THE BIDIMENSIONAL ANALYSIS OF THE NATIONAL CARBON FOOTPRINT BETWEEN 1996-2018

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Abstract:

Recently, climate change phenomenon has gained more and more attention as it it responsible for the declining quality of life, loss of biodiversity, the destruction of ecosystems and the relationships within the socio-ecological complex. The causes that led to the aggravation of this ecological crisis are mainly anthropogenic activities. In the 2030 Agenda, the National Strategy for Sustainable Development 2030 and the Green Deal have been set objectives regarding the reduction of greenhouse gas emissions by 55% before 2030 and and achieving climate neutrality by 2050. In this context, an analysis of the carbon footprint is essential in order to have a starting point for realizing the strategies and policies related to the protection and conservation of the natural environment.

Keywords: carbon footprint, bidimensional analysis, bibliometric analysis, simple linear regression

JELClassification: Q54

REL Classification: 15C Economia mediului

Introduction

In this paper it will be realized a bibliometric analysis in order to determine the scientific interest regarding the climate change and the carbon footprint domain. In addition to this, it will be realized a quantitative analysis, more exactly a simple linear regression, so that the correlation between the Environmental Expenditure and CO2 Emissions can be determined. Nonetheless, it was analyzed the dynamics of the two indicators for the period taken into account.

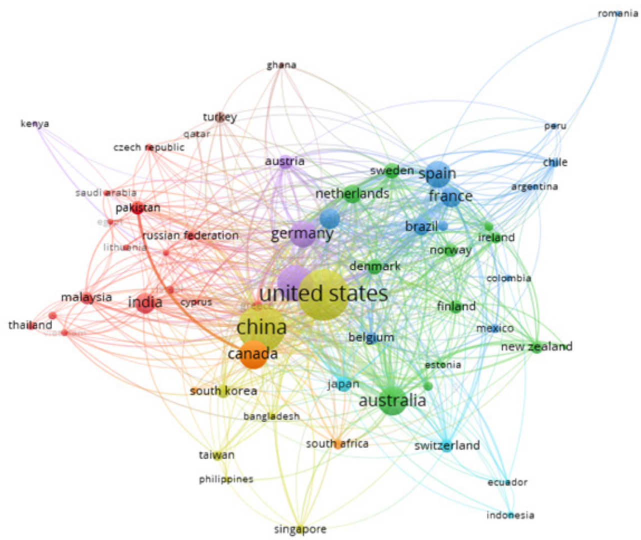
1. Review of scientific literature

Quantitative analysis of scientific documents found in the Scopus database - Bibliometric analysis performed in VOSviewer

In this chapter it was realized a bibliometric analysis of the scientific documents found on Scopus database regarding the climate change and carbon footprint domain. The analysis was realized through VosViewer software, which is free of license. In the first figure, it is presented the Co-autorship analysis.

Co-autorship analysis

Fig.1

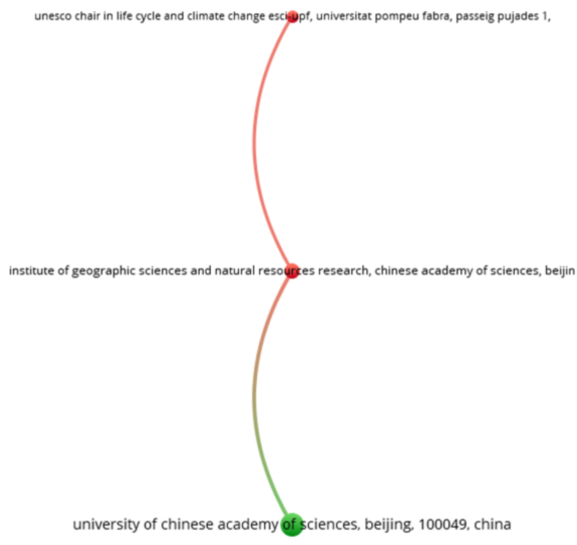


Source: own conceptualization based on Scopus database

The analysis was realized for 60 states. As we can observe from the network visualization above, United States (US) is the country with the highest number of authorship relations. It has 52 links and 511 published documents. On the second place it is situated China with 45 links and 432 published documents in the climate change and carbon footprint domain. The third position is occupied by the United Kingdom with 46 links and 243 published documents.   Regarding Romania, it collaborated with Spain, France and the United States of America to elaborate 5 scientific documents. Figure 2 shows the analysis of the collaboration relations between the organizations that have elaborated papers on the analyzed topic.

Co-autorship of organizations

Fig.2

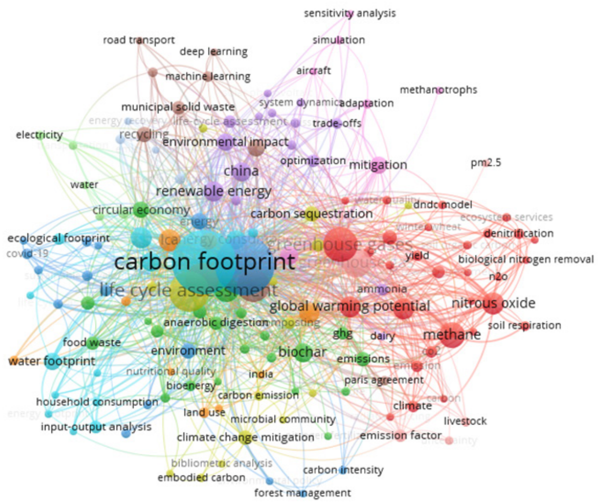


Source: own conceptualization based on Scopus database

It can be noticed that the University of Chinese Academy of Sciences collaborated with the Institute of Geographic Sciences and Natural Research and produced 21 papers referring to the carbon footprint in the context of climate change. The Institute of Geographic Sciences and Natural Research has collaborated with the University of Chinese Academy of Sciences and the Unesco Chair in life cycle and climate change and has developed 8 research papers. Unesco Chair in life cycle and climate change collaborated with the Institute of Geographic Sciences and Natural Research and developed 5 documents. Figure 3 shows the analysis of the keywords used by the authors in the analyzed field.

The analysis of the keywords used by author

Fig. 2



Source own conceptualization based on Scopus database

The most commonly used word is „carbon footprint" with 300 occurrences, followed by „climate change" with 265 occurrences and „life cycle assessment" with 119 appearances. Other words used by authors in specialized works in the field of climate change are „ecological footprint", „water footprint", „electricity", „circular economy", „individual consumption" and „global warming potential".

II. Research methodology

Bibliometrics is a type of quantitative research that analyzes the collaborative relationships between authors, states, organizations, but also the most commonly used words by authors, depending on the field chosen for research. Thus, in this analysis, approximately 2,000 articles were selected from the Scopus database, in the field of climate change and carbon footprint. In the second part of the paper, an econometric analysis was performed in order to determine the influence of environmental protection expenditures on CO2 emissions in the period 1996-2018. Finally, the research results correlate with the targets set in the European Green Deal.

III. Results and discussions

Econometric analysis on the correlation between Environmental Expenditure and CO2 Emissions in the period 1996-2018

The variables utilized for the econometric analysis

Table 1

	Expenditure for environmental protection (mil.lei)	CO2 Emissions (thousands tones Gg)
1996	26.023	136.128,41
1997	46.299	122.103,76
1998	89.337	108.310,47
1999	96.993	92.266,30
2000	134.737	95.794,13
2001	216.224	100.589,18
2002	206.381	106.660,39
2003	394.544	111.772,96
2004	470.778	112.570,38
2005	50.959	106.368,97
2006	89.781	111.654,50
2007	122.773	111.492,95
2009	101.708.000	73.622,91
2010	108.426.000	72.403,38
2011	95.095.000	77.130,90
2012	62.17.000	72.679,73
2013	93.957.000	63.903,34
2014	88.426.000	64.405,45
2015	94.735.000	64.624,94
2016	89.826.000	62.430,48
2017	172.473.000	63.837,06
2018	104.209.000	62.077,31

Source Tempo Online

The table above shows the data required to perform simple linear regression. The data was taken from Tempo Online database, and the analysis is performed over a period of 22 years.

Summay output, simple linear regression realized in Excel

Table 2

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0,879621609
R Square	0,773734176
Adjusted R Square	0,762420884
Standard Error	11328,98184
Observations	22

Source: own conceptualization

Table 2 shows the results obtained after performing the simple linear regression in Excel. Thus, the multiple correlation coefficient (Multiple R) indicates the connection between the two analyzed indicators. As it can be seen, there is a correlation of 87.96% between Environmental Protection Expenditure and CO2 Emissions. The coefficient of determination is expressed as the ratio between the variation of the dependent variable, CO2 emissions, explained by the variation of the independent variable, Expenditures for environmental protection. The corrected value of the coefficient of determination takes into account the number of observations, which in our situation is 22 years. The standard estimation error measures the variability of real Y versus predicted Y values.

The ANOVA test

Table 3

ANOVA	*df*	*SS*	*MS*	*F*
Regression	1	8.777.777.639,05	8.777.777.639,05	68,39160779
Residual	20	2.566.916.591,91	128.345.829,60	
Total	21	11.344.694.230,96		

Source: own conceptualization

The first column presents the degrees of freedom, which take into account the 22 observations to adjust the value of the coefficient of determination. The following columns show the Sums of Squares and the Average of the Sums of Squares Used to Calculate the F Test. F Test indicates whether the analysis performed is justified and is related to the two variables chosen. In this case F has the value 68.3 which means that the simple linear regression model is valid.

The statistical data obtained after realizing the simple linear regression

Table 4

	Coefficients	Standard Error	t Stat
Intercept	107822,635	3190,531856	33,79456461
X Variable 1	-0,000374212	0,00004524970699	-8,269921873

P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
0,0000000000000000004049	101167,3021	114477,9678	101167,302	114477,9678
0,0000000695478047930167	-0,000468601	-0,00027982	-0,0004686	-0,000279822

Source: own conceptualization

The lower and upper limits indicate that any of the coefficients in the first column can fall within the limits of this confidence interval, with a probability of 33.7%.

The residual output

Table 5

RESIDUAL OUTPUT

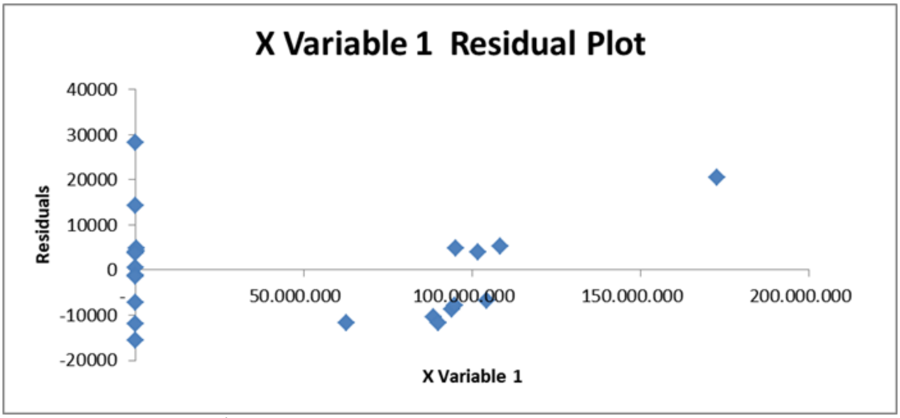
Observation	Predicted Y	Residuals	Standard Residuals
1	107812,8969	28315,51314	2,561109843
2	107805,3093	14298,45066	1,293280561
3	107789,204	521,2659728	0,047147986
4	107786,3391	-15520,03906	-1,40377201
5	107772,2148	-11978,08482	-1,083405792
6	107741,7214	-7152,541447	-0,64694022
7	107745,4048	-1085,014812	-0,098138504
8	107674,992	4097,967955	0,370657103
9	107646,4644	4923,915597	0,445363241
10	107803,5655	-1434,595518	-0,12975773
11	107789,0379	3865,462123	0,349627183
12	107776,6919	3716,25811	0,336131829
13	69762,32749	3860,582507	0,349185826
14	67248,37436	5155,005643	0,466265104
15	72236,98842	4893,911582	0,442649408
16	84352,8355	-11673,1055	-1,055820717
17	72662,84115	-8759,501152	-0,792288118
18	74732,60519	-10327,15519	-0,934080858
19	72371,70457	-7746,764573	-0,700687107
20	74208,70903	-11778,22903	-1,065329035
21	43281,24775	20555,81225	1,859252658
22	68826,42443	-6749,114428	-0,61045065

Source: own conceptualization

The table above shows the standard residue values. Residues represent the difference between real Y and predicted Y. The standardized error value is obtained by relating the residue to the standard deviation of the residual.

Residual output distribution

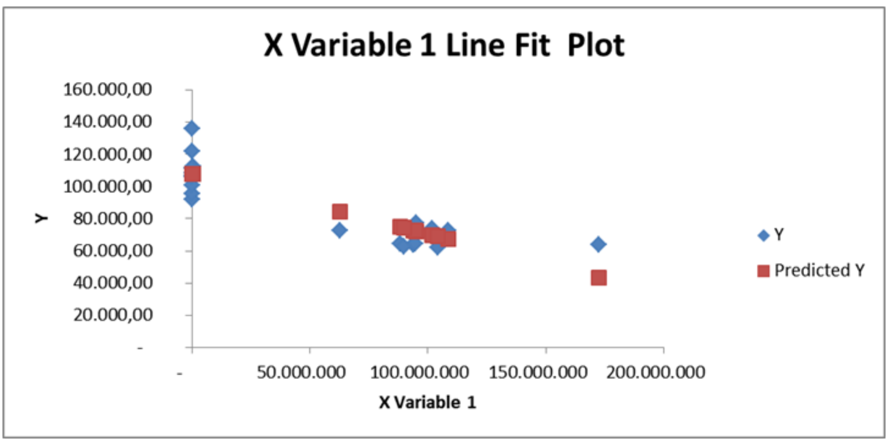
Fig.3.1



Source: own conceptualization

The correlogram

Fig.3.2

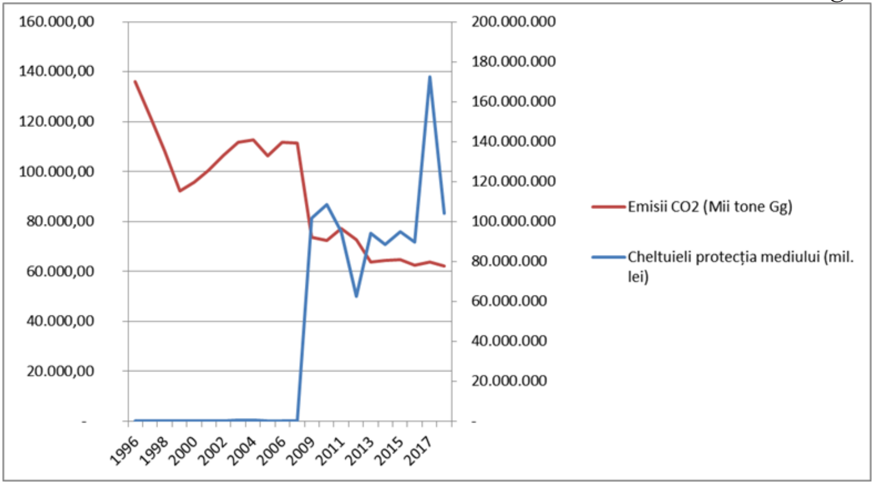


Source: own conceptualization

The first graph shows the residues, and the second graph shows the correlogram. The shape of the graph shows that the model is valid and there is a high degree of correlation between Environmental Expenditure and CO2 Emissions. The correlogram shows the difference between the values of real Y and those of predicted Y. It can be stated that the real values are very similar to the predicted ones, so there is a linear connection between the analyzed variables. The figure below shows the dynamics of CO2 Emissions and Environmental Protection Expenditures in the period 1996-2018.

The dynamics of CO2 Emissions and Environmental Protection Expenditures in the period 1996-2018.

Fig.3.3



Source: own conceptualization

Both CO2 emissions and Environmental Expenditure experienced an oscillating trend during the analyzed period. The highest values of CO2 emissions were recorded in 1996, and the lowest in 2018. These values can be correlated with the evolution of technology. On the other hand, the lowest level of Environmental Protection Expenditure was reported in 1996-2008. According to the graph, the highest value of this indicator was recorded in 2017. However, from 2017 to 2018, Expenditures for environmental protection decreased by approximately 39.5%.

Conclusion

In the context in which anthropogenic actions have led to the aggravation of the phenomenon of climate change, the analysis of the carbon footprint is essential to identify the impact on the socio-ecological complex. Although an analysis realised by sector of activity would more clearly indicate the activities with the highest degree of pollution, the analysis proposed in this paper aims to quantify the evolution of CO2 Emissions and Environmental Expenditure in the period 1996-2018. Thus, it was found that the values of both indicators fluctuated during the analyzed period. Also, the downward trend in CO2 emissions has been based on technological advancement in all sectors of the economy. Based on the econometric model presented, it has been shown that Environmental protection expenditures influence 87.9% of CO2 emissions. Therefore, allocating a higher percentage of Gross Domestic Product to the R&D sector would also significantly reduce greenhouse gas emissions. According to the European Green Deal, the European Union needs a modern, competitive and resource-efficient economy. In this sense, the aim is to achieve climate neutrality by 2050 and decoupling the use of resources from economic growth. The European Green Deal sets out strategies and policies for achieving a sustainable and inclusive economy. Moreover, the European Green Deal aims to stimulate resource efficiency, reduce pollution and restore biodiversity. Actions taken at European level to reduce the carbon footprint include the following:

- Investments in the research and development sector
- Investments in ecological technologies
- Purchasing of sustainable means of transport
- Decarbonizing the energy sector and improving the energy efficiency of buildings
- Improving international relations in order to strengthen global environmental standards

Following the above, it can be stated that the subject of climate change cannot be avoided or postponed. A set of measures and priorities must be established at both national and European level, in order to meet the Sustainable Development Goals, but also to meet the requirements of the 2030 Agenda, the European Green Deal and the National Strategy for Sustainable Development 2030. Although Romania does not live up to the European Commission's expectations of standards for the protection and conservation of the natural environment and the transition to the green economy, through the financial support and technical assistance provided by the European Union, this is achievable.

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