Education and the Political Economy of Environmental Protection

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Abstract

We develop a political economy model that might explain the different environmental performance of countries, through educational choices. Individuals decide whether to invest in additional education according to their expectations regarding future environmental quality. They also vote on a tax that will be used exclusively to finance environmental protection. We show that, under the assumption of perfect foresight expectations, the model may generate multiple equilibria. Agents'expectations may also be self-fulfilling when the public policy is endogenous. Then, we analyse the long-term implications of a public policy that would favour education and make it possible to select the higher equilibrium.

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1 Introduction

What can explain or justify the world distribution of environmental performances? The traditional answer emphasizes the key role played by technology or industrial structure to explain these long-term discrepancies. More recently, another channel has been put forward: agents'preferences with regards to the environment. In particular, those preferences are often associated with a rising income and may help to achieve better environmental conditions. Yet, the relationship linking the two variables is controversial. Because high-income agents may protect themselves against environmental hazards, they might be discouraged to support a public policy in favour of environmental protection. Besides, it has also been highlighted that the societies that are highly dependent on natural resources, exhibit a strong concern for the environment. We can think, for instance, about the Indian "tribus" around the Amazon or poor economies where natural endowment is a crucial factor for further development. Then, the relationship between green awareness and income is not straightforward and needs to be more deeply investigated. In this paper, we propose some micro-foundations that rely on the choices of education and life expectancy. Since agents who invest in human capital benefit longer from the environment, they are also more likely to contribute for environmental preservation. In

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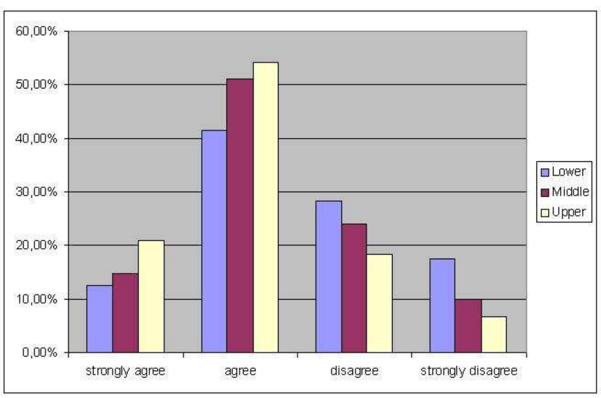
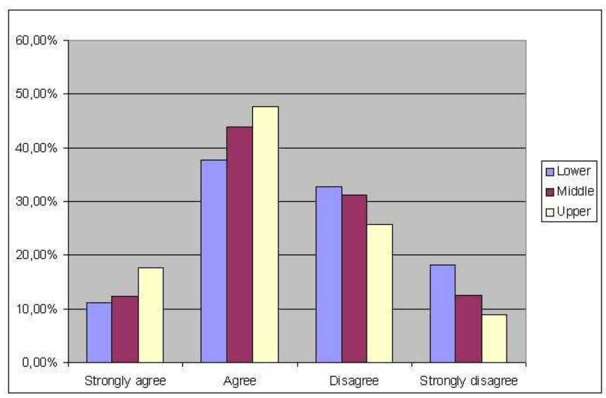
turn, for similar reasons, a clean environment is an incentive to educate. This complementarity may lead to multiple equilibria that account for the observed heterogeneity in environmental performances.

The role played by education in the emergence of a green consciousness can be empirically backed-up. For instance in a study conducted in the USA, Goetz (1998) show that even after controlling for income, age and others socio-economic factors, environmental quality was higher in the States where the proportion of agents who have a high school degree is large. Graduate schooled agents are certainly more aware of environmental risks and outcomes, more sensitive to green campaigning and prevention, are likely to adopt "sustainable" behaviours, etc... Broadly speaking, higher human capital allows individuals to perceive the costs and the benefits of achieving better environmental conditions (see also Carlsson & Johansson-Stenman (2000), Kahn (2002), Brock & Taylor (2005), Fredriksson *et al.* (2005), Farzin & Bond (2006)). This positive relationship may also be captured through the analysis of the green vote. In this respect, Thalmann (2004) and Bornstein & Lanz (2008) show, using the data from a Swiss referendum on green taxes, that the acceptance and approval of green taxes is higher among educated agents. Finally, this evidence can also be illustrated thanks to the World Value Survey data.[1] In particular, we can observe that, in OECD countries, highly educated individuals tend to be more favorable to environmental preservation and may more easily accept the potentiel corresponding fiscal pressure. For instance, at the positive statements "*would give a part of my income for the environment*"(see Figure 1a, or "*increase in taxes if used to prevent environmental pollution*" below) (see Figure 1b), the proportion of upper educated individuals who *strongly agree* or *agree* amounts to around 65 %; on the contrary, the share of lower educated agents who are definitely opposed to additional environmental expenditures may amount to 45% in the first case, and around 35% in the second case.



(a) "*..give a part of income..*"



(b) "*..increase in tax..*"

Figure 1. World Value Survey data dealing with environmental actions

At an aggregate level, these findings imply that environmental quality may crucially depend on the distribution of skills within the population. A country where the share of highly educated agents is large, is more likely to engage itself in environmental protection or more

1. The World Value Survey consists in a study dealing with "*values and cultural changes in societies all over the world*". The data are available on the following web site: http://www.worldvaluessurvey.org/. Individuals are asked to answer a wide range of assertions concerning their own cultural values. Reported answers are ranged from "*strongly agree*" to "*strongly disagree*".

prone to accept a heavier environmental fiscal pressure. The development of human capital may be regarded as a complementary (if not alternative) means of achieving environmental goals, in addition of the more classic instruments, like for instance command-and-control regulations,... Some empirical data may support these conclusions, such that more educated economies display better environmental performance. Indeed, using data from the Center for International Development (CID (2000)) on the secondary school enrollment in 2000 and the Environmental Index Performance (YCELP (2006)), we can observe a positive correlation, as shown in Figure 2, between the two variables.[2] The present chapter aims at capturing this

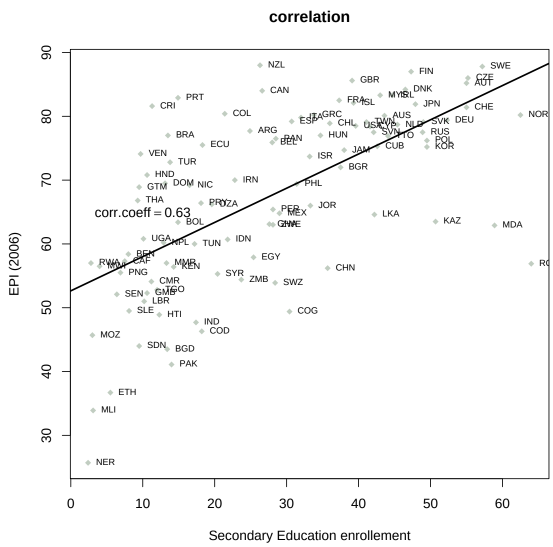


Figure 2: Correlation between second school enrollment and environmental performance

phenomena through a model of political economy.

In this chapter, we consider a continuum of two-period lived agents who get utility from consumption and environmental quality. During adulthood, when all relevant decisions are taken, they share their time endowment between education and work. Once agents have acquired basic skills, they may directly supply *unskilled* labour to the market. Alternatively, they can choose to provide *skilled* labour by investing in additional human capital. In addition, we consider that educated workers also exhibit a higher life expectancy. The key ingredient of our setting is that life expectancy determines the marginal utility of the environment: agents who expect to live longer exhibit stronger concern for the environment since they will benefit more from it. Consequently, choices of education depend ultimately on agents' expectations with respect to future environmental quality. When individuals anticipate deteriorated environmental conditions at next date, they have few incentives to invest in additional human capital and the proportion of *unskilled* workers within the population increases. Conversely, when they fore-

2. The EPI index was built as a synthetic index of environmental performance. It includes various factors, going from "environmental health" (indoor pollution, drinking water, adequate sanitation and urban particulates) to "ecosystems vitality" (air quality, water and productive natural resources, biodiversity). Data are available on-line at http://epi.yale.edu.

cast a clean future environmental quality, they are likely to bear an extra cost of education, to benefit longer from the environment when old.

Once occupational choices are made, agents vote on the level of the poll tax, which is exclusively used to finance public environmental maintenance. It is shown that optimal willingness-to-pay for the environment depends crucially on education and so on longevity: a higher life expectancy increases the level of the preferred tax, by raising stronger concern for the environment, while it reduces private consumption. This result may be backed up by compelling evidence, like Goetz (1998), Carlsson & Johansson-Stenman (2000), Brock & Taylor (2005), that highlight the important role played by both socio-demographic and economic factors, including the level of education or health status, in explaining the positive correlation between the level of education and the public support for environmental protection.

We consider a simple majority voting mechanism so that the political outcome depends on the current distribution of traits within the population. Hence, if the majority within the economy is *unskilled*, the implemented environmental tax is the lower one, and conversely. In turn, as previously exposed, the median voter's feature is itself affected by expected future environmental quality. This dynamic interaction between the economic and political decisions of individuals may generate multiple equilibria and indeterminacy. In particular, we show that agents' expectations regarding future environmental quality may be self-fulfilling as the public policy is endogenous. Hence, the coordination on one outcome allows for multiple equilibrium paths with different long-run consequences in terms of environmental quality and development. On the one hand, if expectations are coordinated on thinking the future environmental quality to be good , there is room for an equilibrium path that self-confirms these anticipations: in the long-run, the economy is driven towards a high equilibrium characterized by both good environmental quality and a more highly educated population. On the other hand, if expectations are more pessimistic, then *skilled* workers are a minority. The resulting effort of maintenance provided publicly is smaller and confirms initial predictions: the economy may be caught in a trap featured by a poor environment and a majority of *unskilled* workers.

Finally, the crucial role played by agents'expectations paves the way for public intervention in order to select the higher equilibrium. Since in our model, agents vote on environmental policy, the authorities are not capable of making a commitment on the future environmental quality. However, the government may aim at encouraging education in order to favour the emergence of optimistic forecasts. Accordingly, we assess the dynamic consequences of a public policy whose goal is to stimulate the investment in human capital in order to escape from the trap. Among many available instruments, we choose to model the impact of a reduction in the fixed cost of education. Public policy is still endogenous, but tax is now used for two alternative purposes: education and environmental maintenance. We show that if initially the economy is trapped, public policy may be first detrimental to the environment to switch the trajectory, while in a second step it allows the economy to reach a better overall situation: an improved environment and a majority of *skilled* workers. We also underline that the policy design optimally varies over time. In fact, public policy in favour of education has to be temporary; after a while, tax benefits must again be entirely devoted to environmental protection.

Our paper is related to those articles that have analysed environmental issues in dynamic OLG framework. In particular, we refers to the setting proposed by John & Pecchenino (1994) or Ono (2002) to describe the evolution of environmental quality over time. A link can also be established with the paper of Ikefuji & Horii (2007) who identify a poor-environment trap associated with a low level of human capital or the one by Mariani *et al.* (2009) where the trap is also characterized by a lower life expectancy. However, our analysis contrasts with those papers as we consider the effort of maintenance being provided publicly, as a consequence of a political equilibrium. On the contrary, Jouvet *et al.* (2008) consider the trade-off between private and public environmental spending, although agents differ, in their framework, in their behaviour with respect to bequest.

This article is also built on recent models of expectation-driven multiplicity like Saint Paul & Verdier (1997), Bisin & Verdier (2000) or Hauk & Saez-Marti (2002), although we concentrate on more environmental dynamical issues, rather than the mechanism of preference transmission. Nevertheless, as in these papers we investigate the opportunities of public intervention in order to select a unique equilibrium. In this respect, our paper may also be related to the article of Glomm & Ravikumar (1995) who study the dynamic implications of equilibrium selection.

The remainder of the paper is organised as follows. In Section 2, we introduce the model and analyse the dynamic behaviours of the economy. Policy implications are discussed in Section 4 and Section 5 concludes.

2 The model

2.1 The basic framework

Let consider an overlapping generations model where individuals live for two periods. Time is discrete, $t = 0, 1, ... + \infty$ and at any date t, there is a continuum of agents of mass 1 being born. Accordingly, no population growth is considered. Lifespan utility of an agent i, at date t, writes as:

$$U_t^i = c_t^i + \pi_t^i E_{t+1} \tag{1}$$

It is defined over private consumption (c_t) during the first period of life and environmental quality (E_{t+1}) when old. In our setting, agents could have valued the environment during their first period of life; however, as we will see below, their choices with respect to environmental conditions do not affect the current environment so that the results hold unchanged.

Utility derived from the second period of life is discounted by a factor $\pi_t^i \in (0, 1]$ which accounts for life expectancy.[3] Since only environmental quality is discounted, life expectancy can also be regarded as the weight given by agents to main environmental concerns so that, it could be interpreted as the level of green preferences. It is worth noticing that here, the discount factor is endogenous since we consider that life expectancy of an individual i crucially depends on educational choices. More specifically, we argue that longevity is widely explained by the level of education (without focusing on the feedback effect of life expectancy on education investment itself): more educated agents adopt healthier behaviours, have more information about risks, etc...Because education and income are positively linked, more educated agents, who often exhibit higher income, may also have better access to health services, adequate living conditions, etc. (see, for instance, Barro & Sala-i Martin (1995), Chakraborty (2004), de la Croix & Licandro (2007) or Lleras-Muney (2005)).

3. Throughout the paper, we interchangeably use the terms "life expectancy" and "longevity" since both concepts exhibit similar properties. It can be either a probability of surviving to old age or the length of the second period of life, thus being included in the interval $(0, 1]$. In either case, the benefit drawn from the environment is discounted by a time-length factor.

2.1.1 Education

During the first period of life, each agent is endowed with one unit of time, which can be shared among education and work. All individuals spend a fixed period of time at school, $\lambda \in (0,1)$, in order to acquire basic skills. Once they get this primary knowledge, they can directly supply *unskilled* labour to the market. However, they may also become *skilled*, through acquisition of additional human capital. Since individuals rather than their parents decide about their education, the choice of acquiring human capital implies a trade-off: human capital allows for a higher wage while it requires a loss in the valuable time, z. Let us suppose that this time cost is distributed uniformly within the population on the range $[0,1]$. As in Cervellati & Sunde (2005), this parameter z may be interpreted as innate abilities in terms of learning capacities. However, in our model, individual abilities affect the cost of education rather than its return. Consequently, a high z (equivalent to lower abilities) implies that the time spent educating is longer and the remaining time working on the market, shorter. Then, the labour income (y_t^i) for both types of existing workers, during the first period of life, is given by:

$$\begin{cases} y_t^s = (1-\lambda-z)w_t^s \\ y_t^u = (1-\lambda)w_t^u, \end{cases} \tag{2}$$

where $i = \{s, u\}$, for *skilled* workers and *unskilled* ones, respectively. If two types of workers co-exist within the population, we can also define two distinct levels of life expectancy corresponding to the educational choices. Therefore, we denote π^i, the life expectancy of a worker i, where $0 < \pi^u < \pi^s \leq 1$, according to empirical evidence mentioned in the Introduction.

2.1.2 Environmental quality

Agents use their labour income to consume but are also subjected to a poll tax ($\tau_t > 0$).[4] Since environmental quality is mostly a public good and costs required to abate pollution are very high, individuals or groups within the population are unable to effectively provide them. Then, we assume that this tax is levied by the government in order to alleviate pollution, to improve or, at least, to preserve environmental quality. Accordingly, in our framework, we consider a political equilibrium where agents take an active part in the decision-making process concerning the design of the environmental policy, by voting on the level of such a tax. Consequently, the effective tax which is implemented will depend on the distribution of skills among the population.

Finally, all decisions are taken during the first period of life and the budget constraint writes as:

$$y_t^i - \tau_t = c_t^i \tag{3}$$

This tax, used by the government considerably affects the evolution of environmental quality over time. In fact, in line with the seminal work of John & Pecchenino (1994), we express the law of motion of environmental quality as:

$$E_{t+1} = (1-\eta)E_t - P_t + \sigma g(\tau_t) \tag{4}$$

4. Of course, it could be the case that the tax is proportional to the wage; however, as we will see later, in that case, the choice regarding extra education would depend on both expectations with respect to future environmental quality, but also predictions about the future tax rate. Moreover, the preferred tax rate it-self would depend on wages, and so would be distributed within the population of educated agents. Finally, this would heavily complicate the analysis.

where $0 < \eta < 1$ is the natural depreciation rate of the environment, P_t, harmful pollution flows, $g(\tau_t)$, the environmental maintenance provided by the authorities and $\sigma > 0$, the efficiency of such environmental expenditure on the environment. Let us underline that here, agents value the environment that may encompass environmental conditions (going from air quality to quality of water, soils etc.) as well as resources availability (like, for instance, biodiversity, forestry, fisheries and so on..). Broadly speaking, this variable $E_t \geq 0$ is multidimensional and can be regarded as an indicator of all amenities provided by nature.

Furthermore, it is worth noticing that in our set-up, maintenance outcome (as well as pollution flows) account only for the next period so that adults' choices with respect to the environment can not directly affect current environmental conditions. Indeed, the natural environment and most kinds of ecosystems react slowly to pollution flows or environmental measures so that environmental changes are postponed and often occur after a long period.

2.1.3 Production

In the end, one good is produced (and privately consumed) thanks to labour. Both kinds of workforce are perfectly substitute, so that:

$$Y_t = A^s H_t + A^u_t L_t, \tag{5}$$

where H_t represents the aggregate *skilled* workforce (so called human capital) and L_t the aggregate *unskilled* labour available in the economy. [5] Then, A^i stands for the productivity level of each labour force. We assume that $A^s > A^u$ since we want to capture the greater capacity of educated agents to adopt and apply a given technology, to learn additional knowledge: it is less "costly" to adapt to advanced technologies being already educated (for further discussion see, among others, Fershtman *et al.* (1996), Caselli (1999), Galor & Moav (2000)). Finally, for ease of presentation, we assume constant productivity and do not consider any growth process.

Besides, so as the market is competitive and labour forces exhibit constant returns to scale, each input is paid to its marginal productivity. Therefore, a skill premium for educated workers exists, which involves a positive wage gap between both kinds of occupations. From (5), wage rates are deduced:

$$\begin{cases} w^s = A^s \\ w^u = A^u \end{cases} \tag{6}$$

Finally, we consider that pollution flows in the economy arise from the production process such that:

$$P_t = \beta Y_t, \tag{7}$$

with $0 < \beta \leq 1$, which reveals the cleanness degree of production.[6] The higher β, the dirtier the production. Here, we neglect the fact that pollution intensity may differ from one kind of labour to an other, like Ikefuji & Horii (2007) do, but we consider a whole production-induced pollution. In this respect, it could be quite similar to assume that pollution is associated with consumption flows in the economy. We could have considered that *unskilled* labour was more polluting, similar to Ikefuji & Horii (2007). More specifically, we would have endogeneized

5. This perfect substitutability between *skilled* and *unskilled* types of labour is very restrictive and may be discussed. However, allowing for the complementarity would heavily complicate the model, although the reasoning with respect to the choices of education is preserved.

6. We consider here a linear relationship between pollution flows and production for the sake of simplicity.

the parameter β, so that it evolves positively with the share of *unskilled* workforce within the economy: $\beta(\frac{L}{H})$ and $\beta'(\cdot) > 0$. In that case, our results would have been reinforced. Indeed, a large proportion of *unskilled* workers would induce a heavier pressure on the environment as well as a lower level of environmental protection: the deterioration of the environment would probably accelerate.

2.2 Microeconomic choices

In this section, we present the microeconomic choices of agents. On the one hand, we show that educational choices hinge on utilities comparison; on the other hand, the effort of maintenance is derived from a simple majority voting mechanism. Then, using the dynamic complementarity between choices of education and the demand for environmental protection allows us to study the global dynamics of the environment in Section 3.

In order to clearly present our analysis, we consider a specific timing during the first period of life: at first, agents choose whether to educate or not, and in a second step, they vote, according to their skills, on the level of the tax.

2.2.1 Educational choices

An individual i with a time cost equal to z is indifferent between educate himself or not, if, for a given tax,

$$U_t^s = U_t^u \Leftrightarrow [(1-\lambda-z)w^s - \tau_t] + \pi^s E_{t+1} = [(1-\lambda)w^u - \tau_t] + \pi^u E_{t+1} \tag{8}$$

Using (6), a threshold value on z, is deduced from the above equality:

$$\tilde{z}_t = \frac{(1-\lambda)(A^s - A^u) + [\pi^s - \pi^u]E_{t+1}^a}{A^s} \equiv \tilde{z}(E_{t+1}^a), \tag{9}$$

with E_{t+1}^a, the expected future state of the environment. Since agents derive utility from the environment during their second period of life, they have to anticipate future environmental conditions when they decide about their additional education. The uncertainty that leads agent to form expectations with regards to the environment, lies in the fact that choices of education will have an impact on both the effort of maintenance and the pollution flows. The static comparison of utility (see equation (8)) implies that for any distributed $z \leq \tilde{z}(E_{t+1}^a)$, agents choose to acquire additional knowledge; conversely, if $z > \tilde{z}(E_{t+1}^a)$, individuals do not invest in further education and provide *unskilled* labour force. Obviously, if $\tilde{z}(E_{t+1}^a)$ is very high that is for $E_{t+1}^a \geq \hat{E} \equiv \frac{\lambda(A^s-A^u)+A^u}{[\pi^s-\pi^u]}$, everybody educates (*i.e.* the proportion of highly educated agents equals unity); the production is only ensured thanks to type-s workers. When $E_{t+1}^a = 0$, there is still a positive share of agents that spend time educating, $\tilde{z}(E_{t+1}^a) = \frac{(1-\lambda)(A^s-A^u)}{A^s}$[7].

Not surprisingly, this threshold value $\tilde{z}(E_{t+1}^a)$ depends on two main factors. The first one, quite usual, is the income effect: a rise in the wage gap between *skilled* and *unskilled* activities

7. More specifically, it becomes impossible to solve the model in an analytical way. For instance, considering a Cobb-Douglas production function (such that the two types of labour are complement) would prevent from computing a threshold value on z. Nevertheless, using such production function, we are able to state that there exists a unique value of z, which also depends positively on expectations with respect to environmental quality and which determines when agents decide to invest in human capital or not. (see Appendix F)

spurs the extra investment in human capital, while λ, the fixed cost of primary education tends to discourage it. The second factor is represented by agents' expectations regarding the future state of the environment. Individuals are prone to suffer a higher cost of education if they anticipate improved future environmental conditions. In fact, an expected good environmental quality fosters education, because, in that case, agents hope to benefit longer from the environment when old. This positive effect holds all the more so as the longevity gap is large between the two types of workforce. Figure 3 depicts the relationship between $\tilde{z}(E^a_{t+1})$ and the future state of the environment.

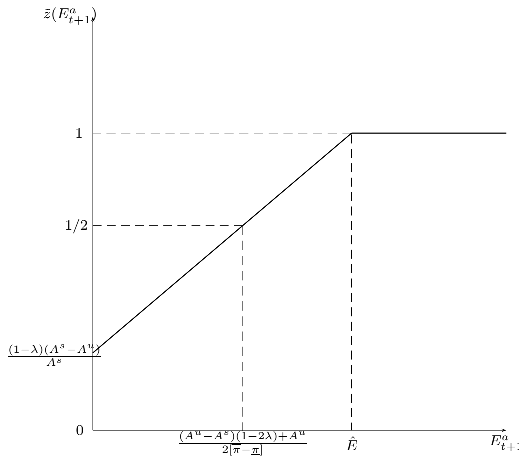


Figure 3: share of *skilled* agents within the population

Finally, let us notice that the global impact of the *skilled* workers' productivity (A^s) is not clear cut. In particular, despite the positive income effect, it turns out that education is costly, with zA^s measuring the individual cost of acquiring human capital (see equation (2)). Yet, when agents educate they receive a fixed gain derived from the environment, altered by a longevity effect. Then, the relative gain of being *skilled* ($[\pi^s - \pi^u]E^a_{t+1}/A_s$) falls with A^s. In fact, the net utility derived from the environment is cut down by the global cost of education.

Provided that z is uniformly distributed within the population, the aggregate labour supplies of both types of workers, at date t, are given by:

$$H_t = \int_0^{\tilde{z}_t} dz = \tilde{z}(E^a_{t+1}) \tag{10}$$

and

$$L_t = \int_{\tilde{z}_t}^1 dz = (1 - \tilde{z}(E^a_{t+1})) \tag{11}$$

Here, $\tilde{z}(E^a_{t+1})$ is exactly the proportion within the population that does educate.

Furthermore, using equations (10) and (11), the production in the economy can be rewritten as:

$$Y_t = \begin{cases} \tilde{z}(E^a_{t+1})(A^s - A^u) + A^u & \text{if } 0 < E^a_{t+1} < \hat{E} \\ A^s & \text{if } E^a_{t+1} \geq \hat{E} \end{cases} \tag{12}$$

When all workers are *skilled*, the production is fully determined by the productivity level of highly educated workers; when both types of workers co-exist, the share of *skilled* individuals in the economy boosts production.

In the end, using equation (7) and (12), it follows that pollution flows in the economy (P_t) may be expressed as:

$$P(E^a_{t+1}) = \begin{cases} \beta[\tilde{z}(E^a_{t+1})(A^s - A^u) + A^u] & \text{if } 0 < E^a_{t+1} < \hat{E} \\ \beta A^s & \text{if } E^a_{t+1} \geq \hat{E} \end{cases} \tag{13}$$

Since a rise in the proportion of highly educated workers stimulates both production (12) and pollution (13), a feedback effect of expectations on environmental quality arises: optimistic predictions trigger extra investment in education, which in turn, by increasing the share of *skilled* workers, induces more pollution and so more pressure on the environment. Finally, the net impact of agents' expectations on the evolution of the environment will crucially depend on the effort of maintenance provided by the government and on the adopted tax within the society.

2.2.2 Political equilibrium

As mentioned before, the poll tax is exclusively used to provide environmental maintenance expenditure (this could also be a direct reduction of pollution). The government's budget is balanced, so that:

$$\tilde{z}_t \tau_t + (1 - \tilde{z}_t)\tau_t = \tau_t, \tag{14}$$

the sum of the contributions finances the global effort of maintenance. The environmental protection provided by the authorities writes as:

$$g(\tau_t) = \tau_t^\theta, \tag{15}$$

with $\theta \in (0, 1]$, which could embody the efficiency of the maintenance technology (*cf.* Ballestra & Dottori (2009)). Here, tax revenue translates into maintenance, but we consider that this maintenance technology exhibits decreasing marginal returns: as tax receipts rise, the marginal efficiency of abatement reduces. It is more easy to abate pollution at the beginning of the cleaning process, but as the receipt grows, it becomes more tricky. Alternatively, this parameter θ could be regarded as the efficiency of government institutions, meaning that a low value of θ induces a larger wasted part of tax receipts. Tax revenue may be partly dissipated in collection costs; otherwise said, marginal collection costs increase in the tax, due, for instance, to the existence of bureaucratic inefficiencies (Saint Paul & Verdier (1997), Lightart & Ploeg (1999)). In the end, both interpretations of θ implies that utility is concave in environmental maintenance and so satisfies usual properties: individuals face a trade-off between private consumption and future environmental quality (consumption of a public good).

Once they have decided about their education, agents aim at maximising their lifetime utility under equations (3), (4) and (15) in order to determine their optimal willingness-to-pay for environmental preservation. From the First Order Condition (FOC), we obtain the optimal poll tax for both types of workers in a decentralized equilibrium:

$$\tau^i = (\sigma \pi^i \theta)^{\frac{1}{1-\theta}} \tag{16}$$

It is worth noticing that this optimal willingness-to-pay for the environment is constant over time and is fully determined by the level of education through life expectancy, which might differ according to the type of agent. Provided that $\pi^s > \pi^u$, it follows obviously that $\tau^s > \tau^u$ and environmental quality is indeed a normal good. Hence, high-income agents are more prone to pay for environmental protection.

Our result is thus consistent with widespread empirical evidence such that higher income or/and higher level of education raise stronger concern for the environment (Goetz (1998), Carlsson & Johansson-Stenman (2000), Brock & Taylor (2005)). To some extent, this result may also be related to a theoretical literature that adresses the determinants of green consciousness, relying on the evolution of agents'income.

Finally, because the weight paid to environmental quality depends on agents' life expectancy, agents are merely capable of contributing more, if they expect to benefit longer from the environment, and conversely. As in Mariani *et al.* (2009), life expectancy becomes a major determinant of environmental performance.

In the end, such kind of microeconomic behaviours shape environmental quality at a macroeconomic level. Indeed, as individuals exhibit single-peaked preferences with respect to the environment, the theorem of the median voter holds. Therefore, the political outcome depends on the median voter's feature, be it *skilled* or *unskilled*, and writes as:

$$\begin{cases} \tau = \tau^u \text{ if } E^a_{t+1} < \tilde{E} \\ \tau = \tau^s \text{ if } E^a_{t+1} \geq \tilde{E} \end{cases} \tag{17}$$

with

$$\tilde{E} \equiv \frac{A^u - A^s(1-2\lambda) + A^u}{2[\pi^s - \pi^u]}, \tag{18}$$

where $\tilde{E}$ is defined as the level of E^a_{t+1} such that $\tilde{z}(E^a_{t+1}) = 1/2$.

The poll tax effectively chosen is crucially affected by agents'expectations with respect to environmental quality. If E^a_{t+1} is low, less agents invest in education and the share of *unskilled* workers is greater than half ($\tilde{z}(E^a_{t+1}) < 1/2$). Consequently, the effort of environmental preservation provided in the economy is mitigated. The oppposite is true if E^a_{t+1} is high. Agents are prone to suffer a higher extra cost of education: the share of *skilled* workers rises, the median voter becomes *skilled* ($\tilde{z}(E^a_{t+1}) \geq 1/2$).[8] Accordingly, the demand for environmental protection raises so as the tax.

3 Dynamics

Substituting (7)-(17) into the law of motion of environmental quality, we obtain a system that describes the global dynamical behaviour of the economy. Depending on the median voter's feature, we can characterize the dynamics of the economy. In particular, when the median voter is *unskilled*, we define $E_{t+1} \equiv \psi_u(E_t, E^a_{t+1})$ so that

$$\psi_u(E_t, E^a_{t+1}) = (1-\eta)E_t - P(E^a_{t+1}) + \sigma {\tau^u}^\theta, \tag{19}$$

8. Notice that here, there exists a usual problem when $\tilde{z}(E^a_{t+1}) = 1/2$ to determine which group wins the elections. In order to avoid this, and for the sake of simplicity, we simply assume that when $\tilde{z}(E^a_{t+1}) = 1/2$, the winner majority is *skilled.*

with $P(E^a_{t+1})$ defined in (7). Pollution flows may vary according to E^a_{t+1}, since the expected value of th environment the population of *skilled* workers within the economy and therefore the pollution level. Alternatively, when the median voter is *skilled*, we define $E_{t+1} \equiv \psi_s(E_t, E^a_{t+1})$ such that

$$\psi_s(E_t, E^a_{t+1}) = \begin{cases} (1-\eta)E_t - P(E^a_{t+1}) + \sigma\tau^{s^\theta} & \text{if } E^a_{t+1} < \hat{E} \\ (1-\eta)E_t - \beta A^s + \sigma\tau^{s^\theta} & \text{if } E^a_{t+1} \geq \hat{E}. \end{cases} \tag{20}$$

Finally, the global dynamics can be summarized by:

$$E_{t+1} = \begin{cases} \psi_u(E_t, E^a_{t+1}) & \text{if } E^a_{t+1} < \tilde{E} \\ \psi_s(E_t, E^a_{t+1}) & \text{if } E^a_{t+1} \geq \tilde{E} \end{cases} \tag{21}$$

The dynamics are dramatically influenced by expectations agents have about the future environment. These anticipations determine the share of *skilled* workers within the population and accordingly the type of the median voter. Hence, the evolution of environmental quality over time relies on individuals anticipations. Using equation (21), we can argue that the median voter is *skilled* only for fairly high values of E^a_{t+1}. If initially agents anticipate good future environmental conditions, they choose to educate, since they expect to benefit longer from the environment. As the proportion of type-s workers increases, the median voter is likely to be *skilled*. Consequently, the government implements a heavier tax and the receipts devoted to environmental preservation are larger. Symmetric reasoning could apply when dealing with pessimistic expectations, that is when $E^a_{t+1} < \tilde{E}$.

However, even if the effect of the tax is clear cut, the distribution of skills within the population might display ambiguous effects. Because pollution flows grow with the share of highly educated workers in the economy, agents'expectations may translate into more pressure on the environment (see equation (7)). Yet, those anticipations become beneficial to environmental quality, only through a "cliquet" effect, that is when the economy shifts from one regime to another. In that case, optimistic predictions also implies a larger effort of maintenance, so that environmental quality improves.

3.1 Perfect foresight dynamics

In order to solve the dynamics, we assume that agents perfectly anticipate future environmental conditions, thus inducing that $E^a_{t+1} = E_{t+1}$. Under this assumption, the perfect foresight dynamics of the economy is obtained by solving the system (21) for $E^a_{t+1} = E_{t+1}$. Hence, a one-dimensional dynamical system describes the evolution of environmental quality over time:

$$E_{t+1} = \begin{cases} \Psi_u(E_t) & \text{if } E_{t+1} < \tilde{E} \\ \Psi_s(E_t) & \text{if } E_{t+1} \geq \tilde{E}, \end{cases} \tag{22}$$

with:

$$\Psi_u(E_t) = \frac{A^s[(1-\eta)E_t + \sigma\tau^{u^\theta}] - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + \beta A^u A^s(1-2\lambda)}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)} \tag{23}$$

and

$$\Psi_s(E_t) = \begin{cases} \frac{A^s[(1-\eta)E_t + \sigma\tau^{s^\theta}] - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + \beta A^u A^s(1-2\lambda)}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)} & \text{if } E_{t+1} < \hat{E} \\ (1-\eta)E_t - \beta A^s + \sigma\tau^{s^\theta} & \text{if } E_{t+1} \geq \hat{E} \end{cases} \tag{24}$$

The global perfect foresight dynamics (equation (22)) are in two parts differing by the median voter's feature. We start by analyzing separately the two trajectories and then we study the global dynamics.

More specifically we can prove that each part of the dynamics, $\Psi_u(E_t)$ or $\Psi_s(E_t)$, taken separately, admits only one globally stable steady-state, E^u and E^s, characterized by a low and a high environmental quality, respectively (see Appendix A). Here, a steady-state is defined as a fixed point E^i with $i = \{s, u\}$ such that: $\Psi_i(E_t) = E_t$. In particular, using equations (23) and (24), for $0 < E_{t+1} < \hat{E}$, we will have that:

$$E^u = \frac{A^s[\sigma \tau^{u^\theta}] - \beta[(1-\lambda)(A^{s^2} + A^{u^2}) - A^s A^u (1-2\lambda)]}{\beta(A^s - A^u)(\pi^s - \pi^u) + \eta A^s} \quad (25)$$

$$E^s = \frac{A^s[\sigma \tau^{s^\theta}] - \beta[(1-\lambda)(A^{s^2} + A^{u^2}) - A^s A^u (1-2\lambda)]}{\beta(A^s - A^u)(\pi^s - \pi^u) + \eta A^s}, \quad (26)$$

where $E^s > E^u$, since $\tau^s > \tau^u$. The sole difference between the two stationary values stands in the level of the tax.[9]

Given that properties, let us now study the global dynamics of the economy. In particular, it is described by the trajectory $\Psi_u(E_t)$ if the expected environmental quality is damaged, while it is characterized by $\Psi_s(E_t)$, if expectations are much more optimistic. Here, we assume that when two trajectories exist in $t+1$, the economy follows the one prevailing at date t. Hereafter, this property refers to the concept of stationary expectations.[10] In order to describe clearly the global dynamics, we also define the threshold values on environmental quality that determine the area of existence of each trajectory. We denote by $\overline{E}$, the value of E such that $\Psi_u(\overline{E}) = \tilde{E}$: beyond $\overline{E}$, $\Psi_u(E_t)$ does not exist anymore, or otherwise said the majority is no longer *unskilled*. Similarly, we define $\underline{E}$ such that $\Psi_s(\overline{E}) = \tilde{E}$. Since, in turn, the median voter's feature depends on expected future environmental conditions, we can claim that:

Proposition 1 *Let assume that agents have perfect foresight expectations, then*

(i) E_t *always converges towards* E^u*, if* $\underline{E} > E^s$*;*

(ii) E_t *always converges towards* E^s*, if* $\overline{E} < E^u$*;*

(iii) when $\underline{E} < E^u < E^s < \overline{E}$*, there always exist stationary expectations such that:*

- *if* $E_0 < \tilde{E}$, $E_{t+1} = \Psi_u(E_t)$ *and* E_t *converges towards* E^u
- *if* $E_0 \geq \tilde{E}$, $E_{t+1} = \Psi_s(E_t)$ *and* E_t *converges towards* E^s

Proof. See Appendix B ■

Part *(i)* of Proposition 1 is likely to arise when the value of $\tilde{E}$ is very high, thus implying that the majority may hardly be *skilled*. For instance, if primary education is already very costly, agents will have less incentives to invest in further education. Similarly, a very dirty production

9. It is worth noticing that for $E_{t+1} \geq \hat{E}$, $E^s = \frac{\sigma \tau^{s^\theta} - \beta A^s}{\eta}$. However, we choose to report in the text the solutions depicted in Figure 4.

10. This assumption is made for ease of presentation and in order to give the main insights of the model. It will be relaxed in Subsection 3.2, where we present a more general case.

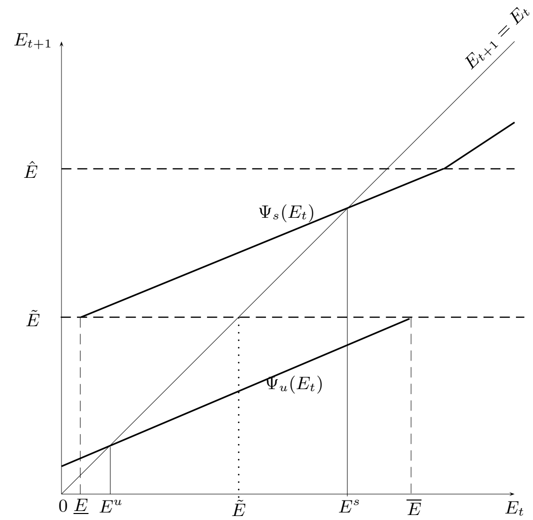


Figure 4: Multiple equilibria, case (iii) of Proposition 1

technology might prevent the high equilibrium to exist. In that case, no matter initial conditions, the economy converges towards the low, unique and globally stable equilibrium, E^u. Conversely, part *(ii)* might occur if the longevity gap is large. A high efficiency degree of maintenance expenditure compared to β may also favour the achievement of the high equilibrium, E^s.

Part *(iii)* of Proposition 1 is depicted in Figure 4. When the two steady-states co-exist, then, depending on initial conditions, the economy may converge towards either E^u or E^s. If initially, environmental quality is somewhat low (for $E_0 < \tilde{E}$), majority is *unskilled* so as the median voter. Under the assumption of stationary expectations, anticipations are and remain quite pessimistic, and incentives to educate drop. Then, the tax which is implemented is lower and the economy converges towards E^u, following the trajectory described by the function $\Psi_u(E_t)$. The resulting stationary value of environmental quality is low and the share of *unskilled* workers within the population is large. In that case, we can say the economy is caught in an environmental trap featured by a damaged environmental quality and a low level of development. Conversely, if initially the environment is clean (for $E_0 \geq \tilde{E}$), the median voter is *skilled*. Stationary expectations are optimistic and incentives to invest in extra education are boosted. The level of maintenance provided publicly is higher and the economy reaches E^s, a stationary value characterized by improved environmental conditions and a more educated population. In our framework, an increase in the proportion of *skilled* workers does not imply necessarily a heavier pressure on the environment. In fact, it also induces a rise in the environmental maintenance provided by the public authorities. Yet, as discussed above, this latter effect overcomes the former and so environmental quality at the high steady-state is well improved compared to the trap.

In our framework, the presence of multiple equilibria directly stems from the complementarity between incentives to invest in human capital and the willingness-to-pay for environmental protection, through the longevity effect. These multiple equilibria, linking environmental quality and level of education, can be backed up by some empirical evidence, which show that more educated economies are likely to exhibit better environmental conditions (see, for instance, Magnani (2000), Bimonte (2002), Fredriksson *et al.* (2005), Farzin & Bond (2006)). As shown previously, this positive relationship may be micro-founded. In particular, a higher level of education may in it-self trigger stronger concern for the environment (Goetz (1998), Carlsson & Johansson-Stenman (2000), Brock & Taylor (2005)), thus encouraging the emergence of a green consciousness. At an aggregate level, this green concern of skilled individuals has more chance to translate into improved environmental quality through the greater ability of educated agents to influence political decisions *via*, for instance, lobbying groups, non-governmental organizations, ecological political groups, etc....

3.2 Indeterminacy and self-fulfilling equilibria

In this section, we relax the assumption of stationary expectations. In particular, we show that expectations might be self-fulfilling and might determine the long-run political outcome. In fact, there exist some values of E_t such that E_{t+1} is undetermined. Then, as in Bisin & Verdier (2000) or Hauk & Saez-Marti (2002), we focus on the case where the two stationary values of the environment belong to this indeterminacy area; finally, we study the dynamic implications of agents' coordination on a particular outcome regarding future environmental quality. We can then state that:

Proposition 2 *Expectations might be self-fulfilling since two different values of E_{t+1} are compatible with a unique value of E_t, $\forall E_t \in [\underline{E}, \overline{E}]$.*

Proof. See Appendix C ■

Interestingly, our model exhibits self-fulfilling expectations as claimed in Proposition 2. This implies that when, initially, the distribution of abilities within population is relatively balanced, the role of anticipations and their coordination on a particular issue become a key ingredient for the determination of long-run environmental evolutions.

Consider, for instance, a situation where initially agents of type-u are a majority and $E_t \in [\underline{E}, \overline{E}]$. If all of them are pessimistic and thus expecting that future environmental quality will remain damaged, the share of *unskilled* workers remains majority. The resulting effort of maintenance is thus small and self-confirms initial predictions. Consequently, if agents coordinate on this same pessimistic belief all along the dynamical process, the environment converges towards E^u. Conversely, starting from the same situation, that is a majority of *unskilled* workers within the population but if agents coordinate on a more optimistic anticipation, the stationary value of environmental quality may be improved. In fact, agents are more likely to invest in additional education for them-selves: type-s workers may become a majority and the tax equals τ^s, thus increasing mechanically the effort of maintenance. Again, expectations are realised while environmental quality reached by the economy is better. Moreover, *unskilled* workers turn out to be minority.

Proposition 1 states that the stationary values of the environment are stable under stationary expectations while Proposition 2 defines an indeterminacy area, in which expectations may be self-confirmed. Then, it turns out that these stationary values may be destabilized following a change in expectations. The Corollary below summarizes this result:

Corollary 1 *When E^s and $E^u \in [\underline{E}, \overline{E}]$, one economy that would have converged towards one of both equilibria under the assumption of stationary expectations, might rather reach the other steady-state thanks to a change in expectations.*

In the configuration depicted in Figure 4, the low equilibrium E^u belongs to the indeterminacy area $[\underline{E}; \overline{E}]$. Consequently, one economy initially trapped in E^u might jump onto the optimistic trajectory $\Psi_s(E_t)$ and converge towards E^s by means of change in expectations. In this case, switching from pessimistic anticipations to more optimistic ones allows the economy to escape from the initial poor-environment trap. Notice that this mechanism works also in the opposite way, so that an economy initially located in E^u might, in the end, be pushed towards the low equilibrium, if anticipations become suddenly pessimistic.

In our setting, the change in agents'expectations is a possible way, among others, to switch the trajectories followed by one economy. As pointed out by some other theoretical papers like Glomm & Ravikumar (1995), Bisin & Verdier (2000) or Hauk & Saez-Marti (2002), these multiple equilibria arise due to failures in the expectations coordination. Then, the implementation of public policies or the authorities commitment might be a solution that enables to correct these inefficiencies. Otherwise said, the success of any environmental policy, which aims at reducing environmental deterioration, could be realised, at least partially, if authorities are able to coordinate agents' beliefs on quite optimistic expectations with respect to the environment it-self. However, it is worth noticing that here, the government can not commit it-self with respect to the effort of maintenance since agents do decide on the prevailing level of maintenance provided publicly: the authorities can not announce any environmental policy in advance neither shape the median voter's ability. Expectations can not be influenced directly by the government. Nevertheless, in order to select one specific equilibrium and to ensure the achievement of its environmental goal, the government may choose to modify the cost of education. Indeed, education is a crucial factor that influencing agents green preferences.

In the following section, we emphasize the role played by a public policy on the opportunity of switching the equilibria. However, let us underline that, the selection of one specific equilibrium is not a trivial choice. In fact, the welfare analysis leads to ambiguous results due to the existence of heterogeneous agents: it is then tricky to rank both equilibria. On the one hand, the high equilibrium E^s always seems to be preferred by *skilled* workers: first, the implemented tax is exactly the one they vote for; second, environmental quality is higher. However, even if *unskilled* individuals benefit from a better environmental quality in E^s, they have to pay an undesirable and heavier tax τ^s. Then, the high equilibrium might not be optimal for *unskilled* workers. A governmental policy that would aim at reaching E^s and escaping the trap, might not be Pareto-optimal, if the taxation effect dominates the green benefits. Nonetheless, since the level of development is also higher in E^s, we will consider such an objective and assess the instrument to achieve it.

4 Policy implications

As mentioned above, an improved environmental quality and a higher level of development are reached, at the steady-state, if agents exhibit optimistic expectations, thus being more likely to educate. Accordingly, in order to step out from the poor-environment trap, the government may aim at encouraging agents to invest in additional human capital. Since the government is not capable of coordinating agents'beliefs, we consider stationary expectations and study the opportunities of achieving a better environmental performance, starting from the low equilibrium E^u.

Consistently with our previous results, we consider, among the various available instruments, that the government reduces the fixed cost of education (λ) in order to boost the share of highly educated workers within the population. Here, as education is time consuming, the decrease of λ includes all improvements made in order to ameliorate the "learning technology": a better access to school, an increase in the size of teaching profession, more schools, and the like.

The starting point in time of our analysis is date T and the economy is pinned-down to E^u, the environmental trap such that $E^u < \overline{E}$. From that moment, the government announces that tax benefits are used for two alternative purposes: environmental maintenance and education. More precisely, the authorities decide to devote a share $\alpha \in (0, 1)$ of public receipt to environmental maintenance, while the remaining amount of tax $(1 - \alpha)$ are invested in education.

Because of the timing in the decision process, at date T, the share of both *skilled* and *unskilled* agents within the population is unaffected. Even if the public policy in favour of education is announced, unless the government contracts a debt, he can not fund the reduction in the fixed cost of education. As long as the public policy takes place, the government uses the receipts from the tax to finance the "subsidy" to education. Every thing goes as if the "educational" side of the policy is funded by the previous generation. This implies necessarily that the young generation at date T only suffer from the "green" side of the public policy. Agents' behaviour is instantaneously altered when dealing with the optimal poll tax and therefore, the environmental quality law of motion evolves from date $T + 1$. Let us underline that the public policy is still endogenous, although agents do not vote on the distribution of the tax benefits among the two purposes: they only choose the level of the tax, taken as given the share devoted to environmental efforts.

In order to assess the potential consequences of such kind of endogenous public policy, we first describe the changes that occur during the transition phase at date T; then, we expose the resulting dynamics of the economy when the policy is fully implemented, from date $T + 1$.

4.1 Transition phase

The governmental action has a direct effect on the future environmental quality, which enters the utility function of agents born at date T. Differently from (4), environmental quality now evolves according to:

$$E_{T+1} = (1 - \eta)E_T - P_T + \sigma(\alpha\tau^p)^\theta, \tag{27}$$

where τ^p is the implemented tax, noted with superscript p that stands for *policy*. Provided that initially the economy is located in E^u, the value of P_T is given.

Since the level of technology is given and constant over time, agents maximise (1), under (2), (6) and (27) in order to determine the amended optimal poll tax. Notice that the design of the policy (α) is taken as given when agents determine their optimal willingness-to-pay. It yields for an individual of type-i:

$$\tau^{p,i} = (\sigma\pi^i\theta\alpha^\theta)^{\frac{1}{1-\theta}}. \tag{28}$$

This result captures the positive and one-way relationship between the share of tax revenue dedicated to environmental expenditure and the level of the tax: an increase in α fosters the investment in environmental maintenance. Otherwise said, since extra education is not triggered by any altruistic motive, a larger share of receipt devoted to education does not provide any additional gain of utility, but only a smaller incentive to invest in maintenance. Finally, compared to the benchmark model (that is when α equals unity), for both types of agents, the willingness-to-pay for improving environmental conditions is smaller, since $\alpha < 1$.

Under the assumption of stationary expectations, and because we only consider E^u as a starting point of the analysis, the dynamics are described by the following equation:

$$E_{T+1} = \Omega_u(E_T) \tag{29}$$

where $\Omega_u(E_T)$ is the "transitional" value of environmental quality. In fact, this dynamics is slightly amended compared to the benchmark model. Formally, using (9), (7), (27) and (28), it yields for $0 < E_{T+1} < \tilde{E}$:

$$\Omega_u(E_T) = \frac{A^s[(1-\eta)E_T + \sigma(\alpha\tau^{p,u})^\theta] - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + \beta A^u A^s(1-2\lambda)}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)} \tag{30}$$

The economy jumps from E^u onto $\Omega_u(E_T)$. During this period, date T, the majority is *unskilled* and the environmental quality evolves taking into account the new willingness-to-pay. At next date, we can state that:

Lemma 1 *Starting from E^u, if the government implements a public policy in favour of education at date T, environmental quality deteriorates at date $T+1$.*

Proof. The slope of $\Omega_u(E_T)$ is identical to the one of $\Psi_u(E_t)$, $\forall\, E_t$ and $t = 0, ..T.. + \infty$. However, $\Omega_u(0) < \Psi_u(0)$. Thus, $\Omega_u(E_T)$ crosses the 45° line before E^u. ■

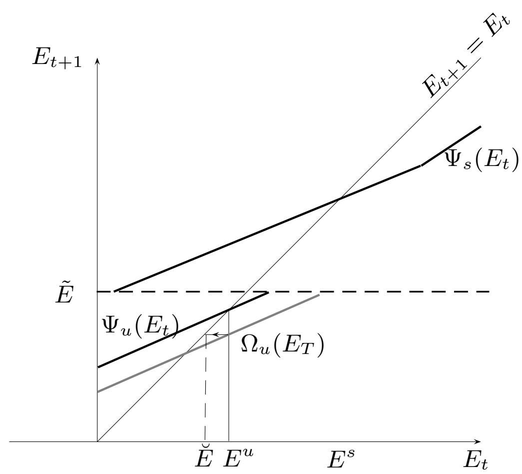


Figure 5: First phase of transition

As depicted in Figure 5, starting from the low equilibrium E^u, at date $T+1$, the economy ends up in $\check{E}(\alpha)$, defined such that $\Omega_u(E^u) = \check{E}(\alpha)$. This level of environmental quality crucially depends on the distribution of tax benefits. In fact, in the benchmark model, the whole revenue collected by the government is devoted to environmental maintenance. As soon as the public policy is implemented, the aggregate level of maintenance provided by the authorities is reduced. Obviously, since pollution flows are constant, environmental quality deteriorates compared to the initial situation. However, the larger the share granted to environmental protection, the less deteriorated the environment.

4.2 Long-run dynamics

Equation (27) describing the law of motion of the environment holds as soon as the public policy is implemented. However, from now on, the generation born at date $T+1$ benefits from the subsidy to education (ν_t) and so the proportion of *skilled* and *unskilled* workers in the economy might change.

4.2.1 Educational choices

Taking into account this fall into the cost of primary education, the budget constraint for both types of agents is now given by the following system:

$$\begin{cases} y^s_{T+1} = [1-(1-\nu_{T+1})\lambda - z]w^s \\ y^u_{T+1} = [1-(1-\nu_{T+1})\lambda]w^u, \end{cases} \tag{31}$$

where $\nu_t \in [0,1]$. The government's budget constraint is still balanced (see equation (14)); however a share $(1-\alpha)$ of these receipts are now devoted to education. The reduction in the fixed cost of education is financed by the previous generation. Once the level of the tax has been determined, the subsidy to education is deduced:

$$\nu = \begin{cases} [(1-\alpha)\tau^{p,u}]^\kappa & \text{if } E_T < \tilde{E} \\ [(1-\alpha)\tau^{p,s}]^\kappa & \text{if } E_T \geq \tilde{E}, \end{cases} \tag{32}$$

where $\kappa \in [0,1]$. Consistently with the benchmark model, we consider that κ reveals the efficiency of the learning technology: investing in schooling facilities exhibits decreasing marginal returns, meaning that initial tax benefits are more productive. Moreover, this parameter could capture the effectiveness of the tax collection, as previously. A higher value of κ would then imply that tax revenue are slightly dissipated in collection costs.

The investment in education is still shaped by the comparison of indirect utilities but now, using (1), (6) and (31), the threshold value on the private cost of education, z, writes as:

$$\tilde{z}^p_{T+1} = \frac{(A^s - A^u)[1-(1-\nu)\lambda] + (\pi^s - \pi^u)E^a_{T+2}}{A^s} \equiv \tilde{z}^p(E^a_{T+2}) \tag{33}$$

Obviously, the positive effect of optimistic agents' expectations is preserved; in addition, the higher the subsidy, the greater the threshold education cost. This implies mechanically that agents with a higher individual education cost, who would have been *unskilled* in the basic model, may now invest in extra education. As previously, $\tilde{z}^p(E^a_{T+2})$ accounts for the share of *skilled* workers within the economy, so that if $E^a_{T+2} \geq \hat{E}^p \equiv \frac{A^u-(A^s-A^u)\lambda(1-\nu)}{(\pi^s-\pi^u)}$, $\tilde{z}^p(E^a_{T+2})$ equals unity. As we focus on a specific configuration, that is E^u as starting point, we can directly deduce the value of ν and the resulting threshold value on $\tilde{z}^p(E^a_{T+2})$. Indeed, at the previous date the majority was still *unskilled*, and so the poll tax was equal to $\tau^{p,u}$.[11]

This threshold value depends ambiguously on the parameter α, which captures the design of the policy. Let us recall that individuals care about the environment so that α positively

11. Notice that now the threshold value on z at date $T+1$ may take two different values according to the tax prevailing at date T. As we focus on a specific case, we do not present the alternative value of $\tilde{z}^p(E^a_{T+2})$ when the tax equals $\tau^{p,s}$ at date T.

influences agents willingness-to-pay for environmental protection . Then, on the one side, a higher value of α involves larger tax receipts, which may, in turn, trigger the investment in additional education and increase the share of *skilled* agents in the economy. On the other side, this also implies a smaller share of tax benefits dedicated to education, and so α also influences the decision of extra investment, but in the opposite way.

4.2.2 Political outcome

Similarly to our benchmark model and in order to determine their own optimal poll tax, agents maximise their utility (1), under (27) and (31). Solving this program yields the result already exposed in equation (28). Then, anticipations with respect to future environmental quality shape the long-run dynamic implications of the model. To determine which tax prevails in the economy, we proceed as in subsection 2.2.2. Hence, we can state that:

$$\begin{cases} \tau = \tau^{p,u} \text{ if } E^a_{T+2} < \tilde{E}^p(\alpha) \\ \tau = \tau^{p,s} \text{ if } E^a_{T+2} \geq \tilde{E}^p(\alpha) \end{cases} \tag{34}$$

where

$$\tilde{E}^p(\alpha) \equiv \frac{A^s - 2(A^s - A^u)[1 - (1 - [(1-\alpha)\tau^{p,u}]^\kappa)\lambda]}{2(\pi^s - \pi^u)} \tag{35}$$

Notice that $\tilde{E}^p(\alpha) \leq \tilde{E}$. The central point here is that, as shown by the following derivative, the threshold $\tilde{E}^p(\alpha)$ depends in a non-monotonic way of α:

$$\frac{\partial \tilde{E}^p(\alpha)}{\partial \alpha} = \frac{(\alpha - \theta)\kappa\lambda(A^s - A^u)[(1-\alpha)\tau^{p,u}]^\kappa}{(1-\alpha)(1-\theta)\alpha A^s(\pi^s - \pi^u)} \tag{36}$$

In particular, the impact of α is twofold such that $\tilde{E}^p(\alpha)$ is described by a U-shape, according to the values of α. Starting from large values of α, a fall in the parameter induces high returns on the educational public policy. Incentives to invest in human capital rise, and predictions have to be slightly optimistic to ensure a majority of *skilled* workers. As soon as α is small enough, then receipts reduces sharply. For very low values of the parameter, tax receipts are small, while the return on the environmental effort is very high. Agents have less incentives to educate, expectations have to be very optimistic (*i.e.*, E^a_{T+2} very high) to allow the majority to become *skilled*.

Since the goal pursued by the government is to step out from the trap, the threshold value $\tilde{E}^p(\alpha)$ should be as small as possible: this would ensure a *skilled* majority. Yet, this threshold is U-shaped following changes in α. Then, there might exist a range of intermediate values of the parameter α, such that $\tilde{E}^p(\alpha)$ is small enough and allows optimistic expectations to be self-confirmed. Therefore, this paves the way for an eventual optimal allocation of the public receipt among education and environmental maintenance.

Once again, starting from date $T+1$ and depending on the median voter's feature, we are able to characterize the dynamics of the economy. When the median voter is *unskilled*, we define $E_{T+2} \equiv \phi_u(E_{T+1}, E^a_{T+2})$ and formally, using (7), (27) and (34), we obtain:

$$\phi_u(E_{T+1}, E^a_{T+2}) = (1-\eta)E_{T+1} - P(E^a_{T+2}) + \sigma(\alpha\tau^{p,u})^\theta. \tag{37}$$

When the median voter is highly educated, we have $E_{T+2} \equiv \phi_s(E_{T+1}, E^a_{T+2})$ such that

$$\phi_s(E_{T+1}, E^a_{T+2}) = \begin{cases} (1-\eta)E_{T+1} - P(E^a_{T+2}) + \sigma(\alpha\tau^{p,s})^\theta & \text{if } E^a_{T+2} < \hat{E}^p \\ (1-\eta)E_{T+1} - \beta A^s + \sigma(\alpha\tau^{p,s})^\theta & \text{if } E^a_{T+2} \geq \hat{E}^p. \end{cases} \tag{38}$$

Finally, the global dynamics can be summarized by the following system:

$$E_{T+2} = \begin{cases} \phi_u(E_{T+1}, E^a_{T+2}) & \text{if } E^a_{T+2} < \tilde{E}^p(\alpha) \\ \phi_s(E_{T+1}, E^a_{T+2}) & \text{if } E^a_{T+2} \geq \tilde{E}^p(\alpha) \end{cases} \tag{39}$$

As before, we consider rational expectations implying that $E^a_{T+2} = E_{T+2}$. Then, we can characterize a perfect foresight dynamics by solving (37) and (38), for $E^a_{T+2} = E_{T+2}$. This assumption allows us to obtain a one dimensional dynamical system, that describes the evolution of environmental quality from date $T+1$ (see Appendix D):

$$E_{T+2} = \begin{cases} \Phi_u(E_{T+1}) & \text{if } E_{T+2} < \tilde{E}^p(\alpha) \\ \Phi_s(E_{T+1}) & \text{if } E_{T+2} \geq \tilde{E}^p(\alpha) \end{cases} \tag{40}$$

Similarly to the benchmark model, we can claim that, under proper conditions, each dynamic trajectory, $\Phi_u(E_T)$ or $\Phi_s(E_T)$ taken separately, admits only one globally stable steady-state, $E^{p,u}$ and $E^{p,s}$, characterized by a low and a high environmental quality, respectively. Moreover, when E_t belongs to the interval $[\underline{E}^p, \overline{E}^p]$, there exists an area of indeterminacy: in that case, expectations might be self-fulfilling.[12]

In particular, we have:

$$E^{p,u} = \frac{\sigma A^s(\alpha\tau^{p,u})^\theta + A^s A^u \beta(1-2\lambda) - \beta(1-\lambda)(A^{s^2} + A^{u^2}) - \beta\lambda(A^s - A^u)^2[(1-\alpha)\tau^{p,u}]^\kappa}{\beta(A^s - A^u)(\pi^s - \pi^u) + \eta A^s} \tag{41}$$

and

$$E^{p,s} = \frac{\sigma A^s(\alpha\tau^{p,s})^\theta + A^s A^u \beta(1-2\lambda) - \beta(1-\lambda)(A^{s^2} + A^{u^2}) - \beta\lambda(A^s - A^u)^2[(1-\alpha)\tau^{p,s}]^\kappa}{\beta(A^s - A^u)(\pi^s - \pi^u) + \eta A^s} \tag{42}$$

Notice that $E^{p,u} < E^u$ and $E^{p,s} < E^s$, since $\tau^{i^\theta} > (\alpha\tau^{p,i})^\theta$. Introducing this public policy that aims at stimulating investment in additional education lowers the stationary values of environmental quality. However, this kind of public policy may become very useful, under specific parameter configuration, when the objective of the government is to escape from the low equilibrium, E^u.

4.3 Out of the trap

Let us remind that when $\alpha = 1$, then $\overline{E}^p = \overline{E}$ and $E^u = \check{E}$. Yet, starting from a situation where $\overline{E} > E^u$ and the economy is stuck in the environmental trap, the objective of this section is to determine the parametric conditions on α, such that the economy escape from the trap. A sufficient condition to achieve this goal is written as: $E_{T+2} = \check{E}(\alpha) > \overline{E}^p(\alpha)$. Indeed, in that

12. The two threshold values are defined respectively such as: $\Phi^s(\underline{E}^p) = \tilde{E}^p(\alpha)$ and $\Phi^u(\overline{E}^p) = \tilde{E}^p(\alpha)$.

case, at date $T+2$, the majority of workers choose to invest in human capital and the economy converges towards the high equilibrium $E^{p,s}$. In other words, the majority can only be *skilled* and so more prone to engage maintenance expenditure. The parameter α seems to be a relevant and available instrument to achieve this target: the share of public receipt devoted to environmental maintenance, and consequently to education, plays a crucial role by determining the median voter's feature.

Depending on the situation at date $T+1$, we can claim that, as shown in Figure 6:

Proposition 3 *Starting from E^u and under proper conditions, there exist two thresholds α_1 and α_2 with $0 < \alpha_1 < \alpha_2 < 1$, such that for $\alpha \in [\alpha_1, \alpha_2]$, $\overline{E}^p(\alpha) < \check{E}(\alpha)$. Then, the economy jumps onto the optimistic trajectory described by $\Phi_s(E_{T+1})$ and, in the long-run, reaches the high equilibrium, $E^{p,s}$.*

Proof. See Appendix E ■

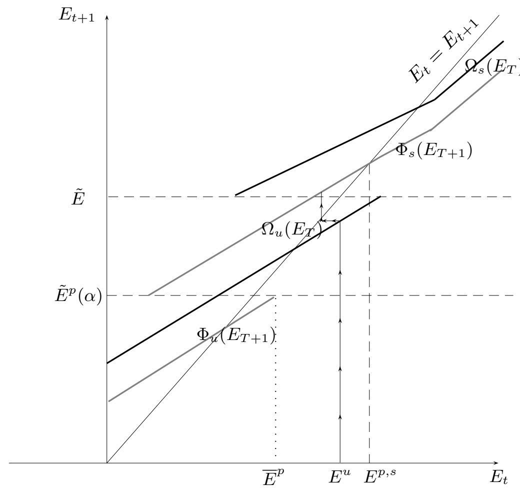


Figure 6: Policy

There exists a set of values of α, in particular for $\alpha \in [\alpha_1, \alpha_2]$, so that the economy jumps onto the optimistic trajectory, which is unique. Therefore, the economy may attain, in the long-run, the stable stationary value $E^{p,s}$. Indeed, starting from E^u, at date T, environmental quality deteriorates and the economy ends up in $\check{E}(\alpha)$, since incentives to expand in environmental protection drop. Then, from $T+1$, the public policy affects agents' educational choices; a new dynamics arise. For intermediary values of α, $\overline{E}^p(\alpha)$ sharply falls while incentives to invest in education are boosted. In particular, if $\alpha \in [\alpha_1, \alpha_2]$, $\check{E}(\alpha)$ does no longer belong to the indeterminacy area. As depicted in Figure 6, from date $T+2$, the economy follows directly the trajectory of $\Phi_s(E_{T+1})$. In that case, the majority within the population is *skilled* and so exhibits a higher willingness-to-pay. The public policy succeeds in coordinating agents'expectations and the economy escapes from the trap. Let us now study in detail under which conditions on the design of the public policy, this configuration may occur.

The opportunity of switching from the pessimistic trajectory to the optimistic one relies on the comparison between $\check{E}(\alpha)$, that is the situation of the economy at date $T+1$, and $\overline{E}^p(\alpha)$. In particular, if $\check{E}(\alpha) > \overline{E}^p(\alpha)$, the majority of workers within the population is *skilled* at date

$T + 2$ and environmental quality evolves according to the optimistic trajectory, $\Phi_s(E_{T+1})$. Indeed, similarly to the threshold value $\tilde{E}^p(\alpha)$, the relationship between $\overline{E}^p(\alpha)$ and α is U-shaped. Moreover, $\breve{E}(\alpha)$ is monotonously increasing in the parameter α. Figure 7 describes the situation where the two thresholds α_1 and α_2 exist.

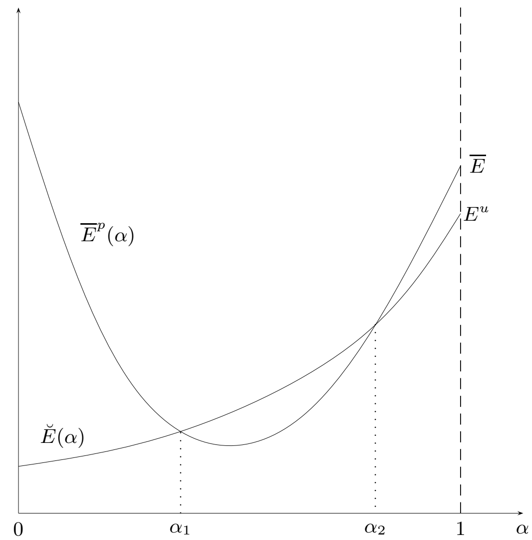


Figure 7: Policy design

In the situation depicted in Figure 7, when $\alpha = 1$, the economy is trapped in the low equilibrium ($\overline{E} > E^u$). Let us now consider that a share of the public receipts are devoted to education ($\alpha < 1$). As shown previously, the economy reaches $\breve{E}(\alpha)$, characterized by a damaged environmental quality. This decrease in α, if small enough, also reduces $\overline{E}^p(\alpha)$ sharply, as the public educational spending are very efficient. In the case where $\alpha \in [\alpha_1, \alpha_2]$, the later effect dominates the former: investment in human capital is high enough to ensure a majority of *skilled* workers. Finally, when α becomes too small, the public receipts diminish while educational spending are less efficient. This implies that $\overline{E}^p(\alpha)$ goes up as $\breve{E}(\alpha)$ is still decreasing.

Let us notice that from a strict environmental point of view, it could be in the interest of the government to choose the highest value of α, among the range of available values, that is α_2. In fact, as soon as $\alpha \in [\alpha_1, \alpha_2]$, the economy is capable of escaping the trap, and converges towards the higher stationary value of the environment, $E^{s,p}$. However, this steady-state depends positively on the parameter α, since it represents the share of public receipts devoted to public environmental maintenance. Then, in order to reach the highest stationary value of environmental quality, the authorities should implement a policy characterized by α_2.

Even if the public policy is still endogenous, the authorities may intervene in order to stimulate education. Starting from a low environmental quality, the economy may experience a non-monotonous convergence towards the high equilibrium. Following the implementation of the public policy, at first environmental quality deteriorates but then, if the policy design is balanced, the environment may improve and the proportion of highly educated agents within the society increases. However, as mentioned above, the stationary values of environmental quality when the policy is implemented are lower compared to the benchmark case, that is when education is not "subsided". Therefore, it may be the interest of the government to implement a temporary policy, in order to reach ultimately the highest equilibrium E^s.

Corollary 2 *Starting from E^u, a temporary public policy in favour of education may allow the economy to achieve the highest steady-state $E^s > E^{p,s}$, and so have long-lasting consequences.*

Once the economy reaches the optimistic trajectory $\Phi_s(E_{T+1})$, then it seems possible to return on the initial optimistic trajectory, described by $\Psi_s(E_{t+1})$, in order to attain the highest equilibrium, E^s. In fact, it is optimal at some specific point in time to stop the public policy and to devote all resources to environmental maintenance ($\alpha = 1$). Obviously, the economy attains a higher stationary value, since incentives to contribute for environmental maintenance are stronger, and the share of highly educated agents is larger.

The main message of this kind of policy is that educating the population may be a mean to improve in the long-run the overall situation, including environmental quality. The optimal dynamic design of the policy evolves overtime: it is in the interest of the government to transfer to education a share of resources initially devoted to environmental maintenance, and then, in a second step to stop the educational spending in order to focus again on the environmental issue. This kind of conclusion may be related with some experimental studies dealing with the education, the information about environmental risks, or environmental protection. (see, for instance, Jalan & Somanathan (2008))

5 Conclusion

In this paper we have studied the interaction between the political and economic decisions of agents. Agents decide whether to invest in additional human capital or not, according to their expectations regarding future environmental quality. Two types of workers co-exist within the population, some of them being *skilled*, the others *unskilled*. Once, their occupational choices are made, they vote for a poll tax that will be used to finance environmental protection and the level of the effective implemented tax depends finally on the median voter's feature. First, under the hypothesis of rational and constant expectations, the model may provide multiplicity of equilibria. Then, we show that agent's expectations may be self-fulfilling when public policy is endogeneised: for instance, if agents coordinate on optimistic expectations with regards to the future environment, they are likely to invest in additional education, display a higher willingness-to-pay for environmental protection, and the economy reaches in the long-run, the higher equilibrium, and conversely. This property of indeterminacy paves the way for a public policy implementation, in order to coordinate anticipations on one specific outcome. Finally, the level of education and environmental quality are positively correlated in the long-run.

Our model also proposes to investigate the opportunities of a public intervention in order to select a higher equilibrium. In this respect, we model the dynamic implications of a subsidy to education. We show that under specific conditions on the policy's design, reducing the fixed cost of education may allow for reaching the high equilibrium.

Finally, as interesting extensions for further research, we would suggest (i) to explore alternative public policies suitable for the selection of one outcome, (ii) to introduce other policy options that would allow for coordinating agent's expectations and (iii) to enhance the realistic dimension of the model, by endogeneising, for instance, technological progress.

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A Appendix A

The dynamic system is described by equation (22) and explicitly by both (23) and (24). Let us now determine the conditions of *existence* and *stability* of the steady-states, E^u and E^s. $\Psi_u(E_t)$ is increasing and piecewise linear in E_t. The slope of the function belongs to the range $[0,1]$. It follows that the solution of the equation $E_t = \Psi_u(E_t)$ is unique and globally stable. We denote this steady-state E^u. Hence, when $E_t > \Psi_u(E_t)$ ($<$), environmental quality deteriorates (improves).

Similarly, $\Psi_s(E_t)$ is increasing and piecewise linear in E_t. The slope of the function belongs to the range $[0,1]$. It follows that the solution of the equation $E_t = \Psi_s(E_t)$ is unique and globally stable. We denote this steady-state E^s. Hence, when $E_t > \Psi_s(E_t)$ ($<$), environmental quality deteriorates (improves).

B Proof of proposition 1

Let us determine under which conditions *multiplicity* may arise.

In order to determine the area of existence of each dynamics, we need to define two threshold values on E_t. First, $\Psi_u(E_t)$ exists for all $E_{t+1} < \tilde{E}$. Then, we define $\overline{E}$ such that $\Psi_u(E_t) = \tilde{E}$. It follows that:

$$\overline{E} = \frac{\beta(A^s + A^u) + (A^u - A^s)(1-2\lambda) + A^u - 2\sigma {\tau^u}^{\theta}}{2(1-\eta)(\pi^s - \pi^u)} \tag{B.1}$$

Then, Ψ_u exists for all $E_t < \overline{E}$. Similarly, $\Psi_s(E_t)$ exists for all $E_{t+1} \geq \tilde{E}$. Then, we define $\underline{E}$ such that $\Psi_s(E_t) = \tilde{E}$. Using equation (B.1) and substituting τ^u by τ^s yields the value of $\underline{E}$. Obviously, since $\tau^s > \tau^u$, then $\overline{E} > \underline{E}$. Finally, Ψ_s exists for all $E_t > \underline{E}$.

(i) $\overline{E} > \underline{E} > E^s > E^u$.

For $E_t > \overline{E}$, the unique perfect foresight is described by $\Psi_s(E_t)$. Since, for $E_t > E^s$, environmental quality deteriorates, ultimately it becomes lower than $\overline{E}$. For $E_t \in [\overline{E}, \underline{E}]$, there exist two trajectories compatible with perfect expectations: $E_{t+1} = \Psi_u(E_t)$ or $E_{t+1} = \Psi_s(E_t)$. Since, $E_t > E^s > E^u$, environmental quality deteriorates, whatever the trajectory and becomes ultimately lower than $\overline{E}$. For $E_t < \overline{E}$, the unique perfect foresight path is described by $E_{t+1} = \Psi_u(E_t)$. Hence, the economy converges towards E^u.

(ii) $E^s > E^u > \overline{E} > \underline{E}$.

For $E_t < \underline{E}$, the unique perfect foresight is described by $\Psi_u(E_t)$. Since, for $E_t < E^u$, environmental quality improves, ultimately it becomes larger than $\underline{E}$. For $E_t \in [\overline{E}, \underline{E}]$, there exist two trajectories compatible with perfect expectations: $E_{t+1} = \Psi_u(E_t)$ or $E_{t+1} = \Psi_s(E_t)$. Since, $E_t < E^s < E^u$, environmental quality improves, whatever the trajectory and becomes ultimately larger than $\overline{E}$. For $E_t > \overline{E}$, the unique perfect foresight path is described by $E_{t+1} = \Psi_s(E_t)$. Hence, the economy converges towards E^s.

(iii)$\overline{E} > E^s > E^u > \underline{E}$

For any $E_0 < \tilde{E}$, $\Psi_u(E_t)$ describes the dynamics of the economy: the equilibrium reached is E^u. Conversely, for any $E_0 \geq \tilde{E}$, the dynamics of the economy is described by $\Psi_s(E_t)$ and the equilibrium attained is E^s.

C Proof of Proposition 2

Both $\Psi_s(E_t)$ and $\Psi_u(E_t)$ are monotonically increasing in E_t. Hence, for $E_t \in [\overline{E}, \underline{E}]$, $\Psi_s(E_t) \geq \Psi_s(\underline{E}) = \tilde{E}$ and $\Psi_u(E_t) \leq \Psi_u(\overline{E}) = \tilde{E}$. Consequently, if agents expect that the median voter will be *skilled* in $t+1$: $E_{t+1} = \Psi_u(E_t) \leq \tilde{E}$ and the median voter is effectively *skilled*. In a similar way, if agents expect that the median voter will be unskilled, $E_{t+1} = \Psi_s(E_t) \geq \tilde{E}$, and expectations are then self-confirmed.

D Dynamic implications of the public policy

The dynamics are described by equation (40). Let us now determine the conditions of *existence* and *stability* of the steady-states, $E^{p,u}$ and $E^{p,s}$. $\Phi_u(E_{T+1})$ is increasing and piecewise linear in E_T. The slope of the function belongs to the range $[0, 1]$. It follows that the solution of the equation $E_{T+2} = \Phi_u(E_T)$ is unique and globally stable. We denote this steady-state $E^{p,u}$. Hence, when $E_T > \Phi_u(E_T)$ (<), environmental quality deteriorates (improves).

Similarly, $\Phi_s(E_T)$ is increasing and piecewise linear in E_T. The slope of the function belongs to the range $[0, 1]$. It follows that the solution of the equation $E_{T+2} = \Psi_s(E_{T+1})$ is unique and globally stable. We denote this steady-state $E^{p,s}$. Hence, when $E_T > \Psi_s(E_T)$ (<), environmental quality deteriorates (improves).

Let us determine under which conditions *multiplicity* may arise.

We define two threshold values on E_T. First, $\Phi_u(E_{T+1})$ exists for all $E_{T+2} < \tilde{E}^p$. We determine define $\overline{E}^p$ such that $\Phi_u(E_{T+1}) = \tilde{E}^p$. It follows that:

$$\overline{E}^p = \frac{\beta(A^s + A^u) + (A^u - A^s)(1-2\lambda) - 2\sigma(\alpha\tau^{p,u})^\theta(\pi^s - \pi^u) - 2\lambda(A^s - A^u)[(1-\alpha)\tau^{p,u}]^\kappa}{2(1-\eta)(\pi^s - \pi^u)} \tag{D.1}$$

Then, the dynamics is described by $E_{T+2} = \Phi_u$ for all $E_t < \overline{E}^p$. Similarly, $\Phi_s(E_{T+1})$ holds for all $E_{T+2} \geq \tilde{E}^p$. Then, we define $\underline{E}^p$ such that $\Phi_s(E_{T+1}) = \tilde{E}^p$. Using equation (D.1) and substituting $\tau^{p,u}$ by $\tau^{p,s}$ yields the value of $\underline{E}^p$. Obviously, since $\tau^{p,s} > \tau^{p,u}$, then $\overline{E}^p > \underline{E}^p$. Finally, $\Phi_s(E_{T+1})$ holds for $E_t > \underline{E}^p$.

Once these two thresholds are defined, the dynamics exhibit the same properties as the one described in Appendix B. Then, if we consider that expectations are no longer stationary, we can define an area of indeterminacy, if $E^{p,s}$ and $E^{p,u}$ belong to $[\underline{E}^p, \overline{E}^p]$.

E Proof of Proposition 3

In this appendix we aim at showing that for some values of α, it could be the case that $\check{E}(\alpha) > \overline{E}^p(\alpha)$, thus implying that the implemented policy allows from escaping the low equilibrium.

First, let us study the properties of $\check{E}(\alpha)$.

$$\check{E}(\alpha) = \frac{\beta A^s A^u(1-2\lambda) - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + A^s(1-\eta)E^u + A^s\sigma(\alpha\tau^{p,u})^\theta}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)} \tag{E.1}$$

$$\check{E}(0) = \frac{\beta A^s A^u(1-2\lambda) - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + A^s(1-\eta)E^u}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)} \tag{E.2}$$

$$\check{E}(1) = \frac{\beta A^s A^u (1-2\lambda) - \beta(1-\lambda)(A^{s^2} + A^{u^2}) + A^s(1-\eta)E^u + A^s\sigma(\tau^{p,u})^\theta}{A^s + \beta(A^s - A^u)(\pi^s - \pi^u)}, \tag{E.3}$$

with $\check{E}(1) > \check{E}(0)$. Moreover $\check{E}(\alpha)$ is increasing and monotonous over the range $\alpha \in [0,1]$.

Second, let us analyse the properties of $\overline{E}^p(\alpha)$ and then study the impact of the parameter α on this threshold value.

$$\overline{E}^p(0) = \frac{\beta(A^s + A^u) + (1-2\lambda)(A^u - A^s)}{2(1-\eta)(\pi^s - \pi^u) + A^u} \tag{E.4}$$

and

$$\overline{E}^p(1) = \frac{\beta(A^s + A^u) + (1-2\lambda)(A^u - A^s) - 2\sigma(\pi^s - \pi^u)(\tau^{p,u})^\theta}{2(1-\eta)(\pi^s - \pi^u) + A^u}, \tag{E.5}$$

with $\overline{E}^p(0) > \overline{E}^p(1)$.

$$\frac{\partial \overline{E}^p}{\partial \alpha} = \frac{[-\sigma(\pi^s - \pi^u)(1-\alpha)\theta(\alpha\tau^{p,u})^\theta + \lambda(A^s - A^u)\kappa(\alpha - \theta)[(1-\alpha)\tau^{p,u}]^\kappa]}{(1-\eta)\alpha(\pi^s - \pi^u)(1-\theta)(1-\alpha)} \tag{E.6}$$

The sign of $\frac{\partial \overline{E}^p}{\partial \alpha}$ depends on the value of α. Let us define $g(\alpha) = \alpha^{\frac{(1-\kappa)\theta}{1-\theta}}\sigma(\pi^s - \pi^u)\theta(\sigma\pi^u\theta)^{\frac{\theta-\kappa}{1-\theta}}$ and $f(\alpha) = \lambda(A^s - A^u)\kappa(\alpha - \theta)(1-\alpha)^{\kappa-1}$. Then,

$$sign\left\{\frac{\partial \overline{E}^p}{\partial \alpha}\right\} = sign\left\{g(\alpha) - f(\alpha)\right\} \tag{E.7}$$

Studying the properties of each function, we can define α^* such that: $f(\alpha) > g(\alpha)$ $(<)$, for $\alpha > \alpha^*$ $(<)$.

Indeed, $g(0) = 0$, $g'(\alpha) > 0$ and $\lim g(\alpha)_{\alpha \to 1} = \sigma(\pi^s - \pi^u)\theta(\sigma\pi^u\theta)^{\frac{\theta-\kappa}{1-\theta}}$ is finite. Moreover, $f(0) < 0$, and $\lim f(\alpha)_{\alpha \to 1} = +\infty$. The sign of $f'(\alpha)$ is positive for $0 < \alpha < 1$ if $\frac{1-\theta(1-\kappa)}{\kappa} < 1$. Yet, this conditions is always satisfied since $\kappa < 1$. Then, $f'(\alpha) > 0$. Finally, $g(\alpha)$ and $f(\alpha)$ cross only once and we define α^* such that: $f(\alpha^*) = g(\alpha^*)$.

We can deduce that if $\alpha > \alpha^*$ (<), then $\frac{\partial \overline{E}^p}{\partial \alpha} > 0$ $(<)$. Hence the thresholds $\overline{E}^p(\alpha)$ draws a u-shaped pattern.

Finally, $\check{E}(\alpha)$ and $\overline{E}^p(\alpha)$ may cross twice of the slope of $\check{E}(\alpha)$ is lower than the slop of $\overline{E}^p(\alpha)$ for $\alpha = 1$. We have shown that $\partial\check{E}(\alpha)/\partial\alpha|_{\alpha=1}$ is finite while $\partial\overline{E}^p(\alpha)/\partial\alpha|_{\alpha=1}$ is infinite. Then we can claim that:

$$\left.\frac{\partial \check{E}(\alpha)}{\partial \alpha}\right|_{\alpha=1} < \left.\frac{\partial \overline{E}^p(\alpha)}{\partial \alpha}\right|_{\alpha=1} \tag{E.8}$$

Then, if the distance between $\overline{E}^p(1)$ and $\check{E}(1)$ is not too large, the two functions may cross twice, thus defining two threshold values, α_1 and α_2, with $\alpha_1 < \alpha_2$. In that case, $\overline{E}^p(\alpha) < \check{E}(\alpha)$ for $\alpha \in (\alpha_1, \alpha_2)$. In that case only, the policy will be efficient and allows the economy to jump directly on the optimistic trajectory, $\Phi_s(E_{T+2})$. On the contrary, if the distance between $\overline{E}^p(1)$ and $\check{E}(1)$ is too large, then the two functions do not cross, and the policy is never efficient.

F Substitutability vs Complementarity

In this section, we want to prove that under a more standard production function our results hold. In particular, let consider the following production function, so that *skilled* and *unskilled* types of labour are no longer substitutable:

$$Y_t = (A^s H_t)^\alpha (A^u L_t)^{1-\alpha}, \tag{F.1}$$

with $\alpha \in [0,1]$. Since the labour market is perfectly competitive, wages equal the marginal productivity of each type of workforce:

$$\begin{cases} w^s = \dfrac{\alpha Y_t}{H_t} \\ w^u = \dfrac{\alpha Y_t}{L_t} \end{cases} \tag{F.2}$$

Then, substituting the equations above into (9), we obtain the following expression:

$$\tilde{z} = \frac{(1-\lambda)(\alpha L_t - (1-\alpha)H_t)}{\alpha L_t} + \chi(\frac{H_t}{L_t})^{1-\alpha}, \tag{F.3}$$

with $\chi \equiv \frac{(\pi^s - \pi^u)E^a_{t+1}}{\alpha A}$ and $A \equiv A^{s^\alpha} A^{u^{(1-\alpha)}}$.

Using (10) and (11) into the equation above, and the threshold value $\tilde{z}$ is the solution of the following equation:

$$A(z) = B(z), \tag{F.4}$$

with $A(z) = z\alpha(1-z) - (1-\lambda)(\alpha - z)$ and $B(z) = \chi z^{1-\alpha}(1-z)^\alpha \alpha$.

Let us now study the properties of $A(z)$: $A(0) < 0$ and $\lim A(z)_{z\to 1} = (1-\lambda)(1-\alpha)$

$$\frac{\partial A(z)}{\partial z} = \alpha(1-2z) + (1-\lambda) \tag{F.5}$$

with

$$\left.\frac{\partial A(z)}{\partial z}\right|_{z=0} = \alpha + 1 - \lambda \ \text{ and } \ \left.\frac{\partial A(z)}{\partial z}\right|_{z\to 1} = -\alpha + 1 - \lambda \tag{F.6}$$

and

$$\frac{\partial^2 A(z)}{\partial z^2} = -\alpha z \tag{F.7}$$

$A(z)$ reaches a maximum for $z = 1/2 + (1-\lambda)/\alpha$. Let us now study the properties of $B(z)$: $B(0) = 0$ and $B(1) = 0$. In addition,

$$\frac{\partial B(z)}{\partial z} = \chi \alpha z^{-\alpha}(1-z)^{\alpha-1}[1-z-\alpha] \tag{F.8}$$

with

$$\left.\frac{\partial B(z)}{\partial z}\right|_{z\to 0} = +\infty \ \text{ and } \ \left.\frac{\partial B(z)}{\partial z}\right|_{z\to 1} = -\infty \tag{F.9}$$

and

$$\frac{\partial^2 B(z)}{\partial z^2} = -\alpha\chi z^{-\alpha-1}(1-z)^{\alpha-2}(1-\alpha)(\alpha+2z) \tag{F.10}$$

$B(z)$ reaches a maximum value for $z = 1 - \alpha$.

Given that properties, we can deduce that $A(z)$ and $B(z)$ cross only once for $z \in (0, 1)$. Moreover, this threshold value increases with χ, and so with agents expectations with respect to environmental conditions. Similarly to our case where the two labour force are complementary, in that case there exists a unique value of z such that above this threshold agents do not invest in human capital.