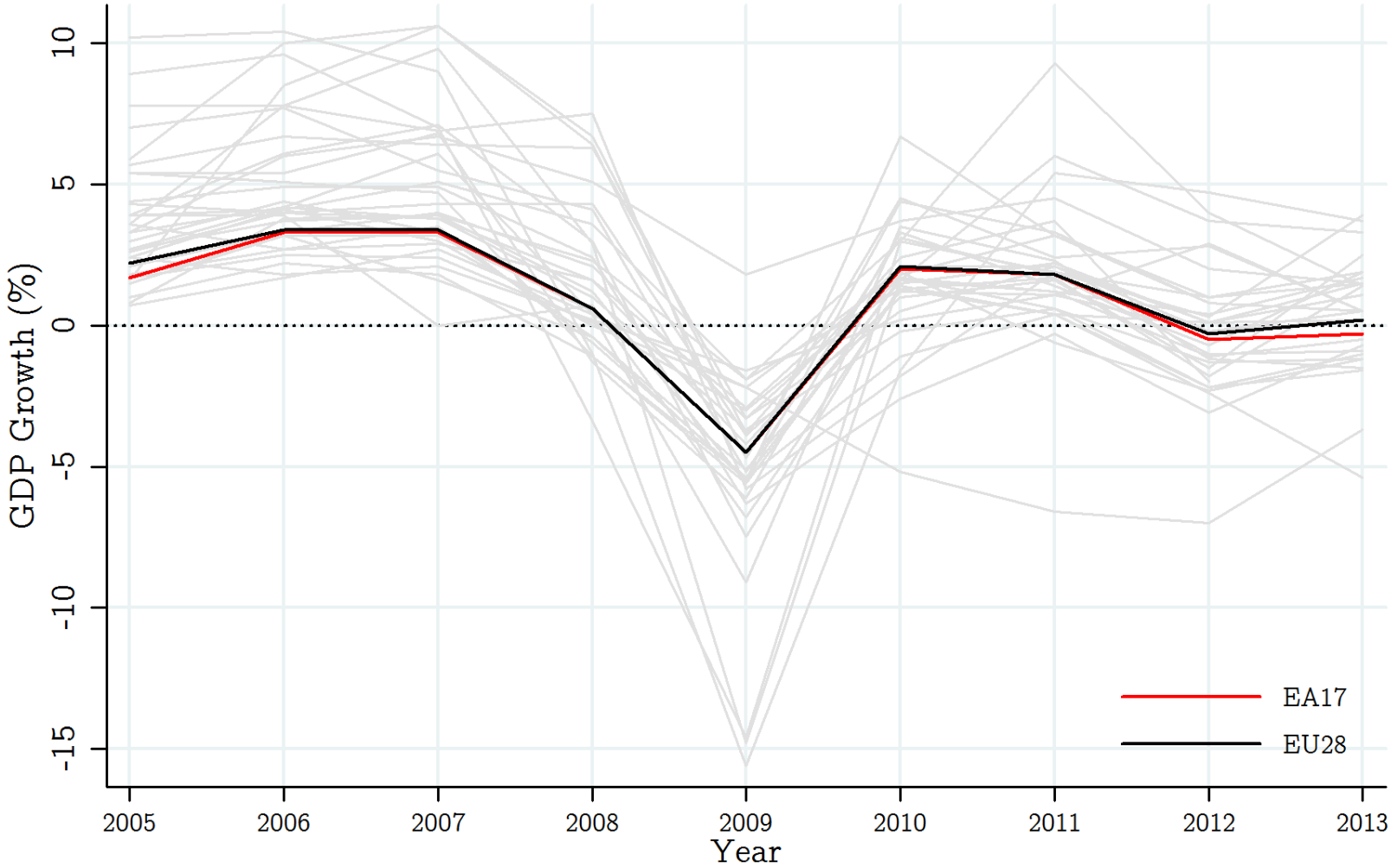
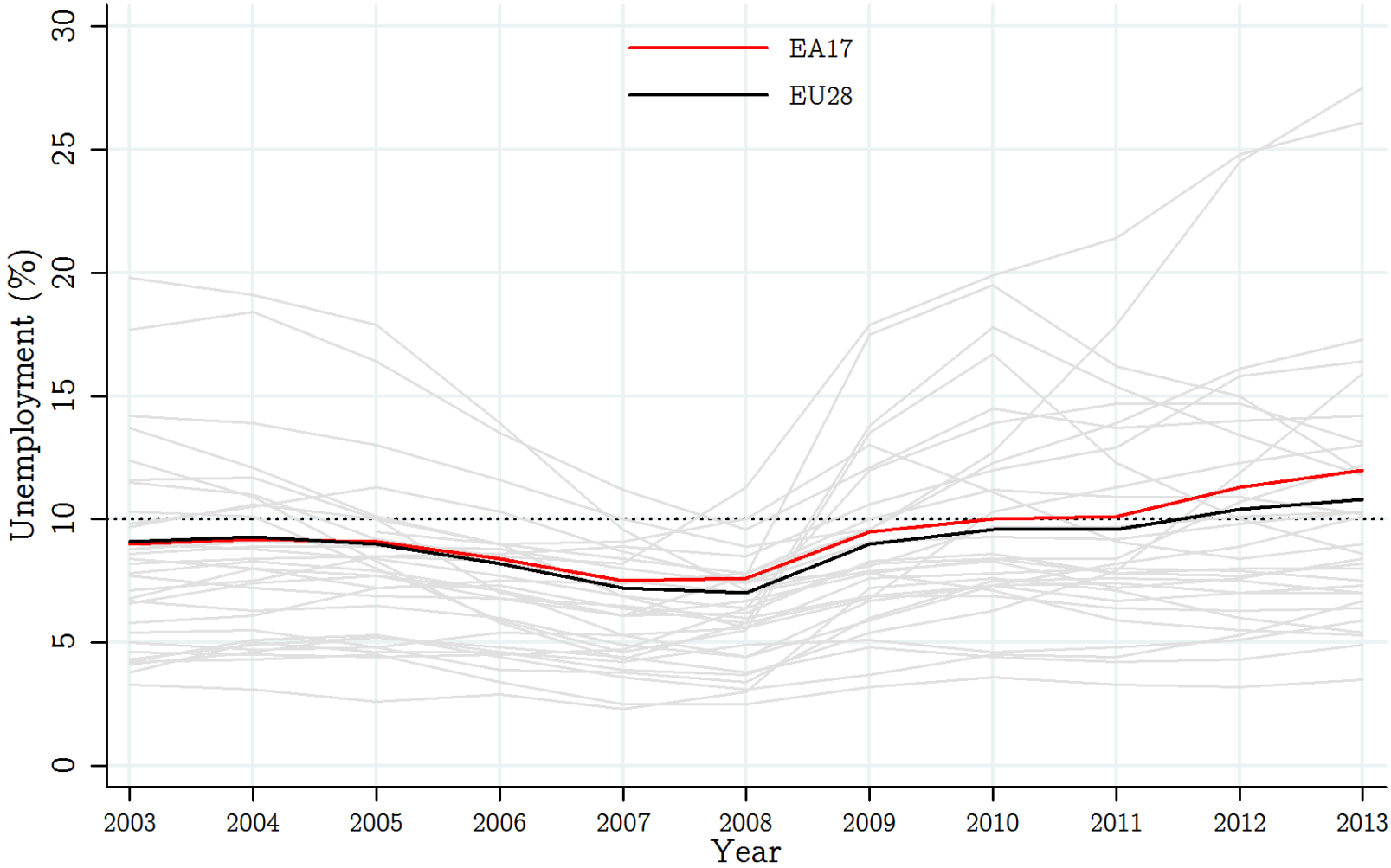
Challenge 1: GDP growth falling



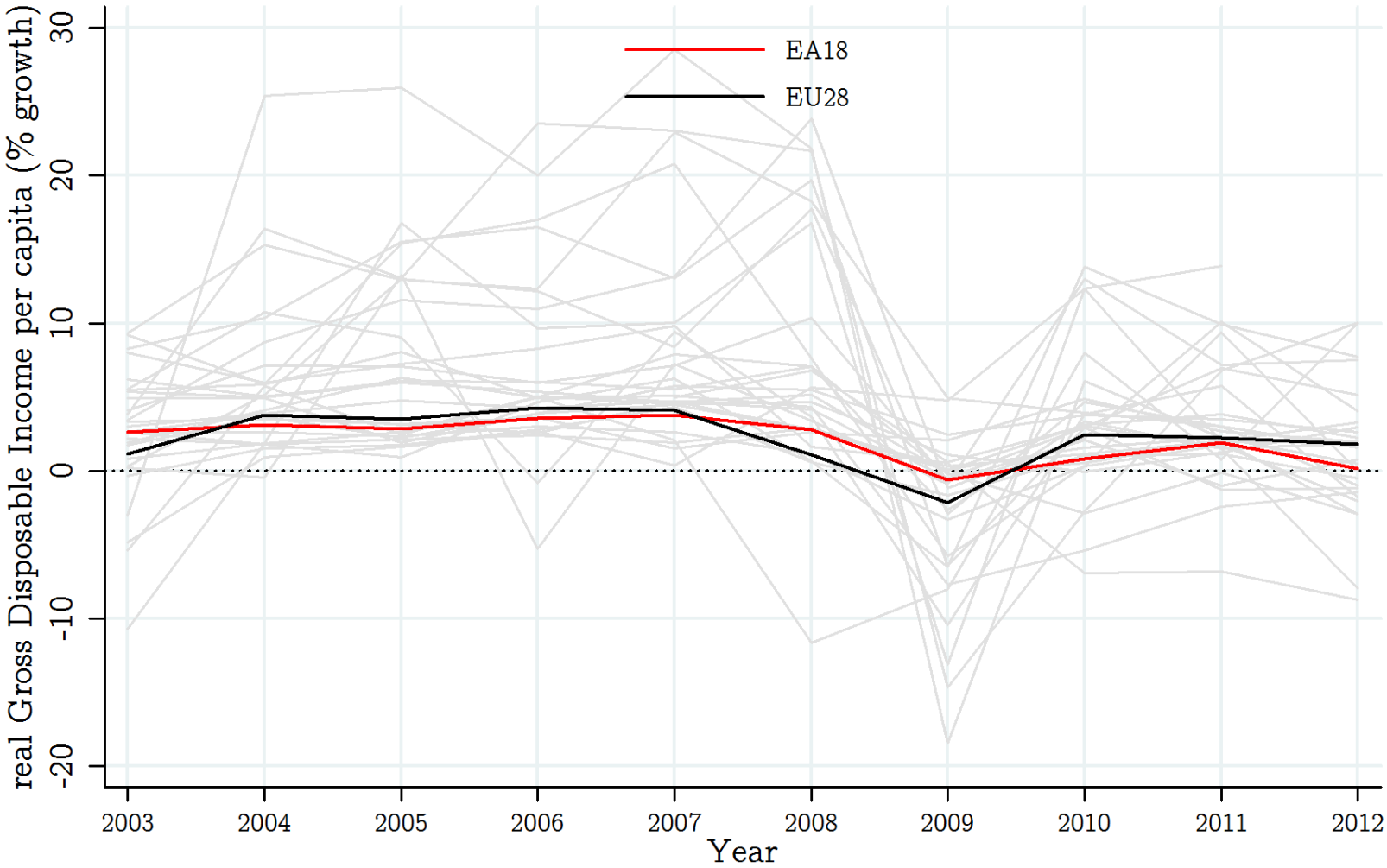
Source: Eurostat Table nama_gdp_k

Challenge 2: Unemployment rising



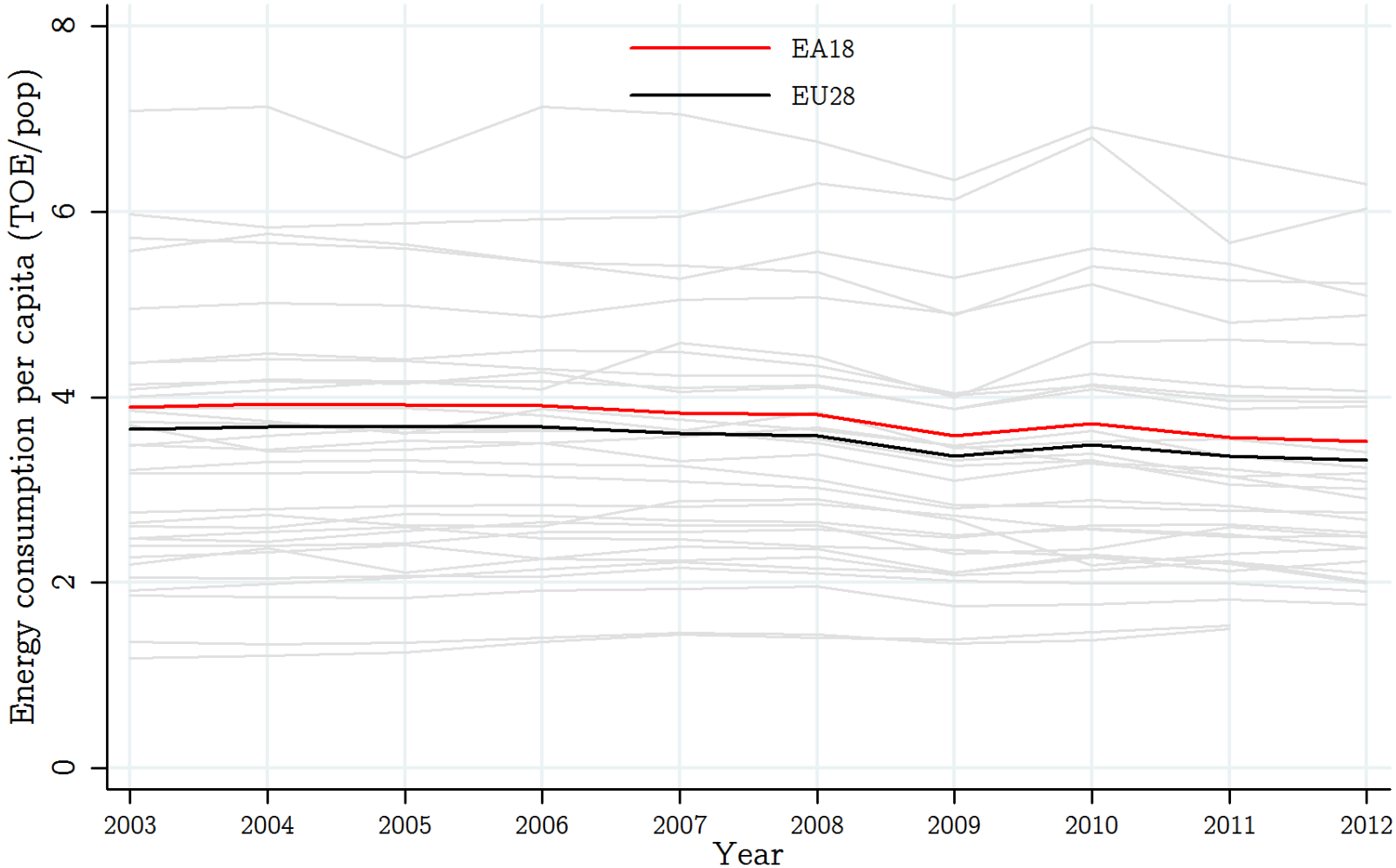
Source: Eurostat Table une_rt_a

Challenge 3: Real disposable incomes falling



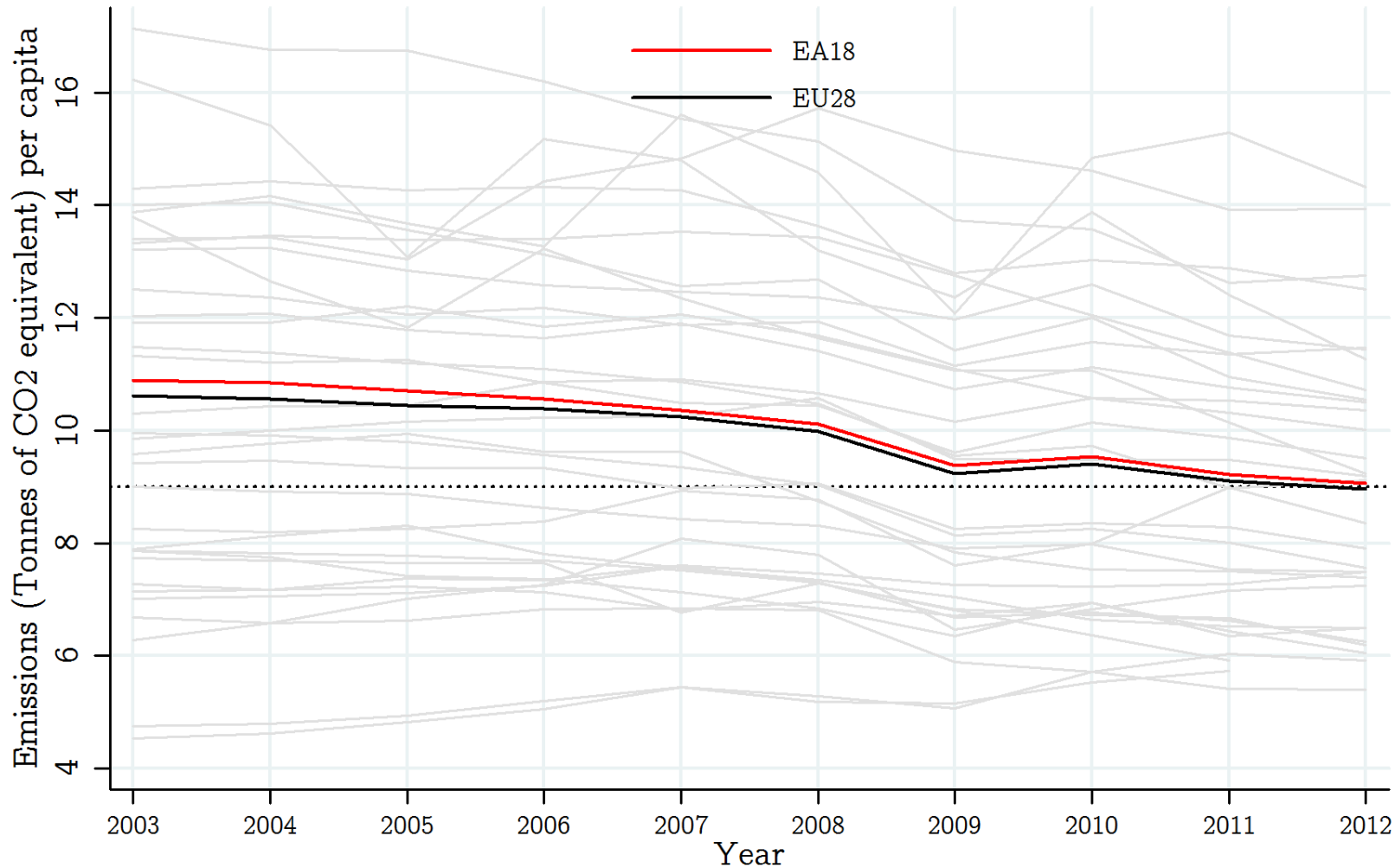
Source: Eurostat Table nasa_nf_tr

Challenge 5: Energy consumption stagnant



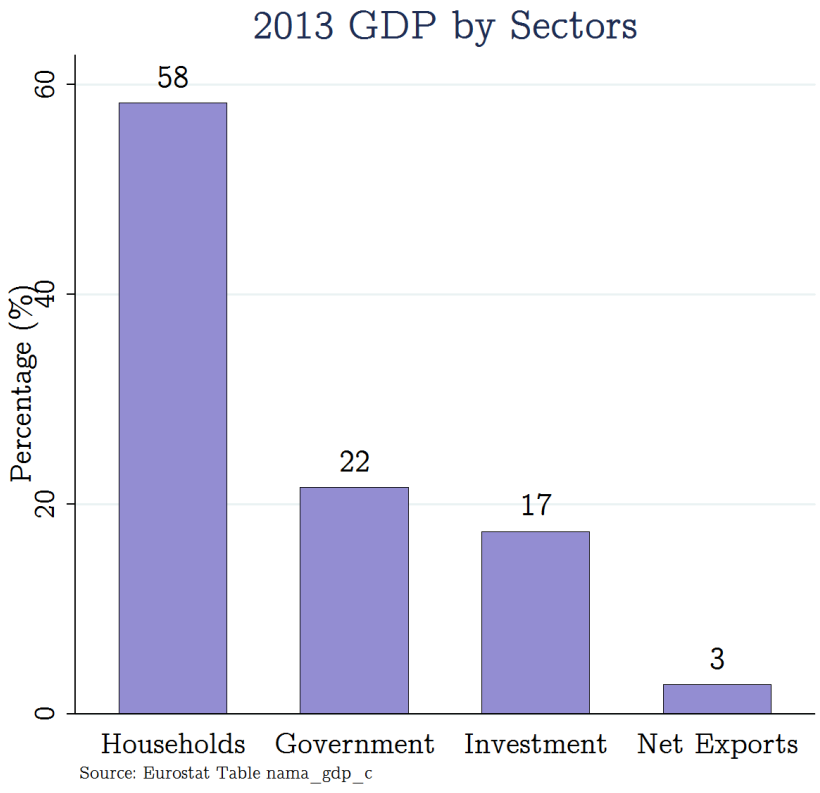
Source: Eurostat Table nrg_100a. Luxemburg and Iceland excluded.

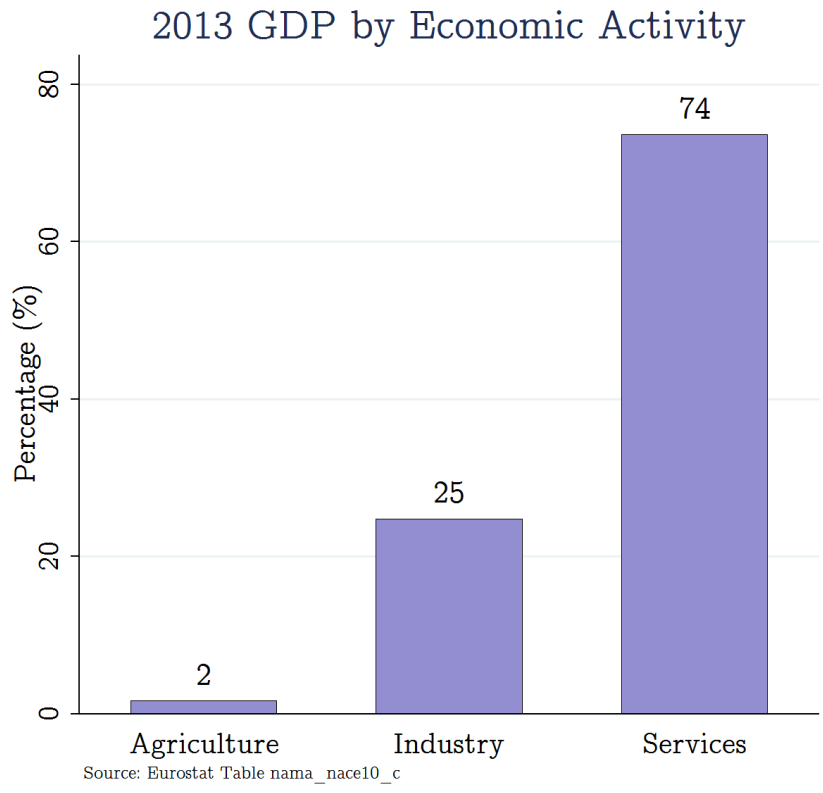
Challenge 6: Some emissions targets missing



Source: UNFCCC_v15

GDP composition





Growth vs Environment

- EU is a closed economy
  - 90% of demand is internal
- Increase in real incomes can boost demand, lead to growth, employment
- BUT
- Higher growth can result in higher output and subsequently higher emissions
- Several proposed solutions

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Some proposed solutions

- Keep growth very low or even zero
  - Through reduction in demand (who reduces?)
- High investment in innovation technologies
  - Absolute decoupling (who invests?)
- Emissions regulation through climate taxes (tax whom?)
- Carbon pricing (how do you price?)
- Redistribution?

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The Policy Challenge

- Regardless of policy decision, solutions are not trivial
- The economy is complex with multiple integrated sectors
  - HH, firms, financial, government
  - Policy response in one sector might feedback a negative response in another
- Need to have a framework that tracks policy response across all sectors of the economy
  - Social Accounting Matrices (SAMs) (Taylor 2004)
  - Stock-flow consistent models (SFCs) (Godley and Lavoie 2007)

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National Accounts

- Economic activity is captured in monetary terms in two primary accounts
  - **Balance sheets**: Net worth (asset, liabilities) $\rightarrow$ Stocks
  - **Flow of funds**: sources and uses of funds $\rightarrow$ Flows
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Euro region Household Sector

Table: Household Balance Sheet (EUR Billions)

Category	Balance	**2012-Q4**	**2013-Q4**	%	Δ
Non financial assets	Non-financial assets	29,625	29,041	68%	-584
	Housing wealth	*28,055*	*27,435*	64%	*-620*
Financial assets	Currency and deposits	7,046	7,225	17%	179
	Securities and derivatives	1,537	1,365	4%	-172
	Loans	-6,196	-6,152	14%	44
	Shares and equities	4,310	4,858	11%	543
	Insurance and pension	5,939	6,184	14%	-245
	Other	195	169		-26
	Net worth	**42,456**	**42,685**		**229**

Source: ECB Monthly Bulletin May 2014

Euro region Household Sector

Table: Household Flow of funds (EUR Billions)

Flows	**2013-Q4**
Total income (all sources)	7,059
Net social contributions receivable	182
Tax	-962
Gross disposable income	6,279
Consumption	*-5,507*
Gross savings	829
Consumption of fixed capital	-407
Net capital transfers	-4
Change in worth of stocks	-189
Net savings (Δ net worth)	**229**

Source: ECB Monthly Bulletin May 2014

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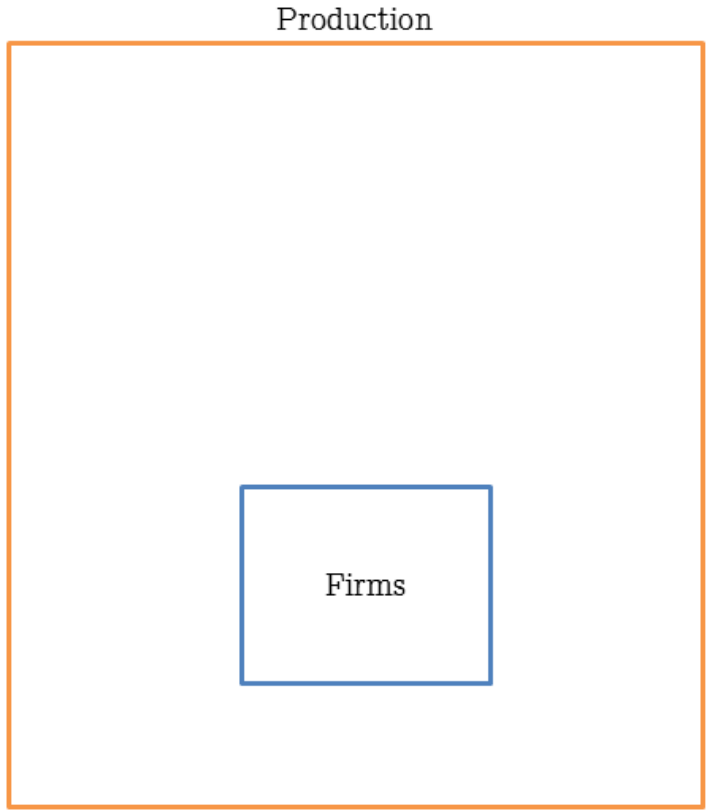
Modeling Framework



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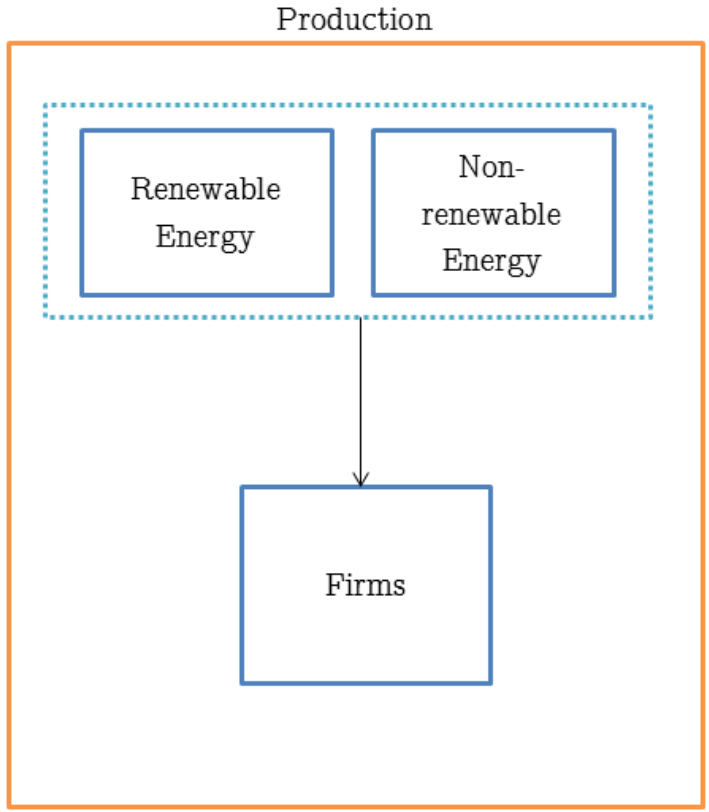

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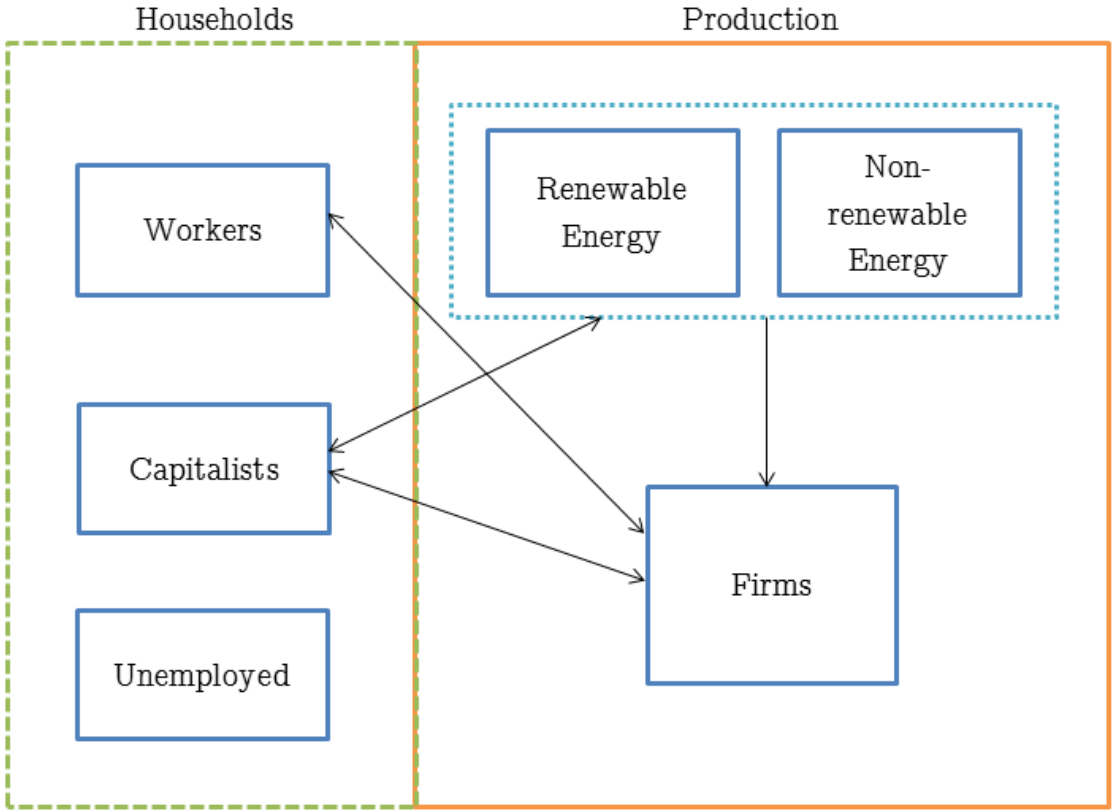

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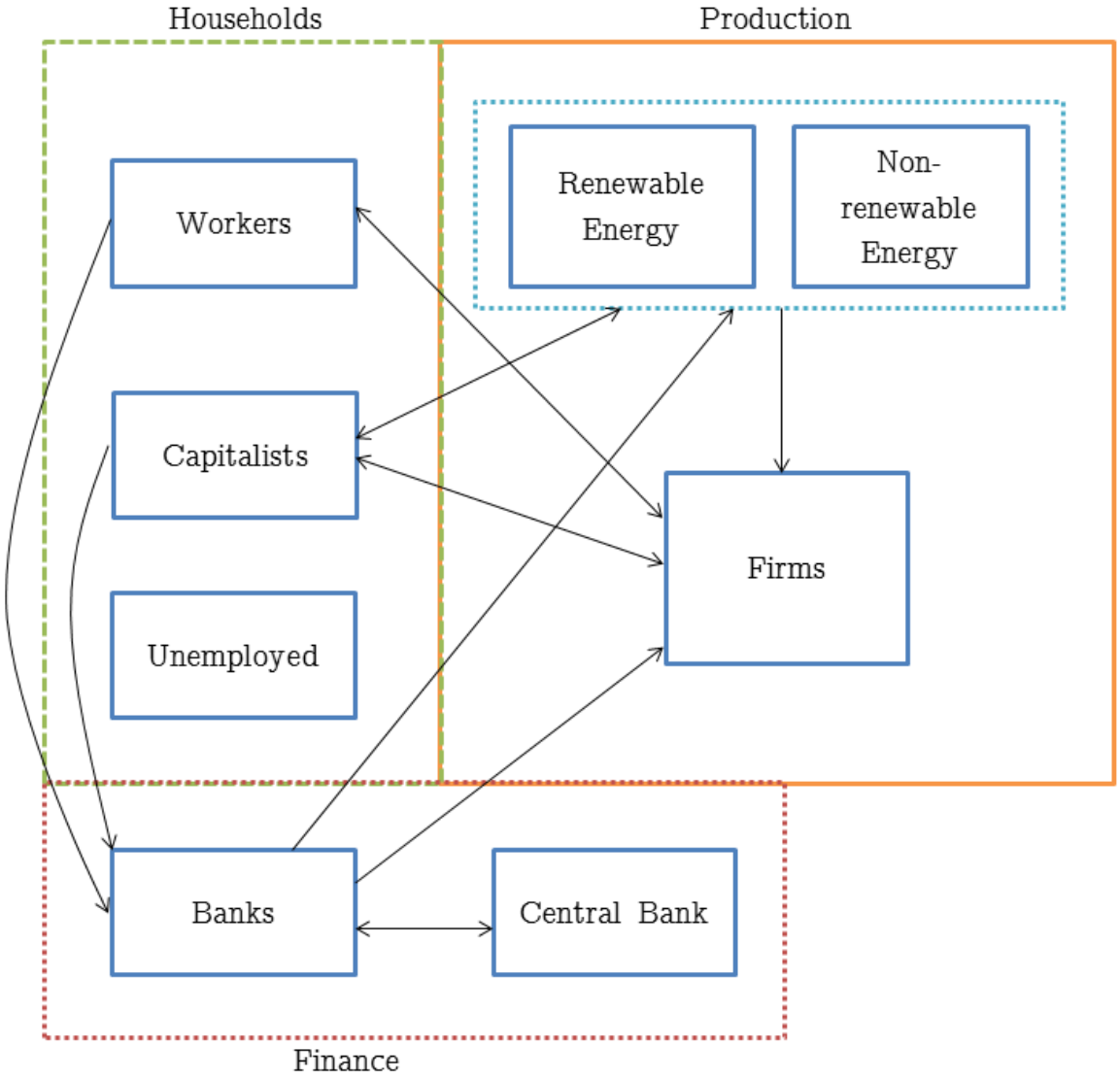

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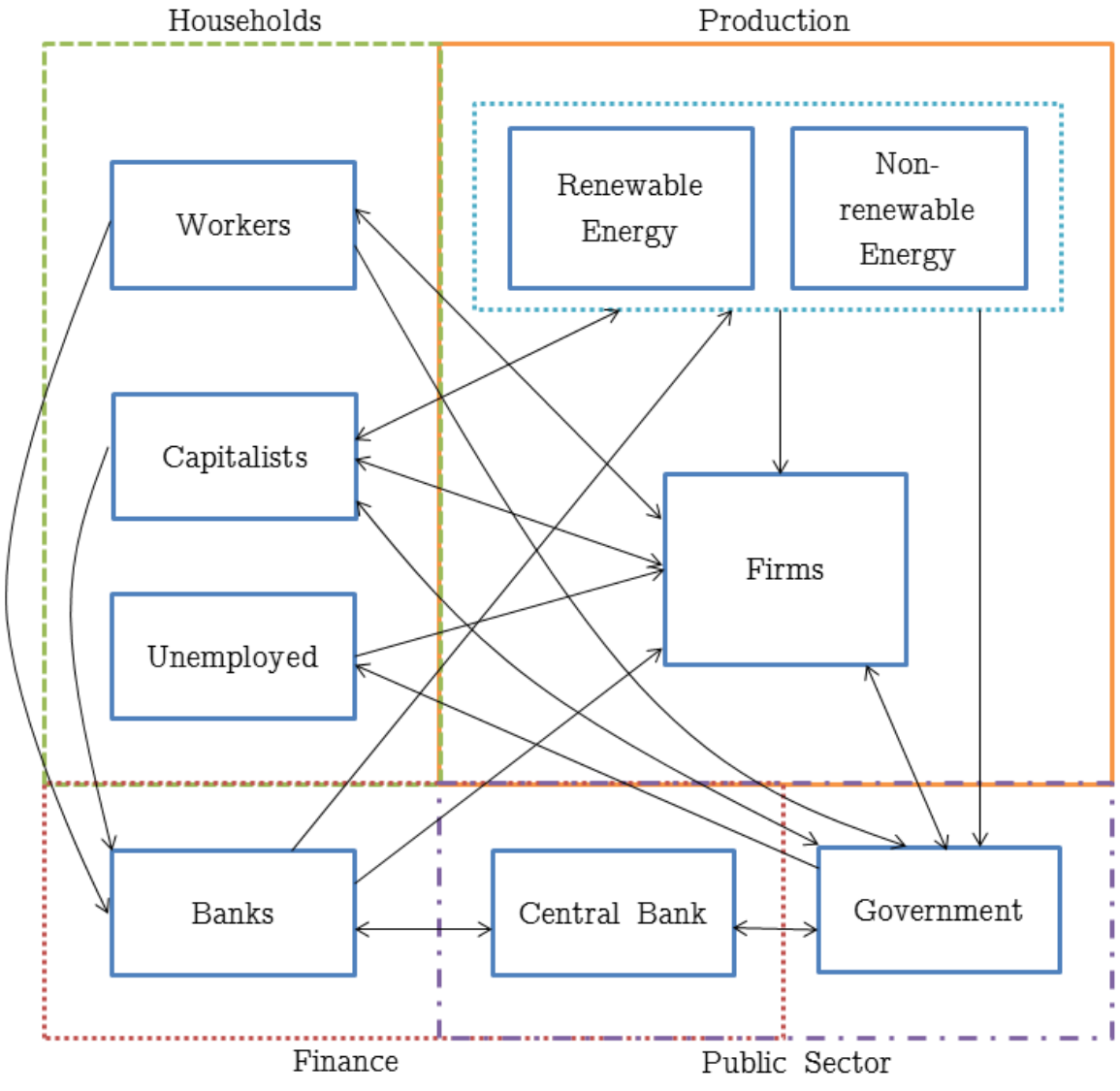

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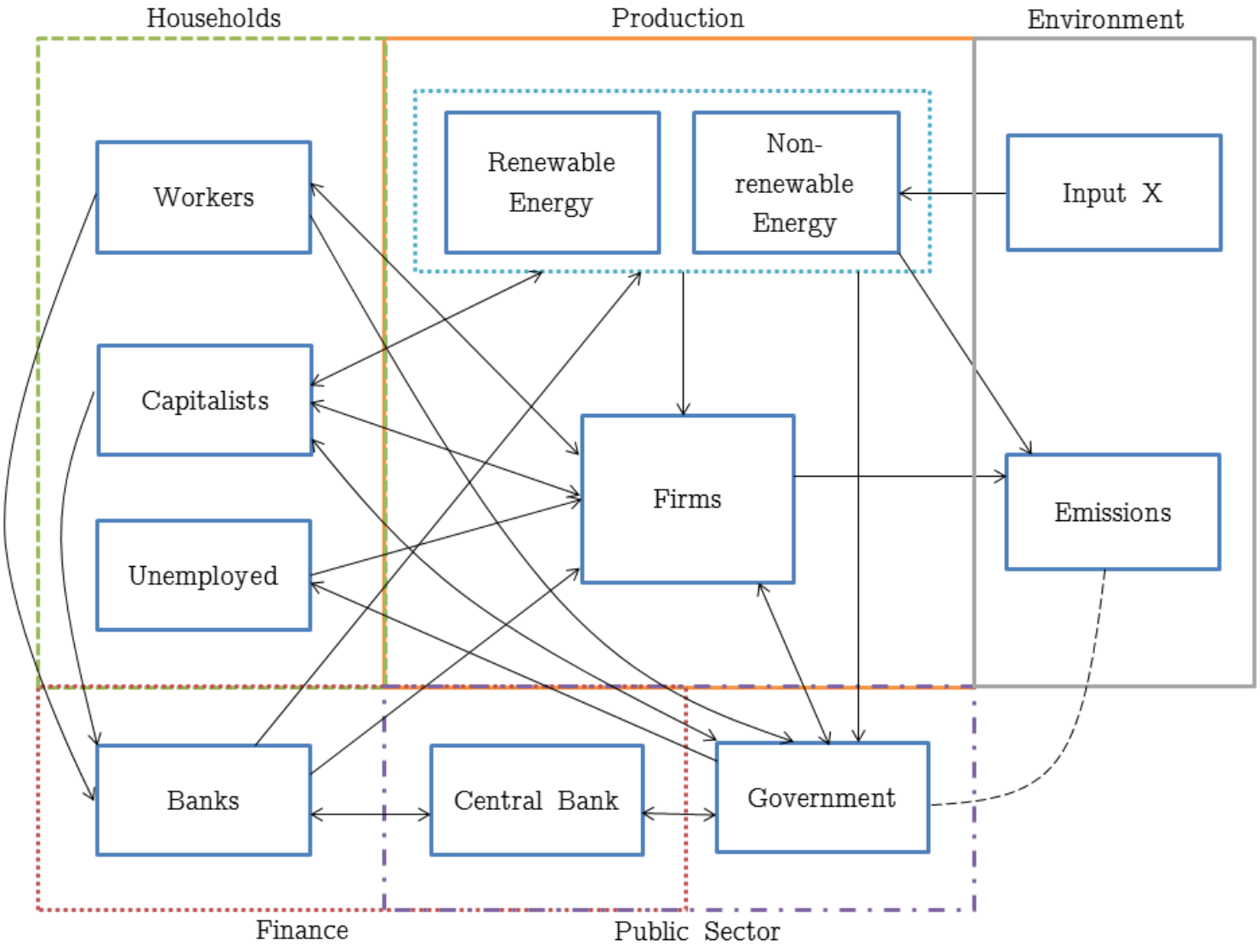

Balance Sheet

	Households			Production			Financial		Govt.	$\sum$
	Unemp.	Workers	Capitalists	Firms	Energy - X	Energy - R	Banks	Central Bank		
Capital stock				$+K$	$+K^X$	$+K^R$				$+K$
Inventories				$+IN$	$+IN^X$					$+INV$
Cash		$+M^h$	$+M^k$					$+M$		0
Bank Deposits		$+D^h$	$+D^k$				$-D^b$			0
Advances							$-A^b$	$-A$		0
Bills							$+B^b$	$+B^{CB}$	$-B$	0
Loans				$-L^f$	$-L^X$	$-L^R$	$+L$			0
$\sum$	0	$+V^h$	$+V^k$	$+V^f$	$+V^X$	$+V^R$	0	0	$-V^G$	$+NV$

Transition Matrix

	Households			Production			Financial		Govt.	$\sum$
	Unemp.	Workers	Capitalists	Firms	Energy - X	Energy - R	Commercial Banks	Central Bank		
Consumption	$-C^u$	$-C^h$	$-C^k$	$+S$					$-G$	0
Energy				$-EB$	$+E^X$	$+E^R$				0
Investment				$+I$	$+I^X$	$+I^R$				0
ΔInventories				$+\Delta IN$	$+\Delta IN^X$					0
Wages		$+WB$		$-WB$						0
Unemp. Benefits	$+UB$								$-UB$	0
Bank profits			$+\Pi^b$				$-\Pi^b$			0
Firm profits			$+\Pi^f$	$-\Pi^f$						0
Energy profits			$+\Pi^E$		$-\Pi^X$	$-\Pi^R$				0
CB profits								$-\Pi^{CB}$	$+\Pi^{CB}$	0
Taxes		$-T^h$	$-T^k$	$-T^f$	$-T^X$	$-T^R$			$+T$	0
i Advances							$-r_a A_{t-1}$	$+r_a A_{t-1}$		0
i Deposits		$+r_d D^h_{t-1}$	$+r_d D^k_{t-1}$				$-r_d D_{t-1}$			0
i Bills							$+r_b B^b_{t-1}$	$+r_b B^{CB}_{t-1}$	$-r_b B_{t-1}$	0
i Loans				$-r_l L^f_{t-1}$	$-r_l L^X_{t-1}$	$-r_l L^R_{t-1}$	$+r_l L_{t-1}$			0
ΔAdvances							$+\Delta A$	$-\Delta A$		0
ΔCash		$-\Delta C^h$	$-\Delta C^k$					$+\Delta C$		0
ΔDeposits		$-\Delta D^h$	$-\Delta D^k$				$+\Delta D$			0
ΔBills							$+\Delta B^b$	$+\Delta B^{CB}$	$-\Delta B$	0
ΔLoans				$+\Delta L^f$	$+\Delta L^X$	$+\Delta L^R$	$-\Delta L$			0
$\sum$	0	0	0	0	0	0	0	0	0	0

Key model assumptions

- Agent's decisions are adaptive, based on past variables
- Decisions are made on real variables, accounts maintained in nominal variables
- Agents have a liquidity preference
  - Households: deposits
  - Firms: inventories
- Production requires three complimentary inputs: Labor, Capital, Energy
- Prices are set by producers as markup over costs
- Investment decisions are determined by capacity utilization rate

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Firms - Production

- Output (Y_t) = Sales (S_t) + change in inventories (ΔIN_t)
  - Sales (S_t) = HH demand (C_t) + Government demand (G_t)
  - Inventories (IN_t) = unsold stock of produced goods
- Production process requires three complimentary inputs
  - Capital: $K_t = Y_t/\xi_{YK}$
  - Labor: $N_t = Y_t/\xi_{YN}$
  - Energy: $E_t = K_t/\xi_{KE}$
- Prices = markup over unit costs times tax
  - $p_t = UC_t(1+\theta)(+\tau)$

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- Desired investment in inventories
  - Fraction of past sales as inventories
  - Investment = target stock less existing stock
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Energy and Emissions

- Energy is supplied by two energy producers
  - a high-emissions, non-renewable input X
  - a 0-emissions, renewable input R
  - Share of clean energy is exogenously determined (policy variable)
- Energy production = energy demand by firms
  - price of energy = $p_t^E = UC_t^E(1+\theta)(1+\tau).X_t$
  - X_t is an exogenous extraction cost
- Firms and non-renewable energy production $\rightarrow$ results in emissions
  - $GHG_t = GHG_{t-1}(1-\Phi) + (y_t + y_t^X)/\xi_{GE}$

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- Experiment 2: Investment in capital and energy productivity

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Experiment 1 - Reduction in Consumption

- Slow growth hypothesis:
  - Consumption$\downarrow \rightarrow$Demand$\rightarrow$Production$\downarrow$
  - $\rightarrow$Wages$\downarrow \rightarrow$Production$\downarrow \rightarrow$Emissions$\downarrow$

- But what about secondary effects of this policy?
  - Impact on consumption distribution?
  - Impact on unemployment?
  - Impact on government spending?

- Test the above questions with a 10% reduction in consumption expenditure

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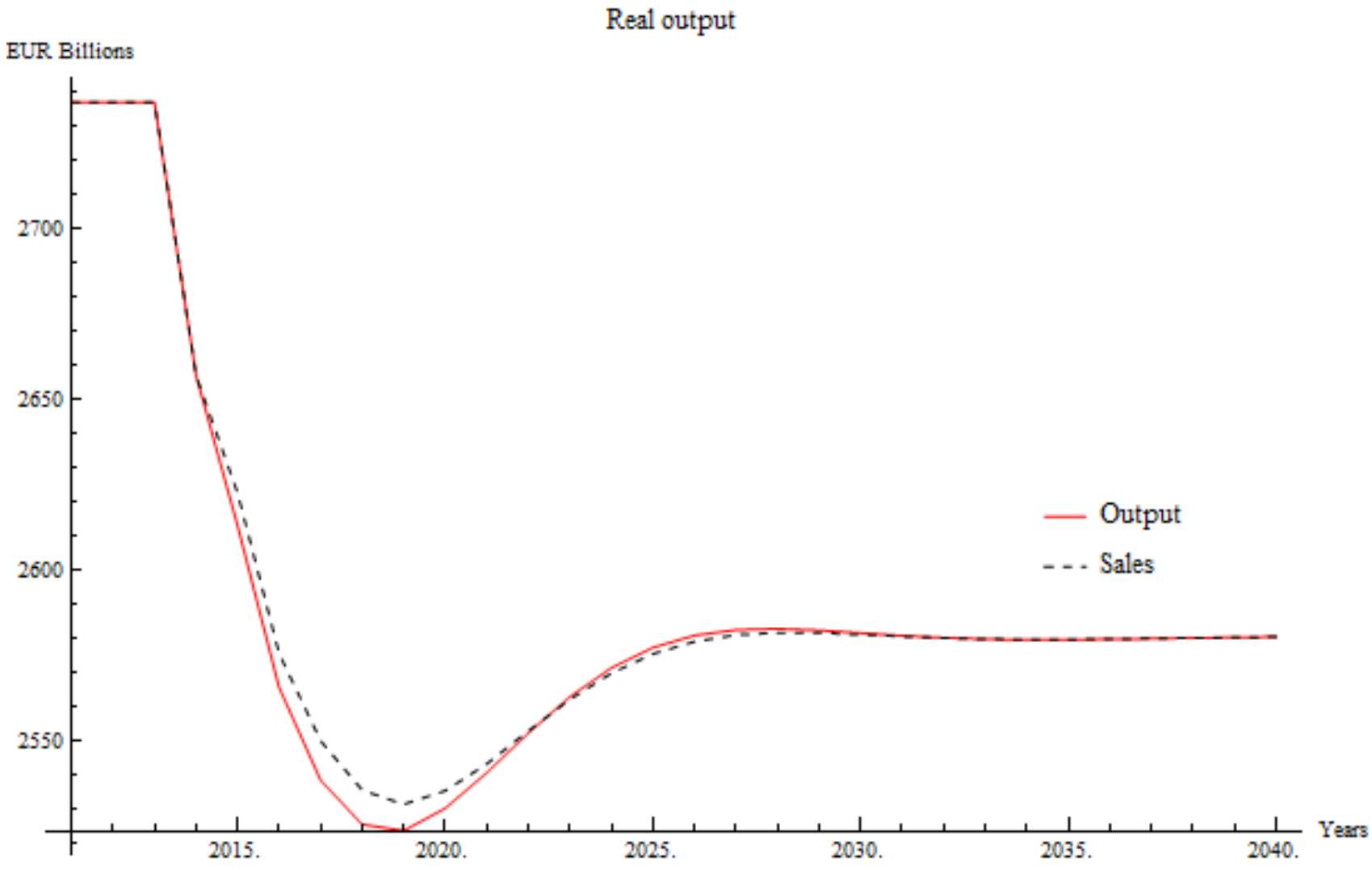
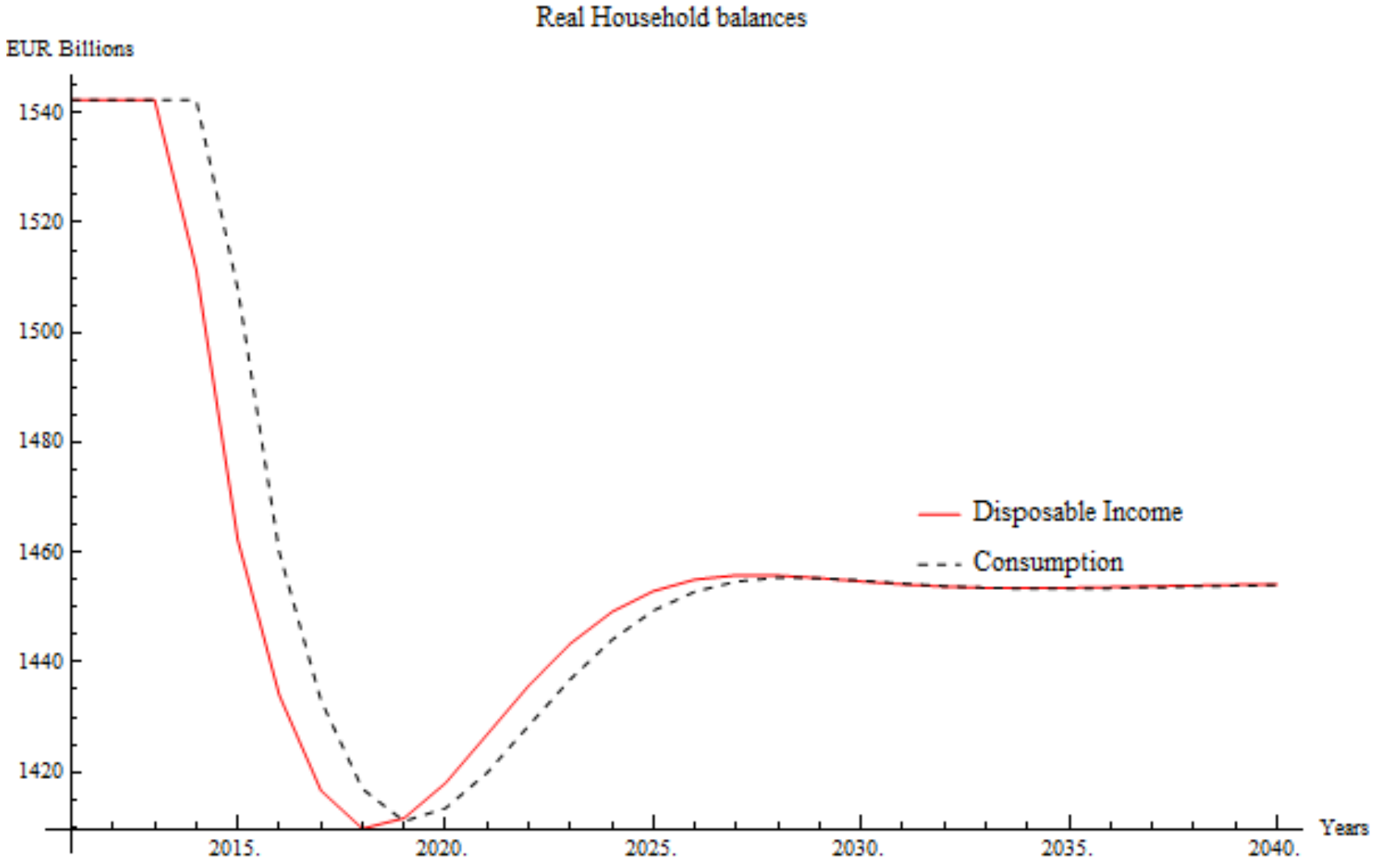
Key parameters

Parameter	Value	Description
N^k	5%	Capitalist population
ω	1	Unit wage rate
κ	1	Labor productivity per unit of labor
α_1	0.8	MPC income
α_2	0.2	MPC wealth
δ	0.1	Depreciation rate
τ	0.2	Tax rate
θ	0.1	Mark-up on costs
ϵ	0.5	Minimum consumption
Φ	0.01	GHG decay
ϕ	0.1	Share of renewable resource

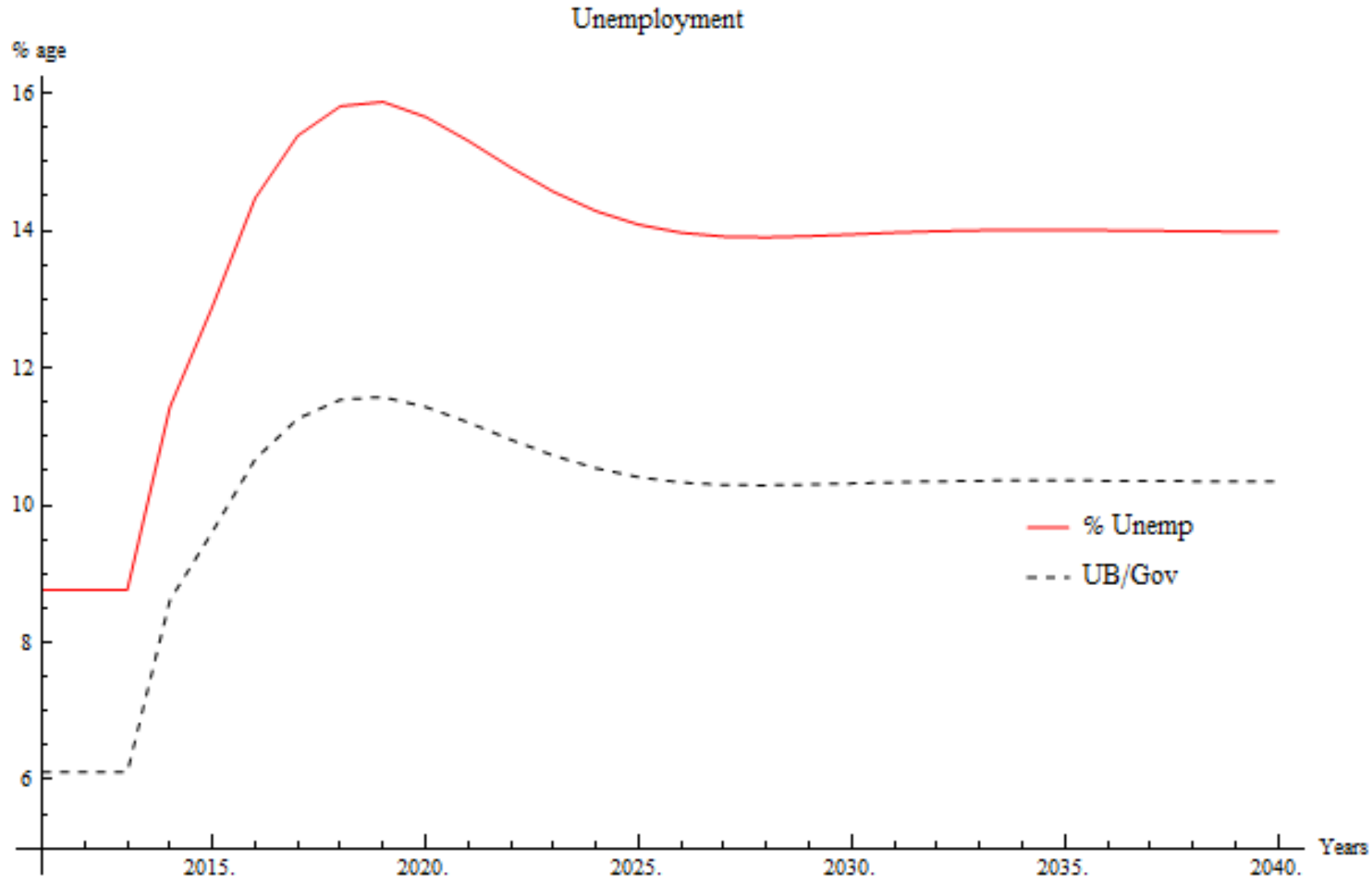
Experiment 1 - Output



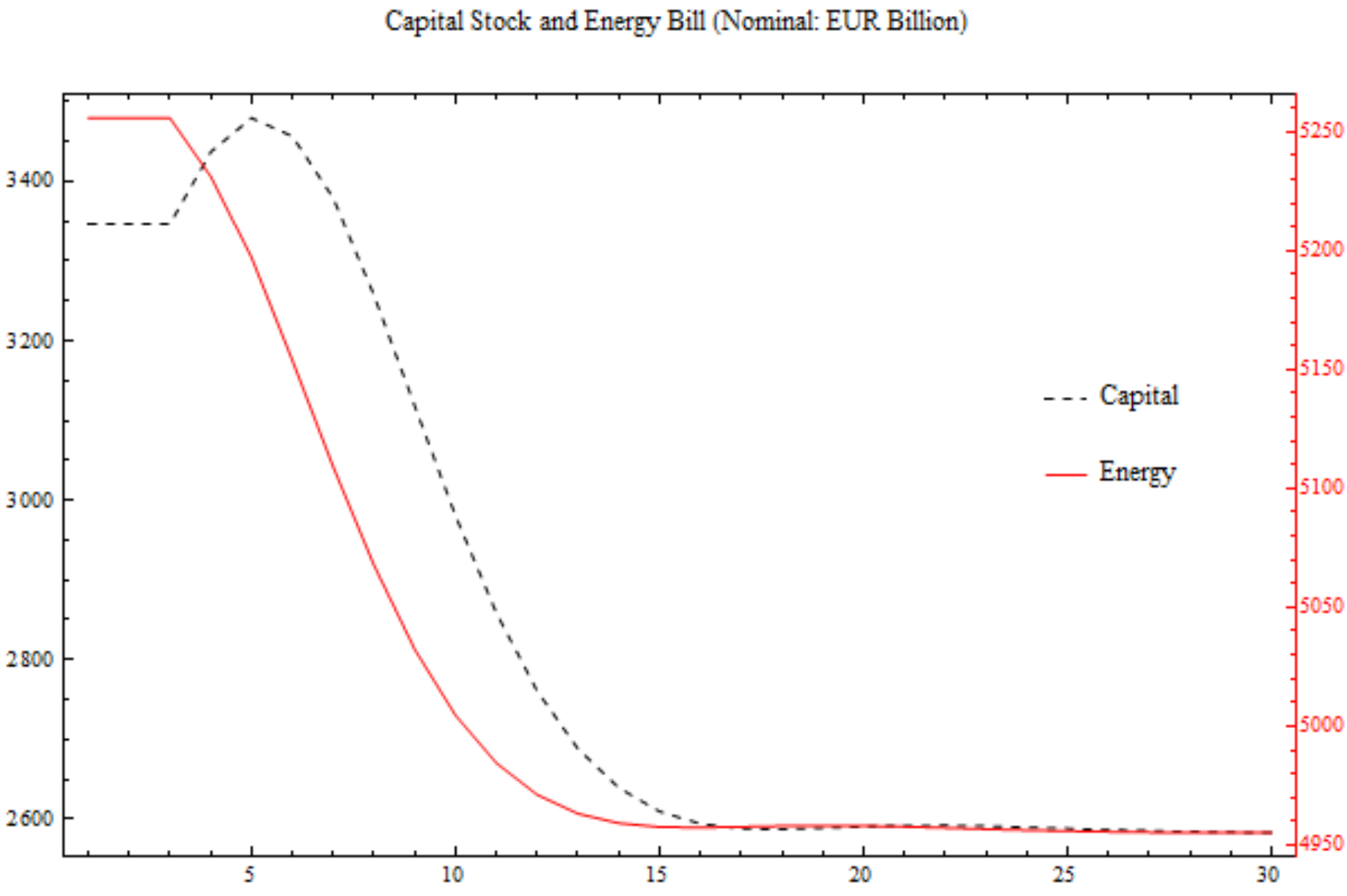
Experiment 1 - Income



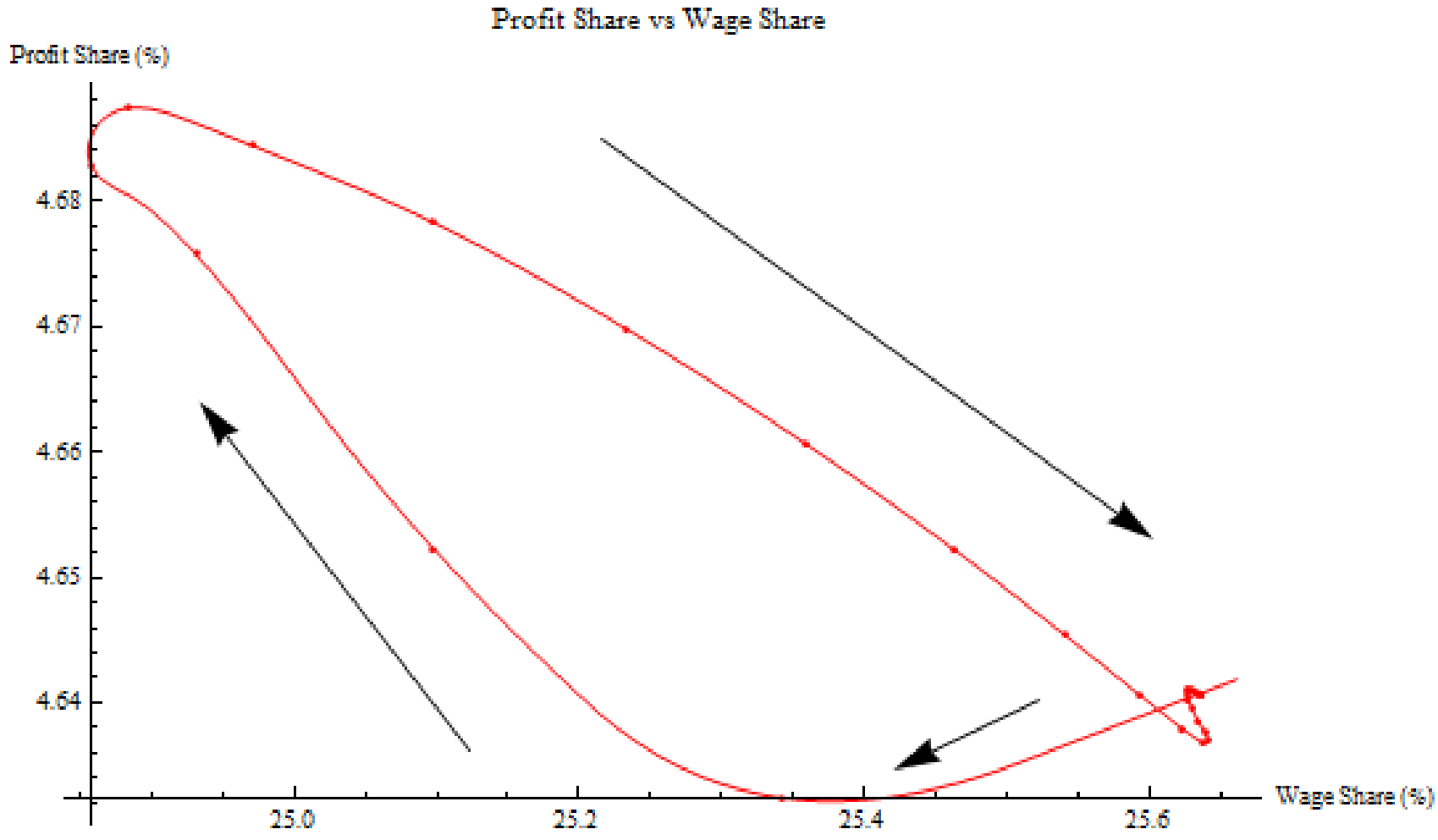
Experiment 1 - Unemployment



Experiment 1 - Capital and Energy



Experiment 1 - Cyclical adjustment



Experiment 2 - Innovation

- Generic production function of firms:
  - Output: $Y = f\left(K^f, L, E\right)$,
  - Y=output, K^f=firm capital, L=labor, E=energy
- Generic production function of energy producers:
  - $E = f\left(K^E, X\right)$
  - K^E =Energy capital, X =non-renewable input

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- Generic production function of energy producers:
  - $E = f\left(K^E, X\right)$
  - K^E =Energy capital, X =non-renewable input

Experiment 2 - Innovation

- Two innovation parameters
  - Capital per unit of output: $K = Y/\xi_{YK}$
  - Energy per unit of capital: $E = K/\xi_{KE}$

- ξ is a technology parameter
  - Increase in values of ξ implies technological innovation (efficiency)
  - Lower input requirement

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- We can derive the following identity

$$E \equiv \frac{Y}{\xi_{YK}\xi_{KE}}$$

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  - Assuming $\xi_{YK} = \xi_{KE} = 1$ and there is no change $(\Delta\xi = 0)$
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- Scenario 2
  - If innovation is allowed $(\Delta\xi > 0)$ and output goes up $\hat{Y} > 0$
  - then for the energy to go down $(\hat{E} < 0)$ the following condition must hold

$$\hat{\xi}_{YK} + \hat{\xi}_{KE} > \hat{Y}$$

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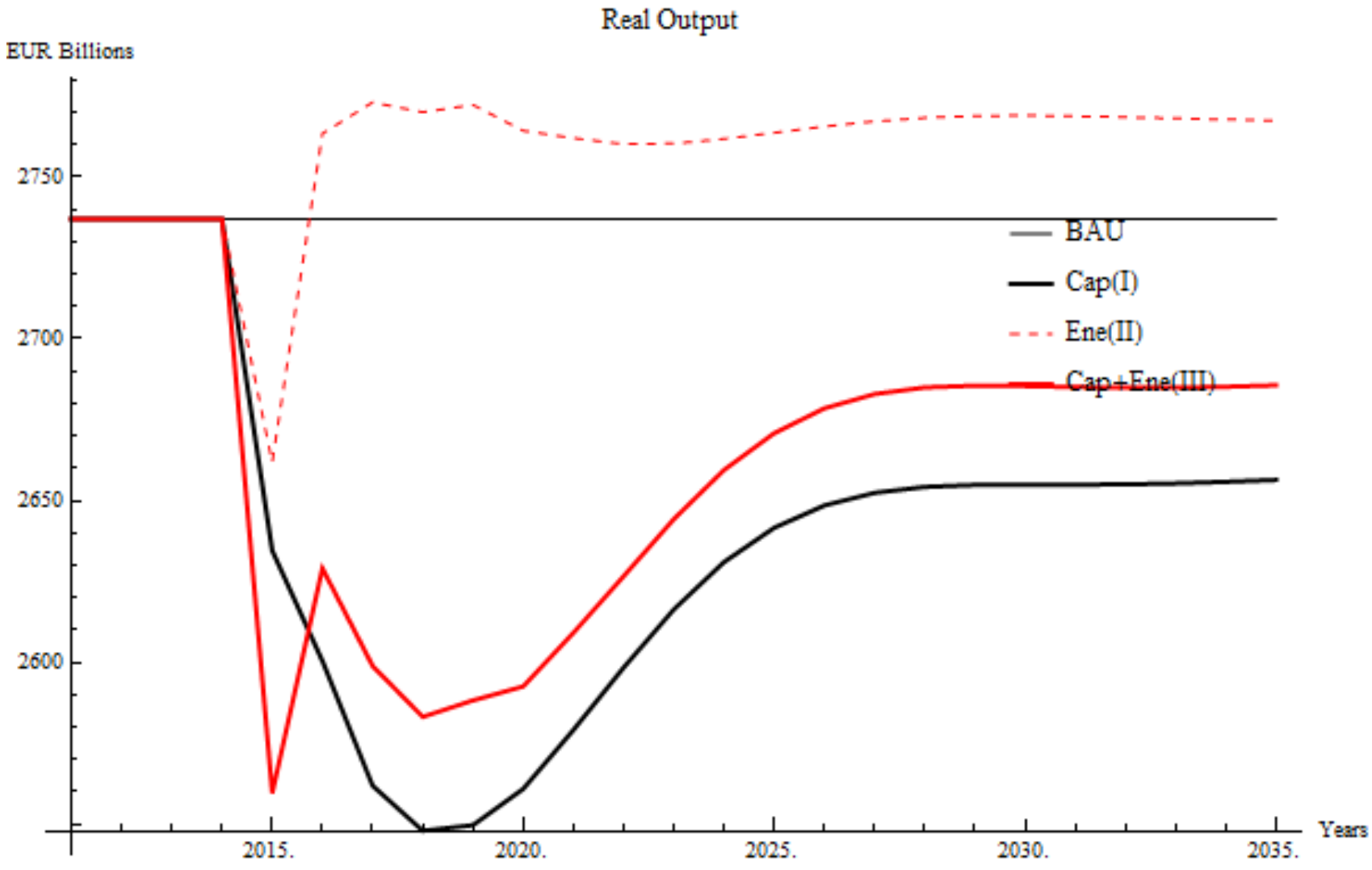
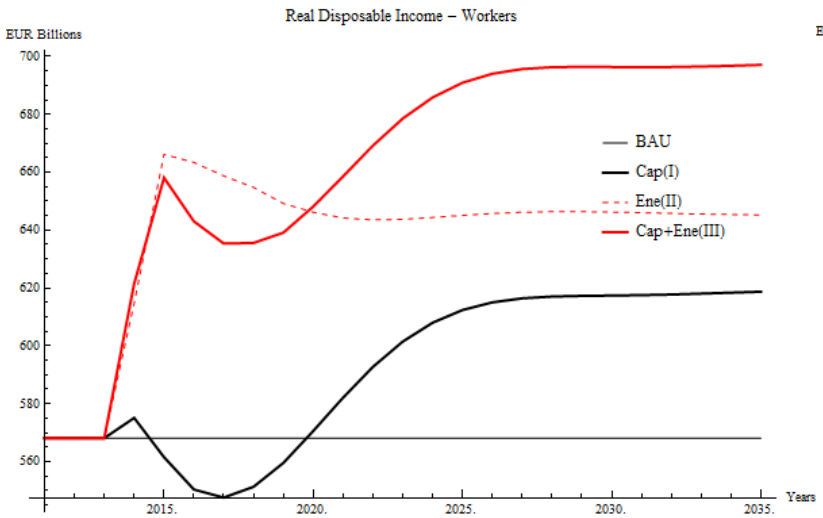
Experiment 2 - Three innovation scenarios

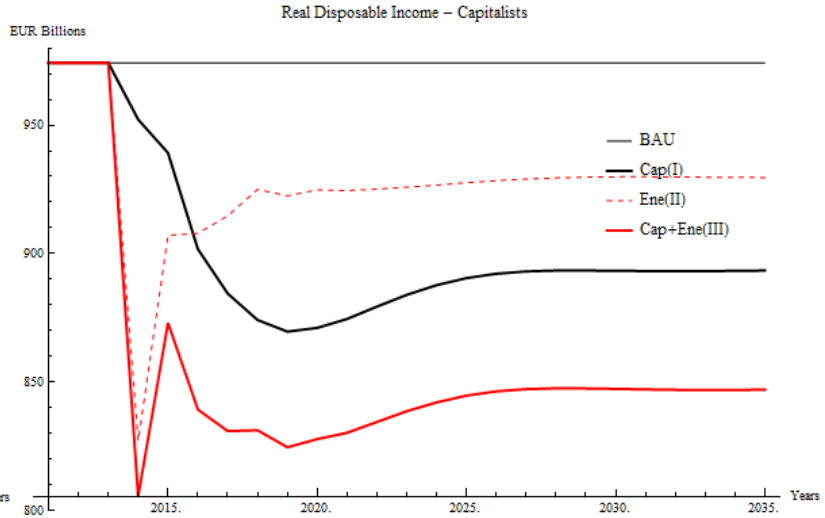
	Scenario	ξ_{YK}	ξ_{KE}
Business-as-usual	BAU	1	1
Increase in capital efficiency only	I	1.2	1
Increase in energy efficiency only	II	1	1.2
Increase in capital and energy efficiency	III	1.2	1.2

Experiment 2 - Output

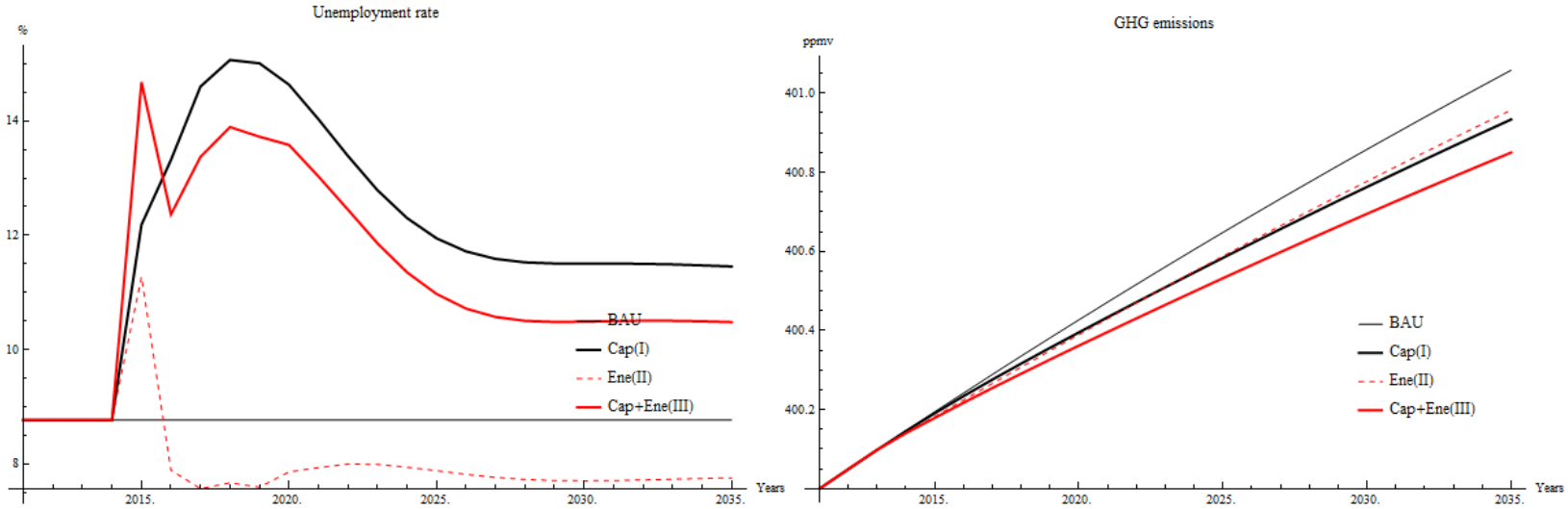


Experiment 2 - Income





Experiment 2 - Unemployment and emissions



Conclusions

- Experiment 1 - Reduction in consumption expenditure
  - Double burden on the government: high unemployment transfers, lower tax revenues
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  - Little change on aggregate demand, reduction of inequality by redistributing from capitalists to workers

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Further Possible Experiments

- Endogenous tax
- Endogenous depreciation rate
- Endogenous labor productivity
- endogenous non-renewable input X extraction costs
- Higher share of renewable energy

Future extensions

- HH investment in financial and physical assets
- Distinction between firm owning capitalists and bank owning capitalists
- Profit, capital gain taxes
- Employment in multiple sectors
- Endogenous technological change
- Endogenous energy allocation
- Output and population growth
- Model calibration: (Eurostat data for the EU)

Modeling framework

- The model factors in all major sectors in an economy
- Analytical and tractable
- Can be increased in complexity
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- Can be adapted for country/world level analysis

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Thank you!

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