Carbon Emissions and Economic Growth:
A Granger Causality Analysis across 18 Countries

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Abstract:

In this paper, an analysis of the relationship between Economic Growth and Carbon Emissions will be done using data from 9 Developed Countries, and 9 Less Developed Countries, as determined by the World Bank and United Nations. The countries analyzed will be Canada, France, Germany, Italy, Japan, Korea (South), Spain, United Kingdom, United States of America (9 Developed Countries); and India, Indonesia, Iran, Malaysia, Mexico, Brazil, Russian Federation, Saudi Arabia, and South Africa (9 Less Developed Countries). This research expands on the research done by Barassi and Spagnolo (2012), and Coondoo and Dinda (2003).

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1.0 Introduction

Carbon emissions over time and their effects on the environment and its impact on the economy have been studied since the 1980s. However, the theory of the environmental Kuznets curve (henceforth, EKC) and its relevance in environmental economics has become more popular since the 1990s with working papers like "Stoking the fires?" by Holtz-Eakin and Selden (1995). Furthermore, while it has been econometrically difficult to prove the EKC as more than just a theoretical phenomenon, it has been a topic of debate among many researchers. More of this will be discussed in Literature review below.

One point of contention among the research is the ongoing debate regarding the causality between carbon emissions and economic growth. Does economic growth spur greater carbon emissions, is an increase in carbon emissions a leading indicator of economic growth, are they collinear, or are they unrelated? In other words, what affects what: carbon emissions affect growth, vice versa, or not at all? One way to determine the answer to these questions is with Granger causality testing. This will be further discussed in the Literature review below.

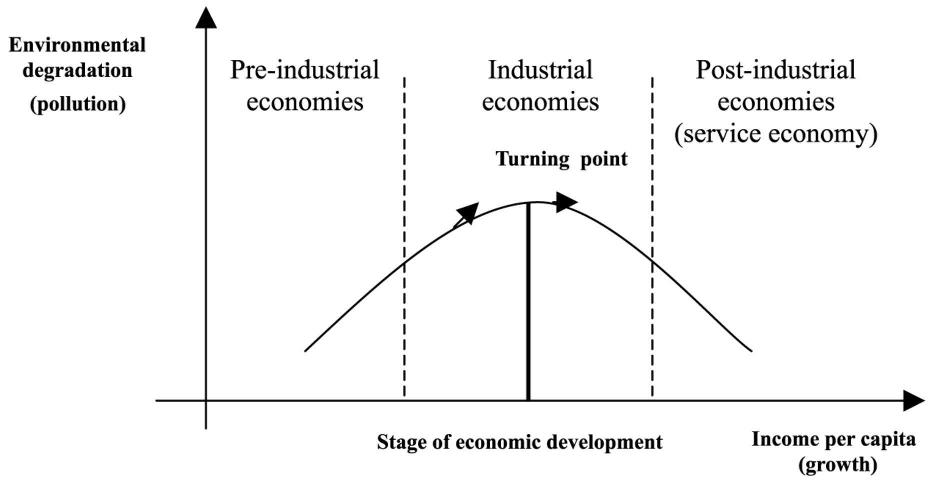
The Kuznets Curve was initially developed by Simon Kuznets, and was not initially intended for its application in environmental economics. It was first hypothesized that the rise in income would initially raise inequality, however, over time, after an inflection point where income is high enough, inequality would again fall. However, in the 1990s, the Kuznets Curve has found other useful applications, especially through the development of the Environmental Kuznets Curve. The Environmental Kuznets Curve has been used to determine at which income level the specific pollutant will see a reduction in emission.

Finally, most of the research has been done using panel data on large sample sizes in countries, 76 capturing all with usable data. However, in the following paper, the countries were selected based on their diverse size, location, and availability of reliable data. These countries were selected as a way to take a critical look at a series of several countries, rather than a single country, or an aggregate of all countries for which there is sufficient data.

2.0 Trends

There are several different trends in the data and in the research for each of the countries and their relationship with the EKC. The EKC is displayed in Figure 1 below. As it can be seen, the EKC suggests that at a certain level of Per Capita GDP, pollution levels, as measured by Carbon Emissions, actually begin to fall.

Figure 1: The Environmental Kuznets Curve



Source: Panayotou (1993)

As depicted in Figure 1, the EKC suggests that after a certain point, the marginal propensity to emit, or MPE, as coined by Holtz-Eakin and Seldon (1995), begins to fall. As a part of the research for this paper, using Granger Causality this study seeks to determine which of the variables causes the other, and if the results suggests the existence of the EKC.

There are many issues surrounding the EKC which have been developed over the years as criticism has mounted regarding the theory. One example of this criticism is in regards to the simplicity of the theory. It suggests that only two umbrella variables affect one another, which may be too few variables in the model.

Furthermore, as suggested by Dasgupta et al. (2002) and Grossman and Krueger (1995), the results and findings of the theory changes depending on the measure of pollution the study uses. While many studies, such as Barassi and Spagnolo (2012), use C02 Emissions as this is a readily available data source, many others, such as Grossman and Krueger (1995) use urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins by heavy metals to measure pollution levels.

Besides other econometric issues and data problems, further criticism for the EKC surrounds the effectiveness of the studies for helping to determine policy issues. Determining the relevance in policy making is difficult because the EKC suggests that the total pollution emissions will only begin to fall after a certain level of economic prosperity, which would suggest to the country that has not reached that level yet to continue to pollute at a normal rate, because naturally the country will eventually thereafter enter the period where the economy becomes service based and pollution will start to fall. Policy decisions then do not surround pollution regulations, but would strictly be for economic growth and reaching the inflection point in the EKC, with environmental damage stricken as a priority because of the prospect of it falling in the future.

3.0 Literature Review

Dinda and Coondoo (2002) specifically look at the causality issue of emissions and income based on panel data for 88 countries. In less developed countries, Dinda and Coondoo (2002) find that there is either no causality, or that causality runs from income to emissions. However, in developed countries, the causality runs in the other direction in that emissions are a causal force in income. As stated by Dinda and Coondoo (2002):

> "[W]e have found that for seven country groups (viz., Africa, Central America, America as a whole, Eastern Europe, Western Europe, Europe as a whole and World as a whole) income and emission are cointegrated. Thus, for these country groups over a long period of time income and emission tend to move in unison" (Coondoo and Dinda 2002, pp17)

The problem is, however, in running additional tests, such as the Engle-Granger test which measures the error of the tests, Coondoo and Dinda (2002) find that the relationship is bidirectional, implying that the model was unstable and that a change in one variable would change the other.

Other questions then began to arise, as researchers asked "Will continued economic growth bring ever greater harm to the earth's environment? Or do increases in income and wealth sow the seeds for the amelioration of ecological problems?" (Grossman and Krueger (1995) pp1). They build from the inverted U-shape that was found in earlier studies of the incomes of the nations and their emission levels over time, and develop the notion of the EKC from there. However, they do not stop with just carbon emissions. Grossman and Krueger (1995) observe four types of indicators: urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins by heavy metals. The findings indicate that the turning point for the U-shaped curve is at $8000 per capita income levels.

The work done by Holtz-Eakin and Seldon (1995) was pivotal in that they were among the first to suggest the Marginal Propensity to Emit as a country becomes wealthier. In other words, in less developed countries or developing countries the data suggest that there is an increase in the amount of carbon emissions. However, after a certain point, the country becomes wealthy enough to either invest in cleaner energy, or becomes more service based in its economy, and therefore has less carbon to emit.

Furthermore, growth in the carbon emissions globally at a projected rate of 1.8 percent, and that this is largely due to the developing countries with a higher Marginal Propensity to Emit. The work done by Holtz-Eakin and Seldon (1995) is pivotal because of their findings and because they found no evidence of simultaneity in the variables of income and growth in carbon emissions.

While some of the research has gotten carried away with the statistical findings and the empirical existence of the EKC, there are researchers that continue to focus on the theoretical application of the EKC and adding new proofs and arguments for the application of the EKC. Andreoni and Levinson (1998) strip away the econometric conditions and focus on the conditions necessary for the inverse U-shaped curve. The research includes other variables in hopes of eliminating the omitted variable bias in their work. The other variables include many consumers, normality of goods, and more. The research is intriguing for their findings, such as the optimal quantity of pollution, the assumptions that are made, such as a one-person economy, for simplicities sake change the results and make the model that is presented simple, but impractical. However, the focus on technology as the major factor in the development of the EKC was an important implication of the research.

Researchers also have tried to tie the EKC with other macroeconomic principles. Brock and Taylor (2010) in “The Green Solow Model” argue that there is a relationship between the

EKC and the Solow Growth Model, one of the cornerstones of macroeconomic theory. The paper argues that with technology incorporated into the Solow Growth Model, the approach towards the steady state can also be seen as the EKC's convergence towards sustainable growth. Furthermore, "the forces of diminishing returns and technological progress identified by Solow as fundamental to the growth process, may also be fundamental to the EKC finding" (pp24).

Barassi and Spagnolo (2012) are among the later researchers looking into the relationship between emissions and economic growth. Their work build on much of the research that had been previously done, however, they use different techniques which yielded in similar results: several variability's among the countries and several exceptions to every rule. For example, they provide evidence for casualty links between per capita carbon dioxide and economics growth, but there are exception when drilling further into the matter and analyzing short term and long term causality. Barassi and Spagnolo (2012) cite the UK and Canada as a few these exceptions.

4.0 Data and Empirical Methodology

4.1 Data

The data used was collected from various sources. The carbon emission data was downloaded from the World Resources Institute (WRI), and was measured as CO2 Total Emissions from 1980 to 2011. Emissions are measured as millions of metric tons of CO2 equivalent. The data available covers 185 countries, from 1850-2008 for CO2 Emissions. The WRI uses other data sources to compile and check their numbers. These sources include IEA, CDIAC, EPA, EIA, and EC-JRC/PBL. The WRI develops the data and presents it as the Climate Analysis Indicators Tool (CAIT), which are the WRI's compilations of greenhouse gas inventory data sets in order to support policy decisions and provide data for other forums.

Data for the Per Capita GDP, Constant Prices were downloaded from the International Monetary Fund. Data was gathered from 1980 to 2011. The data was compiled from the World Economic Outlook database which contains selected data from the World Economic Outlook Report, last published in October 2012. The units used for the PCGDPCP are expressed in billions of national currency units.

4.2 Empirical Methodology

This study was modeled from the work done by Barassi and Spagnolo (2012), who modeled their work on Granger Causality from Toda and Yamamoto (1995) which used an augmented Granger Causality with a lag on the effects of the variable on the other when assessing the Null and Alternative hypothesis.

Granger Causality tests, developed by Granger (1969, 1980), is a system of null hypothesis that tests to see whether variables cause one another. There are 2 null hypotheses which are tested in each Granger Causality: X does not Granger Cause Y, and Y does not Granger Cause X. Therefore, there are four possible outcomes of a Granger Causality test: (1) X does not Granger Cause Y, or the first null hypotheses was failed to be rejected; (2) Y does not Granger Cause X, or the second null hypotheses was failed to be rejected; (3) X does Granger Cause Y, or the first null hypotheses was rejected; or (4) Y does Granger Cause X, or the second null hypotheses was rejected. Therefore, the results can determine if X causes Y only, if Y causes X only, if they cause one another bi-directionally or simultaneously, or if there is no causation.

In order to complete the Granger Causality tests with accurate results, several steps must be done in order to prepare the data and test to ensure that the data is suitable for an accurate Granger Causality test. As outlined in Mohan (2006), (1) Conduct a unit root test using an Augmented Dickey-Fuller Test. (2) Difference the data and retest for unit root using Augmented Dickey-Fuller. (3) Dismiss countries that present evidence of a stationary variable with a non-stationary variable. (4) Estimate cointegration using the same order of integrated variables. (5) Use Vector Auto Regression (VAR) or Vector Error Correction (VEC) to test causality.

The Unit Root test equation is as follows:

$$\Delta X_t = \beta X_{t-1} + \sum_{i=2}^{p} \eta_i \, \Delta X_{t-1+i} + \varepsilon_t$$

$$\Delta X_t = \alpha_0 + \beta X_{t-1} + \sum_{i=2}^{p} \eta_i \, \Delta X_{t-1+i} + \varepsilon_t$$

$$\Delta X_t = \alpha_0 + \beta X_{t-1} + \delta t + \sum_{i=2}^{p} \eta_i \, \Delta X_{t-1+i} + \varepsilon_t$$

Where *x* is the variable PCGDPCP, or Total Carbon Emissions, whichever is being focused on during of the execution of the Unit Root Test. The *p* is the maximum lag length, ε is the stationary random error, and *t* is time. The results of the Unit Root tests are discussed below in the Empirical Results.

The Unit Root tests for non-stationarity. This is important because stationary data, or data that follow one another and trend over time, can present a strong R^2 value. This can present problems because the data would present inaccurate statistics, and create assumptions based on faulty empirical results. If the data is stationary, then the hypotheses cannot be taken with validity, and the data must be removed out from the study.

After differencing the data in order to retest for the Unit Root using the same Augmented Dickey-Fuller model, the countries India and Saudi Arabia were dismissed from the study as they presented evidence of a Unit Root. Using an automatic lag length based on a Schwarz Information Criterion (SIC), the lag lengths that were to be used in the Granger Causality testing were determined. In running the Granger causality tests, the cointegration using Vector Auto Regression (VAR) or Vector Error Correction (VEC) was done.

In the Granger Causality outputs, each Null Hypothesis tested to see if Per Capita GDP, Constant Prices (PCGDPCP) does not Granger Cause C02 Emissions Total. Each Alternative Hypotheses tested the opposite: it tested if C02 Emissions Total does not Granger Cause PCGDPCP. At the start of each Granger Causality analysis, a Unit Root Test was taken in order to correct stationary conditions.

The mathematical statement for the Granger Causality is as follows:

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_m y_{t-m} + \text{residual}_t.$$

As x and y are stationary time series data, the above equation finds the optimal lag time manually. However, the next regression includes x and y to augment the included lagged logs.

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots a_m y_{t-m} + b_1 x_{t-1} + \cdots + b_q x_{t-q} + \text{residual}_t.$$

The Granger Causality tests were done with 3 to 5 units of lag time, as Barassi and Spagnolo (2012) do in their research. This would allow the results of this paper to align and be comparable to the results presented in with work of Barassi and Spagnolo (2012). Barassi and Spagnolo (2012) arrived at running 3 to 5 unit lag tests as a result of Wald tests of joint significance of lags. Granger Causalities in this study was also done with 0, 2, and 3 lags in order to test for different results from the study done by Barassi and Spagnolo (2012), and others. The 2 unit lag time is also interesting to test as this would be able to determine if there is a shorter lag time for the effects of PCGDPCP or CO2 Emissions Totals to affect one another, as compared to other research. The 0-lag Granger Causalities were done as this was the automatic lag showed by the Schwarz Information Criteria test done as a part of the Augmented Dickey-Fuller Unit Root test. Such analysis would bear results that would show whether PCGDPCP affect CO2 Emissions Totals, if CO2 Emissions Totals affect PCGDPCP, if they are independent of one another, or if they both affect one another.

Finally, the data that was used in this study goes back to 1980, unlike much of the data that are used in other papers. The research conducted in this paper seeks to analyze short-term trends, and track the effects over a shorter, more recent period of time in order to investigate the existence and status of the EKC. This will help see the short-term effects and relationship between PCGDPCP and CO2 Emissions. This is important for policy makers as they must often make decisions regarding the short term, with updated figures, and eliminating the chance of faulty historical data, the empirical results in this study can be more heavily relied on for a better prediction of the direction of Granger Causation due to the Recency Effect.

5.0 Empirical Results

The results of the Augmented Dickey-Fuller Unit Root Tests indicate that countries India and Russia both experience unit roots. This means that the stochastic process is not stationary, and the model may present itself with inflated R^2 values, or t-statistic values that are incorrect. The results of the Augmented Dickey-Fuller Unit Root Tests, and the first difference tests, are shown in Appendix A. These countries were dismissed from the tests. Also displayed in Appendix A is the Schwarz information Criterion (SIC), the automatic measure for the augmented lag. Unlike in Barassi and Spagnolo (2012), the most optimal lag time in this study is 0 in most countries, and 0 to 1 in Germany, South Korea, and Saudi Arabia. The problem is, however, that lags of 0 in a Granger Causality study are not supported by the Granger Causality equation.

The empirical results are as follows for lags of two:

Country	PCGDPCP Does not Granger Cause CO2 Emissions	CO2 Emissions Does not Granger Cause PCGDPCP
Canada	Rejected	Rejected
France	**Failed to be Rejected**	Rejected
Germany	**Failed to be Rejected**	Rejected
Italy	**Failed to be Rejected**	Rejected
Japan	**Failed to be Rejected**	Rejected
Korea South	Rejected	Rejected
Spain	**Failed to be Rejected**	Rejected
UK	Rejected	Rejected
US	Rejected	Rejected
Brazil	Rejected	Rejected
India	Omitted Due to Unit Root	Omitted Due to Unit Root
Indonesia	Rejected	Rejected
Iran	Rejected	**Failed to be Rejected**
Malaysia	Rejected	Rejected
Mexico	Rejected	**Failed to be Rejected**
Russia	Omitted Due to Unit Root	Omitted Due to Unit Root
Saudi Arabia	Rejected	Rejected
South Africa	Rejected	**Failed to be Rejected**

*1% level of significance
**5% level of Significance
***10% level of significance

The results above suggest that the majority of developed countries, 5 of the 9 tested, show evidence that the PCGDPCP does indeed Granger Cause CO2 Emissions. Furthermore, with the exception of India and Russia, most of the developing countries that rejected the null hypothesis, rejected the hypothesis that CO2 Emissions does not Granger Cause PCGDPCP, indicating that for most of the developing countries where a relationship was found, it was in the opposite direction as compared to the developed countries. This is in alignment with the work done by many of the researches. However, the empirical results above have been studied with a shorter lag that many other studies which use a lag of three periods. Here, two lags were used for aforementioned reasons.

The following are the empirical results for lags of three:

Country	PCGDPCP Does not Granger Cause CO2 Emissions	CO2 Emissions Does not Granger Cause PCGDPCP
Canada	Rejected	**Failed to be Rejected**
France	Rejected	Rejected
Germany	**Failed to be Rejected**	Rejected
Italy	**Failed to be Rejected**	Rejected
Japan	Rejected	Rejected
Korea South	Rejected	Rejected
Spain	**Failed to be Rejected**	Rejected
UK	Rejected	Rejected
US	Rejected	Rejected
Brazil	Rejected	**Failed to be Rejected**
India	Omitted Due to Unit Root	Omitted Due to Unit Root
Indonesia	Rejected	Rejected
Iran	Rejected	Rejected
Malaysia	Rejected	Rejected
Mexico	Rejected	**Failed to be Rejected**
Russia	Omitted Due to Unit Root	Omitted Due to Unit Root
Saudi Arabia	**Failed to be Rejected**	Rejected
South Africa	Rejected	Rejected

*1% level of significance
**5% level of Significance
***10% level of significance

When comparing the 2-lag tests and the 3-lag tests, a number of differences are highlighted in the results. Ten of the eighteen countries experienced no change in the results when testing with 2-lags or 3-lags. These countries were Germany, Italy, South Korea, Spain, The United Kingdom, The United States, India, Indonesia, Malaysia, and Mexico. Furthermore, Canada, Brazil, and Saudi Arabia developed Granger Causality after adding the additional lag, indicating that the effects of CO2 Emissions causing PCGDPCP, or in the case Saudi Arabia, the effects of PCGDOCP causing CO2 Emissions, took three years to develop.

Whereas in the 2-lag Granger Causality results much of the results rejected the null hypothesis and found that PCGDPCP does affect CO2 Emissions, in the 3 period lag Granger Causality, there are only three Developed countries that found that PCGDPCP does affect CO2 Emissions: Germany, Italy, and Spain, though these countries were also among the ones that experienced no change in the significance of their results between two and three period lags.

For the Less Developed countries in the 2-period lags, many of the countries found the opposite to hold true from the Developed countries. Iran, Mexico, Russia, and South Africa found that CO2 Emissions Granger Cause PCGDPCP in the 2-period lag regressions. However, only one, Mexico, retains those results in the 3-period lag.

6.0 Conclusions

The Empirical results of this study develop many theories as outlined from the studies below. However, one finding in particular is the patterns that emerged when differentiating between Developed Countries and Less Developed Countries, and when comparing between the results of all countries when using two period lags or three period lags.

With the two-period lags on the Granger Causalities, the Developed countries found that PCGDPCP does Granger Cause CO2 Emissions. However, more Less Developed countries, when rejecting the null hypothesis, more often found that CO2 Emissions does Granger Cause PCGDPCP, the opposite Granger Causality than the Developed countries. This is interesting because these findings show that for more Developing Countries, PCGDPCP causes CO2 Emissions to change, whereas in more Less Developed Countries, CO2 Emissions fuels change in PCGDPCP levels.

Clarifying, industrial expansion or decline in Less Developed Countries leads to changes in GDP. This in accordance with the theory of the EKC as in Less Developed countries, growth in the industrial sectors of these countries, in manufacturing, mining, and other highly pollutant activities, is what fuels further growth in the economy and leads to economic prosperity in Less Developed Countries. The opposite is true in Developed countries because the PCGDPCP is already high, or in other words, they are past the inflection point where now the level of prosperity and standard of living has reached a point where money can be spent on technologies that lower the Marginal Propensity to Emit (MPE), as developed by Holtz-Eakin and Seldon (1995).

The difference in lags, and changes in significance levels, the second part of this paper, is also noteworthy because it indicates that the effects of CO2 Emissions or PCGDPCP on each other are made quicker than anticipated. The lag on the effects is not 3 years, but two. While not in the scope of this study, this finding opens the possibility to testing single-period lags. In this case, changes in CO_2 Emissions or PCGDPCP over the course of one year can be analyzed to determine if the effects of CO_2 Emissions or PCGDPCP are felt faster than has been tested for in previous studies. While not optimized using a series of tests, studies in the future in this field can test for speed of the effects empirically. This is important because it provides insight on the timeframe within which policy makers must operate within if seeking to make environmental, economical, or other changes.

Another important factor to note is that this was for a small group of random countries, very much unlike the work done much of the other researches. This sample size was small and manageable, but may require expansion into other countries. Also, as pointed out by some researches, often the countries chosen in the model in this paper were not necessary "less developed" but were in fact fully developed or emerging or simply misclassified.

Due to the fact that these findings do not present information on the direction of the causation, it is difficult to provide many policy recommendations to implications. In the case of the Granger Causality, it is a test that allows researchers to determine the causation, not the direction, or how the variable is affecting the other; only that it does or does not affect the variable. If there are policy actions taken, there is still debate as to the threshold level of income at which carbon emissions becomes a priority in providing measures to abate it. These would have to be measured by looking into a regression model to capture that directional pattern the variables have with each other, and the inflection point for these countries.

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8.0 Appendices

Appendix A: Augmented Dickey-Fuller Unit Root Test

Country	Unit Root	Probability	1st Differenced Probability	Lags Used from SIC
Canada	Unit Root Does Not Exist	0.0000		0
France	Unit Root Does Not Exist	0.0000		0
Germany	Unit Root Does Not Exist	0.0000		0 to 1
Italy	Unit Root Does Not Exist	0.0007		0
Japan	Unit Root Does Not Exist	0.0000		0
Korea South	Unit Root Does Not Exist	0.0000		0 to 1
Spain	Unit Root Does Not Exist	0.0019		0
UK	Unit Root Does Not Exist	0.0000		0
US	Unit Root Does Not Exist	0.0007		0
Brazil	Unit Root Does Not Exist	0.0001		0
India	Unit Root Does Exists	0.2317	0.2317	0
Indonesia	Unit Root Does Not Exist	0.0002		0
Malaysia	Unit Root Does Not Exist	0.0001		0
Mexico	Unit Root Does Not Exist	0.0000		0
Russia	Unit Root Does Exist	0.0181	0.0181	0
Saudi Arabia	Unit Root Does Not Exist	0.0009		0 to 1
South Africa	Unit Root Does Not Exist	0.0001		0

Appendix B: Granger Causality results with Two Lags

Country	PCGDPCP Does not Granger Cause CO2 Emissions	CO2 Emissions Does not Granger Cause PCGDPCP
Canada	0.3108	0.8667
France	**0.061*** **	0.6727
Germany	**0.034** **	0.9294
Italy	**0.0171** **	0.2716
Japan	**0.0511*** **	0.1522
Korea South	0.7306	0.5621
Spain	**0.0186** **	0.5572
UK	0.264	0.4607
US	0.4136	0.9797
Brazil	0.5564	0.2201
India	Omitted Due to Unit Root	Omitted Due to Unit Root
Indonesia	0.4024	0.1243
Iran	0.1375	**0.0761*** **
Malaysia	0.883	0.4569

Mexico	0.1053	**0.0007***
Russia	Omitted Due to Unit Root	Omitted Due to Unit Root
Saudi Arabia	0.4713	0.6188
South Africa	0.3452	**0.009***

*1% level of significance
**5% level of Significance
***10% level of significance

Appendix C: Granger Causality results with Three Lags

Country	PCGDPCP Does not Granger Cause CO2 Emissions	CO2 Emissions Does not Granger Cause PCGDPCP
Canada	0.2164	**0.068****
France	0.2535	0.5414
Germany	**0.0167****	0.7152
Italy	**0.0282****	0.1873
Japan	0.1141	0.3364
Korea South	0.8861	0.8724
Spain	**0.0529*****	0.2301
UK	0.2007	0.1558
US	0.415	0.1325
Brazil	0.2379	**0.0664*****
India	Omitted Due to Unit Root	Omitted Due to Unit Root
Indonesia	0.5925	0.2608
Iran	0.3546	0.0833
Malaysia	0.544	0.3213
Mexico	0.2924	**0.0043***
Russia	Omitted Due to Unit Root	Omitted Due to Unit Root
Saudi Arabia	**0.0566*****	0.6183
South Africa	0.4682	0.0873

*1% level of significance
**5% level of Significance
***10% level of significance