Roads to Prosperity without Environmental Poverty: The Role of Impatience

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September 21, 2019

Abstract

This paper advances the hypothesis that impatience negatively depends on environmental quality and aims to explain why some countries stagnate in an 'environmental and economic poverty trap'. For low levels of environmental quality, advancements in productivity lead impatient agents to direct income increases to consumption (rather than savings), depleting further the environment. Given that productivity increases do not help such economies to escape the trap (contrary to perceived notions), policies should focus on the implementation of behavioral changes.

JEL classification: D90, E21, E62, H31, O44, Q28.
Keywords: Time preference, growth, environmental quality, fiscal policy, productivity.

Acknowledgments: We have benefited from comments and suggestions by J. Caballé, K. Neanidis, S. Kalyvitis, S. Michalopoulos, M. Gil Molto, A. Navas, T. Xepapadeas, R. Wendner; and feedback from participants at the JPET 2014 conference in Seattle, AMES 2016 in Kyoto, EAERE 2017 conference in Athens, and the audience at the research seminar presentation in Graz. Part of the project was conducted during Evangelos Dioikitopoulos visit in Brown University, whose hospitality is gratefully acknowledged. Eugenia Vella acknowledges funding from Generalitat de Catalunya through grant 2017 SGR 1765. The usual disclaimer applies.

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1 Introduction

Higher economic growth is widely perceived to result in greater environmental degradation through higher pollution in the early stages of development, which tends to get reversed beyond a point. Following Grossman and Krueger (1995), this inverse U-shaped relation between growth and pollution is commonly refered to as the Environmental Kuznets Curve (EKC). However, countries are often stuck in 'environmental and economic poverty traps' characterized, at the same time, by environmental degradation and low growth, without ever reaching the turning point of the EKC (see, e.g., Prieur, 2009, Varvarigos, 2014). This paper proposes a framework that can explain economic and environmental stagnation through a *behavioral* mechanism.

A distinguishing feature of our paper is endogenous discounting or a non-constant rate of time preference. From a historical perspective, Galor and Ozak (2016) show that in societies where the ancestral population experienced a higher crop yield (for a given crop growth cycle), the rewarding experience of agricultural investment set in motion the traits for higher long-term orientation among the descendants of individuals who resided in such geographical regions during that period. In drawing a parallel with what could be expected in an environmental context, better nurturing and protection of the environment in a particular era could result in higher long-term orientation (and hence, a lower rate of time preference) among members of subsequent generations as environmental quality improves (see, among others, Yanase, 2011; Vella et al., 2015). Figure 1 displays the positive relationship between the contemporary rate of time preference from Falk et al. (2019) against the Environmental Performance Index (EPI) score for 2018, vindicating this argument.[1]

The contribution of our paper is twofold. First, we extend the literature on growth, environment and endogenous discounting (see, among others, Yanase, 2011; Vella et al., 2015; Chu, 2016; Pittel, 2002). We model environmental resources as stock, which enables us to capture the existence of environmental and economic poverty traps through the behaviour of agents due to low environmental quality. Second, we shed light on the emergence of policies toward behavioural changes (for instance, through focused educational programs) since improvements in productivity are not enough for a country to escape an environ-

[1]The EPI (produced by Yale University and Columbia University) ranks countries on performance indicators across ten issue categories covering environmental health and ecosystem vitality (EPI, 2018).

Figure 1: **Long term orientation vs. EPI**. The graph shows the std. deviation from the world mean of the rate of time preference against the EPI score for 2018 for 90 countries (developed – orange, developing – green, based on the UN classification); better environmental quality is associated with higher long-term orientation. The solid line shows the linear regression fit. Sources: EPI (2018); RTP, Falk et al. (2019)

mental poverty trap. While, with productivity gains, people become more productive and enjoy higher incomes, they spend a higher proportion of their incomes to consumption because of their low long-term orientation (that increases pollution), rather than savings (that enhance resources for abatement policies). The next section presents the set-up of our closed-economy model. Section 3 solves the decentralized equilibrium. Section 4 concludes.

2 The model

2.1 Firms and Households

The production function of the single good in this economy is given by:

$$Y = AK^{a}L^{1-a}{K_g}^{1-a}, \tag{1}$$

where Y denotes output, $a \in (0, 1)$ denotes the share of physical capital, K, in the production function, K_g refers to the public capital stock (e.g. infrastructure), funded by the government, and A represents TFP. Labor is contant and normalized to unity ($L = 1$). The firm maximizes profits, $\pi = (1-\tau)Y - (r+\delta_K)K - w$, where $\tau \in (0,1)$ is a tax rate on output, $r \in (0,1)$ is the economy-wide interest rate and $\delta_K \in (0,1)$ the depreciation of the private capital stock; $r + \delta_K$ is the rental cost of capital. The first-order conditions of the firm maximization problem are given by:

$$r = Aa(1-\tau)\left(\frac{K}{K_g}\right)^{a-1} - \delta_K, \tag{2}$$

$$w = A(1-a)(1-\tau)\left(\frac{K}{K_g}\right)^{a} K_g. \tag{3}$$

The representative household maximizes her lifetime utility:

$$\int_0^\infty ln(C)\exp\left[-\int_0^t \rho(N_v)dv\right]dt, \tag{4}$$

where C is consumption and N is the stock of economy-wide natural resources, interpreted as an index for environmental quality.[2] In turn, $\rho(N) > 0$ denotes the endogenous rate of time preference (RTP), which depends negatively on environmental quality, i.e. $\rho_N \leq 0$. Further, we assume that there exists a lower positive bound for the RTP, denoted by $\breve{\rho}$, i.e. $\lim_{(N\to 0)} \rho(N) = \breve{\rho} > 0$.

Households are the owners of private capital. Besides the return on their assets at a rate r, they receive labor income, w, and dividends, π. The dynamic budget constraint reads:

$$\dot{K} = rK + w - C + \pi, \qquad \text{given} \qquad K(0) > 0. \tag{5}$$

Household maximization of (4) s.t. (5) leads to the familiar Euler equation:

$$\frac{\dot{C}}{C} = r - \rho(N). \tag{6}$$

[2] We use a logarithmic utility function to focus on the *intertemporal* effect of endogenous discounting in a simple framework.

2.2 Motion of environmental quality

Following Jouvet et al. (2005) and Angelopoulos et al. (2013), the stock of environmental quality evolves over time according to:

$$\dot{N} = (1 - \delta_N)(\bar{N} - N) - D, \qquad \text{given} \qquad N(0) > 0, \tag{7}$$

where $\bar{N}$ denotes environmental quality without degradation, $D > 0$, and $\delta_N \in (0, 1)$ is the degree of environmental persistence. Environmental degradation is a positive function of polluting emissions, P, and a negative function of public abatement expenditures, E:

$$D = D(P, E) = \frac{P}{\theta E}, \tag{8}$$

where $\theta > 0$ denotes the endogenous efficiency of the abatement technology in alleviating environmental degradation, which we define below. We further assume that P occurs as a by-product of consumption:

$$P = sC, \tag{9}$$

with $s > 0$ denoting the emissions intensity of consumption.

In the same vein as Andreoni and Levinson (2001) and Quaas (2007), the efficiency of abatement expenditures depends on the size of the economy and the level of infrastructure. In particular, it is a positive function of infrastructure stock as a share of total output, $\frac{K_g}{Y}$:

$$\theta \equiv \theta\left(\frac{K_g}{Y}\right) = \xi \frac{K_g}{Y}. \tag{10}$$

$\xi > 0$ is a scaling parameter. Intuitively, higher investment in public infrastructure complements public expenditures on abatement and makes it possible to clean the environment in a more efficient way (e.g. public infrastructure, such as roads, is important for the impact of government policies on environmental protection).

2.3 Government budget constraint

The government spends G on infrastructure and E on environmental policy, and collects revenues through a tax on output, $\tau \in (0, 1)$. Assuming a balanced budget, we can write

$G + E = \tau Y$. Equivalently, this can be written as:

$$G = b\tau Y \qquad \text{and} \qquad E = (1-b)\tau Y, \tag{11}$$

where $b \in (0,1)$ is the fraction of tax revenue used to finance infrastructure and $1-b$ is the fraction that finances environmental investment. Thus, government policy can be summarized by the two policy instruments, τ and b. The law of motion for the public capital stock is given by:

$$\dot{K}_g = G - \delta_{K_g} K_g, \qquad \text{given} \qquad K_g(0) > 0, \tag{12}$$

where δ_{K_g} denotes the depreciation rate.

3 Decentralized competitive equilibrium

In this section we derive the equilibrium, which holds for any feasible policy $\{\tau, b\}$, and analyze its properties. By combining (1)-(11), assuming without loss of generality that $\delta_K = \delta_{K_g} = \delta$, and defining the auxiliary stationary variables, $\omega \equiv \frac{C}{K}$ and $z \equiv \frac{K}{K_g}$, the dynamics of the economy, are provided by:

$$\frac{\dot{\omega}}{\omega} = A(a-1)(1-\tau)z^{a-1} - \rho(N) + \omega, \tag{13}$$

$$\frac{\dot{z}}{z} = A(1-\tau)z^{a-1} - Ab\tau z^{a} - \omega, \tag{14}$$

$$\dot{N} = (1-\delta_N)\bar{N} - (1-\delta_N)N - \left(\frac{s}{\xi(1-b)\tau}\omega z\right), \tag{15}$$

along with the transversality condition $\lim_{t\to\infty} \frac{K(t)}{C(t)} \exp\left[-\int_0^t \rho(N_s)\, ds\right] = 0$.

It follows that on the Balanced Growth Path (BGP) $\frac{\dot{\omega}}{\omega} = \frac{\dot{z}}{z} = \frac{\dot{N}}{N} = 0$. From (13)-(15) at the steady-state, the long-run value of physical to public capital ratio, $\hat{z}$, is determined by:[3]

[3]We use hats to denote steady-state values.

$$\Phi(\hat{z}) \equiv -Ab\tau\hat{z}^{a} + Aa(1-\tau)\hat{z}^{a-1} - \rho(\hat{N}(\hat{z})) = 0, \tag{16}$$

with $\hat{N}(\hat{z}) \equiv \bar{N} - \Xi[(1-\tau)A\hat{z}^{a} - b\tau A\hat{z}^{a+1}]$ and $\Xi \equiv s/(\xi\tau(1-\delta_N)(1-b))$. Provided there exists a solution $\hat{z} > 0$ in (16), the steady state values for growth and consumption-to-capital ratio are determined by $g = r - \rho\left(\hat{N}(\hat{z})\right)$ and $\hat{\omega}(\hat{z}) = A(1-\tau)\hat{z}^{a-1} - Ab\tau\hat{z}^{a}$, respectively. We can now prove the existence and uniqueness of multiple equilibria.

Proposition 1 *(Existence and Uniqueness) Under endogenous time preference, there exist parameter values where two stable equilibria arise, with different growth rates ranked* $g_1 < g_2$ *where* $\hat{\rho}_1 > \hat{\rho}_2$, $\hat{\omega}_1 > \hat{\omega}_2$, $\hat{z}_1 < \hat{z}_2$, $\hat{N}_1 < \hat{N}_2$.

Proof. See Supplementary Appendix A ▪

Following Proposition 1 our model solves for two stable equilibria: a low-(high-) growth one with low (high) environmental quality, a high (low) rate of time preference, a high (low) consumption-capital ratio and a low (high) physical-to-public capital ratio. In the former case, the propensity to consume is larger, and this generates more pollution, a lower environmental quality and, in turn, ties in with a high value for the degree of impatience. The higher degree of impatience in turn leads to a lower growth rate reinforcing a vicious cycle of lower environmental quality and low growth propagates to keep the economy in an "environmental and economic poverty trap" situation. The opposite occurs for countries in the good equilibrium.

3.1 Productivity, growth and environmental quality

We now study the effect of a change in productivity (TFP) on environmental quality and growth. The following proposition states that for economies trapped in an equilibrium of low environmental quality, high impatience and low growth, an increase in productivity will further deteriorate environmental quality and long-run growth.

Proposition 2 *If the response of time preference to environmental quality is relatively high, then for the low growth, bad environment equilibrium* $(g_1, \hat{N}_1)$*, an increase in productivity,* *A, has a negative effect on steady-state environmental quality,* $\frac{\partial \hat{N}_1}{\partial A} < 0$*, the long-run economic growth rate,* $\frac{\partial g_1}{\partial A} < 0$*, and the physical to public capital ratio,* $\frac{\partial \hat{z}_1}{\partial A} < 0$*, while it has a positive effect on the consumption to physical capital ratio,* $\frac{\partial \hat{\omega}_1}{\partial A} > 0$.

Proof. See supplementary Appendix B. ▪

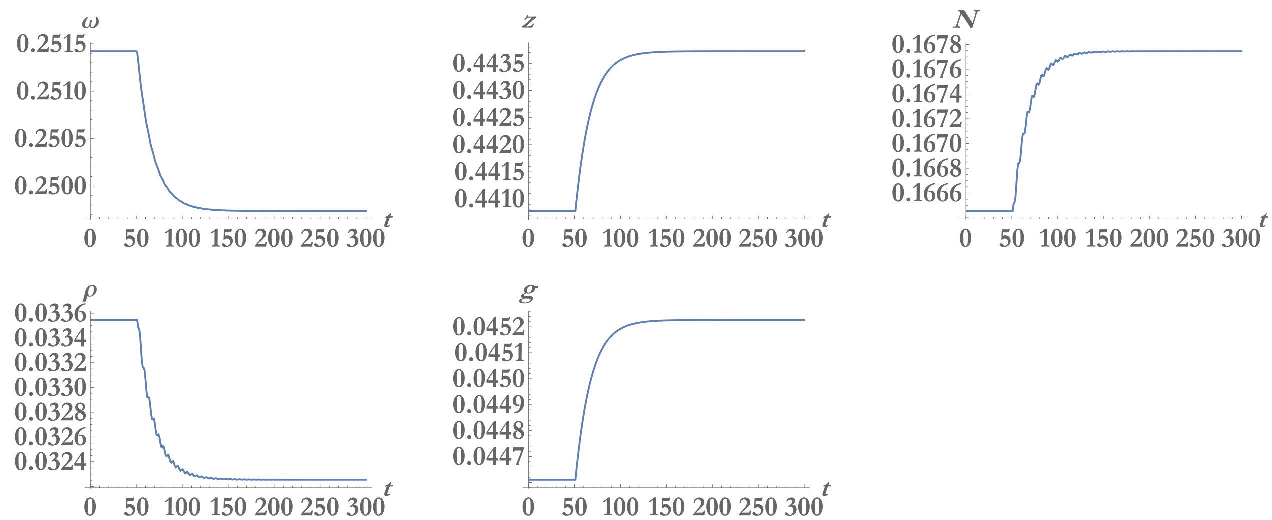
Intuitively, if the environmental quality is low, individuals' long-term orientation is weak and, in turn, their propensity to save is low. Then, while with an increase in productivity, their income initially increases (first order effect), agents increase their consumption proportionally more than their savings, $\frac{\partial \omega_1}{\partial A} > 0$. Higher consumption increases pollution and lowers savings, leading to lower income and growth in the future. Subsequently, lower growth results in a lower tax base (for a given tax rate), and the resources for abatement become insufficient to restore the environmental damage (second order effect). If patience is strongly related with environment (negatively), then the first order, positive, effect of productivity on income (static) is outweighted by the second order, dynamic, effect of increase in consumption and, in turn, pollution. This results in lower environmental quality and growth as Proposition 2 formally addresses. Figure 2 provides a numerical example and justifies Proposition 1 (multiple, stable equilibria with non-monotonic dynamics as provided in Appendix A) and Proposition 2 (different responces of the two equilibria to a productivity shock).

4 Conclusion

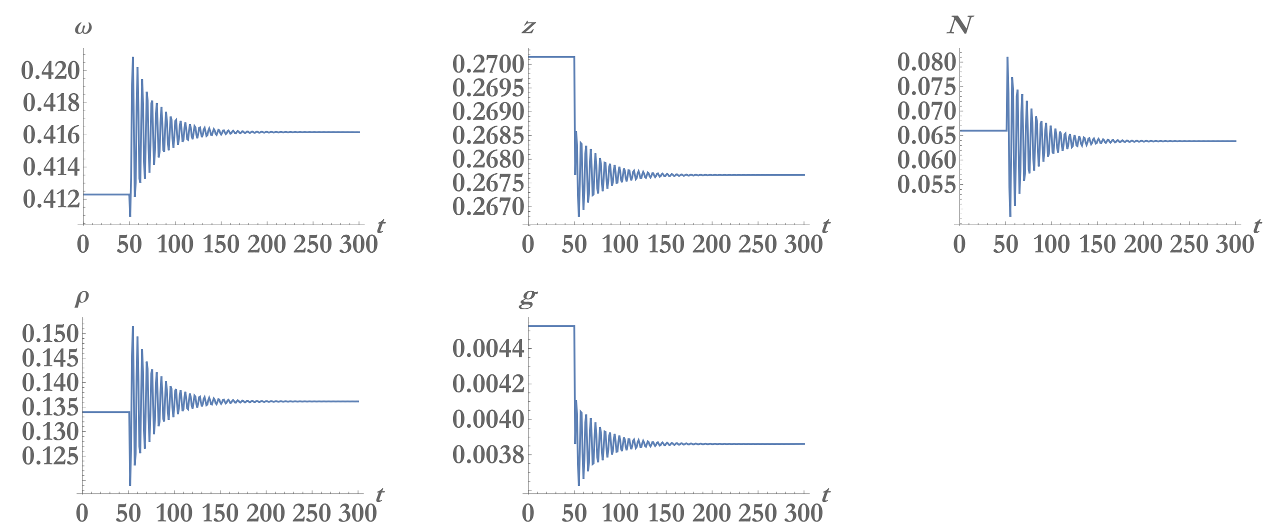
In this paper we provided a new mechanism for the fact that some countries often stagnate in environmental and economic poverty traps. In contrast to conventional wisdom, we showed that productivity increases may lead to lower growth and lower environmental quality when the latter shapes individuals' views for the future.

Figure 2: **Dynamics for the good and the bad steady state**. A small productivity increase at $t = 50$ (from $A = 0.659$ to $A = 0.66$) improves both environmental and development prospects in the good equilibrium (a); it worsens both in the bad equilibrium (b). $\alpha = 0.5, \delta = 0.14, \delta_N = 0.9, s = 1, \xi = 0.4, \bar{N} = 20, \tau = 0.561, b = 0.751, \breve{\rho} = 0.2, \gamma = 1.$

(a) Good Equilibrium



(b) Bad Equilibrium



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