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International ranking of climate change action: An analysis using the indicators from the Climate Change Performance Index

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Abstract

It is hard to argue against the reality of global warming, its consequences are becoming increasingly evident not only due to the effects of extreme weather that are changing the terrain of our planet, but also due to the impact on human health. Most countries are undergoing a process of change to ensure the appropriate use of their resources, striving for excellence in their efforts to reduce greenhouse gas emissions. Using information from the 2021 Climate Change Performance Index, the empirical analysis carried out in this study is aimed at examining the profiles of countries' performance in tackling climate change and confirming the connection between actions and achievements. To do so, cluster analysis and contingency tables are employed. The results show that concern about the need to curb climate change does not depend on countries' wealth, and no common pattern is observed in geographically proximate areas. Furthermore, the study yields statistical evidence of the connection between climate change policies, the use of renewable energy in electricity supply and the reduction of harmful gas emissions.

Highlights

Environmental concern is not driven by matters of wealth or geography

Causality exists between *GHG Emissions* and *Energy Use* and *Renewable Energy*

The effectiveness of climate policies facilitates the use of Renewable Energies

Cluster analysis identified six homogeneous groups of countries

Keywords: Climate Change Performance Index; Cluster; Contingency Tables; Renewable Energy; Climate Change Policies; GHG Emissions.

Word Count:6197 without references

List of abbreviations

CCPI: Climate Change Performance Index

CT: Contingency Table

EU: European Union
FDI: Foreign Direct Investment
GDP: Gross Domestic Product
GHG: Greenhouse Gas
RE: Renewable Energy

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1. Introduction

Climate change and the resulting environmental degradation is having a major impact on the planet. Intense heat waves followed by heavy storms are bringing about not only remarkable transformations in the ecosystem, but also significant economic losses, underscoring the magnitude of the challenge facing humanity [1]. There is a need to modify consumption habits and production methods to break the existing nexus between economic growth and global warming caused by greenhouse gas (GHG) emissions. Recent studies have shown that proper management of GHG emissions could boost the performance of the productive sectors and improve people's quality of life [2,3,4].

Under the United Nations Framework Convention on Climate Change, the primary objective of the related international agreements signed to date is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (Kyoto Protocol, Copenhagen Accord, Paris Agreement). According to the United Nations, while there are more than 7.7 billion people living on Earth in 2020, this figure is expected to reach 9.7 billion by 2050; further protocols must therefore be introduced to prevent human activity from accelerating environmental pollution and resource depletion. Countries have accepted the need to reduce their levels of CO_2 emissions in order to ensure sustainable development for the population [5]. Thus, the European Union (EU) aims to be climate neutral by 2050, encouraging the efficient use of resources while restoring biodiversity and reducing pollution [6]. The level of involvement of European nations will be a turning point in their economies, with a push for renewable energies (REs) and a shift away from fossil fuels.

The literature points to REs and energy efficiency as the main tools for curbing climate change and achieving the goals set at the various summits held [7,8,9]. The complexity of the approach taken lies in the need to change current energy systems through a shift to renewables, thereby ensuring energy security as well as improvements in quality of life and health [10]. However, renewables' deployment is not sufficient to prevent even an increase in emissions, and although it is connected to climate policies, it does not comprise in any way the entirety of climate policies.

This transition process requires active policies whereby government leaders allocate funds to investment projects aimed at mitigating the causes of global warming, while supporting and providing incentives for the deployment of renewable technologies [11]. The process of change calls for the private sector and public institutions to work together to pinpoint problems, set goals and identify possible synergies between sectors [12].

In a context where globalisation is further accelerating global economic development, necessitating a shift towards REs that reduce GHG emissions, there is an incontrovertible need to adopt policies aimed at mitigating the causes and effects of climate change. This research has been carried out with the aim of providing decision-makers with more accurate information on the existing climate change paradigm and the scope of the policies adopted. The empirical analysis proposed seeks to provide a comprehensive understanding of 57 countries around the world that are responsible for 90% of GHG emissions. To that end, two objectives are established: (1) to identify homogeneous groups of countries based around the central pillars of the paradigm of analysis (GHG emissions, Renewable Energy, Energy Use and Climate Change) using the results of the 2021 Climate Change Performance Index (CCPI) and applying clustering techniques; (2) to study, by means of contingency tables, the effect of climate change policies on energy strategies, and how they in turn can influence the reduction of GHG emissions. The results of the empirical analysis are aimed at resolving two question research that will provide further insight into both the environment of countries and the scope of policies adopted to date, in order to determinate where the next efforts should be directed.

QR 1. Does geographical and economic proximity between countries gives rise to homogeneous patterns in climate change performance?

QR 2. Are Climate change policies responsible for countries' commitment to the deployment of renewable and efficient energy supplies, thereby ensuring reductions in GHG emissions?

The international importance of climate change has led to the development of a powerful scientific paradigm, providing solutions aimed at alleviating its consequences. The literature reflects the progress made on key aspects such as environmental policy analysis, the shift towards the deployment and efficient functioning of REs, and even the adaptation of energy systems in certain economic sectors [13,14,15,16]. The novel aspects of this research will help to more accurately guide the lines of action undertaken by leaders. Specifically, the study (1) identifies homogeneous groups of countries determined in relation to the essential pillars of climate change performance, facilitating the adoption of specific policies for each territory; (2) provides statistical evidence of the interaction between CCPI indicators; and (3) is based on recent data meaning it can help guide future developments and the findings can be extrapolated to other countries with similar characteristics.

The rest of the article is structured in the following sections. Section 2 provides a review of the literature aimed at assessing the progress made on climate change. Section 3 describes the method and the sample used in the empirical analysis. Section 4 presents the results obtained, which allow us to resolve the hypotheses proposed. Section 5 summarises the main findings of the paper.

2. Literature review

Between the 1992 United Nations Framework Convention on Climate Change, initially signed by 166 countries, and the 2019 Climate Action Summit, a total of 12 international conventions on climate change have been held. At each one, agreements and commitments have been signed recognising the need to achieve stable economic growth by reducing GHG emissions and ensuring environmentally sustainable progress, with the use of REs must play a significant role. The social development of humanity requires us to take a stand against global warming and make the shift towards clean production and energy efficiency [17,18].

GHG emissions generated by human activities are continuously and exponentially altering the energy balance of the planet. Together with land use modifications, they are accelerating global warming and contributing to a worrying increase in CO2. We have witnessed an indisputable rise in the average global surface air temperature, estimated at 1ºC (1.8 ºF) since 1900 [19]. Technological and political changes are needed in order to modify the current trajectory of emissions, with the ability to slow global warming depending on it.

The origin of international climate negotiations can be traced back to the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, which gave rise to the United Nations Framework Convention on Climate Change (UNFCCC), securing an international consensus aimed at tackling climate change. Efforts got underway with the signing of the Kyoto Protocol (KP) in 1998, in which all signatories pledged to curb the emissions responsible for global warming. However, its implementation was not immediate as it did not enter into force until 2005. From that date on, successive agreements have emerged, with the following notable directives: to provide 100 billion dollars for climate finance projects in developing countries, to limit the global temperature rise to below 2°C, to bind global climate agreement for the post-2020 era, to extend the second commitment period of the KP, and to involve the general public and increase their role in the process of global climate action [20].

Another important milestone has been the signing of the Paris Agreement in 2015, which establishes a global framework to keep global warming below 2ºC and bolster countries' capacity to react to climate change. Among the key elements of this agreement are: comprehensive national climate action plans to reduce emissions, governments' commitment to transparency between countries and with citizens regarding the progress made, international assistance to adapt to the consequences of climate change, and encouraging all citizens' involvement in efforts to slow global warming [21].

Subsequently, in April 2021, the Council and the European Parliament committed to reducing GHG emissions by 55% by 2030 and achieving climate neutrality by 2050. A roadmap has been drawn up through the European Green Deal with the aim of involving all European nations in legislative and non-legislative initiatives to achieve this objective. Furthermore, the European climate law is being negotiated to make political commitments on climate legally binding [22].

Authors such as Camargo et al [23] have expressed their concern about the dangerous gaps that lie between what is required to reach the 1.5 ºC objective, what governments have pledged and what is happening in reality. They argue that the measures needed to deter climate change are still far from the speed and range necessary to effectively address it. They present climate policy gap graphics for Portugal, Spain and Morocco, concluding that there is a built-in feature of underreaction in climate policy, which renders the trajectory of emissions incompatible with the possibility of slowing temperature rises. Furthermore, Castro (2020) [24] claims that the coalitions needed for international negotiations in the United Nations Framework Convention on Climate Change entail a cost when their members have differing preferences.

As China is one of the most polluting countries, there is a broad literature focused on analysing Chinese actions aimed at reducing emissions in order to achieve the goals set [25,26,27,28,29]. However, the results obtained cannot always be extrapolated to other geographical areas, due to the very specific socio-economic conditions of the Asian country. It is a major world power whose high growth rate has made it the world's biggest consumer of energy and emitter of CO_2. Other studies have compared groups of countries such as the G7 (Canada, France, Germany, Italy, Japan, United Kingdom, and USA) and the BRICs (Brazil, Russia, India, China and South Africa), which account for more than 60% of global GHG emissions, revealing disparities in their climate change mitigation actions [30,31,32,33].

The commitment to move towards the use of REs and abandon polluting energies must be backed up by policies that foster this transition. Measures are called for to support their deployment at all levels of the economy, from domestic uses such as heating and cooling, to more global applications such as in transport or the industrial sector. In addition, society at all different levels must continuously adapt to meet the new challenges that are emerging. Table 1 presents some of the studies carried out to guide the introduction of the most appropriate policies.

Table 1. Literature review

Authors	Objective	Data	Conclusions
[34]	Assess the effectiveness of a comprehensive strategy for RE sources	Euro area	The environmental policy based on technology-push measures may produce better dynamic effects than demand-pull measures based on a subsidy policy of equal monetary amount.
[35]	Verify whether RE innovation programmes meet the requirements for being classified as mission-oriented programmes	Brazil	General mission-oriented programmes must be adapted to the energy transition context.
[36]	Analyse causality between income, CO2, fossil fuel and RE consumption	N-11 countries	Robust RE policy can be designed by complementing the various causality test results, rather than focusing on one particular causality test.
[37]	Comparative analysis of existing non-conventional renewable resources, energy policies and gaps in BRICS countries	BRICS countries.	There is a need to redefine their energy policies based on their existing geographical, economical, societal and environmental conditions, which will help in shaping global energy policies and improving financial stability.
[38]	Demonstrate how a planned decrease in power system reliability, without impacting access to energy, could lead to better integration of REs.	Tunisia	There is high rate of RE sources penetration with a decrease in the power system reliability relying on energy efficiency actions.
[39]	Analyse the main vectors and actors that influence RE policy adoption and identify differences between developed and developing countries	194 countries, 102 of which are developing countries	Strong evidence of socialisation and learning on international policy diffusion to developing countries, while domestic factors play a major role, especially with regard to market liberalisation in developed countries.
[40]	Investigate the effects of RE incentive policies, as facilitators of ‘substitutability’	420 energy firms in OECD countries	Substituting RE for fossil fuels, incentivised through RE policies, stimulates improved financial performance of energy companies in OECD countries.
[41]	Examine RE growth and analyse the government policies to substantially scale up the deployment of renewables for power generation.	Southeast Asia	Social, political and economic pressures hinder the implementation of RE policy.
[42]	Examine how different renewable energy support policies affect innovation in solar and wind power technologies	194 countries	Consistently positive impact of feed-in tariffs and no technology-specific differences detected in the effectiveness of this policy instrument.
[43]	Econometric analysis of the effectiveness of RE policies	Europe and Latin America	Support policies are the main drivers of RE diffusion in Europe and Latin America.

The connection between GHG emissions and elements such as GDP, foreign direct investment (FDI), energy efficiency and REs use has also sparked the interest of researchers [44,45,46,47,48]. The results of those studies provide evidence of the existence of a direct relationship between GHG emissions and GDP, RE, and energy efficiency, while the short-term effects of FDI on emissions are less clear-cut. They all agree on the need for countries to ensure that economic growth is accompanied by optimal technological development to ensure higher levels of energy efficiency.

The complexity of jointly analysing widely varying aspects of climate change has prompted studies aimed at constructing composite indices that allow researchers to cover a broader spectrum of the paradigm, focusing on specific territories [49,50,51,52,53,54]. Their objective is to establish indicators that facilitate the early detection of potential sources of vulnerability and to guide the actions of the responsible agencies. Efforts have also been made to cover a wider range of countries and thus establish rankings according to their situation regarding specific issues such as RE [55,56], energy efficiency [57], sustainable energy [58,59,60] or energy security [61,62].

Other papers analyse the common profiles shared by geographical areas in order to be able to extrapolate the conclusions drawn to other regions with similar characteristics. In this vein, Argolino et al. [63] use cluster analysis and a panel data model with fixed effects to evaluate energy policy effectiveness in Italian regions due to a coercive policy transfer generated by the EU. Foguesatto et al. [64] categorise farmers into different types according to their perceptions of environmental issues and climate change. Likewise, Opach et al. [65] use clustering techniques to identify groups of communities with similar resilience profiles, focusing on Norwegian municipalities. All this underlines the need for homogeneous information in order to be able to appropriately manage environmental actions.

3. Methodology and sample

Cluster analysis has been successfully applied in various areas of research such as tourism [66], medicine [67], communications [68] or the analysis of REs, among others [69,70,71,72]. This multivariate technique is commonly used to identify patterns in large samples, by assessing the links between data elements [73]. The detection of patterns and subsequent grouping of observations is carried out using information relating to the study in question. In this case, the clustering has been based on the four CCPI indicators (*GHG Emissions*, *Renewable Energy*, *Energy Use* and *Climate Policy*), with the aim of establishing homogeneous groups of countries according to their performance with respect to these issues.

The application of this method first requires the number of clusters to be determined using Ward's agglomerative method and taking the squared Euclidean distance as a measure of similarity. According to Kuiper and Fisher [74], this classification technique combines different elements, seeking to minimise the within-group variance. The results yield a dendrogram from which the ideal number of clusters can be determined. Lastly, the Kruskal-Wallis test is used to confirm the adequacy of the defined groups, by verifying that the mean of each one is statistically different from the rest.

Additionally, in line with the research objectives, contingency tables are used to analyse the relationships between the CCPI indicators, based on the theoretical approach proposed by Burck et al. [75]. This method has often been used in the field of energy policy and climate change [76,77,78,79,80]. The general structure is illustrated in Table 2, where rows and columns present the number of countries whose score for that indicator is at the same level, constituting the observed frequency. The scores have been transformed into qualitative variables ranging between [high, very low], in line with the approach established in the methodology for the CCPI index[1].

Table 2. General structure of contingency tables of observed frequencies

		INDICATOR “A”				
	Criterion *i*	High	Medium	Low	Very low	Total
INDICATOR “B”	High	$n_{1,1}$	$n_{1,2}$	$n_{1,3}$	$n_{1,4}$	$n_{1,\bullet}$
	Medium	$n_{2,1}$	$n_{2,2}$	$n_{2,3}$	$n_{2,4}$	$n_{2,\bullet}$
	Low	$n_{3,1}$	$n_{3,2}$	$n_{3,3}$	$n_{3,4}$	$n_{3,\bullet}$
	Very low	$n_{4,1}$	$N_{4,2}$	$n_{4,3}$	$n_{4,4}$	$n_{4,\bullet}$
	Total	$n_{\bullet,1}$	$n_{\bullet,2}$	$n_{\bullet,3}$	$n_{\bullet,4}$	$n_{5,\bullet}$

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[1] According to CCPI scores, all the countries could be clustered into a not achieving the objectives of climate change.

Based on the data in Table 2, the expected frequencies are calculated using the following expression:

$$E_{ij} = \frac{n_{i\cdot} n_{\cdot j}}{N} \quad (1)$$

where, N is the total number of observations in the table, $n_{i,\bullet}$ is the number of observations in row i, and $n_{\bullet,j}$ is the number of observations in column j.

Both the observed and expected frequencies are necessary to perform the χ^2 test showing whether the variables considered in the study are independent or not. The result of the χ^2 test confirms whether the levels of a qualitative variable influence those of another variable. The χ^2 test is defined by the following expression:

$$\chi^2 = \frac{\sum_{i=1}^{h} \sum_{j=1}^{k} (n_{ij} - E_{ij})^2}{E_{ij}} \quad (2)$$

where, n_{ij} is the observed frequency, and E_{ij} is the expected frequency. The null hypothesis is that of independence between factors. The alternative hypothesis is that of dependence between factors.

The empirical analysis carried out focuses on climate change policies, using data on the components from the 2021 CCPI, which in turn are based on information referring to 2018. As such, the most recent developments and effects of the COVID-19 pandemic are not reflected in these figures. This index has been produced annually since 2005 by the organisation Germanwatch, the NewClimate Institute and the Climate Action Network. Around 400 climate policy experts at national and international levels are involved in producing the index.

The CCPI evaluates the actions taken to foster environmental protection in 57 countries (see list at the bottom of the dendrogram), assessing their compatibility with the goal of keeping global warming below 2°C or even 1.5°C. There are no countries in the top three positions because, according to the CCPI, no country (out of the 57 + EU) is doing enough to achieve the UNFCCC's treaties and protocols ultimate goals, to prevent climate change.

The results lead greater transparency to international policy issues, facilitating the comparison of efforts to curb climate change. In addition, they provide information on the achievement of the goals set in the Paris Agreement, based on the analysis of the following indicators:

- *GHG emissions* (40% of overall score): quantitatively assesses the measures taken by countries to reduce GHG emissions, a goal set for all countries to guard against harmful climate change. It is assigned a higher weight than the other components because, according to experts, it bears the greatest responsibility for global warming. The CCPI uses the PRIMAP database to assess all GHG emissions.
- *Renewable Energy* (20% of overall score): measures actions aimed at increasing the use of REs in each of the countries analysed. The CCPI uses statistical information provided by the International Energy Agency.
- *Energy Use* (20% of overall score): assesses improvements in energy efficiency and therefore control over domestic energy use. The CCPI uses statistical information provided by the International Energy Agency.
- *Climate Policy* (20% of overall score): quantifies the effectiveness of climate policies implemented in the different countries. Evaluations of countries' performance in climate policy are based on an annually updated survey of national climate and energy experts from civil society.

The overall index places countries within the interval [0, 100], where higher values indicate more "climate friendly" behaviour. The final CCPI ranking is calculated from the weighted average of the scores achieved in the individual indicators, using the following formula [75]:

$$CCPI = \sum_{i=1}^{n} W_i * X_i \tag{3}$$

where, X_i is a normalised indicator, and W_i the weighting of X_i

Table 3. Descriptive statistics of CCPI indicators

	GHG Emissions	**Renewable Energy**	**Energy Use**	**Climate Policy**
Mean	20.52	7.28	11.33	8.58
Max	33.15	14.17	18.54	19.38
Min	2.84	0.55	3.50	0.80
ST	6.89	3.65	3.01	4.24

The *GHG Emissions* values range between 0 and 40, and the rest of the indicators between 0 and 20. The statistics shown in Table 3 reveal that no country has been able to achieve the maximum value assigned to each component, with greater room for improvement seen in *Renewable Energy* and *GHG emissions*. According to Burk et al. [75], the top three positions in the country ranking are empty. Therefore, the index provides the responsible agencies with valuable information that can help them target their efforts on the changes needed to ensure effective improvements in the different countries. Moreover, there is no uniform pattern in countries' performance: while Sweden has the highest value in *GHG Emissions* (33.15), Latvia leads the way in the use of *Renewable Energy* (14.17), Ukraine in the appropriate *Energy Use* (18.54) and Finland shows the greatest effectiveness in the implementation of *Climate Policy* (19.38). Similarly, Kazakhstan is the worst rated in *GHG Emissions* (2.84), Iran in *Renewable Energy* (0.55), Canada in *Energy Use* (3.5), and the USA in *Climate Policy* (0.8), reflecting, in this case, a lack of concern about the issues under study. The wide range of values between the maximum and minimum scores for each pillar justifies the application of cluster analysis to try to homogenise the sample. This method allows homogeneous groups of countries to be determined, thus revealing the factors underpinning best actions.

4. Results

Based on the results of the empirical analysis, the proposed hypotheses on actions taken to slow climate change can be resolved. The CCPI includes a variety of countries with very different economic and environmental characteristics. Thus, it is first necessary to carry out a cluster analysis to obtain homogeneous groups of countries according to the actions they have taken to tackle their environmental concerns (RQ 1). Second, contingency tables are used to demonstrate the possible connection between the pillars that compose the CCPI (RQ 2).

RQ 1. Does Geographical and economic proximity between countries gives rise to homogeneous patterns in climate change performance?

The hierarchical clustering of the sample is based on the four CCPI indicators: *GHG Emissions*, *Renewable Energy*, *Energy Use* and *Climate Policy*. The dendrogram yielded by the cluster analysis identified six homogeneous groups of countries (Figure 1A of the Appendix). The Kruskal-Wallis test confirms that this grouping is appropriate, as it reveals significant differences between groups in terms of the mean value of the indicators. In Table 4, the Chi-Squared statistic is significant with a p-value <0.05 in all four indicators.

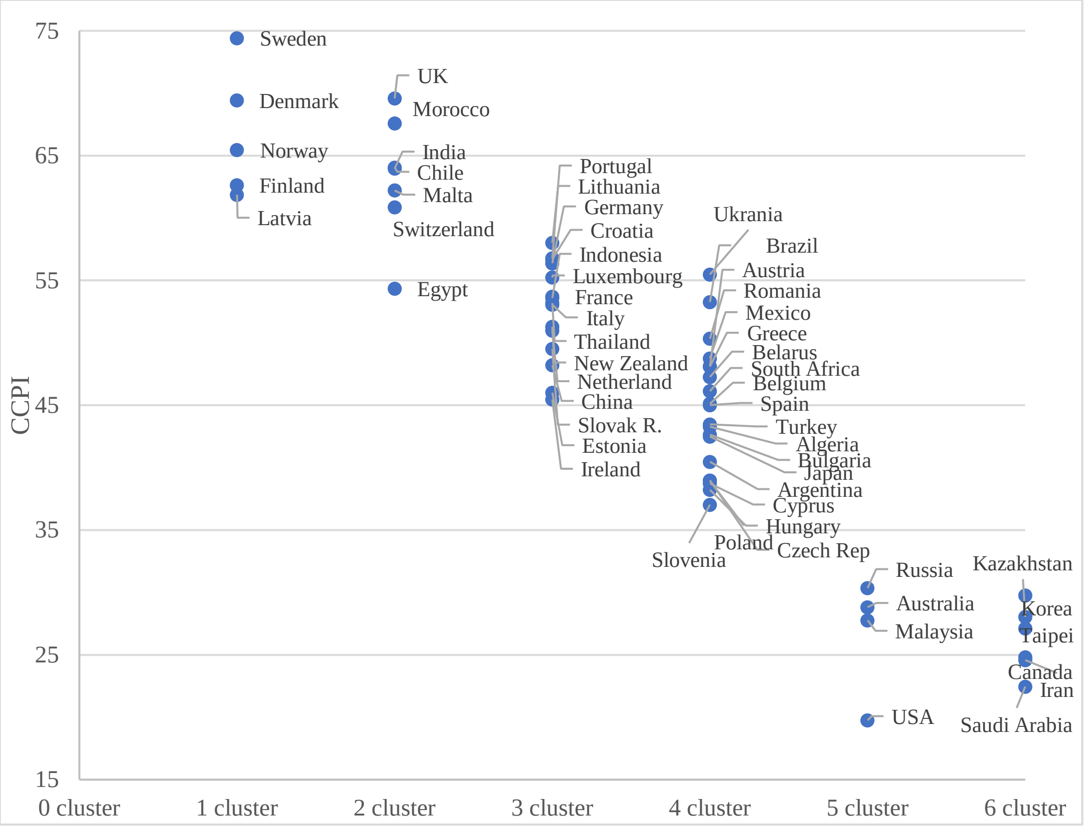
Table 4. Means of the indicators for the 6 clusters and Kruskal-Wallis Test

		GHG Emissions	**Renewable Energy**	**Energy Use**	**Climate Policy**
Media	Cluster 1	27.05	13.87	9.75	16.10
	Cluster 2	30.41	8.05	14.65	10.10
	Cluster 3	21.35	8.99	11.31	10.90
	Cluster 4	20.26	6.16	12.40	5.77
	Cluster 5	13.35	2.26	9.08	1.98
	Cluster 6	7.15	3.65	6.77	8.55
	Total mean	**20.52**	**7.27**	**11.33**	**8.58**
		Kruskal-Wallis Test			
	Chi-Squared	39.14	33.67	25.98	38.35
	p-value	0.000	0.000	0.000	0.000

The comparison between the mean score of each CCPI indicator for the total sample of countries and the mean score for each cluster (Table 4), makes it possible to establish a characteristic behavioural profile of the clusters and thus to confirm whether geographical or economic proximity determines their level of commitment to environmental issues. Thus, the 6 clusters have been rated from *High* to *Low* commitment. A rating of *High* has been given if the difference between the means is greater than 3 points. For example, Cluster 1 has been rated as *High* commitment in *GHG Emissions, Renewable Energy and Climate Policy* (27.05-20.52; 13.87-7.27; 16.10-8.8 respectively).

According to the overall CCPI score, it can be observed that Clusters 1 and 2 are the ones that are most actively involved in developing measures to prevent actions that are harmful to the environment. At the other extreme, Clusters 5 and 6 are characterised by holding the bottom positions in all the issues analysed by the CCPI and registering below-average scores. Somewhere in between are Clusters 3 and 4, which contain the largest number of countries. Although they should redouble their efforts to prevent environmentally harmful actions and thus curb climate change, they are comparatively close to the mean values for the countries analysed. The description of the groups is based on the country details provided in the CCPI report (https://ccpi.org/countries/).

Figure 1. Overall CCPI score for each country and the cluster to which it belongs



Note: The clusters have been calculated based on the CCPI pillars, but the figure compares the cluster groupings with the global indexes.

Cluster 1 “High commitment to GHG Emissions, Renewable Energy and Climate Policy”

This cluster is made up of countries in northern Europe that hold high positions in the CCPI ranking. All of them are seeking to achieve a reduction in GHG emissions and contribute to the Green Climate Fund[2], playing an active and constructive role in climate policies. Sweden attests to the theory that the most developed countries tend to be more pro-environmental [81], targeting 100% renewable electricity production by 2040 and imposing the highest carbon tax in the world [82]. Nevertheless, despite these good results, there is still room for improvement in terms of energy efficiency (Sweden and Norway), reducing fossil fuel subsidies (Latvia) or cutting emissions in the transport,

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[2] The Green Climate Fund was set up by the United Nations Framework Convention on Climate Change to fund climate change mitigation and adaptation projects in developing countries.

construction and agriculture sectors (Denmark): as a result, none of them reach the maximum score in the CCPI pillars.

Cluster 2 "*High commitment to GHG Emissions and Energy Use*". Unlike in Cluster 1, the seven countries belonging to this cluster are geographically distant from one another and have high *GHG Emissions* and *Energy Use* scores. However, greater commitment to *Renewable Energy* and *Climate Policy* is required because, even though they are above the mean, they would have to double their efforts to achieve everything stipulated in these pillars. In general, these countries show positive progress in all four categories; in particular, India and Morocco have ensured the compatibility of their commitments with the goal of keeping global warming below 2ºC [83]. Furthermore, although India is the third largest producer of carbon dioxide emissions in the world [84], the optimal evaluation of its actions to reduce them places it among the top 10 countries in the CCPI.

Cluster 3*"High/medium commitment to GHG Emissions, Renewable Energy and Climate Policy"*. This is the second largest cluster, comprising 15 EU countries that are relatively geographically distant, along with 4 countries: 3 Asian ones (China, Thailand and Indonesia) and New Zealand. These countries are considered proactive in EU negotiations, but the intermediate position and larger size of this cluster means that it encompasses countries with widely disparate practices on certain environmental issues. Thus, some European countries such as the Netherlands have strategies to eliminate the use of coal for electricity generation, while others such as Portugal apply a carbon tax that remains ineffective; these issues have recently been discussed in the literature [85,86,87,88,89]. New Zealand's forecasts are also noteworthy: by 2035 it intends to have eliminated the use of coal and to have achieved 100% renewable electricity production [90]. For its part, the Asian giant, considered the largest GHG emitter, is rapidly deploying non-hydroelectric REs and is in the process of developing a national emissions trading system, which will limit CO_2 emissions from the energy sector and whose consequences have been the subject of analysis [91,92,93].

Cluster 4 "*High/medium commitment to Energy Use*". This is the largest group, composed of 11 EU countries, mainly from Eastern Europe, as well as 9 other nations from other continents. These are countries whose commitment to fighting climate change should be strengthened by more effective actions aimed at reducing GHG emissions and boosting the use of REs; that is, they need stricter environmental policies. Specifically, the mediocre actions taken in Hungary and Poland are an obstacle to the EU's 2030 Climate

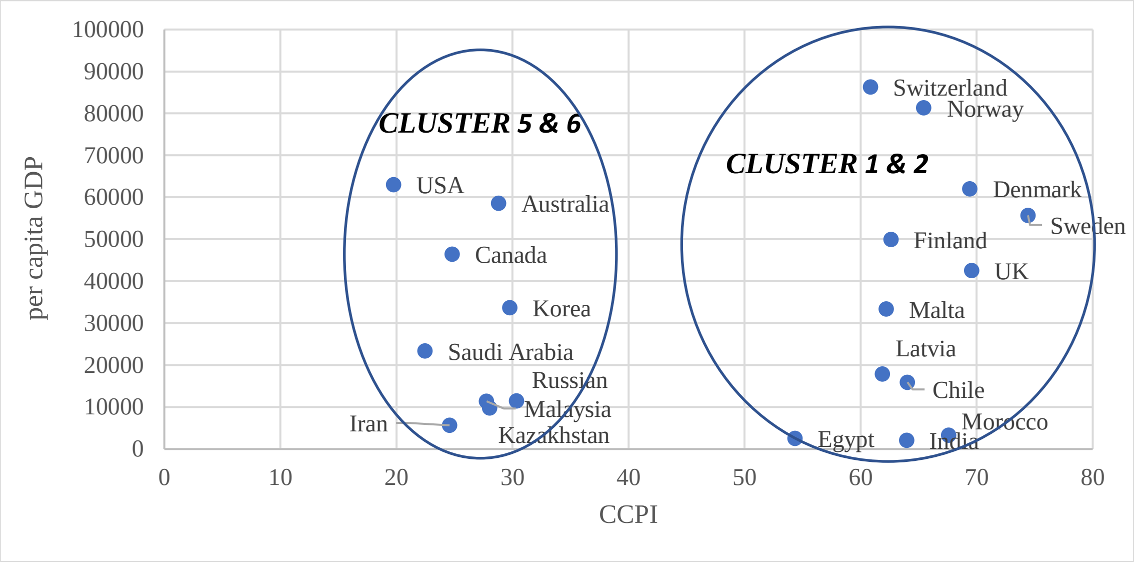
Target Plan [94]. Others such as Romania and Bulgaria do not have a strategy for eliminating coal and are heavily reliant on fossil fuels for their energy supply [95]. Usually, they are countries with sufficient economic resources to engage far more actively in the transition to cleaner technologies, but there is a need for greater awareness and more action by the responsible agencies.

Cluster 5 “*Low commitment to GHG emissions, Renewable Energy and Climate Policy*”. This cluster is made up of four geographically distant countries. Notable among them is the USA, whose low scores in all four categories are due to its withdrawal from the Paris Agreement. The country has no targets for reducing GHG emissions and has a high per capita energy use (more than double that for the EU and 10 times more than India, according to Dw [82]), in short revealing a worrying lack of climate policy [96]. This cluster contains the largest producers and exporters of fossil fuels: the USA, Russia and Australia. As such, they register very low CCPI scores. Their carbon pollution levels and high energy consumption demonstrate the ineffectiveness of their climate policies. This shows the influential power of fossil fuel industries in these countries and underscores their passive attitude towards climate change despite their wealth [75].

Cluster 6 “*Low commitment to GHG Emissions, Renewable Energy and Energy Use*”. This cluster is composed of five Asian countries and Canada, which are in the bottom positions in the CCPI ranking. Overall, the poor performance on climate is due to high GHG emissions per capita—particularly in Canada, which ranks first among the most active emitters [97]; a low level of commitment to implementing REs; and a lack of long-term planning on energy. Saudi Arabia merits special mention, this is a country that is heavily dependent on fossil fuels and faces great difficulties in achieving a transition to REs. Likewise, nearly 80% of the energy demand of Iran's power generation sector is met by fossil fuels [84].

In order to gain a more accurate understanding of the possible relationship between countries' wealth and their concern about global warming, Figure 3 displays the countries in the different clusters. For reasons of space and clarity, only those corresponding to the most extreme groups—Cluster 1 and 2 compared to Cluster 5 and 6—are depicted, given that the conclusions can be generalised to the whole sample.

Figure 3. Relationship between CCPI score and GDP per capita



The countries that comprise Cluster 1 and 2 diverge widely in terms of wealth. Together in the same cluster are India, with a GDP per capita of €2,050, and Switzerland, with €86,315. However, both these countries hold high positions in the CCPI ranking. All this underlines the fact that there is no correlation between the score a country is awarded for its actions against climate change and its wealth. Clusters 5 and 6 also confirm this discrepancy, take, for example, the USA compared to Iran. The economic power of the USA stands in contrast to the paradoxical mishandling of its national and international climate policy under the Trump administration, placing the country among those with the lowest CCPI scores even though it registers one of the highest values for GDP per capita (€63,014). Apart from China, all the major fossil fuel producers are in the cluster with the lowest CCPI, which clearly points out to another factor relating climate action to climate legislation and renewables deployment: the existence of strong fossil fuel industries in each country, impeding climate action, and the strong network of political influence by business.

In short, except for Cluster 1, where there is a degree of geographical proximity among the countries and they are all categorised as high-income according to the World Bank, the results reject hypothesis 1. The level of concern about introducing climate change mitigation actions into the day-to-day productive activities of an economy does not depend on countries' location or wealth. Morocco, with a GDP per capita currently far below that of Switzerland or the USA, has demonstrated its potential to produce 96% of its electricity using REs by 2050 [98]. This African country has striven to introduce changes to curb climate change and thereby mitigate the foreseeable disastrous consequences. However, Morocco is in the same cluster as Switzerland, but it has higher CCPI score.

RQ 2. Are Climate change policies responsible for countries' commitment to the deployment of renewable and efficient energy supplies, thereby ensuring reductions in GHG emissions?

In line with the research objectives, contingency tables have been designed to answer RQ 2. This method enables the analysis of relationships between qualitative variables; therefore, the scores for each of the CCPI pillars have to be transformed into attributes categorised in four levels (from *High* to *Very Low*), as indicated by Burck et al. [75]. Table 5 shows the range of scores assigned to each category, for each CCPI indicator.

Table 5. Qualitative levels of CCPI indicators

	GHG Emissions	**Renewable Energy**	**Energy Use**	**Climate Policy**
High	33.15-25.42	14.17-9.34	18.54-13.60	19.38-11.20
Medium	24.99-20.75	8.77-6.47	13.24-10.87	10.76-7.87
Low	20.48-17.23	6.37-3.12	10.67-10.09	7.78-5.28
Very Low	16.55-2.84	2.59-0.55	9.18-3.50	5.03-0.80

As shown in the diagram produced by Burck et al. [75] depicted in Figure 4, *Climate Policy* is an instrument that can ensure greater use of *Renewable Energy* and appropriate *Energy Use*, which in turn both enable reductions in harmful *GHG* emissions. Therefore, a reduction in emissions is considered the goal of any measure taken by the authorities to meet the established environmental targets.

Figure 4. Logic applied by the CCPI

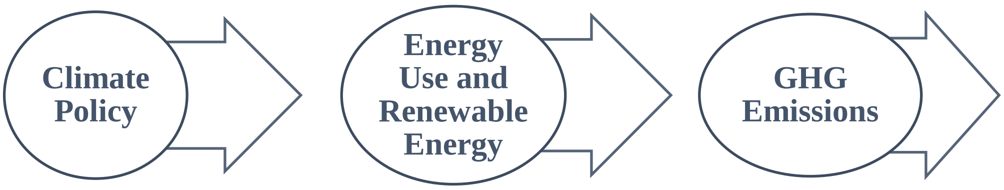


Table 6 shows the four contingency tables (CT1, CT2, CT3, CT4) that indicate whether the established relationships are supported by statistically significant results. CT1 and CT2 analyse the connection between *Climate Policy* and the *Energy Use* and *Renewable Energy* pillars, respectively, while CT3 and CT4 determine the possible link between the latter two pillars and *GHG Emissions*.

Table 6. Results of contingency tables

CT1		**CLIMATE POLICY**				
		High	**Medium**	**Low**	**Very Low**	**Total**
ENERGY USE	**High**	3 (5.2%)	4 (6.9%)	6 (10.3%)	1 (1.7%)	**14 (24.1%)**
	Medium	7 (12.1%)	5 (8.6%)	3 (5.2%)	5 (8.6%)	**20 (34.5%)**
	Low	2 (3.4%)	4 (6.9%)	3 (5.2%)	4 (6.9%)	**13 (22.4%)**
	Very Low	4 (6.9%)	3 (5.2%)	2 (3.4%)	2 (3.4%)	**11 (19%)**
	Total	**16 (27.6%)**	**16 (27.6%)**	**14 (24.1%)**	**12 (20.7%)**	**58 (100%)**

Pearson's Chi-Squared: χ^2 = 6.686 (p-value: 0.670)

CT2		**CLIMATE POLICY**				
		High	**Medium**	**Low**	**Very Low**	**Total**
RENEWABLE ENERGY	**High**	9 (15.5%)	3 (5.2%)	3 (5.2%)	3 (5.2%)	**18 (31%)**
	Medium	6 (10.3%)	5 (8.6%)	3 (5.2%)	0	**14 (24.1%)**
	Low	1 (1.7%)	5 (8.6%)	5 (8.6%)	7 (12.1%)	**18 (31%)**
	Very Low	0	3 (5.2%)	3 (5.2%)	2 (3.4%)	**8 (13.8%)**
	Total	**16 (27.6%)**	**16 (27.6%)**	**14 (24.1%)**	**12 (20.7%)**	**58 (100%)**

Pearson's Chi-Squared: χ^2 = 18.374 (p-value: 0.031)

CT3		**ENERGY USE**				
		High	**Medium**	**Low**	**Very Low**	**Total**
GHG EMISSIONS	**High**	6 (10.3%)	4 (6.9%)	2 (3.4%)	0	**12 (20.7%)**
	Medium	6 (10.3%)	8 (13.8%)	0	2 (3.4%)	**16 (27.6%)**
	Low	1 (1.7%)	6 (10.3%)	8 (13.8%)	0	**15 (25.9%)**
	Very Low	1 (1.7%)	2 (3.4%)	3 (5.2%)	9 (15.5%)	**15 (25.9%)**
	Total	**14 (24.1%)**	**20 (34.5%)**	**13 (22.4%)**	**11 (19%)**	**58 (100%)**

Pearson's Chi-Squared: χ^2 = 40.493 (p-value: 0.000)

CT4		**RENEWABLE ENERGY**				
		High	**Medium**	**Low**	**Very Low**	**Total**
GHG EMISSIONS	**High**	6 (10.3%)	3 (5.2%)	2 (3.4%)	1 (1.7%)	**12 (20.7%)**
	Medium	6 (10.3%)	7 (12.1%)	1 (1.7%)	2 (3.4%)	**16 (27.6%)**
	Low	4 (6.9%)	2 (3.4%)	9 (15.5%)	0	**15 (25.9%)**
	Very Low	2 (3.4%)	2 (3.4%)	6 (10.3%)	5 (8.6%)	**15 (25.9%)**
	Total	**18 (31%)**	**14 (24.1%)**	**18 (31%)**	**8 (13.8%)**	**58 (100%)**

Pearson's Chi-Squared: χ^2 = 22.126 (p-value: 0.008)

The results of the analysis corroborate the causal relationship of *Climate Policy* with *Renewable Energy* (CT2) but not with *Energy Use* (CT1). The latter indicator refers to energy efficiency; that is, it reflects the extent to which countries are committed to achieving reductions in the energy used in the production of goods and services. Its importance lies in the need to achieve the goal of net zero emissions, which is crucial to curb climate change. However, the results of the χ^2 test (p-value>0.05) for the *Climate Policy* and *Energy Use* analysis reveal the absence of a relationship between the two indicators.

In CT2, the χ^2 test confirms the link between *Climate Policy* and *Renewable Energy* (p-value<0.05). Specifically, of the 18 countries that have a *High* level in *Renewable Energy*, half achieve the same level in *Climate Policy*. The transition to the use of REs requires major government involvement with assistance programmes to facilitate their deployment. Thus, the USA, Russia, Saudi Arabia and Australia are among the top carbon polluters, with *Low* or *Very low* levels in *Renewable Energy*; moreover, none of them have a useful federal climate policy facilitating the transition to the use of clean energies aimed at reducing pollution. Paradoxically, in countries with fewer resources, such as Portugal, Morocco or Chile, among others, the authorities show greater commitment to promoting the use of REs by reducing the use of fossil fuels, which will help them prevent GHG emissions and facilitate change climate mitigation [99].

Next, CT3 and CT4 analyse the connection between the other pillars of the CCPI. The results confirm the causality between *GHG Emissions* and the indicators *Energy Use* and *Renewable Energy* (p-value<0.05 in both cases), as reported by Burck et al. [75]. Regarding country frequencies, it is observed that of the 12 countries categorised as *High* for *GHG Emissions* half of them are also categorised as *High* for *Energy Use* and *Renewable Energy*, demonstrating that energy strategies positively influence emission reductions. Specifically, Germany needs to improve its RE options and thus lower its level of emissions [100], while India, despite its low level of development, has invested heavily in REs, achieving a *High* level in its fight to prevent GHG emissions [82].

To sum up, there is a connection between the pillars of CCPI, all of which are aimed at achieving a reduction in GHG emissions, which in turn helps slow down climate change and prevent irreversible adverse effects on the planet. However, there is no statistically significant evidence that government actions are translating into more efficient use of energy. Support for these results can be found in the literature, which reveals conflicts between economic growth and energy change [101].

5. Conclusions

Global warming due to climate change has become the greatest threat to life on the planet. Its effects are ever-more evident and cannot be ignored by the government agencies tasked with ensuring their citizens' security and quality of life. An active position is called for in the face of this serious problem, the consequences of which have only just begun to emerge. What is needed is an orderly transition towards the use of clean, efficient energies that enable the reduction of toxic emissions harmful to all ecosystems.

Using the most recent information from the CCPI, this study has focused on identifying patterns of performance that can provide valuable information to the authorities responsible for setting climate policies. Cluster analysis and contingency tables were used to resolve the two hypotheses proposed concerning countries' environmental practices and the relationship between commitment to implementing related actions and the reduction of GHG emissions.

The results confirm that environmental concern is not driven by matters of wealth or geography. Neighbouring countries may have very different perceptions of the environmental situation. Moreover, those with fewer resources are sometimes more active than others that are still primarily concerned with production volumes, ruling out the use of clean, efficient energies that could reduce economic profits. In addition, countries taking active measures are managing to incorporate REs into their production systems, thereby reducing GHG emissions. However, the χ^2 test indicates a non-existent relationship between climate change policies and energy use, therefore, policy makers should design their policy strategies to incentivise businesses to reduce the energy used in the production of goods and services.

There is a need for a 45-55% global emissions' cut by 2030 compared to 2010 (according to the SR1.5ºC from the IPCC in 2018), which means that, beyond the deployment of renewables, the shutdown of fossil fuel infrastructures and abandonment of fossil fuels reserves is a necessary condition to achieve the UNFCCC's objectives, as well as the need for adaptation measures, in particular in the poorest countries, as well as massive financial support for this to happen at the global scale.

The sample used is representative of the existing problem, it covers a relatively small group of countries that together account for about 90% of CO_2 emissions. However, a broader sample of emerging countries would reinforce the findings of the research. At the same time, regional or even sectoral analysis would provide a more accurate picture of the situation. The extension of this research would be to analyse the determinants of emissions reduction, checking whether the introduction of innovative processes in industries fosters the use of clean energy. Finally, other indexes should be considered like the Climate Action Tracker or the Paris Equity Check, (and there's even complementary or even contradiction between the indexes).

References

[1] Cucchiella F, D’Adamo I, Gastaldi M, Miliacca M. Efficiency and allocation of emission allowances and energy consumption over more sustainable European economies. J Clean Prod 2018; 182: 805-17. https://doi.org/10.1016/j.jclepro.2018.02.079.

[2] Da Rosa FS, Lunkes RJ, Brizzola MMB. Exploring the relationship between internal pressures, greenhouse gas management and performance of Brazilian companies. J Clean Prod 2019; 212: 567-75. https://doi.org/10.1016/j.jclepro.2018.12.042.

[3] Bojanic DC, Warnick RB. The Relationship between a Country’s Level of Tourism and Environmental Performance. J Travel Res 2019; 59(2): 220-30. https://doi.org/10.1177/0047287519827394.

[4] Vasylieva T, Lyulyov O, Bilan Y, Streimikiene D. Sustainable Economic Development and Greenhouse Gas Emissions: The Dynamic Impact of Renewable Energy Consumption, GDP, and Corruption. Energies 2019; 12: 3289. https://doi.org/10.3390/en12173289.

[5] United Nations. World population prospects: the 2017 revision. Retrieved from. 2017. https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html.

[6] COM. A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank. 2018.

[7] Xu R, Chou LC, Zhang WH. The effect of CO2 emissions and economic performance on hydrogen-based renewable production in 35 European Countries. Int J Hydrogen Energ 2019; 44(56): 29418-29425. https://doi.org/10.1016/j.ijhydene.2019.02.167.

[8] Østergaard PA, Johannsen RM, Duic N. Sustainable development using renewable energy systems. Int J Sust Energ Plan Manage 2020; 29: 1-6. https://doi.org/10.5278/ijsepm.4302.

[9] Spillias S, Kareiva P, Ruckelshaus M, McDonald-Madden E. Renewable energy targets may undermine their sustainability. Nat Clim Change 2020; 10: 974–76. https://doi.org/10.1038/s41558-020-00939-x.

[10] Buonocore J, Luckow P, Norris G, Spengler JD, Biewald B, Fisher J, Levy J. Health and climate benefits of different energy-efficiency and renewable energy choices. Nat Clim Change 2016; 6: 100–105. https://doi.org/10.1038/nclimate2771.

[11] Bhardwaj A, Joshi M, Khosla R, Dubash NK. More priorities, more problems? Decision-making with multiple energy, development and climate objectives. Energy Res Soc Sci 2019; 49: 143-157. https://doi.org/10.1016/j.erss.2018.11.003.

[12] Rincón-Ruiz A, Arias-Arévalo P, Núñez JM, Cotler H, Aguado M, Meli P, Tauro A, Ávila VD, Avila-Foucat VS, Cardenas JP, Castillo LA, Castro LG, Cerón VA, Contreras A, Deschamps-Lomeli J, Galeana-Pizaña M, Guillén K, Hernández JA, Jimenez AD, López LA, Márquez L, Moreno ML, Marín W, Ochoa V, Sarmiento MA, Tauro MA, Díaz J, Tique LL, Trujillo A, Waldron T. Applying integrated

valuation of ecosystem services in Latin America: Insights from 21 case studies. Ecosyst Serv 2019; 36: 100901. https://doi.org/10.1016/j.ecoser.2019.100901.

[13] Dirk-Jan van dV, González-Eguino M, Arto I. The potential of behavioural change for climate change mitigation: A case study for the European Union. Mitig Adap Strat Gl 2018; 23(6): 853-86. http://dx.doi.org/10.1007/s11027-017-9763-y.

[14] Khan MTI, Ali Q, Ashfaq M. The nexus between greenhouse gas emission, electricity production, renewable energy and agriculture in Pakistan. Renew Energ 2018; 118 (8): 437-51. https://doi.org/10.1016/j.renene.2017.11.043.

[15] Sarkodie SA, Strezov V, Weldekidan H, Asamoah EF, Owusu PA, Nutifafa I, Yawo Doyi Y. Environmental sustainability assessment using dynamic Autoregressive-Distributed Lag simulations—Nexus between greenhouse gas emissions, biomass energy, food and economic growth. Sci Total Environ 2019; 668: 318-32. https://doi.org/10.1016/j.scitotenv.2019.02.432.

[16] Fujiwara N, van Asselt H, Bößner S, Voigt S, Spyridaki NA, Flamos A, Alberola E, Williges K, Türk A, Donkerlaar M. The practice of climate change policy evaluations in the European Union and its member states: results from a meta-analysis. Sustain Earth 2019; 2(9):1-16. https://doi.org/10.1186/s42055-019-0015-8.

[17] Wang B, Mi Z, Nistor I, Yuan XC. How does hydrogen-based renewable energy change with economic development? Empirical evidence from 32 countries. Int J Hydrogen Energ 2018; 43(25): 11629-11638. https://doi.org/10.1016/j.ijhydene.2017.03.059.

[18] Destek MA, Sinha A. Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. J Clean Prod 2020; 242: 118537. https://doi.org/10.1016/j.jclepro.2019.118537.

[19] National Research Council. Climate Change: Evidence and Causes: Update 2020. Washington, DC: The National Academies Press. https://doi.org/10.17226/25733.

[20] Stavins R, Zou, J, Brewer T,Conte Grand M, den Elzen M, Finus M, Gupta J, Höhne N, Lee MK, Michaelowa A, Paterson M, Ramakrishna K, Wen G, Wiener J, Winkler H. International Cooperation: Agreements and Instruments. In Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, Seyboth K, A. Adler A, Baum I, Brunner S, Eickemeier P, Kriemann B, Savolainen J, Schlömer S, von Stechow C, Zwickel T, Minx JC, editors. Climate Change, 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, New York: Cambridge University Press; 2014; 1001-1082.

[21] United Nations, Climate Change,. Katowice climate package. 2018 Accessed https://unfccc.int/process-and-meetings/the-paris-agreement/the-katowice-climate-package/katowice-climate-package.

[22] European Council, Climate change: what the EU is doing. 2021.Accessed. https://www.consilium.europa.eu/en/policies/climate-change/.

[23] Camargo J, Barcena I, Soares PM, Schmidt L, Andaluz, J. Mind the climate policy gaps: climate change public policy and reality in Portugal, Spain and Morocco.

Climatic Change 2020; 161: 151–169. https://doi.org/10.1007/s10584-019-02646-9.

[24] Castro P. National interests and coalition positions on climate change: A text-based analysis. Int Political Sci Rev. 2020; 1-19. https//doi.org/10.1177/0192512120953530.

[25] Hao H, Geng Y, Wang H, Ouyang M. Regional disparity of urban passenger transport associated GHG (greenhouse gas) emissions in China: A review. Energy 2014; 68: 783-93. https://doi.org/10.1016/j.energy.2014.01.008.

[26] Yang F, Li Y, Xu J. Review on Urban GHG Inventory in China. Int Rev Spatial Plann Sustain Dev 2016; 4(2): 46-59. http://dx.doi.org/10.14246/irspsd.4.2_46.

[27] Wang T, Seo S, Liao PC, Fang D. GHG emission reduction performance of state-of-the-art green buildings: Review of two case studies. Renew Sust Energ Rev 2016; 68: 484-93. https://doi.org/10.1016/j.rser.2015.11.037.

[28] Jia X, Klemeš JJ, Varbanov PS, Wan Alwi SR. Analyzing the Energy Consumption, GHG Emission, and Cost of Seawater Desalination in China. Energies 2019; 12 (3): 463. https://doi.org/10.3390/en12030463.

[29] Hu M, Sardans J, Yang X, Peñuelas J, Tong C. Patterns and environmental drivers of greenhouse gas fluxes in the coastal wetlands of China: A systematic review and synthesis. Environ Res 2020; 186: 109576. https://doi.org/10.1016/j.envres.2020.109576.

[30] Climate Transparency. Brown to Green Report 2018. The G20 transition to a low-carbon economy. 2018. Accessed https://www.climate-transparency.org/wp-content/uploads/2019/01/2018-Brown-To-Green-Report-Final.pdf.

[31] Climate Action Tracker. Climate action tracker warming projections global update. 2018. Accessed https://climateactiontracker.org/documents/507/CAT_2018-12-11_Briefing_WarmingProjectionsGlobalUpdate_Dec2018.pdf.

[32] Chang MC, Hu JL. A Long-Term Meta-Frontier Analysis of Energy and Emission Efficiencies between G7 and BRICS. Energy Effic 2018, 12, 879-893. https://doi.org/10.1007/s12053-018-9696-7.

[33] Zheng X, Streimikiene D, Balezentis T, Mardani A, Cavallaro F, Liao H. A review of greenhouse gas emission profiles, dynamics, and climate change mitigation efforts across the key climate change players. J Clean Prod 2019; 234: 1113-33. https://doi.org/10.1016/j.jclepro.2019.06.140.

[34] Argentiero A, Bollino CA, Micheli S, Zopounidis C. Renewable energy sources policies in a Bayesian DSGE model. Renew Energ 2018; 120: 60-68. https://doi.org/10.1016/j.renene.2017.12.057.

[35] Mendonça HL, van Aduard de Macedo-Soares TDL, Fonseca MVA. Working towards a framework based on mission-oriented practices for assessing renewable energy innovation policies. J Clean Prod 2018; 193: 709-719. https://doi.org/10.1016/j.jclepro.2018.05.064.

[36] Sinha A, Shahbaz M, Sengupta T. Renewable energy policies and contradictions in causality: A case of Next 11 countries. J Clean Prod 2018; 197(1): 73-84. https://doi.org/10.1016/j.jclepro.2018.06.219.

[37] Pathak L, Shah K. Renewable energy resources, policies and gaps in BRICS countries and the global impact. Front Energy 2019; 13: 506–21. https://doi.org/10.1007/s11708-018-0601-z.

[38] Dhakouani A, Znouda E, Bouden C. Impacts of energy efficiency policies on the integration of renewable energy. Energ Policy 2019; 133: 110922. https://doi.org/10.1016/j.enpol.2019.110922.

[39] Cia Alves EE, Steiner A, Medeiros M.A, da Silva MEA. From a breeze to the four winds: A panel analysis of the international diffusion of renewable energy incentive policies (2005–2015). Energ Policy 2019; 125: 317-29. https://doi.org/10.1016/j.enpol.2018.10.064.

[40] Hassan A. Do renewable energy incentive policies improve the performance of energy firms? Evidence from OECD countries. OPEC Energ Rev 2019; 43(2): 168-92. https://doi.org/10.1111/opec.12146.

[41] Erdiwansyah R, Mamat R, Sani MSM, Sudhakar K. Renewable energy in Southeast Asia: Policies and recommendations. Sci Total Environ 2019; 670: 1095-1102. https://doi.org/10.1016/j.scitotenv.2019.03.273.

[42] Hille E, Althammer W, Diederich H. Environmental regulation and innovation in renewable energy technologies: Does the policy instrument matter?. Technol Forecast Soc 2020; 153: 119921. https://doi.org/10.1016/j.techfore.2020.119921.

[43] Bersalli G, Menanteau P, El-Methni J. Renewable energy policy effectiveness: A panel data analysis across Europe and Latin America. Renew Sust Energ Rev 2020; 133: 110351. https://doi.org/10.1016/j.rser.2020.110351.

[44] Liobikienė G, Butkus M. Scale, composition, and technique effects through which the economic growth, foreign direct investment, urbanization, and trade affect greenhouse gas emissions. Renew Energ 2019; 132: 1310-22. https://doi.org/10.1016/j.renene.2018.09.032.

[45] Sarkodie SA, Strezov V. Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. Sci Total Environ 2019; 646: 862-71. https://doi.org/10.1016/j.scitotenv.2018.07.365.

[46] Lyeonov S, Pimonenko T, Bilan Y, Štreimikienė D, Mentel G. Assessment of green investments' impact on sustainable development: linking gross domestic product per capita, greenhouse gas emissions and renewable energy. Energies 2019; 12(20): 3891. https://doi.org/10.3390/en12203891.

[47] Fan W, Hao Y. An empirical research on the relationship amongst renewable energy consumption, economic growth and foreign direct investment in China. Renew Energ 2020; 146: 598-609. https://doi.org/10.1016/j.renene.2019.06.170.

[48] Shahbaz M, Raghutla C, Chittedi KR, Jiao Z, Vo XV. The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. Energy 2020; 207: 118162. https://doi.org/10.1016/j.energy.2020.118162.

[49] Vincent K. Creating an index of social vulnerability to climate change for Africa. Working Paper 56, Tyndall Centre for Climate Change Research and School of Environmental Sciences 2004. University of East Anglia, Anglia.

[50] Deressa T, Hassan RM, Ringler C. Measuring Ethiopian farmers' vulnerability to climate change across regional states. International Food Policy Research Institute 2018. http://www.ifpri.org/pubs/dp/ IFPRIDP00806.pdf.

[51] Pandey R, Jha S. Climate vulnerability index - measure of climate change vulnerability to communities: a case of rural Lower Himalaya, India. Mitig Adapt Strat Gl 2012; 17(5): 487-506. https://doi.org/10.1007/s11027-011-9338-2.

[52] Liua L, Chena T, Yina Y. Energy consumption and quality of life: Energy efficiency index. Energy Procedia 2016; 88: 224-229. https://doi.org/10.1016/j.egypro.2016.06.152.

[53] Baležentis T, Li T, Streimikiene D, Baležentis A. Is the Lithuanian economy approaching the goals of sustainable energy and climate change mitigation? Evidence from DEA-based environmental performance index. J Clean Prod 2016; 116: 23-31. https://doi.org/10.1016/j.jclepro.2015.12.088.

[54] Shortall R, Davidsdottir B. How to measure national energy sustainability performance: An Icelandic case-study. Energy Sustain Dev 2017; 39: 29-47. https://doi.org/10.1016/j.esd.2017.03.005.

[55] Lee CW, Zhong J. Construction of a responsible investment composite index for renewable energy industry. Renew Sust Energ Rev 2015; 51: 288-303. https://doi.org/10.1016/j.rser.2015.05.071.

[56] Cîrstea SD, Moldovan-Teselios C, Cîrstea A, Turcu AC, Darab CP. Evaluating Renewable Energy Sustainability by Composite Index. Sustainability 2018; 10(3): 811. https://doi.org/10.3390/su10030811.

[57] Ang BW. Monitoring changes in economy-wide energy efficiency: From energy–GDP ratio to composite efficiency index. Energ Policy 2006; 34(5): 574-82. https://doi.org/10.1016/j.enpol.2005.11.011.

[58] Iddrisu I, Bhattacharyya SC. Sustainable Energy Development Index: a multi-dimensional indicator for measuring sustainable energy development. Renew Sust Energ Rev 2015; 50: 513–30. https://doi.org/10.1016/j.rser.2015.05.032.

[59] García-Álvarez MT, Moreno B, Soares I. Analyzing the sustainable energy development in the EU-15 by an aggregated synthetic index. Ecol Indic 2016; 60: 996-1007. https://doi.org/10.1016/j.ecolind.2015.07.006.

[60] Peng C, Wu X, Fu Y, Lai KK. Alternative approaches to constructing composite indicators: an application to construct a Sustainable Energy Index for APEC economies. Oper Res 2017; 17: 747–59. https://doi.org/10.1007/s12351-016-0235-z.

[61] Sovacool BK, Mukherjee I, Drupady IM, D'Agostino AL. Evaluating energy security performance from 1990 to 2010 for eighteen countries. Energy 2011; 36: 5846–53. https://doi.org/10.1016/j.energy.2011.08.040.

[62] Sovacool BK. An international assessment of energy security performance. Ecol Econ 2013; 88: 148–58. https://doi.org/10.1016/j.ecolecon.2013.01.019.

[63] Arbolino R, Boffardi R, Ioppolo G. The effectiveness of European energy policy on the Italian system: Regional evidence from a hierarchical cluster analysis approach. Energ Policy 2019; 132: 47-61. https://doi.org/10.1016/j.enpol.2019.05.021.

[64] Foguesatto CR, Borges JAR, Machado JAD. Farmers’ typologies regarding environmental values and climate change: Evidence from southern Brazil. J Clean Prod 2019; 232: 400-07. https://doi.org/10.1016/j.jclepro.2019.05.275.

[65] Opach T, Scherzer S, Lujala P, Rød JK. Seeking commonalities of community resilience to natural hazards: A cluster analysis approach. Norsk Geografisk Tidsskrift - Nor J Geogr 2020; 74(3): 181-99. https://doi.org/10.1080/00291951.2020.1753236.

[66] Del Chiappa G, Atzeni M, Ghasemi V. Community-based collaborative tourism planning in islands: A cluster analysis in the context of Costa Smeralda. J Destin Mark Manage 2018; 8: 41-48. https://doi.org/10.1016/j.jdmm.2016.10.005.

[67] Carbone EA, Pugliese V, Bruni A, Aloi M, Calabrò G, Jaén-Moreno MJ, Segura-Garcia C, De Fazio P. Adverse childhood experiences and clinical severity in bipolar disorder and schizophrenia: A transdiagnostic two-step cluster analysis. J Affect Disorders 2019; 259: 104-111. https://doi.org/10.1016/j.jad.2019.08.049.

[68] Ližbetinová L, Štarchoň P, Lorincová S, Weberová D, Průša P. Application of Cluster Analysis in Marketing Communications in Small and Medium-Sized Enterprises: An Empirical Study in the Slovak Republic. Sustainability 201; 11(8): 2302. https://doi.org/10.3390/su11082302.

[69] Gómez-Muñoz VM, Porta-Gándara MA. Local wind patterns for modeling renewable energy systems by means of cluster analysis techniques. Renewable Energy 2002; 25: 171–82. https://doi.org/10.1016/S0960-1481(01)00013-1.

[70] Parobek J, Paluš H, Kalamárová M, Loučanová E, Šupín M, Križanová A, Štofková K. Energy Utilization of Renewable Resources in the European Union — Cluster Analysis Approach. Bioresources 2016; 11(1): 984-95.

[71] Ntanos S, Skordoulis M, Kyriakopoulos G, Arabatzis G, Chalikias M, Galatsidas S, Batzios A, Katsarou A. Renewable Energy and Economic Growth: Evidence from European Countries. Sustainability 2018; 10: 2626. https://doi.org/10.3390/su10082626.

[72] Scaramuzzino C, Garegnani G, Zambelli P. Integrated approach for the identification of spatial patterns related to renewable energy potential in European territories. Renewable and Sustainable Energy Rev 2019; 101: 1–13. https://doi.org/10.1016/j.rser.2018.10.024.

[73] Everitt BS, Landau S, Leese M, Stahl D. Cluster Analysis. 2011. 5th edition. Wiley.

[74] Kuiper FK, Fisher LA. Monte Carlo comparison of six clustering procedures. Biometrics 1975; 31(3): 777-83. https://doi.org/10.2307/2529565.

[75] Burck J, Hagen U, Bals C, Höhne N, Nascimento L. CCPI Background and Methodology 2020. Germanwatch e.V.

[76] Kamath C. Associating weather conditions with ramp events in wind power generation. IEEE/PES Power Systems Conference and Exposition 2011. https://doi.org/10.1109/PSCE.2011.5772527.

[77] Castán Broto V, Bulkeley H. A survey of urban climate change experiments in 100 cities. Global Environ Chang 2013; 23 (1): 92–102. https://doi:10.1016/j. gloenvcha.2012.07.005.

[78] Jaber JO, Awad W, Rahmeh TA, Alawin AA, Al-Lubani S, Dalu SA, Dalabih A, Al-Bashir A. Renewable energy education in faculties of engineering in Jordan: Relationship between demographics and level of knowledge of senior students'. Renew Sust Energ Rev 2017; 73: 452-59. https://doi.org/10.1016/j.rser.2017.01.141.

[79] Adentunji KE, Akinlabi AO, Meera KJ. The sustainability and efficient use of renewable energy sources in rural areas. AIP Conference Proceedings 1952, 020046, 2018. https://doi.org/10.1063/1.5032008.

[80] Matschoss K, Repo P. Governance experiments in climate action: empirical findings from the 28 European Union countries, Env Polit 2018; 27(4): 598-620. https://doi.org/10.1080/09644016.2018.1443743.

[81] Lapacz A, Miladinova Y, Yesiloglu S. Human values and news' impact on climate change beliefs: A comparative study on millennials in Sweden and Russia. J Promotional Commun 2019; 7 (2): 79-107.

[82] Dw. Lideres y rezagados en la protección del clima. 2019. https://www.dw.com/es/l%C3%ADderes-y-rezagados-en-la-protecci%C3%B3n-del-clima/a-51615280.

[83] Mills-Novoa M, Liverman DM. Nationally Determined Contributions: Material climate Commitments and Discruve Positioning in the NDCs". WIREs Clim Change 2018. https://doi.org/10.1002/wcc589.

[84] Shahsavari A, Akbari M. Potential of solar energy in developing countries for reducing energy-related emissions. Renew Sust Energ Rev 2018; 90: 275–91. https://doi.org/10.1016/j.rser.2018.03.065.

[85] IEA. The Netherlands 2020. Energy policy review. IEA 2020, Paris. https://www.iea.org/reports/the-netherlands-2020.

[86] van Doren D, Runhaar H, Raven R, Giezen M, Driessen P. Institutional work in diverse niche contexts: The case of low-carbon housing in the Netherlands. Environ Innov Soc Tr 2020; 35: 116-34. https://doi.org/10.1016/j.eist.2020.03.001.

[87] Pereira AM, Pereira RM, Rodrigues PG. A new carbon tax in Portugal: A missed opportunity to achieve the triple dividend? Energ Policy 2016; 93: 110-18. https://doi.org/10.1016/j.enpol.2016.03.002.

[88] Pereira AM, Pereira RM. Achieving the triple dividend in Portugal: a dynamic general-equilibrium evaluation of a carbon tax indexed to emissions trading. J Econ Policy Reform 2019; 22(2): 148-63. https://doi.org/10.1080/17487870.2017.1348298.

[89] Rodríguez M, Robaina M, Teotónio C. Sectoral effects of a Green Tax Reform in Portugal. Renew Sust Energ Rev 2019; 104: 408-18. https://doi.org/10.1016/j.rser.2019.01.016.

[90] Schumacher K. Approval procedures for large-scale renewable energy installations: Comparison of national legal frameworks in Japan, New Zealand, the EU and the US. Energ Policy 2019; 129: 139-52. https://doi.org/10.1016/j.enpol.2019.02.013.

[91] Zhang D, Wang J, Lin Y, Si Y, Huang C, Yang J, Huang B, Li W. Present situation and future prospect of renewable energy in China. Renew Sust Energ Rev 2017; 76: 865-71. https://doi.org/10.1016/j.rser.2017.03.023.

[92] Liu J. China's renewable energy law and policy: A critical review. Renewable and Sustainable Energ Rev 2019; 99: 212-19. https://doi.org/10.1016/j.rser.2018.10.007.

[93] Zhang W, Li J, Li G, Guo S. Emission reduction effect and carbon market efficiency of carbon emissions trading policy in China. Energy 2020; 196: https://doi.org/10.1016/j.energy.2020.117117.

[94] Farand C. Poland, Hungary threaten to derail EU plans to raise 2030 climate ambition. Climate Home News 2020. https://www.euractiv.com/section/climate-environment/news/poland-hungary-threaten-to-derail-eu-plans-to-raise-2030-climate-ambition/.

[95] Zlateva P, Yordanov K, Tudorache A, Cirtina LM. An Analysis of Energy Resources in Bulgaria and Romania. International Symposium on Electrical Apparatus & Technologies (SIELA) 2020. https://doi.org/10.1109/SIELA49118.2020.9167132.

[96] Climate Action Tracker. USA 2020. https://climateactiontracker.org/countries/usa/.

[97] Davis M, Ahiduzzaman Md, Kumar A. How will Canada’s greenhouse gas emissions change by 2050? A disaggregated analysis of past and future greenhouse gas emissions using bottom-up energy modelling and Sankey diagrams. Appl Energ 2018; 220: 754–86. https://doi.org/10.1016/j.apenergy.2018.03.064.

[98] Hatim Y. Renewable Energy Could Produce 96% of Electricity in Morocco by 2050. Morocco World News 2020, Acceded https://www.moroccoworldnews.com/2020/07/309093/renewable-energy-could-produce-96-of-electricity-in-morocco-by-2050/.

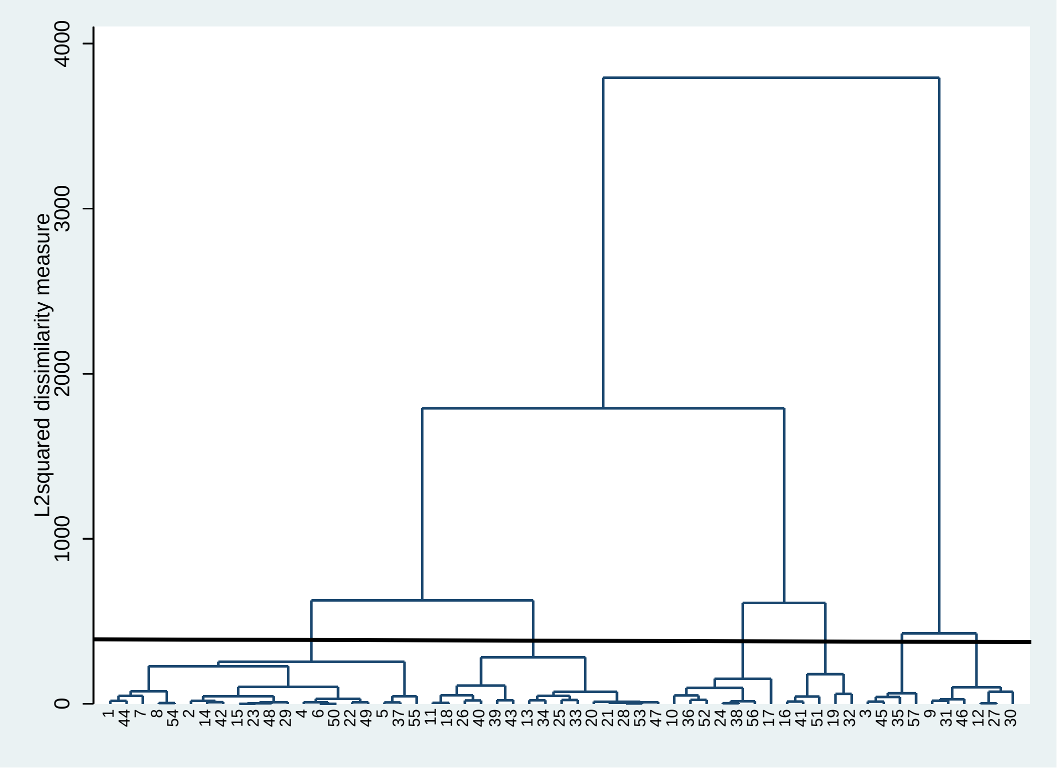
[99] Climate Action Network. Second time in a row, USA at the bottom of the ranking, below Saudi Arabia, in the Climate Change Performance Index 2021. 2020. https://yubanet.com/usa/second-time-in-a-row-usa-at-the-bottom-of-the-ranking-below-saudi-arabia-in-the-climate-change-performance-index-2021/.

[100] Proctor E. These countries do the most for the climate. 2020 https://www.iamexpat.de/lifestyle/lifestyle-news/these-countries-do-most-climate.

[101] Skovgaard J. EU climate policy after the crisis. Environ Polit 2014; 23(1): 1-17. https://doi.org/10.1080/09644016.2013.818304.

Appendix.

Figure 1A. Dendogram



1 Algeria	11 China	21 Germany	31 Korea	41 Norway	51 Sweden
2 Argentina	12 Chinese	22 Greece	32 Latvia	42 Poland	52 Switzerland
3 Australia	13 Croatia	23 Hungary	33 Lithuania	43 Portugal	53 Thailand
4 Austria	14 Cyprus	24 India	34 Luxembourg	44 Romania	54 Turkey
5 Belarus	15 Czech Rep	25 Indonesia	35 Malaysia	45 Russia	55 Ukraine
6 Belgium	16 Denmark	26 Ireland	36 Malta	46 Saudi Arabia	56 The UK
7 Brazil	17 Egypt	27 Islamic	37 Mexico	47 Slovak Rep	57 USA
8 Bulgaria	18 Estonia	28 Italy	38 Morocco	48 Slovenia	
9 Canada	19 Finland	29 Japan	39 Netherlands	49 South Africa	
10 Chile	20 France	30 Kazakhstan	40 New Zealand	50 Spain	