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Analyzing the Influence of Philanthropy on Eco-Efficiency in 108 Countries

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Abstract: This paper analyzes philanthropy's influence on countries' eco-efficiency. The hypothesis to be verified is that philanthropy can favour the eco-efficiency. A data panel was built with statistical information from 2009 to 2018. Two methods were applied. First, a Data Envelopment Analysis model output oriented was estimated to identify the situation of overall efficiency in countries. We consider the relationship between Gross Domestic Product per capita and carbon dioxide per capita as our desirable and undesirable products, respectively. The second estimated method was a Stochastic Frontier, through which it was possible to assess the impact of philanthropy on eco-efficiency (rank of overall efficiency from DEA). Assessing the average eco-efficiency of countries around the world, it is possible to state that the results are worrying, since they reveal a fall in the average eco-efficiency of the countries over the years. Moreover, according to the second econometric model, the philanthropy index positively impacts on eco-efficiency. These empirical results fill a gap in the literature on donations' effect on countries' eco-efficiency. They allow policymakers to see how philanthropy can be one more tool to help countries improve their eco-efficiency. However, there is a warning that some attention is needed (control and regulation) for the best use of donations.

Keywords: eco-efficiency; philanthropy; DEA; Stochastic Frontier

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1. Introduction

Many people and institutions worldwide spend time and/or money on the environment. Moreover, in times of crisis, philanthropy becomes more prominent. Philanthropy is not exclusive to public or private institutions (for profit or not). Any person can contribute (even if on a small scale) to a better world. Furthermore, philanthropy is not static, and its good use can benefit society. This article intends to bring to the debate the importance of philanthropy for the eco-efficiency of the world's countries while extolling the need for public policies for the good management of funds.

Philanthropy is defined as great generosity towards other human beings [1]. According to data from the Charities Aid Foundation (CAF), it is possible to see that worldwide, 2.5 billion people have helped a stranger. In addition, almost 1 in 5 adults are globally volunteers [2]. Philanthropy can be practised in several ways, one of the main (and simplest) being the donation of money.

The "eco-efficiency", in turn, is achieved by the delivery of competitively priced goods and services that satisfy human needs and contribute to the quality of life while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity [3].

This paper aims to analyze philanthropy's influence on countries' eco-efficiency. A gap in the literature inspired us to achieve this objective. Indeed, researchers have not yet answered the following question: How do philanthropic factors impact the eco-efficiency of countries? The hypothesis to be verified is that philanthropy collaborates to improve countries eco-efficiency. Therefore, a data panel was built to fulfil the objective and collaborate to answer the question. In this paper, 108 countries of the world are considered. However, due to a limitation of statistical data, our analysis is confined to the period from 2009 until 2018.

Two empirical methods were used in this research. First, the Data Envelopment Analysis (DEA) model with constant returns to scale allows us to identify the current eco-efficiency situation in each country. As proposed by Picazo-Tadeo et al. [4], the carbon dioxide emissions per capita (CO_2) (undesirable product), and Gross Domestic Product per capita, based on purchasing power parity (GDP) (desirable product), will be used to obtain our eco-efficiency measure. Moreover, in this paper we used a Stochastic Frontier estimation introduced by Aigner et al. [5], and extended by Greene [6,7], through which it is possible to assess the impact of philanthropy on eco-efficiency (rank of overall efficiency from DEA). In this study, the composition of the philanthropy indicator considered giving money, giving time, and helping a stranger.

Globally, countries try to find a balance between economic growth and CO_2 emissions. Figure 1 shows the historical trade-off between GDP (a proxy of economic growth) and CO_2 emissions, based on data from the World Bank.

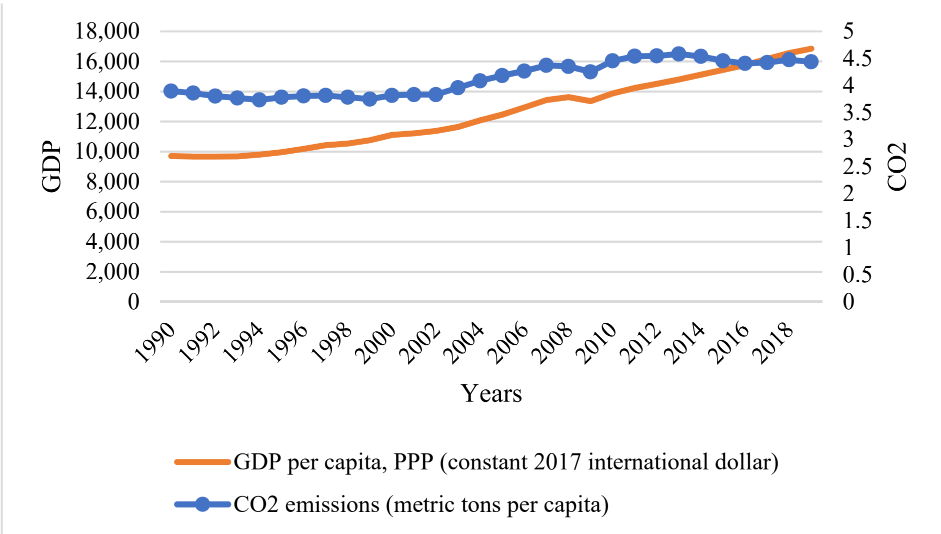

Figure 1. GDP and CO_2. (Author's elaboration.)

The paper's organisation adopts the following sequence: Section 2 presents the literature review; Section 3 is dedicated to the methodological aspects (empirical approach and methods) that guide this research; Section 4 is devoted to econometric results; in Section 5, the discussion and public proposals are made. Finally, in Section 6, we show the conclusions.

2. Literature Review

2.1. Eco-Efficiency

Eco-efficiency is a key concept encompassing economic and environmental aspects to promote more efficient use of resources and lower emissions [8]. Eco-efficiency has been proposed to transform unsustainable development into sustainable development [9,10]. The definition of eco-efficiency has its roots in the business world [10]. However, currently, eco-efficiency can be sought by different agents, people, families, public or private institutions, sectors of the economy and even countries. Countries seek the optimum point across their economic development, controlling the consumption of natural goods, and minimizing the pollution they generate. However, this is not always an easy task, with viewpoints not even consensual in the literature [11].

Eco-efficiency assessment was initially approached using simple indicators, such as GDP over CO_2 at the macro-level [4]. It is possible to find examples in the literature that describe the general definition of eco-efficiency as a ratio between an environmental element and a production value [12]. Some authors show that environmental intensity metrics are widely used in eco-efficiency studies. A typical example is CO_2. This variable was used by Rodríguez-García et al. [13] and indicated that a decrease in the CO_2 ratio over sales implies a lower environmental intensity or an improvement in its eco-efficiency; at the macro level, this eco-efficiency assessment ratio would consider GDP and CO_2 as variables.

An important role that the concept of eco-efficiency can play is if used to support policymakers' decisions, aiming at long-term sustainable development [14]. Therefore, analyzing patterns can be an important contribution to studying eco-efficiency in countries. In a way, it is possible to identify, in the most eco-efficient countries (or cities), patterns, policies, and strategies that made them stand out as more eco-efficient. Furthermore, in this sense, measuring the eco-efficiency of products, services, and design can be an important tool to assist in decision-making [8].

The literature is rich in research that presents eco-efficiency as an output of more sustainable production [13]. There are examples in literature that have studied cities [15], regions of a country [10,16], or groups of countries [13,14,17,18]. Several approaches were applied in these studies, with DEA being one of the most common [16–18].

The eco-efficiency of countries and/or economic sectors has already been evaluated using DEA techniques [19] and combined with regressions [8,18]. For example, Castilho et al. [18] considered CO_2 emissions as input and GDP as output to assess the impact of the tourism sector on eco-efficiency in Latin American and Caribbean countries. Their results indicated that tourism arrivals decrease these countries' eco-efficiency in the short and long term [18].

Moutinho et al. [19] studied the eco-efficiency of 26 European countries from 2001 to 2012. The technical eco-efficiency rankings were identified using the DEA-variable returns-to-scale and DEA-constant returns-to-scale models. Their results indicated that the share of renewable and non-renewable energy sources was important in explaining the differences in emissions. Furthermore, they suggested a significant change in European countries' economic and environmental efficiency trends and pointed out their large disparities [19].

Xiao et al. [15] applied a two-stage network DEA framework, which is proposed to measure eco-efficiency and sectoral efficiency. The authors' results reveal that the average eco-efficiency of China's resource-based cities shows a promising increase between 2007 and 2015. Belucio et al. [8], on the other hand, studied the sector of building rehabilitation in Southern European scenarios and proposed a multi-methodological analysis (combining LCA, DEA and regression) to obtain more eco-efficient results.

De Araújo et al. [16] evaluated eco-efficiency and its determinants in 41 Brazilian municipalities with DEA and Tobit regression between 2014 and 2016. The authors show which reference municipalities (those with the greatest eco-efficiency) support public policymakers (local, national and international).

Yu et al. [20] studied the impact of the pollution information transparency index on eco-efficiency using a new panel dataset covering 109 key environmental protection cities in China from 2008 to 2015 with significant eco-efficiency temporalities; they conclude that the links between the different regions must be strengthened so that eco-efficiency can be promoted in a coordinated way, improving industrial agglomeration, and optimising the allocation of resources [20].

Analyzing the eco-efficiency of countries may not be intuitive. Moreover, several efforts in the literature have shown the different reasons to explore the topic [8,15,16,18–20]. Eco-efficiency can be influenced by characteristics such as the composition of a country's economic activity [14] and environmental factors. Therefore, investigating the eco-efficiency of countries is important for societies in general. Since the environment and economy are related, both must be considered together to analyze eco-efficiency.

2.2. Philanthropy and the Environment

The biggest international charity/philanthropy actions that have taken place recently have been triggered by the emergence of the world COVID-19 pandemic and the Russian War against Ukraine. Philanthropists/charities reacted quickly to the request for help from governments and international organisations in the case of COVID-19 [21] and there are several reports of donations of vaccines, and supplies, medical equipment, to fight the disease. In the case of the war, still in the winter of 2022, many cases of donations to Ukraine are found.

Several types of charity/philanthropy are related to the environment in the literature. For example, Tesselaar et al. [22] show the relationship between natural disasters (floods), government aid and insurance in European countries. Sadrnia et al. [23] show that networks of charities to repurpose a variety of home appliances to reduce municipal solid waste (which enters the environment) and help low-income families are possible. In recent decades, people, institutions, and countries that work to preserve the environment have begun to receive donations for this purpose. Authors also consider that each person can contribute to the growth of initiatives for a less carbon-intensive economy [24].

Philanthropy is not a practice exclusive to the West and is present and growing in many places [21]. However, the various forms of philanthropy have little prominence in economic science research. Nevertheless, Michelson [25] recalls that in science and technology policy, it is important to recognise philanthropies' role in establishing research directions. Furthermore, philanthropy is central to environmental movements [26].

For institutions from different economic sectors, philanthropy plays a crucial role through corporate social responsibility [27–29]. Donations to important causes improve institutions' image and generate more brand engagement. However, there are several cases where companies "omit" to mention their environmental malpractice [30] and make these donations is commonly known as greenwashing.

Lu and Zhu [29] show important aspects of the relationship between philanthropy and corporate taxes. Some companies aim to make more profits and use philanthropy to deduct taxes.

Ames [26] shows that individual donations and grants from foundations have sustained organisations, people, and programs in the independent sector that, although small, have contributed significantly to shaping environmental issues and setting directions for public policy. Currently, the influence of donations continues to impact public policies. For example, Farrell [31] shows that in the case of the USA, the development of the influence of private sector philanthropy is one of the agents that most affect policy, but the author also relates philanthropy to misinformation about climate change [32].

When well directed, the vast volumes of money from philanthropy circulating through economies can be a starting point for the fight against climate change. Nevertheless, Beer [32], who studies the Chilean case of the preservation of Chilean Patagonia, shows how philanthropy plays a more prominent role in funding biodiversity protection. This case also suggests that funding is no longer sufficient for some donors. Environmental philanthropists increasingly seek to get their hands on the state apparatus itself, leveraging their money and influence to demand structural changes in the political framework [32].

Fuentenebro [21] brings an essential question to the debate on the importance of philanthropy in the world: why has philanthropy that has existed for decades not worked to solve structural problems? A possible answer (and in line with [32]) may be how those who hold positions of public policy decision-making and managers of philanthropic institutions have worked. Pope Francis' concerns in the *Laudato Si'* encyclical remain unresolved and demonstrate the weakness of international policy in creating a normative system that includes inviolable limits and ensures the protection of ecosystems [33]. Philanthropy can be a way to collaborate to reduce climate change but it requires more joint efforts and cannot be performed as isolated actions.

Agenda 2030 Sustainable Development Goals [34] shed light on important global environmental topics. Corporate and individual philanthropy can contribute to fulfilling these goals. However, public policies, regulations and philanthropy/charity control tools must be in place so that donations do not become a "trap". In this sense, countries must create/update legislation and controls to ensure that donations reach the proper destination.

In line with the control mechanisms, the implementation of systems that facilitate procedures for raising funds should be encouraged by the State. The institutions that receive the funds must have well-designed programs to fulfil their core business, eliminating gaps in their operations and collaborating for the environmental, socioeconomic, and personal development of those who benefit from philanthropy.

3. Methodology

The methodology section will be divided into three subsections (Figure 2 summarizes the methodology). The first subsection will show the selected data and statistical characteristics. In the second subsection, the DEA model with constant returns to scale is the first method applied to identify the overall efficiency of countries (i.e., the eco-efficiency). Finally, in the last subsection, a panel analysis with Stochastic Frontier estimation will be applied to find the impact of philanthropy on the abovementioned eco-efficiency index built by the DEA.

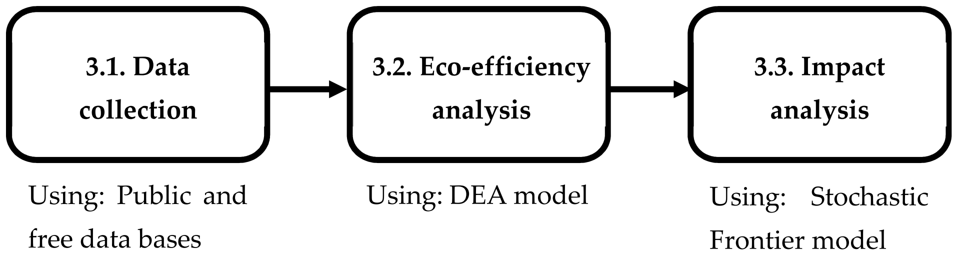

Figure 2. DEA and Stochastic Frontier estimation. (Author's elaboration.)

3.1. Statistical Data

Statistical data are essential for suggesting robust public policies. In this paper, all data were obtained from public and free databases. Thus, other researchers can replicate studies of this nature. Furthermore, we built a data panel with the variables normalised through per capita values. An advantage of using this normalisation is that it can remove distortion produced by population variations [35]. Next, in Table 1, we present some details about the characteristics of the data.

Table 1. Variables.

Variables	Acronyms	Units	Databases
GDP per capita based on purchasing power parity	GDP	Constant (2017) international dollar	World Bank | World Development Indicators
CO_2 emissions per capita	CO_2	metric tons	
Giving money	MON	%	CAF—World Giving Index
Giving time	TIME	%	
Helping a stranger	STRAN	%	

The period was limited due to several variables: the indicators of philanthropy of the World Giving Index began in 2009, and the CO_2 emissions data covers the period up to 2018, impeding the econometric analysis from being extended. Nevertheless, this period is important for many countries worldwide as it marks the beginning of the economic recovery after the 2008 financial crisis [36]. It was possible to select 108 countries worldwide (Afghanistan, Albania, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chad, Chile, China, Colombia, Congo (Brazzaville), Costa Rica, Croatia, Cyprus, Czech Republic, Democratic Republic of the Congo (Kinshasa), Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Haiti, Honduras, Hungary, India, Indonesia, Iraq, Ireland, Israel, Italy, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Latvia, Lebanon, Lithuania, Luxembourg, Madagascar, Malawi, Mali, Malta, Mauritania, Mexico, Mongolia, Montenegro, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Tajikistan, Thailand, Tunisia, Turkmenistan, Uganda, Ukraine, United Kingdom, United Republic of Tanzania, USA, Uruguay, Uzbekistan, Zambia, and Zimbabwe). The criterion for selecting the countries for this analysis was that there was no break in the data structure. Table 2 presents the descriptive statistics of the dataset. The exact number of observations confirms the balanced panel data.

Table 2. Descriptive statistics.

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
GDP per capita	1080	9.3574	1.1049	6.7282	11.6404
CO_2 emissions per capita	1080	0.7092	1.4697	−3.6441	3.0827
Giving money	1080	28.8482	18.0739	2.0000	87.0000
Giving time	1080	20.3833	10.8174	2.0000	61.0000
Helping a stranger	1080	47.3861	12.2994	13.0000	81.0000

3.2. Data Envelopment Analysis—DEA

The DEA developed in 1978 by Charnes, Cooper, and Rhodes (CCR) [37] was selected for eco-efficiency analysis. This model assumes constant returns to scale (CRS). In the CCR model, each Decision-Making Unit (DMU) k ($k = 1, \ldots, n$) is a country that used p inputs x_{ik}, ($i = 1, \ldots, p$) to produce d outputs y_{jk} ($j = 1, \ldots, d$). In this study, CO_2 emissions per capita is our input parameter, i.e., undesirable product. GDP per capita is our output parameter, i.e., desirable product. Thus, each DMU represents the economic and environmental situation of the country (N) in the year (T). A linear programming formulation is presented in the model (1) [37]:

$$\begin{gathered} Max\ Eco\ efficiency_0 = \sum_{j=1}^{d} m_j y_{j0} \\ \text{Subject to,} \\ \sum_{i=1}^{p} v_i x_{i0} = 1 \\ \sum_{j=1}^{d} m_j y_{jk} - \sum_{i=1}^{p} v_i x_{ik} \leq 0,\ \ k = 1, 2, 3, \ldots, n \\ v_i,\ m_j \geq 0\ ,\ \ i = 1, \ldots, p;\ j = 1, \ldots, d. \end{gathered} \tag{1}$$

where $Eco\ efficiency_0 \in [0,1]$ is the efficiency score for DMU_0 (the DMU under analysis); y_{j0} and x_{i0} are the inputs and outputs of DMU_0; and v_i are the weights of the inputs i and m_j are the weights of the outputs j.

Belucio et al. [8] indicate that this formulation is called the envelopment model. It computes the weights for the inputs and the outputs that maximise the efficiency of DMU_0. Those weights are not subjectively set but reflect the benevolent perspective of evaluating the DMU under the most favourable weights maximising its eco-efficiency. If it is possible to choose weights such that $Eco\ efficiency_0 = 1$, then DMU_0 is efficient. Otherwise, $Eco\ efficiency_0 < 1$ indicates an inefficient DMU (the lower, the worse) [8].

3.3. The Panel Data Analysis with a Stochastic Frontier Estimation

After building the eco-efficiency variable through the DEA model we will estimate how philanthropy can impact it. To this end, firstly we will build the philanthropy index (PHI) by using the following equation (simple arithmetic average):

$$\text{PHI} = \frac{\text{MON} + \text{TIME} + \text{STRAN}}{3} \tag{2}$$

where, MON, TIME and STRAN indicate some dimensions of philanthropy, namely "Giving money", "Giving time" and "Helping a stranger", respectively. The behaviour of the PHI index will be presented in due course. Secondly, we apply the panel analysis with a Stochastic Frontier estimation [5–7] that takes into account the fixed effects, composed of the following equations:

$$\text{ECO}_{it} = \alpha_0 + \alpha_1 ln\text{GDP}_{it-n} + \alpha_2 ln\text{CO2}_{it-n} + \alpha_3 trend + v_{it} + u_{it} \tag{3}$$

$$\sigma^2_{ui} = \exp(\beta_1 \text{PHI}_{it-n} + z_{it}) \tag{4}$$

In Equation (3), v_{it} represents residuals and u_{it} captures the inefficiency, namely the distance from the frontier of each country. This case represents the frontier equation that builds the frontier with the best country performances in terms of eco-efficiency, given the GDP and CO_2 emissions levels. Equation (4), where z_{it} is the residual, is called the inefficiency equation, because it estimates with an exponential function which factor can influence the distance of a country from the frontier of the best performances (technical efficiency); a negative coefficient means that philanthropy reduces this distance.

The use of lagged variables has twofold value: it considers both the potential endogeneity concerning the reverse relationships and the potential timing of the relationships considered. The main idea is that philanthropy can influence how economic and technological factors impact eco-efficiency. Given the same technologies and economic factors, philanthropy offers all operators, individually and collectively, more propensity for the actions and choices more environmentally sustainable.

4. Results

First, we recall that the objectives of the study is to provide an overview of the relationship between philanthropy and eco-efficiency. For this reason, we have chosen not to illustrate specific country cases throughout the section.

We present a map built with the PHI index for the year 2018 (Figure 3). The results show scale between 0 to 100%. However, only eight countries in the sample (Australia, Canada, Indonesia, Ireland, Netherlands, New Zealand, United Kingdom, and the United States of America) have a PHI index between 50% and 58.3%. They suggest that all countries (and their populations) have a great opportunity to grow and positively impact the eco-efficiency of the planet.

When we disaggregate the economies according to their income level we see that countries have new behaviour patterns (details in Table 3). The classification was performed using data from the World Bank [38]. The indicator shows that economies' income level is divided into four categories: (i) low-income economies equate to those with a Gross National Income (GNI) per capita of 1085 USD or less in the year 2021; (ii) lower-middle-income economies are those between 1086 and 4255 USD; (iii) upper-middle-income economies are those between 4256 and 13,205 USD; and (iv) high-income economies are those of 13,205 USD or more [38]. Throughout the section, the same criteria for classifying countries according to their income will be maintained.

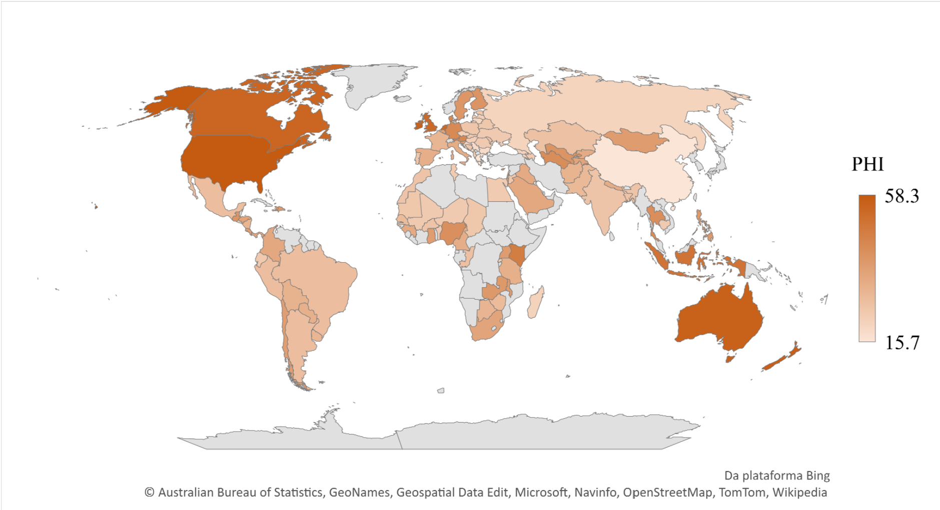

Figure 3. 2018 PHI index. (Author's elaboration).

Table 3. 2018 PHI ranking grouped by country income.

	Low	Lower-Middle	Upper-Middle	High
1st	Zambia	Indonesia	Turkmenistan	United States of America
2nd	Malawi	Kenya	Thailand	New Zealand
3rd	Uganda	Nigeria	Guatemala	Australia
4th	Guinea	Uzbekistan	Dominican Republic	Ireland
5th	Afghanistan	Haiti	Costa Rica	Canada
6th	Burkina Faso	Philippines	South Africa	United Kingdom
7th	Chad	Mongolia	Colombia	Netherlands
8th	Mali	Ghana	Iraq	Malta
9th	Niger	Honduras	Paraguay	Austria
10th	Madagascar	Tajikistan	Botswana	Denmark
11th	Rwanda	Kyrgyzstan	Argentina	Germany
12th	Democratic Republic of the Congo (Kinshasa)	Nepal	Brazil	Cyprus
13th		Cameroon	Mexico	Finland
14th		United Republic of Tanzania	Peru	Luxembourg
15th		Bolivia	Kazakhstan	Sweden
16th		Lebanon	Republic of Moldova	Israel
17th		Nicaragua	Belarus	Chile
18th		Pakistan	Bosnia and Herzegovina	Slovenia
19th		Zimbabwe	Jordan	Belgium
20th		Senegal	Ecuador	Panama
21st		Congo (Brazzaville)	Azerbaijan	Saudi Arabia
22nd		Bangladesh	Georgia	Italy
23rd		India	Armenia	Spain
24th		Morocco	Russian Federation	France
25th		Mauritania	Montenegro	Uruguay
26th		El Salvador	Bulgaria	Poland
27th		Cambodia	Serbia	Portugal
28th		Ukraine	China	Estonia
29th		Egypt		Slovakia
30th		Tunisia		Romania
31st		Benin		Hungary
32nd				Latvia
33rd				Czech Republic
34th				Croatia
35th				Lithuania
36th				Greece

High-income countries are expected to do more philanthropic actions since Maslow's base-of-pyramid problems (basic physiological and safety needs) are not a concern. Seven of the eight countries with a philanthropy index above 50% belong to the high-income category. This result demonstrates the ability of rich countries to help those most in need. The five countries with the worst philanthropy index are Lithuania 20%, Bulgaria 19%, Serbia 18.7%, Greece 16.3% and China 15.7%. These countries have GNI per capita which places them in the "upper-middle" and "high" income categories. There are possible problems of income inequality in populations, which may affect a country's ability to do philanthropy. In addition, the cultural factor exerts an important influence on the decision to donate.

Next, after checking the correlation between CO_2 and GDP, it is possible to affirm (at a 5% statistical significance) that the variables are relationship positive, which means the parameters maintain an isotonic relationship [39] and can be used on the proposed DEA model. Details about the correlation matrix are shown in the Appendix A (Table A1). In this test, a positive correlation shows that the variables have symmetrical behaviour, i.e., both increase and decrease simultaneously. This result suggests the existence of common factors in the increase or decrease of GDP and CO_2. Moreover, the result of this test showing the correlation between variables should not be read as an impact between variables. Instead, it should be considered an indicator of their behaviour in pairs (symmetric, asymmetric, or neutral).

The DEA model was estimated considering the constant returns to scale. We show the eco-efficiency ranking (Figure 4) for the year 2018. The ranking DEA was obtained through the CRS. The Gross Domestic Product per capita was considered a desirable product. On the other hand, carbon dioxide per capita was considered an undesirable product. The results show a scale from 0 to 1.

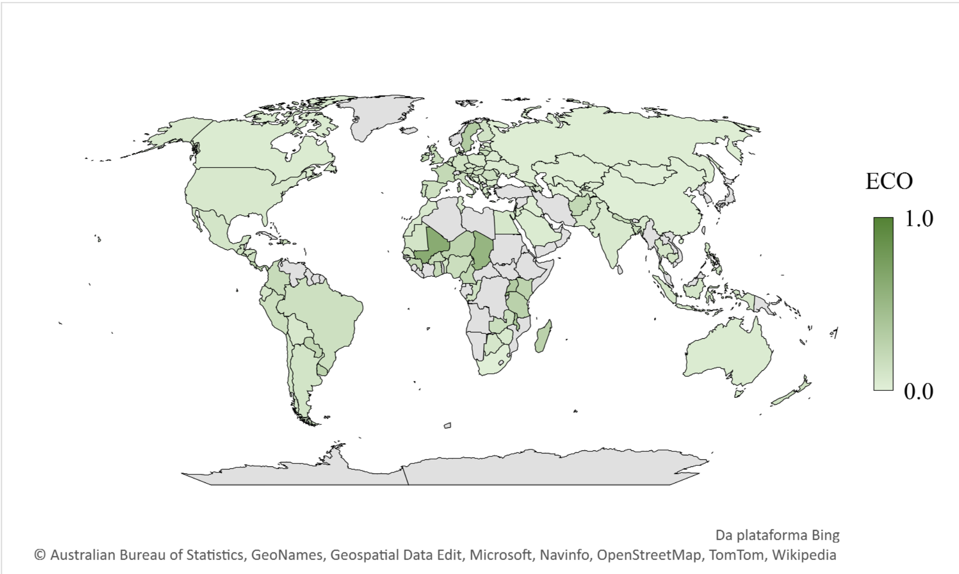

Figure 4. 2018 eco-efficiency ranking. (Author's elaboration.)

Next, average DEA results are shown in Figure 5. We found results that show countries' average eco-efficiency regressed between 2009 and 2018. In addition, we also present the average results by income category, as classified by the World Bank [38]. Countries classified as low-income had the highest average eco-efficiency and were the ones that dropped the most in the indicator when analyzing the first and last years of the sample. If we go to the other extreme, the average of high-income countries also showed a drop, but the smallest drop among the different income categories of countries.

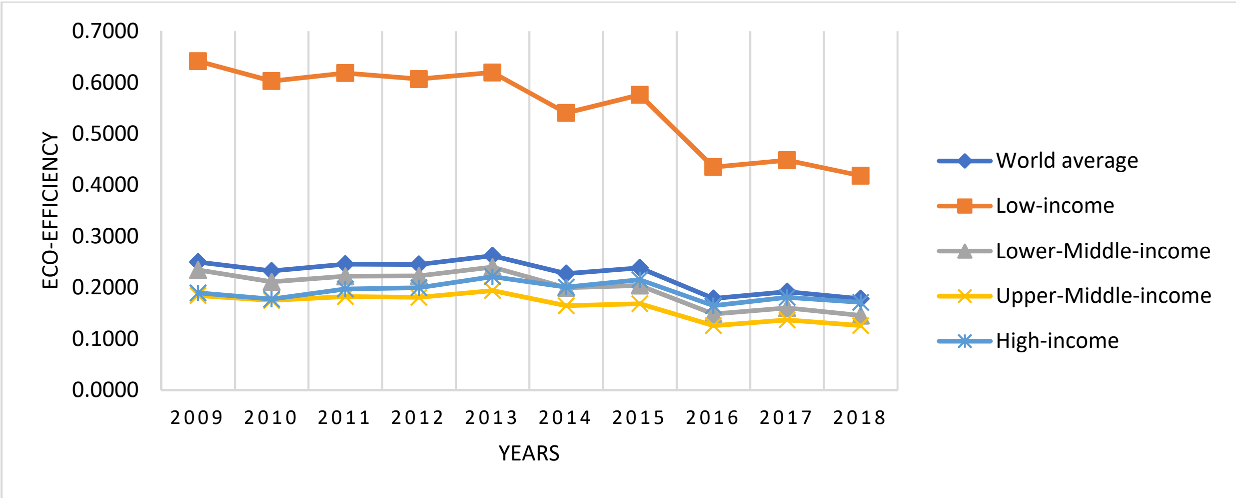

Figure 5. Eco-efficiency per year. (Author's elaboration.)

In Table A2 (see Appendix A), we show the ranking of countries' classification by year and eco-efficiency. We also show the eco-efficiency average by country, the standard deviation, and the coefficient of variation. We can indicate that we have null, tiny, or small correlations when evaluating the coefficient of variation. For example, Pakistan was the only country with a moderate variation coefficient. Finally, through the mean Variance Inflation Factor (VIF) statistic (see Appendix A Table A3), it is possible to affirm that there is no multicollinearity in the DEA model. Thus, the estimated DEA model is robust, with an average VIF value of 1.00.

In Table 4, we again disaggregate eco-efficiency ranking by classifying economies according to their income level (low, lower-middle, upper-middle, and high). Again, a new a configuration of countries occupies the top positions regarding eco-efficiency when sorted by income category.

Table 4. 2018 eco-efficiency ranking grouped by country income.

	Low	**Lower-Middle**	**Upper-Middle**	**High**
1st	Democratic Republic of the Congo (Kinshasa)	United Republic of Tanzania	Costa Rica	Sweden
2nd	Mali	Kenya	Paraguay	Malta
3rd	Rwanda	Cameroon	Colombia	Panama
4th	Chad	Haiti	Guatemala	Uruguay
5th	Malawi	Ghana	Peru	Ireland
6th	Uganda	Nepal	Dominican Republic	France
7th	Madagascar	Bangladesh	Brazil	Denmark
8th	Niger	El Salvador	Albania	Lithuania
9th	Afghanistan	Nigeria	Armenia	United Kingdom
10th	Guinea	Nicaragua	Argentina	Italy
11th	Burkina Faso	Congo (Brazzaville)	Georgia	Austria
12th	Zambia	Philippines	Mexico	Latvia
13th		Cambodia	Montenegro	Romania
14th		Honduras	Ecuador	Luxembourg
15th		Mauritania	Thailand	Spain
16th		Senegal	Botswana	Portugal
17th		Indonesia	Azerbaijan	Croatia
18th		Pakistan	Jordan	Hungary
19th		Benin	Republic of Moldova	New Zealand
20th		Egypt	Bulgaria	Cyprus
21st		Bolivia	Belarus	Netherlands
22nd		Tajikistan	Serbia	Belgium

Table 4. *Cont.*

	Low	Lower-Middle	Upper-Middle	High
23rd		Tunisia	Russian Federation	Germany
24th		Morocco	Bosnia and Herzegovina	Finland
25th		Zimbabwe	Kazakhstan	Israel
26th		Lebanon	Iraq	Slovenia
27th		India	China	Chile
28th		Ukraine	South Africa	Slovakia
29th		Kyrgyzstan		Greece
30th		Uzbekistan		Czech Republic
31st		Mongolia		United States of America
32nd				Poland
33rd				Australia
34th				Canada
35th				Saudi Arabia
36th				Estonia

In Table 5 we show the eco-efficiency ranking for 2018 per geographical area to underline the relevance of the particular territorial characteristics. The countries in the general rank were grouped according to the continent. The region where the countries are inserted and their border neighbours can influence the management of wealth and the environment. All regions have the potential to stand out; in some cases, however, the mechanisms of corruption do not allow a good distribution of income aligned with measures to combat environmental degradation to evolve.

Table 5. Eco-efficiency ranking by continent in 2018.

	Africa	Asia	Europe	North America	Oceania	South America
1st	Democratic Republic of the Congo (Kinshasa)	Afghanistan	Sweden	Panama	New Zealand	Uruguay
2nd	Mali	Nepal	Malta	Costa Rica	Australia	Paraguay
3rd	Rwanda	Bangladesh	Ireland	Haiti		Colombia
4th	Chad	Armenia	France	El Salvador		Peru
5th	Malawi	Cyprus	Denmark	Guatemala		Brazil
6th	Uganda	Philippines	Lithuania	Dominican Republic		Argentina
7th	United Republic of Tanzania	Cambodia	United Kingdom	Nicaragua		Chile
8th	Madagascar	Israel	Italy	Honduras		Ecuador
9th	Niger	Georgia	Austria	Mexico		Bolivia
10th	Kenya	Indonesia	Latvia	United States of America		
11th	Cameroon	Thailand	Romania	Canada		
12th	Guinea	Pakistan	Luxembourg			
13th	Burkina Faso	Azerbaijan	Spain			
14th	Ghana	Tajikistan	Portugal			
15th	Zambia	Jordan	Albania			
16th	Nigeria	Lebanon	Croatia			
17th	Congo (Brazzaville)	India	Hungary			
18th	Mauritania	Saudi	Netherlands			
19th	Senegal	Kyrgyzstan	Belgium			
20th	Botswana	Kazakhstan	Germany			
21st	Benin	Iraq	Finland			
22nd	Egypt	China	Slovenia			
23rd	Tunisia	Uzbekistan	Slovakia			
24th	Morocco	Mongolia	Montenegro			
25th	Zimbabwe	Turkmenistan	Greece			
26th	South Africa		Czech Republic			
27th			Republic of Moldova			
28th			Poland			
29th			Bulgaria			
30th			Belarus			
31st			Ukraine			
32nd			Estonia			
33rd			Serbia			
34th			Russian Federation			
35th			Bosnia and Herzegovina			

Next, we show the results of the Stochastic Frontier estimation (Table 6). The coefficients (Coef.) of LnGDP and LnCO2 are positive and negative, respectively. As both are statistically significant, this indicates how each variable impacts the eco-efficiency indicator for 1, 2, and 3 lags. Furthermore, 1 to 3 lags are considered in estimation to take into account the potential endogeneity/simultaneity. In all estimations a temporal trend was used. Finally, the PHI variable reveals a negative coefficient (statistically significant) to 1, 2, and 3 lags, i.e., it means that philanthropy reduces the distance of a country from the frontier of the highest performances, in other terms philanthropy impacts positively on the process of improving eco-efficiency.

Table 6. Stochastic Frontier results.

Dependent Variable: ECO		1 Lag		2 Lags		3 Lags	
		Coef.	**P > |z|**	**Coef.**	**P > |z|**	**Coef.**	**P > |z|**
Frontier							
	LnGDP	0.723	0.000	0.472	0.000	0.319	0.051
	LnCO2	−0.483	0.000	−0.263	0.000	−0.122	0.017
Years		−0.039	0.000	−0.042	0.000	−0.045	0.000
Usigma							
	PHI	−0.030	0.009	−0.040	0.072	−0.158	0.000
	Constant	−4.491	0.000	−4.962	0.000	−2.982	0.003
Vsigma							
	unef	−0.012	0.750	−0.014	0.599	0.008	0.593
	Constant	−7.024	0.000	−6.436	0.000	−5.832	0.000
	E(Sigma_u)	0.066		0.051		0.025	
	E(sigma_v)	0.031		0.043		0.056	
	Trend	YES		YES		YES	
	Observations	972		864		756	
	Log likelihood	1297.028		1167.306		1030.296	
	Prob>chi2	0.000		0.000		0.075	
	Wald chi2	5.10e+07		3.80e+07		5.19	

Note: "Ln" denotes "natural logarithm"; "unef" (female unemployment) by World Bank | World Development Indicators is the explanatory variable for the idiosyncratic error variance function.

Based on the results found in the Stochastic Frontier model, it can be stated that it is appropriate to motivate philanthropy to leverage the eco-efficiency of countries. Thus, the results show that philanthropy collaborates to reduce the inefficiency of the countries

The results show that philanthropy collaborates to reduce the inefficiency of the countries, and it can be considered the main finding of our study. In this study, the composition of the philanthropy indicator considered giving money, giving time, and helping a stranger. However, we warn that some attention is needed (control and regulation) to ensure that donations/philanthropic actions that reach their intended and good destination.

5. Discussion and Policy Implications

Based on the results obtained with the DEA model, we can say that, on average, the eco-efficiency situation in the world has worsened since 2009. The possible explanation for this phenomenon is that after the shock caused by the financial crisis (due to sub-prime mortgages, etc.), countries reduced their concern for the environment in pursuit of economic growth, ultimately increasing greenhouse gas emissions. This explanation corroborates [36], which shows that countries tend to prioritise economic recovery and loosen environmental regulation in times of crisis. In this sense, the current crises (pandemic crisis caused by the COVID-19 virus and the crisis of the Russia-Ukraine war) should generate public policies attentive to post-crisis measures, as there is a tendency to seek economic recovery by loosening environmental regulations [36]. As in the European case, an increase in coal consumption is expected, due to the lack of gas that results from the war. There are indications that many countries in the world speak in favor of the environment but are willing to implement short-term measures that harm it.

Our data cover dozens of countries on all continents. There are many with different policies regarding the preservation of the environment and the search for high eco-efficiency. Even those who align with pro-environmental policies by signing international treaties do not always comply with them (as in the case of the United States of America, for example, which reversed several pro-environment policies after the election of President Trump). Furthermore, some countries that make up the sample are among the world's poorest. The low GDP is the result of weak and underdeveloped economic activity. The lack of industrialisation, the low sectorial diversification of the economy, and corruption can help explain the low eco-efficiency. The optimum point of pollution and growth is easily exceeded by developed countries that seek rapid recovery and/or more growth. In developing countries, the optimal point is rarely reached, and the most common result is a low level of CO_2 emissions and little (or no) economic growth, which worsens the poverty situation of these nations.

The world's countries must cooperate in dealing with the problem of decarbonisation, and measures that facilitate the transfer of technology to reduce emissions must be encouraged. High-income countries can also finance part of the sustainable development of other nations. These measures are commonly known as "green growth". Althouse et al. [40] show that, in theory, green growth policies can result in a virtuous shift to high-value-added sectors. Another policy proposal could be the end of tax havens combined with policies that allow the richest to donate their taxes to countries or institutions that preserve the environment directly. Some countries allow individuals and companies to allocate part of their taxes directly to institutions.

Donations of money or, in some cases, skilled labour can promote an increase in global eco-efficiency. However, world organisations first choose to make loans to support economic recovery; typically, these loans increase the public debt, drive away foreign investors, and make the country ineligible for new future programs/loans. In this way, donations become a viable option for the first step towards economic recovery, which can boost important sectors of the recipient economy. Regarding philanthropic factors in societies, donating money (transferring from the rich to the poor) can help in some ways, but it does not solve the problems of eco-inefficiency and corruption. Therefore, programs must be supported by robust measures that guarantee the correct application of funds. Control mechanisms are needed for countries to find the best solutions according to their national and regional characteristics. Furthermore, Duquette [41] makes an important observation about a problem associated with philanthropy, as it can increase the extent of inequality between places over time. Therefore, public donation policies must be well-targeted, filling gaps and ending corruption in this economic sector; philanthropic programs should last for the strictly necessary time, building personal and institutional capacity so as not to create a long term dependency, but generating opportunities to improve eco-efficiency on a sustainable basis.

The elaboration of regulations for national and international charity/philanthropy and the elaboration of methods of evaluation and control of the destination of donations are fundamental to avoid the creation of lobbies that influence a specific sector and/or country through donations. In addition, these control measures tend to contribute to the correct destination of the fruits of philanthropic actions.

Donation of time to charitable causes can be relevant in environmental and economic aspects. Therefore, the volume of philanthropic activities in the poorest countries should be encouraged through more international programs and policies that facilitate this type of action. However, the security factor of host countries can be a barrier to these initiatives and requires the attention of policymakers. Another important point to be considered regarding the donation of time in philanthropic activities should be the final activity of the donor. Well-structured programs are needed, so that philanthropic activity does not revert to a negative impact in the longer term. The correct selection of people is essential, considering that to carry out an activity, many stakeholders must be consulted. In some case, a development activity may cause displacement and an associated negative environmental impact. In this way, the donor's exit strategy should be planned from the start so that the overall gains outweigh any loss of impetus and possible residual negative impact. An example of a policy that can favour philanthropy's impact on countries' eco-efficiency is to align charity with institutions focused on social enterprise and small businesses. This type of charity investment, rated as positive by the literature, can if well implemented make a difference for many people with support for education, combating poverty, and promoting gender equality, and access to clean energy, among others.

6. Final Considerations

The aim of this paper (to analyze the influence of philanthropy on eco-efficiency) has been accomplished. It was possible to build a panel of data from 108 countries worldwide. The period covered by the analyses started in 2009 and lasted until 2018. Two econometric methods were used in this research, a DEA model with constant returns to scale to find the rank of overall efficiency (our eco-efficiency parameter) and a Stochastic Frontier to verify the influence of philanthropy on eco-efficiency.

The results of the DEA model were estimated considering CO_2 emissions per capita (undesirable product) and GDP in purchasing power parity per capita (desirable product). They show that the world's average eco-efficiency situation has worsened in the analyzed period.

Based on Stochastic Frontier, we find that philanthropy reduces the distance of a country from the frontier of the most performing countries. This result suggests that public policies encouraging money donations can reinforce other measures to improve the eco-efficiency of the countries.

Well-targeted public policies can contribute to a more eco-efficient world. Furthermore, it is essential to assess the situation of less efficient countries to establish assertive measures for sustainable (economic and environmental) development. The search for standards in the most (or less) eco-efficient countries can help public policymakers to design better solutions for society. Philanthropy can be a way to help combat the decline in global eco-efficiency. However, this path alone has only a small positive impact, so philanthropy must be combined with other actions to maximise results.

Regulatory and control mechanisms for the correct distribution of charity/philanthropic funding should be encouraged to reduce corruption, especially in the most vulnerable countries.

In this research, some barriers and limitations were not overcome. Therefore, it is suggested that the theme be revisited in the future to try to resolve the following limitations: the period and the number of countries that it was possible to include in the analysis; the need to consider the direct and indirect effects of the health crisis caused by COVID-19 virus, and more recently the Russia-Ukraine war on eco-efficiency.

Furthermore, it would be interesting to deepen additional investigations by working with individual or neighboring countries or groups of countries (e.g., Latin Americans, Europeans, Africans, Asians, OECD, MENA, BRICS, and others). The selection of countries could also be made in line with research priorities of leading institutions active in promoting eco-efficiency. It is possible to analyze countries according to globalisation or industrialisation or environmental factors. Another suggestion for future research will be to verify the existence of a pattern in the sample of the most eco-efficient/inefficient countries and assess the speed and time required to move from inefficiency to efficiency.

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Appendix A

Table A1. Spearman correlation matrix.

	LnGDP	**LnCO2**
LnGDP	1.0000	
LnCO2	0.9170 **	1.0000

Note: Ln denote natural logarithm; "**" denotes statistical significance at a 5% level.

Table A2. Countries' eco-efficiency by year.

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
1st	Democratic Republic of the Congo (Kinshasa)	Mali	Mali	Mali	Mali	Mali	Mali	Democratic Republic of the Congo (Kinshasa)	Democratic Republic of the Congo (Kinshasa)	Democratic Republic of the Congo (Kinshasa)	Afghanistan	0.2582	0.0421	0.1632
2nd	Mali	Democratic Republic of the Congo (Kinshasa)	Chad	Democratic Republic of the Congo (Kinshasa)	Chad	Chad	Democratic Republic of the Congo (Kinshasa)	Mali	Mali	Mali	Albania	0.2196	0.0348	0.1586
3rd	Rwanda	Rwanda	Rwanda	Chad	Rwanda	Rwanda	Chad	Chad	Chad	Rwanda	Argentina	0.1821	0.0282	0.1549
4th	Madagascar	Chad	Democratic Republic of the Congo (Kinshasa)	Rwanda	Democratic Republic of the Congo (Kinshasa)	Malawi	Rwanda	Rwanda	Rwanda	Chad	Armenia	0.1938	0.0195	0.1004
5th	Chad	Malawi	Malawi	Malawi	Malawi	Democratic Republic of the Congo (Kinshasa)	Malawi	Malawi	Malawi	Malawi	Australia	0.0915	0.0106	0.1163
6th	Nepal	Madagascar	Uganda	Uganda	Uganda	Uganda	Uganda	Uganda	Uganda	Sweden	Austria	0.2244	0.0274	0.1220
7th	Uganda	Zambia	Madagascar	Nepal	Paraguay	Paraguay	Nepal	Malta	Sweden	Uganda	Azerbaijan	0.1468	0.0278	0.1897
8th	Malawi	Nepal	Zambia	Paraguay	Nepal	Sweden	Sweden	Sweden	Malta	Malta	Bangladesh	0.2736	0.0434	0.1587
9th	Zambia	Uganda	Nepal	Kenya	Madagascar	Nepal	Paraguay	Niger	Uruguay	Panama	Belarus	0.0953	0.0136	0.1423
10th	Niger	Paraguay	Paraguay	Madagascar	Zambia	Madagascar	Costa Rica	Madagascar	Costa Rica	United Republic of Tanzania	Belgium	0.1833	0.0224	0.1222
11th	Haiti	United Republic of Tanzania	Burkina Faso	Zambia	Kenya	Uruguay	Uruguay	Costa Rica	Panama	Costa Rica	Benin	0.1670	0.0372	0.2231
12th	United Republic of Tanzania	Burkina Faso	Niger	Haiti	Sweden	Kenya	Niger	Uruguay	United Republic of Tanzania	Madagascar	Bolivia	0.1388	0.0231	0.1662
13th	Paraguay	Niger	United Republic of Tanzania	Costa Rica	Niger	Costa Rica	Madagascar	United Republic of Tanzania	Niger	Uruguay	Bosnia and Herzegovina	0.0640	0.0088	0.1373
14th	Burkina Faso	Kenya	Kenya	Burkina Faso	Costa Rica	Burkina Faso	Zambia	Paraguay	Madagascar	Niger	Botswana	0.1951	0.0592	0.3033
15th	Kenya	Haiti	Costa Rica	Sweden	Haiti	Zambia	Malta	Panama	Paraguay	Kenya	Brazil	0.2237	0.0398	0.1777
16th	Costa Rica	Costa Rica	Sweden	Niger	Burkina Faso	Niger	Kenya	Burkina Faso	Kenya	Ireland	Bulgaria	0.1019	0.0113	0.1105
17th	Sweden	Uruguay	Haiti	United Republic of Tanzania	Guinea	United Republic of Tanzania	Panama	Kenya	Cameroon	Paraguay	Burkina Faso	0.3664	0.0853	0.2329

Table A2. *Cont.*

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
18th	Nigeria	Sweden	Guatemala	Cameroon	Uruguay	Guinea	United Republic of Tanzania	Zambia	Afghanistan	Cameroon	Cambodia	0.2384	0.0665	0.2790
19th	Bangladesh	Guatemala	Uruguay	Guatemala	United Republic of Tanzania	Haiti	Burkina Faso	Cameroon	Ireland	Afghanistan	Cameroon	0.2951	0.0459	0.1556
20th	Ghana	Nigeria	Panama	Panama	Cameroon	Cameroon	Cameroon	Afghanistan	Guinea	Haiti	Canada	0.0962	0.0123	0.1276
21st	Guinea	Panama	Ghana	Guinea	Panama	Panama	Haiti	Nepal	Ghana	Guinea	Chad	0.7768	0.1549	0.1995
22nd	Guatemala	Bangladesh	France	Nigeria	Guatemala	France	Guinea	Ghana	Haiti	Burkina Faso	Chile	0.1696	0.0251	0.1483
23rd	Panama	Botswana	Bangladesh	Colombia	Cambodia	Afghanistan	France	Haiti	Burkina Faso	France	China	0.0524	0.0038	0.0721
24th	Afghanistan	Ghana	Cameroon	France	Mauritania	Ghana	Nigeria	Guinea	Denmark	Denmark	Colombia	0.2691	0.0357	0.1328
25th	Mauritania	Colombia	Colombia	Bangladesh	Bangladesh	Guatemala	Ireland	France	France	Ghana	Congo (Brazzaville)	0.1841	0.0348	0.1888
26th	Colombia	Mauritania	Nigeria	Uruguay	France	Bangladesh	Denmark	Nigeria	Colombia	Colombia	Costa Rica	0.3683	0.0441	0.1197
27th	Uruguay	Cambodia	Cambodia	Cambodia	Nigeria	Nigeria	Afghanistan	Ireland	Nepal	Nepal	Croatia	0.1910	0.0215	0.1128
28th	France	France	Mauritania	Ghana	Ghana	Denmark	Ghana	Denmark	Nigeria	Bangladesh	Cyprus	0.1871	0.0240	0.1285
29th	Cambodia	Guinea	Guinea	Mauritania	Afghanistan	Colombia	Colombia	Bangladesh	Lithuania	Lithuania	Czech Republic	0.1132	0.0113	0.0997
30th	Brazil	Tajikistan	Tajikistan	Denmark	Colombia	Lithuania	Lithuania	Lithuania	El Salvador	United Kingdom	Democratic Republic of the Congo (Kinshasa)	0.8937	0.1495	0.1672
31st	Tajikistan	Brazil	Botswana	El Salvador	El Salvador	Mauritania	Bangladesh	Colombia	Bangladesh	El Salvador	Denmark	0.2477	0.0301	0.1214
32nd	Albania	Cameroon	Brazil	Albania	Lithuania	Cambodia	Guatemala	United Kingdom	Zambia	Zambia	Dominican Republic	0.2112	0.0219	0.1035
33rd	Cameroon	Georgia	El Salvador	Philippines	Denmark	Ireland	Congo (Brazzaville)	Latvia	United Kingdom	Italy	Ecuador	0.1540	0.0207	0.1343
34th	Philippines	El Salvador	Philippines	Tajikistan	Nicaragua	El Salvador	El Salvador	Mauritania	Guatemala	Austria	Egypt	0.1398	0.0196	0.1404
35th	El Salvador	Albania	Ireland	Austria	Tajikistan	Italy	United Kingdom	Guatemala	Latvia	Nigeria	El Salvador	0.2385	0.0300	0.1259
36th	Austria	Philippines	Lithuania	Lithuania	Peru	Austria	Italy	Italy	Italy	Guatemala	Estonia	0.0756	0.0076	0.1010
37th	Peru	Portugal	Denmark	Brazil	Italy	Nicaragua	Austria	Luxembourg	Dominican Republic	Latvia	Finland	0.1644	0.0195	0.1186
38th	Botswana	Afghanistan	Portugal	Peru	Ireland	Latvia	Latvia	El Salvador	Luxembourg	Peru	France	0.2821	0.0315	0.1116
39th	Latvia	Peru	Austria	Ireland	Albania	Spain	Mauritania	Austria	Peru	Dominican Republic	Georgia	0.1857	0.0401	0.2159

Table A2. *Cont.*

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
40th	Italy	Spain	Italy	Portugal	Austria	Dominican Republic	Luxembourg	Spain	Austria	Romania	Germany	0.1759	0.0188	0.1068
41st	Lithuania	Italy	Peru	Italy	Spain	Portugal	Peru	Albania	Romania	Luxembourg	Ghana	0.2827	0.0299	0.1057
42nd	Georgia	Austria	Albania	Nicaragua	Portugal	Malta	Spain	Romania	Nicaragua	Spain	Greece	0.1394	0.0159	0.1140
43rd	Spain	Armenia	Spain	Latvia	Philippines	United Kingdom	Albania	Dominican Republic	Spain	Brazil	Guatemala	0.2770	0.0600	0.2166
44th	Portugal	Ireland	Dominican Republic	Spain	Latvia	Peru	Dominican Republic	Nicaragua	Congo (Brazzaville)	Nicaragua	Guinea	0.2938	0.0459	0.1564
45th	Ireland	Dominican Republic	Georgia	Afghanistan	Brazil	Philippines	Nicaragua	Peru	Brazil	Portugal	Haiti	0.3498	0.0879	0.2513
46th	Nicaragua	Nicaragua	United Kingdom	Dominican Republic	Dominican Republic	Congo (Brazzaville)	Philippines	Congo (Brazzaville)	Armenia	Albania	Honduras	0.1621	0.0168	0.1033
47th	Dominican Republic	Lithuania	Nicaragua	Botswana	Malta	Romania	Romania	Portugal	Albania	Croatia	Hungary	0.1888	0.0249	0.1320
48th	Armenia	Denmark	Latvia	Georgia	Botswana	Hungary	Portugal	Brazil	Portugal	Armenia	India	0.1048	0.0108	0.1034
49th	Denmark	Argentina	Argentina	Croatia	Congo (Brazzaville)	Albania	Brazil	Armenia	Croatia	Hungary	Indonesia	0.1624	0.0207	0.1273
50th	Montenegro	United Kingdom	Armenia	United Kingdom	Romania	Brazil	Cambodia	Philippines	Philippines	New Zealand	Iraq	0.0704	0.0101	0.1436
51st	United Kingdom	Cyprus	Cyprus	Cyprus	Hungary	Luxembourg	Hungary	Croatia	Hungary	Cyprus	Ireland	0.2490	0.0284	0.1140
52nd	Argentina	Azerbaijan	Belgium	Benin	United Kingdom	Croatia	Armenia	New Zealand	Belgium	Congo (Brazzaville)	Israel	0.1430	0.0135	0.0944
53rd	Netherlands	Croatia	Netherlands	Hungary	Cyprus	Belgium	Croatia	Hungary	New Zealand	Netherlands	Italy	0.2243	0.0252	0.1123
54th	Romania	Romania	New Zealand	Belgium	Croatia	Netherlands	Cyprus	Belgium	Cyprus	Philippines	Jordan	0.1237	0.0195	0.1574
55th	Chile	Malta	Croatia	Argentina	Benin	Armenia	New Zealand	Cyprus	Finland	Belgium	Kazakhstan	0.0569	0.0065	0.1140
56th	Croatia	New Zealand	Germany	Netherlands	Luxembourg	New Zealand	Belgium	Cambodia	Netherlands	Germany	Kenya	0.3670	0.0680	0.1852
57th	Benin	Chile	Malta	New Zealand	Armenia	Cyprus	Finland	Netherlands	Germany	Cambodia	Kyrgyzstan	0.0976	0.0175	0.1799
58th	Cyprus	Latvia	Hungary	Germany	Argentina	Chile	Netherlands	Germany	Honduras	Finland	Latvia	0.2160	0.0255	0.1180
59th	Senegal	Hungary	Benin	Malta	Belgium	Argentina	Germany	Indonesia	Argentina	Argentina	Lebanon	0.1360	0.0286	0.2100
60th	New Zealand	Netherlands	Luxembourg	Armenia	Georgia	Germany	Argentina	Finland	Mauritania	Israel	Lithuania	0.2374	0.0280	0.1177
61st	Malta	Senegal	Pakistan	Romania	New Zealand	Benin	Chile	Montenegro	Cambodia	Georgia	Luxembourg	0.1940	0.0178	0.0916

Table A2. *Cont.*

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
62nd	Belgium	Pakistan	Chile	Congo (Brazzaville)	Netherlands	Georgia	Indonesia	Argentina	Montenegro	Slovenia	Madagascar	0.4456	0.1334	0.2995
63rd	Hungary	Germany	Romania	Luxembourg	Pakistan	Tajikistan	Tajikistan	Honduras	Indonesia	Honduras	Malawi	0.5956	0.1079	0.1811
64th	Germany	Luxembourg	Honduras	Pakistan	Indonesia	Finland	Slovenia	Botswana	Slovenia	Mauritania	Mali	0.8972	0.1472	0.1640
65th	Luxembourg	Honduras	Senegal	Chile	Germany	Pakistan	Pakistan	Chile	Georgia	Chile	Malta	0.2595	0.0707	0.2727
66th	Azerbaijan	Belgium	Ecuador	Finland	Chile	Slovenia	Benin	Slovenia	Mexico	Mexico	Mauritania	0.2428	0.0622	0.2561
67th	Honduras	Benin	Afghanistan	Senegal	Finland	Indonesia	Georgia	Slovakia	Chile	Senegal	Mexico	0.1525	0.0168	0.1102
68th	Indonesia	Indonesia	Congo (Brazzaville)	Ecuador	Honduras	Botswana	Slovakia	Mexico	Ecuador	Indonesia	Mongolia	0.0533	0.0068	0.1271
69th	Pakistan	Lebanon	Lebanon	Honduras	Senegal	Mexico	Mexico	Georgia	Senegal	Slovakia	Montenegro	0.1577	0.0241	0.1528
70th	Ecuador	Ecuador	Finland	Indonesia	Montenegro	Montenegro	Botswana	Israel	Israel	Montenegro	Morocco	0.1244	0.0173	0.1388
71st	Bolivia	Congo (Brazzaville)	Azerbaijan	Mexico	Ecuador	Honduras	Honduras	Pakistan	Slovakia	Ecuador	Nepal	0.4271	0.1443	0.3379
72nd	Finland	Bolivia	Indonesia	Montenegro	Mexico	Slovakia	Montenegro	Ecuador	Botswana	Thailand	Netherlands	0.1821	0.0218	0.1195
73rd	Slovenia	Egypt	Slovenia	Slovakia	Slovenia	Israel	Israel	Senegal	Pakistan	Botswana	New Zealand	0.1839	0.0183	0.0995
74th	Greece	Mexico	Mexico	Slovenia	Lebanon	Senegal	Ecuador	Greece	Thailand	Pakistan	Nicaragua	0.2125	0.0296	0.1393
75th	Mexico	Slovenia	Egypt	Bolivia	Israel	Ecuador	Senegal	Tajikistan	Benin	Greece	Niger	0.3869	0.0735	0.1900
76th	Egypt	Greece	Bolivia	Lebanon	Azerbaijan	Greece	Greece	Benin	Greece	Benin	Nigeria	0.2799	0.0489	0.1748
77th	Tunisia	Thailand	Montenegro	Azerbaijan	Slovakia	Azerbaijan	Azerbaijan	Thailand	Zimbabwe	Egypt	Pakistan	0.1639	0.0290	0.1767
78th	Lebanon	Jordan	Thailand	Egypt	Egypt	Egypt	Egypt	Egypt	Tajikistan	Azerbaijan	Panama	0.3177	0.0261	0.0823
79th	Thailand	Montenegro	Slovakia	Thailand	Bolivia	Lebanon	Thailand	Azerbaijan	Egypt	Bolivia	Paraguay	0.4097	0.0926	0.2260
80th	Jordan	Finland	Tunisia	Tunisia	Tunisia	Thailand	Bolivia	Bolivia	Azerbaijan	Tajikistan	Peru	0.2201	0.0296	0.1345
81st	Morocco	Tunisia	Jordan	Greece	Greece	Bolivia	Tunisia	Tunisia	Bolivia	Tunisia	Philippines	0.2152	0.0390	0.1810
82nd	Slovakia	Slovakia	Greece	Israel	Thailand	Tunisia	Lebanon	Zimbabwe	United States of America	Czech Republic	Poland	0.1080	0.0119	0.1101
83rd	Israel	Morocco	Israel	Morocco	Republic of Moldova	Morocco	Morocco	Morocco	Tunisia	United States of America	Portugal	0.2127	0.0314	0.1475
84th	Congo (Brazzaville)	Israel	Morocco	Jordan	Morocco	Republic of Moldova	Czech Republic	United States of America	Czech Republic	Jordan	Republic of Moldova	0.1127	0.0160	0.1416
85th	Zimbabwe	Kyrgyzstan	United States of America	United States of America	Jordan	Czech Republic	United States of America	Lebanon	Morocco	Morocco	Romania	0.1953	0.0188	0.0962
86th	Kyrgyzstan	Zimbabwe	Czech Republic	Zimbabwe	United States of America	Jordan	Jordan	Jordan	Republic of Moldova	Zimbabwe	Russian Federation	0.0739	0.0097	0.1317

Table A2. *Cont.*

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
87th	United States of America	India	Kyrgyzstan	Czech Republic	Czech Republic	Zimbabwe	Republic of Moldova	Czech Republic	Jordan	Republic of Moldova	Rwanda	0.7833	0.1496	0.1910
88th	Czech Republic	United States of America	India	Poland	Zimbabwe	United States of America	Poland	Republic of Moldova	Lebanon	Lebanon	Saudi Arabia	0.0925	0.0137	0.1479
89th	India	Czech Republic	Zimbabwe	Republic of Moldova	Bulgaria	Poland	Zimbabwe	Poland	Poland	Poland	Senegal	0.1591	0.0242	0.1523
90th	Republic of Moldova	Republic of Moldova	Republic of Moldova	India	Poland	Bulgaria	India	India	India	Bulgaria	Serbia	0.0779	0.0103	0.1323
91st	Bulgaria	Poland	Poland	Belarus	India	India	Belarus	Bulgaria	Bulgaria	India	Slovakia	0.1459	0.0169	0.1161
92nd	Poland	Bulgaria	Belarus	Bulgaria	Belarus	Belarus	Bulgaria	Canada	Kyrgyzstan	Australia	Slovenia	0.1553	0.0158	0.1017
93rd	Saudi Arabia	Canada	Saudi Arabia	Canada	Canada	Australia	Canada	Kyrgyzstan	Canada	Canada	South Africa	0.0518	0.0070	0.1344
94th	Canada	Saudi Arabia	Canada	Saudi Arabia	Saudi Arabia	Canada	Australia	Belarus	Belarus	Saudi Arabia	Spain	0.2148	0.0252	0.1175
95th	Belarus	Belarus	Bulgaria	Australia	Australia	Kyrgyzstan	Kyrgyzstan	Australia	Australia	Belarus	Sweden	0.3762	0.0373	0.0991
96th	Australia	Australia	Australia	Kyrgyzstan	Kyrgyzstan	Serbia	Saudi Arabia	Saudi Arabia	Ukraine	Ukraine	Tajikistan	0.2000	0.0673	0.3365
97th	Iraq	Serbia	Russian Federation	Serbia	Serbia	Saudi Arabia	Estonia	Estonia	Saudi Arabia	Kyrgyzstan	Thailand	0.1378	0.0152	0.1106
98th	Estonia	Iraq	Iraq	Estonia	Russian Federation	Ukraine	Ukraine	Ukraine	Estonia	Estonia	Tunisia	0.1320	0.0211	0.1600
99th	Serbia	Russian Federation	Serbia	Russian Federation	Ukraine	Russian Federation	Serbia	Serbia	Serbia	Serbia	Turkmenistan	0.0301	0.0026	0.0869
100th	Russian Federation	Ukraine	Estonia	Iraq	Iraq	Estonia	Russian Federation	Russian Federation	Russian Federation	Russian Federation	Uganda	0.5163	0.1053	0.2040
101st	Ukraine	Bosnia and Herzegovina	Ukraine	Ukraine	Estonia	Bosnia and Herzegovina	Iraq	Iraq	Iraq	Bosnia and Herzegovina	Ukraine	0.0756	0.0067	0.0881
102nd	Bosnia and Herzegovina	Estonia	Bosnia and Herzegovina	Bosnia and Herzegovina	Bosnia and Herzegovina	Kazakhstan	Bosnia and Herzegovina	Bosnia and Herzegovina	Bosnia and Herzegovina	Kazakhstan United Kingdom	0.2143	0.0164	0.0766	
103rd	Kazakhstan	Kazakhstan	South Africa	Kazakhstan	Mongolia	Iraq	Kazakhstan	Kazakhstan	Kazakhstan	Iraq	United Republic of Tanzania	0.3750	0.0667	0.1778
104th	South Africa	South Africa	Mongolia	South Africa	South Africa	Mongolia	Mongolia	China	China	China	United States of America	0.1149	0.0120	0.1043
105th	Mongolia	Mongolia	Kazakhstan	Mongolia	Kazakhstan	Uzbekistan	Uzbekistan	Uzbekistan	Uzbekistan	Uzbekistan	Uruguay	0.3357	0.0383	0.1141
106th	China	China	China	China	China	China	China	Mongolia	Mongolia	Mongolia	Uzbekistan	0.0487	0.0075	0.1533

Table A2. *Cont.*

Rank	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Country	Mean	SD	CV
107th	Uzbekistan	Uzbekistan	Uzbekistan	Uzbekistan	Uzbekistan	South Africa	South Africa	South Africa	South Africa	South Africa	Zambia	0.3942	0.1332	0.3379
108th	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Turkmenistan	Zimbabwe	0.1153	0.0107	0.0927

Note: "SD" denote standard deviation; "CV" denote coefficient of variation.

Table A3. VIF statistic.

Variable	VIF	1/VIF
LnCO2	1.00	1.0000
Mean VIF	1.00	

Note: LnGDP values were used as dependent variables in VIF statistics of DEA analysis.

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