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Protected Areas and the Environmental Kuznets Curve in European countries

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ABSTRACT

Protected areas are a natural instrument for preserving biodiversity and a major defence against climate change. This paper uses an Environmental Kuznets Curve (EKC) perspective to examine the relationship between the percentage of national territory under protection (PA%) and per capita GDP (GDPpc) in European countries. Building on the results of a previous study (Bimonte, 2002) that found a U-shaped relationship between GDPpc and PA%, it explores fate of this relationship two decades later, after two economic crises and a pandemic. It also investigates the effect of the European Union (EU) enlargement. In a dynamic perspective, it analyses the effect, if any, on national conservation policy. Due to the characteristics of the indicator chosen, which is stock-sensitive and subject to saturation effect, it verifies whether the relationship between income level and PA% is still an EKC, or whether a convergence in conservation policy has emerged and PA% is tending to a steady state. This is done by running regression models on the countries to test said EKC and β-convergence hypotheses. The results confute the persistence of an EKC and show a convergence in conservation policy in the last two decades, albeit with interesting differences between groups of countries, in particular latecomers as opposed to old member states of the EU. The results have important policy implications: when dealing with public or collective goods, or goods that produce externalities, centralised (federal) guidance is more effective than local and decentralised approaches (subsidiarity principle).

1. Introduction

Environmental concerns have increased in recent decades, mainly due to the greenhouse effect and climate change. Economic growth and modern lifestyles are widely held to be the primary causes of environmental degradation. However, the question of how environment and socio-economic aspects are interrelated is not straightforward. Many studies have analysed the relationship between economic growth and environmental impacts such as pollution, emission of greenhouse gases and biodiversity loss in relation to the Environmental Kuznets Curve (EKC) hypothesis (for a review see Caravaggio, 2020a, 2020b; Farooq and Dar, 2022).

According to United Nations Climate Action,[1] biodiversity offers powerful natural protection against climate change and human land use is a major driver of biodiversity loss (Pörtner et al., 2021). Managing land use, protecting and/or restoring ecosystems, like forests, is an effective way to mitigate the effects of greenhouse (FOREST EUROPE, 2020). Therefore, conservation policies, such as the institution of protected areas, are essential for addressing biodiversity and forest loss,[2] and consequently for mitigating climate change (Pörtner et al., 2021). The IUCN World Commission on Protected Areas defines a protected area as "*a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve long-term conservation of nature with associated ecosystem services and cultural values*" (UNEP, WCMC, 2018, p. 8).

Protected Areas are also a direct measure of a country's environmental attitude: they indicate community demand for environmental amenities and/or actions and environmental expenditure by governments to meet that demand (Antle and Heidebrink, 1995). This is confirmed by their opportunity cost (Caravaggio, 2022). Like money,

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[1] https://www.un.org/en/climatechange/science/climate-issues/biodiversity

[2] Besides being important reservoirs of species, most parks protect important forest heritage. Nearly 24% (almost 50 million ha) of forests are in areas protected for the conservation of biodiversity and landscape (FOREST EUROPE, 2020, p. 16).

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land is a finite resource: the more the government sets aside for parks, the less is left for other goals, such as real estate development.[3]

Using a specific line of investigation, known as the Environmental Kuznets Curve, Bimonte (2002) analysed the relationship between per capita income (GDPpc) and the percentage of Protected Area (PA%) in national territory of European countries. His results did not reject the existence of an EKC, and showed that inclusive economic growth (i.e. growth that promotes equity, education and information) can foster environmental demand and investment, somehow confuting the simplistic assertion that the surest way to improve the environment is just to become rich (Beckerman, 1992; Mert and Bölük, 2016).

The EKC literature accepts implicitly the hypothesis that economic growth leads to better environmental quality and higher environmental investment in the long run, because of the social and economic changes it produces, and the assumed income elasticity of demand for environment (Selden and Song, 1994). Economic growth should therefore produce a convergence of environmental policy and quality, especially when the indicator used to measure environmental quality is subject to saturation, like land allocated to parks (Bimonte, 2009).

Speculating on these considerations and results, the present study investigates the relationship between GDPpc and PA% to determine whether the EKC is a persistent phenomenon or whether a "catch-up" effect (convergence) occurred. The main research questions are:

Q1. Does the relationship between GDPpc and PA% evidence an EKC or, rather, since the countries in the sample are in advanced stage of the development process, the relationship depict an increasing curve (i.e. countries are on the second part of the EKC)?
Q2. In dynamic term, since the indicator (PA%) is a stock, is there evidence of convergence between the environmental policy of countries and an imminent steady state?
Q3. If so, do differences between groups of countries emerge?

To address these questions, we use OECD data and run regression models on a sample of European countries. Before describing the model and empirical analysis, we briefly review the concept of EKC and the literature.

2. Growth, environment and the EKC: an essential analysis and literature review

The EKC posits that environmental impacts may be decoupled from economic growth, at least beyond a certain level of economic development. Empirical evidence suggests the existence of a stylised fact, namely that the relationship between environmental degradation and per capita income is represented by an inverted U-shaped curve (quadratic function). In other words, in the early stage of economic development, growth occurs to the detriment of the environment, whereas once per capita income exceeds a certain threshold, the nexus between economic growth and environmental quality becomes beneficial (Grossman and Krueger, 1995; Shafik and Bandyopadhyay, 1992; World Bank, 1992).

The main theoretical argument in support of this process is that growth is linked to environmental degradation in the early stage of development process, because the scale effect initially dominates both the composition and technical effect (Farooq and Dar, 2022). Then, further economic growth occurs together with structural, technological and social changes (Dasgupta et al., 2002; Munasinghe, 1999; Panayotou, 2003, 1995). The ultimate link between growth and environmental quality therefore depends on the scale effect and the combined effects of reallocation of resources across sectors (agriculture, manufacture, services) and technical and technological changes. In the first stage of economic development, environmental impacts are generally limited and the agricultural sector produces a large share of a country's GDP. As development proceeds, the manufacturing sector expands and so do pollution and waste generation. In the final stage (maturity), "structural change towards information-based industries and services, more efficient technologies and increased demand for environmental quality result in levelling-off and a steady decline in environmental degradation" (Panayotou, 2003, p. 46).

The relationship between growth and environmental quality therefore hinges on a mix of supply- and demand-side phenomena (Antle and Heidebrink, 1995). Regarding the latter, it is postulated that the environment is a superior good, i.e. the demand for better environmental conditions is income-elastic. This means that in the first stage of industrialization, abatement and environmental regulation are weak because people are too poor to be willing to pay for them, whereas in the mature stage of the development process, better economic and social conditions make people more environmentally conscious and willing to pay. This leads to political pressure for stronger environmental policies and increased investment in environmental protection (Antle and Heidebrink, 1995; Dasgupta et al., 2002; Grossman and Krueger, 1995; Panayotou, 1995; Selden and Song, 1994; Torras and Boyce, 1998).

However, a word of caution is in order. In its strict deterministic interpretation, the EKC suggests that growth is the "ultimate" environmental policy (Beckerman, 1992), and in the long run, countries' environmental quality converges to similar levels (equilibria) (Bimonte, 2009; Brock and Scott Taylor, 2010; List, 1999). Actually, it is still debated whether, why and under what circumstances the EKC occurs (see for example Harbaugh et al. (2002); Stern and Common (2001); Yang et al. (2015)).[4]

Empirical evidence shows that the process is not deterministic or automatic and results depend on a country's policies, trade openness, indicators (type of pollutant or resource) and development model (Arrow et al., 1995; Grossman and Krueger, 1995; Kaika and Zervas, 2013a, 2013b). For example, due among other factors to the income elasticity hypothesis, it has been shown that other things being equal, a more equitable and inclusive development path ensures better environmental performance (Bimonte, 2002; Magnani, 2000; Torras and Boyce, 1998). Simultaneously, higher consciousness and pressure for more stringent environmental policies may lead to relocation of polluting production to countries with lower environmental standards (Cole, 2004; Kearsley and Riddel, 2010; Suri and Chapman, 1998). So while an EKC may emerge at country level, it may not necessarily do so at global level, and if anything, it may simply reflect a juxtaposition of positive and negative relationships for developing and developed countries, respectively (Vincent, 1997), also linked to the existence of "pollution haven" or "race to the bottom" phenomena (Aşici and Acar, 2015).

With regard to indexes, in some cases they may produce results that are little more than an artifact. Overall environmental impact depends on *aggregate*, not on *unit* (per dollar or per capita) emissions and resource use and on stocks rather than flows (Bimonte, 2012; Common, 1995). As shown by the environmental impact equation IPAT, scale and intensity of use effects intermingle and the ultimate outcome depends on the algebraic sum of the growth rate of the driving forces (Perman et al., 2011).

Much existing empirical research focuses on flows, i.e. emission of pollutants or extraction of resources. But, the stock-nature of many environmental problems may prevent a full account of environmental impacts (Kaufmann and Cleveland, 1995; Rothman and De Bruyn,

[3] Bimonte and Stabile (2017a, 2017b) analysed the relationship between land consumption (developable land) and per capita income in Italy. They showed that the income elasticity hypothesis holds for developable land (for housing) rather than for environment. In other words, over a certain level of economic development, social preferences shift from social towards private goods, from long- to short-run goals.

[4] For a critical review of the literature see Dinda (2004), Leal and Marques (2022) and Dkhili (2023).

1998). The same applies to depletion of natural resources (for example a forest):[5] the sustainability of a certain extraction flow depends on the dimension of the residual stock. Taking it to the extreme, a zero-extraction flow could indicate a halt on exploitation or exhaustion of the resource. Regarding pollutants, a convergence of unit (per capita or per dollar) emissions does not necessarily mean convergence on environmental policy (total emissions trend).[6]

To address some of these aspects, Bimonte (2002) empirically tested the EKC hypothesis using a stock-sensitive indicator: the percentage of protected area at country level. He showed the existence of a U-shaped relation and the importance of other variables (income distribution, education, access to information) in determining the level of environmental quality associated with a growth path. He highlighted that while the turning point is mainly determined by income, other variables affect the level of environmental quality at that point.

Building on this study, we set out to explore fate of the relationship (GDPpc vs PA%), to discover whether the EKC still holds after more than 20 years, whether there has been convergence, or whether, having most of the countries in the sample passed the income threshold (turning point) identified in the previous study, the relationship is represented by an increasing curve, namely the second part of the EKC. Empirical data shows that in the 20th century and also in the past two decades, the number and percentage of protected areas at global level have steadily increased (Wolf et al., 2021; Green and Paine, 1997).

3. Testing the EKC and the convergence hypothesis: method and regression results

Here we critically replicate and strengthen the analysis of Bimonte (2002). To test persistence of the EKC hypothesis and the impact of equity, higher education and information on environmental policy, as measured by PA%, we ran a regression using 2021 data from the same sample of countries and variables.[7] The sample consisted of all European countries (see Table 1A). A qualitative difference is worth noting. Twenty-seven are now members of the European Union, 13 of which acceded to the EU in enlargements since 2004 and 2013.[8] All countries are in advanced, albeit diverse, stages of economic development.[9] Like Bimonte (2002), we ran an Ordinary Least Squares (OLS) regression to test our research hypothesis. According to the Gauss-Markov theorem, since the estimated relationship is linear in parameters, OLS regressions produce BLUE estimates (Best Linear Unbiased Estimators), i.e. unbiased estimates with the smallest variance of all possible linear estimators. We first tested for persistence of the standard EKC hypothesis, using the standard reduced functional form:

$$PA_i = \beta_1 logY_i + \beta_2 (logY_i)^2 + \varepsilon_i \text{ with } i = 1, 2, \ldots, n \quad (1)$$

where PA_i is the percentage of protected area at national level and Y_i is the GDPpc. Unlike in the previous study, no clear-cut relationship between per capita income and PA% emerged (Fig. 1); if anything, once we excluded the outliers, the curve was an inverted EKC, as the first model in Table 1 shows.

Things did not change when we extended the model to the other covariates. We ran the following regression model:

$$PA_i = \beta_1 logY_i + \beta_2 (logY_i)^2 + \beta_m X_{mi} + \varepsilon_i \text{ with } i = 1, 2, \ldots, n \quad (2)$$

where PA_i is PA%, Y per capita income (thousands of dollars) measured in PPP (Purchasing Power Parity), X_{mi} the other covariates, i.e. information and income distribution, β the parameters to be estimated and ε_i the random error component. With regard to information, to account for technological evolution and changes in habits, instead of using the number of newspapers per 1000 people sold yearly, we used the percentage of people reading online news sites/newspapers/news magazines.[10] To accept the EKC hypothesis, we require $\beta_1 < 0$ and $\beta_2 > 0$. Table 1 (model 2) shows the results of the OLS regression.

The regression confirmed rejection of the EKC hypothesis. As for variables other than income, only the Gini index seemed to explain differences between national environmental policies. The second model showed that inequality in income distribution is negatively related with the demand for environmental protection (i.e. the higher the inequality, the lower the demand for environment), in line with Bimonte (2002). On the contrary, information turned out to be not significant and with an unexpected (negative) sign. This could be due to the fact that the variable (yearly percentage of people reading online news sites/newspapers/news magazines) did not specify the type of newspaper or the news read.

These results confuted research questions 1. An inverted EKC is in the realm of possibility since all the countries in the sample are in the mature stage of economic development, albeit at different levels. Moreover, from a dynamic viewpoint, one has to consider that in the last 20 years, the income of all the countries in the sample passed the threshold (turning point) identified in the previous study. This, combined with the fact that the indicator used is stock-sensitive and subject to a kind of saturation effect, may mean that countries on the "wings" of the old curve invested comparatively less in PA than those towards the centre, that is those that were near or had just passed the turning point, in actual fact revealing a sort of convergence. This process could have been fed by national economic performance, i.e. the countries' rates of growth of GDP.

To look more closely at these last aspects, we analysed the relationship between the growth rates of *GDPpc* and *PA%* and then tested for β-convergence of PA% between countries, in other words we investigated the transition period 1996–2021. To verify the first heuristic hypothesis, we ran a regression between the growth rates of per capita income and *PA%*. Data on *PA%* is not available on an annual basis; for this variable it would not make sense calculating year-to-year variations, which would presumably be quite small with many zeros after the decimal point. We used data from the OECD dataset on Protected Areas which were produced for 1990, 2000, 2010, 2015, 2018 and 2021. We then computed the average growth rate for each sub-period. In order to have comparable data, we did the same with the *GDPpc* growth rates.

The usual estimation procedures for panel data are "Fixed individual effects", "Random individual effects" and the so-called "OLS-Pooled", i.e. ordinary OLS. We ran all of them. In the end we selected OLS-Pooled, as suggested by the tests between the estimation procedures (Hausman, Fisher's F for "fixed effects", Breusch and Pagan for "random effects") and the correlation between individual effects and regressors. To obtain coefficient estimates with the necessary statistical properties, we also ran an OLS regression with heteroscedasticity-robust standard errors

[5] An analysis and updated survey on deforestation and growth may be found in Farooq and Dar (2022), Tsiantikoudis et al. (2019) and Zafeiriou et al. (2023).

[6] In fact, the 2030 Climate Target Plan speaks of cutting total greenhouse gas emissions by at least 55% and becoming climate neutral by 2050.

[7] For an in-depth analysis on the issue and the indicator used, see the original paper.

[8] Cyprus, Estonia, Latvia, Lithuania, Malta, Poland, Czech Republic, Slovakia, Slovenia and Hungary joined the EU in 2004, Bulgaria and Romania in 2007 and Croatia in 2013. For details see Table 1A.

[9] According to the World Bank classification, all the countries in our sample are classified as upper middle or high income (https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html).

[10] In the original paper the number of newspapers sold was a proxy for access to information and the quality of human capital endowment (functional literacy rate). The Gini ratio was considered a proxy for political power and modification of preferences. The latter implies a higher demand for environment (considered a superior good). These aspects are not necessarily captured by per capita income.

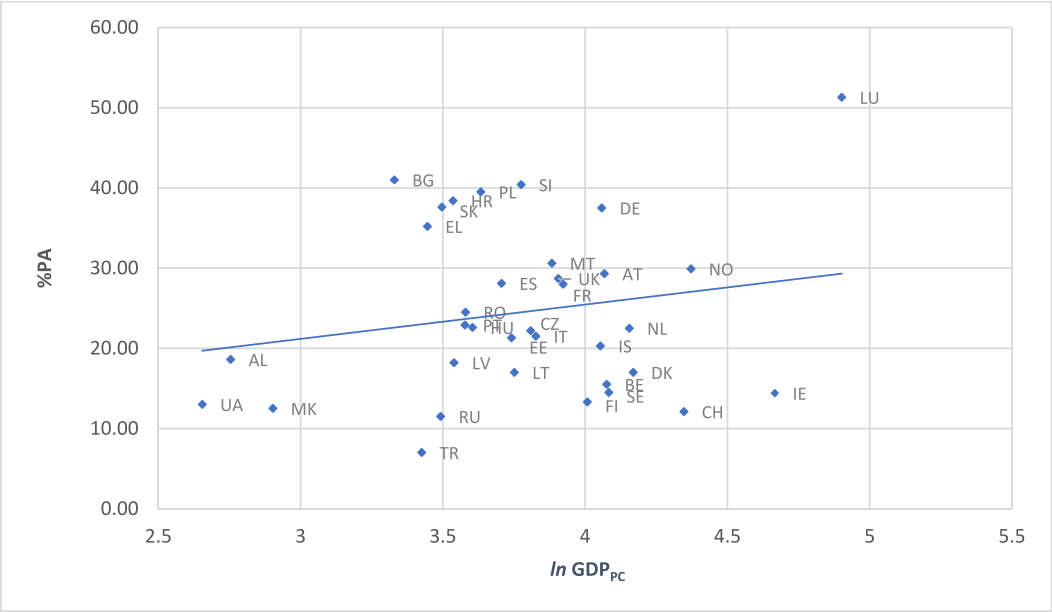

Fig. 1. Percentage of national protected area (PA%) and natural log of per capita GDP (in $ PPP) in European countries (data 2021)

Table 1
Estimate results

Variables	(1)	(2)
	EKC no cons	No-outliers
logY	16.61***	39.30***
	(3.212)	(3.384)
logY2	−2.638*	−5.445**
	(−1.959)	(−2.769)
Gini		-0.879*
		(−1.987)
Online newspapers		−0.254
		(−1.653)
Observations	31	31
R-squared	0.881	0.899
Fstat	107.2	60.41
Prob > F	0	0
AdjR_squ	0.873	0.885
RMSE	9.441	8.985

t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

and free of anomalous observations (outliers). The estimated model is as follows:

$$g_{PA,i,t} = \alpha + \gamma g_{Y,i,t} + \varepsilon_{i,t} \quad (3)$$

where $g_{PA,i,t}$ and $g_{Y,i,t}$ are the average growth rate of *PA%* and *GDPpc* of country *i* over each sub-period, respectively. Table 2 shows the results that indicate a positive relationship between economic growth and investment in conservation. One percentage point of economic growth produced a 1.3% growth in *PA%*, showing that demand for environment increases with income.

However, since land is a limited resource, we thought it interesting to investigate whether past investment in conservation affected national conservation policies, leading to a sort of convergence. To do so we tested for β-convergence in PA% between countries using the following model:

$$g_{PA,i} = \alpha + \gamma log\left(PA_{i,0}\right) + \varepsilon_{PA,i} \quad (4)$$

where $g_{PA,i}$ is the average growth rate of *PA%* of country *i* over the period analysed (1996–2021), $PA_{i,0}$ is PA% of country *i* at time zero (1996), $\varepsilon_{PA,i}$ is the random error component, while α and γ are estimated parameters. β –convergence hypothesis is not rejected with $\gamma < 0$. Fig. 2 and Table 3, model 1, show the results (outliers are not considered). They demonstrate that countries with a lower initial PA% invested comparatively more in environmental protection than those with a higher initial PA%, i.e. the former experienced a greater increment in PA%. Our results show that countries tend toward an average PA% of about 25%. This stylized fact confirms the second research question.

However, for a deeper understanding, this stylised fact calls for more detailed analysis. While it is true in general, at closer analysis differences emerge between groups of countries. We separated EU from non-EU countries and latecomers from old member states in our sample. In 2004 and 2013, as stated, new mainly eastern countries joined the EU. To test the hypothesis, we estimated the following model only for EU countries:

$$g_{PA,i} = \alpha + \gamma log\left(PA_{i,0}\right) + \beta EUlc + \delta EUlc^{*} log\left(PA_{i,0}\right) + \varepsilon_{PA,i} \quad (5)$$

where *EUlc* is a dummy variable set at one for latecomer countries and at zero for old EU members. The results are shown in Table 3 model 2. They confirm that latecomers invested comparatively more, speeding up their convergence, confirming the third research question. This can be inferred from the parameters β and δ: the former highlights that latecomers ($EUlc = 1$) generally showed a higher growth rate of PA%, while the latter shows that the negative relationship between the growth rate of PA% and initial PA% was greater for latecomers, indicating a speeding of the convergence process. Fig. 3 summarizes the results of regressions 4 and 5, comparing the convergence process for three groups of countries: all European countries, old EU-member states and EU-Latecomers.

4. Discussion of the results

The results confute research question 1 and do not reject research questions 2 and 3. In fact, the relationship between GDPpc and PA% does not describe an EKC or an increasing curve. Rather, when the outliers are discarded, the curve is a slight inverted EKC. This suggests that at a certain level of development, further growth may cause competition in resource use, and the more resources become finite, the greater the likelihood that this happen. Land is a limited resource. A strong correlation has been demonstrated between growth and

Table 2
PA% and GDPpc growth rates – regression results.

Growth rate of PA%	Coeff.	Robust SE	t	P>|t|	[95% Conf. Interval]	
Growth rate of GDPpc	1.307514	0.4846562	2.70	0.008	0.3498269	2.265201
cons	11.98363	17.47312	0.69	0.494	−22.54348	46.51074
Number of obs	151	Outliers with Cook's d>k/n = 1/6				
F(1, 149)	7.28					
Prob > F	0.0078					
R-squared	0.0709					
Root MSE	155.13					

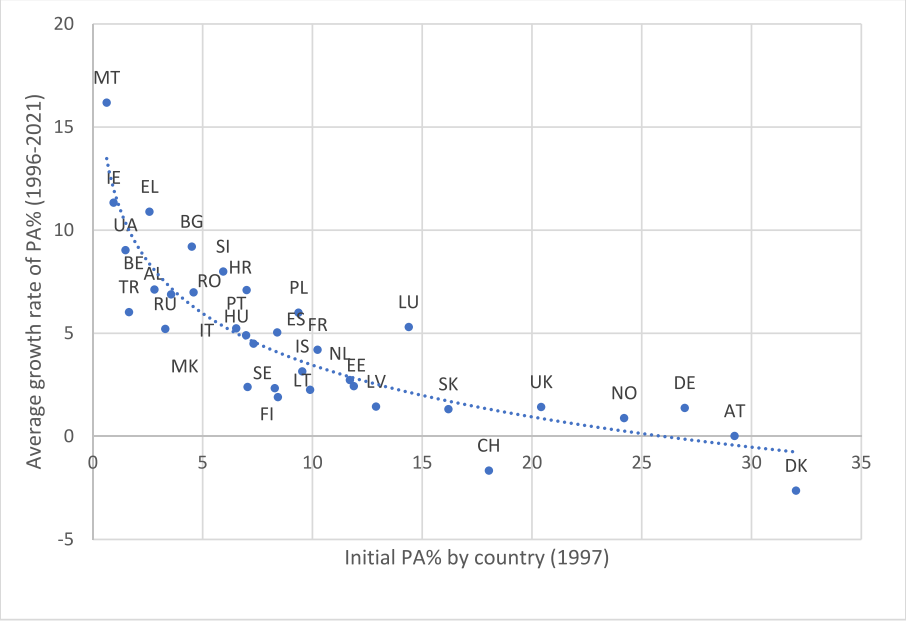

Fig. 2. Observed β-convergence in PA% between countries.

Table 3
Regression results

Variables	Model 1	Model 2
logPA	−6.163***	−3.309***
	(−5.536)	(−3.421)
Eulc		24.68***
		(7.003)
Eulc#c.logPA		−11.36***
		(−6.834)
Constant	16.34***	9.863***
	(6.722)	(4.528)
Observations	34	26
R-squared	0.489	0.861
Fstat	30.64	45.45
Prob > F	4.18e−06	1.35e−09
AdjR_squ	0.473	0.842
RMSE	6.092	3.750

urbanization (Jedwab and Vollrath, 2015). The latter is a major cause of land consumption (EEA, JCR, 2010). At a certain stage we can therefore expect that urbanization and infrastructure, as well as new industrial settlements related to growth and innovation, will occur to the detriment of protection.[11] In other words, once income passes a certain threshold, the positive relationship between income and PA% may become negative.[12] Beyond the turning point, further economic growth may change the private and social appraisal of environmental resources, due also to real estate speculation and/or investment opportunities (Bimonte and Stabile, 2017a, 2017b). This result is consistent with studies that argue that the relationship between income and environment is more likely to be an N-shaped curve, at least in the long run (Farooq and Dar, 2022; Lee et al., 2009; Narcisse et al., 2023; Pezzey, 1989). Unlike what Beckerman (1992) argued, this confirms that growth is not automatically beneficial for environment or, as Mert and Bölük (2016, p. 21678) warn, "environmental goals cannot await economic".

As regards research question 2 and 3, the results posit convergence in the conservation policy of European countries. They also suggest that this stylised fact warrants deeper investigation. While the convergence process is true in general, investment in protection was somehow affected by the economic performance of the countries (growth in GDPpc) and EU environmental policy. A positive relationship emerged between growth in per capita income and growth in PA%. Regarding convergence towards a steady state, the analysis demonstrated that convergence was more pronounced for EU-member countries. This is consistent with EU Biodiversity Strategy 2030 which sets the target of protecting 30% of EU land and sea by 2030. Moreover, shared EU

[11] For example, the discovery of rare earth minerals crucial for the green transition in Kiruna, Sweden, close to the Arctic circle, frustrates efforts to protect the language and culture of the indigenous Sámi population.

[12] With respect to this issue, it is worth noting that Denmark and Switzerland reduced their PA% in the period considered in the present study (see Table 1A in the appendix). Moreover, in December 2023 the Abruzzo regional council passed a law that substantially would reduce the Nature Reserve of the Borsacchio by 98%.

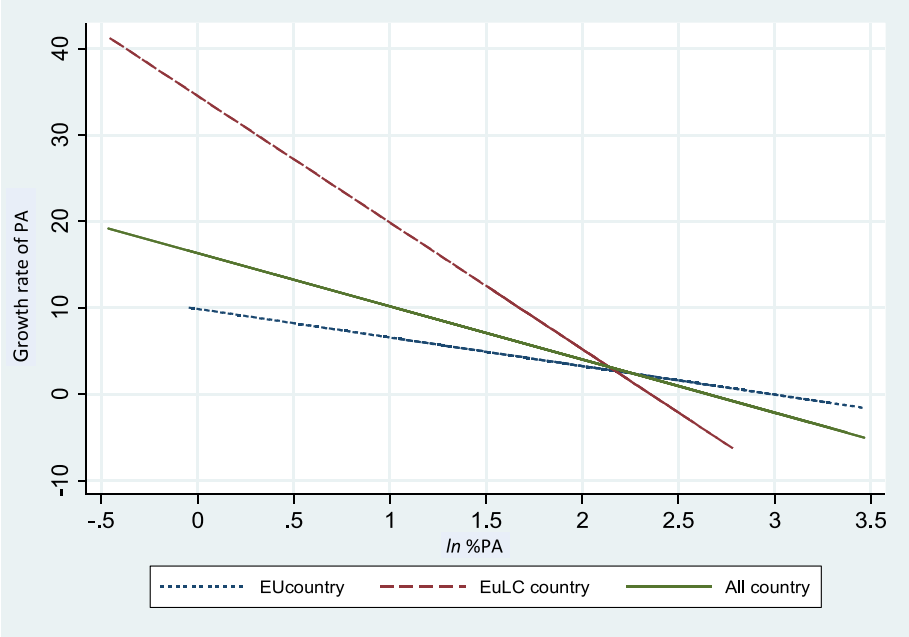

Fig. 3. Predicted β-convergence between groups of European countries: EU countries before enlargement, Latecomers, All (EU and non-EU) countries.[a]
[a]The countries in the three groups are listed in Table A1 of the appendix.

environmental principles seem to have affected the conservation policy of the latecomer countries, for whom qualitative analysis of the data revealed other important information. The trend of latecomers was a little erratic: before entering the EU, they showed a spurt in PA%, whereas their investment slowed once they joined the EU.[13] This indicates that the shared conservation principles of the EU and conditionality principles[14] positively affected their environmental policy.

5. Conclusions

In recent decades, many empirical studies have tested whether various indicators of environmental degradation show an inverted U-shaped relation with income, while others have critically analysed and questioned the concept (for a recent review see Caravaggio, 2020b; Dkhili, 2023). The majority deals with emissions or resources depletion, like forests (Caravaggio, 2022; Farooq and Dar, 2022). An important active policy to preserve resources and ecosystems is conservation. In 2002, Bimonte investigated the existence of an EKC for a particular type of environmental indicator, i.e. the percentage of protected area at national level, in a sample of European countries. The EKC hypothesis was not rejected, but the author questioned the determinism underlying it, not only showing the role played by income, but also income distribution, information and literacy.

More than 20 years after Bimonte's paper, considering the properties of the selected indicator and the social and economic difficulties faced with in the last two decades, the present paper investigated the relationship between countries' conservation policy and income. If we are allowed to use a metaphor, almost like Alexander Dumas,[15] who two decades after the musketeers (the royal guard for the king) triumph over Cardinal Richelieu, brings his heroes out of withdrawal to cross again swords with the humans' malevolence, we analysed what happened to the "natural guard" for our future, i.e. Protected Areas. We did it after two severe economic crises and a pandemic. We compared two different ages for signs of a transition; in the framework of our metaphor, the ages of Cardinal Richelieu and Cardinal Mazzarino.

The study offers a new view and perspective compared to previous research. The results showed that the conservation policy of European countries converged in the last two decades. Countries with a lower percentage of protected area in 1996 invested comparatively more in conservation. It also emerged that in the long run and depending also on the country's characteristics, once the level of protection passed a certain threshold, further growth caused competition in resource use, determining a sort of resource crowding-out effect, similar to the competing land use between agriculture and forest shown by Caravaggio (2022). Accordingly, our study verified the existence of an inverted EKC. This raises important concern and confirms that, although important, focusing solely on growth is misleading. Other social and political responses are needed.

Together offering new insights and empirical evidence on the relationship between growth and environment, our results contain important political lessons. The first is that situations and preferences may change in time and a beneficial relation between economic growth and environmental protection may turn negative. Depending on the distribution and appraisal of costs and benefits, short-term desires could triumph over long-term interests. Norms are therefore needed to commit countries to a longer-term perspective, in our case to protect nature and reverse the deterioration of ecosystems, avoiding any resource crowding-out effect. This is more urgent, the more resources or goals (for example biodiversity) have *public-good*[16] characteristics, which reward free riding. In these cases, federal (centralised) policies must be preferred to local and decentralised approaches (subsidiarity principle). Being part of a "group" (community) makes free riding more difficult and goals achievable at lower costs (efficient). The three musketeers'

[13] This is one of the issues addressed by Zafeiriou et al. (2023) in discussing their results on deforestation in central and eastern countries. To measure it, they used CO_2 emissions generated by deforestation as proxy. Using the same index, Tsiantikoudis et al. (2019) also showed a break in the time series of Bulgaria in 2006.

[14] Conditionality normally refers to basic rules that a country of entrepreneur has to conform with in order to join EU or receive EU income support.

[15] *Twenty years after* is the famous novel by A. Dumas, the sequel to *The Three Musketeers*.

[16] In economics, a good is defined as public if it is both non-excludable and non-rivalrous.

motto "one for all, all for one "should be the guiding principles of environmental policies.

Moreover, as evidenced by latecomer countries in the case of EU, the requirement to meet the necessary criteria for membership speeded up the convergence process. In Munasinghe (1999)'s words, this is similar to a "tunnelling process". According to him, low-income countries could learn from the experiences of richer nations, and restructure development to `tunnel' through any potential adverse effect of growth. This is easier to obtain in the case of countries wishing to join a group, in our case the EU.

Our study is not without limitations, many of which are common to similar research. In particular, all the criticisms and limits of EKC regressions apply to it. Conservation policy is just one part of a country's environmental policy and not necessarily the most relevant. Caution is therefore warranted when analysing the results and making inferences about the effectiveness and quality of a country's environmental policy. At the same time, aggregate data (percentage) tells us nothing about the quality and appropriateness of national park and nature reserve management.

We nevertheless believe that this paper (and conservation policy) offers a special way to look at micro (change in individual preferences) and macro aspects (structural changes) of the relationship between per capita income and environmental quality, because it directly reflects public demand (preferences) for environmental services and government actions to meet that demand. These aspects warrant further study.

Future research could investigate the relationship between protected areas and growth, discovering the role of other covariates and comparing the dynamics in regions with different levels of political integration to provide empirical evidence that when "public or common goods" are involved, political integration can be beneficial for the environment.

Author statement

The authors declare that our work has not been published previously, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

CRediT authorship contribution statement

Salvatore Bimonte: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Arsenio Stabile:** Data curation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix:

Table 1A
Percentage of protected area in the countries of the sample

Country	1996^	2021°
Members of the EU before 2004		
Austria	29.23	29.3
Belgium	2.81	15.5
Denmark	32.03	17
Finland	8.43	13.3
France	10.24	28
Germany	26.96	37.5
Greece	2.58	35.2
Ireland	0.95	14.4
Italy	7.32	21.5
Luxemburg	14.39	51.3
Netherlands	11.71	22.5
Portugal	6.53	22.9
Spain	8.4	28.1
Sweden	8.29	14.5
Latecomer EU countries		
Bulgaria	4.51	41
Czech Rep	16.2	22.2
Croatia	7.01	38.4
Estonia	11.89	21.3
Hungary	6.98	22.6
Latvia	12.9	18.2
Lithuania	9.9	17
Malta	0.63	30.6
Poland	9.37	39.5
Romania	4.59	24.5
Slovak Rep		37.6
Slovenia	5.94	40.4
Non-EU countries		
Albania	3.57	18.6
Russian Fed	3.3	11.5

(*continued on next page*)

Table 1A (*continued*)

Country	1996^	2021°
Iceland	9.54	20.3
Macedonia	7.05	12.5
Norway	24.2	29.9
Switzerland	18.04	12.1
Turkey	1.65	7
Ukraine	1.49	13
United Kingdom	20.42	28.7

Source:^Bimonte (2002)
° https://www.worldbank.org

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