Sustainability traps: patience and innovation

Evangelos V. Dioikitopoulos & **Christos Karydas**

Athens University of Economics and Busines & ETH Zurich

CRETE 2021

July 12, 2021

Main idea

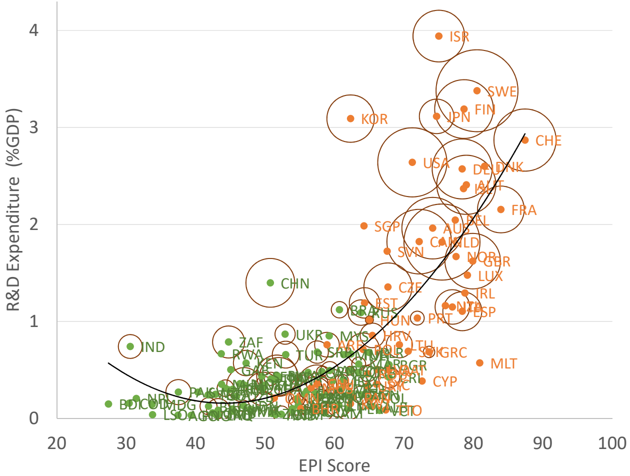
Fact 1:
Some countries thrive both economically and environmentally;
others stagnate in environmental and economic poverty traps.

Fact 2:
These countries won't benefit from short-term technological advancements
(e.g. foreign aid, technology transfer, small scale R&D).

Contribution:

- Behavioral mechanism to explain 1&2;
- R&D-driven endogenous growth model; the quality of natural environment influences long-term orientation and investment into sustainable technologies
- Multiple equilibria of development: high / low growth & environm. quality

Environmental performance and economic development



- R&D Expenditure (% of GDP) avg. over 1960-2016;
- EPI for 2018 (24 env. performance indicators);
- green: low income / orange: non-low income (Unit. Nations);
- circles: Rate of Time Preference (relative) - RTP (Falk et al., 2018)

Literature

Not unanimous in its views on environment-poverty traps:

- geographic location and ecological scarcity
  (e.g., Jalan and Ravallion, 2002, Barbier and Hochard, 2019)
- poor institutions
  (e.g., Burnside and Dollar, 2000, Acemoglu and Robinson, 2012, Greenstone and Jack, 2015)
- aid increases misallocation of resources
  (e.g., Djankov et al., 2008, Rajan and Subramanian, 2011)
- climate change suppresses growth prospects unevenly (Bretschger and Valente, 2011, Bretschger and Suphaphiphat, 2014)

Motivation and Main Message

Galor and Özak (2016, AER)

- positive relationship between environmental quality and long-term orientation;
- good climatic conditions in the pre-industrial era made people long-term oriented and prone to investments in agricultural technologies of the time
- Relevant in the modern era is investment in R&D versus investment in manufacturing. But why some countries innovate more than others?
- What is the join relation between environmental quality, long-term orientation and R&D?

Environmental Quality and Time Preference: Contemporary

Main Message

- This paper argues that the joint relation between long-term orientation, environmental quality and innovation plays a key role in explaining environment-poverty traps.

- We show that multiple equilibria of economic development and environmental quality can arise due to an endogenous trade-off between the demand for innovation that promotes sustainability, and the ephemeral pleasure from polluting manufacturing that impedes sustainability.

Main Implication

Policies that target environmental protection will provide a double-dividend of economic and environmental sustainability through an environment – patience – innovation channel.

Model in Words

- R&D-based endogenous growth model
- Tradeoff between industrial activity and environmental quality
  - Traditional manufacturing: constant returns to scale, poor quality assurance, large material (toxic) waste
    vs.
  - Modern manufacturing: R&D-intensive and increasing returns to scale, better quality assurance and lower waste
- Environmental degradation due to traditional manufacturing affects investment decisions via RTP
- Average environmental quality positively affects patience.

Model

Production

- **Final good**

$$Y = L_Y^{1-\beta} \int_0^1 q_j^{1-\beta} x_j^{\beta} dj, \qquad j \in [0,1], \tag{1}$$

L_Y labor in manufacturing, x_j intermediate good j with technology q_j; as in Acemoglu and Cao (2015), among others.

- **Intermediates j**

Produce intermediate goods x_j with a marginal cost $\psi > 0$. Also, they invest in R&D which happens in-house:

$$\dot{q}_j = A q_j l_j, \tag{2}$$

l_j research labor, $A > 0$ a productivity parameter.

Model

Optimization

- **Households** solve:

$$\max_{\{C_t\}_{t=0}^{\infty}} \int_0^{\infty} \log(C_t) e^{-\int_0^t \rho(N_s) ds} dt, \tag{3}$$

s.t. $\dot{K} = rK + wL - C$, with $\rho'(N) < 0, \rho''(N) > 0$.

- **Final good** sector chooses L_Y, x_j taking prices as given

- **Intermediate** producer j solves $\max_{\{x_{jt}, l_{jt}\}_{t=0}^{\infty}} \int_0^{\infty} [\pi_{jt} - w_t l_{jt}] e^{-\int_0^t r_s ds} dt$, with $\pi_j = p_j x_j - \psi x_j$ s.t. (2);

Model

Dynamics of the Natural Environment

- Environmental quality evolves as follows

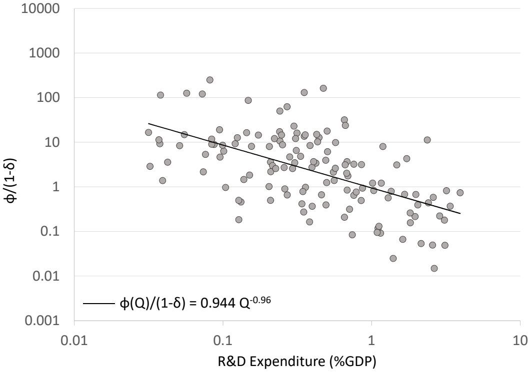
$$\dot{N}_t = -E_t + (1 - \delta)(\bar{N} - N_t), \tag{4}$$

- Production creates emissions, E, that pollutes the environment. In particular, emissions $E = \phi(Q)Y$ are positive function of production where ϕ denotes emissions intensity.

Model

Emissions intensity

- Following Nordhaus and Boyer (2000), Bosetti et al. (2006) and Agnolucci and Arvanitopoulos (2019) emissions intensity is a negative function of average level of technological quality, $Q \equiv \int_0^1 q_j dj$, $\phi'(Q) < 0$.
- Further support from (4), $\frac{\phi(Q)}{1-\delta} = \frac{\bar{N}-N}{Y}$ vs Q:



Model

Equilibrium

- Capital market clears: in equilibrium $V_j = V = K, \pi_j = \pi, q_j = q = Q$
- Labor market clears: $L = L_Y + L_S$, with $L_S = \int_0^1 l_j dj$
- Resource constraint: $Y = C + I$, with $I = \int_0^1 \psi x_j dj$, in equilibrium also $Y = QL_Y, C = (1 - \beta^2)Y$

Model

Dynamics

- Labor allocation between manufacturing and R&D (equiv. of investment)

$$\frac{\dot{L}_Y}{L_Y} = \beta A L_Y - \rho(N). \tag{5}$$

- Environmental quality in equilibrium evolves as follows

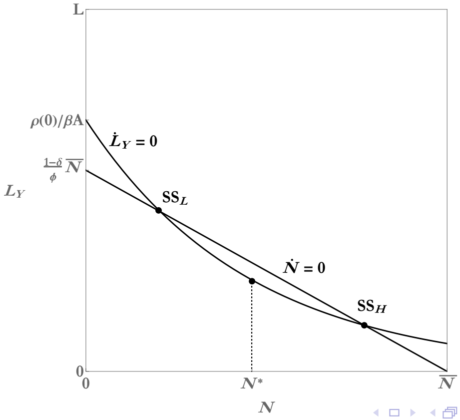
$$\dot{N} = -\varphi L_Y + (1 - \delta)(\bar{N} - N), \tag{6}$$

BGP in a Graph

Balanced Growth

On the BGP $\dot{L}_Y = \dot{N} = 0$ and $\dot{C}/C = \dot{Y}/Y = g$ with $g = AL - (1/\beta)\rho(N^{SS})$
N^{SS} solves

$$\underbrace{\frac{\rho(N^{SS})}{\beta A}}_{\dot{L}_Y=0} = \underbrace{\frac{1-\delta}{\varphi}(\bar{N} - N^{SS})}_{\dot{N}=0} \tag{7}$$



Results

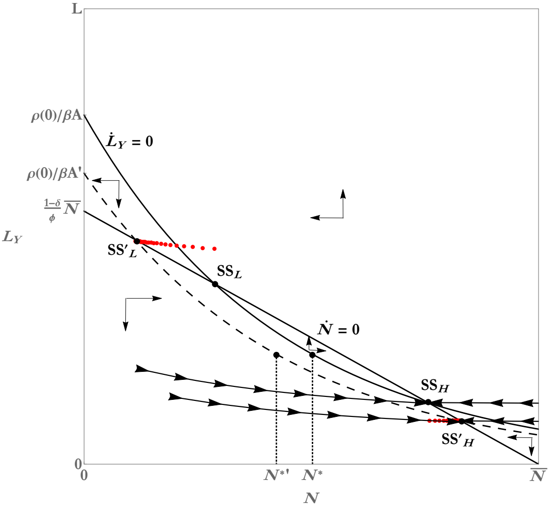
Proposition 1 (Multiplicity of equilibria)
There are two interior balanced growth equilibria that solve (7): one with low environmental quality and low growth – for which $N^{SS} < N^*$; one with high environmental quality and high growth – for which $N^{SS} > N^*$.

Proposition 2 (Stability)
(i) The high equilibrium ($N^{SS} > N^*$) is always saddle stable;
(ii) The low equilibrium ($N^{SS} < N^*$) is stable if $\beta AL < 1 - \delta$; the type of stability is either an attractive focus or an attractor.

Proposition 3 (Small Technological Improvements)
(i) An increase in productivity A improves environmental quality and economic growth in the high equilibrium ($N^{SS} > N^*$);
(ii) In the low equilibrium ($N^{SS} < N^*$) it unambiguously worsens environmental quality; it also worsens growth prospects when $\rho(N^{SS})\epsilon_{\rho N}^{SS}\epsilon_{NA}^{SS} > \beta AL$.

Results

Productivity increase ($A \to A' > A$)



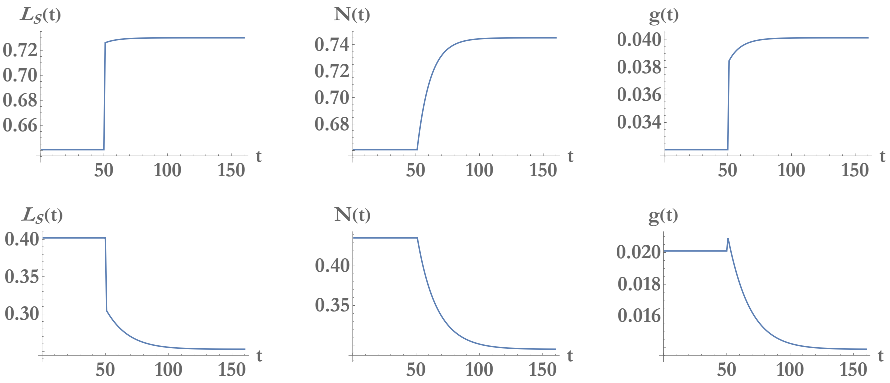
Here $\rho(N) = \rho_0 e^{-\eta N}$

Intuition

- An exogenous increase in A has a first-order effect on household budget by increasing the income of individuals through the return on equity $(r(N^{SS}) = AL - \frac{1-\beta}{\beta}\rho(N^{SS}))$.
- Societies with very good environmental quality, exhibit higher patience (low ρ) and thus can reap the benefits of such a productivity increase to further invest in R&D firms that advance both their economic and environmental situation.
- On the other end of the spectrum, societies with poor environmental quality are oriented towards the short-term (high ρ).
- Provided that their ρ is high and their productivity level A is already low, a productivity increase would trigger relatively more consumption rather than investment, thus worsening both their economic and environmental development prospects.

Results - Numerical Example

Productivity increase ($A \to A' > A$) (good up, bad down)



Conclusion

- We contribute a new mechanism behind environment-poverty traps that builds on the joint relation between long-term orientation, environmental quality and innovation
- Negative relationship of RTP with the quality of local environment
- Households long-term orientation (as affected by endowments of natural environment) to indicate whether productivity increases translate into clean growth or polluting stagnation
- Results suggest that development aid policies should aim at influencing long-term views in countries that face weak environmental conditions (environmental technology transfer, support education)

Thank you!