Sustainable growth in a net zero circular economy: Problems and Prospects

Work in Progress

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Challenges

- The title of this session is "**Just Transition**".
- In this audience we all want green transition. How? and For whom? "Just" pertains to the last question. Let us first discuss "how?"
- Recent years have seen a divisive debate over the pathways that governments choose to reach the net zero target.
- Some criticise the climate policy as excessive "greenwashing" which corporations and countries complain ostensibly ambitious without verifiable policy instruments ((Valenzuela and Lezaun, 2024).
- Others have criticised the government for doing too little and even weakening/cancelling net zero policies (WEF 2024).
- Another argument revolves around decoupling growth from netzero which is difficult in a world in which the government has promised that growth and green environment are complementary goals (Ajayi and Politt, 2022).

What we do

- To the best of our knowledge, our inititative is the first to bring these broad policy narratives within one unifying growth theoretic framework,
- We highlight the need for a pragmatic alternative, such as recycling, to convert waste and pollutants from the production of economic output including carbon (e.g. through Carbon Capture, Use and Storage) and reintroduce them into the production process in a circular loop.
- In resource economics, the latter is referred to as "**circular economy**."

What we do

- We establish a simple neoclassical growth model that integrates three sub-disciplines.
  - (i) the net-zero carbon target, which addresses the challenges of environmental economics,
  - (ii) the circular economy, which deals with waste management in resource economics,
  - (iii) sustainable growth, a research topic in growth economics.
- Trilemma or Trinity? (Basu et al., Energy Economics 2024)
- Optimal policy instruments to achive the Trinity. This is what we are presently doing here.

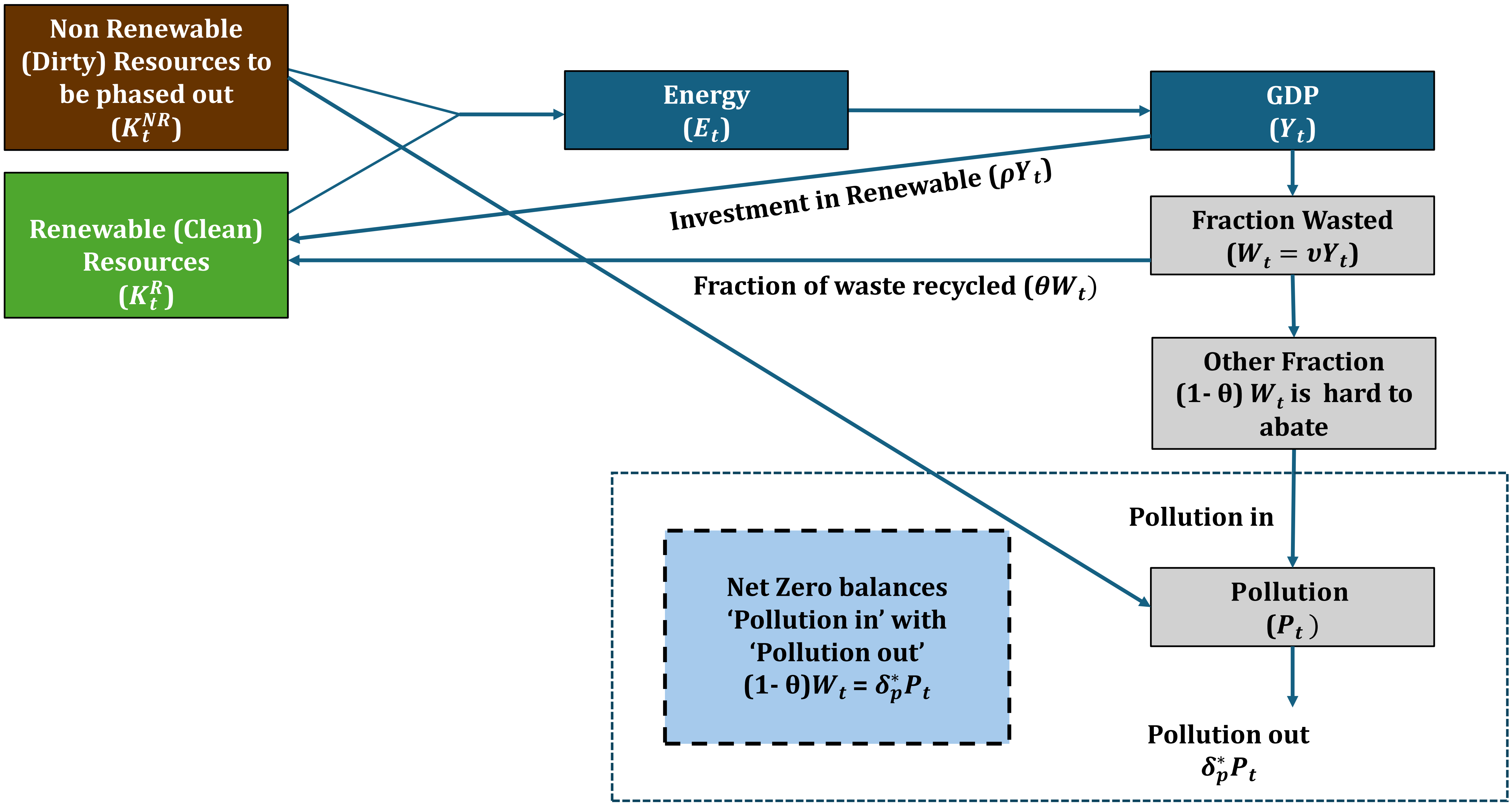
Main results

- To ensure a smooth transition from non-renewable to renewable growth paths, it is essential that the production technology allows for substitution between these two types of resources. Technically, this requires the production function to have an elasticity of substitution between non-renewable and renewable exceeding unity.
- The higher the value of this elasticity, the greater the growth potential from non-renewable to renewable substitution.

Main results

- Net-zero cannot be achieved solely with the substitution of non-renewable with renewable resources; i.e., substitution is a necessary but not sufficient condition. It is essential to have efficient waste management, and technologies and environmental policies that prioritize waste recycling. This can be achieved through circular economy.
- Waste management and pollution removal are costly to the society which values both growth and environment. We characterize optimal waste management and pollution removal strategies which maximizes social welfare.
- Countries which care more for productivities will grow faster and spend less tax money on abatement compared to countries which care more for environment.

Model Flowchart



The core model (Basu et al. 2024)

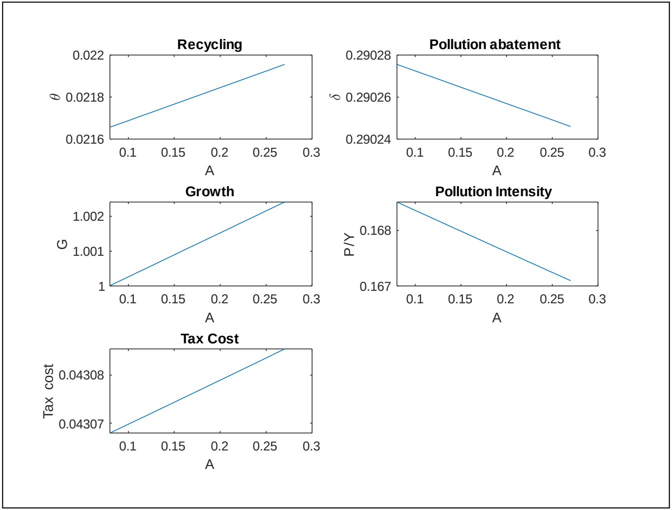
$$
\begin{aligned}
\text{Output} &: \quad Y_t = \left[(1-\omega) {K_t^N}^{\frac{\sigma-1}{\sigma}} + \omega {K_t^R}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\
\text{Waste:} & \quad W_t = \nu Y_t \\
\text{Renewable} &: \quad K_{t+1}^R = (1-\delta_R) K_t^R + \theta W_t + \rho Y_t \\
\text{Pollution} &: \quad P_{t+1} = (1-\delta_p) P_t + (1-\theta) W_t + \varkappa K_t^N \\
\text{Netzero:} & \quad NETCO2_t = (1-\theta) W_t - \delta_p^* P_t = 0 \\
\text{Pollution Intensity:} & \quad \frac{P_t}{Y_t} = \frac{(1-\theta)\nu}{\delta_p^*} \\
\text{Long-run growth rate } G &= 1 - \delta_R + (\nu\theta + \rho) A \omega^{\frac{\sigma}{\sigma-1}}
\end{aligned}
$$

Key Results

- The long run growth rate with net zero target is feasible if two conditions are met: (i) rate of pollution removal exceed the balanced growth rate; (ii) the substitution elasticity between nonrenewable and renewable exceed unity.
- The long run growth rate is rising in σ. In other words, the greater the substitutability between nonrenewable and renewable capital, the higher the long run growth rate.
- The long run growth rate is higher if recycling rate θ and investment rate ρ are higher.
- The long run growth rate in a circular economy (with $\nu > 0$) is higher than in a linear economy with $\nu = 0$. The last two features of our growth model highlight the importance of a circular economy for growth.

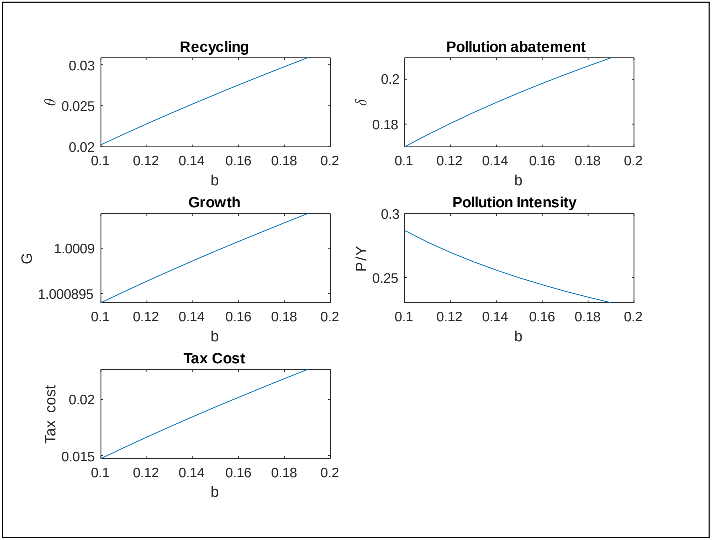
Optimal recycling and abatement

- The government maximises societal welfare: $W = G - b(P/Y) - 0.5\kappa_1\theta^2 - 0.5\kappa_2\delta_p^2$. The rationale for the term P/Y is that net-zero carbon does not eliminate carbon fully. We need to manage waste and pollution abatement. Plugging the steady state P/Y in the welfare function, we get: $W = G - b((1-\theta)\nu/\delta_p^*) - 0.5\kappa_1\theta^2 - 0.5\kappa_2\delta_p^{*2}$ where b is the pollution distaste parameter.



Effect of an increase in Energy TFP (A)

- More productive economies (higher A) recycle more but abate less. The pollution intensity is lower and growth is higher. The cost of abatement is lower while cost of recycling is higher. The total cost borne by the society (tax cost) is still higher, but the rise is negligible in more productive economies due to offsetting movements in recycling and abatement cost.

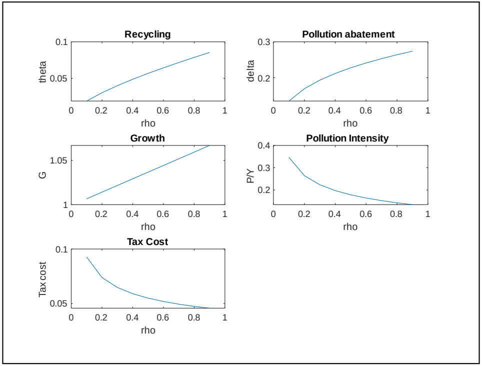


Effect of a higher pollution distaste

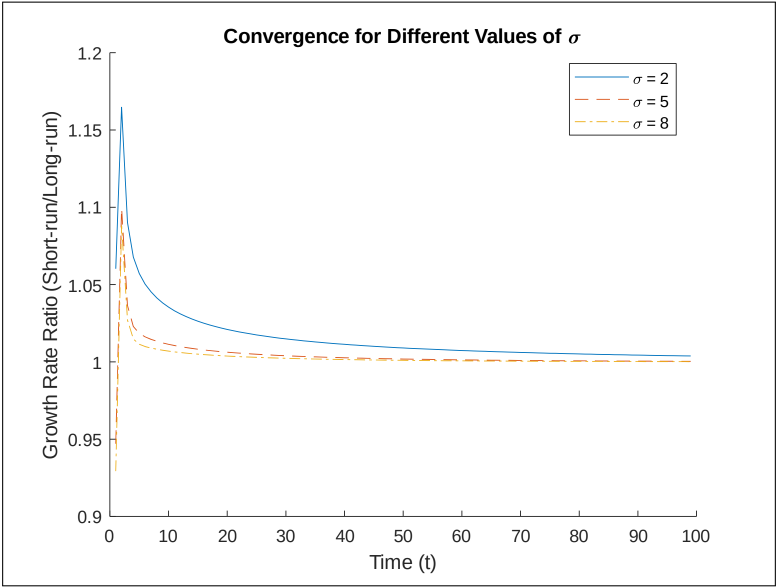
- Countries with more concern for pollution (higher b) would recycle more, abate more as well. Growth experience will be better and pollution intensity will be less. No free lunch! Costs of pollution abatement and recycling will be considerably higher than more productive economies. This means greater tax burden. The bottomline is that the tax burden is considerably higher in more pollution sensitive economies.

When private sector is incentivised to investment more in renewable

- Assume $\kappa_1 = \kappa_2 = \kappa$ and $\kappa = 1/\rho$ which means when the private sector has greater renewable investment propensity, cleaning up cost is lower which means they are charged lower carbon tax.



Effect of an increase in ρ



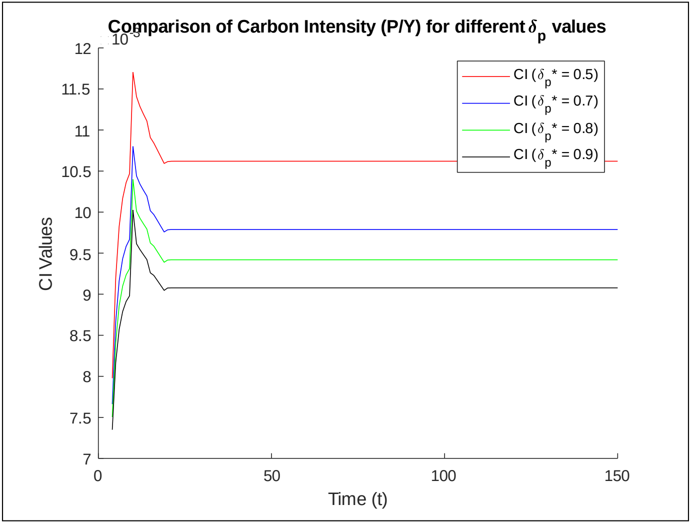
Fast transition to green growth when there are greater substitution possibilities

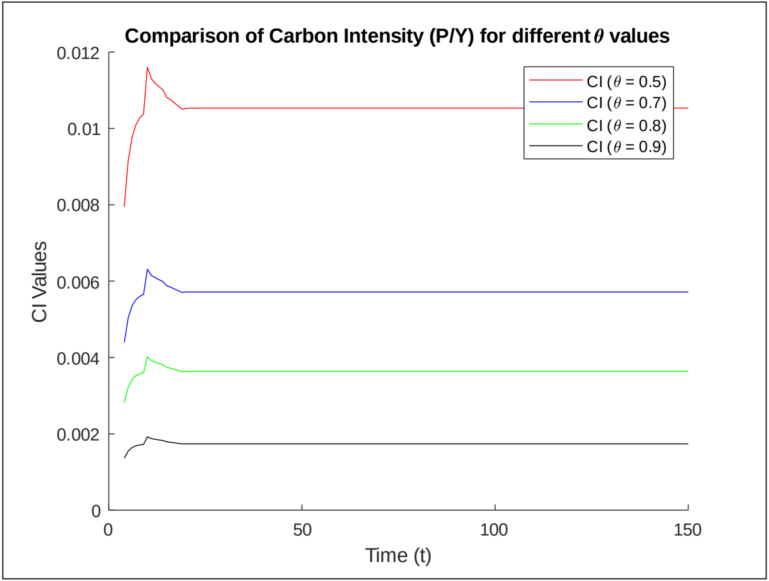
Climate Shock

- The climate shock is modelled as an one time shock to the pollution technology:

$$P_{t+1} = (1-\delta_p)P_t + (1-\theta)W_t + \xi^p_{t+1}$$

  where ξ^p_{t+1} is a one time positive shock at a pre-specified date (say $t+T$). In other words, $\xi^p_{t+T} > 0$ and zero at all other dates. Such a climate shock is assumed to impact the TFP (A) at the time of the shock negatively. The shock recedes after 10 periods.
- Pollution intensity stabilises more quickly in economies with more recycling (higher θ) and more abatement (higher δ^*_p)


Comparison of Carbon Intensity (P/Y) for different δ_p values
$\times 10^{-3}$
CI Values
Time (t)
CI (δ_p* = 0.5)
CI (δ_p* = 0.7)
CI (δ_p* = 0.8)
CI (δ_p* = 0.9)
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
0
50
100
150


Comparison of Carbon Intensity (P/Y) for different θ values
CI (θ = 0.5)
CI (θ = 0.7)
CI (θ = 0.8)
CI (θ = 0.9)
CI Values
0.012
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
Time (t)

Summing up

- The rate of pollution (carbon) abatement (δ_p^*) needs to be higher than the natural depletion of carbon (δ_p) to achieve a net zero carbon target without compromising a sustainable growth target.
- Countries must achieve high rates of substitution to renewable technologies, prior to halting investment in nonrenewable. Otherwise, prospect of sustainable growth is compromised. Technically, this requires the production function to have an elasticity of substitution between nonrenwable and renewable (σ) exceeding unity.
- Countries with a higher σ make transition to net zero sustainable growth target faster.
- Fiscal costs of abatement and recycling is lower if policymakers incentivise private sector to invest in renewables, lowering burden on taxpayers.
- Countries with effective abatement and waste management policies are more resilient to 'climate shocks'.

Just Transition: For Whom?

- There are winners and losers from this green transition
- Winners are our future generation if we can offer them a clean environment
- During the transition phase fiscal cost is higher as illustrated earlier. Will polluters pay?
- When fossil fuel is phased out there will be losers. As nonrenewable sectors are phased out, the shadow of unemployment will darken. Need for redistributive policy.
- Emerging market economies which heavily rely on coal and biofuels will be hard hit. India is a case in point.
- Complicated political economy questions also arise when greenhouse gas is exported abroad.