L'Economia Política Clàssica en el Context de la Desigual Crisi Climàtica

des de la perspectiva actual de la ciència de la complexitat

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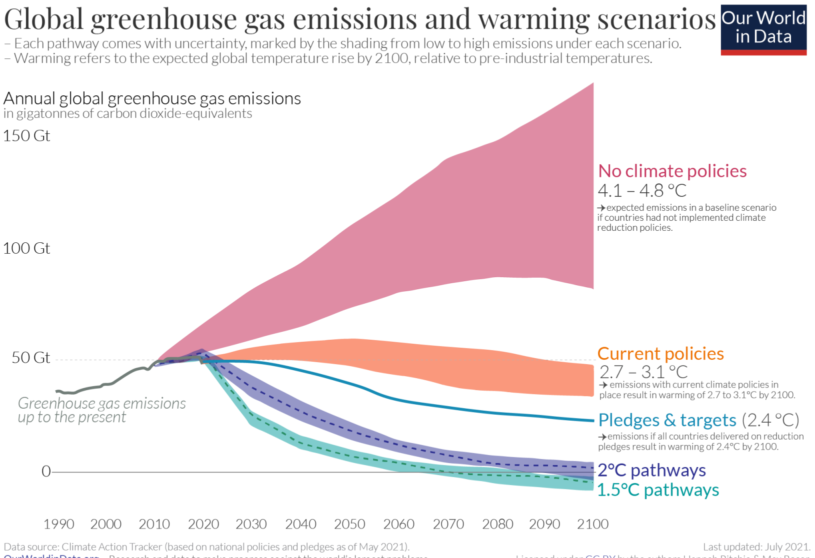
Towards a Climate Catastrophe?



Climate Change, Ultimate Challenge for Economics

- Carbon pricing is the current consensus optimal policy among economists [Nordhaus, 2019]
- Current climate models, such as Integrated Assessment Modeling (e.g. Nordhaus' DICE), may be grossly misleading [Stern, 2007, Anderson and Bows, 2011, Pindyck, 2013, Keen, 2020]
    - **Underestimation of the security threat** of the climate crisis
    - **The environment is a complex system**, subject to nonlinear feedback effects, beyond tipping points of no return
    - Inflationary pressures in energy and food markets

Economic Theory in the Face of the Uneven Climate Crisis

- **Research Question** How can fiscal policy accelerate the decarbonization of the economy to keep world temperatures rising below 2°C, while stabilizing energy and food markets? *How much time have we left to address the climate crisis?*
- **Macroeconomics of Complex Structural Change**
  - Input-Output Analysis
  - Dynamical-Systems Theory
- Classical **time** and **reproduction** instead of neoclassical **optimality**
- **Mazzucato: shaping the market** instead of **fixing market failures** [Kattel et al., 2018]
- Green **quantities** and carbon **prices**

New Directions

- Conventional framing of climate policy is economically detrimental as a poor description of strategic incentives [Mercure et al., 2021]
- Positive spillover effects in green employment and output of climate policy [Mittnik et al., 2014]
- Mobilizing green finance? De-risking private investment through green bonds [Heine et al., 2019, Semmler et al., 2021, Braga et al., 2021]
- Ecologically-extended North-South stock-flow consistent models [Jackson et al., 2016, Dafermos et al., 2018]
- Directed technical change via fiscal policy mixes [Acemoglu et al., 2012, Acemoglu et al., 2016]

Self-Reproducing Ecosystems [Cerina et al., 2015]

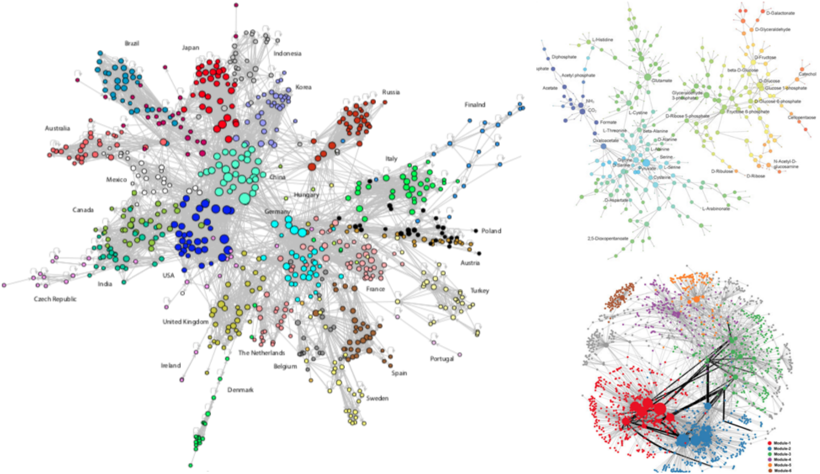
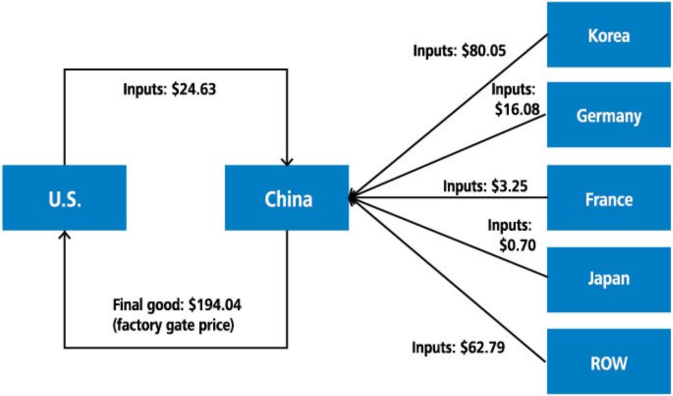


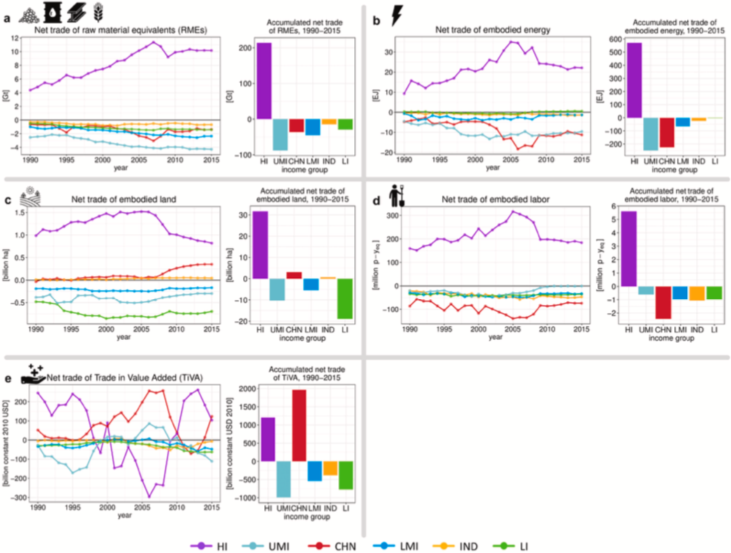
Figure: The World Input-Output Network (left), a metabolic network (top-right), and a gene regulation network (bottom-right)

The Global Value Chain of an iPhone [OECD 2011]

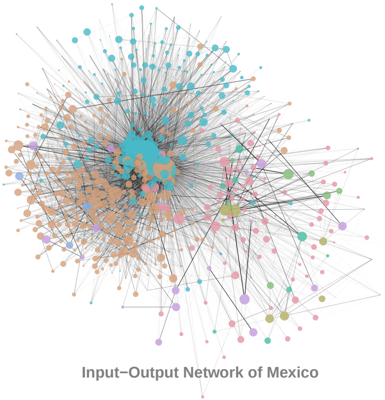


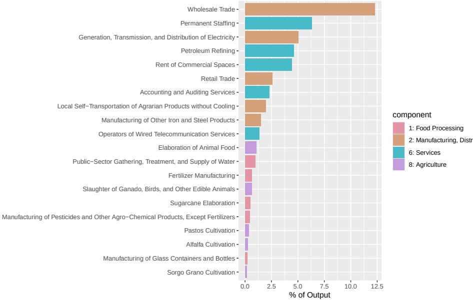
Us trade balance with	China	Korea	Germany	France	Japan	Rest of world	World Total
Gross	-$169.41	0	0	0	0	0	-$169.41
Value added	-$6.54	-$80.05	-$16.08	-$3.25	-$0.70	-$62.79	-$169.41

Ecological North-South Uneven Exchange [Dorninger et al., 2021]



The Economic Structure of Mexico





Kondratieff's long waves in history

long wave phase	begin	end	historical period
upswing	1780-1790	1810-1817	French revo. - Napoleonic wars
downswing	1810-1817	1844-1851	Napoleonic wars - 1848 revos
upswing	1844-1851	1870-75	Liberal revos - German unification
downswing	1870-1875	1890-1986	Long Depression, Africa Scramble
upswing	1890-1896	1914-1920	Liberal Belle Époque - WW1
downswing	1914-1928/29	1939-1950	Fascism, Great Depression
upswing	1939-1950	1968-1974	WW2 - Wirtschaftwunder
downswing	1968-1974	1984-1991	Great Stagflation - collapse USSR
upswing	1984-1991	2008-2010?	Great Moderation, neoliberalism
downswing	2008-2010?	2030-2040?	Arab Spring, neofascism

Table: Kondratieff's long waves [Korotayev and Tsirel, 2010]

Schumpeter's creative destruction

Major waves of radical innovations in technology, followed by diffusion and lock-in of incremental innovations:

- **water-powered** mechanization of industry in 18th and early 19th centuries
- **steam-powered** mechanization of industry and transport in mid-19th century
- **electrification**, end of 19th century
- **motorization** of industrial production, war machinery (1914 - onward)
- **computerization** and information technology (1960/1970s - onward, oil)

Classical Dynamics

Exponential Growth in a Limited-Resource World		
Model	**Dimensions**	**Topic**
Bhaduri-Harris	1	Complex Dynamics of the Simple Ricardian System

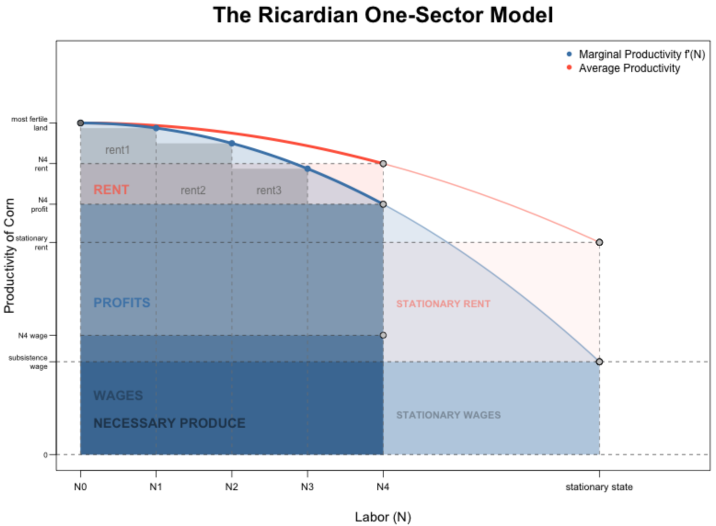
Predator-Prey Oscillations with 2+ Dimensions				
Model	**Dimensions**	**Topic**	**Prey**	**Predator**
Goodwin	2	Distribution	employment rate	labor share of income
Flaschel-Semmler	$2N$	Growth	prices/profits	quantities/capital

Ricardian Logistic Growth

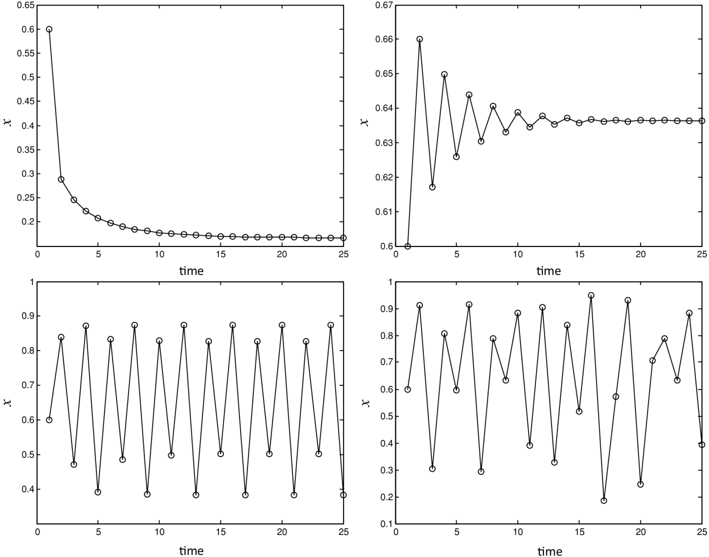
"The idea that the process of capitalist accumulation ultimately terminates in a stationary state is deeply rooted in the classical tradition of political economy. Ricardo, in particular, visualized the process of accumulation that is almost inexorably driven toward its end because the capitalists gradually lose command over the investible surplus as their profit dwindles due to increasing pressure of rent on **limited natural resources like land**."

[Bhaduri and Harris, 1987]

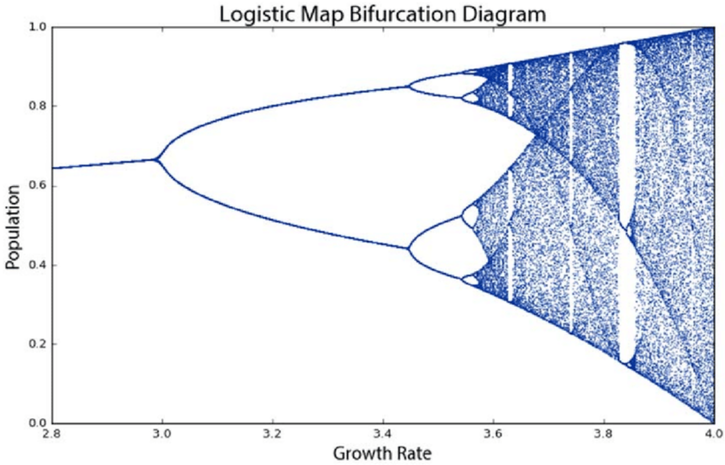
Visual Depiction of the Ricardian Model [Pasinetti, 1977]



Growth for 4 values of the rate parameter



Bifurcation Diagram: Chaotic Windows



Lotka-Volterra / Predator-Prey Oscillations

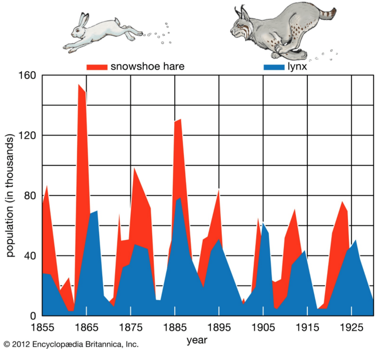


Figure: The Lotka-Volterra equations are frequently used to describe the dynamics of biological systems in which two species interact. Originally proposed in the theory of **autocatalytic chemical reactions**. In the Goodwin model, the employment rate plays the role of prey and the labor share of income, the role of predator.

Goodwin's model of capital accumulation [Goodwin, 1982]

- Lotka-Volterra oscillations, with **employment rate** as prey and the **labor share of income** as predator
- **class struggle** distributional conflict produces endogenous cycles
- fluctuating workers' bargaining power over wages depends on fluctuating unemployment rate regulated by investment and the profit share of income
- "profit squeeze" model with wage-price dynamics

Goodwin Cycles International Empirical Evidence

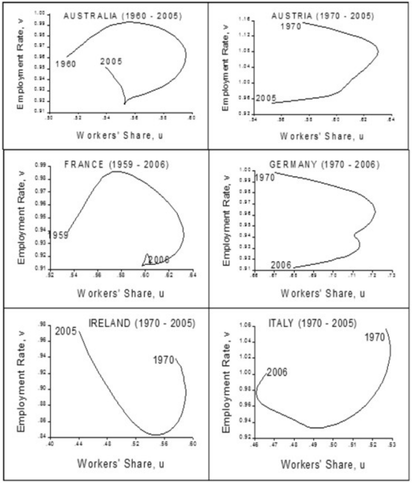


Figure: Clockwise Cycles in the Employment-Distribution Space [García Molina and Herrera Medina, 2010]

Assessing the Speed of the Green Transition

- A dynamical model of multi-sector growth with technological innovation [Flaschel and Semmler, 1992] is employed in order to assess the **adjustment speeds of the technical substitution of specific carbon sectors** by green sectors:
  - C19, Manufacture of coke and refined petroleum products
  - D, Electricity, gas, steam and air conditioning supply
- Complex pattern of classical oscillations around equilibrium as center of gravity (prices/profits as prey, quantities/capital as predator)

Method: A Machine-Learning Algorithm

- The linear adjustment coefficients are empirically calibrated for Germany, France, Italy, Netherlands, Japan, and the US using a random-effects model with varying slopes on EU KLEMS and WIOD input-output data.
- Directed technical change is enforced by a tax-subsidy policy mix [Acemoglu et al., 2016]
- Simulations are computed to evaluate the impact of specific parameters on the speed of the transition:
  - relative technical efficiency θ [0.7-1.1] between the carbon and green sectors
  - initial investment ratio $\sigma = x_g/x_c$ [$<$.1]
  - tax on carbon output τ
  - green subsidy τ' (raised on the taxed carbon output)

Expanded Reproduction Sraffa-von Neumann Equilibrium

1. **Equilibrium in Quantities: Supply equals Demand**

$$\underbrace{x}_{\text{outputs}} = \underbrace{Ax}_{\text{inputs}} + \underbrace{f}_{\text{final demand}} = \underbrace{(1+r^*)}_{R} Ax \tag{1}$$

2. **Equilibrium in Prices: Expansion (profit) rates are uniform across sectors**

$$\underbrace{p^*}_{\text{unit revenues}} = \underbrace{(1+r^*)}_{R} \underbrace{p^* A}_{\text{unit costs}} \tag{2}$$

Balanced Growth p^* and x^* are the positive eigenvectors of A, the matrix of input-output coefficients, and $R = 1 + r^*$, the expansion factor, corresponds to the dominant eigenvalue.

Constant-Technology Dynamics

The model is based on the dynamic cross-dual linear adjustment between prices and quantities.

1. **Law of Excess Demand** demand-supply imbalances trigger changes in prices

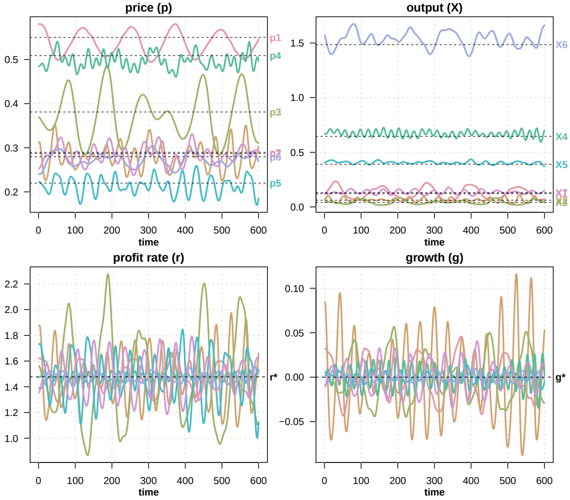
$$\left(\frac{\dot{p}}{p}\right)^T = -\delta_p[B - RA]x = \delta_p[\underbrace{RAx}_{\text{demand}} - \underbrace{Bx}_{\text{supply}}] \qquad (3)$$

2. **Law of Excess Profitability** profit imbalances trigger changes in quantities

$$\frac{\dot{x}}{x} = +\delta_x[B - RA]^T p^T = \delta_x[\underbrace{B^T p^T}_{\text{revenue}} - R\underbrace{A^T p^T}_{\text{cost}}] \qquad (4)$$

δ_p and δ_x are vectors of adjustment coefficients to estimate econometrically in order to calibrate the model.

Synthetic example for 7-sector US economy



Synthetic Example

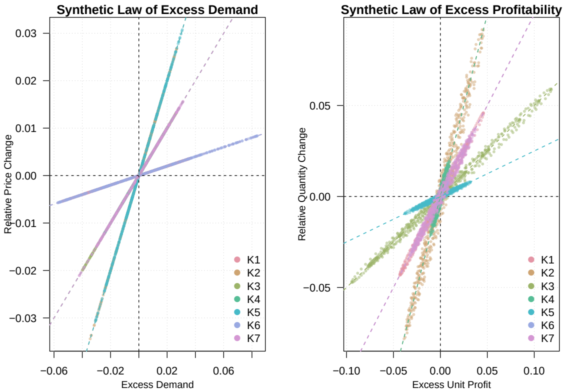
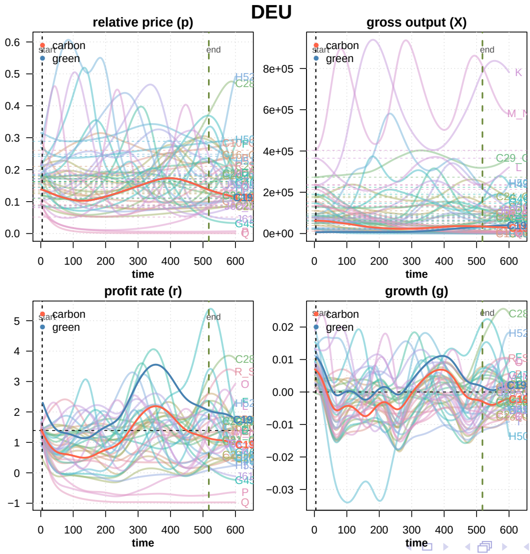
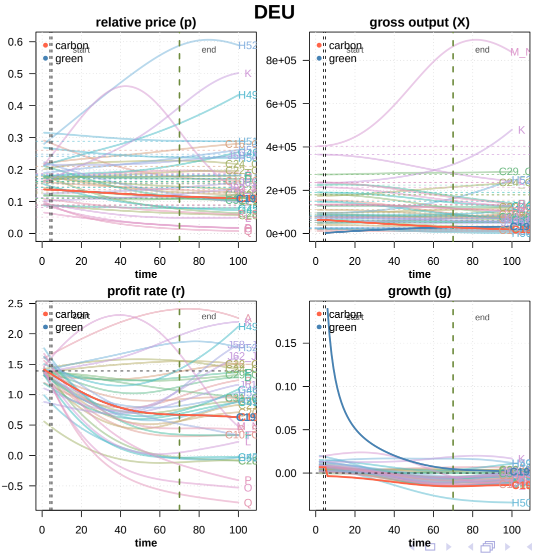


Figure: Linear slopes correspond to the adjustment parameters δ_p and δ_x. Regressions are of the simple form $y_t = \beta_k x_t + \varepsilon_t$ for sector k

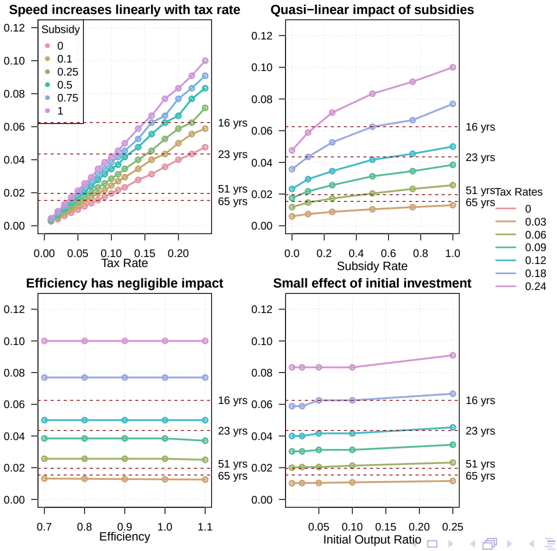
Substitution C19 Sector DEU, no policy $\theta = 0.7$, $\sigma_0 = 0.1$, $\tau = 0$



C19 Sector, DEU, with policy $\theta = 1$, $\sigma_0 = .055$, $\tau = .01$, $\tau' = 1$



Decarbonization Speed wrt τ, τ', θ, and σ_0



Decarbonization Speed wrt τ, τ', θ, and σ_0

initial.output.ratio	0.028***
	(0.001)
efficiency	−0.002***
	(0.0003)
tax	0.322***
	(0.001)
subsidy	0.023***
	(0.0001)
Constant	−0.011***
	(0.0003)
Observations	13,341
R^2	0.945
Adjusted R^2	0.945
Residual Std. Error	0.006 (df = 13336)
F Statistic	57,437.620*** (df = 4; 13336)

Conclusions

- Fiscal policy greatly accelerates carbon phase-out, irrespective of production structure and relative technical efficiency, in particular at the earliest stages of the transition.
- Without fiscal policy, it is impossible for any economy to reach the IPCC targets on time.
- Although effective on their own, carbon taxes should be complemented with green subsidies:
    - a tax rate of 10% without subsidy decarbonizes in 51 years vs. 23 years fully using the taxed output as green subsidy
    - a tax rate of 24% without subsidy decarbonizes in 22 years vs. 10 years fully using the taxed output as green subsidy

Thank you!

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Comparative Statics

Input-output coefficients of the green sector g are defined as constant over time and proportional to the carbon sector c,

$$\theta = \frac{a_{ig}}{a_{ic}} \quad \forall i = 1, ..., N$$

Profit Rate Differentials without Policy

$$1 + r_t^c = \frac{p_t^c x_t^c}{\kappa_t^c x_t^c} = \frac{p_t^c}{\kappa_t^c} \tag{5}$$

$$1 + r_t^g = \frac{p_t^c}{\theta \kappa_t^c} = \frac{1 + r_t^c}{\theta} \tag{6}$$

Profit Rate Differentials with Policy

$$1 + \hat{r}_t^c = \frac{p_t^c x_t^c (1 - \tau)}{\kappa_t^c x_t^c} = (1 + r_t^c)(1 - \tau) \tag{7}$$

$$1 + \hat{r}_t^g = \frac{p_t^c x_t^c (\sigma_t + \tau)}{\theta \kappa_t^c x_t^c \sigma_t} = (1 + r_t^c) \frac{1 + \frac{\tau}{\sigma_t}}{\theta} \tag{8}$$

Logistic Growth

$$x_{t+1} = rx_t(1 - x_t) \tag{9}$$

where x_t is a number between zero and one that represents the ratio of existing population to the maximum possible population. The values of interest for the parameter r are those in the interval [0,4]. This nonlinear difference equation is intended to capture two effects:

- **reproduction** for small population sizes, population grows at a proportional rate
- **density-dependent mortality** for population values close to the environment's "carrying capacity", population decreases at a rate proportional to 1 minus itself