INTERNATIONAL HELLENIC UNIVERSITY

An Empirical Analysis of Convergence in CO_2 Emissions

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Student ID: 3303210005

SCHOOL OF SCIENCE AND TECHNOLOGY

A thesis submitted for the degree of Master of Science (MSc) in Energy and Finance

DECEMBER 2022

THESSALONIKI – GREECE

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Abstract

This dissertation was generated as a part of the Master of Science (MSc) in Energy and Finance at the International Hellenic University (IHU) in the academic year 2022, by the postgraduate student Toliou Konstantina under the supervision of Professor Theologos Pantelidis.

Throughout the years, the increasing and rapid amount of the CO_2 emissions on a global scale has affected the world in many sides and dimensions of the human and everyday life. The present paper attempts to analyze the CO_2 emissions per capita in four (4) groups of different countries from 1990 to 2019. The paper is mainly divided into two (2) parts, the literature review, and the empirical analysis. In the first part, an analytical review of previous studies on the Economic Convergence is thoroughly implemented and in the second part, the empirical analysis takes place accompanied with the presentation of results and conclusions.

At this point, I would like to express my deepest gratitude to my supervisor Professor Theologos Pantelidis for his outstanding and prestigious mentoring throughout my whole academic journey. I am deeply indebted to my professor for giving me the opportunity to work with him on a very interesting, innovative, and challenging project via the whole dissertation procedure.

Lastly, I am also very thankful to my family as well as my friends who have supported me mentally, morally, and physically throughout my Master studies and my academic career in general.

Toliou Konstantina

27/12/2022

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Abstract

The present paper attempts to present an analytical review on the CO_2 emissions as well as to examine and analyze the CO_2 emissions per capita from 1990 to 2019 within four (4) different groups of countries. The groups are the BRICS, the G7, the G12 and finally, the Eurozone countries. The results indicated that BRICS was the only country group that presented indications of convergence. G7, G12, and the Eurozone countries showcased no indications of convergence. Furthermore, in G7 as well as G12, three (3) separate convergence clubs were formulated, respectively. Lastly, in Eurozone countries, the CV graph line was mainly affected by the behavior of Luxembourg.

Key words: CO_2 Emissions per capita, Economic convergence, Climate Change, Significant – Convergence, BRICS, G7, G12, Eurozone countries.

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	CO_2	***Population***
	$MtCO_2$ per year	
World	22,750	5,327,529,078
International Transport	558	
World without International transport	22,192	
Dataset 212 countries	22,192	5,318,336,356
Dataset to World	100.0%	99.8%

Table 1. Completeness of data for 1990.

	CO_2	***Population***
	$MtCO_2$ per year	7,794,798,725
World	34,807	
International Transport	1,004	
World without International transport	33,803	
Dataset 212 countries	33,790	7,782,877,679
Dataset to World	100.0%	99.8%

Table 2. Completeness of data for 2020.

		1990	**2020**
CO_2 emissions	$MtCO_2$/year	22,192	33,803
1990-2020 change	%/year		+1.41%
Population		5,327,529,078	7,794,798,725
1990-2020 change	%/year		+1.28%
CO_2 per capita	tCO_2/year, cap	4.1655	4.3366
1990-2020 change	Per period		4.1%
Average annual change	%/year		+0.13%

Table 3. World averages from 1990 to 2020 and adjustments throughout time.

Glossary

ARDL: Auto Regressive Distributed Lag

AV: Average

BA: Bayesian Analysis

BRI: Belt & Road Initiative

BRICS: Abbreviation for Brazil, Russia, India, China, and South Africa

CO_2: Emissions of Carbon Dioxide

CV: Coefficient Variance

EC: Eurozone Countries

EF: Ecological Footprint

EFL : Environmental Footprint Levels

EU : European Union

FDI: Foreign Direct Investment

G7: Canada, France, Germany, Italy, Japan, United Kingdom and United States

G12: Canada, France, Germany, Italy, Japan, United Kingdom, United States, Australia, Belgium, Netherlands, Switzerland, Sweden, and Spain

GW: Global Warming

MERCOSUR: The Southern Common Market countries (Brazil, Paraguay, Argentina, Uruguay, and Venezuela (suspended since December 2016)).

OECD: Organization for Economic Cooperation and Development

PCCF: Per Capita Carbon Footprint

PCEF: Per Capita Ecological Footprint

RTP: Relative Transition Path

Introduction

The primary aim of this paper is to organize and analyze data in order to allot to the public and the academic community, in general, with useful information and conclusions about the CO_2 emissions among four (4) sets/ groups of different countries. In the imminent study, the data was extracted from the World Bank website. The data provided a detailed and accurate representation regarding the CO_2 emissions per capita from 1990 to 2019 in four (4) specific country groups. These country groups are a) the BRICS (Brazil, Russia, India, China, and South Africa), b) the G7, c) the G12 and finally, d) the Eurozone countries. For each country set, the Sigma - Convergence will be utilized to examine and detect the effect of convergence or divergence among the members of the country sets. This kind of convergence refers to the diachronic decline of interstellar variance of the variable of interest. Within an interpretational context, the Sigma – Convergence states that as time passes, the differences between the members of the group are substantially reduced. As a result, there is a movement towards a common equilibrium point in the long run *(Barro & Sala-I-Martin, 1990)*.

Background

The Economic Convergence phenomenon was initially introduced and analyzed in the 1960s. Clark Kerr, an Economics Professor at Berkeley University was the first one to initiate that term at the University of California. Another professor and well-known physicist, Andrei Sakharov, had also contributed to the aforementioned theory by analyzing it within a more social context. To be more specific, Sakharov argued that the United States of America (U.S) and the Soviet Union are moving increasingly together regarding to their technological, military, and environmental problems thus their political systems *(The Conscience of Humanity, 2016).* The imminent paper attempts to organize and analyze a large series of environmental data as far as the CO_2 emissions are concerned. The data utilized in the present paper were taken from the World Data Bank and cover the period starting from 1990 to 2019. The economic convergence model that was utilized is focusing solely on the Sigma – Convergence category and analyses the Coefficient Variance (CV) and the Relative Transition Path (RTP).

Literature Review

The existing literature engulfs a wide spectrum of empirical and practical reviews, reports, and papers that have been carried out and published throughout the years. As previously stated, the Economic Convergence phenomenon was firstly initiated during the 1960s by Clark Kerr, a Berkeley Professor at the University of California. The Convergence theory is sometimes referred to as the "catch-up effect" *(McCann et al.,2020)*.

The aforementioned effect meticulously explicates the significance of the technological factor in the industrialization procedures of a country, especially in the early stages. In parallel, other nations may place large amounts of money in order to develop and take advantage of that opportunity. As a result, these nations may become more accessible as well as susceptible to both global and international markets. In that way, they earn the right/ privilege to "catch up" with more advanced and excelled nations. However, if the capital is not properly invested and international markets do not take notice of any opportunity, the catch- up effect will not occur. Consequently, the country will diverge significantly. What is more, via the convergence theory,

the economies of developing nations will grow in a bigger and larger scale than those of industrialized countries under these circumstances *(Crossman, 2020)*.

Wand and Zhang (2014) analyze the economic convergence in carbon dioxide emissions in six (6) sectors among twenty-eight (28) different provinces of China. The study focuses on period 1996-2010 and concludes that the per capita carbon dioxide emissions show convergence but the factors that affect convergence vary significantly among sectors.

Li et al. (2020) examine convergence in production- and consumption-based CO_2 emissions. The analysis instates evidence of convergence in both cases. Moreover, the results indicate that convergence in the production-based emissions grows relatively faster compared to convergence in the consumption-based emissions. Meanwhile, the authors detect different convergence paths when developing and developed countries are examined.

In the European road transport sector, CO_2 emissions project convergence under specific conditions such as the fuel prices or the economic activity of the country. Furthermore, the results unambiguously state that the implementation of European policies wield the power to reduce the differences in structural factors among the European countries *(Marrero et al., 2021).*

According to a study that occurred in twenty-seven (27) OECD countries, the World Bank includes the carbon emissions in the carbon footprint as well as in the CO_2 emissions data. However, the two indexes were calculated on different methodological standards and procedures. The study clearly indicates that the only difference that was observed for structural breaks between LM and RALS-LM test is the case of Japan in 1991 *(Solarin, 2019).*

Salman and Vaseem (2019) conduct a club convergence analysis of ecological and carbon footprint within seventy-seven (77) countries from 1961-2014. The analysis depicts that the countries which have the lowest Per Capita Ecological Footprint (PCEF), and Per Capita Carbon Footprint (PCCF) are converging (growing) faster than those countries which have the highest PCEF and PCCF. In addition, their findings suggest that the policies related to the environmental parameter should take into consideration the convergence paths of each country within the cluster for PCEF and PCCF, respectively.

In the Southern Common Market countries, otherwise known as Mercosur (Brazil, Paraguay, Argentina, and Uruguay), the convergence analysis of ecological footprint projects significant evidence from 1961 to 2016. Apparently, the results indicate that countries present different convergence tendencies at different time scales. What is more, the convergence hypothesis holds for only four (4) countries in the medium, and for three (3) of the five (5) countries in the long run. Surprisingly, the only country that seems to hold the convergence hypothesis for the whole timescale is Uruguay *(Ursavaş & Yılancı, 2022).*

Another study specifically investigates the effect and role of globalization on the ecological footprint from 1980-2016 within a set of one hundred and thirty (130) countries. The ultimate results clearly illustrate that globalization projects a positive and significant relationship to the ecological footprint, not only for the full panel sample but also for all the convergence clubs. Howbeit, the findings indicate that the effect of globalization on ecological footprint varies across the convergence clubs and the full panel sample *(Apaydın et al., 2021).*

Across sixteen (16) European countries, between 1961 and 2016, a time-varying Convergence analysis of the Environmental Footprint Levels (EFL) is conducted by utilizing five (5) different indicators of ecological footprints. These indicators are a) cropland, b) grazing land, c) fishing, d) forest, and finally e) total footprint. Whereupon the study reveals that there is neither divergence nor convergence over a long period of time. Furthermore, the results show that

the environmental policies implemented in different periods result in different effects in the European Union (EU) *(Yıldırım et al., 2021).*

In a more specific geographical context, an analytical study investigates the impact of economic growth, CO_2 emissions, globalization, and fossil fuel energy on the ecological footprint of Romania from 1990-2018. The study evidently depicts a mixed relationship between the CO_2 emissions and the ecological footprint. To be more specific, their relationship is positive and negative in the long and short term, respectively *(Topor et al., 2022).*

Ngoc and Awan (2021) examine the effect of economic growth, financial development, and human capital on ecological footprint (EF) in Singapore from 1980 to 2016. Initially, the results that derive from the implementation of the Auto Regressive Distributed Lag (ARDL) method are not providing a clear influence of the financial development on the EF. However, after conducting the Bayesian Analysis (BA), the results explicitly indicate that the economic growth as well as the financial development have a devastating and harmful impact on EF. Ultimately, the study yet showcases that the influence of human capital on the EF is both advantageous and beneficial.

Haider and Akram (2019) conduct a club convergence analysis of the per capita ecological footprint (PCEF) and the per capita carbon footprint (PCCF) by utilizing a sample of seventy-seven (77) countries from 1961 to 2014. The results indicate that the countries with the lowest PCCF and PCEF are growing (converging) in a more rapid way than those with the highest PCCF and PCEF.

Another study examines the potential of energy transition in meeting the ecological goals from 1992-2018 in five (5) major economies that stand by the acronym BRICS (Brazil, Russia, India, China, and South Africa). These ecological goals incapsulate the roles of technology, economic and governmental stability. The final outcomes of the analysis state that the energy transition in BRICS is effective in limiting the ecological footprint (EF). Moreover, it proven that both economic and governmental stability are having a severe contribution to the alleviation and soothing of the environmental degradation *(Tang et al., 2022).*

Additionally, Peng et al. (2022) examine the connection among the economic growth, technology, and CO_2 emissions in BRICS by collecting and analyzing a large series of panel data from 1992 to 2018. In the long run, the results indicate that in a higher level of economic complexity, the benefits of the mitigation of CO_2 emissions in BRICS are bigger and higher. On the other hand, when the economic complexity is low, the CO_2 mitigation benefits are also low. In other words, the relationship between these measures of comparison is proportionate. Lastly, the study reveals that both the economic growth and population density proliferate, augment, and intensify the CO_2 emissions.

Ahmed et al. (2019) investigate the relationship between the ecological footprint and globalization from 1971 to 2014 in Malaysia. The disclosure of the results illustrates that globalization is not severely and significantly affecting the ecological footprint. Thus, it also reveals that globalization specifically increases and intensifies the ecological carbon footprint. Additionally, the study evidently projects that the ecological footprint as well as the carbon footprint are reduced by the population density.

Last but not least, Baloch et al. (2019) make an attempt to examine and detect the effect of the financial development on the ecological footprint from 1990 to 2016 in the Belt and Road Initiative (BRI) countries, by utilizing a panel – regression model. The findings suggest that the ecological footprint is increasing due to the financial development. In addition, the ecological footprint is vividly increasing from parameters such as the energy consumption, economic growth, urbanization, and foreign direct investment (FDI). Eventually, the study adduces a

plethora of policy implications for the minimization of the ecological footprint in the BRI countries.

Ultimately, Nowarski (2022) attempts to analyze to CO_2 emissions per capita for a set of two hundred and twelve (212) countries from 1990 to 2020. Incipiently, he examines the correlation between the cumulative CO_2 emissions and the Global Warning (GW) phenomenon. The study indicates that one hundred (100) countries, between 1990 and 2020, reduce their per capita emissions by 21% on average. Meanwhile, the world average increases by 53%. On top of that, the OECD countries group (forty-one countries) reduces CO_2 emissions by 21% between 1990 and 2020. Both tables one (1) and two (2) present the completeness data from 1990 to 2020, respectively. Table three (3) projects the world averages in the CO_2 from 1990 to 2020 in accordance with the population change.

Implementations

In the imminent study, we utilized and undertaken a variety of different and diverse tests and checks so as to generate our results. To begin with, the first step was to collect and organize the data from 1990 to 2019 in the excel platform. The Economic Convergence model that was utilized was based on the calculation and estimation of the Sigma – Convergence. Two main measures were used in order to produce and generate the results. The first equation calculates the Coefficient of Variance (CV) and the second one the Relative Transition Path (RTP). Below, both CV and RTP equations are provided and explained analytically so as to meticulously portray the whole empirical analysis procedure.

Specifically:

1) ***Coefficient of Variance equation:***

$$CV = \frac{\sigma}{\mu} * 100\%,$$

Figure 1. Coefficient of Variance (CV) equation.

To begin with, in order to estimate the CV, we first calculate the average as well as the standard deviation (Std) of each year for every group of countries. The CV is derived from the division of the Std by the average.

2) ***Relative Transition Path equation:***

$$h_{it} = \frac{X_{it}}{\frac{1}{N}\sum_{i=1}^{N} X_{it}}$$

Figure 2. Relative Transition Path (RTP) equation.

In order to estimate the second (2^{nd}) equation, we divided the data of each group of countries for each year with the average that was generated from the previous equation.

The Relative Transition Path (RTP) signifies the position of each country in comparison with the average. On the one hand, if the RPT of a country is bigger than one (1), that means that

the country is above the average of all the countries in the group under examination. On the other hand, if the RTP of a country is less than one (1), then the country is below the average of all countries tested in a specific group.

Results

The results that were generated, according to our undertaken procedures, provided us with a more specific and clear vision about the current situation. First and foremost, the empirical analysis indicated that all four (4) country groups generated different and diverse results within the same time periods. Below, all four (4) country group results are provided and analyzed.

BRICS

According to Figure 3, the results clearly indicate that the differences among the members of BRICS decrease over time. This is a clear indication of convergence among the countries under examination. Convergence is faster during the first period of our sample (1991-1999). From 1999 to 2003 convergence is disrupted. Afterwards, BRICS continue the convergence process until 2015. In the recent of our sample (after 2015) the convergence process seems to stop.

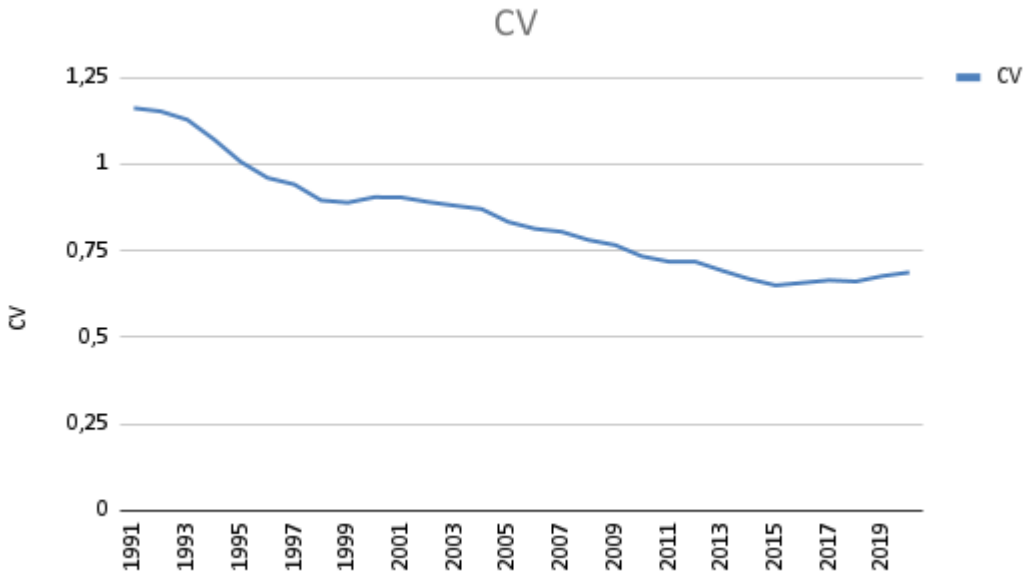

Figure 3. CV in BRICS from 1990 to 2019.

Figure 4 confirms the findings from the CV. In other words, the RTP reported in Figure 4 clearly shows evidence of convergence. Among the five members of BRICS, Russia is the country with the highest CO2 emissions, while Brazil and India are the two countries with the lower per capita emissions. Convergence seems to be driven by the tendency of Russia to move towards the panel average. Moreover, the differences between China and South Africa disappear in the recent years.

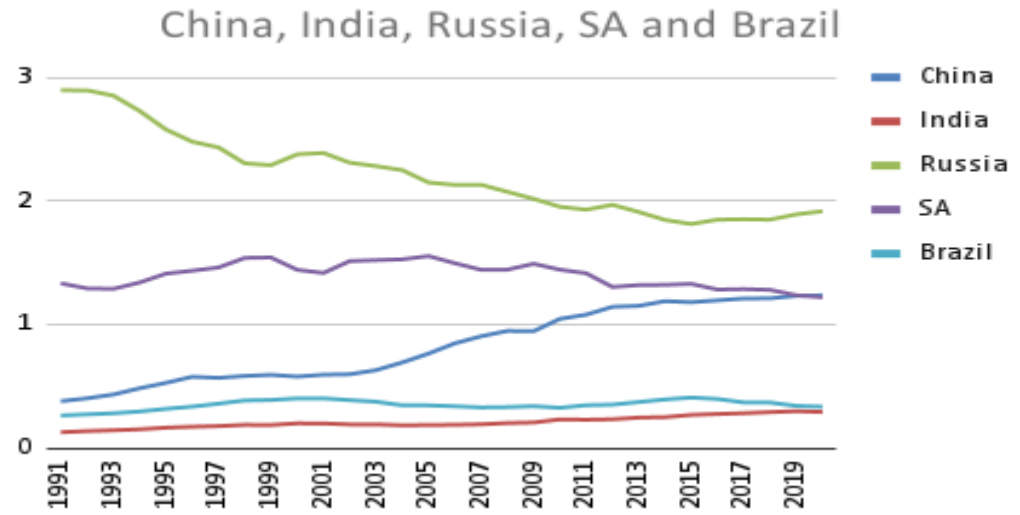

Figure 4. RTP in BRICS from 1990 to 2019.

G7 Countries

According to Figure 5, the results clearly projected that the differences among the members of the G7 group (Canada, France, Germany, Italy, Japan, United Kingdom and United States) do not decrease over time. In other words, there is no indication of convergence among the countries under examination. Specifically, after 2013, the CV graph projects strong indications of divergence.

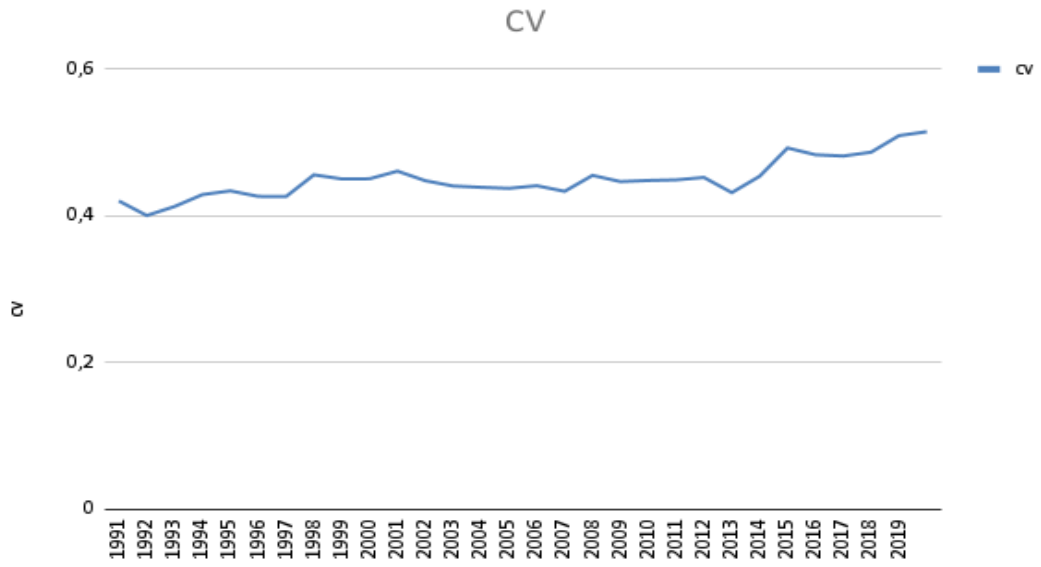

Figure 5. CV in G7 countries from 1990 to 2019.

Below, Figure 6, confirms the evidence and findings from the CV. To be more specific, the RTP in the figure below shows no indications of convergence. Among the members of G7, the United States as well as Canada are the countries with the highest CO_2 emissions per capita. Meanwhile, the countries with the lowest CO_2 emissions per capita are France and Italy.

In other words, the graph below clearly divides the G7 countries in three (3) convergence clubs. The first club is consisted of USA and Canada and the second one Germany and Japan. The third and last group, includes France, Italy, and the United Kingdom. What is more, US and

Canada are moving above the average whereas the second group of countries (France, Germany, Italy, Japan, and United Kingdom) is moving below the average of the whole group.

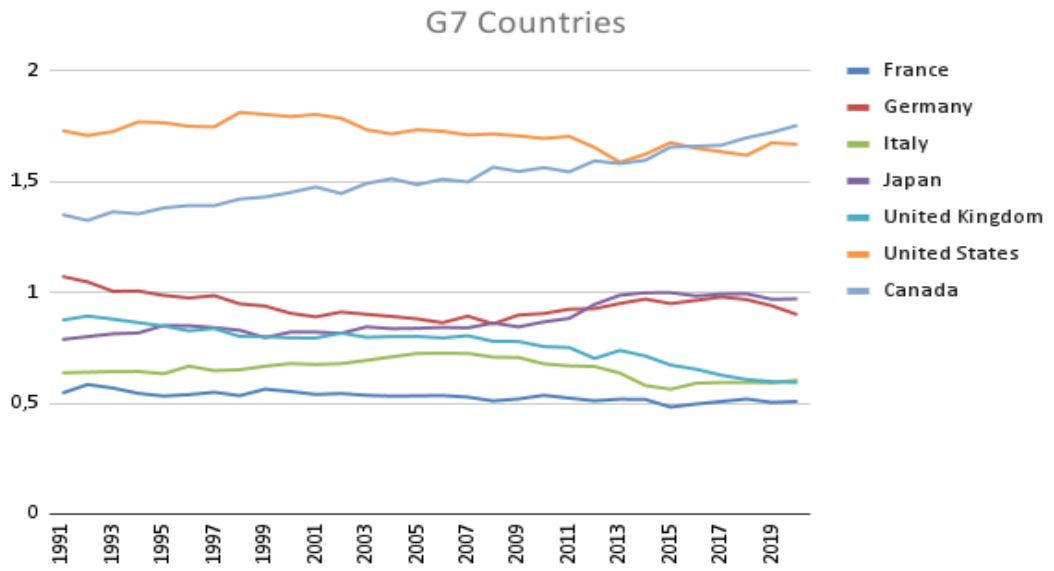

Figure 6. RTP in G7 countries from 1990 to 2019.

In the next stage, we decided to exclude both Canada and United States from our study and observe the results again. From the abovementioned exclusion, we concluded that Canada as well as US have significantly influenced the G7 group in both graphs.

According to Figure 7, the results clearly illustrated that the differences of the members of the G5 group (Germany, Italy, Japan, United Kingdom and France) increase over time. Consequently, this is a clear indication of divergence among the countries that are under examination, especially between 2010 and 2015.

Until 2000, mild indications of convergence are portrayed. From 2000 to 2010, the graph presents evident stagnation and after 2010, the indications of divergence are strong and evident.

From all the above, it is evidently proven that the direct exclusion of Canada and US guided to the immediate change in the CV line. Additionally, it is clearly proven that even two (2) outlier countries (in that case Canada and US), severely influenced the CV measure unit prior to their exclusion.

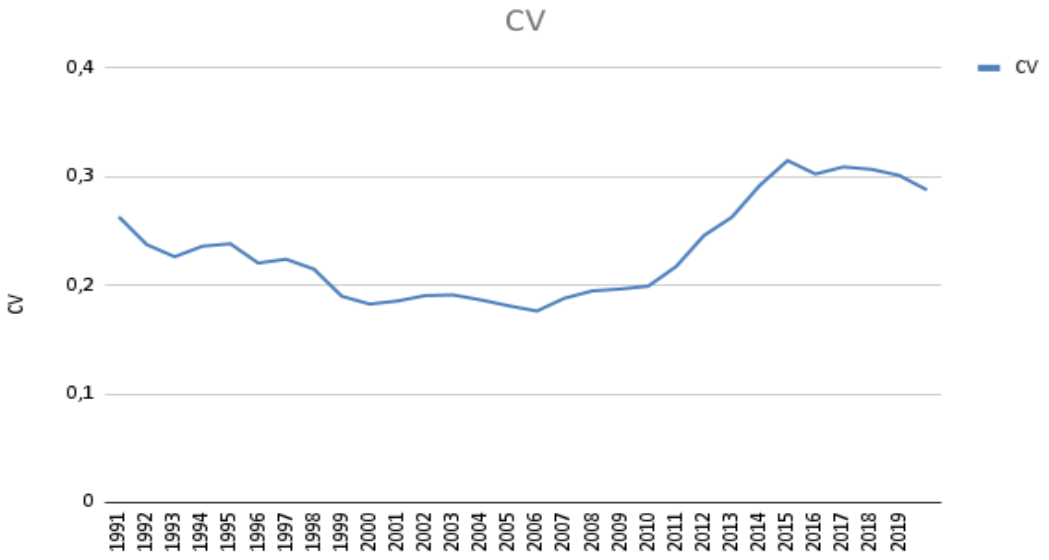

Figure 7. CV in G7 countries (without Canada and US) from 1990 to 2019.

Below, Figure 8 confirms the evidence as well as the findings that were portrayed in the CV line-graph before. In other words, the RTP depicted in Figure 8 clearly showcases no evidence of convergence. Among the members of G5, the countries with the highest CO_2 emissions per capita are Japan and Germany, while the countries with the lowest per capita emissions are Italy and France. Consequently, two (2) separate country clubs were created in the G5 countries group.

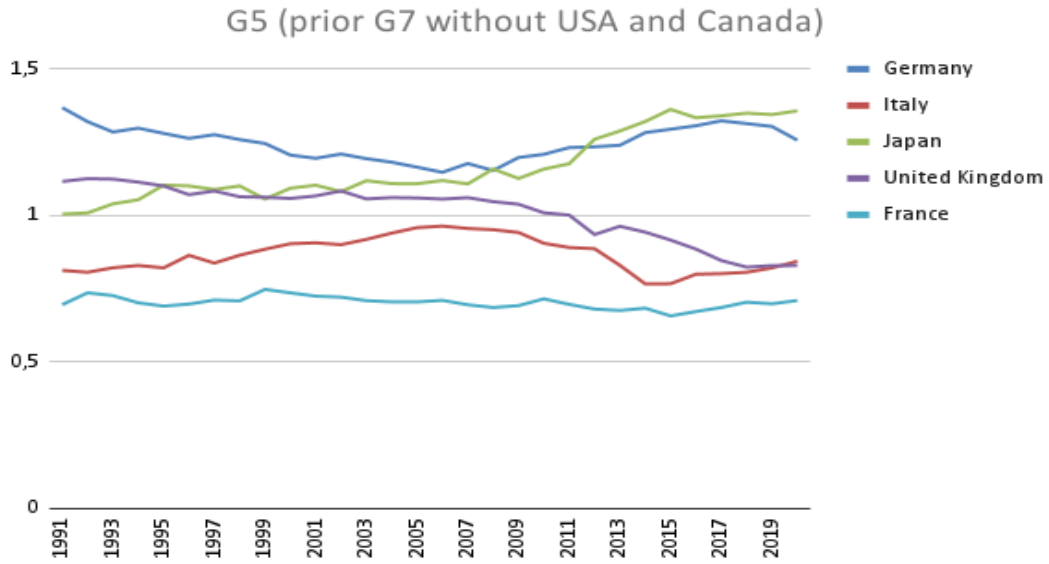

Figure 8. RTP in G7 countries (without Canada and US) from 1990 to 2019.

G12 Countries

According to Figure 9, the findings revealed that the differences among the members of the G12 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States, Australia, Belgium, Netherlands, Switzerland, Sweden, and Spain) do not decrease over time. Consequently, there are no indications of convergence among the countries that are

examined. In fact, before 2008, G12 portrayed indications of slow divergence that after 2008 accelerated.

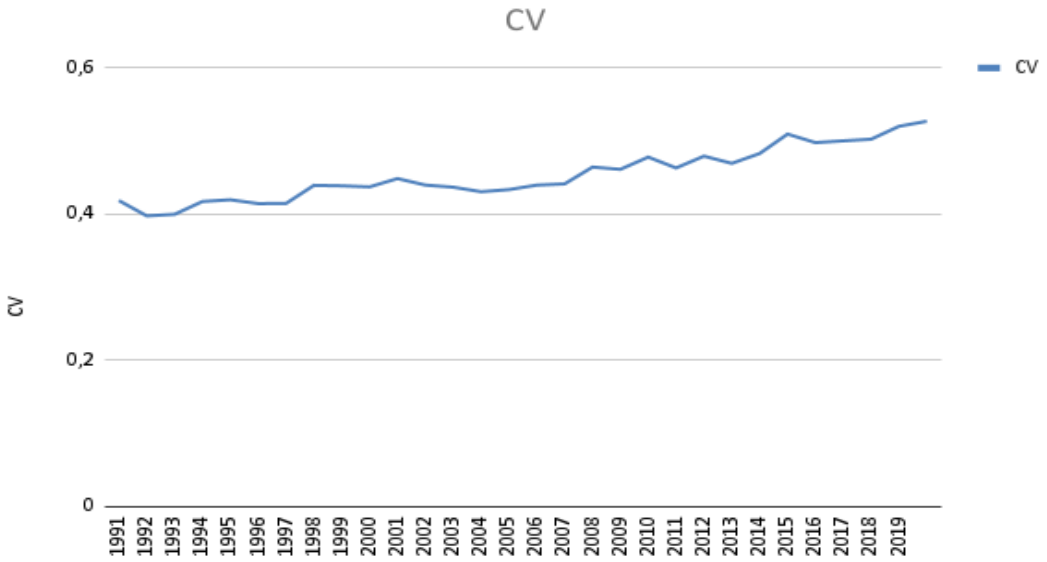

Figure 9. CV in G12 countries from 1990 to 2019.

Furthermore, Figure 10 confirms the findings that were depicted in the CV line- graph before. In other words, the RTP graph presented no effects of convergence among the members of the countries in the group.

Among the members of G12, RTP blatantly categorizes the countries in three (3) separate clubs. The first club includes the countries with the highest CO_2 emissions per capita (Canada, United States, and Australia). The second club consists of the countries a CO_2 emissions per capita level that is moving along with the average of the country group (Germany, Belgium, Japan and, the Netherlands). Finally, the last group includes the countries with the lowest per capita CO_2 emissions, and these are Italy, Spain, Switzerland, Sweden, and the United Kingdom.

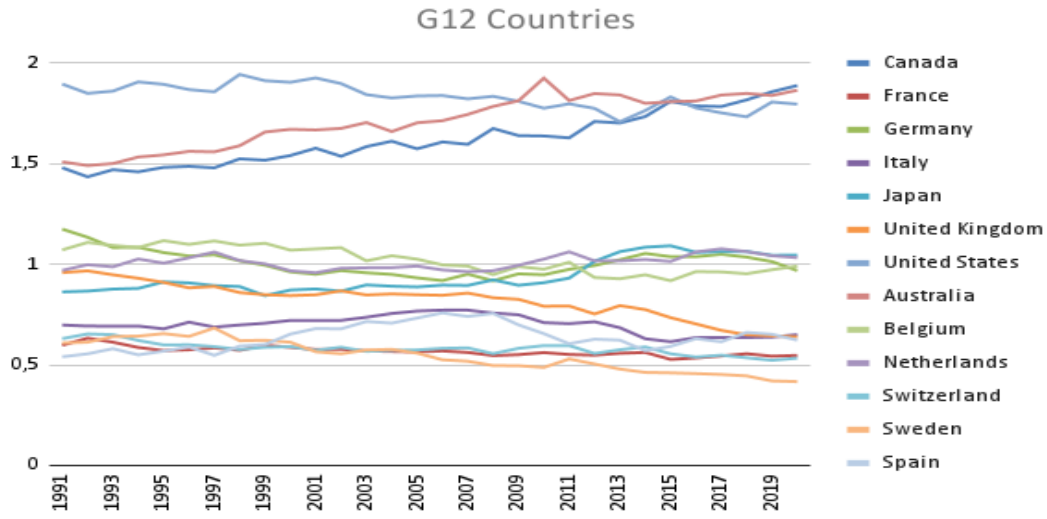

Figure 10. RTP in G12 countries from 1990 to 2019.

In this country group, G12, we decided to reapply the same formula but this time by excluding Canada, Australia, and the US.

Below, it is visibly obvious that the exception of Australia, Canada and US automatically generated a different CV graph with discernible signs of economic divergence, especially after 2006. That plainly suggests, again, that the influence of the excluded countries was relatively big to the point that is dramatically influenced the CV on a wide and large scale.

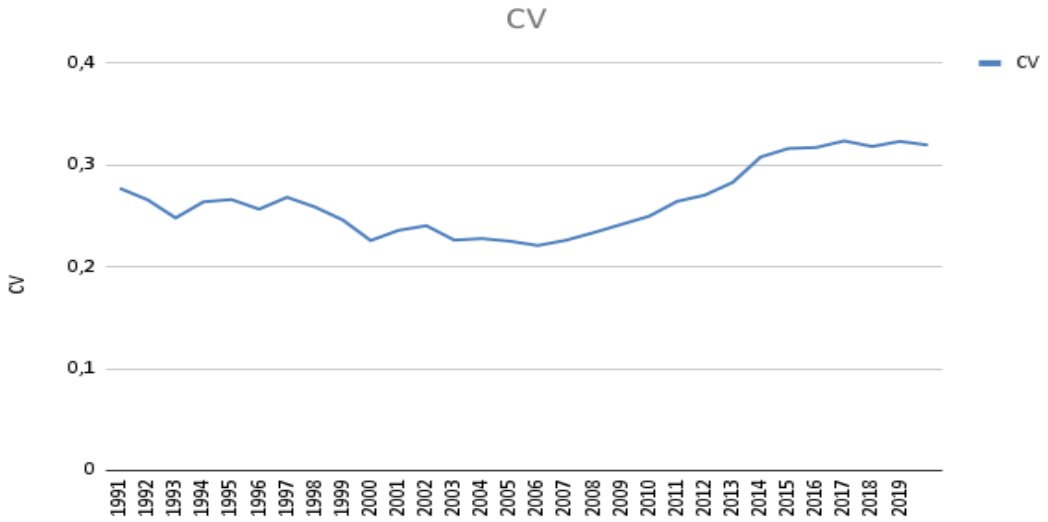

Figure 11. CV in G12 countries (without Canada, Australia, and the US) from 1990 to 2019.

According to Figure 11, the results clearly indicate that the differences among the members of the G10 countries (France, Germany, Italy, Japan, United Kingdom, Belgium, Netherlands, Switzerland, Sweden, and Spain) do not decrease over time. Therefore, there is no indication of convergence in our sample. From 2006 until 2014 the divergence is growing faster. In the recent years, the graph depicts a distinct stagnancy.

Additionally, Figure 12 confirms the evidence and findings that were presented in the CV line – graph. Indeed, the RTP graph clearly presented no indication of convergence among the members of the countries of the group. Among the members of the G10 group, the countries with the highest levels of CO_2 emissions per capita are Japan, Germany, Belgium, and the Netherlands. Meanwhile, the countries with the lowest CO_2 emissions per capita are Sweden, France, and Switzerland. Moreover, the graph lines of Spain, Italy, and the United Kingdom are moving between the abovementioned groups and evidently intersect in 2019.

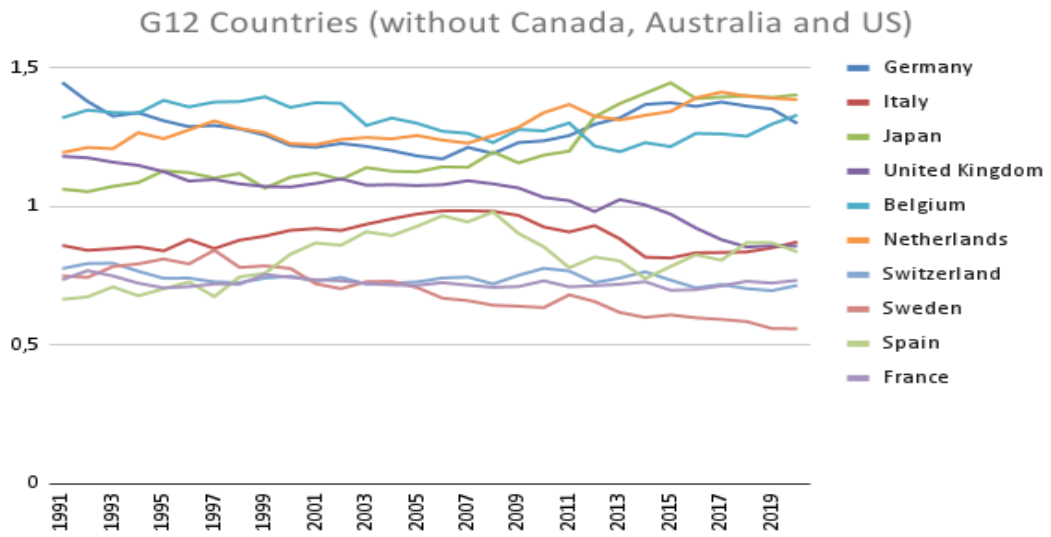

Figure 12. RTP in G12 countries (without Canada, Australia, and the US) from 1990 to 2019.

Eurozone Countries

In the fourth (4th) and final group, Eurozone countries, strong indications of convergence were existent until 1999 and after 1999, an evident stagnancy occurred until the recent years.

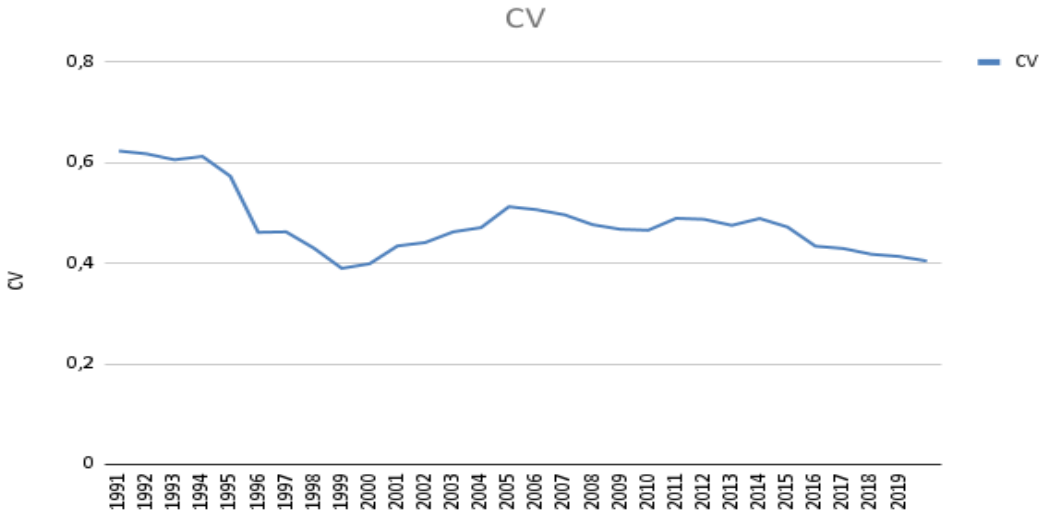

Figure 13. CV in Eurozone countries from 1990 to 2019.

In the following graph, it is evidently proven that among the Eurozone countries only Luxembourg had the tendency to override the rest Eurozone countries. Consequently, the findings portrayed in the CV line – graph are confirmed in Figure 14.

Among the members of the Eurozone countries, the countries with the highest CO_2 emissions per capita are Luxembourg and then, Estonia, while the countries with the lowest CO_2 per capita emissions are Lithuania and Latvia. In between, the remaining Eurozone countries are moving around the average of the group.

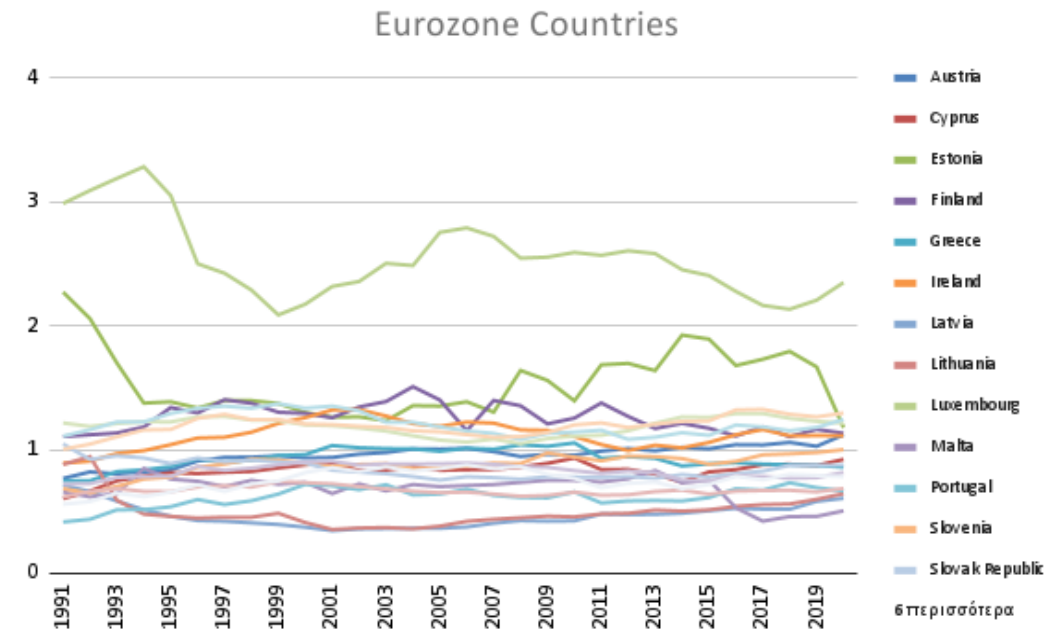

Figure 14. CV in Eurozone countries from 1990 to 2019.

Additionally, we reapplied the above procedure once more, this time by excluding Luxembourg from the Eurozone countries. After the exclusion of Luxembourg, no indications of economic convergence were existent.

According to Figure 15, the results suggest that the differences among the members of the Eurozone countries (except for Luxembourg) decrease and increase in different periods over time. So, there is no clear indication of convergence of divergence among the countries under examination. From 1991 to 1994, the convergence is fast and after the line graph indicates small increases and decreases throughout time. To sum up, there are no indications of convergence or divergence.

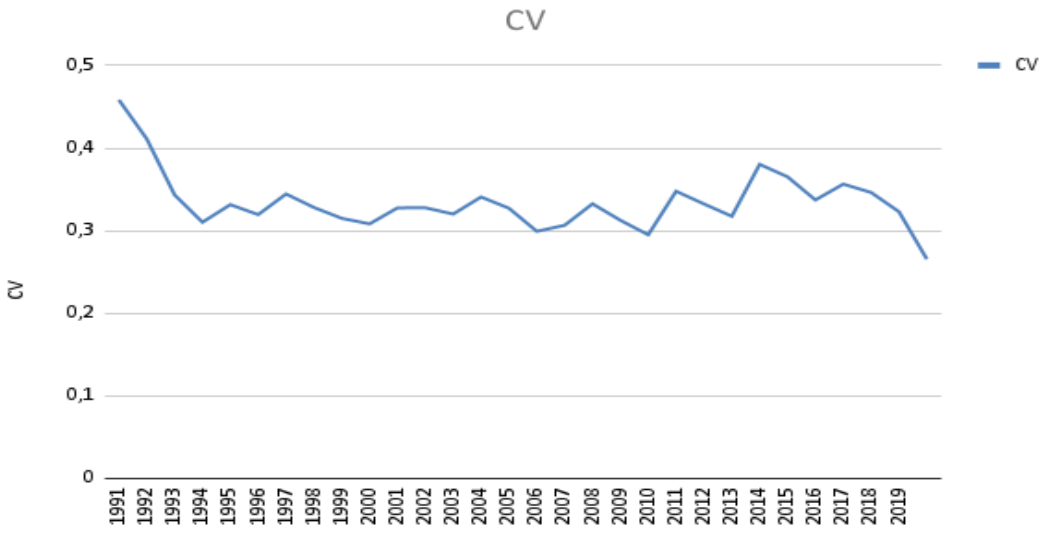

Figure 15. CV in Eurozone countries (without Luxembourg) from 1990 to 2019.

Figure 16 confirms all the findings that were illustrated in the CV line – graph. The absence of convergence is clearly verified from the RTP graph. Among the members of the Eurozone

countries (except for Luxembourg), the country with the highest CO_2 emissions per capita is Estonia. Meanwhile, the countries with the lowest CO_2 emissions per capita are Latvia and Lithuania. The remaining Eurozone countries are moving around the average of the group.

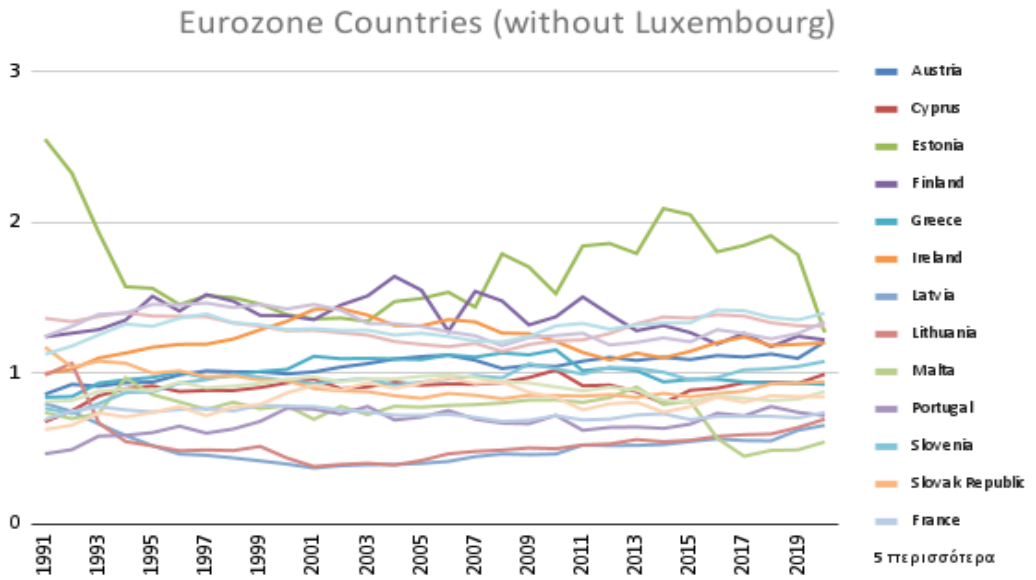

Figure 16. RTP in Eurozone countries (without Luxembourg) from 1990 to 2019.

All in all, all line graphs presented different and diverse results before and after the exclusions. The exclusion selections occurred purposely after the observation of our first results. In other words, the exclusions were implemented on purpose in order to portray the existence and nonexistence of economic convergence and/or divergence.

Testing and Evaluation

Throughout the whole analysis and testing procedure, we examined a large amount of data so as to produce the results and make the appropriate conclusions. The testing was fully generated and produced by utilizing solely the Microsoft Excel platform. Then, we produced line graphs for each and every group of countries for the CV as well as for the RTP.

To sup up, the whole evaluation process was carried out successfully without any severe difficulties or disfunctions. The fundamental evaluation criteria were centered around the existence of economic convergence or divergence among the members of each group as far as the CO_2 emissions per capita are concerned.

In other words, the main purpose was to detect if the differences among the country groups decrease over time so that all the countries that belong into the same group tend to converge at a common equilibrium point. The type of convergence that was selected for the present empirical analysis was the Sigma – Convergence and the measures utilized were both the CV and the RTP.

Conclusions

From all the above, it can be easily inferred that the present paper has generated a plethora of diverse results for a set of different country groups. The main conclusions will be clearly stated and presented below.

To begin with, the first conclusion concerns the BRICS country group and mainly indicates that the above group of countries projected strong indications of convergence throughout the whole testing period.

In the G7 country group, three (3) separate convergence clubs were formulated. The first group includes Canada and the United States. The second group consists of Germany and Japan and the third one includes France, Italy, and the United Kingdom.

In the G12 country group, the findings clearly stated that there are no indications of convergence. In that case, also, three (3) convergence clubs were formulated. The first club includes the countries with the highest CO_2 emissions per capita (Canada, United States, and Australia). The second club consists of the countries a CO_2 emissions per capita level that is moving along with the average of the country group (Germany, Belgium, Japan and, the Netherlands). Finally, the last group includes the countries with the lowest per capita CO_2 emissions (Italy, Spain, Switzerland, Sweden, and the United Kingdom).

Finally, the Eurozone countries portrayed indications of convergence until 1999 and after they remained stagnant. That result was mainly driven by the behavior of Luxembourg.

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