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Abstract

This article analyzes the impact of income inequality on environmental policy in the presence of green consumers. We develop a theory with three main ingredients: first, citizens have different income capacities; second they have access to two different commodities whose consumption differs in terms of price and environmental impact, and third, they have to vote on the environmental policy. In this setting, there exists a unique political equilibrium such that the population is split in two groups, depending on whether there is positive consumption of the green good. The analysis shows that higher income inequality is generally associated with lower public spending in environmental protection. We then test this prediction in a fixed-effect model with robust standard errors using a panel of European countries over the period 1996-2019. We indeed find that income inequality negatively affects both public expenditures in environmental protection.

Keywords: income distribution, inequality, green consumption, environmental policy, probabilistic voting, political equilibrium.

JEL classification: Q58, H23, D31, D72

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1 Introduction

The 2019 European elections highlighted the political clout of green parties, particularly in Central and Northern European countries.[1] In Southern and Eastern Europe, this phenomenon has not been observed yet. Of course, the reasons behind this heterogeneity are many. They are for instance related to socio-economic, historical and cultural factors, or involve characteristics of the political system. Among socio-economic factors, the most salient seems to be the heterogeneity of the income distribution. This paper seeks to investigate the link between income distribution, especially income inequality, and environmental policy in European countries.

Taking a look at the data collected in Europe for several measures of environmental policy,[2] we first observe a positive correlation between GDP per capita and general government expenditure in Environmental Protection Per Capita (EPPC) (see Figure 1). This is in line with the intuition and supported by most of the arguments put forward to explain the decreasing part of the so-called Environmental Kuznets curve (EKC).[3] In particular, as people get richer, one expects that the demand for environmental protection rises.

[Insert Figure 1 here]

More interesting is the scatter plot obtained when connecting public expenditure on the environment with the Gini index. Here the evidence is more mitigated (see Figure 2). One can undertake a rough division of the sample into two sub-samples – top vs. bottom observations – and conclude that the relationship between income inequality and

[1] The greens/EFA political group has increased its seats in European parliament of 42% compared to the European election in 2014.

[2] Information about data collection is explained in details in Section 4.

[3] The EKC is the inverted U-shaped relationship linking income per capita to some measures of pollution. It was detected in the early 90s, and has been a subject of lively debate since then.

environmental policy may not be monotone.[4] Precisely, a higher level of inequality impairs environmental protection where/when it is already low to moderate, while the opposite conclusion holds true where/when environmental policy is say more ambitious.

[Insert Figure 2 here]

As noticed by Stiglitz (2014), there seems to be a two-way relationship between the environmental policy/protection and inequality. The causal link going from environmental policy to income distribution is examined in Environmental Economics. A recent literature addresses the optimal design of environmental taxes when distributional effects are taken into account. It also deals with the impact of an environmental tax reform on the different (poor vs. rich) groups that compose society, and with the efficiency of the economic and fiscal system (see among others, Aubert and Chiroleu-Assouline, 2019, and Jacobs and van der Ploeg, 2019). Papers on environmental taxation generally conduct their analysis in micro – partial or general equilibrium – models, and in second best world. They assume that the population is heterogenous in terms of income capacities, and sometimes in terms of the exposure to environmental damages. When it comes to the preferences, they often consider non-homothetic utility functions defined over two types of goods, clean vs. polluting, both featuring the same price. The latter good is named this way because its consumption is at the origin of a polluting externality. Finally, the public policy combines an income tax with a linear tax on the dirty good, while fiscal revenues can be recycled through lump-sum transfers, public spending, or used to reduce distortionary tax.

In the coming analysis, we basically look at the problem the other way around. This question has long been debated in Ecological Economics. Dating back to the seminal paper of Boyce (1994), this literature provides a series of arguments explaining why more

[4]Top countries are defined as the group with the top 5% in terms of expenses for environmental protection by the general (left-panel) or the local (right-panel) government in Figure 2.

inequality is bad for the environment, or the reverse. In a very good survey, Berthe and Elie (2015) classify these arguments into two categories depending on whether they involve individual behaviors, and how they relate to environmental pressure, or emphasize collective decision making. Central to all this strand of literature is the idea that there exist potential conflicts in societies among social and income groups – typically the poor vs. the rich – especially regarding the demand for environmental protection, and that these conflicts are exacerbated by inequality. As mentioned by the authors, there is no theoretical nor empirical consensus on this topic though.[5]

In Environmental Economics, Eriksson and Persson (2003) is the only formal study of the impact of inequality on pollution. They consider a continuum of uniformly distributed individuals who take care of consumption and pollution in Stokey (1998)'s static model. Individual consumption is equal to the product of a common pollution standard and production, which is an increasing and convex transformation of the individual type. They capture inequality as an increase in the gap between the median voter's production and the average one, and show that when this gap increases, the median voter asks for a less stringent standard (yielding more pollution). As it will be apparent soon, our approach is at the same time more general,[6] and more suitable for empirical application.

On empirical ground, Magnani (2000) is the work that is closest to ours. The author studies the impact of the Gini index on environmental policy in OECD countries over the period 1980 and 1991. Results show a negative correlation between inequality and environmental policy, as measured by public R&D expenditure for environmental protection. However, these results seem valid only for high-income countries.[7]

[5]Related papers put forward quite different assumptions sometimes yielding opposite conclusions as to how income inequality affects environmental protection, sometimes not. The comparison between Boyce (1994) and Scruggs (1998) papers gives a typical illustration of this opposition.

[6]Referring to the two categories of arguments mentioned before, they only deal with the collective decision dimension. They in fact also look at the role of the more or less democratic political system.

[7]Note however that the small number of observations of the empirical analysis allows the author to

In sum, there is no compelling theory to explain the impact of inequality on environmental policy, nor is there any clear evidence pointing to the nature of this impact. Our objective is thus to provide a comprehensive analysis of the link between on the one hand, average income and income inequality, and on the other, environmental policy. For that purpose, we first develop a theoretical model in order to highlight the factors susceptible to shape these relationships. Then we switch to the data in order to test our main findings.

We model individual and collective decision making in an economy with (income) heterogeneity in the population. Our approach is in the direct line of papers assessing the link between the income distribution and the collective choice regarding the funding of public education (de la Croix and Doepke, 2009; Arcalean and Schiopu, 2016; Melindi-Ghidi, 2018). It combines the following ingredients. First, the public policy consists in taxing the income and using the resulting revenue to finance environmental public expenditure. Second, the level of environmental protection provided by the government is the outcome of a probabilistic voting procedure. Third, a distinction is made between environmentally-neutral and environmentally-friendly – in short, environmental or green – goods. The latter category refers to goods whose consumption benefits to the environment. A non-comprehensive list of those goods includes organic food, energy saving household appliances, hybrid and electric vehicles etc.

As documented in recent works, people display a willingness-to-pay for green goods and a willingness-to-accept a price premium compared to their neutral counterparts (McFadden and Huffman, 2017, Poder and He, 2017). Individuals thus exhibit green consumerism, that is, a preference for those goods that should be distinguished from the value attached to conventional ones. This consumption cannot find its origin in individuals' ability to perfectly internalize its environmental impact though. It is better explained by other

derive qualitative empirical conclusions only. More recently, Martínez-Zarzoso and Phillips (2020) find that inequality has a negative effect on environmental policy stringency, and therefore on environmental quality, but only for low to middle income countries. See also the related paper by Grunewald et al. (2017).

private motives like being more healthy (organic food) and the existence of warm-glow effect (clean vehicles) (Chander and Muthukrishnan, 2015). In other words, there still exists an environmental externality of consumption. Preferences are also defined over environmental quality that is determined by private green consumption and public expenditure. Finally, we account for the existence of a price premium.[8]

Solving for the model, we first show the existence of a unique political equilibrium. The resulting tax is associated with a critical income level that splits the population into two groups. Green consumerism is the key original mechanism underlying this outcome.[9] Next, we assess how the features of the income distribution shape environmental policy at the equilibrium. In line with the intuition and stylized fact reported in Figure 1, we find that public environmental expenditure unconditionally increases with the average income, keeping the standard deviation constant. Considering a mean preserving spread,[10] conclusions are less clear-cut as we get that an increase in inequality induces a decrease in environmental expenditure if and only if the equilibrium tax is lower than a critical threshold. A variation in the level of inequality changes the size and composition of both groups. This in turn affects both the marginal benefit and each group's marginal cost of the policy, and consequently the outcome of the electoral process. We carefully dissect the mechanisms at stake and interpret our results. Therefore, our original unified framework enables us to generate and then reconcile the two opposing views in the Ecological Economics literature. Moreover, our results remarkably reproduce stylized facts (Figure 2). Last but not least, we identify a sufficient condition, depending on the environmental concern and relative price parameters, for having a negative impact of income inequality on

[8] This is consistent with several reports by public organizations (Carlson and Jaenicke, 2016; European Commission, 2019) and papers (Islam and Colonescu, 2019, Weiss et al., 2019) that show evidence that green products are significantly more expensive than conventional ones.

[9] As the evidence suggests (Liu, 2014), wealthier people consume the green good, poorer people do not.

[10] This boils down to considering a change in the coefficient of variation, a measure of income inequality that is positively correlated to the Gini index.

environmental policy. The intuition behind the result sounds like a confirmation of Stiglitz (2014) when he claims (p. 382): *"...in democracies, the desperately poor tend to have less of an interest in pursuing policies designed to protect the environment, because their most important concern is doing whatever's necessary to get out of the current situation."*

We then perform an empirical analysis using a sample covering 31 European countries over the period 1996-2019. Through the adoption of a fixed-effect model with robust standard errors, we analyze the impact of inequality, as measured by the Gini index, on three different dependent variables: general and local government expenditures in environmental protection, and total environmental taxation. We confirm that GDP per capita is positively correlated with both public environmental spending and taxation. More importantly, we find that inequality has a negative effect on environmental policy variables, even though the overall effect. More precisely, empirical results thus point to the existence of a decreasing and convex relationship between inequality and environmental protection measures.

The paper is organized as follows. Section 2 presents the model. Section 3 is devoted to the equilibrium analysis and contains a series of predictions regarding the impact of the income distribution on the public policy. Section 4 is dedicated to an empirical test of our main finding. Section 5 concludes.

2 Model

As in the literatures on environmental taxation and voting on public funding of education, the fundamental ingredient of our model is the (income) heterogeneity of the population. Our work is closely connected to the former series of papers because of its problematic even if we adopt a different (yet complementary) perspective. In the modeling approach, we share with them the general shape of preferences. In particular, we work with a non-homothetic utility function, account for the environmental impact of consumptions, and assume the existence of a consumption externality. And that's it, since in the main, we adapt and extend de la Croix and Doepke (2009)'s framework.

We consider two types of commodities that differ in terms of their environmental impact. We work with an index of environmental quality, Q, with reference level normalized to 0.[11] The first commodity, whose consumption is denoted by c, is environmentally-neutral while the second, d, is environmental-friendly. Consuming good d has a positive side-effect on the environment. Typical examples of consumptions that improve environmental quality along some – possibly different – dimensions are organic food (quality of soils etc.) and electric vehicles (atmospheric pollution). Beside the consumption channel, environmental quality can be increased thanks to environmental expenditure by the government. Overall, environmental quality is taken as given by the citizens, which means that there exists a positive consumption externality.[12]

The population is constant with its size normalized to 1. There is a continuum of individuals who differ with respect to the wage rate. Wages are distributed on the support $[w_m, \infty)$, with $w_m > 0$, according to density and cumulative distribution functions $f(w)$ and $F(w)$. In the analysis to come, we make use of a Pareto distribution:[13]

$$F(w) = 1 - \left(\frac{w_m}{w}\right)^k, \; f(w) = k w_m^k w^{-(1+k)} \text{ with } k > 2,$$

and pay attention to its two main features, the average, μ, and standard deviation, σ.

Following the discussion conducted in the Introduction, people exhibit a willingness-

[11] It is defined in relation to a business-as-usual level of pollution taken as given.

[12] We then adopt a symmetric yet similar approach as the literature on environmental taxation.

[13] Uniform and Pareto distributions are the most commonly used in the literature because of their tractability. de la Croix and Doepke (2009) deal with a uniform distribution while Arcalean and Schiopu (2016) extend their analysis to a Pareto distribution.

to-pay (or willingness-to-accept a price premium) for green goods. At the same time however, it seems difficult to assign this WTP(A) to some sort of environmental awareness whereby they would be able to evaluate the impact of their (consumption) decisions on the environment. From a modeling view point, this leads us to represent preferences by a utility function with three components: the two consumptions and the level of environmental quality, taken as given. For the sake of the analysis, we choose a quasilinear representation of the non-environmental utility that is combined with a linear environmental benefit. We also assume that people display the same preferences, with utility function:[14]

$$U(c, s, Q) = u(c, d) + \beta Q = \frac{\gamma}{\alpha}(c)^{\alpha} + d + \beta Q \tag{1}$$

with $\alpha \in (0, 1)$ and $\gamma, \beta > 0$, the relative weight of respectively non green (or environmentally neutral) consumption and the environment in the preferences. Consumption decisions are subject to the budget constraint:

$$(1 - t)w = c + \pi d \tag{2}$$

with $t \geq 0$ the (linear) income tax, and π the (relative) price of the green good. Hereafter we impose $\pi > 1$, which sounds like a very reasonable assumption for categories of goods of interest.[15] Indeed, focusing on organic products, the United States Department of Agriculture (USDA, see Coleman-Jensen et al. (2017)) gets an estimate for the price premium that ranges from 7% to 82%.[16] Liu (2014) also measures a differential of about

[14] Our results would remain qualitatively the same with Stone-Geary preferences in consumptions (like in Aubert and Chiroleu-Assouline, 2019), and a (strictly) concave function for the environmental benefit. However the resolution and comparative statics would require unnecessary complicated algebra. Moreover, de la Croix and Doepke (2009) use a log-additive utility defined over consumption, the quantity and quality of children. Utility derived from the latter depends on a discrete choice to educate children in the private vs. public schooling system. In our setting, our "discrete choice" is whether or not to consume the green good. As we want a smooth representation of preferences, we cannot use the log form. Finally, their problem does not include any externality.

[15] It is used for instance by Nyborg et al. (2006).

[16] That is, the price of organic products relative to that of conventional alternatives.

17% between the mean price of hybrid cars and of conventional cars sold in the US.

In the same vein as de la Croix and Doepke (2009), we consider a generic income tax whose purpose is to finance the public provision of environmental quality, or environmental public spending, G. In addition, the government follows a balanced budget rule:

$$G = \int_{w_m}^{\infty} twf(w)dw = t\mu.$$

Public spending adds up to private consumption of the green good to determine the realized level of environmental quality:

$$Q = G + \int_{w_m}^{\infty} df(w)dw.$$

The timing of events is the following: citizens first elect a government that pre-commits to a policy platform $\{t, G\}$. Once elected, the government sets the tax rate. People then choose their consumption levels, which finally results in a level of environmental spending and quality. We assume perfect foresight which especially means that when political parties choose their strategy in the electoral competition, they perfectly anticipate people's reaction to the public policy. This a typical Stackelberg game that can be solved backwards by first determining individual decisions as a function of policies and then choosing policies taking this dependency into account.[17]

This baseline model serves as a vehicle for the coming analysis where our main is first to establish that the problem above has a solution – a political equilibrium – and next to examine how the equilibrium features, especially the public policy, change when the main

[17]Note that de la Croix and Doepke (2009) consider the other timing where individuals "move first," before the policy is chosen. They provide the argument that contrary to the public policy, decisions on fertility and education can not be revised frequently. In our setting, we can support the timing considered by providing the exact opposite argument because we are dealing with consumption decisions. Moreover, this timing is similar to the one arising in second best analyses of environmental taxation (Jacobs and van der Ploeg, 2019).

characteristics of the income distribution, average and standard deviation, vary.

3 Theoretical investigation

3.1 Political equilibrium

Let us start with individual decisions. Environmental quality enters utility as a pure externality: each consumer takes the quality of the environment as given when she/he maximizes (1) subject to (2), and $c, d \geq 0$. Solving for this program, we identify a (unique) critical income level

$$\tilde{w}(t) = \frac{(\gamma\pi)^{\frac{1}{1-\alpha}}}{1-t}, \text{ with } \tilde{w}'(t) = \frac{\tilde{w}(t)}{1-t} > 0, \tag{3}$$

that determines whether or not a consumer purchases the green good. In fact, a consumer devotes a positive amount of resources to green consumption if and only if she earns enough money, i.e., $w > \tilde{w}(t)$. For an interesting problem, this threshold must belong to (w_m, ∞). This leads us to identify two boundaries, t^m and t^M with $t^m = 1 - w_m^{-1}(\gamma\pi)^{\frac{1}{1-\alpha}} < 1 = t^M$. The lower bound t^m can be positive or negative, which does not matter for the analysis.

Whatever the tax rate $t \in (\max\{0, t_m\}, t_M)$, the population can be split into two groups, respectively labeled by N and G (for "non green" or 'neutral" *vs.* "green" consumers). Membership to a particular group is determined by the individual's income. It is a member of group N whenever $w \in (w_m, \tilde{w}(t))$, otherwise she belongs to G (for $w \in (\tilde{w}(t), \infty)$). So wealthier people form group G while poorer folks are part of group N. This dichotomy is in line for instance with descriptive statics provided by Liu (2014) that illustrate that demand for hybrid cars essentially arises from people that belong to the upper income classes. Decisions made by individuals within each group are summarized by the following equations (for decisions we use a superscript letter):

$$\text{Group } N: \qquad d^n = 0,\ c^n(w,t) = (1-t)w, \tag{4}$$

$$\text{Group } G: \quad d^g(w,t) = \pi^{-1}\left((1-t)w - (\gamma\pi)^{\frac{1}{1-\alpha}}\right),\ c^g = (\gamma\pi)^{\frac{1}{1-\alpha}}. \tag{5}$$

A member of group N can not afford the green good and thus devotes her entire income to purchasing the environmentally neutral and cheaper good. By contrast, a green consumer spends a constant amount of money on the neutral good and the extra money goes to the green good.[18] Hereafter, we will make use of the indirect utility functions:

$$v^g(t,w) = \pi^{-1}\left((1-t)w - (\gamma\pi)^{\frac{1}{1-\alpha}}\right) + \tfrac{\gamma}{\alpha}(\gamma\pi)^{\frac{\alpha}{1-\alpha}},$$
$$v^n(t,w) = \tfrac{\gamma}{\alpha}((1-t)w)^{\alpha}.$$

Both are decreasing in the tax rate, and the larger the income, the larger the marginal disutility from taxation.

The level of environmental quality is obtained by adding environmental public expenditure, which is financed by the income tax (under the balanced budget rule), and aggregate private consumption of the green good:

$$Q(t) = t\mu + \int_{\tilde{w}(t)}^{\infty} d^g(w,t) f(w)dw.$$

Environmental quality is increasing and convex in the tax rate. In fact, increasing the tax has two opposite effects on Q:

$$Q'(t) = \mu + \int_{\tilde{w}(t)}^{\infty} \frac{\partial d^g(w,t)}{\partial t} dw. \tag{6}$$

A higher tax means more public expenditure for a given tax base, which is good for the

[18]The quasilinear utility explains why c^g is constant. This is innocuous for the analysis.

environment. However, it diverts consumers away from the green good, which negatively affects Q. The overall effect remains positive though: $Q'(t) > 0$.

With all this information in hand, we can move back to the analysis of the electoral competition. To deal with this issue, we consider a probabilistic voting model as in de la Croix and Doepke (2009), Arcalean and Schiopu (2016), and Melindi-Ghidi (2018). Probabilistic voting, by "smoothing" the payoffs of parties involved in the political game, generally ensures the existence of a Nash equilibrium in situations where the majority voting rule does not.[19] The key point with probabilistic voting is that it introduces "noise" in the outcome of the electoral process. Indeed, it is assumed that besides the policy platforms the different – generally two – candidates offer, voters' preferences also depend on a non-policy outcome of the election. In the literature, this additional concern is typically associated with the ideology. In the end, for any policy platform, a party does not know the exact number of voters who will support it. Indeed, contrary to standard (majority) voting models, individuals belonging to the same economic group do not have the same ideological preferences. So the best a party can do is to evaluate its vote share that is defined as the sum of probabilities that people in each group vote for it multiplied by the relative group size.[20] A party's objective is then to choose the platform that maximizes its vote share. As in a two-party electoral competition, parties' decision problems are symmetric, one generally focus on the symmetric Nash equilibrium in pure strategies of the zero-sum game. It is then pretty easy to show that parties' equilibrium policies maximize the following utilitarian social welfare function:

$$\int_{w_m}^{\tilde{w}(t)} (v^n(t,w) + \beta Q(t))\theta(w)f(w)dw + \int_{\tilde{w}(t)}^{\infty} (v^g(w,t) + \beta Q(t))\theta(w)f(w)dw,$$

[19] See the above mentioned papers and references therein for details.

[20] If there are two parties A and B, then the probability that an individual votes for party A is an increasing function of the difference of utility levels brought by each party once elected. This function is a cumulative distribution function that captures how ideology is spread in society.

where $\theta(w)$ represents the political power of a voter with income w. For simplicity, we assume away this particular dimension of the problem by considering that citizens share the same political power, i.e., $\theta(w) = 1$ for all w.[21] This implies that the only weights that matter in the objective function, denoted by $W(t)$, are given by the relative size of each group, and this function reduces to:

$$W(t) = \int_{w_m}^{\tilde{w}(t)} v^n(t, w) f(w) dw + \int_{\tilde{w}(t)}^{\infty} v^g(w, t) f(w) dw + \beta Q(t).$$

On may note that its first derivative,

$$W'(t) = \beta Q'(t) + \int_{w_m}^{\tilde{w}(\tau)} \frac{\partial v^n(w, t)}{\partial t} f(w) dw + \int_{\tilde{w}(t)}^{\infty} \frac{\partial v^g(w, t)}{\partial t} f(w) dw, \tag{7}$$

illustrates the simple trade-off faced by the economy when collectively deciding upon the public policy. Increasing the tax rate induces a marginal environmental benefit, hereafter MB (first term). But it also comes with marginal costs because of the decrease in the indirect utility of both groups, resulting from the decrease in consumptions, denoted respectively by MC^n and MC^g (last two terms).

Overall, solving for the political equilibrium boils down to searching for the tax that maximizes $W(t)$. Assessing its properties, we first identify a threshold t^c, with

$$t^c = 1 - wm^{-1} (\gamma\pi)^{\frac{1}{1-\alpha}} \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1}{\alpha-k}},$$

such that $W''(t) < 0 \Leftrightarrow t > t^c$. To ease the discussion, we assume that this critical tax rate is positive. This boils down to imposing

$$w_m > (\gamma\pi)^{\frac{1}{1-\alpha}} \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1}{\alpha-k}}, \tag{8}$$

[21] This is not the aim of the paper to account for this additional source of heterogeneity. It would be an interesting extension of the present work though.

and denote the corresponding critical income level as $\tilde{w}(t^c) = \tilde{w}^c$. Then, we can establish the following existence result (see the Appendix A.1):

Proposition 1. *A necessary and sufficient condition for the existence of a unique political equilibrium associated with policy platform* (t^*, G^*) *is* $W'(t^c) > 0$. *This is equivalent to imposing*

$$\pi > \underline{\pi}(\beta) \equiv \beta^{-1}\left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1-\alpha}{k-\alpha}}. \tag{9}$$

The existence condition (9) can be interpreted in terms of two critical parameters of the current analysis, the environmental concern β and the relative price of green goods, π. Indeed, the threshold $\underline{\pi}(\beta)$ is decreasing in β. It is difficult to get a precise estimate of the environmental concern. Following a tradition that finds its origin in Sociology, scholars run surveys that include a series of questions to elicit respondents' WTP for environmental protection, knowledge about environmental issues, and so on and so forth. In the end, they build an environmental concern index with the purpose of identifying its main drivers.[22] They all reach a consensus regarding the most important determinant of environmental concern, that is the level of wealth. When it comes to the representation of the utility function, one may argue that as individuals prioritize consumptions, the relative weight of the environment should be lower than one. From a more aggregate perspective, findings of this literature strongly suggest that on average, environmental concern should be the highest in the richest countries. Taking $\beta \in (0,1)$, we obtain that $\underline{\pi}(\beta) > 1$. Intuitively, not only people should care enough about the environment but also the price of the green good should be high enough (but the higher β the less stringent the condition on π) for them to be willing to incur the cost of the public provision of environmental quality. A political equilibrium of this sort is then more likely to arise in relatively rich countries, like OECD and European countries.

The equilibrium tax t^* is defined implicitly only. But it is quite easy to check that t^*

[22] For an interesting work representative of this line of research, see Franzen and Meyer (2009).

is increasing in both β and π. On the one hand, a larger β means that the population cares more about the environment, which raises the incentive to tax incomes in order to finance public expenditure on the environment. On the other hand, a larger π makes green consumption more costly, thereby lowering it. Thus taxation and public provision of the environment should increase as a compensation.

The next Section is devoted to a comprehensive comparative statics exercise.

3.2 Impact of a change in the income distribution

We want to explain how public policy changes as a response to the two important statistics of the income distribution, which are the average and standard deviation. Intuition suggests that taxation and environmental public expenditure should be higher, the larger the average income. Things may not be so obvious when it comes to the impact of σ. The main purpose of this Section is then to understand what is the impact of inequalities on the public provision of environmental quality.

In order to address these issues, we proceed in two separate steps. We assess the change in the equilibrium tax resulting from 1/ a variation in the average income, taking the standard deviation as given, and 2/ a variation of the standard deviation taking the average income as given. Our analysis, summarized in the Appendix A.2, leads to the following results:

Proposition 2.

- *An increase in the average income translates into an increase in the equilibrium tax, t^*, for given standard deviation.*
- *There exists a critical tax rate $t^s \in (t^c, 1)$ such that an increase in the standard deviation induces a decrease in the equilibrium tax, t^*, for given average income, if and only if $t^* < t^s$.*

Not surprisingly, we find that *rich* countries – that is, countries where the average income is high – levy a larger fiscal revenue to finance environmental quality than poor countries. This outcome is very much in line with stylized facts reported in Figure 1. A change in μ has repercussions on all the components of marginal welfare (7), especially on the MB through a tax base effect (see the first terms in (6) and (7)). Dissecting the various channels through which μ impacts $W'(t^*)$ would be an interesting yet unnecessary exercice. Indeed, the comparative statics result is unambiguous, and the analysis would share many similarities (and then be redondant) with what comes next, that is the most important study of the impact of σ on public policy.

Hereafter we focus on the interpretation of the impact of inequalities, captured by the standard deviation.[23] A change in the standard deviation affects marginal welfare by changing not only the distribution of the population between the two groups (size effect), but also the composition of each group (composition effect).

Denote the size of group $I = G, N$ as N^i with $i = g, n$, given that $N^g = 1 - N^n$, and $\tilde{w}^* = \tilde{w}(t^*)$, $\tilde{w}^s = \tilde{w}(t^s)$.

The overall impact of a marginal change in σ can be decomposed into three terms:

$$\frac{\partial^2 W(t^*)}{\partial t \partial \sigma} = \frac{\partial MB}{\partial \sigma} - \left[\frac{\partial MC^g}{\partial \sigma} + \frac{\partial MC^n}{\partial \sigma}\right],$$

with

$$\begin{aligned}
\tfrac{\partial MC^g}{\partial \sigma} &= \tfrac{\pi^{-1}\tilde{w}^*}{k-1}\left(-\tfrac{N^g}{k-1}\tfrac{\partial k}{\partial \sigma} + k\tfrac{\partial N^g}{\partial \sigma}\right), \\
\tfrac{\partial MB}{\partial \sigma} &= -\beta\tfrac{\partial MC^g}{\partial \sigma}, \\
\tfrac{\partial MC^n}{\partial \sigma} &= \tfrac{\pi^{-1}\tilde{w}^*}{k-\alpha}\left[-\tfrac{\alpha}{k-\alpha}\tfrac{\partial k}{\partial \sigma}\left(\left(\tfrac{w_m}{\tilde{w}^*}\right)^{\alpha} - 1 + N^n\right) + k\tfrac{\alpha}{\tilde{w}^*}\left(\tfrac{w_m}{\tilde{w}^*}\right)^{\alpha-1}\tfrac{\partial w_m}{\partial \sigma} + k\tfrac{\partial N^n}{\partial \sigma}\right].
\end{aligned}$$

[23] In fact, working with a constant mean, a variation of σ exactly corresponds to a variation of the coefficient of variation, that is a measure of the level of inequality. It is different yet positively correlated to the Gini index. See also the discussion in Section 4.

and $\frac{\partial w_m}{\partial \sigma}, \frac{\partial k}{\partial \sigma} < 0$.

We observe that MB and MC^g move in opposite direction, in a proportional way. It means that these two components add up to change marginal welfare. So let us focus on the marginal cost components, starting with MC^g. The sign of $\frac{\partial MC^g}{\partial \sigma}$ is determined by the aggregation of the composition effect (first term between the parentheses, positive) and the size effect (second term). The composition effect works as follows. The interval of incomes associated with the green group is invariant but the density of people at each income levels within this interval is affected by the variation of σ. Now it turns out that the density increases for the highest income levels.[24] Given that the disutility of taxation (resulting from the decrease in green consumption) is larger, the larger the income, this composition effect tends to increase MC^g. The size effect may add or, on the contrary, alleviate the composition effect depending on whether or not the size of group G increases as a result of the increase in the level of inequalities. As to group N, the same two effects are at play but the composition effect features another component. Indeed, the lower bound of the interval of incomes corresponding to that group, w_m, decreases as a result of the increase in σ. According to this additional part (second term between the parentheses in the expression of MC^n, negative), and other things equal, there are more people located around the lower income levels as σ increases. This pushes toward a lower MC^n. Let us call it the dispersion effect, which is part of the composition effect.

Given the expressions above, a particular comparative statics result can be obtained *via* different combinations of the sign of $\frac{\partial MC^g}{\partial \sigma}$ and $\frac{\partial MC^n}{\partial \sigma}$. And it is unclear a priori what is the relevant case to consider.[25] It turns out that we can ease the discussion simply by

[24] It may or may not decrease for income levels closed to the threshold, $\tilde{w}^*$, that determines the division of the population into groups N and G at the equilibrium.

[25] The problem is that we do not have the explicit form of t^* and t^s. As a result, $\frac{\partial^2 W(t^*)}{\partial t \partial \sigma} > 0$ can be the outcome of MC^g increasing and MC^n decreasing, the latter effect prevailing over the former etc. This leads to several (four) possibilities.

imposing:

$$\pi < \exp^{\frac{k-1}{k}}.$$

So we set an upper bound on the price of the green good. For example, taking $k = 3$, $\exp^{\frac{k-1}{k}} \approx 1,95$: we ask the price of the green goods to be less than twice the price of the other non-green goods. This seems acceptable given the figures we provided earlier for organic food and hybrid vehicles.

In this situation, $\frac{\partial MC^g}{\partial \sigma} < 0$, which implies $\frac{\partial N^g}{\partial \sigma} < 0$. Green people become less numerous and the size effect dominates the composition one. As a result, their (positive) contribution to the marginal cost of taxation – remind that green consumption, d^g, is decreasing in the tax – shrinks. And so does their (negative) contribution to the marginal benefit for the very same reason. Measuring the impact of a change in σ on the cost borne by group N is less simple. The relative size of group N increases. So the size effect is positive. In addition, their density at any income level in the interval $(w_m, \tilde{w}^*)$ decreases ($\frac{\partial f(w)}{\partial \sigma} < 0$), while this interval expands thanks to the dispersion effect. Overall, it is unclear whether the composition effect is positive or negative. This is where the ranking between the critical levels $\tilde{w}^*$ and $\tilde{w}^s$ comes into the picture.

In Proposition 2, we prove that when the equilibrium tax is pretty high so that $\tilde{w}^* > \tilde{w}^s$, the composition effect is negative and strong enough to offset – partly or totally – the size effect for group N. In other words, either MC^n decreases, or it increases but overall we have:

$$\left| \frac{\partial MC^n}{\partial \sigma} \right| < \left| \frac{\partial MC^g}{\partial \sigma} - \frac{\partial MB}{\partial \sigma} \right|.$$

This is all driven by the dispersion effect that finds full expression when the threshold $\tilde{w}^*$ is high enough (compared to w_m). So we can conclude that $\frac{\partial W'(t^*)}{\partial \sigma} > 0$: t^* should increase when the standard deviation goes up.

In the opposite situation, $\tilde{w}^* < \tilde{w}^s$, MC^n necessarily increases. This time, the composition effect remains positive but is dominated by the size effect as:

$$\left|\frac{\partial MC^n}{\partial \sigma}\right| > \left|\frac{\partial MC^g}{\partial \sigma} - \frac{\partial MB}{\partial \sigma}\right|,$$

which gives $\frac{\partial W'(t^*)}{\partial \sigma} < 0$, calling for a decrease in t^*.

The statement in Proposition 2 is interesting because it highlights that the impact of inequalities on the public policy varies depending a country's characteristics. This finding quite remarkably echoes the stylized fact reported in Figure 2. Indeed splitting roughly the observations into two groups, we observed that the impact of inequalities on environmental spending was seemingly opposite for these two groups. However, it is fair to say that in its current version, Proposition 2 does not allow us to draw more insightful conclusions essentially because t^* and t^s are both endogenous variables whose ranking is a priori undetermined. This means that we need to dig deeper into the analysis to identify some condition that provides us with a clear-cut policy message. This is precisely the purpose of the next corollary that brings together the results of Proposition 1 and 2.

Corollary 1. *From the existence condition (9), we get:*

$$\lim_{\pi \to \underline{\pi}(\beta)} t^* = t^c.$$

By construction, we have $t^c < t^s$. In that situation, an increase in inequality induces a reduction of the equilibrium tax, t^*, and of the resulting public provision of environmental quality, G^*, for given average income. By a continuity argument, the same conclusion holds true for π higher than, but close enough to, the threshold $\underline{\pi}(\beta)$.

Remind that, from the discussion following Proposition 1, the threshold $\underline{\pi}(\beta)$ is larger than 1 and decreasing in β.[26] In addition, the critical level t^s identified in Proposition 2 does not depend on π. This all points to the following conclusion. In countries where

[26]The former property holds for β low enough, and is always satisfied for $\beta \in (0, 1)$.

people display enough concerns for the environment (β high enough, which in turns implies $\underline{\pi}(\beta)$ low enough), and where the relative price of green goods is above 1 but remains mild, we expect that a higher level of inequality negatively impairs the public provision of environmental quality. Finally note that these conditions are more likely to be met in wealthy developed countries.

We are now equipped with a testable hypothesis: income inequality impairs environmental policy. It is worth noting though that as Corollary 1 provides a sufficient condition only for this negative relationship, we cannot rule out the occurrence of the opposite connection. This is the purpose of the empirical investigation conducted in the next Section to definitely settle this issue.

4 Empirical analysis

This Section aims at examining the general prediction that inequality negatively impacts the public provision of environmental quality through changes in public policy. In our model, public environmental expenditure are monotone increasing in the tax rate. So we can work with either variables and select the former due to data availability and modeling options. We first provide a short description of the panel dataset we use to test this hypothesis. We then describe our econometric models and go over the main results.

4.1 Data description

We build our dataset using data from Eurostat, the statistical office of the European Union. We capture environmental policy using two main dependent variables that are extracted from the category *government expenditure in environmental protection*: variable (*gov_10a_exp*).[27] As to the first dependent variable, we take *general government* environmental protection expenditures.[28] To account for different types of political systems, we deal with a second dependent variable that corresponds to environmental protection expenditure by *local governments*.[29] Finally, we consider a third dependent variable, for robustness check: the *total environmental taxation*: variable *env_ac_tax*.[30] We express all the dependent variables in per-capita terms since the variable Q, introduced in the model, also represents the average environmental quality when population size is normalized to 1.

The main explanatory variables are the GDP per capita in current euros and the Gini index.[31] In Section 3.2, we assessed the impact of income inequality on policy by considering a mean preserving spread – that is a change in the standard deviation for given average income – which boils down to measuring inequality via the coefficient of variation (CV). Here we use the Gini index because it is strongly (positively) correlated with the CV, and this is the measure of inequality the most commonly used in the literature. We also control for population and urbanization variables adding to the database population growth and density. We use population size to calculate population growth and habitants by km as a proxy of population density. We include these variables because they are potential determinants of both environmental pressure and protection.[32]

[27]This dataset provides the total government expenditure by functions (defined on the basis of European System of Accounts (ESA 2010) and by type of institution. In this dataset there are data for 31 European countries over the period 1996-2019. List of countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK.

[28]According to the ESA, general governments are *"institutional units which are non-market producers whose output is intended for individual and collective consumption, and are financed by compulsory payments made by units belonging to other sectors, and institutional units principally engaged in the redistribution of national income and wealth"*.

[29]The ESA defines local government as: *"public administration whose competence extends to only a local part of the economic territory, apart from local agencies of social security funds"*.

[30]Even though the theoretical model does not consider environmental taxation, we look at this outcome variable because we expect that taxation and public environmental spending move in the same directions. There are 34 countries in the latter dataset, with Liechtenstein, Serbia and Turkey in the sample.

[31]Data come from the European Union Statistics on income and living conditions survey (EU-SILC).

[32]Focusing on US cities, Ribeiro et al. (2019) find a positive correlation between the population size

4.2 Specification tests and Econometric model

Our basic empirical model is given by the following equation :

$$y_{it} = \alpha + \beta_1 Gini_{i,t-k} + \beta_2 Gini^2_{i,t-k} + \beta_3 GDP_{i,t} + \beta_j X'_{i,t} + u_{i,t}$$

where i denotes the cross-sectional unit (country) and t the time period (year). The variable y_{it} is the log of the GDP per capita, $Gini_{i,t-k}$ is the k-year lagged Gini index, and X_{it} is a vector of controls. We take a five-year lag for the Gini index ($k = 5$) to account for causality between income inequality and environmental policy.[33] Moreover Gini observations are average values over 5 years. We introduce the lagged Gini-squared in the model to account for possible non-linearity, perhaps non-monotonicity, as suggested by our theory and the stylized facts described in Figure 2. The vector X_{it} controls for population density and growth.[34] Parameter α is a common intercept, β_j are coefficients associated with the independent variables, and $u_{i,t}$ is the error term.

Table 1 summarizes the transformations we made in the coming regressions, for each country i and period t.

[Insert Table 1 here]

There are different approaches to deal with cross-country panel data. Fixed-effect and random-effect models are the most common.[35] We use the following decomposition: $u_{it} = \mu_i + \epsilon_{i,t}$, where μ_i is an unobserved individual specific effect, while $\epsilon_{i,t}$ refers to an

(changes) and CO_2 emissions, while the correlation turns negative for population density.

[33] Although this does not affect our results to control for $Gini_{i,t}$, the use of lagged regressors reduce the number of observations from 621 to 548. In the robustness Section 4.4, we do provide the estimation results with the current $Gini_{i,t}$.

[34] We do not include other controls because fixed-effect models do not allow to estimate the coefficients of time-invariant regressors, such as education, gender, land, etc.

[35] We exclude pooled OLS since F-tests reject at 1% level equal fixed effects across units for all dependent variables.

idiosyncratic error term. Whether μ_i is treated as a random or fixed effect determines the estimation method. To decide which model better fits with our panel dataset, we run different specification tests, summarized in Table 2.

First, we run the Hausman specification test (Hausman, 1978). The test rejects the null hypothesis (preferred model is random effects), which suggests that unobserved country-specific effects are better modeled by a fixed-effect model. Put differently, this test indicates the existence of a correlation between the individual errors and the regressors in the model that should be analyzed with a fixed-effects model.[36] We then check if time dummies among the regressors should be included in the regression. We test if the dummies for all years are equal to 0 and we reject this assumption for both dependent variables at 1% significance level. Inclusion of time fixed effect is particularly important here, given that environmental policies have been influenced by European and international treaties for the last 25 years, and cannot be fully explained by variations in observed socio-economic variables at country level.

[Insert Table 2 here]

Before moving to the analysis, we should also consider tests for heteroskedasticiy, autocorrelation and cross-sectional dependence. The modified Wald test for groupwise heteroskedasticity in fixed-effect models and the Wooldridge test for autocorrelation show that parameters can be consistently estimated using robust or clustered standard errors, that is, by treating each country as a cluster (Wooldridge, 2010). Since the Hausman test does not support robust standard errors, we implement a test of overidentifying restrictions (Sargan-Hansen test) robust to arbitrary heteroskedasticity and within-group correlation (Schaffer and Stillman, 2006). This test again rejects the null hypothesis (preferred model

[36] It should be observed that the Hausman test is valid under restrictive assumptions and does not support robust standard errors.

is random effects) and clearly suggests we implement fixed-effect models at 1% significance level for both outcome variables. We then verify the presence of cross-sectional independence within the residuals using the test of Pesaran (Pesaran, 2020). This test of cross sectional dependence provides no evidence for rejecting the null hypothesis of no cross-sectional dependence at 5% level. However, since the average absolute correlation of the residuals is quite high for both outcome variables, we will also perform estimations using Driscoll and Kraay standard errors, usually implemented in presence of cross-sectional dependence (Hoechle, 2007).

The final check has to do with the model specification. More precisely, we implement the test developed by Lind and Mehlum (2010) to check the existence of a non-monotone/linear relationship between our dependent variables and the independent variable measuring income inequality, i.e., the Gini index. The null hypothesis is either a monotone or inverted $U-$shaped relationship. The test rejects the null hypothesis for both dependent variables, showing the existence of either $U-$shaped or a $L-$shaped relationship between public expenditures on the environment and the Gini index.[37]

4.3 Empirical results

Let us now run the regression considering fixed-effects, time dummies and robust standard errors clustered by country. Following the recommendations obtained from the above tests, we estimate the following equation with country fixed effects (μ_i) and time effects affecting all countries uniformly (λ_t):

$$y_{it} = \alpha + \beta_1 Gini_{i,t-5} + \beta_2 Gini^2_{i,t-5} + \beta_3 GDP_{i,t} + \beta_j X'_{i,t} + \lambda_t + \mu_i + \epsilon_{i,t} \tag{10}$$

Table 3 summarizes the results when general government expenditure on environmental

[37]Results are robust with 5-years lagged and non-lagged Gini index.

protection per capita (EPPC) is the dependent variable, while Table 4 considers local government EPPC. In both Tables, column (1) does not incorporate the time effects and the control variables, thereby focusing only on the effect of GDP per capita and the Gini index. In column (2), we add the time effects to the regression. Column (3) includes population density, while in column (4) we also take into account population growth. Column (5) provides estimation results using Driscoll and Kraay standard errors.

In Tables (3 and 4), the effects of inequalities are captured by the coefficients *Gini* and $Gini^2$. All specifications exhibit a negative effect of the Gini index on the variables describing the EPPC. A higher Gini index is associated with the following first order effect: it makes the environmental policy less stringent. Remind that it is possible to interpret this correlation as a causal effect thanks to the lag introduced for the Gini index. On average, the coefficients captured by general or local spending are the same for *Gini*: -0.22. If we consider general government expenditures in EPPC, the effect seems to be more volatile, because the coefficients vary more according to the specification with expenditures by local government.[38] Considering the R^2 (within), it appears that the most significant specification, i.e. columns (3) and (4) – as also indicated by the different tests conducted earlier – displays consistent coefficients on average equal to -0.25.

As of second order effects, we find that coefficients of $Gini^2$ are positive but very small for all specifications, and both for general and local government environmental spending. This seems to indicates a non-monotone relationship. By conducting the simple exercise of computing the ratio $\beta_1/(2\beta_2)$, we find that the minimum is reached, on average, for $Gini = 30$. It turns out that almost 75% of our observations are below this threshold, even if it is exactly the mean of our sample, the median being at 29. When $Gini < 30$, our results clearly highlight the existence of a decreasing and convex relationship between

[38] For the first variable, the coefficients of specifications (1) to (5) are respectively: -0.1781,-0.2415, -0.2345, -0.2705, -0.1741.

inequality and environmental expenditure. For $Gini \geq 30$, the curve becomes flat. To sum up, considering all the observations, the interaction between outcome variables and the Gini index can be interpreted as a $L-$shaped, rather than a $U-$shaped, relationship. This means that an increase in the Gini index is first associated with a decrease in environmental expenditure at a decreasing rate, and from $Gini = 30$ onwards, we reach a plateau. We check this will claim with some robustness tests run in Section 4.4.

As of now, we can draw the following parallel with the results of Section 3.2. Most of the observations fall into the decreasing part of the relation, which perfectly fits with the conclusion of Corrolary 1. Moreover, the fact that for the rest of the observations, we obtain a plateau, and even a slight increase in EPPC with the Gini, is not incompatible with our theory. Indeed, the general result stated in Proposition 2 highlights the possibility that more inequality translates into a more ambitious public policy.

[Insert Table 3 here]

Looking at the effect of the GDP per capita on environmental expenditure, coefficients are positive for both dependent variables. This positive effect is consistent with both the theoretical results and conclusions drawn in the related literature. Finally, the control variables – population density and population growth – effects on governmental expenditures in EPPC are given by the coefficients *Density* and ΔPop, respectively. The introduction of both controls increases slightly the significance of the model, the R^2 (within) for general (local) government spending is equal to 0.35 (0.29) with the controls while it is equal to 0.34 (0.28) without them. However, the most important features of the specifications come from the inclusion of time and country fixed effects with the use of clustered standard errors. They allow us to control for most of the unobservable interactions which are not captured by the model.

[Insert Table 4 here]

4.4 Robustness checks

In this section, we perform some robustness tests in order to sharpen our empirical results. We first study the non-linear vs. non-monotone relationship between inequality and public expenditure in environmental protection. As previously discussed, the test of Lind and Mehlum (2010) rejects the null hypothesis of either a monotone or inverted $U-$shaped relationship. Looking at Figure 2, the data seems better described by a $L-$shaped than a $U-$shaped relationship. According to Haans et al. (2016), several conditions have to be met in order to confirm the existence of a $U-$shaped curve. First, both linear and quadratic variables' coefficients must be significant. Second, the turning-point shouldn't be "extreme": it has to lie strictly inside the sample. Finally, the slope on both sides of the $U-$shaped curve must be steep enough. While the first two conditions are verified in our analysis, the third condition is not, because the coefficients associated with Gini^2 are very small, ranging from 0.0030 to 0.0045.

To test the shape of the relationship between Gini index and public expenditures, we conduct the two more regressions on two sub-samples, as suggested by Qian et al. (2010). The lower (upper) sub-sample comprises the observations with a Gini smaller (greater) than or equal to the average threshold value, that is $Gini = 30$. We choose this value because it corresponds to the average of all the minima found in the regressions, and it is also the mean of the entire sample. According to this test, if the $U-$shaped relationship were to be confirmed, the we would observe a negative and significant coefficient for the lower sub-sample, and positive and significant coefficient for the Gini in the upper sub-sample. Tables 5 and 6 describe the results for the lower and upper samples respectively.

As expected, for the lower sub-sample, coefficients of the linear Gini are significant whatever the specification.[39] We also find that coefficients are greater than – but close enough to – those obtained when considering the entire sample.[40] The Gini^2 coefficient is not always significant. For the upper sample, the coefficients of Gini index (linear and quadratic term) are not significant whatever the outcome variable considered (see Table 6). Therefore, the interaction between inequalities and per capita environmental public policy is better described by a $L-$curve than a $U-$shaped curve. This result clearly indicates the existence of a negative and convex correlation between income inequality and public expenditure on the environment. In addition, it is consistent with the stylized fact reported Figure 2, that does not exhibit any market increase in the EPPC for the observations with a Gini index greater than 30.

[Insert Table 5 here]

[Insert Table 6 here]

In a second robustness test, we consider a different dependent variable, which is the total environmental taxation per inhabitant. Overall, we get the same qualitative results with total environmental taxation as those found with environmental expenditure. We report in Table 7 the estimated coefficients for specifications considering this outcome variable. Proceeding as before, the results of the tests are similar to those we obtained with environmental protection expenditure. However, the Pesaran's test indicates cross-sectional dependence at 1% level. Therefore, the accurate model for this outcome variable is the regression with the Driscoll and Kraay standard errors. As for government environmental spending, coefficients for the *Gini* and the $Gini^2$ display a significant convex and negative

[39] This is true whether we analyze the cluster-robust (4) or the Driscoll and Kraay standard error (5) regressions.

[40] For the first dependent variable, the coefficient for the lagged Gini is -0.31 (-0.18 for (5)) instead of -0.27 (-0.17 for (5)) in the original regression. For the second variable, the coefficient obtained on the sub-sample is equal to -0.30 (-0.20 for (5)), while it was -0.23 (-0.21) in the complete analysis.

correlation between inequalities and environmental tax. Also, the computed turning point – close to 30 – is consistent with the previous regressions. In all specifications, the GDP per capita has a positive and significant effect on the taxation, as also suggested by our theoretical results. The coefficients for this outcome variable are ranked from 0.66 to 0.90. The introduction of controls improves the results even if their coefficients are not significant in specifications (3) and (4). Surprisingly, the sign of the coefficient for the population growth given by ΔPop in column 1 is negative and significant for specification (5), while it was positive for central government expenditures in environmental protection. A plausible explanation is the following: as the regressions show, omitted controls are already well captured by the fixed effects (country and time). Therefore, the residual mechanisms involved by the population density, as well as the population growth, are quite intricate and differ depending on whether taxation or public expenditure are under scrutiny.

[Insert Table 7 here]

Finally, we conduct the analysis considering the Gini index without the lag. Regression results are very similar for the Cluster-robust (CR) model. For the Drisc/Kraay (DK) standard errors model, the coefficients of the Gini index for the total environmental taxation are strongly significant, while they are not for expenditure variables. The simple comparison between R^2 (within) for CR and DK, show that our preferred model (the Cluster-robust model) is also robust to time lags.

[Insert Table 8 here]

5 Conclusion

In this paper, we have shown that income inequality plays an important role in explaining environmental policies. We have found that countries with low level of income inequality exhibit higher public spending in environmental protection than highly unequal countries. More precisely, from the theoretical side, our analysis highlights that when people display enough concerns for the environment, a higher level of inequality negatively impairs the public provision of environmental quality. This conclusion is more likely to be met by wealthy developed countries. Our empirical investigation on European countries confirms this prediction. These results help to understand the role that European policies might have to address socio-economic inequalities as an indirect means of preserving environmental quality.

However, our results ought not be interpreted as precise forecasts between changes in income distribution and future environmental policies. Rather, they indicate how high levels of income inequality are generally associated with low policy interests in environmental protection. Indeed, the effects of income inequality on environmental policies might depend on different factors, such as the environmental concern of citizens and the policy already in place.

A promising future line of research, on theoretical ground, might consist of the inclusion of different political powers in the hands of the socio-economic groups. It would be interesting to understand how the heterogeneity in political power could affect the outcome of the electoral process and resulting public policy. Such analysis would contribute to the literature discussing how political power and conflict among opposing interest groups affect the design of the environmental policy.

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A Appendix

A.1 Proof of Proposition 1

First and second derivatives of $Q(t)$ w.r.t to t:

$$Q'(t) = E[w] - \pi^{-1} \int_{\tilde{w}(t)}^{\infty} w f(w) dw > 0,$$
$$Q''(t) = \pi^{-1} \tilde{w}'(t) \tilde{w}(t) f(\tilde{w}(t)) > 0.$$

For the Pareto distribution, the marginal benefit and costs of the public policy are:

$$MB = \beta \left[\mu - \frac{k\pi^{-1}\tilde{w}(t)}{k-1} \left(\frac{w_m}{\tilde{w}(t)} \right)^k \right],$$
$$MC^g = \frac{k\pi^{-1}\tilde{w}(t)}{k-1} \left(\frac{w_m}{\tilde{w}(t)} \right)^k,$$
$$MC^n = \frac{k\pi^{-1}\tilde{w}(t)}{k-\alpha} \left(\frac{w_m}{\tilde{w}(t)} \right)^k \left[\left(\frac{w_m}{\tilde{w}(t)} \right)^{\alpha-k} - 1 \right].$$

The relative size of group G, N^g, is equal to: $N^g(\tilde{w}(t)) = \left(\frac{w_m}{\tilde{w}(t)} \right)^k$. So we observe that MC^g is proportional to N^g, while the MB is linearly decreasing in this size.

Using this expression, we get the expression of the marginal value, $W'(t) = MB - (MC^g + MC^n)$:

$$W'(t) = \mu \left[\beta - \pi^{-1} \left(\frac{w_m}{\tilde{w}(t)} \right)^{k-1} \left(1 + \beta - \frac{k-1}{k-\alpha} + \frac{k-1}{k-\alpha} \left(\frac{w_m}{\tilde{w}(t)} \right)^{\alpha-k} \right) \right] \quad (11)$$

First, we have to check that the second order optimality condition holds, given that

$$W''(t) = -\frac{k w_m \pi^{-1}}{1-t} \left(\frac{\tilde{w}(t)}{w_m} \right)^{1-\alpha} \left[\frac{1-\alpha}{k-\alpha} - \left(1 + \beta - \frac{k-1}{k-\alpha} \right) \left(\frac{\tilde{w}(t)}{w_m} \right)^{\alpha-k} \right].$$

We obtain $W''(t) < 0 \Leftrightarrow \tilde{w}(t) > w_m \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1}{k-\alpha}} \equiv \tilde{w}^c$, which is equivalent to

$$t > t^c \text{ with } t^c = 1 - w_m^{-1}(\gamma\pi)^{\frac{1}{1-\alpha}} \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1}{\alpha-k}},$$

and one may note that $t^c > (\leq) 0$ if and only if

$$w_m > (\leq)(\gamma\pi)^{\frac{1}{1-\alpha}} \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1}{\alpha-k}}.$$

We can easily verify that $\lim_{t\to 1} W'(t) = -\infty$. Assuming $t^c > 0$ (which holds under condition (8)), a necessary and sufficient condition for existence is: $W'(t^c) > 0$. This is equivalent to:

$$\beta\pi > \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1-\alpha}{k-\alpha}}. \tag{12}$$

Rearranging, the existence condition can be stated as follows: $W'(t^c) > 0 \Leftrightarrow \pi > \underline{\pi}(\beta)$, with

$$\underline{\pi}(\beta) = \beta^{-1} \left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1-\alpha}{k-\alpha}}.$$

A.2 Proof of Proposition 2

First we express the two parameters of the Pareto distribution in terms of the average, μ, and standard deviation, σ:

$$w_m(\mu,\sigma) = \frac{(k(\mu,\sigma)-1)\mu}{k(\mu,\sigma)} \text{ and } k(\mu,\sigma) = 1 + \sqrt{1 + \left(\frac{\mu}{\sigma}\right)^2},$$

and we obtain, after some computations, $\frac{\partial w_m}{\partial \mu}, \frac{\partial k}{\partial \mu} > 0$, and $\frac{\partial w_m}{\partial \sigma}, \frac{\partial k}{\partial \sigma} < 0$.

Next, we differentiate the expression of MB, MC^g and MC^n w.r.t w_m, k, and μ:

$$\begin{aligned}
dMC^g &= \tfrac{\Psi dw_m}{k-1}\left[1+\tfrac{w_m}{k^2}\left(k\ln\left(\tfrac{w_m}{\tilde{w}^*}\right)-\tfrac{1}{k-1}\right)\tfrac{dk}{dw_m}\right],\\
dMB &= \beta\left(d\mu - dMC^g\right),\\
dMC^n &= \tfrac{\Psi dw_m}{k-\alpha}\left[\tfrac{\alpha}{k}\left(\tfrac{w_m}{\tilde{w}^*}\right)^{\alpha-k}-1-\tfrac{w_m}{k}\left(\tfrac{\alpha}{k(k-\alpha)}\left(\left(\tfrac{w_m}{\tilde{w}^*}\right)^{\alpha-k}-1\right)+\ln\left(\tfrac{w_m}{\tilde{w}^*}\right)\right)\tfrac{dk}{dw_m}\right].
\end{aligned} \tag{13}$$

with $\Psi = k^2\pi^{-1}\left(\frac{w_m}{\tilde{w}^*}\right)^{k-1} > 0$, and $\tilde{w}^* = \tilde{w}(t^*)$.

Hereafter, we conduct the analysis of the impact of a mean preserving spread (change in $d\sigma > 0$ taking $d\mu = 0$ as given). Then we turn to the analysis of a change in μ keeping σ constant.

A.2.1 Mean preserving spread

Under a mean preserving spread, the joint variation of w_m and k satisfies: $\frac{dk}{dw_m} = \frac{k(k-1)}{w_m}$. Using this relationship in the expressions above, we get:

$$\begin{aligned}
\tfrac{\partial MC^g}{\partial\sigma} &= \tfrac{\Phi^\sigma}{k-1}\left[1+(k-1)\ln\left(\tfrac{w_m}{\tilde{w}^*}\right)-\tfrac{1}{k}\right],\\
\tfrac{\partial MB}{\partial\sigma} &= -\beta\tfrac{\partial MC^g}{\partial\sigma},\\
\tfrac{\partial MC^n}{\partial\sigma} &= \tfrac{\Phi^\sigma}{k-\alpha}\left[-\left(1+(k-1)\ln\left(\tfrac{w_m}{\tilde{w}^*}\right)\right)+\tfrac{\alpha(k-1)}{k(k-\alpha)}+\tfrac{\alpha(1-\alpha)}{k(k-\alpha)}\left(\tfrac{w_m}{\tilde{w}^*}\right)^{\alpha-k}\right].
\end{aligned} \tag{14}$$

with $\Phi^\sigma = k^2\pi^{-1}\left(\frac{w_m}{\tilde{w}^*}\right)^{k-1}\frac{\partial w_m}{\partial\sigma} < 0$.

We want to determine the sign of $\frac{\partial^2 W(t^*)}{\partial t\partial\sigma} = \frac{\partial MB}{\partial\sigma} - \frac{\partial MC^g}{\partial\sigma} - \frac{\partial MC^n}{\partial\sigma}$. Rearranging, we obtain:

$$\frac{\partial^2 W(t^*)}{\partial t\partial\sigma} = \Phi^\sigma\left(\frac{w_m}{\tilde{w}^*}\right)^{\alpha-k}\left[G(t) - \frac{\alpha(1-\alpha)}{k(k-\alpha)^2}\right],$$

with,

$$G(t) = \left(\frac{\tilde{w}(t)}{w_m}\right)^{\alpha-k}\left[\left(1+\beta-\frac{k-1}{k-\alpha}\right)\left(\ln\left(\frac{\tilde{w}(t)}{w_m}\right)-\frac{1}{k}\right)+\frac{1-\alpha}{(k-\alpha)^2}\right].$$

As to the features of $G(.)$: We get that $\lim_{t\to 1} G(t) = 0$, and

$$G(t^c) > \frac{\alpha(1-\alpha)}{k(k-\alpha)^2} \Leftrightarrow \frac{1-\alpha}{\beta(k-\alpha)}\left(1+\frac{\beta(k-\alpha)}{1-\alpha}\right)\ln\left(1+\frac{\beta(k-\alpha)}{1-\alpha}\right) > 1,$$

which always holds. Moreover, either $G(.)$ is monotone decreasing on $(t^c, 1)$, or it is bell-shaped. So we can conclude that there exists a unique $t^s \in (t^c, 1)$ such that $G(t^s) = \frac{\alpha(1-\alpha)}{k(k-\alpha)^2}$ and $G(t) > 0 \Leftrightarrow t < t^s$. Put differently, we have shown that

$$\frac{\partial^2 W(t^*)}{\partial t \partial \sigma} < 0 \Leftrightarrow t^* < t^s,$$

which completes the first part of the proof.

A.2.2 Average income variation (constant standard deviation)

Here, it is more convenient to start from the expression of $W'(t)$ given in (11) once we observe that the coefficient in front of the squared brackets is simply μ and that the term between the squared brackets is equal to 0 for $t = t^*$. We have to combine $d\mu > 0$ and $d\sigma = 0$, the latter restriction imposing $\frac{dk}{dw_m} = \frac{k(k-1)(k-2)}{w_m(k-1+k(k-2))}$. After some calculations, we get

$$\frac{\partial^2 W(t^*)}{\partial t \partial \mu} = \Phi^{\mu}\left[H(t) - \Delta\right],$$

with $\Phi^{\mu} = \mu\pi^{-1}\left(\frac{\tilde{w}^*}{w_m}\right)^{1-\alpha}\frac{\partial k}{\partial \mu} > 0$,

$$H(t) = \left(\frac{\tilde{w}(t)}{w_m}\right)^{\alpha-k}\left[\left(1+\beta-\frac{k-1}{k-\alpha}\right)\left(\ln\left(\frac{\tilde{w}(t)}{w_m}\right) - \frac{k-1+k(k-2)}{k(k-2)}\right) + \frac{1-\alpha}{(k-\alpha)^2}\right],$$

and

$$\Delta = \frac{(1-\alpha)(k(k-2)-(k-\alpha)(k-1+k(k-2)))}{k(k-2)(k-\alpha)^2} < 0.$$

We immediately observe that $G(t) > H(t)$ for all $t < 1$ and $\lim_{t\to 1} H(t) = 0$. In addition, we have $H(t^c) > \Delta$ because

$$G(t^c) > \frac{\alpha(1-\alpha)}{k(k-\alpha)^2} \Leftrightarrow H(t^c) > \Delta.$$

Given that $H(.)$ is either monotone decreasing or increasing then decreasing on $(t^c, 1)$, we finally conclude that

$$\frac{\partial^2 W(t^*)}{\partial t \partial \mu} > 0 \text{ for all } t,$$

which completes the second part of the proof.

A.3 Mean preserving spread: discussion

Here we provide some elements that help to understand the comparative statics results, for a change in σ.This change negatively affects both the lower bound of the support, w_m, and the parameter, k, of the Pareto distribution $F(w)$.

Differentiating the expression of group G's relative size w.r.t w_m and σ yields:

$$dN^g = N^g dw_m \left[\frac{k}{w_m} + \ln\left(\frac{w_m}{\tilde{w}^*}\right) \frac{dk}{dw_m} \right].$$

Considering a change in the parameters resulting from a change in σ, for a constant μ, we have

$$\frac{\partial N^g}{\partial \sigma} = N^g \frac{\partial w_m}{\partial \sigma} \frac{k}{w_m} \left(1 + (k-1) \ln\left(\frac{w_m}{\tilde{w}^*}\right)\right),$$

and

$$\frac{\partial f(w)}{\partial \sigma} = \frac{\partial w_m}{\partial \sigma} \frac{k}{w_m} f(w) \left(1 + (k-1)\left(\frac{1}{k} + \ln\left(\frac{w_m}{w}\right)\right)\right).$$

From the last expression, we see that there exists a critical $w^f = w_m \exp^{\frac{1}{k(k-1}}$ such that $\frac{\partial f(w)}{\partial \sigma} > 0 \leftrightarrow w > w^f$.

Recall that:

$$\frac{\partial^2 W(t^*)}{\partial t \partial \sigma} = \frac{\partial MB}{\partial \sigma} - \left[\frac{\partial MC^g}{\partial \sigma} + \frac{\partial MC^n}{\partial \sigma}\right].$$

We want to sign the expressions in (14) and see how it relates to $t^* \gtrless t^s$. Focusing on the changes in MC^g and MC^n, there are four possible cases:

1. $\frac{\partial MC^g}{\partial \sigma}, \frac{\partial MC^n}{\partial \sigma} < 0$ iff $\frac{1}{k} < 1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) < \Psi$,
2. $\frac{\partial MC^g}{\partial \sigma} < 0$ and $\frac{\partial MC^n}{\partial \sigma} > 0$ iff $\max\left\{\frac{1}{k}, \Psi\right\} < 1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right)$,
3. $\frac{\partial MC^g}{\partial \sigma} > 0$ and $\frac{\partial MC^n}{\partial \sigma} < 0$ iff $1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) < \min\left\{\frac{1}{k}, \Psi\right\}$,
4. $\frac{\partial MC^g}{\partial \sigma}, \frac{\partial MC^n}{\partial \sigma} > 0$ iff $\Psi < 1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) < \frac{1}{k}$,

with $\Psi = \frac{\alpha(k-1)}{k(k-\alpha)} + \frac{\alpha(1-\alpha)}{k(k-\alpha)}\left(\frac{w_m}{\tilde{w}^*}\right)^{\alpha-k} > 0$.

We don't know much a priori about the signs and rankings between those different terms. To start with, let us determine whether $1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) \gtrless \frac{1}{k}$. We obtain $1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) > \frac{1}{k} \Leftrightarrow \tilde{w}^* < \tilde{w}^x$ with $\tilde{w}^x = w_m \exp^{\frac{1}{k}}$. Evaluating the expression of $W'(t)$ given by (11) at $\tilde{w}(t) = \tilde{w}^x$, we get

$$W'(t)|_{\tilde{w}(t)=\tilde{w}^x} < 0 \Leftrightarrow \beta(1 - \pi^{-1}\exp^{\frac{k-1}{k}}) < \frac{\pi^{-1}\exp^{\frac{k-1}{k}}}{k-\alpha}\left(1 - \alpha + (k-1)\exp^{\frac{\alpha-k}{k}}\right),$$

and imposing

$$\pi < \exp^{\frac{k-1}{k}},$$

is sufficient to conclude that $\tilde{w}^* < \tilde{w}^x$. Under this (weak) restriction, we know that $\frac{\partial MC^g}{\partial \sigma} < 0$. This also implies $\frac{\partial N^g(\tilde{w}^*;\mu,\sigma)}{\partial \sigma} < 0$ as $\frac{\partial N^g(\tilde{w}^*;\mu,\sigma)}{\partial \sigma} < 0 \Leftrightarrow 1 + (k-1)\ln\left(\frac{w_m}{\tilde{w}^*}\right) > 0 \Leftrightarrow \tilde{w}^* < \tilde{w}^\sigma = w_m \exp^{\frac{1}{k-1}}$ and $\tilde{w}^x < \tilde{w}^\sigma$.

So we know that the increase in σ translates into both a decrease in MC^g and an increase in MB. In this situation, two possibilities remain regarding the evolution of MC^n. They correspond to the cases 1. and 2. listed above. We also know that the relative size of group N increases while the density at each income levels in $(w_m, \tilde{w}^*)$ decreases since while $(\tilde{w}^* <)\tilde{w}^x < w^f$ implies that $\frac{\partial f(w)}{\partial \sigma} < 0$ for all $w < \tilde{w}^*$.

Suppose that equilibrium tax is pretty high so that $\tilde{w}^* > \tilde{w}^s$. A necessary condition for this to occur is $\tilde{w}^s < \tilde{w}^x$. Either MC^n decreases and we can directly conclude that $\frac{\partial^2 W(t^*)}{\partial t \partial \sigma} > 0$ (case 1.). Or, MC^n increases (case 2.). But then, based on the results of Appendix A.2.1, we can conclude that

$$|\frac{\partial MC^n}{\partial \sigma}| < |\frac{\partial MC^g}{\partial \sigma} - \frac{\partial MB}{\partial \sigma}| \Leftrightarrow \frac{\partial^2 W(t^*)}{\partial t \partial \sigma} > 0.$$

Consider next that the tax is low so that $\tilde{w}^* < \tilde{w}^s$. Then we know that MC^n necessarily increases, which places us in case 2. Relying on our previous results, we can furthermore conclude that:

$$|\frac{\partial MC^n}{\partial \sigma}| > |\frac{\partial MC^g}{\partial \sigma} - \frac{\partial MB}{\partial \sigma}| \Leftrightarrow \frac{\partial^2 W(t^*)}{\partial t \partial \sigma} < 0,$$

which ends the discussion.

A.4 Proof of Corollary

This proof is based on the following observation. Unlike the equilibrium tax, the critical level t^s, that determines whether a mean preserving spread stimulates taxation, is independent of π. Noticing that the necessary and sufficient existence condition (12) can be rewritten as:

$$\pi > \underline{\pi}(\beta) = \beta^{-1}\left(1 + \frac{\beta(k-\alpha)}{1-\alpha}\right)^{\frac{1-\alpha}{k-\alpha}}.$$

with $\underline{\pi}'(\beta) < 0$ because $k > 1$, and $\underline{\pi}(\beta) > 1$ for $\beta \in (0, 1)$. Actually, only for very high β would the threshold fall below 1 (and then become irrelevant).

Under this condition, we know that there exists a unique t^* satisfying $W'(t^*) = 0$. Now, simply observe that

$$\lim_{\pi \to \underline{\pi}(\beta)} t^* = t^c,$$

which is by construction lower than t^s. Then, by a continuity argument, we can conclude that in situations where π is close enough to $\underline{\pi}(\beta)$, a mean preserving spread induces the policy maker to reduce the income tax and the public provision of environmental quality.

Figures and Tables

Figure 1: General EPPC and GDP per capita 1996-2019.

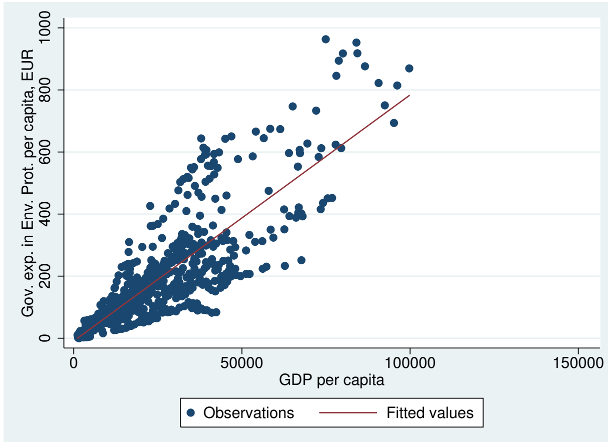

Figure 2: General and local EPPC and Gini coefficient 1996-2019

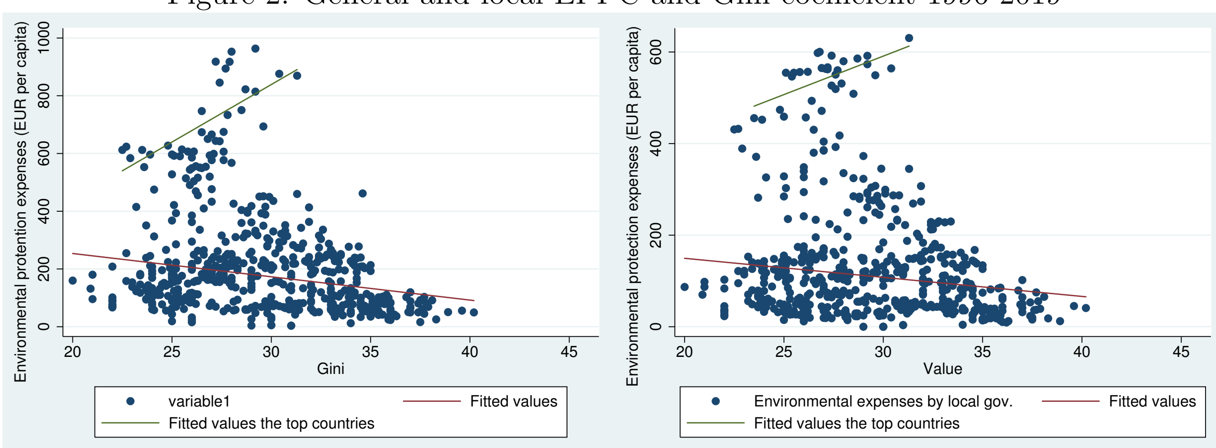

Table 1: Data description

Variable	Original Eurostat variable	Variable used in the regression at a date t
Dependent variables		
Gen Gov Exp	Government expenditure in environmental protection by general government in million current euros	$\log\left(\frac{\text{Gov\_10a\_exp\_1}_{i,t}\times 10^6}{\text{Population}_{i,t}}\right)$
Loc Gov Exp	Government expenditure in environmental protection by local government in million current euros	$\log\left(\frac{\text{Gov\_10a\_exp\_2}_{i,t}\times 10^6}{\text{Population}_{i,t}}\right)$
Tot Env Tax	Environmental tax revenues in million current euros	$\log\left(\frac{\text{env\_ac\_tax}_{i,t}\times 10^6}{\text{Population}_{i,t}}\right)$
Independent variables		
GDP per capita	GDP in million current euros	$\log\left(\frac{\text{nama\_10\_gdp}(t)\times 10^6}{\text{Population}_{i,t}}\right)$
Population growth	Population - total on 1 January	$\frac{\text{Population}_{i,t}-\text{Population}_{i,t-1}}{\text{Population}_{i,t}}$
Population density	Population - total on 1 January and land cover in total	$\frac{\text{Population}_{i,t}}{\text{Total\_Landcover}_i}$
Lagged Gini index	Gini coefficient of equivalised disposable income	$\text{lag\_gini}_{i,t} = \frac{\sum_{j=5}^{10}\text{gini}_{i,t-j}}{5}$

Table 2: Specification Tests

Test	Gen Gov Exp	Loc Gov Exp
Hausman Test H0: Random vs. Fixed	$\chi^2(5) = 13.88$ $Pr > \chi^2 = 0.0164$	$\chi^2(5) = 75.24$ $Pr > \chi^2 = 0.0000$
Time-fixed Effects Test H0: No Time Dummies	$F(18, 383) = 3.69$ $Pr > F = 0.0000$	$F(18, 385) = 2.66$ $Pr > F = 0.0003$
Modified Wald Test H0: $\sigma(i)^2 = \sigma^2\ \forall i$	$\chi^2(28) = 4593.75$ $Pr > \chi^2 = 0.0000$	$\chi^2(28) = 6809.86$ $Pr > \chi^2 = 0.0000$
Wooldridge Test H0: no first-order autocorrelation	$F(1, 27) = 33.626$ $Pr > F = 0.0000$	$F(1, 27) = 13.660$ $Pr > F = 0.0010$
Sargan-Hansen test H0: Random vs. Fixed (robust)	$\chi^2(15) = 1700.827$ P-value = 0.0000	$\chi^2(14) = 7106.747$ P-value = 0.0000
Av. abs. value diagonal elements H0: Cross Sectional Independence	0.341 Pr = 0.316	0.365 Pr = 0.092
Test of presence of a U-shape H0: Monotone or Inverse U-shape	t-value=2.70 $P > \|t\| = 0.00591$	t-value=2.09 $P > \|t\| = 0.02300$

Note: to perform the Hausman test, we have scaled the variable population growth (x10) to obtain coefficients on a similar scale.

Table 3: General Government Expenditures in EPPC

	(1)	(2)	(3)	(4)	(5)
Gini	-0.1781*	-0.2415**	-0.2345**	-0.2705***	-0.1741***
	(0.094)	(0.090)	(0.100)	(0.093)	(0.041)
$Gini^2$	0.0031*	0.0041**	0.0040**	0.0045***	0.0030***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
GDP	0.7380***	0.5013*	0.4675	0.3369	0.7323***
	(0.164)	(0.296)	(0.324)	(0.341)	(0.201)
Density			-0.0006	-0.0017	-0.0007
			(0.001)	(0.001)	(0.001)
ΔPop				0.7859*	0.2043
				(0.445)	(0.354)
Year	NO	YES	YES	YES	NO
R^2 (within)	0.25	0.34	0.33	0.35	0.24
σ_u	0.44	0.53	0.64	0.85	N/A
σ_e	0.21	0.20	0.21	0.21	N/A
ρ	0.81	0.87	0.90	0.94	N/A
Observations	459	459	434	434	434

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (1-4) and Drisc/Kraay standard errors are in parentheses. All regressions include country fixed effects. Year represents the time fixed effect. The dependent variable and GDP per capita are expressed in log.

Table 4: Local Government Expenditures in EPPC

	(1)	(2)	(3)	(4)	(5)
Gini	-0.2060**	-0.2315**	-0.2064**	-0.2360**	-0.2055*
	(0.076)	(0.085)	(0.094)	(0.088)	(0.111)
$Gini^2$	0.0037***	0.0041***	0.0038**	0.0042***	0.0037*
	(0.012)	(0.014)	(0.001)	(0.001)	(0.002)
GDP	0 .6226***	0.6367***	0.6597***	0.5524*	0.6398**
	(0.164)	(0.205)	(0.236)	(0.287)	(0.260)
Density			-0.0006	-0.0015*	-0.0016*
			(0.001)	(0.001)	(0.001)
ΔPop				0.6510	0.5203
				(0.538)	(0.333)
Year	NO	YES	YES	YES	NO
R^2 (within)	0.20	0.28	0.28	0.29	0.20
σ_u	0.65	0.66	0.67	0.75	N/A
σ_e	0.22	0.22	0.22	0.22	N/A
ρ	0.90	0.90	0.90	0.92	N/A
Observations	461	461	436	436	436

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (1-4) and Drisc/Kraay standard errors are in parentheses. All regressions include country fixed effects. Year represents the time fixed effect. The dependent variable and GDP per capita are expressed in log.

Table 5: U-shaped robustness test (Gini<30)

	Exp. by general gov. (4)	Exp. by general gov. (5)	Exp. by local gov. (4)	Exp. by local gov. (5)
Gini	-0.3159*	-0.1764***	-0.2966*	-0.1961**
	(0.179)	(0.207)	(0.168)	(0.303)
$Gini^2$	0.0055	0.0029***	0.0055	0.0034*
	(0.004)	(0.049)	(0.003)	(0.086)
GDP	0.8023**	0.9366***	0.9367	0.7365**
	(0.382)	(0.001)	(0.576)	(0.002)
ΔPop	0.0174	-0.1002	0.1332	0.1985
	(0.344)	(0.275)	(0.447)	(0.238)
Density	-0.0005	-0.0011	-0.0014	-0.0023**
	(0.001)	(0.001)	(0.002)	(0.001)
Year	YES	NO	YES	NO
R^2 (within)	0.43	0.30	0.29	0.14
σ_u	0.62	N/A	0.73	N/A
σ_e	0.16	N/A	0.19	N/A
ρ	0.94	N/A	0.94	N/A
Observations	247	247	247	247

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (4) and Drisc/Kraay (5) standard errors are in parentheses. All regressions include country fixed effects. Year represents the time effect. The dependent variable and GDP per capita are expressed in log.

Table 6: U-shaped robustness test (Gini $\geq$ 30)

	Exp. by general gov. (4)	Exp. by general gov. (5)	Exp. by local gov. (4)	Exp. by local gov. (5)
Gini	0.1657	-0.0006	0.4637	0.1787
	(0.548)	(0.206)	(0.431)	(0.274)
$Gini^2$	-0.0024	0.0001	-0.0066	-0.0024
	(0.008)	(0.414)	(0.006)	(0.341)
GDP	-0.1415	0.5395**	0.1087	0.5232*
	(0.354)	(0.006)	(0.242)	(0.005)
ΔPop	1.333**	0.3392	1.0846	0.6134
	(0.622)	(0.612)	(0.866)	(0.63)
Density	-0.0220*	0.0025	-0.0216**	-0.0031
	(0.012)	(0.004)	(0.008)	(0.004)
Year	YES	NO	YES	NO
R^2 (within)	0.38	0.13	0.38	0.15
σ_u	6.95	N/A	6.38	N/A
σ_e	0.23	N/A	0.22	N/A
ρ	1.00	N/A	1.00	N/A
Observations	187	187	189	189

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (4) and Drisc/Kraay (5) standard errors are in parentheses. All regressions include country fixed effects. Year represents the time effect. The dependent variable and GDP per capita are expressed in log.

Table 7: Total Environmental Taxation

	(1)	(2)	(3)	(4)	(5)
Gini	-0.1184**	-0.1344**	-0.1705***	-0.1763***	-0.1326***
	(0.047)	(0.052)	(0.057)	(0.056)	(0.315)
$Gini^2$	0.0020**	0.0022**	0.0027***	0.0028***	0.0022***
	(0.008)	(0.009)	(0.009)	(0.001)	(0.001)
GDP	0 .8575***	0.7319***	0.6790***	0.6576***	0.9005***
	(0.085)	(0.193)	(0.198)	(0.206)	(0.352)
Density			-0.014	-0.0015	-0.0008***
			(0.009)	(0.001)	(0.001)
ΔPop				0.1315	-0.2119**
				(0.196)	(0.091)
Year	NO	YES	YES	YES	NO
R^2 (within)	0.65	0.67	0.70	0.70	0.66
σ_u	0.24	0.27	0.49	0.52	N/A
σ_e	0.11	0.11	0.10	0.10	N/A
ρ	0.83	0.87	0.96	0.96	N/A
Observations	506	506	462	462	462

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (1-4) and Drisc/Kraay standard errors are in parentheses. All regressions include country fixed effects. Year represents the time effect. The dependent variable and GDP per capita are expressed in log.

Table 8: Robustness check with Gini not lagged

	Exp gen gov		Exp loc gov		Tot env tax	
	(CR)	(DK)	(CR)	(DK)	(CR)	(DK)
Gini	-0.2169**	-0.1191	-0.1206*	-0.0528	-0.0766**	-0.0766***
	(0.088)	(0.115)	(0.065)	(0.085)	(0.033)	(0.023)
$Gini^2$	0.0034**	0.0019	0.0019*	.0001	.0011*	.0011***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
GDP	1.0741***	1.2161***	0.9487***	0.9601***	0.9324***	0.9580***
	(0.256)	(0.189)	(0.238)	(0.180)	(0.090)	(0.032)
Density	-0.0009	-0.0013*	-0.0011	-0.0021***	-0.0013*	-0.0011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔPop	-0.0755	-.1320	0.1803	0.2668	-0.1457	-0.1836
	(5.18)	(3.417)	(5.790)	(3.627)	(2.084)	(1.132)
Year	YES	NO	YES	NO	YES	NO
R^2 (within)	0.64	0.57	0.53	0.45	0.83	0.82
σ_u	0.56	N/A	0.60	N/A	0.40	N/A
σ_e	0.25	N/A	0.24	N/A	0.11	N/A
ρ	0.83	N/A	0.86	N/A	0.92	N/A
Observations	503	503	501	501	527	527

Notes: ***p<0.01 **p<0.05 *p<0.10. Cluster-robust (CR) and Drisc/Kraay (DK) standard errors are in parentheses. All regressions include country fixed effects. Year represents the time effect. The dependent variable and GDP per capita are expressed in log. The Gini index is not lagged

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