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Abstract

This paper uses a quantile fixed-effect panel data approach to investigate how environmental policy stringency affects CO_2 emissions in a set of 32 OECD countries from 1990 to 2015. This approach allows us to identify the asymmetric impact of policy stringency on emissions, considering the emission level recorded in each analysed country. More precisely, we posit that the effectiveness of environmental regulations and policies is influenced by the air pollution level. Our results show that an increase in policy stringency has a negative impact on emissions. As a new contribution, we show that environmental stringency has a more powerful impact in the countries with lower level of carbon emissions. This result is also recorded for the subset of EU member countries of the OECD. Moreover, we show that policy stringency measures only become effective after the implementation of the Kyoto agreement. Finally, the policy stringency effect is stronger for EU countries at high risk of missing the 20-20-20 target in terms of greenhouse gas emissions.

Keywords: CO_2 emissions; environmental policies; environmental Kuznets curve; pollution haven hypothesis; panel quantiles regression.

JEL codes: Q43, Q56, F21

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1. Introduction

Environmental degradation in general, and the increase in greenhouse gas emissions in particular, requires urgent action and policy measures to fight against global warming. Although the European Union (EU) recorded an emission reduction by 24% between 1990 and 2019[1], at the global level, emission levels are constantly rising. Most emissions are generated by the energy sector, which accounts, according to the International Energy Agency (IEA), for more than 80% of CO_2 emissions (IEA 2019). In finding solutions to a low-carbon economy and increasing energy security, the guidelines of the Organization for Economic Cooperation and Development (OECD) for over 60 years has aimed at increasing and improving the quality of the environment, bringing to the fore stringent actions for climate change awareness.[2] In fact, promoting green innovation and regulating emissions through carbon pricing are the two fundamental driving forces of climate change policies on carbon abatement (Hashmi and Alam 2019). Regarding the environmental policies and regulations of carbon emissions, environmental taxes and environmental policy stringency represent the main instruments used by authorities to fight against climate change (Wolde-Rufael and Mulat-Weldemeskel 2021).

Only a few empirical works, however, have assessed the efficiency of these instruments in moving down the emission level (e.g. Albulescu et al. 2020; Hashmi and Alam 2019; Ma et al. 2018; Niedertscheider et al. 2018; Wenbo and Yan 2018; Zhao et al. 2015). A portion of these works (Wang et al. 2020a; Wolde-Rufael and Mulat-Weldemeskel 2021) investigate the effectiveness of environmental policy stringency in reducing CO_2 emissions. Stringency is associated with a specific pollution price imposed by environmental policies. The OECD computes a specific environmental policy stringency index (EPSI), combining market-based (taxation, trading schemes, deposit and refund schemes, etc.) with non-market-based policies (standards and limitations, research and development expenditures, etc.).[3] While Wang et al. (2020a) investigated the EPSI's impact on air pollution, with a focus on different dimensions of air pollution in 23 OECD countries from 1990 to 2015, more recently Wolde-Rufael and Mulat-Weldemeskel (2021) have tested the U-shaped relationship between CO_2 emissions and EPSI for a set of seven emerging economies.

[1] https://ec.europa.eu/clima/policies/strategies/progress_en

[2] According to Sadik-Zada and Ferrari (2020), over 90% of the population in OECD countries are aware of climate change, and over 60% of them believe that climate change poses a serious threat to sustainable livelihoods and international security.

[3] https://www.oecd.org/environment/how-stringent-are-environmental-policies.htm

We add to this narrow strand of the literature, and we analyse the non-linear and asymmetric effect of environmental policy stringency on carbon emissions in a set of 32 countries, using OECD data and the fixed-effect quantile panel data approach by Canay (2011). Our empirical investigation covers the period from 1990 to 2015.

Consequently, we contribute to the existing literature as follows. First, we argue that the environmental policy stringency effect on CO_2 emissions is influenced by the emission level recorded in each analysed country. This way, we can shed light on the mixed findings reported so far in the literature, showing either a significant (e.g. Zhao et al. 2015) or an insignificant (e.g. Niedertscheider et al. 2018) impact of environmental regulation on carbon emissions. Indeed, the impact of policy stringency on CO_2 emissions is asymmetric, being influenced by the pollution level. This is because policy measures should target specific pollution sources and their magnitude should be correlated with the pollution intensity. However, we cannot say a priori whether the increase in policy stringency will lead to a stronger reduction in environmental degradation in the countries with lower or higher pollution levels. On the one hand, if the emission levels record higher dynamics (the case of emerging economies), the authorities will be forced to adopt more restrictive policy measures to prevent environmental degradation. On the other hand, the authorities from the countries which are exposed to additional environmental constraints as regional targets or policies (the EU case), even in the presence of negative dynamics of carbon emissions, might be forced to take action and enhance the policy stringency. If this is the case, the environmental regulations have a more powerful impact in the countries with lower levels of carbon emissions. Canay's (2011) approach will allow us to verify and test these hypotheses. As far as we know, this is the first paper which resorts to a fixed-effect quantile panel data approach to investigate the relationship between environmental policy stringency and CO_2 emissions.

Second, we perform a series of analyses to see whether the asymmetric effect of EPSI on CO_2 emissions also manifest inside the EU group of OECD member countries or whether this effect is stronger after the adoption of the Kyoto protocol. For example, Albulescu et al. (2020) has shown that the entry into force of the Kyoto protocol has had no significant effect on carbon emissions in EU countries, whereas the "Climate and Energy Package 2020" adopted in 2009 has had only a marginal effect on CO_2 emissions.

Third, we perform a deeper analysis of the EU sample of OECD member states, and we split the group into two parts, considering the countries at risk and not at risk of achieving the 20-20-20 target. We posit that countries that are in a position to miss the target over the analysed time horizon will take more vigorous actions to prevent environmental degradation.

Finally, in line with previous papers on this topic, we check the environmental Kuznets curve (EKC) and the pollution haven hypotheses(PHH). To this end, similar to Albulescu et al. (2020) and Apergis and Ozturk (2015), we address the endogeneity effect between emissions and foreign direct investment (FDI). Moreover, we posit that the endogeneity effect might also manifest between carbon emissions and environmental policy stringency. Indeed, if carbon emissions are high, this element could force the authorities to impose more stringent policy measures.

To preview our findings, we show that policy stringency has a negative impact on CO_2 emissions. That is, more restrictive environmental policies and measures contribute to a reduction in emissions. Interestingly, we document that environmental regulations and restrictions have a stronger impact on carbon emissions in countries with a lower level of emissions (i.e. EU countries). Our results thus confirm the findings by Hashmi and Alam (2019) and Wang et al. (2020a), showing the negative impact of EPSI on carbon emissions in OECD countries. However, as a new contribution, we show that the impact is asymmetric and more powerful for lower quantiles, that is, for countries with a lower level of emissions. This result proves the efficiency of EU environmental regulations compared to the effect of similar regulations in other OECD member states.

The rest of the paper presents a review of the literature (Section 2), the data and methodology (Section 3), the main empirical findings (Section 4) and the robustness checks (Section 5). The last section concludes with the asymmetric impact of environmental policy stringency on carbon emissions.

2. Literature review

Acknowledgment of environmental degradation brought stringent actions from different countries around the world that introduced policy stringency instruments (e.g. environmental taxes, trading schemes, emission standards, etc.) in response to environmental challenges (Machiba 2010). One of the strictness measures was developed by Botta and Koźluk (2014) through the environmental policy stringency index, distinguishing between market-based instruments and non-market ones. EPSI focuses on climate and air policies in key upstream sectors and combines information on selected environmental policies to create a composite measure of relative policy across countries over a period of time, which represents its main advantage (for additional explanations, please refer to Botta and Koźluk 2014). The use of EPSI is based on different assumptions. The first assumption is that the omission of certain types of instruments creates heterogeneity between countries, which makes comparison of their stringency across time and eventually across countries problematic. Thus, in the recent research, there are some interpretations of EPSI in terms of multidimensionality, sampling, identification (and enforcement) and lack of data (Brunel and Levinson 2013; Koźluk and Zipperer 2015). The second assumption can prove that the stringency of environmental policies encourages green innovation and works to set international standards to improve economic performance. In this line, the research conducted by Ahmed (2020), Martínez-Zarzoso et al. (2019), Wang et al. (2020a, 2020b), Ouyang et al. (2019) resorted to policy instruments for innovation, productivity, technological innovation and green growth.

The applicability of EPSI has therefore caught the attention of researchers and was employed in investigating the connection between climate change and economic growth (e.g. De Angelis et al. 2019) or in assessing the impact of environmental regulations in reducing greenhouse gases (e.g. Ahmed and Ahmed 2018). However, recent literature strongly emphasises that the unavailability of a reliable measure of environmental policy strictness generates an asymmetric response to environmental issues among countries (Galeotti et al. 2020). Therefore, the OECD measure of policy stringency represents a reliable indicator to perform cross-country analyses. Figure 1 describes the construction logic of the EPSI index.

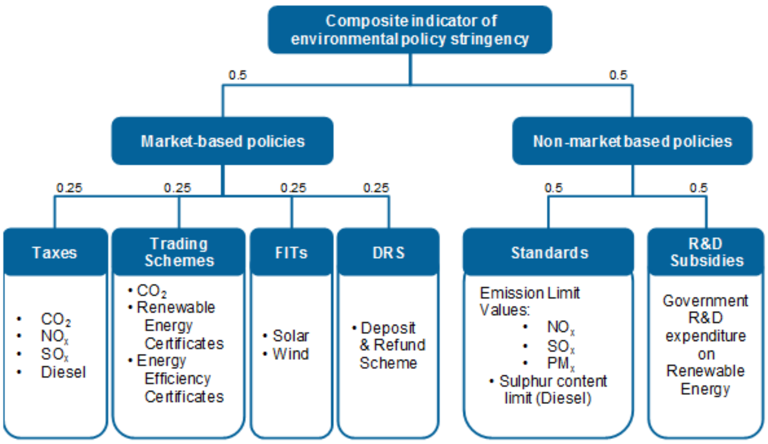

Fig. 1 The OECD Environmental Policy Stringency Index

Source: https://www.oecd.org/economy/greeneco/how-stringent-are-environmental-policies.htm

2.1 The effectiveness of environmental regulations and policies

The role of global political debates on environmental degradation is to search for solutions by identifying the best policy mechanisms for a sustainable environment. Following these political debates, some research has arisen that is closely linked to environmental policies (Boyd et al. 1995; Ma et al. 2018; Simões et al. 2008; Yin et al. 2015; Zhao et al. 2015), economic growth modelling (Pao et al. 2011), the impact of pollution on the environment and energy consumption (Benvenutti et al. 2019; Li et al. 2017; Mao et al. 2012).

The effectiveness of environmental regulations might be explained by two driving forces, namely the political willingness to achieve the environmental targets and the trade-off between economic and environmental short-run objectives.

First, the implementation of environmental policies is closely linked to the political parties in power. For example, Asafu-Adjaye and Mahadevan (2013) underlined the fact that a focus of the Australian government on distortionary state and federal taxes, such as income tax, savings tax, property tax and indirect taxes, may negate the efficiency gains of the emissions trading scheme (ETS). In Austria, Niedertscheider et al. (2018) indicated some concerns regarding the future of climate policy integration (CPI) due to the perpetuation of the conflict "economic growth versus climate protection" by political parties. The authors showed that political parties are closely connected to the business environment, which negatively affects the implementation of CO_2 emission decisions and policies. Further, policy adjustments also influence the impact of economic and social factors on CO_2 emissions (Huo et al. 2015).

Second, the economic interest of some countries might affect the effectiveness of their environmental regulations. This is the case for emerging market economies, which record high economic growth rates. In this context, one book in the literature under review addressed the case of China, analysing the effectiveness of environmental regulations in specific industries or its overall effect on climate change. In this line, Ma et al. (2018) analysed whether government regulations influence the efficiency of the mining sector in China and identify heterogeneity in the effect of regulations according to property type. The authors stated that the absence of an effective incentive, a monitoring mechanism and a deviation from the profit maximisation objective hinders eco-efficient performance. They proposed market-oriented regulatory instruments, such as tax breaks and subsidies, for private enterprises, and for state-owned enterprises, command-and-control instruments combined with appropriate target-based regulations. Similarly, Xu et al. (2018) have pointed out that coal tax policy reform is conducive to promoting reductions in emissions and environmental benefits, but the impact is different when different tax rates are used. The 5% tax rate on coal resources can effectively inhibit excessive resource consumption, improve resource efficiency and reduce environmental damage, which can be a reasonable choice to reduce CO_2 emissions in China. Wenbo and Yan (2018) analysed in their turn the relationship between CO_2 emissions and energy consumption in 30 regions of China between 2004–2015, using Tapio decoupling models, GMM differential methods and peak forecasting models. They controlled for the role of environmental regulations and discovered an inverted U-shaped relationship between environmental regulations and CO_2 emissions. In the same spirit, Zhao et al. (2015) conducted an empirical study on 137 power plants in China and performed a micro-level analysis of the role of environmental regulations. They concluded that market-based regulations and government subsidies help to reduce the CO_2 emissions of China's power plants. In contrast, Cheng et al. (2017) showed that command-and-control policy tools are conducive to emissions reduction, but their effects on technical progress are not significant; market-based policy tools are conducive to technical progress, but their effects on emissions reduction are relatively weak.

A different approach has been taken by Mao et al. (2012), who compared the effectiveness of various policy instruments, such as CO_2 tax, fuel tax and energy tax, on influencing carbon emissions. Among these instruments, energy and fuel taxes are the two most promising instruments for CO_2 emission intensity reduction, and subsidies are the least promising options. The authors also show that CO_2 tax could be an effective policy tool. With a focus on three types of environmental policies in China (energy structure policies, energy efficiency improving policies and production scale policies), Li et al. (2018) demonstrated that CO_2 reduction benefits a lot from cleaner electricity generation. The connection between environmental policies and CO_2 emissions was recorded for all categories of policies.

Other similar studies have focused on Chile (Mardones and Flores 2018), Malaysia (Yahoo and Othman 2017) or BRICS countries as a group (Adedoyin et al. 2020), and have underlined the importance of environmental taxes, abatement policies and coal rents on the reduction of CO_2 emissions. Table A1 (Appendix), presents a comparison of early studies focusing on the effectiveness of environmental regulations and policies.

2.2 Environmental policy stringency and CO_2 emissions in OECD countries

As previously mentioned, a reliable approach to identify the effectiveness of environmental regulations and policies on environmental pollution is to consider an aggregate policy stringency index. OECD countries have worked together to establish policy measures to reduce the impact of economic activities that have negative effects on society and environment (Johnstone et al. 2012). One measure was the construction of EPSI in 2014. Since then, several recent empirical papers have addressed the non-linear effect of environmental regulations on carbon emissions.

Likewise, the paper by Álvarez et al. (2017) explores the impact of improvements in energy innovation—an EPSI component—on GHG emissions in 28 OECD countries for the period of 1990–2014. They showed that the effect of energy innovation on environmental correction requires a significant time lag. Similar, Hashmi and Alam (2019) examined the effects of environmental regulation and innovation on the carbon emission reduction of OECD countries during the period 1999–2014 and aimed to optimise market-based instruments, such as patents and carbon pricing, for the implementation of efficient and cost-effective climate change policies. At the same time, Ahmed (2020) has argued that stringent environmental policies coupled with environmentally friendly innovation are the impetus for sustainable development. A different approach was taken by Ahmed and Ahmed (2018) who considered environmental policy stringency and economic activity as controlling variables in forecasting CO_2 emissions in China. Sadik-Zada and Ferrari (2020) employed in their turn the EPSI to test the EKH and PHH in a set of 26 OECD countries over the period 1995 to 2011.

More recently, Ouyang et al. (2019) found an inverted U-shaped relationship between the environmental policy stringency index and PM2.5 emissions for 30 OECD countries. A similar result was reported by Wolde-Rufael and Mulat-Weldemeskel (2021), who documented the existence of an inverted U-shaped relationship between CO_2 emissions and EPSI, suggesting that it takes time for environmental policy stringency measures to be effective. Finally, Wang et al. (2020b) analysed the strictness of environmental regulatory policies and measured the growth of ecological productivity using an extended SBM-DDF approach. The authors validated the idea that environmental policy has a positive impact on increasing ecological productivity to a certain level of strictness.

Most of these recent papers posit that the relationship between EPSI and environmental pollution is non-linear. Nevertheless, none of these papers investigated the asymmetric response of CO_2 missions to the EPSI level. To overcome this limitation, we proceed to a panel fixed regression in quantiles to see the effectiveness of policy stringency in low, medium and high polluter OECD countries.

3. Data and methodology

3.1. Data

We use annual data from 1990 to 2015 (OECD statistics) to analyse the emissions–environmental regulation nexus, with a focus on 32 countries (Table A2—Appendix). EPSI represents our variable of interest, and it is used as a *proxy* for environmental regulations. These data are available until 2015 only. However, the time span we analysed is long enough to identify the effect of worldwide major changes in terms of environmental policies and regulations at a global level (e.g. the entry into force of the Kyoto protocol) or the effect of environmental and climate change policies at the EU level (e.g. 20-20-20 targets) on carbon emissions.

In line with previous papers assessing the impact of environmental regulations on air pollution levels (e.g. Albulescu et al. 2019, 2020; Ma et al. 2018; Niedertscheider et al. 2018; Sapkota and Bastola 2017; Wenbo and Yan 2018; Zhao et al. 2015), we focus on the CO_2 emissions (metric tons per capita). These data are extracted from the World Development Indicators database (World Bank). The explanatory variables come from the same database and are represented by the level of GDP per capita, expressed in natural log (which allows us to test the EKC hypothesis), the net inflows of FDI as a percentage of GDP (necessary to test the PHH), the energy use (kg of oil equivalent per capita in natural log) and the renewable energy consumption as a percentage of total final energy consumption.

A series of other control variables have been advanced in the literature to check the determinants of CO_2 emissions (i.e. human capital, gross fixed capital formation, population density, unemployment rate, etc.). However, as Albulescu et al. (2020) have shown, the impact of these variables is either reduced or insignificant. Therefore, we have focused on the main drivers of carbon emissions, which are the energy consumption and economic growth levels while placing special emphasis on the role of environmental regulations and policies. We also address the potential impact of using renewable energy on CO_2 emissions. Most previous studies have shown that this impact is marginal (e.g. Aliprandi et al. 2016; Chen et al. 2019; Dong et al. 2018), although the use of renewables represents a promising solution to control and mitigate air pollution levels. The descriptive statistics of our variables are presented in Table 1.

Table 1. Descriptive statistics

Variables	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**
CO_2	823	8.283	4.116	0.709	20.17
EPSI	776	1.584	0.963	0.208	4.133
GDP	824	9.944	1.063	6.355	11.42
GDP^2	824	100.0	19.73	40.38	130.5
FDI	823	3.776	7.396	-15.83	86.58
EU	826	8.040	0.649	5.858	9.042
RTEC	832	16.97	15.84	0.441	61.37

Notes: CO_2—carbon emission, EPSI—Environmental Policy Stringency Index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

3.2. Methodology

We ran a panel regression model in quantiles to account for non-linearities and asymmetry in the tested relationship, and we used Canay's (2011) approach with fixed effects to account for unobserved covariates. The general equation we tested is (we used the first lag of explanatory variables to avoid any endogeneity bias):

$$co_{2it} = \alpha_0 + \alpha_1 epsi_{it-1} + \alpha_2 Z_{it-1} + \mu_i + \gamma_t + \varepsilon_{it}, \qquad (1)$$

where co_{2it} are the carbon emissions (metric tons per capita) of the country i in the year t; α_0 represents the intercept; $epsi_{it-1}$ is the environmental policy stringency index; Z_{it-1} is the vector of control variables represented by GDP per capita, FDI, energy use (kg of oil equivalent per capita) and the renewable energy consumption (% of total final energy consumption); μ_i are the time-invariant firm specific effects, γ_t are the time-specific effects and ε_{it} are the error terms.

A series of panel quantile fixed-effects models are proposed in the literature (e.g. Canay 2011; Galvao 2011; Koenker 2004; Lamarche 2010; Rosen 2012). These models might be described as follows:

$$Y_{it} = X'_{it}\theta(U_{it}) + \alpha_i, \qquad (1)$$

where $t = 1, \dots, T$; $i = 1, \dots, n$; Y_{it} and X_{it} represent observable variables; U_{it} is an unobservable component; X'_{it} includes a constant term and $\theta(\tau)$ is the parameter of interest.

If the function $\tau \to X'\theta(\tau)$ is increasing in $\tau \in (0,1)$, for an observable α_i, we have

$$P[Y_{it} \le X'_{it}\theta(U_{it}) + \alpha_i | X_i, \alpha_i] = \tau, \qquad (2)$$

where $U_{it} \sim U[0,1]$, conditional on $X_i = (X'_{i1}, \dots, X'_{iT})'$ and α_i.

For all these models, the challenge is to correctly identify $\theta(\tau)$. If $Q_Y(\tau|X)$ is the τ-quantile of a random variable Y conditional on X and $e_{it}(\tau) \equiv X'_{it}[\theta(U_{it}) - \theta(\tau)]$, equation (2) becomes

$$Y_{it} = X'_{it}\theta(U_{it}) + \alpha_i + e_{it}(\tau). \qquad (3)$$

By assuming that α_i is a location shift, Canay (2011) proved that $\theta(\tau)$ is identified for $T \ge 2$ under independence restrictions and existence of moments. In fact, Canay (2011) assumed that only $\theta(\tau)$ and $e_{it}(\tau)$ depend on τ and transforms equation (1) as follows:

$$Y_{it} = X'_{it}\theta\mu + \alpha_i + u_{it}, \qquad E(u_{it}|X_i, \alpha_i) = 0. \qquad (4)$$

This transformation represents the novelty of Canay's (2011) approach, which allows the author to compute the two-step estimator $\hat{\theta}\mu$. In the first step, a consistent estimator of α_i ($\sqrt{T}$)

and $\theta\mu$ ($\sqrt{nT}$) is obtained, with $\hat{\alpha}_i \equiv E_T[Y_{it} - X'_{it}\hat{\theta}\mu]$. In the second step, the author defines $\hat{Y}_i \equiv Y_{it} - \hat{\alpha}_i$, whereas $\hat{\theta}\mu$ becomes

$$\hat{\theta}\mu \equiv \underset{\theta\in\Theta}{\operatorname{argmin}} \mathbb{E}_{nT}\,[\rho_\tau(\hat{Y}_{it} - X'_{it}\hat{\theta}\mu], \quad (5)$$

where $\mathbb{E}_{nT}(\cdot) \equiv (nT)^{-1}\sum_{t=1}^{T}\sum_{i=1}^{n}(\cdot)$.

4. Results

The main empirical results are presented in Table 2. Firstly, we noticed that the impact of EPSI on carbon emission was negative and very significant, except for the extreme upper quantiles. This means that an increase of environmental policy stringency results in a decrease in CO_2 emissions. The findings are therefore consistent with those reported by Albulescu et al. (2020) for the EU countries and by Zhao et al. (2015) for China, but they contradict those reported by Niedertscheider et al. (2018) for Australia. As a new contribution, we have shown that environmental stringency has a more powerful impact in the countries with lower levels of carbon emissions (that is, for the lower quantiles) compared to the high polluters.

Table 2. Panel conditional quantile regression—entire sample

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.248***	-0.297***	-0.219***	-0.214***	-0.212***	-0.202***	-0.196***	-0.107***	-0.098**	0.178**
	(0.079)	(0.065)	(0.044)	(0.029)	(0.028)	(0.033)	(0.038)	(0.041)	(0.045)	(0.070)
GDP	4.866***	3.357***	2.331***	2.378***	2.266***	2.565***	2.086***	1.754***	1.199**	1.038
	(0.963)	(0.785)	(0.539)	(0.354)	(0.337)	(0.397)	(0.461)	(0.501)	(0.546)	(0.850)
GDP^2	-0.292***	-0.206***	-0.151***	-0.155***	-0.149***	-0.166***	-0.142***	-0.128***	-0.100***	-0.094**
	(0.051)	(0.042)	(0.029)	(0.019)	(0.018)	(0.021)	(0.025)	(0.027)	(0.029)	(0.045)
FDI	0.011	0.011	0.005	0.004	0.004	0.001	0.000	-0.004	-0.003	0.006
	(0.009)	(0.008)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.008)
EU	2.896***	3.010***	3.064***	3.236***	3.277***	3.295***	3.382***	3.555***	3.616***	3.866***
	(0.180)	(0.146)	(0.101)	(0.066)	(0.063)	(0.074)	(0.086)	(0.094)	(0.102)	(0.159)
RTEC	-0.042***	-0.048***	-0.048***	-0.046***	-0.044***	-0.040***	-0.040***	-0.038***	-0.037***	-0.029***
	(0.005)	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)
α_0	-34.12***	-27.92***	-23.55***	-24.82***	-24.56***	-26.00***	-24.15***	-23.57***	-21.26***	-22.35***
	(4.432)	(3.615)	(2.482)	(1.632)	(1.552)	(1.826)	(2.121)	(2.307)	(2.514)	(3.914)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 754 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

In line with most previous papers on the topic, we noted the importance of energy use for CO_2 emissions, and we validated the EKC hypothesis at all quantiles, except for the extreme upper quantiles. The effect of inward FDI was insignificant, a result that explains the mixed findings previously reported by the literature. For example, Sapkota and Bastola (2017) and Albulescu et al. (2019) found evidence for the PHH in the case of Latin American countries, whereas Albulescu et al. (2020) documented opposite findings for EU countries and validated the pollution halo hypothesis.

The impact of the share of renewables in total electricity consumption had a negative impact on emissions, although the effect was reduced. This impact is stronger for lower quantiles, that is, for lower emissions levels. Our results validate most of the previous findings underlining the positive role of renewables in the reduction of carbon emissions (e.g. Albulescu et al. 2020; Aliprandi et al. 2016; Chen et al. 2019; Dong et al. 2018; Inglesi-Lotz and Dogan 2018; Sinha and Shahbaz 2018; Zoundi 2017).

Our sample contains data on a large set of OECD countries but also information about carbon emissions in several emerging countries. In addition, several international treaties were concluded to fight against climate change during the analysed timespan. Therefore, to check the robustness of our findings, we first assessed the impact of the entry into force of Kyoto protocol, namely in 2005. To this end, we worked on two subsamples covering the periods 1990 to 2004 and 2004 to 2015. Second, we focused on the EU countries sample. It is well known that the EU acts as an international leader in fighting against greenhouse gas (GHG) emissions. The EU established precise targets in terms of GHG emissions, renewable energy, and energy efficiency to be achieved in 2020 (the so-called 20-20-20 targets). However, the progressive monitoring of reaching those targets showed that several countries were in difficulty and risked missing the targets. For example, during the 2016 monitoring of the European Commission[4], in the case of four EU countries (Austria, Belgium, Denmark and Ireland), the projected progress underlined some issues in terms of GHG emissions targets. Consequently, we also compared the impact of environmental policy stringency for EU countries not at risk of achieving the 20-20-20 target in terms of GHG emissions with those at risk of missing the targets.

5. Robustness check

5.1. The impact of the Kyoto protocol's entry into force

The Kyoto protocol was adopted in 2003, and its effective entry into force happened in 2005. Consequently, we first looked at the pre-Kyoto period and surprisingly noticed that the sign of EPSI was positive and significant, meaning that previous environmental regulations were completely inefficient in fighting against climate change. The results reported in Table 3

[4] https://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe/trends-and-projections-in-europe-2016/1-overall-progress-towards-the

show that only energy consumption and the use of renewables had an effective impact on CO_2 emissions.

Table 3. Panel conditional quantile regression—entire sample before Kyoto protocol

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	0.085	0.193**	0.124*	0.163**	0.122**	0.092	0.230***	0.355***	0.403***	0.495***
	(0.182)	(0.088)	(0.072)	(0.066)	(0.061)	(0.058)	(0.062)	(0.077)	(0.108)	(0.182)
GDP	-0.505	-0.616	-0.704	-0.483	-0.579	-0.315	-0.045	-0.099	-0.191	0.422
	(1.235)	(0.596)	(0.488)	(0.446)	(0.417)	(0.393)	(0.420)	(0.522)	(0.735)	(1.234)
GDP^2	0.023	0.034	0.037	0.024	0.032	0.018	0.001	0.003	0.007	-0.037
	(0.067)	(0.032)	(0.027)	(0.024)	(0.023)	(0.021)	(0.023)	(0.028)	(0.040)	(0.067)
FDI	0.012	0.011	0.007	-0.002	-0.004	-0.001	0.001	-0.001	0.010	0.033*
	(0.018)	(0.009)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.011)	(0.018)
EU	0.666***	0.575***	0.762***	0.842***	0.788***	0.782***	0.859***	0.907***	0.991***	1.318***
	(0.242)	(0.117)	(0.096)	(0.088)	(0.082)	(0.077)	(0.082)	(0.102)	(0.144)	(0.242)
RTEC	0.019***	0.011***	0.013***	0.015***	0.012***	0.011***	0.014***	0.015***	0.014***	0.016**
	(0.007)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.007)
α_0	4.331	5.560**	4.848**	3.463*	4.268**	3.245*	1.564	1.491	1.429	-2.790
	(5.667)	(2.734)	(2.240)	(2.048)	(1.913)	(1.801)	(1.928)	(2.394)	(3.374)	(5.660)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 455 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

Table 4, however, presents a different situation. It clearly shows that the entry into force of the Kyoto protocol enhanced the environmental policy stringency, with a negative impact on carbon emissions. Again, the impact was higher for lower polluter countries.

Table 4. Panel conditional quantile regression—entire sample after Kyoto protocol

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.414***	-0.357***	-0.472***	-0.426***	-0.425***	-0.457***	-0.455***	-0.364***	-0.335***	-0.295*
	(0.113)	(0.103)	(0.087)	(0.065)	(0.060)	(0.061)	(0.077)	(0.078)	(0.088)	(0.177)
GDP	13.11***	13.08***	12.05***	11.98***	11.65***	11.03***	10.45***	10.52***	9.799***	8.935***
	(1.414)	(1.296)	(1.086)	(0.820)	(0.754)	(0.770)	(0.970)	(0.978)	(1.100)	(2.215)
GDP	-0.679***	-0.674***	-0.618***	-0.617***	-0.597***	-0.566***	-0.537***	-0.544***	-0.505***	-0.443***
	(0.074)	(0.068)	(0.057)	(0.043)	(0.039)	(0.040)	(0.051)	(0.051)	(0.057)	(0.116)
FDI	0.010	0.006	0.005	0.003	0.000	-0.001	-0.004	-0.005	-0.007	-0.015
	(0.008)	(0.008)	(0.007)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)	(0.013)
EU	-0.012	0.080	0.221	0.312**	0.316***	0.432***	0.504***	0.639***	0.647***	0.411
	(0.220)	(0.201)	(0.169)	(0.127)	(0.117)	(0.120)	(0.151)	(0.152)	(0.171)	(0.344)
RTEC	-0.060***	-0.061***	-0.064***	-0.063***	-0.064***	-0.065***	-0.065***	-0.061***	-0.063***	-0.067***
	(0.006)	(0.006)	(0.005)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.010)
α_0	-53.16***	-53.83***	-49.83***	-49.81***	-48.43***	-46.14***	-43.57***	-44.73***	-41.36***	-36.56***
	(6.602)	(6.048)	(5.067)	(3.830)	(3.521)	(3.596)	(4.526)	(4.565)	(5.133)	(10.33)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 296 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

These results partially contradict the findings reported by Albulescu et al. (2020), who documented a significant role of EU environmental regulations in carbon emissions decreasing, but no significant effects for the entry into force of the Kyoto protocol. The discrepancies might be explained by the fact that the Kyoto protocol has not determined an abrupt decline in CO_2

emissions and the dummy variable used in Albulescu et al. (2020) was not efficient in this case. Moreover, the country sample was different. However, in line with this study, we confirmed the EKC hypothesis and the role of renewables for reducing carbon emissions.

5.2. A focus on the EU situation

To get further insight into the role of environmental regulations on carbon emissions, we focused on EU countries (Table 5). Our sample included 18 EU countries with different levels of economic development and energy consumption. These findings are very similar to those reported in Table 2, proving their robustness. However, the EKC hypothesis was only documented for the middle quantiles in this case. In addition, for the EU countries, the effect of environmental policy stringency was higher for the upper quantiles associated with higher polluters. A similar robustness check was conducted for the OECD countries sample (Table A3 – Appendix) and confirmed the main results.

Table 5. Panel conditional quantile regression—EU countries sample

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.261***	-0.264***	-0.189***	-0.231***	-0.239***	-0.269***	-0.294***	-0.302***	-0.307***	-0.238***
	(0.075)	(0.059)	(0.046)	(0.036)	(0.039)	(0.040)	(0.039)	(0.045)	(0.056)	(0.086)
GDP	0.977	3.241	3.739	4.390**	4.665**	3.132	3.860*	2.976	3.338	-3.101
	(4.282)	(3.348)	(2.618)	(2.044)	(2.227)	(2.289)	(2.223)	(2.581)	(3.193)	(4.871)
GDP^2	-0.055	-0.169	-0.199	-0.228**	-0.241**	-0.161	-0.196*	-0.151	-0.167	0.161
	(0.215)	(0.168)	(0.131)	(0.103)	(0.112)	(0.115)	(0.112)	(0.130)	(0.160)	(0.245)
FDI	-0.005	-0.006	-0.009**	-0.003	-0.004	-0.004	-0.005	-0.006	-0.008*	-0.010
	(0.007)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.008)
EU	3.772***	3.917***	4.219***	4.140***	4.190***	4.033***	4.099***	4.238***	4.255***	4.406***
	(0.235)	(0.184)	(0.144)	(0.112)	(0.122)	(0.126)	(0.122)	(0.142)	(0.175)	(0.267)
RTEC	-0.123***	-0.118***	-0.117***	-0.114***	-0.112***	-0.107***	-0.106***	-0.103***	-0.103***	-0.094***
	(0.006)	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.007)
α_0	-25.61	-37.73**	-42.09***	-44.96***	-46.73***	-38.00***	-42.15***	-38.84***	-40.88**	-10.56
	(21.70)	(16.97)	(13.27)	(10.36)	(11.28)	(11.60)	(11.27)	(13.08)	(16.18)	(24.69)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 410 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

The last set of estimations compared the two EU countries subsamples: not at risk and at risk of achieving the 20-20-20 target in terms of GHG emissions. It is expected that countries with a higher risk of missing the targets will enhance policy stringency in order to achieve the targets for 2020. Indeed, if we compare the results from Tables 6 and 7, we observe that EPSI had a negative impact on CO_2 emissions in both cases, whereas the effect was stronger for the countries at risk of achieving the targets. There is mixed evidence regarding the EKC hypothesis, while the FDI impact was insignificant. For both samples, energy use played a major role in carbon emissions, and the renewables contributed to the reduction in CO_2 emissions.

Table 6. Panel conditional quantile regression—EU countries sample not at risk of achieving the 20-20-20 target in terms of GHG emissions, as projected in 2016

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.303***	-0.241***	-0.194***	-0.176***	-0.173***	-0.187***	-0.208***	-0.195***	-0.140**	-0.098
	(0.073)	(0.071)	(0.052)	(0.040)	(0.038)	(0.039)	(0.039)	(0.048)	(0.058)	(0.084)
GDP	-7.974*	-3.111	1.261	1.494	4.036*	4.450*	5.121**	6.959**	7.097*	9.542*
	(4.631)	(4.519)	(3.322)	(2.536)	(2.400)	(2.517)	(2.501)	(3.075)	(3.676)	(5.385)
GDP^2	0.379	0.129	-0.102	-0.113	-0.238*	-0.259**	-0.294**	-0.388**	-0.397**	-0.523*
	(0.235)	(0.229)	(0.168)	(0.129)	(0.122)	(0.128)	(0.127)	(0.156)	(0.186)	(0.273)
FDI	0.004	0.001	-0.001	-0.002	-0.003	-0.004	-0.005	-0.006	-0.008	-0.009
	(0.007)	(0.007)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)	(0.008)
EU	3.511***	3.707***	4.073***	4.105***	4.029***	4.043***	4.060***	4.133***	4.352***	4.751***
	(0.239)	(0.233)	(0.171)	(0.131)	(0.124)	(0.130)	(0.129)	(0.158)	(0.189)	(0.278)
RTEC	-0.084***	-0.085***	-0.082***	-0.082***	-0.079***	-0.075***	-0.072***	-0.067***	-0.065***	-0.056***
	(0.005)	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)
α_0	21.92	-3.020	-26.434	-27.88**	-40.00***	-42.15***	-45.36***	-54.86***	-57.01***	-72.03***
	(23.62)	(23.05)	(16.94)	(12.93)	(12.24)	(12.84)	(12.75)	(15.68)	(18.75)	(27.47)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 318 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

Table 7. Panel conditional quantile regression—EU countries sample at risk of achieving the 20-20-20 target in terms of GHG emissions, as projected in 2016

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.339**	-0.444*	-0.597***	-0.647***	-0.620***	-0.613***	-0.579***	-0.466***	-0.358	-0.647
	(0.145)	(0.234)	(0.149)	(0.129)	(0.126)	(0.158)	(0.176)	(0.176)	(0.266)	(0.596)
GDP	1.119	87.51*	75.84***	66.36***	77.79***	63.27**	62.69*	69.65**	69.61	34.68
	(27.91)	(45.25)	(28.68)	(25.00)	(24.27)	(30.57)	(33.97)	(33.92)	(51.43)	(115.1)
GDP^2	-0.109	-4.165*	-3.594***	-3.141***	-3.679***	-2.990**	-2.966*	-3.284**	-3.285	-1.555
	(1.322)	(2.143)	(1.358)	(1.184)	(1.150)	(1.448)	(1.609)	(1.606)	(2.436)	(5.451)
FDI	-0.000	-0.017	-0.017**	-0.013**	-0.011*	-0.010	-0.006	-0.012	-0.022*	-0.031
	(0.007)	(0.011)	(0.007)	(0.006)	(0.006)	(0.007)	(0.008)	(0.008)	(0.012)	(0.028)
EU	7.458***	6.805***	7.073***	7.201***	7.045***	7.079***	7.043***	7.102***	7.658***	7.850***
	(0.387)	(0.627)	(0.397)	(0.346)	(0.336)	(0.423)	(0.470)	(0.470)	(0.712)	(1.594)
RTEC	-0.121***	-0.133***	-0.124***	-0.121***	-0.115***	-0.113***	-0.111***	-0.124***	-0.134***	-0.127***
	(0.010)	(0.015)	(0.010)	(0.009)	(0.008)	(0.010)	(0.012)	(0.012)	(0.018)	(0.039)
α_0	-50.56	-504.1**	-446.6***	-397.9***	-457.2***	-381.1**	-377.4**	-415.7**	-419.6	-244.6
	(145.5)	(235.9)	(149.5)	(130.4)	(126.6)	(159.4)	(177.1)	(176.9)	(268.2)	(600.2)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 92 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.

6. Conclusions and policy implications

Environmental degradation requires immediate action. Actions can be grouped into two main categories, namely green innovation and adequate environmental regulations and climate policies necessary to reduce pollution levels.

Most of the existing empirical works have focused on air pollution and the role of environmental regulations, such as standards, taxes or penalties. However, only a few works have addressed the effectiveness of environmental regulations, with mixed findings. A focus on the impact of policy stringency is almost non-existent. In this context, our paper contributes to the literature by assessing the asymmetric and non-linear impact of environmental policy stringency on CO_2 emissions in a set of OECD countries. To this end, we rely on Canay's (2011) panel regression in quantiles.

Our main findings show that environmental policy stringency has led to a decrease in CO_2 emissions in OECD countries. However, as expected, this effect has been asymmetric. Likewise, we show that EPSI has a stronger impact on emissions in countries with lower levels of carbon emissions (that is, at lower quantiles). We also document the importance of energy use and revenue on CO_2 emissions levels. However, our findings invalidate the PHH and show that the impact of the share of renewables in the total electricity consumption has only a marginal negative impact on emissions.

The robustness check we performed for a set of 18 EU countries validated the main findings of the paper. Further, additional tests indicated that EPSI negatively impacts the emissions level only during the implementation of the Kyoto protocol, whereas in the pre-Kyoto period, the environmental regulations were completely inefficient. Moreover, policy stringency measures are more effective in EU countries at higher risk of missing the 20-20-20 target in terms of GHG emissions.

Our findings have different implications for policymakers. First, policy stringency measures should be correlated with emissions levels to become effective. EU countries have succeeded in lowering air pollution levels by imposing higher levels of stringency and clear emission targets. If the risk of missing the target is high, environmental policy stringency should increase. Second, in order to record a negative trend in carbon emissions on a global level, emerging economies should follow the EU model. Energy consumption still represents the main driver of emissions, whereas the use of renewables has only a marginal effect on air pollution levels.

The limitation of this papers resides in the data availability, which did not allow us to investigate the recent period. However, the analysis can be developed by making a comparison between market-based and non-market-based policies or by assessing the effectiveness of specific regulations used for environmental protection.

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Appendix

Table A1. Environmental policies and regulations and CO_2 emissions: a recent comparative literature review

Study	Country/area	Period	Methodology	Results
Ahmed (2020)	20 OECD countries	1999–2015	Panel Auto Regressive. Distributed Lag (PARDL), PMG and Error Correction Models (ECM)	Stringent environmental policies promote green innovation. Stricter policies are subject to negative economic shock in the short run.
Albulescu et al. (2020)	12 EU countries	1990–2017	Static panel data models and dynamic GMM models	Mixed evidence on the role of environmental regulations in influencing the reduction of CO_2 emissions in EU countries
Galeotti et al. (2020)	19 OECD countries	1995–2009	Computing different indicators of environmental policy stringency	Indicators based on pollution abatement give rise to significantly different results than emission-based indicators or composite indexes.
Hashmi and Alam (2019)	29 OECD countries	1999–2014	Stochastic impacts by regression on population, affluence, regulation and technology (STIRPART) framework, GMM models	An increase in environmentally friendly patents and in environmental tax revenue per capita reduces carbon emissions.
Johnstone et al. (2012)	77 countries	2001–2007	Panel data, two-stage models	Positive role of both general innovative capacity and environmental policy stringency on environment-related innovation.
Ouyang et al. (2019)	30 OECD countries	1998–2015	Panel threshold model to explore the non-linear effects of environmental regulations on PM2.5 pollutions	This study has revealed the existence of an inverted U-shaped relationship between environmental regulations and PM2.5 emissions.
Sadik-Zada, and Ferrari (2020)	26 OECD countries	1995–2011	Variational model of environmental degradation, pooled mean group (PMG) estimator	Different thresholds of environmental degradation, strong and robust confirmation of the pollution haven conjecture
Wang et al. (2020a)	25 OECD countries	1990–2015	Panel data, system generalised moments (SYS-GMM)	Environmental policy strictness has a significant effect on CO_2, NO_x, and SO_x emissions, whereas the impact on PM2.5 emissions and PM2.5 exposure is very weak.
Wolde-Rufael and Mulat-Weldemeskel (2021)	Czech Republic, Greece, Hungary, Korea, Poland, South Africa, and Turkey	1994–2015	Panel data, augmented mean group (AMG) estimator	Inverted U-shaped relationship between CO_2 emissions and environmental policy stringency

Table A2. Country sample—OECD statistics

Country	**OECD member**	**EU member***	**Emerging economy**
Australia	X		
Austria	X	X*	
Belgium	X	X*	
Brazil			X
Canada	X		
China			X
Czech Republic	X	X	
Denmark	X	X*	
Finland	X	X	
France	X	X	
Germany	X	X	
Greece	X	X	
Hungary	X	X	
India			X
Indonesia			X
Ireland	X	X*	
Italy	X	X	
Japan	X		
Korea	X		
Netherlands	X	X	
Norway	X		
Poland	X	X	
Portugal	X	X	
Russia			X
Slovak Republic	X	X	
South Africa			X
Spain	X	X	
Sweden	X	X	
Switzerland	X		
Turkey	X		
United Kingdom**	X	X	
United States	X		

Notes: * The EU 20-20-20 GHC emission target at risk of not being achieved, as projected in 2015 (https://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe/ trends-and-projections-in-europe-2016/1-overall-progress-towards-the); ** As of 1 January 2021, the United Kingdom has left the EU.

Table A3. Panel conditional quantile regression—OECD countries sample

Quantiles	Lower			Middle				Upper		
	0.05	*0.15*	*0.25*	*0.35*	*0.45*	*0.55*	*0.65*	*0.75*	*0.85*	*0.95*
EPSI	-0.162**	-0.183***	-0.128***	-0.120***	-0.123***	-0.096***	-0.091***	-0.054	-0.057	0.144
	(0.076)	(0.062)	(0.043)	(0.029)	(0.028)	(0.032)	(0.035)	(0.038)	(0.049)	(0.106)
GDP	5.773	-0.196	-1.931	-1.720	-0.842	-0.792	-0.312	-0.908	-2.037	-6.224
	(3.754)	(3.042)	(2.122)	(1.420)	(1.383)	(1.575)	(1.728)	(1.848)	(2.402)	(5.198)
GDP^2	-0.319*	-0.021	0.066	0.053	0.008	0.006	-0.021	0.009	0.070	0.273
	(0.186)	(0.151)	(0.105)	(0.070)	(0.069)	(0.078)	(0.086)	(0.092)	(0.119)	(0.258)
FDI	0.008	0.002	0.004	0.002	0.001	-0.001	-0.002	-0.004	-0.007	0.006
	(0.009)	(0.007)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.006)	(0.012)
EU	3.374***	3.622***	3.764***	3.846***	3.961***	4.008***	4.113***	4.166***	4.091***	4.305***
	(0.201)	(0.163)	(0.114)	(0.076)	(0.074)	(0.084)	(0.093)	(0.099)	(0.129)	(0.278)
RTEC	-0.104***	-0.113***	-0.113***	-0.111***	-0.108***	-0.106***	-0.103***	-0.102***	-0.099***	-0.096***
	(0.006)	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.008)
α_0	-43.42**	-15.11	-7.486	-8.880	-14.00**	-14.56*	-17.49**	-14.81	-8.869	10.91
	(18.63)	(15.10)	(10.53)	(7.05)	(6.868)	(7.823)	(8.579)	(9.178)	(11.92)	(25.81)

Notes: (i) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (ii) standard error in parentheses; (iii) 611 observations; (iv) EPSI—environmental policy stringency index, GDP—GDP per capita, GDP^2—squared GDP per capita, FDI—net FDI inflows, EU—energy use, RTEC—renewable to total electricity consumption.