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Managing Environmental Policy Stringency to Ensure Sustainable Development in OECD Countries

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Abstract: In response to climate change that threatens both economic and social sustainable development, governments adopt strict environmental policy measures to reduce greenhouse gas emissions and encourage the use of energy from renewable sources. The main purpose of this study is to investigate to what extent the strictness of environmental policy can influence the level of greenhouse gas emissions and the consumption of renewable energy in selected Organisation for Economic Co-operation and Development (OECD) countries. The Fully Modified Ordinary Least Squares (FMOLS) method and Granger causality test were employed in order to investigate the long-run relationship between the main components of the environmental policy stringency index and the evolution of greenhouse gas emissions and renewable energy consumption. The results indicate significant influences of the Market-based instruments sub-index and the Technology Support policies sub-index on greenhouse gas emissions reduction, while the Non-Market Based instruments index, which includes policies that impose emission limits and standards, does not exert any significant influence in this regard. Regarding the impact on renewable energy consumption, the results of this study indicate significant positive influences from the perspective of the three sub-indices used in the analysis. These results should send a signal to decision-makers on the effectiveness of policies that impose emission limits and standards, in the sense that their improvement will generate significant influences in mitigating climate change risks.

Keywords: environmental policy stringency; greenhouse gas emissions; renewable energy consumption; market-based instruments; technology support policies

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1. Introduction

Climate change is a reality that cannot be denied, no matter in which country we live. There are several solutions that can be implemented in order to mitigate climate change [1,2]: using renewable energy sources; reducing emissions in the industry sector by investing in less polluting technologies that also need less energy; promoting a more sustainable form of agriculture and food consumption with less food waste; reducing deforestation and the damage brought to the environment; using green transportation and public transport; stimulating the development of sustainable buildings and cities; investments in research and development made by public authorities or by encouraging private organizations in their actions; stricter regulations against activities that generate emissions and thus pollution; green taxation; educational campaigns on climate change. Environmental policy stringency encompasses solutions referring to regulation, green taxation, and incentives for technological development. The aim of our research is to identify the impact of environmental policy stringency on the level of greenhouse gas emissions (GHGs) and renewable energy consumption (REN). Environmental policy stringency refers to the degree to which environmental regulations and standards are enforced and the level of compliance required. When environmental policies are more stringent, they often include measures to reduce GHG emissions, such as setting emission reduction targets, implementing carbon pricing mechanisms, promoting renewable energy, and encouraging energy efficiency [3]. These policies create incentives for industries and individuals to adopt cleaner technologies and practices, reducing their emissions. In order to achieve sustainable economic development, changes at various levels should be implemented. In addition, the changes that can be made by all of us individually, governments have the responsibility to establish and implement environmental policies meant to protect the environment for both present and future generations.

According to the OECD [3], the "Environmental Policy Stringency Index (EPS)" is a country-specific and internationally comparable measure of the stringency of environmental policy. Stringency is defined as "the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour". The importance of the index is revealed by its three main factors that can each have a different impact on individuals' and organizations' behaviours regarding the environment: market-based policies targeting taxation of damaging behaviours; non-market-based policies focused on standards regarding green behaviours; and technology support meant to stimulate innovation and technological progress towards a more sustainable way of doing things. OECD [2] considers that by applying five environmental policies ("invest, regulate, tax and subsidize, lead by example, inform and educate") in five economic sectors ("industry, electricity, agriculture, transport, buildings"), the GHGs would be reduced by 90%. The OECD [4] highlights that most households want to make efforts to reduce their negative impact on the environment, but the public expenses for low-carbon innovations remained at the same level (as a share in the gross domestic product—around 0.04%), and this should change, especially if we consider the policy of leading by example [2].

There are many authors who have studied the importance of EPS for the OECD countries; the index also offers the possibility to compare the countries regarding the environmental efficiency of the policies implemented at the national level [5–7]. Martinez-Zarzoso et al. [6] found that the stringency of environmental policies leads to a higher number of patents, increased research and development activity, and, in general, "cleaner production." Taha et al. [7] studied the role played by environmental policy stringency in the evolution of the gross domestic product (GDP) and reached the conclusion that there is a direct and positive correlation between these two variables.

For our research, we chose to analyse the relationship between the independent variable represented by EPS sub-indexes and two dependent variables with important significance for the way things will evolve regarding climate change in OECD countries, namely GHG and REN. Environmental policies aim to decrease the level of GHGs, which pollute the air, water, and land and affect the health of both people and the planet, and thus mitigate climate change. The same policies can also influence the consumption behaviour of citizens and businesses when they choose renewable energy sources instead of those that pollute more. Both the reduction of GHGs and the rise of REN can have a tremendous impact on having a cleaner planet now and in the future.

The novelty of this study consists, first of all, in the use of an updated version of the environmental policy stringency index, launched in 2022. Secondly, it is the first study that analyses the impact of environmental policy stringency both from the point of view of market and non-market-based policies, as well as from the point of view of the technology support policies component of EPS, which includes policies that support clean technological innovation. Thirdly, a novelty element is represented by the combined analysis of the environmental policy stringency impact on greenhouse gas emissions and renewable energy consumption. Fourthly, a new element is the sample chosen for this study, which includes 20 OECD member countries that are also members of the European Union.

Therefore, the aim of this study is to examine the relationship between the main components of EPS and greenhouse gas emissions and renewable energy consumption for 20 OECD countries over the 1990–2020 period.

2. Literature Review

Wolde-Rufael et al. [8] conducted research on the role of EPS in BRIICTS countries, highlighting that in the long run, the effect is positive, contributing to a reduction of GHGs such as carbon dioxide (CO_2). They emphasise that EPS and the encouragement of REN are both measures needed to reduce the level of "environmental degradation" [8] (p. 568). Yirong [9] also analysed the impact of EPS on CO_2 emissions in the countries with the highest levels of such emissions in the world (China, USA, India, Russia, and Japan). They conclude that the effects, both positive and negative, are seen in the long run, and there is a need for "the highly polluted economies . . . to revisit green environmental regulation policies" [9].

Albulescu et al. [10] reached the same conclusion about the "asymmetric effect" (p. 27311) of EPS on CO2 emissions in OECD countries as Yirong [9] with his analysis of the most pollutant countries. This effect refers to the fact that the impact is more evident and significant in countries where the level of GHGs is lower than in the countries with the highest level of pollution. These findings are important, pointing out the need to reconsider environmental policies and regulations in such a way that brings the most benefits to the environment and the people in those countries.

Chen et al. [5] analyse the impact of both the EPS and environmental laws on environmental performance, focusing on various emissions that pollute the air. Even if it was limited only to China, this study revealed a direct correlation between the stringency of environmental policies and green taxation and the reduction of pollution. Both taxation and regulations targeting the environment can change behaviours and orient them towards greener ones that are friendlier to the environment.

The OECD [11] established the EPS indicator with the aim of comparing data regarding the level of stringency (from 0 to 6) in OECD countries, thus making it possible to analyse the correlation between environmental policies and the results in terms of GHGs and the level of environmental degradation. There are two types of policies [11] (p. 4): "sticky" ones that are also considered to have a higher level of stringency (based on the taxation of pollution) and "carrot" ones focused on stimulating green behaviours like REN, which are perceived as stringent if the subsidies are high.

Akbulut [12] studied the effectiveness of market-based environmental policies and concluded that, in order to reduce emissions, stringency should be increased. In addition, the market-based tools, the EPS index also includes non-market-based instruments, which focus more on stimulating the use of renewable energy. There are many studies comparing the two types of environmental policies in terms of their efficiency in reducing environmental degradation and mitigating climate change [13,14].

According to Jiang et al. [13], a mix of market and non-market-based environmental policies is more efficient, determining companies to innovate in a sustainable way. The authors concluded that the former is more efficient in the long run, while the latter generates effects in the short term. When used independently, the non-market tools are "negatively related" to the sustainable innovation of companies.

Zhang et al. [15] (p. 1113) show that EPS leads to "green innovation in renewable energy technology." The study revealed differences between the various types of energy. The innovation was seen "for geothermal energy, hydro energy, and marine energy, but not for wind energy and solar energy" [15] (p. 1113). Prokop et al. [16] analysed the impact of market-based EPS on the quality of life and found a positive correlation between these two variables. The authors also show that "green innovation does not require as much strictness . . . in the area of market-based regulations."

Stavins and Whitehead [17] emphasize that market-based instruments in environmental policies are more efficient in terms of costs and generated benefits compared to the traditional measures in which specific standards were imposed for everyone without taking into account the implications for the organizations in a country. Market-based measures such as taxation make companies more responsible and, in the long term, more willing to change the way they perform business, investing in less polluting equipment in order to reduce costs.

Akbulut and Burçin Yereli [18] analyse the impact of foreign direct investments (FDI) on the level of GHGs, considering the stringency of environmental policies and their market- and non-market-based instruments. Thus, after a certain level of stringency, FDI leads to a decrease in emissions, but in countries where the regulations are not so stringent, GHGs increase. Thus, environmental policies should also be considered as a tool to direct investments in specific sectors.

Güneş et al. [19] state that business regulations impact economic growth in the short term, but this correlation was not seen for the influence of EPS. The authors also found out that there are differences between countries regarding the impact of EPS on economic growth: in countries like Russia, South Africa, and Brazil, economic growth was negatively affected, whereas in developed economies, the relationship was positive. Such findings are useful for adjusting environmental policies to the specifics of each country and adding stimulating measures to support businesses interested in adopting greener behaviours.

Dechezleprêtre and Sato [20] researched the impact of environmental regulations on the competitiveness of companies, showing that these regulations meant to protect the environment lead to "innovation in clean technologies," but the costs implied by compliance with the regulations are still high compared to the benefits. These should be taken into account when the government establishes the stringency of their environmental policies in order to not compromise the competitiveness of the market.

According to Morales-Lage et al. [6], the stringency of environmental policies positively influences the expenses for research and development and generates a higher number of patents. This is also explained by market-based measures because companies are discouraged by green taxation and seek solutions for reducing the fiscal burden.

If there are many studies [8–11] on the impact of EPS on the level of GHGs, the correlation between EPS and REN is not well covered. Wolde-Rufael et al. [8] analysed the correlation only for the 7 BRIICTS countries, with data covering the period from 1993 to 2014. Climate change and the negative effects generated by pollution on our health are significant reasons to extend research on the most efficient environmental policies. The stringency of environmental policies influences the level of GHGs that are so damaging for humans and the planet, and the REN can be a consequence of EPS but also a factor that in itself can contribute to lowering harmful emissions.

3. Materials and Methods

3.1. Data and Variables

In order to analyse the impact of environmental policy stringency on sustainable development, we used the three component sub-indices of the environmental policy stringency index (EPSI), calculated according to the methodology proposed by the OECD [21]. EPSI was determined for the first time by Botta and Koźluk in 2014 [22]. This involves selecting policies and assigning a score to each policy based on its level of stringency, using a scale ranging from zero to six. The scores are then aggregated to form the index. The three component sub-indices of the EPSI are Market based instruments (MBI), which include policies that put a price on pollution; Non-Market-based instruments (NMBI), which include policies that impose emission limits and standards; and Technology Support policies (TSP), which include policies that support clean technological innovation. As can be seen from

Figure 1, each sub-index contributes equally to the establishment of the environmental policy stringency index.

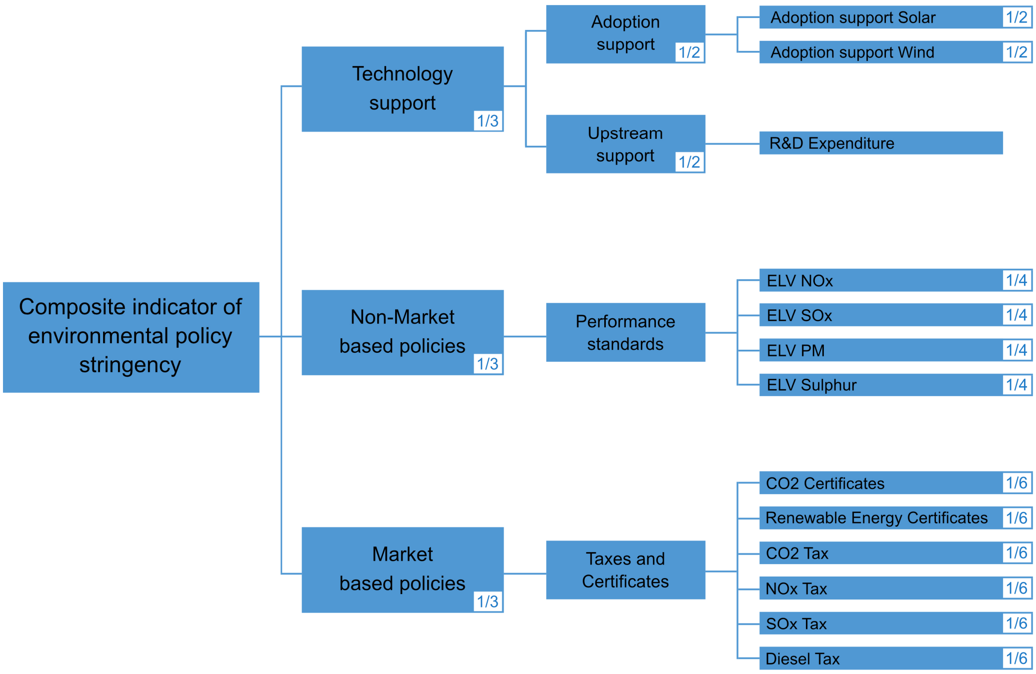

Figure 1. Environmental policy stringency index structure.

For the indicators regarding sustainable development, we used greenhouse gas emissions (GHG) and renewable energy consumption (REN). Greenhouse gas emissions strengthen the greenhouse effect, contributing to climate change risks [23]. Fossil fuel use, deforestation, and some agricultural and industrial practises increase greenhouse gases, notably carbon dioxide and methane [24]. Part of the heat radiated by the Earth is absorbed by greenhouse gases, which trap more heat in the Earth's lower atmosphere, causing global warming. Renewable energy consumption is the share of renewable energy in total final energy consumption. Renewables include the primary energy equivalent of hydroelectric (excluding pumped storage), geothermal, solar, wind, tide, and wave sources. Energy derived from solid biofuels, biogasoline, biodiesel, other liquid biofuels, biogases, and the renewable fraction of municipal waste is also included. Biofuels are defined as fuels derived directly or indirectly from biomass (material obtained from living or recently living organisms). This includes wood, vegetal waste (including wood waste and crops used for energy production), ethanol, animal materials/wastes and sulphite lye. Municipal waste comprises wastes produced by the residential, commercial, and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power [25].

The statistical data for all the indicators used in this study were selected from the OECD and World Bank databases for the period 1990–2020. The 20 EU and OECD member states for which the analysis will be carried out are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden. Table 1 shows the variables used in the analysis.

Table 1. Data and variables used in this study.

Indicator	Acronym	Variable Type	Unit of Measure	Data Souce
Market based instruments	MBI	Independent variable	Index	OECD [26]
Non-Market Based instruments	NMBI	Independent variable	Index	OECD [26]
Technology Support policies	TSP	Independent variable	Index	OECD [26]
Greenhouse gas emissions	GHG	Dependent variable	Tonnes of CO_2 equivalent, Thousands	OECD [27]
Renewable energy consumption	REN	Dependent variable	% of total final energy consumption	World Bank [28]

3.2. Model Specification

Starting from the Porter Hypothesis [29], Ambec et al. [30] developed a schematic representation, extending it to the presumption that a higher environmental policy stringency may lead to environmental performance through innovation growth (Figure 2).

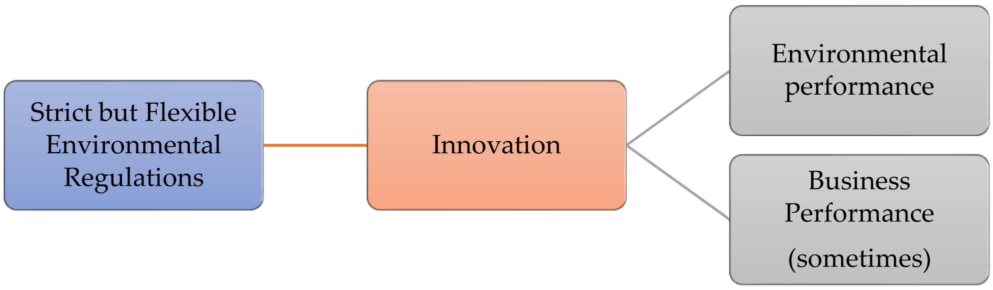

Figure 2. Schematic representation of the Porter Hypothesis [29].

In order to investigate the modified Porter Hypothesis proposed by Ambec et al. [30], we employed the Fully Modified Ordinary Least Squares (FMOLS) method that achieves asymptotic efficiency by modifying the least squares to account for serial correlation effects and tests for the endogeneity in the regressors that results from the existence of cointegrating relationships [31,32]. In order to proceed with the estimation of the long-run parameters, there must be two main conditions: the condition of the stationarity of the data at level or at first difference, and the condition of the existence of a cointegration relation between the variables in the model [33]. To establish the stationarity, three tests were used in this study: Im, Pesaran, and Shin (IPS) and the Fisher-Augmented Dickey–Fuller (Fisher—ADF) and PP tests Fisher Phillips-Perron (Fisher—PP). These tests are all characterised by the combining of individual unit root tests to derive a panel-specific result. Engle and Granger [34] state that when all the variables in the model are stationary at level I(0) or at the first difference I(1), this permits the use of the cointegration technique. To test for cointegration, this study applies the panel cointegration test proposed by Kao [35]. The Kao test follows the same basic approach as the Pedroni tests but specifies cross-section-specific intercepts and homogeneous coefficients on the first-stage regressors. According to Shahbaz [32], two variables are cointegrated if there is a long-term relationship between them. The equation model for the pooled panel proposed by Pedroni [36] performs standard FMOLS on the pooled sample after removing the deterministic components from both the dependent variable and the regressors [37].

In order to investigate the impact of the environmental policy stringency index on sustainable development from the perspective of environmental conservation, we will propose two models for analysis:

$$\text{Model 1: } lnGHG_{\mathrm{it}} = \alpha_{\mathrm{i}} + \beta_1\, MBP_{it} + \beta_2\, NMBP_{\mathrm{it}} + \beta_3\, TSP_{\mathrm{it}} + \varepsilon_{\mathrm{t}} \quad (1)$$

$$\text{Model 2: } REN_{\mathrm{it}} = \alpha_{\mathrm{i}} + \beta_1\, MBP_{\mathrm{it}} + \beta_2\, NMBP_{\mathrm{it}} + \beta_3\, TSP_{\mathrm{it}} + \varepsilon_{\mathrm{t}} \quad (2)$$

where *lnGHG* represents the natural logarithm of total greenhouse gas emissions, *REN* is the share of renewable energy consumption in total energy consumption, *MBP* is the market-based policies sub-index, *NMBP* is the non-market-based policies sub-index, *TSP* represents the Technology Support Policies sub-index, i is the country, t is time, β is the coefficient associated with the variables, and ε is the error term.

4. Results

For the analysis to be conducted, we formed two-panel data sets, each containing a total of 620 observations from four variables in 20 countries over a 21-year period (between 1990 and 2020). As the results in Table 2 show, none of the variables in the model have a normal distribution due to the values of skewness and kurtosis, and subsequent *p*-values reject the null hypothesis of the Jarque–Bera normality test.

Table 2. Descriptive statistics of the variables for OECD countries.

	lnGHG	*REN*	*MBP*	*NMBP*	*TSP*
Mean	11.564	14.426	1.267	3.621	1.742
Median	11.300	10.825	1.000	4.750	1.500
Maximum	14.039	58.400	4.170	6.000	6.000
Minimum	9.058	0.940	0.000	0.000	0.000
Std. Dev.	1.160	11.413	0.789	1.869	1.275
Skewness	0.052	1.144	1.584	−0.501	0.758
Kurtosis	2.444	3.838	5.522	1.783	3.223
Jarque-Bera	8.252	153.493	423.937	64.247	60.681
Probability	0.016	0.000	0.000	0.000	0.000
Sum	7170.236	8944.470	785.800	2245.250	1080.250
Sum Sq. Dev.	833.655	80,629.600	385.355	2164.054	1007.401
Observations	620	620	620	620	620

Note: *lnGHG* is the natural logarithm of Greenhouse gas emissions; *REN* is renewable energy consumption; *MBP* represents the Market-based instruments sub-index; *NMBP* represents the Non-Market-based instruments sub-index; and *TSP* is the Technology Support policies sub-index.

Before proceeding to test the stationarity of the data series, it is necessary to highlight to what extent there is autocorrelation or not between the variables used in the analysis. In this sense, we used a correlation matrix (Table 3). Each cell contains information about the correlation coefficient between two variables: t-statistic and probability. Even if the FMOLS method allows for serial correlation in the data, as well as the existence of endogeneity and cross-sectional heterogeneity, a correlation matrix is used to summarise data, as input into a more advanced analysis, and as a diagnostic for advanced analyses.

Table 3. Correlation matrix for the variables in the models.

	lnGHG	*REN*	*MBP*	*NMBP*	*TSP*
lnGHG	1.000000				
	-				
	-				
REN	−0.281818	1.000000			
	−7.301846	-			
	0.0000	-			
MBP	0.053823	0.539443	1.000000		
	1.339960	15.92633	-		
	0.1808	0.0000	-		
NMBP	0.014350	0.315981	0.420677	1.000000	
	0.356783	8.279342	11.52751	-	
	0.7214	0.0000	0.0000	-	
TSP	0.009281	0.277250	0.271594	0.583862	1.000000
	0.230744	7.173551	7.015419	17.87836	-
	0.8176	0.0000	0.0000	0.0000	-

Note: *lnGHG* is the natural logarithm of Greenhouse gas emissions, *REN* is the renewable energy consumption, *MBP* represents the Market-based instruments sub-index, *NMBP* represents the Non-Market-based instruments sub-index, and *TSP* is the Technology Support policies sub-index.

Analysing the results of the correlation matrix, it can be seen that there is no autocorrelation between the variables included in the two analysis models because the correlation coefficient between two different variables is less than 1. Therefore, we can state the existence of a significant positive correlation between *MBP*, *NMBP*, the *TSP* sub-index, and *REN*.

As mentioned in the methodology section, three tests were applied to investigate the stationarity of the variables in the models. Each variable was tested at level and at the first difference. The results of these panel unit root tests are reported in Table 4. The null hypothesis for all the tests is that there is a unit root in the data. According to the results, the *p*-value allows us to confirm non-stationarity at level but reject the null hypothesis at first difference. Thus, we cannot use traditional estimation methods like OLS, taking into account that all the variables are stationary at first difference I(1).

Table 4. Results for IPS, ADF-Fisher, and PP-Fisher unit root tests.

	IPS		**ADF-Fisher**		**PP-Fisher**	
	Level	First difference	Level	First difference	Level	First difference
lnGHG	6.081	−7.818 ***	16.530	143.734 ***	21.716	303.845 ***
REN	11.776	−7.337 ***	2.321	140.273 ***	2.616	305.869 ***
MBP	2.281	−16.884 ***	33.139	314.076 ***	70.267	571.539 ***
NMBP	2.488	−11.536 ***	13.803	195.500 ***	17.082	375.574 ***
TSP	1.030	−10.843 ***	27.376	186.309 ***	24.877	341.152 ***

Note: *lnGHG* is the natural logarithm of Greenhouse gas emissions, *REN* is the renewable energy consumption, *MBP* represents the Market-based instruments sub-index, *NMBP* represents the Non-Market-based instruments sub-index, *TSP* is the Technology Support policies sub-index, IPS is the Im, Pesaran, and Shin unit root test, ADF-Fisher is the Fisher-Augmented Dickey–Fuller test, and PP-Fisher is the Fisher Phillips–Perron test. *** represents the 1% confidence level.

The Kao cointegration test is the statistical test used to determine whether a set of variables is cointegrated or not. Cointegration refers to the long-term equilibrium relationship between variables that are non-stationary at level but stationary at first difference. The Kao test is an extension of the Engle–Granger two-step cointegration test. It is based on the augmented Dickey–Fuller (ADF) test, which tests for the presence of a unit root in individual time series variables. The Kao test incorporates the ADF test results to assess the cointegration relationship among multiple variables. By conducting the Kao cointegration test, one can determine whether there is a stable, long-term relationship between the variables being analysed. The results of the Kao test for the two proposed models are stated in Table 5.

Table 5. Kao Residual Cointegration Test.

	Model 1		**Model 2**	
ADF	t-Statistic −1.536090	Probability 0.0409	t-Statistic 0.001419	Probability 0.0383
Residual variance	0.002840		2.009713	
HAC variance	0.003345		2.598119	

Comparing the calculated test statistic with the critical values of the Kao test, we can reject the null hypothesis of no cointegration at a significance level of 5%. This suggests that there is evidence of cointegration among the variables in both proposed models.

Taking into account that at least one cointegration relationship is found between the variables in the models according to the results of the cointegration test, the FMOLS method is employed to examine the elasticity of greenhouse gas emissions and renewable energy consumption to environmental policy regulations and to determine the long-term cointegration coefficients (Table 6).

Table 6. Panel FMOLS estimation for the variables in OECD countries.

	Model 1 *lnGHG*				**Model 2** *REN*			
	Coefficient	**Std. Error**	**t-Statistic**	***p*-Value**	**Coefficient**	**Std. Error**	**t-Statistic**	***p*-Value**
MBP	−0.087348	0.017117	−5.102905	0.0000	3.897765	0.557084	6.996724	0.0000
NMBP	−0.008002	0.005754	−1.390687	0.1649	0.980671	0.187274	5.236560	0.0000
TSP	−0.024405	0.008393	−2.907755	0.0038	1.066829	0.273155	3.905576	0.0001

Note: *lnGHG* is the natural logarithm of Greenhouse gas emissions, *REN* is the renewable energy consumption, *MBP* represents the Market-based instruments sub-index, *NMBP* represents the Non-Market-based instruments sub-index, and TSP is the Technology Support policies sub-index.

According to the results for the first model, it can be observed that the environmental policy stringency index has a significant impact on greenhouse gas emission reduction, but only by means of marked-based policies and technology-support policies taking into account the significance interval of 5%. Non-market-based policies such as emission limit values for nitrogen oxides, sulphur oxides, or particulate matter or limits like sulphur content limits for diesel do not have a significant impact on greenhouse gas emissions in the 20 selected OECD countries.

Regarding the second model, environmental policy stringency seems to be more efficient, taking into account that all the sub-indexes have a significant impact on growing the share of renewable energy consumption in total energy consumption. Also, the coefficients associated with the independent variables indicate a higher impact of environmental regulations in the second model.

Moreover, the Granger Pairwise causality test is used to establish the direction of causality between the variables in the models. This test is based on the idea that if variable X "Granger causes" variable Y, then past values of X should provide significant information in predicting future values of Y beyond what can already be predicted by past values of Y alone. The test results provide a *p*-value, which is used to determine the statistical significance of the relationship. If the *p*-value is less than 0.05, it suggests that there is evidence of causality between the variables. Figure 3 represents the causal relationships between the variables.

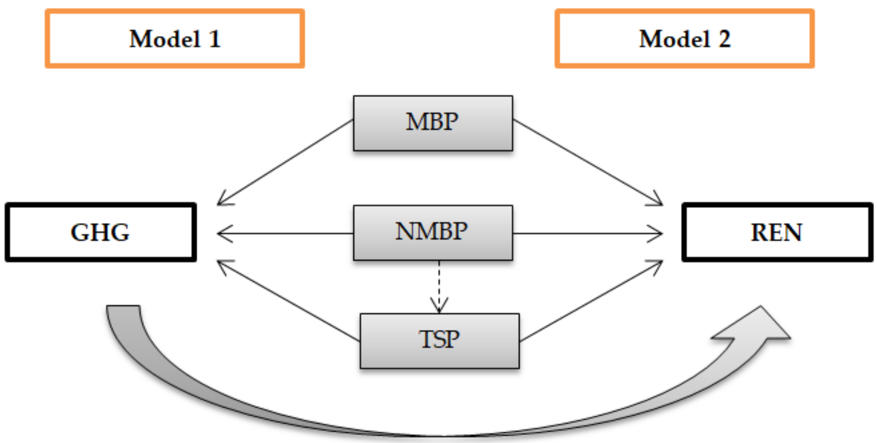

Figure 3. Summary of the Granger causality relationships in OECD countries.

However, it is important to note that Granger causality does not imply a causal relationship in the traditional sense. It only suggests that there is a predictive relationship between the variables. Other factors or variables that are not included in the analysis may also be influencing the relationship.

The influences already recorded through the FMOLS results are also confirmed by the direction of causality between environmental policy stringency sub-indexes and greenhouse gas emissions and renewable energy consumption. In addition to the causality relationships identified within each proposed model, a causality direction from greenhouse gas emissions to renewable energy consumption was identified.

5. Discussions

The results obtained in the present study, taking into account the fact that greenhouse gas emissions also have a significant impact on renewable energy consumption, must signal some important aspects with direct practical implications for decision-makers. First of all, high greenhouse gas emissions from fossil fuels can drive the need for a transition to renewable energy sources. The urgency to reduce emissions can incentivize governments, industries, and individuals to invest in and consume more renewable energy. Second, greenhouse gas emissions can lead to the implementation of policies and regulations that support the growth of renewable energy. Governments may introduce incentives such as tax credits, feed-in tariffs, or renewable portfolio standards to encourage increased consumption of renewable energy. Third, as awareness of the environmental impacts of greenhouse gas emissions grows, there is an increasing demand for renewable energy. This demand can drive the consumption of renewable energy sources as individuals, businesses, and organisations seek to reduce their carbon footprint. Fourth, the need to reduce greenhouse gas emissions can spur innovation and technological advancements in renewable energy technologies. As a result, the cost of renewable energy generation decreases, making it more competitive and attractive for consumption. Moreover, in order to reduce greenhouse gas emissions, there is a need for significant investment in renewable energy infrastructure. Increased consumption of renewable energy can drive investments in the development and expansion of renewable energy generation, transmission, and distribution systems. Overall, greenhouse gas emissions can influence renewable energy consumption by creating a sense of urgency, driving policy support, increasing market demand, promoting technological advancements, and encouraging infrastructure investment in renewable energy sources.

According to a study by the International Energy Agency (IEA) [38], stricter environmental policies implemented by various countries led to a decline in energy-related CO_2 emissions in 2019. The global emissions reduced by 2.9% compared to the previous year. The European Union (EU) has been implementing stricter environmental policies, and as a result, its GHG emissions decreased by 23% between 1990 and 2018, while the economy grew by 61% [39]. Another study found that stricter environmental policies in China led to a decline in the growth rate of CO_2 emissions from the power sector by 65% between 2016 and 2018 [40].

The Renewable Energy Policy Network for the 21st Century (REN21) reported that in 2019, renewable energy accounted for around 72% of global net additions to power capacity. This indicates the increasing importance of renewable energy in the global energy mix [41]. According to the International Renewable Energy Agency (IRENA), renewable energy accounted for 26.2% of global electricity generation in 2018. This demonstrates the growing contribution of renewable sources to the global energy supply [42]. The European Union has been actively promoting renewable energy through policies such as the Renewable Energy Directive. Since the introduction of the Renewable Energy Directive (2009/28/EC), the share of renewable energy sources in EU energy consumption has increased from 12.5% in 2010 to 21.8% in 2021. Sweden had the highest share of renewables in its consumption (62.6%), ahead of Finland (43.1%) and Latvia (42.1%), as reported to Eurostat [43].

The results obtained in this study for the 20 OECD countries are consistent with several studies that found a positive relationship between environmental policy stringency and sustainable development [5,8–10,17,18]. Unlike these studies that revealed the positive impact of the EPS index on the quality of the environment expressed in general by the level of CO_2 emissions, the results of our study indicate that in the long term, not all EPS components have a significant influence on the reduction of greenhouse gas emissions, as is the case with non-market-based policies.

In fact, the existing studies that analysed the impact of EPS components on greenhouse gas emissions [13,14] used only two components (market-based policies and non-market-based policies) without referring to the third component newly introduced, namely technology support policies (TSP), which proved to be much more effective in improving the quality of the environment than the NMBP component, as our results show.

Also, the results of this study resonate with previous studies on the link between EPS and the consumption of renewable energy [15], demonstrating the effectiveness of the demanding regulations of environmental policy on the increase in the consumption of renewable energy.

Some policy implications can be highlighted following the results of the analysis undertaken regarding the environmental policy stringency impact on greenhouse gas emissions and renewable energy consumption. First of all, stringent environmental policies help protect natural resources, ecosystems, and biodiversity. Governments can set limits on pollution, promote sustainable resource use, and encourage the adoption of cleaner technologies and practices. Second, environmental policy stringency can contribute to sustainable development by balancing environmental, economic, and social objectives. It can foster green innovation, promote the transition to a low-carbon economy, and support the development of sustainable industries and jobs. Third, stringent environmental policies require effective compliance and enforcement mechanisms. Policymakers need to ensure that regulations are properly implemented and enforced to achieve the desired environmental outcomes. This may involve monitoring, inspections, penalties, and incentives for compliance. Fourth, environmental policy stringency often requires international cooperation and coordination. Policymakers need to collaborate with other countries to address trans-boundary environmental issues such as climate change, biodiversity loss, and pollution. International agreements and frameworks can help guide and support these efforts. Another policy implication refers to stakeholder engagement. Developing and implementing stringent environmental policies requires engaging stakeholders, including businesses, communities, NGOs, and experts. Policymakers should seek input, build consensus, and address concerns to ensure the effectiveness and legitimacy of their policies. Also, stringent environmental policies should be integrated into broader policy frameworks, such as energy, transportation, agriculture, and urban planning. This can help align different policy goals and avoid trade-offs between environmental protection and other societal needs.

As a limitation of this study, it is important to note that while environmental policy stringency is an important factor, other factors such as economic structure, energy mix, and population density also influence GHG emissions and renewable energy consumption. Therefore, the introduction to the analysis of other indicators for measuring environmental policy stringency will be taken into account in future studies.

6. Conclusions

The obtained results indicated that stricter environmental policies, like market-based policies and technology-supported policies, tend to lead to lower GHG emissions. Therefore, policies such as CO_2 Trading Schemes, Renewable Energy Trading Schemes, and taxes on CO_2, Nitrogen Oxides, Sulphur Oxides, or Fuel Tax (diesel) have proven to be effective in reducing GHG but also in increasing energy consumption from renewable sources. Non-market-based policies such as emission limit values for nitrogen oxides, sulphur oxides, or particulate matter, or limits like sulphur content limits for diesel, are found to be effective in the long term only in improving renewable energy consumption and not in reducing greenhouse gas emissions. Regarding the third component of the EPS, technology support policies that support innovation in clean technologies and their adoption and include policies to support public research and development expenditure and renewable energy support for Solar and Wind have proven to be effective both in reducing greenhouse gas emissions and especially in promoting the consumption of renewable energy.

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