Association for Heterodox Economics
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Future directions of economics teaching: economics and climate change

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Introduction

- Despite the recurrent economic and financial crises, the pandemic, and the climate emergency, **economics teaching has not changed much**.
- Economics is still taught as if capitalist economies were **village fairs**, where perfect-foresight individuals barter products against other products.
- Market forces always allow the economy to achieve a **unique, stable and optimal equilibrium** in the long run.
- Each economic behaviour can (and must) be expressed in terms of a problem of **optimisation of individual wellbeing** subject to constraints.
- Economic policy aims at maximising social welfare (= $\sum$ utility of individual consumption). The ecosystem is just a **constraint**.
- It is, therefore, no surprise that a **standard economics CV** does not include an analysis of CO_2 emissions, climate change or waste.

What to teach: EE and other missing topics

- **Ecological economics** – the economy is embedded within the society, which in turn is embedded within the ecosystem.
- **History of economic thought** – how the economy, the society, and the broad environment interact with each other, thus shaping economics ideas.
- **Philosophy of social sciences** – economics deals with a complex system: emerging behaviour is not the summation of parts.
- **Methodology of social sciences** – we should teach a plurality of methods:
  - Quantitative methods (prey-predator-like models, AB models, SFC models, system dynamics, machine learning, network analysis, input-output analysis, etc.)
  - Qualitative methods (case studies, interviews, etc.)
- **Crucial concepts** from other social and natural sciences (complexity, hysteresis, tipping points, multiple equilibria, circular economy, etc.)

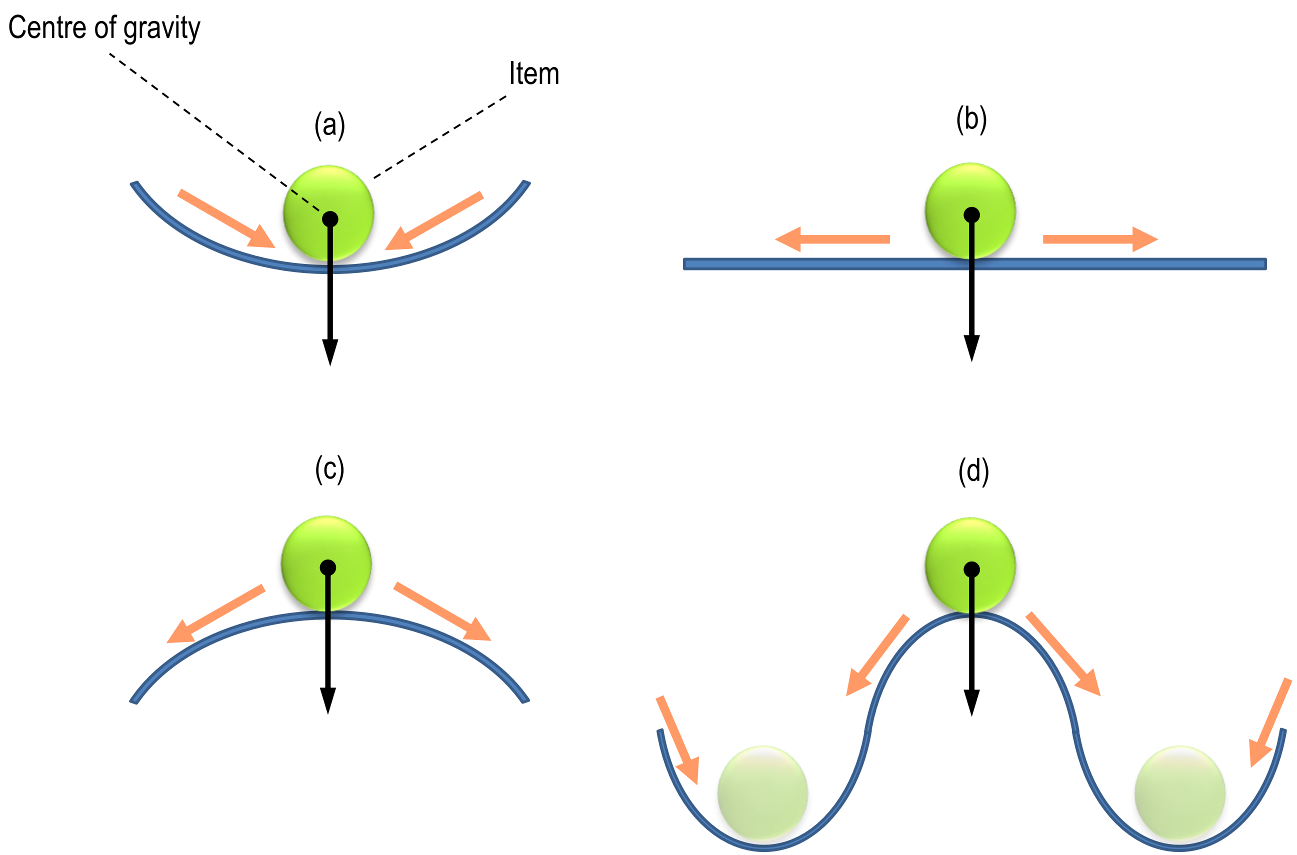
How (*not*) to teach ecological topics

- No dynamic optimisation subject to constraints (e.g. Nordhaus 2018), but **non-linearity, complexity and evolution**
- No objective fine-tuning of the policy rate around its "natural" value, but **political nature** of policy decisions
- No substitution of inputs (e.g. physical capital for natural capital) in the production process, but **"uniqueness" of natural resources**
- No optimal increase in temperature, but **precautionary principle and minimisation of human footprint** (in advanced economies)
- No willingness to pay, as preferences and actual choices are **shaped by social interaction** and institutions
- As a result:
  - At micro level, **standard cost-benefit analysis is not reliable**
  - At macro level, **general equilibrium models are useless**

Two examples

from my modules and papers

Which equilibrium?



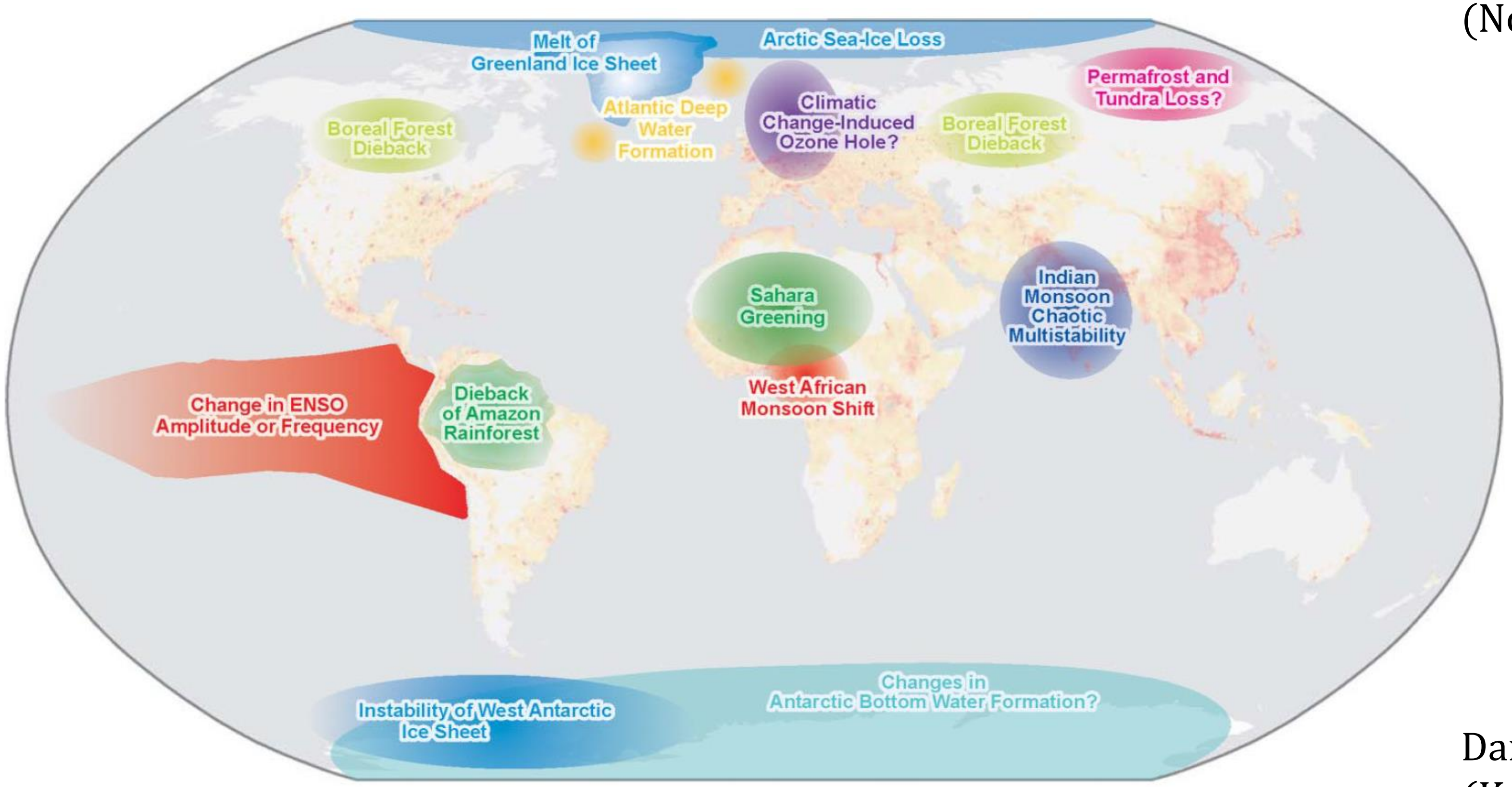
(a) **Unique and stable equilibrium**: Solow growth model, and other general equilibrium models (representative agent).

(b) **Neutrality condition**: Neo-Austrians, Real Business Cycle School (?)

(c) **Unstable equilibrium**: Keynes' *Treatise* (1930), Harrod-Domar model, Marxian reproduction schemes, and other heterodox.

(d) **Multiple equilibria**: Keynes' *General Theory* (1936), and other heterodox. Also Sonnenschein-Mantel-Debreu (1972-1974)!

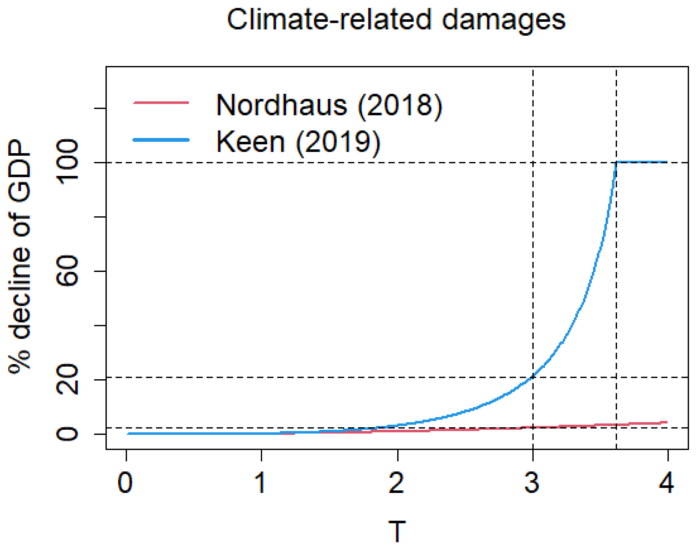
What's a tipping point?



Source: Lenton et al. 2008

Damages to GDP *without* tipping points (Nordhaus 2018):

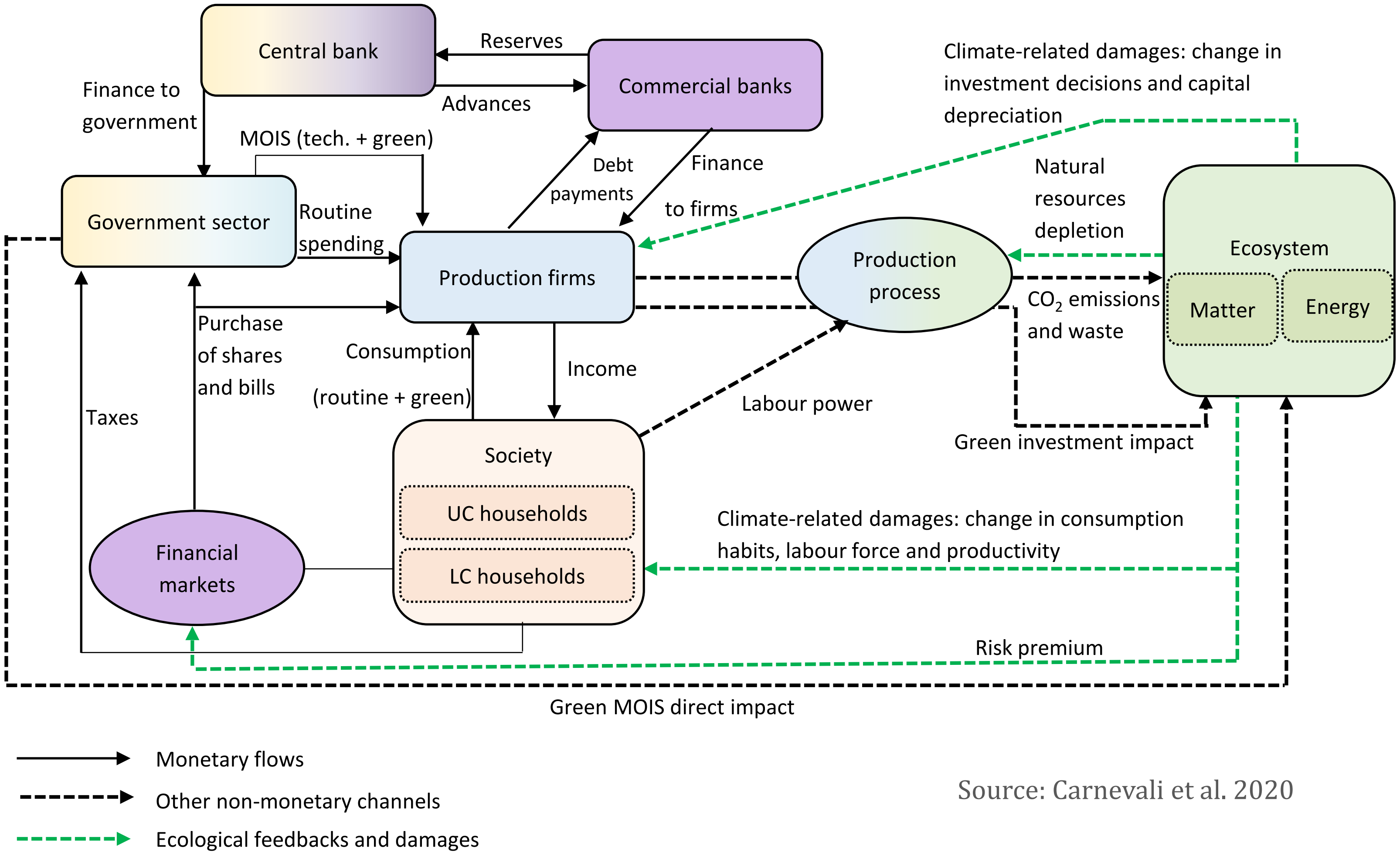
$$D(T_\Delta) = 0.00267 \cdot T_\Delta^2$$



Damages to GDP with tipping points (Keen 2019):

$$D(T_\Delta) = -0.007 \cdot \frac{T_\Delta^3}{T_\Delta - 4}$$

Circular cumulative causation...



Source: Carnevali et al. 2020

How to model it

economic system and climate change

Physical matrices

- Standard economic stock-flow matrices are not enough. They must be associated with two physical matrices.
- The **physical flow matrix**: accounting for the First and the Second Law of Thermodynamics. Matter and energy are transformed (not created or destroyed) by the economic process.
- The **physical stock-flow matrix**: defining the change in the stocks of things that directly influence human activities, e.g. natural reserves of matter and energy, and the socio-economic stock.

Physical flow matrix

	Material balance	Energy balance
Inputs		
Extracted matter	$+MAT$	
Renewable energy		$+ER$
Non-renewable energy	$+CEN$	$+EN$
Oxygen	$+O_2$	
Outputs		
Industrial emissions	$-EMIS_{in}$	
Waste	$-WA$	
Dissipated energy		$-ED$
Change in socio-economic stock	$-\Delta K_{se}$	
Σ	0	0

Source: my elaboration on Dafermos et al. 2017. Notes: Matter is measured in Gt while energy is measured in EJ. A '+' sign denotes inputs in the socio-economic system, whereas '–' denotes outputs.

Physical stock-flow matrix

	Material reserves	Energy reserves	Atmospheric CO_2 concentration	Socio-economic stock	Hazardous waste
Initial stock	$K_{m,-1}$	$K_{en,-1}$	$CO_{2\,AT,-1}$	$K_{se,-1}$	HWS_{-1}
Resources converted into reserves	$+CONV_m$	$+CONV_{en}$			
CO_2 emissions (global)			$+EMIS$		
Production of material goods				$+Y_{mat}$	
Non-recycled hazardous waste					$+haz \cdot WA$
Extraction/use of matter/energy	$-MAT$	$-EN$			
Net transfer to oceans/biosphere			$+TR$		
Demolition of socio-economic stock				$-DES$	
Final stock	K_m	K_{en}	$CO_{2\,AT}$	K_{se}	HWS

Source: my elaboration on Dafermos et al. 2017. Notes: Matter is measured in Gt while energy is measured in EJ. A '+' sign denotes additions to the opening stock, whereas '–' denotes reductions.

A simple model

Selected Model ECO-PC equations

New consumption function:	$C = (\alpha_1 \cdot YD + \alpha_2 \cdot V_{-1}) \cdot (1 - d_{T,-1})$	(5B)
Energy used:	$E = \epsilon \cdot Y$	(E1)
Renewable energy:	$ER = \eta \cdot E$	(E2)
Non-renewable energy:	$EN = E - ER$	(E3)
Stock of energy reserves:	$K_E = K_{E,-1} + CONV_E - EN$	(E4)
Converted resources:	$CONV_E = \sigma_E \cdot RES_E$	(E5)
Energy resources:	$RES_E = RES_{E,-1} - CONV_E$	(E6)
Industrial emissions:	$EMIS_{IN} = \beta \cdot EN$	(E7)
Climate-related damages:	$d_T = 1 - \frac{1}{1+\eta_1 \cdot T_{AT}+\eta_2 \cdot T_{AT}^2+\eta_3 \cdot T_{AT}^z}$	(E8)
Potential output:	$Y^L = \min\left(a \cdot LF \cdot h, \frac{K_{M,-1}+REC}{\mu}, \frac{K_{E,-1}}{\epsilon}\right)$	(E9)
Price level:	$p = \pi_0 + \pi_1 \cdot (Y_{-1} - Y_{-1}^L)$	(E10)

Note 1: $0 \leq d_T \leq 1$ and η_3, z are such that: $d_T = 0.5\ if\ T_{AT} = +6\ °\mathrm{C}$.

Note 2: Additional equations are necessary to close the model.

Identity (E3, E4, E6)

Behavioural equation (5B, E1, E2, E5, E7, E8, E9, E10)

Simulations

Figure E.1 - CO2 annual emissions following an increase in 100 points in the rate of interest on bills (difference with baseline value)

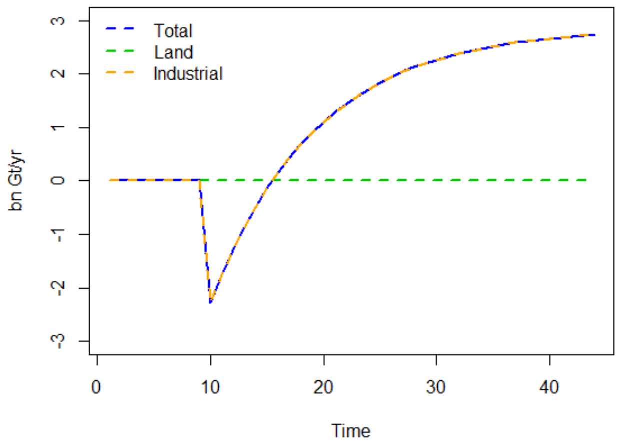


Figure E.2 - Temperature following an increase in 100 points in the rate of interest on bills (difference with baseline)

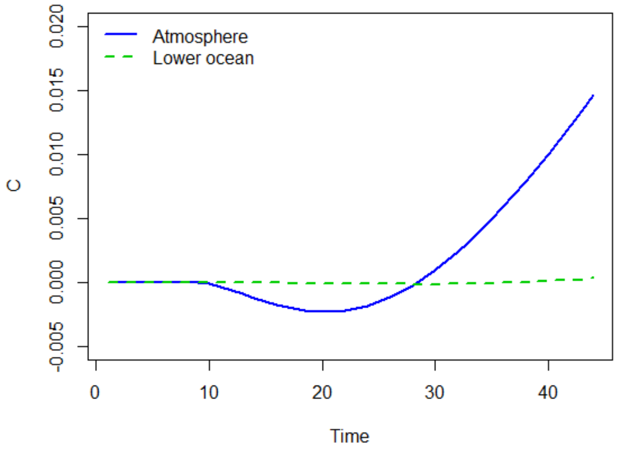


Figure E.3 - Depletion rates following an increase in 100 points in the rate of interest on bills (difference with baseline)

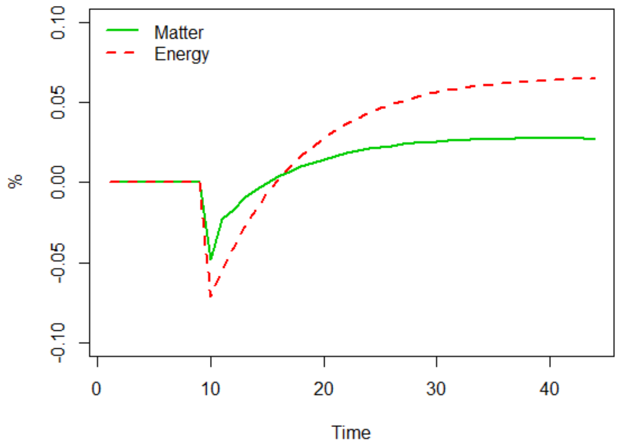
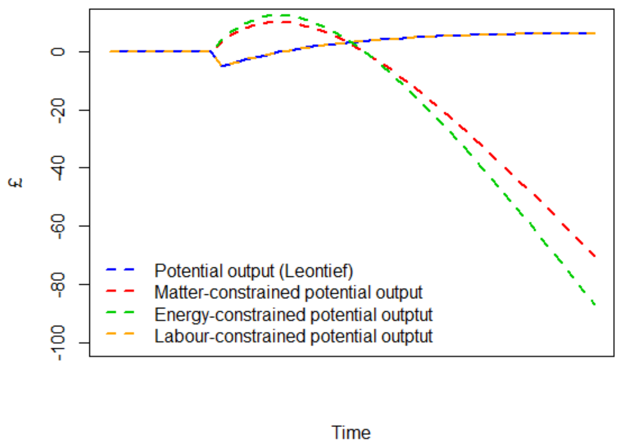


Figure E.4 - potential output following an increase in 100 points in the rate of interest on bills (difference with baseline)



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Thank you

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