Analysis of the nexus between country risk, environmental policies, and human development

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Abstract

There is currently a two-way link between financial risk and climate change. International agreements on climate change involve more sustainable practices regarding the use of renewable energy and the removal of greenhouse gas (GHG) emissions, to which end there is a need for good access to finance. The aim of this research is to carry out an in-depth analysis of said relationship in order to provide decision-makers with additional information to guide the development of the most appropriate policies for each territory. First, the analysis focuses on whether economic and financial capacity is a sufficient and necessary condition for the implementation of pro-climate policies, using a sample of 55 countries spanning all continents. Second, this paper proposes a synthetic index that can be used to jointly assess climate change and country risk, before then determining whether the position reached by a country with respect to the index is similar to its relative level of human development. The research draws on the Climate Change Performance Index, Country Risk Score and Human Development Index, all corresponding to 2018. The results show that good performance in tackling climate change requires adequate economic and financial capacity, although this alone is not sufficient. The USA, Canada and Australia enjoy an economically advantageous position and yet they need to intensify their efforts in terms of policies that support the electricity supply from renewable energy and the reduction of GHG emissions. It is also concluded that good living conditions help drive climate change action and financial market access.

Keywords: Country Risk Score; Climate Change Performance Index; Renewable Energy; GHG Emissions; Human Development Index; Cluster; Cross efficiency

Acronyms

GHG: greenhouse gas emissions

CCPI: Climate Change Performance Index

CRS: Country Risk Score

SI: synthetic index

CE: cross efficiency

DEA: Data Envelopment Analysis

HDI: Human Development Index

RE: renewable energies

DMUs: decision-making units

1. Introduction

Globalization has meant that concepts such as climate change and country risk cannot be analysed in isolation. The first concept refers to long-term shifts in temperatures and weather patterns, while the second encompasses the investment risk associated with a country, such as risk of default on a bond, risk of losing direct investment, and even risk to global business relations. Over time, this juxtaposition has gradually become established, reinforced by the need to ensure all countries' full commitment to implementing measures aimed at mitigating the adverse effects of climate change [1]. Such measures seek to improve environmental quality, which has been severely altered by human activity [2]. Since early1970s [3], sustainable development arose as a broad social goal focused on the demand to embody the need to halt and reverse systematic ecological degradation with the pursuit of improved human wellbeing. The United Nations Framework Convention on Climate Change, established almost three decades ago, marked the beginning of this movement. It reflected the urgent need to set out a roadmap to maximize the implementation of measures aimed at slowing global warming. Following this landmark event, numerous climate summits have been held, at which agreements have been signed with the aim of reducing greenhouse gas (GHG) emissions, the main cause of environmental problems. Nevertheless, without long-term financing, it is not possible to address the climate crisis [4]. The transition to a green economy requires ongoing support from the financial system, not just because of its role as an intermediary and in channelling funds towards this conversion, but also because of the financial risks associated with the actions needed to mitigate climate change [5].

The entry into force of the Kyoto Protocol in 2005, which marked the first recognition of the need to reduce emissions, led to the creation of the European Union Emissions Trading System. This system was established to facilitate the distribution of carbon quotas among companies, in order to ensure compliance with environmental agreements. However, despite the boost given by the banking system, this initiative never really took off, with activity shutting down in early 2010 [6]. The association between the financial system and climate change gained momentum following the Paris Agreement, approved in 2015 and ratified by 194 countries. A fundamental objective of the agreement is to limit the increase in the global average temperature to less than 2°C above pre-industrial levels. Achieving this goal requires not only the development of alternative industries and the forming of new habits among the population, but also an energy revolution at all levels to respond to the urgent need to decarbonize the economy [7, 8, 9].

This new scenario underscores the two-way link between financial risk and climate change. The latter magnifies the former, while at the same time, financial vulnerability limits the possibilities for cleaning up the environment [10]. Climate policies call for radical changes not only in economic sectors but also in consumer preferences. There is a need to implement new, environmentally-friendly technologies that guarantee the sustainable development of the economy [11]. It is against this backdrop that financial institutions start to detect business opportunities, with green growth becoming established as a source of new financing and investment businesses. In addition, there is growing support from central governments, which are being called on to provide funds in the form of subsidies, guarantees or other methods that promote sustainable investments and help address the environmental needs of regional governments [12,13, 14, 15].

The implementation of environmental policies has direct consequences for economic growth [16]. Uncertainty is expected to increase in the medium and long term due not only to constraints on public and private financing, but also to structural changes in the economy. This transformation requires substantial financial flows; it is here that capital markets assume a relevant role, due to the inadequacy of traditional channels [17].

The association between climate change and country risk has sparked the interest of the scientific community, as can be seen in the recent extensive literature on the topic. Capasso et al. [18] study the possible relationship between exposure to climate change and country risk, showing that this nexus is stronger after the entry into force of the Paris Agreement. They conclude that climate risks threaten the stability of credit intermediaries and bond markets. Gianfrate and Peri [19] confirm the market preference for bonds classified as green, with the higher cost associated with their certification being offset. It has also been shown that carbon emissions increase both sovereign risk [20] and the risk of companies in high-emitting sectors [21]. Other authors such as Guo et al. [2] reveal that country risk negatively moderates the link between inequalities and emissions in low-and high-income countries. However, there is no global framework to describe the potential impact that the specific socio-economic characteristics of each country may have on the formulation of policies aimed at mitigating climate change. This research helps identify different regional profiles to gain a better understanding of various governments' shortcomings and the progress they have made in their attempts to curb global warming.

The aim of this research is to undertake a broader study of the association between country risk, climate policies and human development in a set of 55 economies spanning all continents. The analysis of territories with very different socioeconomic profiles will allow to assess the existing differences and determine those countries that need greater progress. The study uses the pillars of the Climate Change Performance Index[1] (CCPI) and the Country Risk Score[2] (CRS), both corresponding to 2018, to address all aspects of both climate change and country risk. The environmental objectives set out in international agreements are often general in application, established without considering the financial and social situation of each territory. This research aims to shed light on possible relationships between the socio-economic and environmental situation of different regions. Policymakers will be able to take precise measures to mitigate climate change, while respecting the specific circumstances of individual countries. The empirical analysis conducted provides answers to two research questions:

Q1. Is the economic and financial capacity of countries a necessary and sufficient condition for the implementation of pro-climate policies?

[1] The CCPI is a tool used to measure the degree to which countries are on track to meet the global goals of the Paris Agreement by evaluating their current status and future targets. It analyses and compares climate change mitigation efforts across 57 countries with the highest emissions (plus the EU as a whole). A total of 400 national experts evaluate their countries' most recent national and international climate policies. The overall index places countries within the interval [0, 100], where higher values indicate more "climate-friendly" behaviour.

[2] The CRS evaluates the investment risk of a country by means of a qualitative model, relying on an expert opinion on risk variables within a country, and combining it with a basic quantitative value. The CRS is indicated on a 100-point scale, with 0 being completely exposed to every risk, and 100 being practically devoid of any risk.

A cluster analysis is applied using all the pillars relating to the CCPI and the CRS to determine which countries with similar economic capacities show homogeneous situtation in tackling climate change. The groups identified by said method will provide an answer to this question.

Q2. Are countries' positions in a joint CCPI and CRS ranking similar to their positions in a human development ranking?

A synthetic index (SI) is constructed by jointly considering countries' financial and climate position, using cross efficiency (CE), an extension of Data Envelopment Analysis (DEA). The proposed SI will make it possible to compare countries' position relative to their level of human development, as determined by the Human Development Index (HDI).

The proposed research bridges the gap in the literature surrounding the nexus between country risk and climate change. Specifically, it makes the following contributions: (1) evidence is provided on the discrepancy between countries' economic and financial situation and their efforts to achieve the objectives established in international agreements on climate change, in an analysis covering a wide range of countries, whereas other authors such as Chiu and Lee [22] have focused on specific areas (OECD countries); (2) the proposed synthetic index allows us to jointly study the guidelines developed in relation to climate change and country risk, which is a novel analysis in the literature; and (3) the relationship between the level of human development and the proposed synthetic index is not significant. All this is useful for demonstrating to the largest economies in the world that their economic position alone is not sufficient to make them a reference for best practices in tackling climate change. In addition, the importance of human development in the context of this research is emphasized.

The rest of the paper is structured as follows. Section 2 reviews the literature on the financial issues involved in implementing climate-friendly measures. Section 3 presents the methods and sample used. Section 4 discusses the results of the research. Lastly, the conclusions, the contribution of the study and its limitations are summarized in section 5.

2. Literature review

Several global agreements and commitments have recognized the need to achieve steady economic growth by ensuring environmentally sustainable progress and the reduction of GHG emissions. The use of renewable energies (RE) plays a significant role in such efforts. Energy transition has increased attention due to the Paris Agreement and the decreasing costs of RE [23]. Thus, investment in RE and redirection of investment flows to these technologies is outstanding to achieve the goals set out in global climate agreements.

The overarching goal is that there should be global access to clean, modern, efficient, and affordable energy facilities by 2030 [24, 25]. Sustainable social development requires countries to fight global warming and to make the shift towards energy efficiency and clean production [26, 27, 25, 28]. Modern, clean, and efficient energy is believed to be a precondition for the achievement of the Millennium Sustainable Development Goals and poverty alleviation [25]. According to Chirambo [24], energy can be considered much more important than the access to finance in this regard [29]. In this setting, the importance of energy efficiency is becoming clearer, as reflected in the large body of literature recently developed [30, 31, 32]. Popkova and Sergi [33] suggest that energy efficiency can be ensured by reducing energy consumption and increasing the share of renewables, creating a model for both emerging and developed countries. It has even been shown that energy poverty translates into a reduction in GDP and can have a direct impact on social welfare [34]. Sun et al. [35] propose technological innovation to guarantee the reduction of energy intensity where globalization eliminates border barriers, allowing the dissemination of knowledge for universal application of technological advances.

In this vein, much of the debate on climate change and RE has been focused on the role of public and private financial actors and institutions, and the access to loan finance, [36, 37]. According to Jiang and Martek [38], the lack of reliable and clean energy represents an obstacle to a country development. Thus, to unlock the full socioeconomic potential of the energy transition, there is a need to encourage foreign direct investment in developing countries [23]. For this purpose, developing countries need to address two highly controversial issues: carrying out proper valuations of RE investments and measuring political risk.

Thus, country risk is a good indicator of economic, financial and political stability and also of the potential credit and financial cost. Access to finance and country risk have been the topic of broad research [39], which has found that the lower the financial cost and the easier the access to finance, the better the environmental performance. For example, Shahbaz [40] finds that financial instability increases environmental degradation. On the other hand, Brunnschweiler [41] and Wu and Broadstock [42] report that overall political stability and avoiding corruption have a potential positive impact on RE projects. Moreover, corruption and unfair competition can also be related to illegal and unfair treatment of foreign companies, which may make international investors and firms reluctant to invest. Country risk also measures a country's level of development, its probability of debt default, political stability and, international investor confidence [43]. There is abundant research which relates investment/financial risk and RE projects (Table 1).

Table 1. Literature review

Authors	Samples	Methods	Empirical findings
[30]	2935 relevant scientific publications over a 30-year period from 1990 to 2019 in the Social Science Citation Index	Bibliometric analysis	This research assists in formulating environmentally sustainable policies to tackle the adverse effects of CO2 emissions and related climate change through providing critical grasps on the scholarly development related to energy efficiency.
[31]	28 OECD economies. Annual data 1990–2014	Panel estimation techniques	The results confirm that environmental technology has a substantial negative influence on energy consumption and plays an important role in improving energy efficiency by reducing energy intensity.
[32]	128 countries	Cluster analysis and contingency tables	Economies with the lowest GDP growth and the highest incomes hold the top positions in the WETI ranking. Also, contingency tables confirm the association between the *Country context* and sustainable energy development.
[33]	5 developed countries (USA, Canada, the UK, Germany, Japan, France, Italy, the Netherlands, Australia, and South Korea) and developing countries (China, India, Brazil, South Africa, Russia, Mexico, Thailand, Turkey, Indonesia, and Saudi Arabia).	Multiple regressions and correlation analyses	The paper indicates the reasonable likelihood of noteworthy achievement results in energy efficiency with insignificant mid-term changes.
[34]	The data is collected from the World Bank Indicators database, the US energy information database, world energy council and the international energy agency database. About 14 countries	Data envelopment analysis and entropy method.	Results reveals that expenditure associated energy poverty has major share while electricity consumption-based energy poverty is the second major factor. Moreover, there is an absence of modern electricity access in less energy efficient areas.
[36]	RE dataset constructed using Bloomberg New Energy Finance (2004-2014)	Entropy-based measures of portfolio balance, and risk direction	Financial actors create directions in innovation by their investment choices. Public investors are increasing their investment in portfolios with higher risk technologies.
[37]	New power plant investments in Germany 2010–2015 using Bloomberg New Energy Finance	Logistic regression	RE are becoming more appealing for low investment risks, in contrast to fossil fuel-based power plants.
[44]	Energy companies that implement projects in Russian and international energy markets	Logistic regression	RE sources projects that received non-repayable subsidies are characterized mainly by a high level of risk at the pre-investment stage.
[45]	Survey given to professional experts	Multi-criteria decision	Economic and business risk is the most significant investment risk factor. RE technology choices represents the most suitable strategy to eliminate risk.

[46]	Solar panel project	Monte Carlo and Net present value risk	In each scenario, the NPV risk method revealed dissimilarities in project performance.
[47]	Survey given to expert team	Hybrid multi-criteria decision-making	The most important factors for RE investment are organizational effectiveness and cost efficiency. To increase organizational effectiveness, RE companies' departments should work more harmoniously.

Source: authors' own elaboration

Furthermore, the scientific community has focused its efforts on explaining how country risk influences energy consumption [40, 48, 49, 50, 23, 51]. In this vein, Chiu and Lee [22] study the impact of country risk on the relationship between financial development and energy consumption for a sample of 34 OECD and 45 non-OECD countries. In their sample, OECD countries are found to have better performance than non-OECD countries. According to Zhang et al. [52], the global energy trade is influenced by country risk. Thus, from a network perspective, they analyse the trade patterns of energy, as well as exploring the impacts of the different kind of country risk (economic risk and political risk) on importers and exporters trade patterns. Network analysis showed countries occupied different roles and influence.

In recent years, Chinese RE sources have accounted for an increasing share of electricity generation [53]. However, some banks have been blamed of financing fossil fuel projects in risky countries. Niczyporuk and Urpelainen [54] show that countries that have higher corruption and country risk levels are more likely to obtain energy finance. All these investment patterns imply lost opportunities for promoting renewable energy and exacerbate the poor climate change performance and risk of host countries.

Focusing on the link between RE and economic development, some authors show a positive impact of RE on economic growth and development [53, 55, 56, 57, 58], primarily in OECD countries. Conversely, others find a negative impact [59, 60, 61] driven by the high costs of RE or by being mainly non-RE consumer economies such as India, Ukraine or the USA. Wang et al. [62] study the relationship between RE and economic growth and development from a risk-based perspective, which includes economic, financial, and political risks, among others.

Recent literature highlights the scientific community's efforts to promote the transition towards an environmentally friendly, energy-sustainable, and socially-inclusive society [63,64,65]. In this vein, the proposed research provides evidence to establish a framework of action adapted to each territory. The aim is to clarify whether the implementation of international agreements is conditioned by the country's financial capacity, while at the same time accounting for quality of life measured in terms of health, education, and per capita income. It can thus be said that the good financial situation of a country conditions its environmental proactivity, and vice versa; furthermore, both aspects influence the level of human development in that country.

3. Methodology and Data

3.1 Methodology

In the context of climate change, the clustering technique has been applied in several studies in order to contribute to the knowledge base about the current situation. For example, Kijewska and Bluszcz [66] use cluster analysis to study the GHG emissions of EU countries. Kwon et al. [67] apply it to identify groupings according to the characteristics of particulate emissions, thus guiding the lines of action aimed at mitigating climate change. Kammermann and Dermont [68] generate clusters to examine the factors that explain clean energy policies and support the transition to RE. More recently, Azócar et al. [69] have applied this method to South American countries to detect similarities in terms of perception of and vulnerability to climate change.

The cluster analysis used to answer *Q1* allows the sample to be divided into groups, in such a way as to ensure that the composition of each group is homogeneous as possible, while also ensuring heterogeneity between the different groups [70]. In this paper, hierarchical clustering has been applied, as it is not necessary to first specify the number of groups when using this technique. We use the agglomerative hierarchical method, starting with n groups (with n being the same as the number of observations) and then merging the similar ones until an appropriate number of groups can be determined from a dendrogram. In social research, this technique is preferred to divisive hierarchical clustering, primarily because of its computational efficiency [71].

There are five different methods that can be used to perform agglomerative hierarchical clustering, of which Ward's method is the most widely used in the related literature. According to Kuiper and Fisher [72], this classification technique is very powerful since it merges different elements while trying to minimize the within-cluster variance. Finally, a post-analysis using the Kruskal-Wallis test is carried out in order to ensure that the groups identified are significantly different from each other. The test allows to verify that the mean of each group is statistically different from the rest.

The second part of the research involves the construction of an SI combining the environmental aspects included in the CCPI and the financial aspects of the CRS. The aim is to provide a joint index that avoids the need to subjectively allocate weights, which can sometimes give rise to errors when applying the same treatment to a wide range of countries with very different socioeconomic characteristics [73, 74] The most commonly used methods in the literature are Multi-Criteria Decision Analysis and DEA; however, only the latter frees researchers from having to assign weights to the assessed items. Both methods have proved popular with the scientific community, where they have been applied to specific topics such as water [75], urban sustainability [76], tourism [77] and quality of life [78]. They have also been very useful for creating links between different research topics, the joint analysis of which can be of great benefit to decision-makers; these include energy and sustainable development [79], finance and growth [80], sustainability and wastewater management [81], and agriculture and economic vulnerability [82].

The proposed SI is constructed using an extension of DEA called CE. It is used to establish a ranking of countries that allows us to answer *Q2.* DEA is based on mathematical programming aimed at calculating the relative efficiency of the decision-making units (DMUs) that comprise the sample under analysis. The method consists of estimating a production function to identify whether, with the inputs used, it has been possible to maximize the outputs (output orientation), or vice versa—if it has been possible to minimize the resources used while still achieving the desired product (input orientation). Originally, Charnes et al. [83] proposed the linear programming model under the assumption of constant returns to scale, where an increase in inputs yields a proportional increase in outputs. This assumption turned out to be quite restrictive when dealing with problems defined by variables of very different scope. In order to provide greater flexibility, Banker et al. [84] introduced the possibility of solving DEA with variable returns to scale, that is, allowing the inputs and outputs that define the production function to vary freely.

In the context of this initial approach, CE was developed as an extension of DEA that could be applied to classify DMUs according to their performance, using CE scores; that is, by performing a peer evaluation [85]. CE calculates efficiency values *n* times for DMUs, using the optimal weights obtained when evaluating each DMU individually. These values form a CE matrix, the elements of which are derived from the application of the following expression:

$$E_{kj} = \frac{\sum_{r=1}^{s} u_{rk} y_{rj}}{\sum_{i=1}^{m} v_{ik} x_{ij}} \quad j = 1, \dots, n; k = 1, \dots, n \tag{1}$$

where: m and s correspond to the number of input and output variables, respectively; y_{rj} the value of output r of the j- th DMU; x_{ij} the value of input i of the j- th DMU; u_{rk} the weight of output r; v_{ik} the weight of input i.

Furthermore, E_{kj} represents the efficiency value of DMU j assessed with the optimal weights for DMU k, such that each unit is evaluated using the best weights of the others, with each E_{kj} constituting an element of the CE matrix. In the proposed empirical study, the CE value of each DMU has been taken as the average of these peer evaluations.

$$CE_j = \frac{1}{n} \sum_{k \neq j} E_{kj} \quad j = 1, \dots, n \tag{2}$$

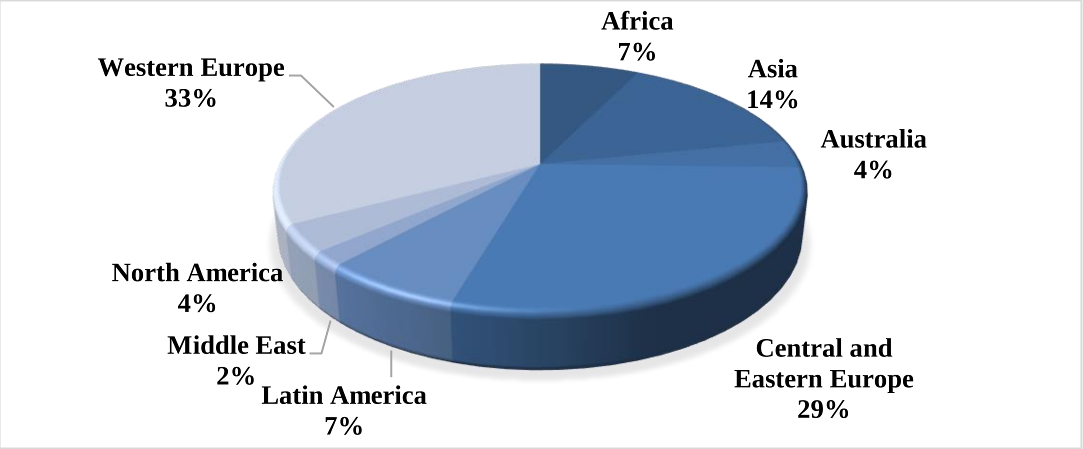
The main advantage this method offers over others lies in its ability to provide a single ranking of DMUs, while avoiding unrealistic weight schemes and without having to elicit weight restrictions from experts in the area of application [86]. Other multi-criteria decision methods such as TOPSIS and ELECTRE have been widely used in the literature to establish rankings based on a set of alternatives [87]. CE requires only the definition of a hypothetical production function, forming a reference frontier relative to which observations can be ordered [88, 89]. Conversely, TOPSIS and ELECTRE require a weight to be assigned to each criterion, reflecting its degree of importance [90]. The calculations were done using the deaR statistical package implemented in Rstudio [91].

3.2 Data

In this study, since the focus is on climate change policies, the data used are sourced from the components of the 2021 CCPI, which is based on 2018 information. The CCPI evaluates 57 countries, together generate 90%+ of global greenhouse gas emissions, and the actions they take to foster environmental protection; CCPI assesses their compatibility with the goal of keeping global warming below 2ºC or even 1.5ºC. Since 2005, this index has been produced annually by Germanwatch, the NewClimate Institute and Climate Action Network-International. The results provide information on the achievement of the goals set in the Paris Agreement based on the analysis of four indicators: GHG emissions, RE, Energy Use and Climate Policy [92]. The overall index places countries within the interval [0, 100], where higher values indicate more "climate-friendly" behaviour.

On the other hand, the CRS is defined by the Euromoney Agency [93][3] as a combination of different categories related to debt, access to credit, political, economic, and structural assessment for 174 countries [94, 95]. Country Risk refers to conditions and events in a foreign country that may adversely affect financial institutions' operations. It also denotes the probability of a foreign government defaulting on its financial obligations. Banks must institute adequate systems and controls to manage the inherent risks in their international activities. It is a term for the risks involved in financial operations when investing in a particular country. As we use the pillars of both the CCPI and CRS, we have had to homogenize the sample, analysing only the countries evaluated in both indices; consequently, the sample has been reduced to 55 countries (Figure 1).

Figure 1. Distribution of countries in the sample by geographical area



3 The CRS is indicated on a 100-point scale, with 0 being completely exposed to every risk, and 100 being practically devoid of any risk. Participants give each country with which they are familiar a score from 0-10 across all sub-factors to equal a score out of 100.

Source: authors' own elaboration

As shown in Figure 1, there is a large presence of European countries; more than half are from Eastern and Western Europe. Given Europe's firm commitment to the approved environmental guidelines, the fact that it is very well represented in the sample will allow us to identify patterns to be followed by less advantaged countries. The rest of the countries are spread around the world, such that all the continents are represented. This wide diversity of socio-economic characteristics covered helps ensure the robustness of the results, allowing a response to any situation. In addition, all of the analysed countries need to take a proactive attitude to curb global warming since they are responsible for most of the world's GHG emissions. The main statistics of the variables analysed in the two indices are presented below (Table 2 and Table 1A in appendix).

Table 2. Descriptive statistics of CCPI indicators and CRS

		Mean	*Max*	*Min*	*SD*	*Interval*	*Weight*
CRS	Economic assessment	59.11	86.50	31.34	12.70	0-10	35%
	Political assessment	63.66	91.55	29.44	17.47	0-10	35%
	Structural assessment	62.08	85.47	29.07	13.16	0-10	10%
	Access to capital	7.68	10.00	2.25	2.34	0-10	10%
	Debt indicators	6.62	9.10	3.91	1.34	0-10	10%
CCPI	GHG emissions	20.98	33.15	2.84	6.57	0-100	40%
	Renewable energy	7.51	14.17	0.79	3.50	0-100	20%
	Energy use	11.43	18.54	3.50	3.02	0-100	20%
	Climate policy	8.59	19.38	0.80	4.32	0-100	20%

Source: authors' own elaboration

Table 2 shows widely differing behaviour depending on the variables under analysis. The mean values corresponding to the CRS pillars all exceed the average of the valuation interval, while in the CCPI only *GHG emissions* and *Climate policy* do, registering merely acceptable results. *Access to capital* stands out in that 42% of the countries in the sample score a 10 in this item. All this underscores the fact that international agreements are not managing to secure the agreed global commitment. Efforts must be made to ensure countries introduce new practices that support climate performance. Currently, climate change is still of secondary importance compared to the economic and financial situation: this is something that must be reversed if we want to put a halt to the disastrous consequences threatened by global warming.

In the process of constructing the SI using the CE method, it is necessary to specify inputs and outputs. The objective is to build a ranking of the countries that make up the sample, rather than to determine their level of efficiency, hence the choice of inputs/outputs is made by the researcher [96, 97, 98]. In this analysis, it is posited that the financial situation (input) determines the capacity to implement clean energy (output), as reflected in the most recent literature [99, 100]. Table 3 shows the variables used as inputs and outputs.

Table 3. Definition of inputs and outputs

Inputs	***Outputs***
Economic assessment	GHG Emissions
Political assessment	Renewable Energy
Structural assessment	Energy Use
Access to capital	Climate Policy
Debt indicators	

Source: authors' own elaboration

The inputs are the pillars of the CRS, while the outputs are those of the CCPI. In this way, we can examine how access to financial resources is transformed into actions aimed at mitigating climate change. The construction of the SI requires the inputs to be converted into "aspects to be improved", by subtracting the value corresponding to each observation from the maximum value. In order to answer the second research question, this SI will be compared with the HDI.

These three indices were chosen in order to be able to conduct a homogeneous assessment of all the countries in the sample. They monitor the three key pillars of the proposed research (financial situation, climate change action, and level of human development), accounting for multiple aspects that would be hard to assess in isolation.

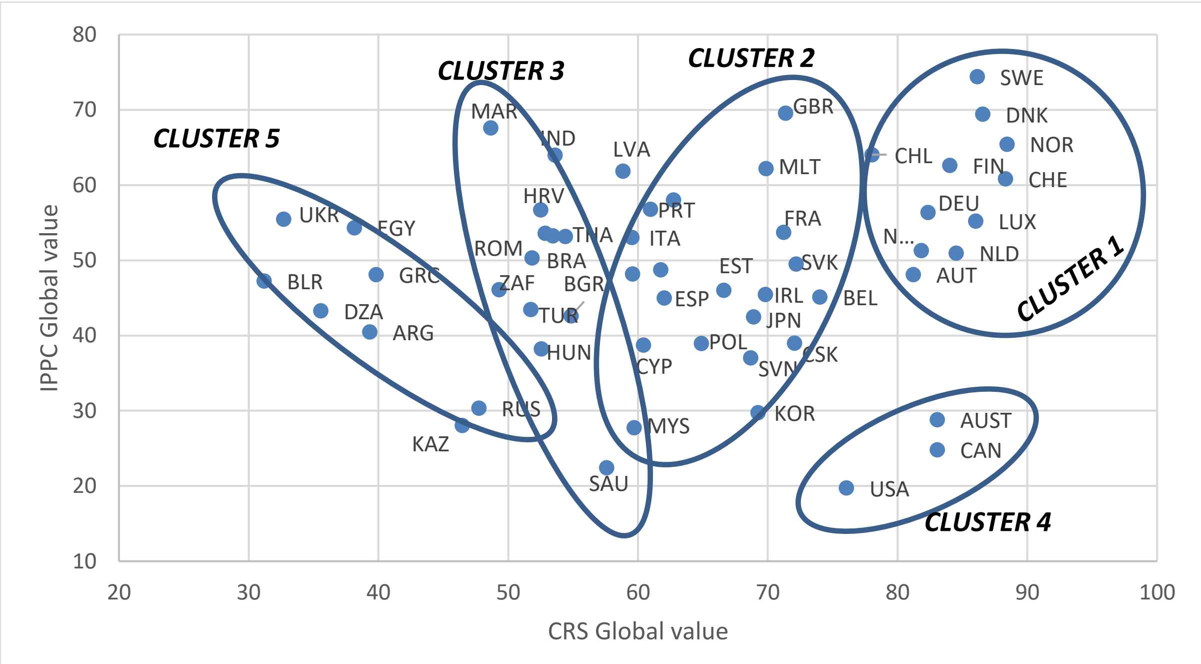
4. Results

By applying the clustering technique to the five pillars of the CRS and the four pillars of the CCPI, we can identify the countries that display homogenous situation in terms of both climate change and country risk. The results provide an answer to the first research question.

> *Q1. Is the economic and financial capacity of countries a necessary and sufficient condition for the implementation of pro-climate policies?*

The dendrogram resulting from the clustering technique has identified five groups out of the countries analysed (Figure 1A in the Appendix). Based on the overall value of the CCPI and CRS, they have all been depicted on a plane, where the resulting clusters can be discerned[4] (Figure 2).

Figure 2. Distribution of countries according to the CCPI and CRS.



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[4] Table 2A in the appendix specifies the countries that belong to each cluster along with their corresponding code.

Source: authors' own elaboration

The homogeneous clusters of countries identify the level of economic and financial capacity of each group. According to Figure 2, clusters 1 and 4 show the best access to finance in the case of highly economically developed nations, cluster 2 registers a medium-high level, 3 is identified with a medium-low level and 5 with the worst conditions. However, climate change performance only shows a fully defined profile in clusters 4 and 1, with extreme values—very low in 4 and very high in 1. Conversely, there is major dispersion in the countries that make up the rest of the clusters.

In order to characterize each group, the mean value of the pillars for each cluster is compared with the mean score obtained for the full sample. Table 4 presents the means and the result of the Kruskal-Wallis test for heterogeneity between clusters.

Table 4. Comparison of mean values between groups

	Economic assessment	*Political assessment*	*Structural assessment*	*Access to capital*	*Debt indicators*	*GHG emissions*	*Renewable energy*	*Energy use*	*Climate policy*
Total Mean	**59.11**	**63.66**	**62.08**	**7.68**	**6.62**	**20.98**	**7.51**	**11.43**	**8.59**
Mean C1	76.40	86.59	79.25	9.91	8.02	25.79	10.93	10.73	12.45
Mean C2	58.37	68.75	65.62	8.59	6.99	19.68	6.71	11.12	8.38
Mean C3	54.97	52.01	52.81	6.07	5.93	20.31	8.32	12.13	8.43
Mean C4	70.21	83.08	77.54	10.00	7.06	11.89	3.06	6.02	3.49
Mean C5	39.01	35.21	42.41	4.89	5.03	22.10	4.01	13.89	5.62
				Kruskal-Wallis Test					
Chi-Squared	38.516	49.422	48.543	33.229	28.705	12.957	22.929	13.744	16.096
p-value	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.008	0.003

MANOVA			
Wilks' lambda: 0.016 p-value:0.000	**Pillai's trace**: 1.851 p-value: 0.000	**Lawley-Hotelling Trace**: 19.016 p-value: 0.000	**Roy's largest root**:17.262 p-value: 0.000

Source: authors' own elaboration

The results of the Kruskal-Wallis test confirm that the classification is appropriate, as it shows that the pillars of all the groups are significantly different (p-value <0.05). Also, four MANOVA test statistics reject the null hypothesis, indicating some kind of difference between the four-dimensional mean vectors of the five clusters. This aggregation allows the individual analysis of the most relevant characteristics of each group.

Cluster 1. Countries with maximum ease of access to finance and good climate performance. This group consists of 4 Northern European economies, 5 Western European ones, Chile and New Zealand. For all the analysed items, they all present mean values above the full sample mean (Figure 2). These are countries that have been able to channel their access to finance into adequate mitigation of GHG emissions and intensive use of RE, all in a context of active environmental policies. These results confirm the findings reported by Stolarski et al. [101] in a study that reveals the good work done by Northern Europe in this regard, serving as a model for the international development of bioenergy. Likewise, Cervelló-Royo et al. [95], following an application of the clustering technique to Latin American countries, confirm that Chile is the only South American country in the group showing positive results.

In short, this group is composed of countries that actively support climate change performance and also have good access to finance, which facilitates their pro-climate commitment. In order for governments to foster the actions needed to bring about the transition, they need to take an active position against global warming and have an adequate economic and financial situation.

Clusters 2 and 3. Countries very close to the full sample mean in the CRS and CCPI pillars. In terms of financial capacity, cluster 2 surpasses cluster 3, but in relation to climate change performance they both present values around the full sample mean, with cluster 3 registering slightly higher values. Cluster 2 consists of 14 European and 3 Asian countries (Japan, Malaysia and South Korea), while cluster 3 contains greater geographical variety: 2 South American countries, 7 Eastern European, 6 Asian, and 2 African. Regarding the latter, Morocco is notable for its high CCPI values and medium-low access to finance; it is an African country that has striven to introduce improvements that allow it to curb climate change [102].

These two clusters need to show greater commitment to all international climate change agreements, to which end better access to financing could be very helpful. Compliance with international climate regulations requires the introduction of new forms of production that are more respectful of the biosphere. As part of the Paris Agreement, the most developed countries committed to mobilizing $100 billion a year to support the needs of less wealthy nations. To date, however, this money has not reached its target, with the commitment being ratified once again at the last climate summit held in Glasgow in 2021 [103].

Cluster 4. Countries with high access to finance and a low level of commitment to climate change. This cluster includes Australia, Canada and the USA, all highly developed countries with easy access to finance, but with low scores in the pillars that indicate their environmental performance. Their poor performance in this regard is exacerbated by very lax climate policies that discourage the private sector from introducing sustainable practices (Figure 2). Hahnel et al. [104] and Zawadzki et al. [105] offer a useful perspective on climate change denial in USA. In the last decade, while Democrats, independents, and even liberal or moderate Republicans have accepted the reality of global warming, conservative Republicans have become more sceptical about the idea of treating it as a real problem requiring the utmost attention [106]. According to Hornsey et al. [107], this phenomenon is stronger in the USA than in other countries with similar characteristics.

Therefore, the composition of this cluster demonstrates that access to finance is a necessary but not a sufficient condition for climate change mitigation performance. If national politics does not support sustainable policies, there is no way to implement the measures needed to try to correct and curb the effects of environmental degradation.

Cluster 5. *Countries with a severe lack of access to finance and little action against climate change.* This cluster consists of 7 countries: 2 African, 1 Latin American and 4 European. These are economies with lower mean values in all aspects covered by the CRS. In regard to the CPPI, however, they reach the maximum in *Energy use* (Ukraine) and are above average in *GHG emissions* (Algeria and Ukraine). In contrast, Russia is a large energy exporter that has not implemented any ambitious climate mitigation measures. This cluster consists of countries that are especially vulnerable to climate change [108] and have scarce economic resources that are difficult to access; nevertheless, they engage in environmentally responsible practices, with the fact that they register average values in the CCPI underlining the effort they have made (Figure 2).

In summary, from the analysis of the situation of homogeneous groups of countries, it can be concluded that good economic and financial capacity is necessary but not sufficient to ensure countries' commitment to tackling problems related to climate change (*Q1*). To ensure compliance with international agreements on climate change, it is essential for a country's politics to be aligned with environmental needs and support sustainable practices. However, it is worth highlighting the efforts of countries such as Ukraine and Egypt, which are characterized by poor access to finance but a marked willingness to adopt measures to curb global warming.

Q2. Are countries' positions in a joint CCPI and CRS ranking similar to their positions in a human development ranking?

The calculation of CE has yielded an SI that jointly considers the CCPI and CRS. It has been used to establish a ranking of the 55 countries analysed (SI Ranking), which is then compared with the level of human development of countries in this sample (HDI Ranking). This analysis, aimed at identifying the countries showing the greatest differences between the areas under study, reveals two markedly different types of economies: countries that have an SI Ranking more than 25 positions lower than their HDI Ranking (Type I); and countries where the SI Ranking exceeds the HDI Ranking by more than 25 positions (Type II). Table 5 presents the results:

Table 5. SI and HDI rankings

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

New Zealand	20	12	Slovenia	40	19
Spearman´s rho: 0.096 (p-value: 0.483)					

Source: authors' own elaboration

The comparison of the two indices reveals no disparity in the countries that occupy the top five positions (none of them are type I or II); however, Spearman's correlation indicates that in the overall sample the two rankings are independent of one another. In a similar context, Akbar [109] confirms the existence of unidirectional negative causality between CO_2 emissions and the HDI; that is, the activity of countries with good living conditions is characterized by low CO_2 emissions. However, from position 6, the two rankings show notable disparities, as identified by the two types established.

Type I. Morocco, India, Ukraine, Mexico, Brazil, Indonesia and Thailand. These are countries that show a high degree of concern about climate change and have a certain ease of access to capital markets, however, their level of development in terms of education, life expectancy and wealth places them at the bottom of the HDI ranking (in relative terms within the current set of countries). Therefore, promoting human development in these countries could be achieved by implementing actions aimed at mitigating climate change.

Type II. These are highly developed economies; namely, the USA, Canada, Australia and South Korea. They all have low SI scores and high HDI scores. Coinciding with the results of cluster 4, these can be identified as highly economically developed nations with good living conditions, but countries that have distanced themselves from the green movement aimed at curbing climate change, thus giving rise to a massive disparity. There is a need to raise awareness in these countries so that they can channel their efforts in the right direction and in line with international climate agreements.

In answer to *Q2*, and according to the criteria established in the study, 18% of the countries in the sample present major disparities between the two rankings, while 82% hold fairly similar positions, or even the same position, as is the case of France (21st). It is important to qualify that above a specific threshold the differences in the HDI are not relevant; these are countries with a "very high" level of HDI and in general are qualitatively very similar. This shows that human development is a driver of action against climate change and access to financial markets, with all nations having ample room for improvement. In this respect, Hickel [110] concluded that countries with better living conditions should significantly reduce their ecological impact, while those with lesser ecological impacts should improve their social outcomes, thus confirming the disparity in the two contexts analysed.

5. Conclusion and Policy Implications

The need to slow global warming has sparked the interest of researchers, who have developed a body of literature aimed at providing insights and guiding decision-makers in the adoption of the most appropriate policies in each situation. This research covers a gap in the literature by examining aspects that a priori may be considered very different but, as has been show here, are profoundly connected: access to finance, commitment to tackling climate change and citizens' living conditions. To do so, we have used a sample of 55 countries spanning all the continents, but the vast majority of the countries included represent the EU and other high-income regions. This allows us to conduct the analysis in a context where developed countries predominate.

It has been confirmed that access to finance is a necessary condition for the ability to implement the drastic changes dictated by international climate demands. In fact, countries with a higher level of human development seem to be more attractive investment destinations; high economic growth rates are found in countries with high levels of both education and macroeconomic openness and stability. However, there is a group of countries that are undertaking ambitious climate mitigation measures, even without major financing opportunities (e.g. Ukraine, Egypt); conversely, there is another group of countries that do not act despite having huge financial resources (the USA, Australia, Canada—note that these are also all large energy producers). Most other countries—predominantly medium and higher income—lie somewhere in-between.

Apart from access to financial resources, another important element in attracting investment is price signals. One of the key reasons for underinvestment in RE generation is uninternalized externalities (e.g. lack of carbon pricing). These externalities weigh more heavily on domestic policies than on international financial resources. In addition, unfavourable financial conditions are largely driven by domestic policies and thus require corresponding political action.

From the analysis carried out using the CCPI, it can be seen that the large producers of fossil fuels (such as Kazakhstan, Russia, Saudi Arabia, Canada or the USA) register very low values for their concern about climate change. Norway, however, is an exception, as despite being one of the main oil producers in the world, it is also very active on the climate front. As such, it offers an example for the aforementioned group of countries to follow.

The analysis carried out refers to 2018: the logical continuity of this research would be to conduct studies with previous or subsequent data to rule out the possibility that these findings correspond to an isolated event. Moreover, ongoing updates of the indices used will make it possible to complete the information extracted, and corroborate possible changes in the behaviour of the main world powers, which is sometimes linked to the political character of the leaders in question. Furthermore, a larger number of low-income countries (e.g. from Sub-Saharan Africa, South Asia, etc.) should be included to show that these countries lack access to finance and do not actively attempt to reduce emissions.

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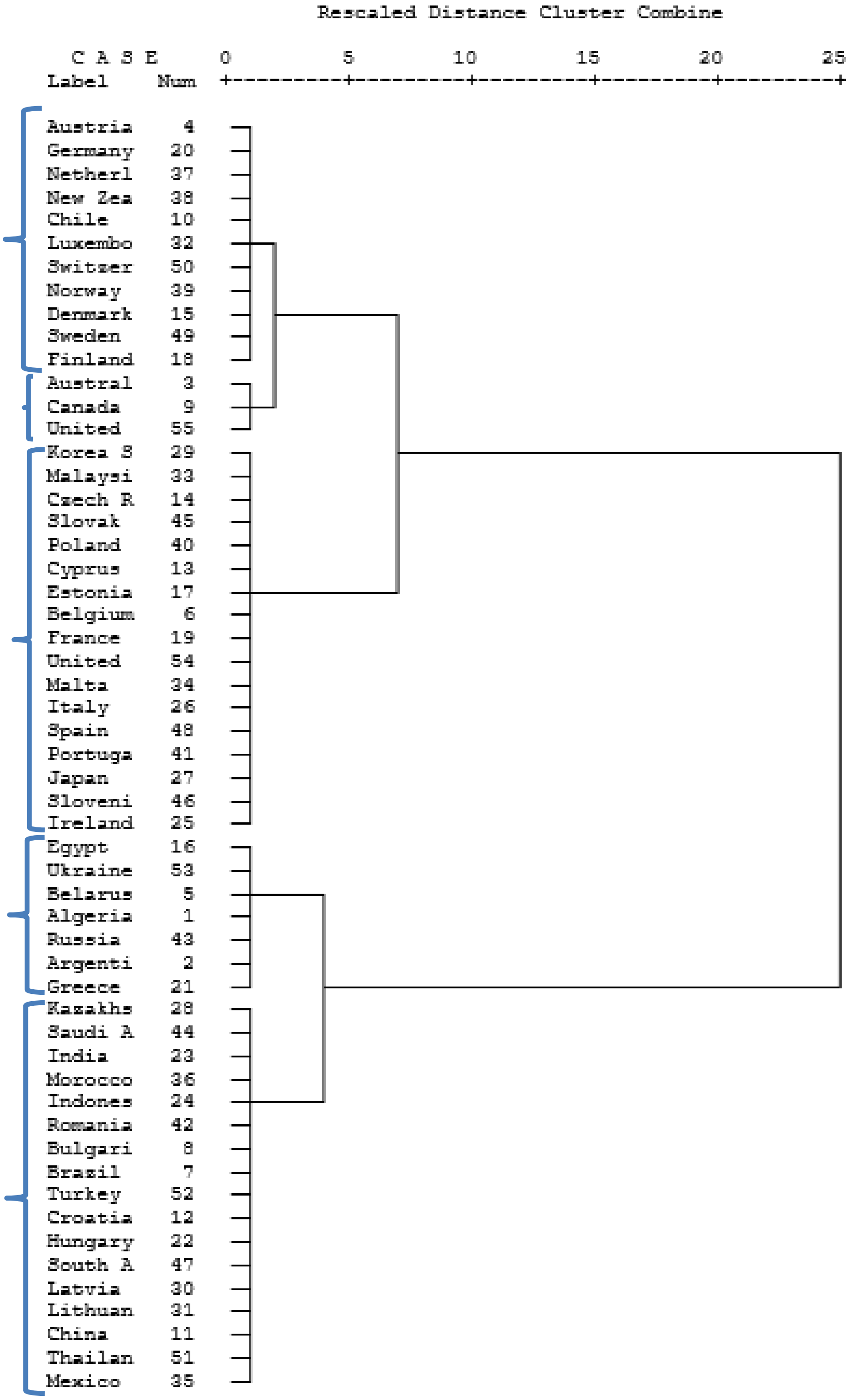
Appendix

Table 1A. Correlations matrix

	EA	*PA*	*SA*	*AC*	*DI*	*GHG*	*RE*	*EU*	*CP*
Economic assessment (EA)	1								
Political assessment (PA)	0.84	1							
Structural assessment (SA)	0.82	0.95	1						
Access to capital (AC)	0.57	0.78	0.77	1					
Debt indicators (DI)	0.61	0.72	0.69	0.61	1				
GHG emissions (GHG)	0.07	0.14	0.11	0.17	0.11	1			
Renewable energy (RE)	0.38	0.39	0.34	0.18	0.34	0.42	1		
Energy use (EU)	-0.41	-0.39	-0.34	-0.28	-0.32	0.58	-0.008	1	
Climate policy (CP)	0.28	0.34	0.29	0.23	0.34	0.34	0.56	-0.04	1

Figure 1A. Dendrogram using Ward's Method



Source: authors' own elaboration

Table 2A. Countries contained in each cluster

Cluster	Countries
Cluster 1	Austria (AUT), Chile (CHL), Denmark (DNK), Finland (FIN), Germany (DEU), Luxembourg (LUX), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Sweden (SWE), Switzerland (CHE)
Cluster 2	Belgium (BEL), Cyprus (CYP), Czech Rep (CZE), Estonia (EST), France (FRA), Ireland (IRL), Italy (ITA), Japan (JPN), Korea South (KOR), Malaysia (MYS), Malta (MLT), Poland (POL), Portugal (PRT), Slovak Rep (SVK), Slovenia (SVN), Spain (ESP), United Kingdom (GBR)
Cluster 3	Brazil (BRA), Bulgaria (BGR), China (CHN), Croatia (HRV), Hungary (HUN), India (IND), Indonesia (IDN), Kazakhstan (KAZ), Latvia (LVA), Lithuania (LTU), Mexico (MEX), Morocco (MAR), Romania (ROM), Saudi Arabia (SAU), South Africa (ZAF), Thailand (THA), Turkey (TUR)
Cluster 4	Australia (AUS), Canada (CAN), United States (USA)
Cluster 5	Algeria (DZA), Argentina (ARG), Belarus (BLR), Egypt (EGY), Greece (GRC), Russia (RUS), Ukraine (UKR)

Source: authors' own elaboration